EUROPEAN ASSOCIATION
OF REMOTE SENSING
LABORATORIES

universität**bonn**

36TH EARSeL SYMPOSIUM
"FRONTIERS IN EARTH OBSERVATION"

20-24 JUNE, 2016
BONN, GERMANY

PROGRAMME & ABSTRACT BOOK

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF BONN

Geographie

CENTER FOR REMOTE SENSING
OF LAND SURFACES

ZFL

European Association
of Remote Sensing
Laboratories

universität**bonn**

36th EARSeL Symposium
"Frontiers in Earth Observation"

20-24 June, 2016
Bonn, Germany

Programme & Abstract Book

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Andreas Rienow, Olena Dubovyk, Frank Thonfeld

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Composite)
City of Bonn and its surroundings.

HyMap

RapidEye
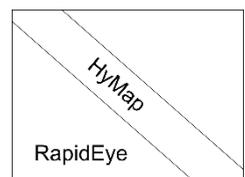
PREFACE

Dear colleagues,

It is my pleasure to welcome you at the 36th EARSeL Symposium in Bonn. The age of 36 years is an age of young, however, already experienced people. Thirty-six symposia dedicated to remote sensing at universities and other scientific laboratories of various institutions is a proof that remote sensing has been developed to an important self-standing tool and thus a matter of research. Even though most people using outcomes of remote sensing do not understand what remote sensing means, we know that our achievements help in many areas of the environment and therefore bring important help to forestry, to agriculture, environmental engineering, hydrologist, city planners, and many other users. There are many users in the world who know our science, however, there are substantially more users in the world, who only use our results for various purposes. Millions of people use navigation systems, weather forecast, computer tomography, etc.

I am happy that results you are going to present at the 36th EARSeL Symposium will bring new tools and new applications and will allow to enlarge number of users of remote sensing. I would like to thank you for your work in remote sensing and for presenting and sharing your experience with all of us.

I wish you a successful meeting – both scientific, and social in Bonn. I believe you will join my acknowledgement to the 36th EARSeL organizers from the Center for Remote Sensing of Land Surfaces & Department of Geography at the University of Bonn in Germany.

Lena Halounová.

EARSeL Chairperson

Dear participants of the 36th EARSeL Symposium 2016,

It is with great pleasure to welcome you in Bonn to this congress. This summer in Bonn the topic of geomatics attracts special interest not only because of the EARSeL Symposium but also throughout a second conference, the Free and Open Source Software for Geospatial.

In 2015 the Geospatial World Forum has awarded Bonn and the whole Geobusiness Region Bonn the title Geospatial Hub of the Year. Hereby it becomes visible that this topic is of essential significance for Bonn and the whole Geobusiness-Region Bonn: with the University, various research institutions and businesses in the fields of geo-IT, geo-data and geo-business you can find a wide range of stakeholders concentrated in one region. To underline this priority, the regional players organize the Bonn Summer of Geomatics 2016: numerous events will attract the political and public attention on Bonn and the surroundings as leading international Science Region and one of the headquarters of scientific and economic development and use of information technology.

Without any doubt in this context the University of Bonn is one of the essential protagonists: it becomes apparent by the importance of earth observation and spatial analysis as part of the students curriculum and as decisive research area and especially by the University's Center for Remote Sensing of Land Surfaces (ZFL). By the realization of the EARSeL Symposium, the ZFL emphasizes its international visibility and its strategic position as partner of crucial stakeholders of the Science Region Bonn, like the German Aerospace Center or the experts for desaster management at UN-SPIDER.

This Abstract Book stresses various topics, which are closely connected to the key topics of the Science Region Bonn: A special focus is on research about developing countries and sustainability, about peace and conflict as well as on risk and catastrophe management. Very concrete contributions – for example about the relevance of earth observation regarding climate change – reflect the importance of those technologies for our planet.

I seriously hope that here in Bonn you will find the opportunity to exchange your findings about this and many other topics relevant for our common future. Your innovative and interdisciplinary approaches and research results will contribute decisively to generate sustainable solutions for global challenges.

Dear participants, I am very pleased that you followed the common invitation of the University and the City of Bonn to come to the Rhineland and I wish you informative and fruitful days in Bonn!

Michael Hoch

Rector of the University of Bonn

Dear participants,

we cordially welcome you to the Federal City of Bonn and Germany's United Nations City. We here at the University of Bonn are pleased to host the 36th EARSeL Symposium during June 20-24, 2016. The motto of this year's symposium is Frontiers in Earth Observation.

In 2001 the University established the inter-departmental Center for Remote Sensing of Land Surfaces (ZFL). In cooperation with the Department of Geography (Faculty of Mathematics and Natural Sciences) and several other departments from the Faculty of Agronomy, ZFL has developed an extensive research program focused on environmental and agricultural satellite remote sensing. In our research, we assess land surface patterns at scales from cells to landscapes along with their spatio-temporal changes. We seek to understand and model the ecological and socio-economic processes behind these changes.

Our goal for the EARSeL scientific program was to assemble an excellent group of keynote speakers -- including young and senior, female and male scientists -- with exceptional research topics. The keynotes will introduce the 25 Symposium sessions that examine a variety of basic and applied research themes. In order to make this event more attractive for young scientists, we follow the successful idea of the Warsaw Symposium in 2014, and are proud to host the Young Scientist Days (YSDs). We have accepted 129 oral and 33 poster presentations; by mid-May 2016, 206 participants from 30 nations had registered.

Besides our excellent scientific programme, we hope our social events will bring you in contact with each other in a less formal atmosphere. On Monday evening, the ice breaker event starts in the Old Town Hall of Bonn; on Thursday evening our symposium dinner will take place on the unique river cruise ship Moby Dick, while we cruise on the River Rhine enjoying the picturesque scenery of the Siebengebirge.

This symposium is being supported by the efforts of many enthusiastic colleagues from the Center for Remote Sensing of Land Surfaces and the Department of Geography. In addition, during the last 2 years the EARSeL Secretariat has provided advice on symposium planning and, in particular, has been most helpful in shaping the meeting in a positive way. Their assistance with numerous particulars of the organization, administration and the scientific program has been invaluable. An event like this would not take place without the support of sponsoring agencies and companies. The Rectors of our University and the Department of Geography have supported this symposium with encouraging words and critical funding. We are extremely grateful to all of them.

We hope that you enjoy the 36th EARSeL Symposium, our University and city and return home with new research ideas and collaborations.

Gunter Menz & Klaus Greve

On behalf of the local organizing team

ORGANISING COMMITTEE

Heide Bierbrauer, EARSeL Office, Germany
Dr. Olena Dubovyk, Center for Remote Sensing of Land Surfaces, Germany
Ellen Götz, Center for Remote Sensing of Land Surfaces, Germany
Prof. Dr. Klaus Greve, University of Bonn, Germany
Prof. Dr. Lena Halounová, EARSeL Chairwoman
Dr. Klaus Komp, EARSeL Vice Chairman
Prof. Dr. Gunter Menz, University of Bonn, Germany
Dr. Andreas Rienow, University of Bonn, Germany
Dr. Frank Thonfeld, University of Bonn, Germany

SPONSORS & EXHIBITION

SCIENTIFIC COMMITTEE

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Prof. Dr. Thomas Blaschke, University of Salzburg, Austria
Prof. Dr. Matthias Braun, University of Erlangen-Nürnberg, Germany
Prof. Dr. Jan Clevers, University of Wageningen, the Netherlands
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Dr. Chris Hecker, University of Twente, The Netherlands
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Prof. Dr. Martin Herold, University of Wageningen, the Netherlands
Prof. Dr. Joachim Hill, University of Trier, Germany
Dr. Karsten Jacobsen, University of Hannover, Germany
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Prof. Dr. Birgit Kleinschmit, Technical University of Berlin, Germany
Dr. Claudia Künzer, DLR Oberpfaffenhofen, Germany
Dr. Tobias Landmann, ICIPE, Nairobi, Kenya
Prof. Dr. Derya Maktav, Istanbul Technical University, Turkey
Dr. Ioannis Manakos, Centre of Research & Technology - Hellas, Thessaloniki,
Greece
Dr. Salvatore Marullo, ENEA Centro Ricerche Frascati, Italy
Prof. Dr. Nicola Masini, IBAM-CNR, Italy
Prof. Dr. Gunter Menz, University of Bonn, Germany
Dr. Andreas Müller, DLR Oberpfaffenhofen, Germany
Ass. Prof. Dr. Konstantinos Nikolakopoulos, University of Patras, Greece
Prof. Dr. Eberhard Parlow, University of Basel, Switzerland
Prof. Dr. Uwe Rascher, Jülich Research Centre, Germany
Dr. Christian Rogaß, German Research Centre for Geosciences Potsdam, Germany
Dr. Rainer Reuter, University of Oldenburg, Germany
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Prof. Dr. Sebastian Schmidtlein, Karlsruhe Institute of Technology, Germany
Prof. Dr. Christiane Schmullius, University of Jena, Germany
Prof. Dr. Alexander Siegmund, University of Education, Heidelberg, Germany
Ass. Prof. Dr. Richhard Sliuzas, University of Twente, the Netherlands
RNDr. Přemysl Štych, Charles University in Prague, Czech Republic
Dr. Jörg Szarzynski, United Nations University, Bonn, Germany
Dr. Sebastian van der Linden, Humboldt University, Berlin, Germany
Ass. Prof. Dr. Jan Verbesselt, University of Wageningen, the Netherlands
Ass. Prof. Piotr Wezyk, Agricultural University of Cracow, Poland
Lars Wirkus, Bonn International Centre for Conversion, Germany
Dr. Stefan Wunderle, University of Bern, Switzerland
Ass. Prof. Bogdan Zagajewski, University of Warsaw, Poland

36th EARSeL Symposium
"Frontiers in Earth Observation"

accompanied by:

EARSeL Young Scientist Days (Chair: B. Zagajewski, F. Thonfeld)

KEYNOTE SPEAKERS

Prof. Dr. Stefan Dech *Challenges of Earth Observation for Global Change Monitoring*
Prof. Dr. Reinhold Ewald *Citizens of Space – Stewards of Earth*
Prof. Dr. Luis Guanter *Space-Based Imaging Spectroscopy for the Monitoring of the Earth's Land Surface*
Prof. Dr. Matthew Hansen *Advancing Global Land Cover Mapping and Monitoring*
Dr. Bianca Hoersch *The Copernicus Programme – A Game Changer in Earth Observation*
Dr. Barbara J. Ryan *International Collaboration for Integrated Earth Observations – Challenges and Opportunities*
Prof. Dr. Wen-zhong John Shi *Towards Reliable Change Detection Based on Satellite Images*
Dr. William L. Stefanov *The International Space Station: A Unique Platform for Earth Observations*

THEMATIC SESSIONS AND CHAIRPERSONS

Agriculture - Dr. Tobias Landmann, Dr. Valerie Graw
Copernicus: Data, Tools, Applications and German Contributions - Dr. Jörn Hoffmann, Dr. Bianca Hoersch
Developing Countries - Dr. Tobias Landmann, Dr. Klaus-Ulrich Komp
Disaster Risk Management - Dr. Juan Carlos Villagran de Leon, Dr. Joachim Post
Earth Observation in Peace & Conflict Studies - Prof. Klaus Greve, Lars Wirkus
Education & Training - Prof. Alexander Siegmund, Dr. Andreas Rienow
Forestry - Dr. Frank Thonfeld, Christina Eisfelder
Geological Applications - Prof. Konstantinos Nikolakopoulos, Dr. Christian Rogass
Imaging Spectroscopy - Prof. Lena Halounova, Dr. Bogdan Zagajewski, Prof. Luis Guanter, Prof. Joachim Hill
Land Degradation - Dr. Tobias Landmann, Dr. Olena Dubovyk
Land Ice & Snow - Prof. Matthias Braun, Dr. Ulrike Falk
Land Use & Land Cover - Dr. Ursula Gessner, Dr. Sebastian van der Linden
OBIA & GEOBIA - Prof. Volker Hochschild, Dr. Stefan C. Lang
SAR - Prof. Steffen Kuntz, Dr. Roland Perko
SAR for Geological Applications - Dr. Christian Rogass, Dr. Karsten Jacobsen
Temporal Analysis - Prof. Eberhard Parlow, Prof. Mattia Crespi
Thermal Remote Sensing - Dr. Claudia Kuenzer, Dr. Corinne Myrtha Frey, Dr. Doris Klein
UAV, UAS & RPAS - Dr. Anna Zmarz, Dr. Olena Dubovyk
Urban - Prof. Derya Maktav, Dr. Roland Goetzke, Prof. Carsten Juergens, Dr. Andreas Rienow
Wetland Monitoring - Prof. Gunter Menz, Dr. Frank Thonfeld

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GENERAL INFORMATION

This booklet contains organisational and programme information as well as abstracts for the 36th EARSeL Symposium on "Frontiers in Earth Observation", held at the Gustav-Stresemann-Institut, Bonn, Germany during June 20-24, 2016

REGISTRATION

The **Reception Desk** for the Symposium is located at the Gustav-Stresemann-Institut and will be opened according to the following schedule:

Monday to Thursday, June 20-23: 8:00am to 5:00pm
Friday, June 24:   8:00am to 12:00pm

FREE WIFI

Wifi Name   GSI
Login   individual registration

INFORMATION FOR SPEAKERS

Speakers are asked to arrive at the room where their session will be held at least **15 minutes** before session starts, so that the session chairs can meet you and give time for any potential last minute issues to be addressed. Bring the copy of your presentation on a USB memory stick in **PPT or PDF** format with you. According to the number of presentations (4-5) in each session, the presentation time is **15-18 minutes plus 5 minutes Q & A**.

INFORMATION FOR AUTHORS

Following the acceptance of your abstract and your registration at the EARSeL Symposium 2016, we would like to invite you to submit full papers to be considered for a publication at a **Special Issue of the European Journal of Remote Sensing** (EuJRS) published in cooperation with the Italian Society of Remote Sensing. The EuJRS (IF:1,4 - 2014) is online and open-access. Follow the register link or just login if you are registered already. During the submission procedure, authors will be instructed to indicate that the paper is for a special issue by entering **"EARSeL Sym 2016"** in the "section" field. The papers will be reviewed following the peer review process of EuJRS. Accepted papers will be published as soon as possible. All submissions to the EuJRS must be received by **September 30, 2016.** Authors shall follow the guidelines of the EuJRS. As an alternative, we would like also to invite you to submit your papers to the EARSeL eProceedings: a full open access remote sensing journal published by the European Association of Remote Sensing Laboratories. The Journal is devoted to peer-reviewed scientific publications in all fields of Earth observation, remote sensing and related ground truth methods. Submission of original contributions and review papers are welcome. Accepted contributions shall be published no later than six months after submission.

INFORMATION FOR POSTER PRESENTATIONS

When preparing your poster, please consider the poster preparation guidelines of EARSeL. We would like to bring to your attention the Best Poster Award which will take place during the EARSeL Symposium in Bonn. We kindly invite you to select your favorite poster and vote for the Best Poster. All participants of the conference will evaluate the posters during the Poster Session and will select the best one. The award will be handed over at the closing session of the Symposium on Friday, 24 June 2016. The filled in forms should be put in a ballot-box during the poser session.

MAP 1: CITY OF BONN OVERVIEW (SOURCE: GOOGLE EARTH)
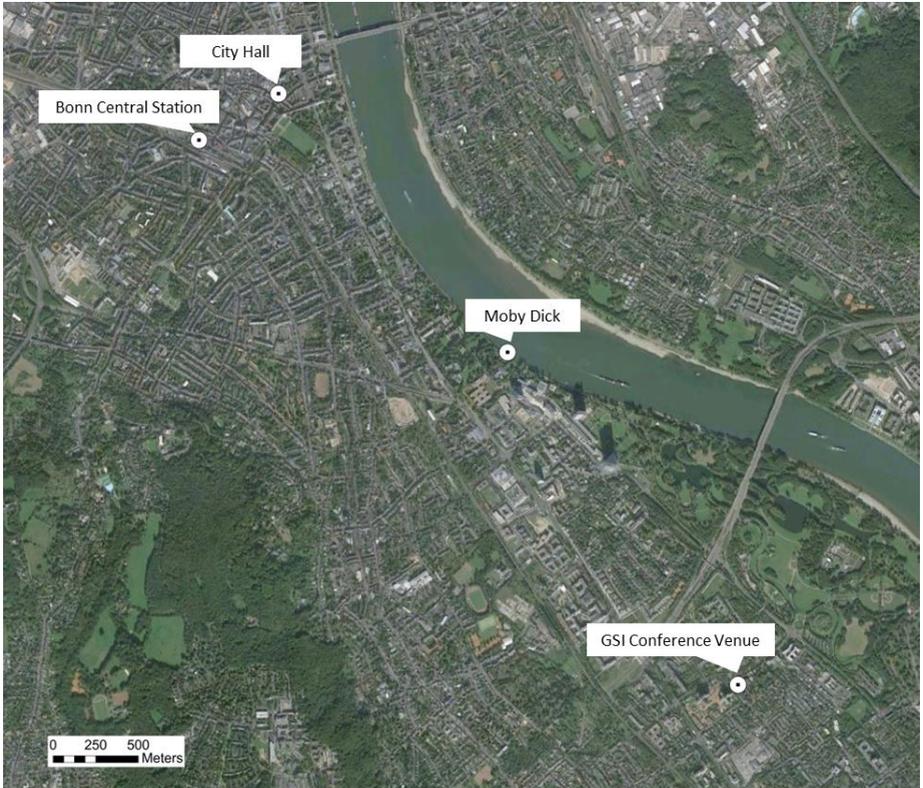
ABOUT THE VENUE

The 36th EARSeL Symposium will be hosted at the Gustav-Stresemann-Institut (GSI) in Bonn (Bundesviertel):
Gustav-Stresemann-Institut e.V.
Langer Grabenweg 68, 53175 Bonn, Germany
(Map 2)

By rail
Between Bonn Central Station (Hbf) and Bonn-Bad Godesberg trams commute every 7 minutes (tram-number 16 and 63)
From Bonn Central station:
- U/tram-line 16 or 63, direction Bad Godesberg
- leave tram at station "Max-Löbner-Straße"
- walk down Max-Löbner-Straße to the end (right side)

From ICE-Station Siegburg / Bonn:
- U/tram-line 66, direction Bonn/ Bad Honnef
- leave tram at station "Robert-Schuman-Platz"
- walk down Kurt-Georg-Kiesinger-Allee, turn left to Jean-Monet-Straße, turn left to Heinemann-Straße

By plane
From airport Cologne / Bonn:
- Bus line SB 60 until Bonn Central Station
- from Bonn Central Station: take U/tram-line 16 or 63, direction Bad Godesberg
- leave tram at station "Max-Löbner-Straße"
- walk down Max-Löbner-Straße to the end (right side)

MAP 2: HOW TO GET TO GSI (SOURCE: GOOGLE MAPS)
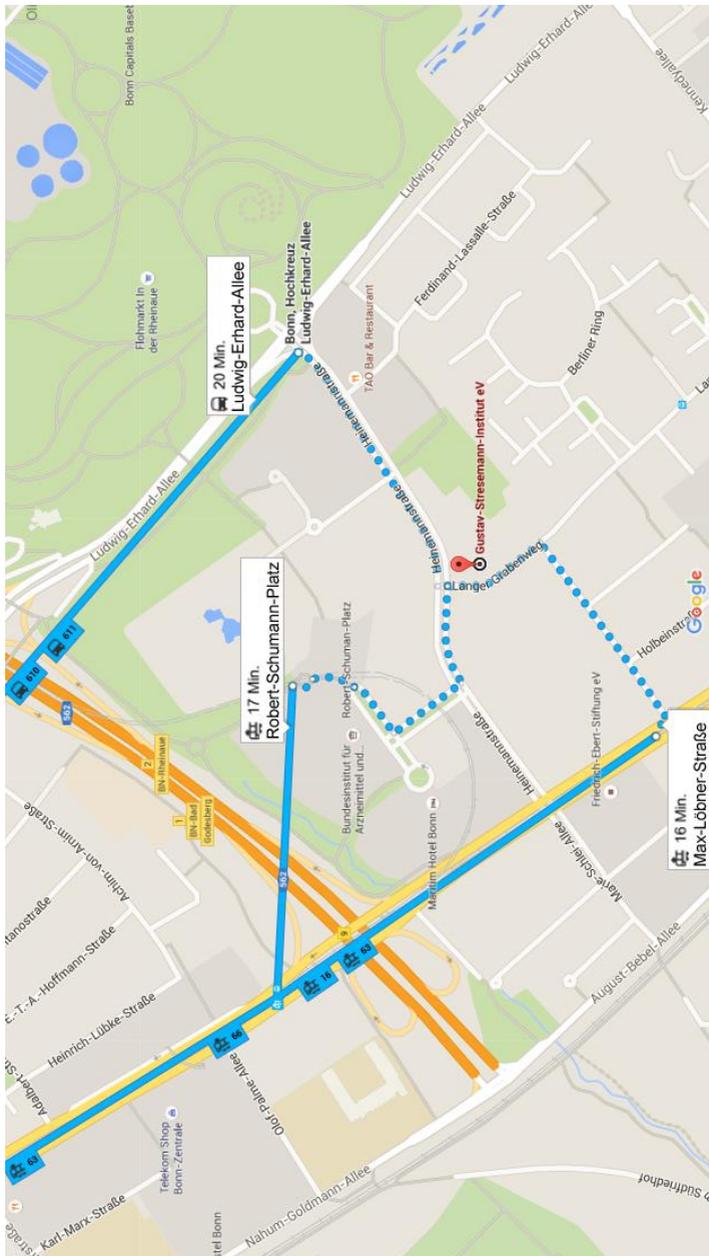
SOCIAL EVENTS

City Hall Reception

All conference participants
are cordially invited by the Lord Mayor
the for an Icebreaker Reception
on June 20, 7pm at the historical
City Hall of Bonn taking place
in the Gobelinsaal (Map 3).

Symposium Dinner

The symposium dinner will
be held on June 23 at 7:00pm
on board of the famous 'Moby Dick'
cruising the River Rhine along the
picturesque scene of the fairytale
Siebengebirge (Map 4).

MAPS 3: HOW TO GET TO CITY HALL RECEPTION (SOURCE: GOOGLE MAPS)
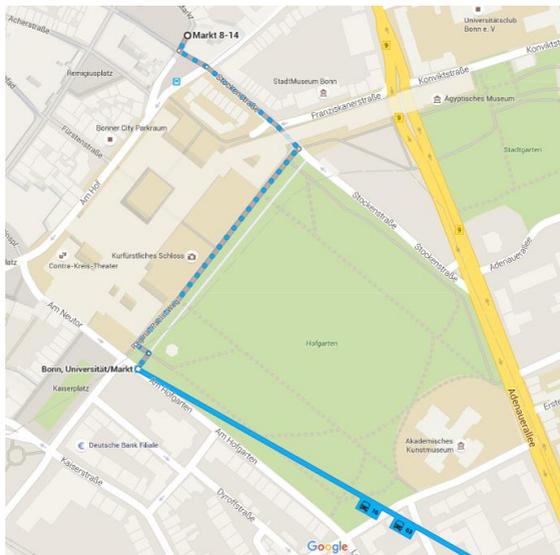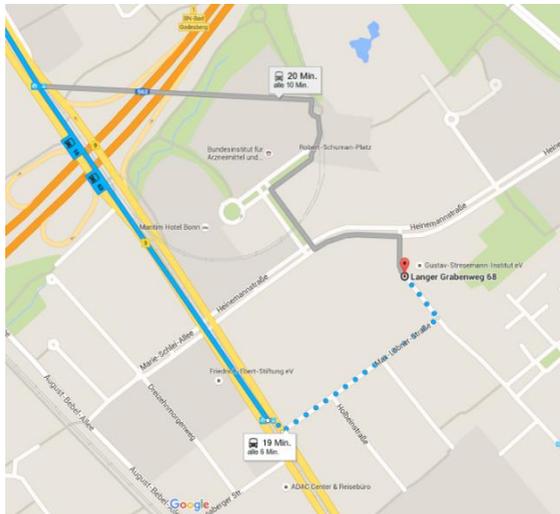
MAPS 4: HOW TO GET TO SYMPOSIUM DINNER (SOURCE: GOOGLE MAPS)
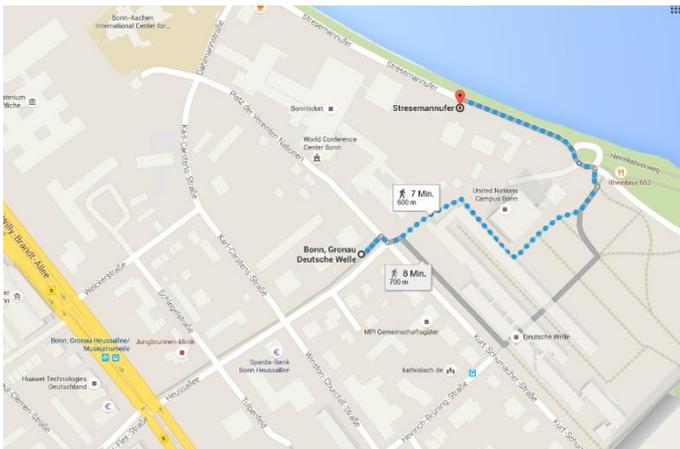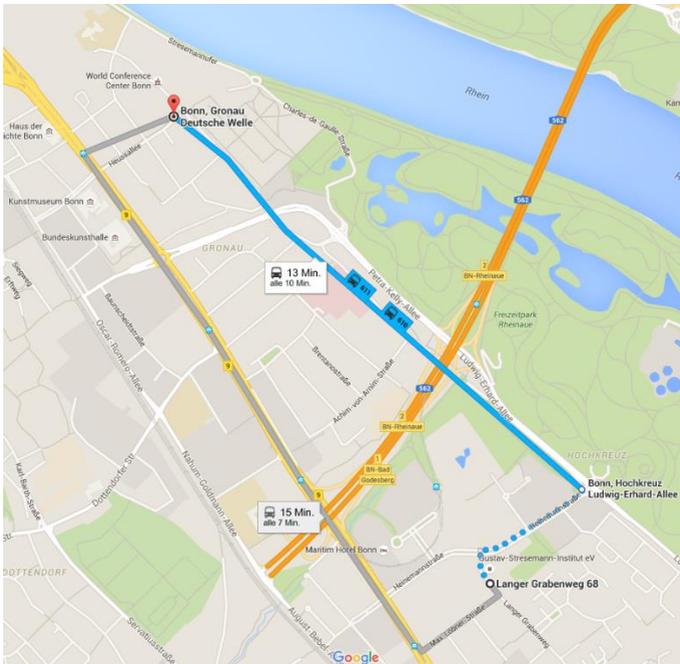
KEYNOTE SESSIONS

PL - 1: OPENING KEYNOTE SESSION (MONDAY, 20 JUNE, 9.00AM)

Welcome Speeches
Prof. Dr. Michael Hoch
Rector of University of Bonn, Germany

Prof. Dr. Lena Halounová
EARSeL, Czech Republic

Prof. Dr. Gunter Menz
Remote Sensing Research Group, University of Bonn, Germany

Citizens of Space - Stewards of Earth
Prof. Dr. Reinhold Ewald
European Space Agency (ESA), Cologne, Germany

The Copernicus Programme - a Game Changer in Earth Observation
Dr. Bianca Hoersch
ESA's European Space Research Institute (ESRIN), Frascati, Italy

PL - 2: KEYNOTE SESSION (TUESDAY, 21 JUNE, 9.00AM)

International Collaboration for Integrated Earth Observations - Challenges and Opportunities
Dr. Barbara Ryan
GEO, Geneva, Switzerland

Challenges of Earth Observation for Global Change Monitoring
Prof. Dr. Stefan Dech
German Remote Sensing Data Center (DFD), Oberpfaffenhofen, Germany

PL - 3: KEYNOTE SESSION (WEDNESDAY, 22 JUNE, 9.00AM)

Advancing Global Land Cover Mapping and Monitoring
Prof. Dr. Matthew Hansen
University of Maryland, USA

Towards Reliable Change Detection Based on Satellite Images
Prof. Dr. Wen-zhong John Shi
Hong Kong Polytechnic University, Hong Kong S.A.R.

PL - 4: KEYNOTE SESSION (THURSDAY, 23 JUNE, 9.00AM)

Space-based Imaging Spectroscopy for the Monitoring of the Earth's Land Surface
Prof. Dr. Luis Guanter
Remote Sensing German Research Centre for Geosciences (GFZ), Potsdam, Germany

The International Space Station: A Unique Platform for Earth Observations
Dr. William L. Stefanov
NASA Johnson Space Center (JSC), Houston, USA

KEYNOTE SPEAKER

Prof. Dr. Stefan Dech

Director of the German Remote Sensing Data Center (DFD) and Professor at the University of Würzburg, Germany

Keynote Title
Challenges of Earth Observation for Global Change Monitoring

Prof. Dr. Reinhold Ewald

Astronaut
European Space Agency, Cologne, Germany

Keynote Title
Citizens of Space – Stewards of Earth

Prof. Dr. Luis Guanter

Head of Section 1.4: Remote Sensing German Research Centre for Geosciences (GFZ), Potsdam, Germany

Keynote Title
Space-Based Imaging Spectroscopy for the Monitoring of the Earth's Land Surface

Prof. Dr. Matthew Hansen

Professor at the Department of Geographical Sciences
University of Maryland, USA

Keynote Title
Advancing Global Land Cover Mapping and Monitoring

Dr. Bianca Hoersch

Sentinel-2 Mission Manager
European Space Research Institute (ESRIN), Frascati, Italy

Keynote Title
The Copernicus Programme – A Game Changer in Earth Observation

Dr. Barbara J. Ryan

Secretariat Director Intergovernmental Group on Earth Observations (GEO), Geneva, Switzerland

Keynote Title
International Collaboration for Integrated Earth Observations – Challenges and Opportunities

Prof. Dr. Wen-zhong John Shi

Head of Department of Land Surveying and Geo-Informatics Hong Kong Polytechnic University, Hong Kong S.A.R.

Keynote Title
Towards Reliable Change Detection Based on Satellite Images

Dr. William L. Stefanov

Program Scientist for Earth Observation NASA Associate International Space Station (ISS) Program, Houston, USA

Keynote Title
The International Space Station: A Unique Platform for Earth Observations
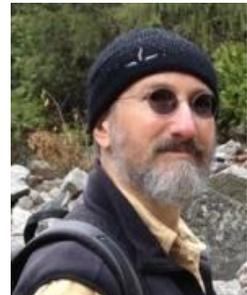
SYMPOSIUM OVERVIEW

Monday, 20/Jun/2016			
9:00am	PL - 1: **Opening Keynote Session** Location: S 29/31		
	Welcome Speeches – L. Halounova, G. Menz, M. Hoch **Citizens of Space - Stewards of Earth** **Prof. Dr. Reinhold Ewald**, *Association of Space Explorers (ASE), Germany* **The Copernicus Programme - a Game Changer in Earth Observation** **Dr. Bianca Hoersch**, *ESA's European Space Research Institute (ESRIN), Germany* Chair: **Prof. Lena Halounová**, *Czech Technical University in Prague, Czech Republic*		
11:00am	Chair: **Prof. Gunter Menz**, *Bonn University, Department of Geography, Germany*		
11:30am	**Coffee Break**		
11:30am	BU - 1: **Big Data and Earth Observation (icw T-Systems)** Location: S 29/31		
12:00am	Chair: **Dr. Frank Thonfeld**, *Bonn University, Department of Geography, Germany*		
12:00pm	**Lunch**		
1:30pm	SE - 01: **Disaster Risk Management 1** *(icw UN-SPIDER)* Location: S 29/31	SE - 02: **UAV, UAS & RPAS** Location: S 30/32	YSD - 1: **Optical Remote Sensing & SAR** Location: S 25/26
	Chair: **Dr. Juan Carlos Villagran de Leon**, *UNOOSA / UN-SPIDER, Germany* Chair: **Dr. Joachim Post**, *United Nations Office for Outer Space Affairs, Germany*	Chair: **Dr. Anna Zmarz**, *University of Warsaw, Poland* Chair: **Dr. Olena Dubovyk**, *University of Bonn, Germany*	Lecturer: **Dr. Francesco Sarti**, *ESA's European Space Research Institute (ESRIN), Italy*
3:00pm	**Coffee Break**		
3:30pm	**UAV, UAS & RPAS - SIG Round Table** Location: S 33	SE - 03: **Developing Countries** Location: S 29/31	SE - 04: **Land Ice and Snow** Location: S 30/32	YSD - 2: **Optical Remote Sensing** Location: S 25/26
		Chair: **Dr. Tobias Landmann**, *International Centre for Insect Physiology and Ecology (ICIPE), Kenya* Chair: **Dr. Klaus-Ulrich Komp**, *EFTAS, Germany*	Chair: **Prof. Matthias Braun**, *Friedrich-Alexander Universität Erlangen-Nürnberg, Germany* Chair: **Dr. Ulrike Falk**, *University of Bremen, Germany*	Lecturer: **Dr. Thomas Bahr**, Harris *Corporation, Germany*
5:00pm				
7:00pm 9:30pm	**Icebreaker – City Hall Reception by Lord Mayor**		

PL: Keynote Session   **SE: SIG Session**   **YSD: Young Scientist Days**

Tuesday, 21/Jun/2016		
9:00am	PL - 2: **Keynote Session** Location: S 29/31 **Challenges of Earth Observation for Global Change Monitoring** **Prof. Dr. Stefan Dech**, *German Remote Sensing Data Center (DFD)* **International Collaboration for Integrated Earth Observations - Challenges and Opportunities** **Dr. Barbara Ryan**, *GEO, Switzerland* Chair: **Prof. Martin Kappas**, *Georg-August-Universität Göttingen, Germany*		
10:30am	**Coffee Break**		
11:00am	SE - 06: **Earth Observation in Peace & Conflict Studies** Location: S 30/32		YSD - 3: **Optical Remote Sensing** Location: S 25/26
	Chair: **Prof. Klaus Greve**, *University of Bonn, Germany* Chair: **Lars Wirkus**, *Bonn International Centre for Conversion - BICC, Germany*		Lecturer: **Dr. Samantha Jane Lavender**, *Pixalytics Ltd, United Kingdom* Chair: **Adriana Marcinkowska-Ochtyra**, *University of Warsaw, Faculty of Geography and Regional Studies, Poland*
12:30pm			
11:00am	SE - 05: **Copernicus: Data, Tools, Applications and German Contributions** (icw DLR) Location: S 29/31		
	Chair: **Dr. Jörn Hoffmann**, *DLR, Germany* Chair: **Dr. Bianca Hoersch**, *ESA's European Space Research Institute (ESRIN), Germany*		
1:00pm			
12:30pm	**Lunch**		
2:00pm	SE - 07: **Disaster Risk Management 2** *(icw UN-SPIDER)* Location: S 29/31	SE - 08: **Land Degradation** Location: S 30/32	YSD - 4: **Big Data with MATLAB** Location: S 25/26
	Chair: **Dr. Juan Carlos Villagran de Leon**, *UNOOSA / UN-SPIDER, Germany* Chair: **Dr. Joachim Post**, *United Nations Office for Outer Space Affairs, Germany*	Chair: **Dr. Tobias Landmann**, *International Centre for Insect Physiology and Ecology (ICIPE), Kenya* Chair: **Dr. Olena Dubovyk**, *University of Bonn, Germany*	Lecturer: **Dmitrij Martynenko**, *Mathworks, Germany* Chair: **Edwin Raczko**, *University of Warsaw, Faculty of Geography and Regional Studies, Poland*
3:30pm			
4:00pm	**Coffee Break**		
	Poster Session		
5:30pm	Location: S 34/35		

PL: Keynote Session   SE: SIG-Session   YSD: Young Scientist Days

Wednesday, 22/Jun/2016		
9:00am — 10:30am	**PL - 3: Keynote Session** Location: S 29/31 **Advancing Global Land Cover Mapping and Monitoring** **Prof. Dr. Matthew Hansen**, *University of Maryland* **Towards Reliable Change Detection based on Satellite Images** **Prof. Dr. Wen-zhong John Shi**, *Hong Kong Polytechnic University, Hong Kong* Chair: **Prof. Eberhard Parlow**, University of Basel, Switzerland		
11:00am	**Coffee Break**		
	SE - 09: **Forestry** Location: S 29/31	SE - 10: **Geological Applications 1** Location: S 30/32	YSD - 5: **SAR** Location: S 25/26
12:30pm	Chair: **Dr. Frank Thonfeld**, *University of Bonn, Germany* Chair: **Christina Eisfelder**, *German Aerospace Center (DLR), Earth Observation Center (EOC), Germany*	Chair: **Dr. Christian Rogass**, *Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, Germany* Chair: **Prof. Konstantinos Nikolakopoulos**, *University of Patras, Greece*	Lecturer: **Dr. Chris Stewart**, *ESA's European Space Research Institute (ESRIN), United Kingdom* Chair: **Dr. Anna Jarocinska**, *University of Warsaw, Faculty of Geography and Regional Studies, Poland*
12:30pm — 2:00pm	**Lunch**		
	EARSeL General Assembly Location: S 29/31	**Geological Applications - SIG Round Table** Location: S 30/32	
3:30pm			
4:00pm	**Coffee Break**		
	SE - 11: **Imaging Spectroscopy 1** Location: S 29/31	SE - 12: **Urban 1** Location: S 30/32	YSD - 6: **Optical Remote Sensing & SAR** Location: S 25/26
5:30pm	Chair: **Prof. Lena Halounova**, *Czech Technical University in Prague, Czech Republic* Chair: **Dr. Bogdan Zagajewski**, *University of Warsaw, Faculty of Geography and Regional Studies, Poland*	Chair: **Prof. Derya Maktav**, *Istanbul Technical University, Turkey* Chair: **Dr. Roland Goetzke**, *Federal Ministry of Transport and Digital Infrastructure, Germany*	Lecturer: **Dr. Chris Stewart**, *ESA's European Space Research Institute (ESRIN), United Kingdom* Chair: **Adrian Ochtyra**, *University of Warsaw, Poland*

PL: Keynote Session   **SE: SIG-Session**   **YSD: Young Scientist Days**

Thursday, 23/Jun/2016				
9:00am 10:30am	PL - 4: **Keynote Session** Location: S 29/31 **Space-based Imaging Spectroscopy for the Monitoring of the Earth's Land Surface** **Prof. Dr. Luis Guanter**, *Remote Sensing German Research Centre for Geosciences (GFZ), Germany* **The International Space Station: A Unique Platform for Earth Observations** **Dr. William L. Stefanov**, *NASA, United States of America* Chair: **Prof. Lena Halounova**, *Czech Technical University in Prague, Czech Republic*			
11:00am	**Coffee Break**			
	SE - 13: **Imaging Spectroscopy 2** Location: S 29/31	SE - 14: **Thermal Remote Sensing 1** Location: S 30/32	SE - 15: **Education & Training** Location: S 34/35	YSD - 7: **UAV & Spectral Measurement Road Show** *(icw SpectAIR, SpectralEvolution, PANalytical)* Location: Field Trip to Klein-Altendorf
12:30pm	Chair**: Prof. Luis Guanter**, *Remote Sensing German Research Centre for Geosciences (GFZ), Germany* Chair**: Prof. Joachim Hill**, *Trier University, Germany*	Chair: **Dr. Claudia Kuenzer**, *German Aerospace Center (DLR), Germany* Chair: **Dr. Corinne Myrtha Frey**, *DLR, Germany*	Chair**: Prof. Alexander Siegmund**, *University of Education & University Heidelberg, Germany* Chair: **Dr. Andreas Rienow**, *University of Bonn, Germany*	Chair: **Dr. Frank Thonfeld**, *University of Bonn, Germany* Chair: **Andreas Tewes**, *University of Bonn, Germany*

PL: Keynote Session   SE: SIG-Session   YSD: Young Scientist Days

Thursday, 23/Jun/2016				
12:30pm 2:00pm	**Lunch**			
	SE - 16: **Land Use & Land Cover** Location: S 29/31	SE - 17: **Geological Applications 2** Location: S 30/32	SE - 18: **SAR** Location: S 34/35	YSD - 8: **UAV & Spectral Measurement Road Show** *(icw SpectAIR, SpectralEvolution, PANalytical)* Location: Field Trip to Klein-Altendorf
	Chair: **Dr. Ursula Gessner**, *German Aerospace Centre, Germany* Chair: **Dr. Sebastian van der Linden**, *Humboldt University, Berlin, Germany*	Chair: **Prof. Konstantinos Nikolakopoulos**, *University of Patras, Greece* Chair: **Dr. Christian Rogass**, *Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, Germany*	Chair: **Prof. Steffen Kuntz**, *Airbus DS GmbH, Germany* Chair: **Dr. Roland Perko**, *Joanneum Research, Austria*	Chair: **Dr. Frank Thonfeld**, *University of Bonn, Germany* Chair: **Andreas Tewes**, *University of Bonn, Germany*
3:30pm 4:00pm	**Coffee Break**			
	SE - 19: **Agriculture** Location: S 29/31	SE - 20: **Urban 2** Location: S 30/32	SE - 21: **OBIA & GEOBIA** Location: S 34/35	YSD - 9: **UAV & Spectral Measurement Road Show** *(icw SpectAIR, SpectralEvolution, PANalytical)* Location: Field Trip
	Chair: **Dr. Tobias Landmann**, International *Centre for Insect Physiology and Ecology (ICIPE), Kenya* Chair: **Dr. Valerie Annemarie Martine Graw**, *Centre for Remote Sensing of Land Surfaces (ZFL), Germany*	Chair: **Prof. Carsten Juergens**, *Ruhr-University Bochum, Germany* Chair: **Dr. Andreas Rienow**, *University of Bonn, Germany*	Chair: **Prof. Volker Hochschild**, *University of Tübingen, Germany* Chair: **Dr. Stefan C. Lang**, *University of Salzburg, Austria*	Chair: **Dr. Frank Thonfeld**, *University of Bonn, Germany* Chair: **Andreas Tewes**, *Universität Bonn, Germany*
5:30pm				
7:00pm 10:00pm	**Symposium Dinner – Cruising the River Rhine**			

PL: Keynote Session   SE: SIG-Session   YSD: Young Scientist Days

Friday, 24/Jun/2016		
9:00am	SE - 22: **Wetland Monitoring** Location: S 29/31	SE - 23: **Thermal Remote Sensing 2** Location: S 30/32
	Chair: **Prof. Gunter Menz**, *Bonn University, Department of Geography, Germany* Chair: **Dr. Frank Thonfeld**, *University of Bonn, Germany*	Chair: **Dr. Claudia Kuenzer**, *German Aerospace Center (DLR), Germany* Chair: **Dr. Doris Klein**, *Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Germany*
10:30am 11:00am	**Coffee Break**	
	SE - 24: **Temporal Analysis** Location: S 29/31	SE - 25: **SAR for Geological Applications** Location: S 30/32
	Chair: **Prof. Eberhard Parlow**, *University Basel, Switzerland* Chair: **Prof. Mattia Crespi**, *University of Rome "La Sapienza", Italy*	Chair: **Dr. Christian Rogass**, *Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, Germany* Chair: **Dr. Karsten Jacobsen**, *Leibniz University Hannover, Germany*
12:30pm	PL - 5: **Closing Session** Location: S 29/31	
1:30pm	Chair: **Prof. Klaus Greve**, *Bonn University, Department of Geography, Germany* Chair: **Dr. Klaus-Ulrich Komp**, *EFTAS, Germany*	

PL: Keynote Session   SE: SIG-Session   YSD: Young Scientist Days

36th EARSeL Symposium
Bonn 2016

SYMPOSIUM SESSIONS

SESSION 01 – OVERVIEW

SE - 01: DISASTER RISK MANAGEMENT 1 (ICW UN-SPIDER)

Time: **Monday, 20/Jun/2016: 2:00pm - 3:30pm**
Location: **S 29/31**

Session Chair: **Dr. Juan Carlos Villagran de Leon**, UNOOSA / UN-SPIDER, Germany
Session Chair: **Dr. Joachim Post**, United Nations Office for Outer Space Affairs, Germany

Space-based Information for Drought Early Warning and Risk Reduction

APhoRISM EC 7FP, integrating satellite and ground data to improve products for seismic and volcanic crisis management: test and validation issues

Integrated System Monitoring for Seismic Surveillance of Vrancea Active Geotectonic Area Through Geospatial And In-Situ Data

A New Automated Approach for Spatio-Temporal Analysis of Remotely Sensed Imagery

Enhancement of Earth Observation and Modeling to Tsunami Disaster Response and Management

Space-based Information for Drought Early Warning and Risk Reduction

Juan Carlos De Villagrán de Léon[1], <u>Joachim Post</u>[2], Antje Hecheltjen[3]

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The more frequent and intense droughts that are taking place in the so called "Dry Corridor" of Central America, in the Dominican Republic and in some islands in the Caribbean; as well as the high vulnerability of rural communities in these regions are forcing national and local governments in countries of these regions to implement a series of measures in order to respond to and prevent the impacts caused by those droughts. Traditional drought early warning systems (DEWS) in these regions rely on rainfall data anomalies and on the observations gathered at specific places by the employees of ministries of agriculture and local authorities. The incorporation of the routine use of the combination of space-based information with in-situ measurement networks and socio-economic data strengthenes current systems significantly. This presentation provides findings of the DEWS-D (Strengthening Early Warning Systems for Drought) project and highlights the improvements of drought early warning through the use of space-based information. The approach address vegetation as a vulnerable element, thus complementing the observations on rainfall deficit that are related to the drought hazard, calculates appropriate indices from satellite composite products that are available free of charge and using open-source software and the products cover the whole country and possess an appropriate resolution for the needs of ministries and food security and nutrition commissions or committees. Additionally applicability to support the implementation of the Sendai Framework for Disaster Risk Reduction 2015-2030 are emphasized.

APhoRISM EC 7FP, integrating satellite and ground data to improve products for seismic and volcanic crisis management: test and validation issues

Guido Luzi[1], Matteo Albano[2], Roberta Anniballe[3], Christian Bignami[2], Elisa Carboni[5], Stefano Corradini[2], Michele Crosetto[1], Marcello De Michele[6], Nuria Devanthery[1], Licia Faenza[2], Don Grainger[5], Gonery Le Cozannet[6], Frank Marzano[3], Luca Merucci[2], Mario Montopoli[7], Marco Moro[2], Nazzareno Pierdicca[3], Alessandro Piscini[2], Daniel Racoules[6], Vito Romaniello[2], Simona Scollo[2], Claudia Spinetti[2], Salvatore Stramondo[2], Lucy Ventress[5], Urs Wegmuller[4]

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APhoRISM is a collaborative project under the theme FP7-SPACE-2013-1 of the Seventh Framework Programme of the European Commission. It proposes the development and testing of two new methods to combine different types of Earth Observation satellite and ground data: one is related to the monitoring of volcanic crises (MACE method) and the other one concerns seismic events (APE method). The APE method (A Priori information for Earthquake damage mapping), concerns the generation of maps to address the detection and estimate of damage caused by a seism. The novelty of this product relies on a preparedness phase, which exploits some a priori information, like the maps derived by InSAR time series to measure surface movements, shake maps obtained from seismological data, and vulnerability information. A data fusion algorithm is proposed to integrate the a-priory information layers with remote sensing change detection maps to estimate the damage likelihood. The outputs of APE method are likelihood index damage maps at different scale: medium resolution, i.e. scale of few building blocks, or very high resolution, i.e. scale of individual buildings.

The second method deals with volcanic crisis management. The method MACE – Multi-platform volcanic Ash Cloud Estimation, concerns the exploitation of GEO sensor platform, LEO sensors and ground measurements, to improve the ash detection and to characterize the volcanic ash clouds. The basic idea of MACE consists of an improvement of volcanic ash retrievals blending the features of LEO and GEO sensors and in situ data at different the space-time scales. Indeed the standard ash thermal infrared retrieval is integrated with data coming from a wider spectral range from visible to microwave thus exploiting the complementarity of these two spectral bands.

Preliminary results of test and validation issues are discussed in this paper. For the seismic case two relevant events have been selected for validation purposes, at two different spatial scales: Christchurch (New Zealand) 21st of February 2011 earthquake, and Port au Prince (Haiti) 12th of January 2010 earthquake, for high and medium resolution, respectively. In both events good ground reference datasets are available.

The site selected for validation of the volcanic product is the Etna Volcano where several eruptive episodes have been monitored in the last years. In this case there is an intrinsic difficulty to provide ground truth literally: an exhaustive and complete estimate of the volcanic ash parameters, i.e. the mass concentration maps in atmosphere together with the altitude and thickness of the volcanic cloud and the ash composition, is often not available due to the great variability of the observed phenomenon and the difficulty to collect data. In order to perform a validation, a different approach is proposed as the use of complementary monitoring technologies, as the ground based radar. In addition, the MACE processor as a whole can be seen as a continuous validation process in which the most frequent products derived from the geostationary MSG-SEVIRI data are compared, and if possible improved, with all the data collected either by polar satellite sensors or by ground-based instruments as soon as they are available to the processing chain.

Integrated System Monitoring for Seismic Surveillance of Vrancea Active Geotectonic Area Through Geospatial and In-Situ Data

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The Vrancea seismogenic zone in Romania, located below the crust, essentially on a vertical lineament, shows a peculiar source of seismic hazard mainly due to the subcrustal earthquakes located at the sharp bend of the Southeast Carpathians, which represents a major concern in Europe, especially to neighbouring countries (Bulgaria, Republic of Moldavia, Serbia etc.). An earthquake is a tremor of the earths surface usually triggered by the release of underground stress along fault lines associated with several geophysical parameters anomalies. The predictability of Vrancea earthquakes, allowing short-term hazard mitigation, remains a challenging problem. Seismic surveillance through earthquake precursors detection selected for this analysis included electric and magnetic fields, gas emissions (radon Rn222), land and air surface temperature changes, surface deformations, and seismicity. Have been used gospatial data for surface deformation assessment (GPS and SAR imaging), MODIS (Terra/Aqua) and AVHRR (NOAA) for land surface temperature anomalies, Landsat TM and ETM for geological lineaments analysis, ground-based monitoring data for electromagnetic and ionospheric anomalies, radon gas emissions in the faults areas prior to earthquakes, as well as seismicity. The physical parameters precursory anomalies of the earthquakes are explained with available or developed lithosphere-surfacesphere-atmosphere-ionosphere coupling physical models which indicate that all of the precursory phenomena are related to deformation that occurs near the fault prior to the main earthquake. In order to define the main geophysical parameters to be surveyed by geospatial and in-situ experiments, this study analysed the strong and medium recorded earthquake events in Vrancea seismic area: 1977, March 4th , Mw = 7.4;May 30th , 1990, Mw = 7; 1986 August , 30th ; 2004, October 27th , Mw =5.9. The joint analysis of geodetic, seismological and geological information on the spatial distribution of crustal deformations is revealing new insights in the understanding of the kinematics and dynamics of the complex plate boundary system present in the Eastern Carpathians.

A New Automated Approach for Spatio-Temporal Analysis of Remotely Sensed Imagery

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Since 2012, the state of California faces an extreme drought, which impacts water supply in many ways. Advanced remote sensing is an important technology to better assess water resources, monitor drought conditions and water supplies, plan for drought response and mitigation, and measure drought impacts. In the present case study latest time series analysis capabilities are used to examine surface water in reservoirs located along the western flank of the Sierra Nevada region of California.

The case study was performed using the COTS software package ENVI 5.3. Integration of custom processes and automation is supported by IDL (Interactive Data Language). Thus, ENVI analytics is running via the object-oriented and IDL-based ENVITask API.

A time series from Landsat images (L-5 TM, L-7 ETM+, L-8 OLI) of the AOI was obtained for 1999 to 2015 (October acquisitions). Downloaded from the USGS EarthExplorer web site, they already were georeferenced to a UTM Zone 10N (WGS-84) coordinate system.

ENVITasks were used to pre-process the Landsat images as follows:

• Triangulation based gap-filling for the SLC-off Landsat-7 ETM+ images.

• Spatial subsetting to the same geographic extent.

• Radiometric correction to top-of-atmosphere (TOA) reflectance.

• Atmospheric correction using QUAC®, which determines atmospheric correction parameters directly from the observed pixel spectra in a scene, without ancillary information.

Spatio-temporal analysis was executed with the following tasks:

• Creation of Modified Normalized Difference Water Index images (MNDWI, Xu 2006) to enhance open water features while suppressing noise from built-up land, vegetation, and soil.

• Threshold based classification of the water index images to extract the water features.

• Classification aggregation as a post-classification cleanup process.

• Export of the respective water classes to vector layers for further evaluation in a GIS.

• Animation of the classification series and export to a common video format.

• Plotting the time series of water surface area in square kilometers.

The automated spatio-temporal analysis introduced here can be embedded in virtually any existing geospatial workflow for operational applications. Three integration options were implemented in this case study:

• Integration within any ArcGIS environment whether deployed on the desktop, in the cloud, or online. Execution uses a customized ArcGIS script tool. A Python script file retrieves the parameters from the user interface and runs the precompiled IDL code. The IDL code is used to interface between the Python script and the relevant ENVITasks.

• Publishing the spatio-temporal analysis tasks as services via the ENVI Services Engine (ESE). ESE is a cloud-based image analysis solution that lets publish and deploy advanced ENVI image and data analytics to existing enterprise infrastructures. For this purpose the complete IDL code can be capsuled in a single ENVITask.

• Integration in an existing geospatial workflow using the Python-to-IDL Bridge. This mechanism allows calling IDL code within Python on a user-defined platform.

The results of the case study verify the drastic decrease of the amount of surface water in the AOI, indicative of the major drought that is pervasive throughout California. Accordingly, the time series analysis was correlated successfully with the daily reservoir elevations of the Don Pedro reservoir (station DNP, operated by CDEC).

Enhancement of Earth Observation and Modeling to Tsunami Disaster Response and Management

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In the aftermath of catastrophic natural disasters, such as earthquakes and tsunamis, our society has experienced significant difficulties in assessing disaster impact in the limited amount of time. In recent years, the quality of satellite sensors and access to and use of satellite imagery and services has greatly improved. More and more space agencies have embraced data-sharing policies that facilitate access to archived and up-to-date imagery. Tremendous progress has been achieved through the continuous development of powerful algorithms and software packages to manage and process geospatial data and to disseminate imagery and geospatial datasets in near-real time via geo-web-services, which can be used in disaster-risk management and emergency response efforts. Satellite Earth observations now offer consistent coverage and scope to provide a synoptic overview of large areas, repeated regularly. These can be used to compare risk across different countries, day and night, in all weather conditions, and in trans-boundary areas.

On the other hand, with use of modern computing power and advanced sensor networks, the great advances of real-time simulation have been achieved. The data and information derived from satellite Earth observations, integrated with in situ information and simulation modeling provides unique value and the necessary complement to socio-economic data. Emphasis also needs to be placed on ensuring space-based data and information are used in existing and planned national and local disaster risk management systems, together with other data and information sources as a way to strengthen the resilience of communities.

Through the case studies of the 2011 Great East Japan earthquake and tsunami disaster., we aim to provide evidence regarding how Earth observations, in combination with local, in situ data and information sources, can support the decision-making process before, during and after a disaster strikes. We also provide evidence regarding how such space-based applications integrated with real-time simulation can contribute to the aims of the post-2015 DRR framework, which has a strong focus on disaster-risk reduction and on avoiding the generation of new risks.

SESSION 02 – OVERVIEW

SE - 02: UAV, UAS & RPAS

Time: **Monday, 20/Jun/2016: 2:00pm - 3:30pm**
Location: **S 30/32**

Session Chair: **Dr. Anna Zmarz**, University of Warsaw, Poland
Session Chair: **Dr. Olena Dubovyk**, University of Bonn, Germany

UAV for Monitoring Antarctic Ecosystems

Evaluation of The Cosicam Hyperspectral Camera with Agricultural Monitoring Experiments

Multi-scale detection and spatial pattern analysis of fog-dependent vegetation (Tillandsia spp.) in the Atacama using WorldView-3 and UAV imagery

Remote Sensing Based Monitoring of Heathland Habitats Inspired by Field Mapping

Development of the Advanced Intelligence Decision Support System

UAV for Monitoring Antarctic Ecosystems

Anna Zmarz[1], Małgorzata Korczak-Abshire[2], Rune Storvold[3], Mirosław Rodzewicz[4], Katarzyna Chwedorzewska[2], Stein Rune Karlsen[3]

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Changes in land and marine ecosystems of the Antarctica result in changes of the range and abundance of the birds and marine mammals, as well as distribution of vascular plants which are an important ecological bioindicators. A program to monitor three Pygoscelis penguin species: Adélie, gentoo and chinstrap in the vicinity of Arctowski Station, King George Island (South Shetlands, Antarctica) has been conducted over the past 38 years. Annual monitoring of these indicator species includes estimation of breeding population sizes and their distribution followed the standards defined by the CCAMLR (Convention for the Conservation of Antarctic Marine Living Resources) Ecosystem Monitoring Program.

A Polish-Norwegian project: "A novel approach to monitoring the impact of climate change on Antarctic ecosystems" started in 2014/15 and has been conducted in two austral summer seasons. This project utilized Unmanned Aerial Vehicles (UAV) to collect baseline geospatial environmental data and covered Antarctic Specially Protected Areas (ASPA) No. 128 and ASPA No. 151 on King George Island (1150 km2).

Two type of UAVs: PW-ZOOM and CryoWing, were used in order to perform the tasks of estimating size of selected penguin breeding populations.

During the flights images were taken with digital SLR Canon 700D, Nikon D5300 and Nikon D5100 with a 35mm objective lens. Flights altitude was 350 m above ground level (AGL) and ground sample distance (GSD) less than 5 cm. Images of this GSD allowed to locate and automatically estimate the number of nests of investigated penguin species.

The use of UAV for purpose of monitoring of inaccessible polar regions, will considerably facilitate the process, reducing time and increasing the level of observer's safety.

Evaluation of the Cosicam Hyperspectral Camera with Agricultural Monitoring Experiments

Stefan Livens[1], Stephanie Delalieux[1], Joris Blommaert[1], Pieter-Jan Baeck[1], Aleksandra Sima[1], Bavo Delauré[1], Miet Boonen[2]

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Agricultural field experiments are essential to acquire detailed information on the effects of fertilizers, cultivation methods, treatments and seed varieties on final crop yield. Comparative field trials on adjacent plots need to be monitored accurately and continuously. To complement and eventually replace ground observations, recent advances in Remotely Piloted Aircraft Systems (RPAS) now allow to perform fast and more cost-efficient collection of aerial imagery on a local scale.

Small RPAS, with a payload capacity often smaller than 500 gr, impose strict mass limitations on the imaging system. To answer this need, VITO has developed the COSI system (COmpact hyperSpectral Imaging system), a solution which consists of a custom instrument and dedicated processing software. The instrument, while very compact and lightweight, allows high resolution true hyperspectral imaging. Miniaturization is achieved by using a novel hyperspectral filter technology. Thin film Fabry-Perot type filters are deposited directly onto a 2 Mpx high sensitivity CMOS image sensor. Varying film thicknesses create continuous spectral coverage with narrow spectral bands (FWHM 5nm to 10 nm). They are arranged in a line wise fashion, with 5 or 8 adjacent lines having the same spectral response.

While scanning over an area, images are taken in rapid succession so that every location on ground is imaged by all spectral bands. . For the COSI system, a specific software solution has been worked out based on photogrammetry. It combines the data of a series of images into a hypercube containing two dimensional hyperspectral images with very high resolution.

Our aim is to evaluate if the quality produced by the system is adequate to derive useful information for better management decision on agricultural fields. To investigate this, we have carried out a number of data acquisitions over agricultural fields. In particular, we will show practical results of a small test field in which a single species of strawberries is planted in a number of plots. Irrigation and fertilization is systematically varied over the field, with identical treatments repeated over 4 plots. Images have been acquired on three different dates during the growth season and reference spectral measurements have been taken with an ASD spectrometer.

From the images, we derive average spectra per plot and relevant vegetation indices. The analysis of the obtained data will demonstrate the capability of the system for deriving useful information from hyperspectral data from the COSI system over agricultural fields.

Multi-scale detection and spatial pattern analysis of fog-dependent vegetation (Tillandsia spp.) in the Atacama using WorldView-3 and UAV imagery

Nils Wolf[1], Alexander Siegmund[1,2], Camilo del Rio[3], Pablo Osses[3], Juan Luis Garcia[3]

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The Atacama Desert in Northern Chile is among the driest places on Earth with a mean annual precipitation of 0.6 mm. Adapted to these hyperarid climate conditions, plants of the genus Tillandsia specialize on the foliar uptake of fog as main water and nutrient source. They occur along the coastal fog belt, exhibiting conspicuous distribution patterns at both micro- and meso-scale which are investigated in this study using a multi-scale remote sensing-based approach. Aerial imagery from three focus sites (1 x 1 km2 each) along the fog belt has been obtained during several UAV flight campaigns and processed to 3 cm-orthoimagery and 6 cm-digital surface models. On this data basis, a knowledge-driven object-based image analysis workflow has been developed to detect Tillandsia spp. presence and to characterize its spatial distribution patterns such as vegetation cover fraction, pattern formations / periodicity (banded vs. irregular patterns), inter-band spacing and patch shape. At a micro- or stand-scale, these parameters are investigated as proxies for population fitness and related to data on fog deposition and wind direction/speed measured in the field. To upscale Tillandsia spp. cover fraction to the entire coastal fog belt of the Tarapacá region at 20 °S - 21 °S, spatial and spectral predictors are extracted from 8-band WorldView-3 surface-reflectance data. Reference data for training, tuning and testing of supervised learning algorithms (partial least square, random forest, neural nets) are extracted from the UAV-based product. Finally, it is demonstrated how the obtained results contribute to a better understanding of Tillandsia spp. as a bio-indicator of the meso-scale climate gradients and provide valuable information in the context of studies on climate change, biogeography and the use of fog as a fresh water resource.

Remote Sensing Based Monitoring of Heathland Habitats Inspired by Field Mapping

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Aims

Heathlands represent important habitats within Europe's natural heritage. Their monitoring is a crucial task and there is little doubt that remote sensing is useful for the periodic reporting's related to habitats directive. However, there is still a gap between applied conservation and the remote sensing community concerning the NATURA2000 monitoring. Remote sensing based approaches often seem to lack practicability. By the example of habitats characterized by common heather (Calluna vulgaris) we want to create a product based on combining field samples and remote sensing data. It has to deliver a spatially exact map of the conservation state and should base on a reproducible approach which was oriented towards the field mapping guidelines

Location

The open heath landscape "Oranienbaumer Heide" in Saxony-Anhalt, Germany.

Methods

Guidelines for field mapping were transferred to remote sensing applications. We simplified the required parameters to three crucial ones: 1) Coverage of the key species Calluna vulgaris, 2) structural diversity, and 3) co-occurring vegetation. We created continuous maps of these layers by combining ground reference (field samples, small scale UAV) and airborne hyperspectral images. Information on the vegetation height was derived photogrammetrically from UAV images. The evaluation space for the mapping was illustrated by combining the layers in one RGB map. Based on field data, this map was classified (A/B/C) according to the mapping guidelines.

Results

The models of the decision parameters delivered satisfying results. The mapping of Calluna allowed for the detection of the target habitat. Patches of old heather vegetation showed highest height values. Lowest vegetation was found in sparse grasslands. Calluna patches with interspersed meadows were characterized by a high structural diversity (sd of mean vegetation height). Diversity was medium in the dense stands of Calluna and very low in the plane meadows. Calcareous grassland is characterized by highest values of the species index. The index was particularly low where grass encroachment causes negative pressure.

The classification of the conservation state had an accuracy of 74 %. Favorable Calluna habitats (state A) are mostly found where the species index is high. Similar conditions with less presence of characteristic species leads to an inadequate

conservation state (B). Dense Calluna stands lack both, structural diversity and other characteristic species and are in a bad state (C).

Conclusions

We showed an appropriate way to transfer the guidelines from field mapping to remote sensing applications concerning Calluna habitats. The decision factors were summarized to three crucial ones. Creating wall-to-wall information of these parameters with remote sensing imagery enables a spatially explicit illustration of the habitat condition. By relating these decision layers to field samples we were able to map the conservation state of the target habitat type. The simplicity of the approach makes it easy to transfer to other comparable areas. However, there is still space for improvement: the results were not good enough to be used in practice. Even though uncertainties remain, it was another step forward to fill the gap between suppliers from remote sensing products and users in the field.

Development of the Advanced Intelligence Decision Support System

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The advanced intelligence decision support system (AI DSS) is the first Mine Action technology in humanitarian demining that combines remote sensing with advanced intelligence methodology into successfully operational system. AI DSS technology was developed and deployed into operations of humanitarian mine action in 2008/2009. Its aim is to support reliable and efficient decisions making about the suspected hazardous area (SHA), based on scientifically developed and validated methodology in FP7 project Space and Airborne Mined Area Reduction Tools (SMART) and advancement in also FP7 project Toolbox Implementation for Removal of Anti-Personnel Mines, Submunitions and UXO (TIRAMISU, and changed its name to T-AI DSS). T-AI DSSs aim is to support reliable and efficient decisions making about suspected hazardous area (SHA), based on scientifically developed and validated methodology. The aim of is to enable following (all without deminers entering into the mine suspected area): enable reliable assessment of the SHA; propose change of the category of the SHA; propose areas that could be excluded from the suspected area (SHA reduction), define areas that are suspected but never have been considered as suspected. The output is in the form of vectors of indicators of mine presence and absence; and thematic maps about mine danger. Multicriteria analysis (analytic hierarchy process (AHP)) and data fusion are use for the purpose of making the thematic display (of mine danger). T-AI DSS is the operational TIRAMISU solution for non-technical survey (NTS) that is proposed to the MACs worldwide because it is adaptable to specific terrain and situations. The system consists of several sub-systems: for aerial multisensor image and data acquisition, for pre-processing and processing, for management of knowledge and contextual information, for implementing the outcomes of subjective photointerpretation, for fusion at pixel level, at features level and at decisions level. T-AI DSS is the only NTS tool within the frame of TIRAMISU that performs fusion. A simplified version (without remote sensing data acquisition) has also been developed that can be used in MACs for the support in the SHA assessment, reduction, re-categorisation and inclusion, indicating only mine presence and mine absence derived from MIS data. Services will be provided to realise NTS mission, to ensure transfer of know-how and capacity building.

SESSION 03 – OVERVIEW

SE - 03: DEVELOPING COUNTRIES

Time: **Monday, 20/Jun/2016: 4:00pm - 5:30pm**
Location: **S 29/31**

Session Chair: **Dr. Tobias Landmann**, International Centre for Insect Physiology and Ecology (ICIPE), Kenya
Session Chair: **Dr. Klaus-Ulrich Komp**, EFTAS, Germany

'One Health' in Africa –opportunities for remote sensing?

Analysing the Diversity of Deprived Areas in Mumbai, India

Spatio - Temporal Patterns of Rift Valley Fever Occurrence in Kenya and Mapping Risk Areas

Urban Greenspace dynamics and socio-environmental (in)justice in Kumasi, Ghana

The Geospatial Approach of Carbon Sequestration in Oluwa Forest, Ondo State, Nigeria

'One Health' in Africa –opportunities for remote sensing?

Tobias Landmann[1], **David Makori**[1], **Magnus Evander**[2], **Per Sandström**[3], **Clas Ahlm**[4], **Jonathan Stiles**[1], **Ayuka Fombong**[1], **Suresh Raina**[1], **Rosemary Sang**[1]

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The 'One Health' paradigm utilizes the understanding of linkages between the animal, human and environment health realms to identify the weakest link in disease or pest transmission cycles so as to optimize pest or disease interventions. To be able to identify linkages in a 'One Health' approach requires a multi-disciplinary set up and an explicit understanding of underlying ecological factors and their inter-relationship, related to the disease itself, the vector and the environment.

In this contribution, two examples are given that show how spatially and temporally remote sensing-derived ecological variables on specifically vegetation activity and seasonality, as well as land surface fluxes, can improve the predictive power of pest and disease distribution models. In the first example, the sensitivity of remote-sensing-based ecological variables to map Rift Valley fever (RVF) occurrence in Kenya is tested using generalized linear modeling (GLM). RVF is a mosquito-borne viral disease that affects both animals and humans. Secondly, the contribution of remote sensing variables to model four key pests in bee hive colonies in Kenya was assessed; herein relative variable importance and predictive accuracy was determined using Maximum Entropy. The relevance to 'One Health' is alluded to and discussed.

'Livestock density' (N-1/km) and 'Small vegetation integral', from vegetation index (Normalized Difference Vegetation Index -NDVI) time-series data, and Evapotranspiration' (ET) metrics (annual means over 13 years) were the three most important variables for mapping RVF occurrence in the GLM model (all $p \leq 0.01$). The two remote sensing-based variables were together more relevant than the 'other' ecological variables such as soil types and elevation. The bee pests modeling results showed that, albeit the overly importance of climate variables in the model, 'maximum NDVI in the season' and 'season's largest NDVI' contributed more than 20% to the prediction probability for Galleria mellonella and Varroa destructor. The spatial distribution patterns of the pest were more realistically mapped when including the remote sensing variables.

Remote sensing observations can help to provide more relevant, accurate and spatially coherent disease vector and pest habitat knowledge within modeling or mapping frameworks. 'One Health' can benefit from developing interventions around a more accurate and poised understanding of environmental factors, specifically if these factors are relevant to several health domains. Results from this assessment indicate that ET, for instance, is highly relevant to RVF occurrence. Remote sensing

observations consider landscape heterogeneity and dynamics which is often a reflection of the socio-ecological system (SES). Better understanding of the SES at various hierarchical levels makes it possible to identify the 'weakest link' in the SES, this being imperative for formulating interventions within the 'One Health' realm.

Analysing the Diversity of Deprived Areas in Mumbai, India

Monika Kuffer[1], Richard Sliuzas[1], Karin Pfeffer[2]

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Many cities in the Global South are facing high developing dynamics and rapid growth of areas with poor living conditions, such areas offer shelter to 1/3 of the urban population in the Global South (UN-Habitat, 2015). The municipal data sets on slums and other deprived areas are often not keeping pace with the high developing dynamics, causing that data are often incomplete, inconsistent, outdated or even absent. Aggregated data such as census-based statistics on wards mostly refer to relatively large and heterogeneous areas, which are often meaningless geographical units. In the last decade, several remote sensing studies developed methods for the extraction of slums, however, very few studies focused on the diversity of deprived areas. Such areas are ranging from unrecognized slum areas (often in the proximity of hazardous areas) to regularized areas with poor basic services. The city of Mumbai, India is an illustrative example of such a diversity.

In this paper we examine the capacity of the random forest classifier to analyse spatial, spectral and textural characteristics of deprived areas for the city of Mumbai using 8-Band images of WorldView-2. We have selected an East-West cross-section of Mumbai, which is strongly dominated by a variety of slums and other deprived areas with poor physical living conditions. The research also employs image segmentation to aggregate the results to homogenous urban patches (HUPs) that approximate geographically meaningful neighbourhood units to produce policy-relevant information. The results of spectral, texture and spatial proxies of physical deprivation are evaluated by ground-truth information collected in the field, showing the scope but also the limitations of image based proxies on the diversity of such areas in Mumbai. Thus the research illustrates how image based proxies from VHR imagery helps in rapidly extracting spatial information on deprived areas. These proxies offer a better understanding of their diverse morphological characteristics (e.g. built-up density, texture and shape), and therefore, providing strategic information for urban management when aggregated to HUP.

UN-Habitat. (2015). HABITAT III ISSUE PAPERS 22 – INFORMAL SETTLEMENTS. New York: United Nations Conference on Housing and Sustainable Urban Development.

Spatio - Temporal Patterns of Rift Valley Fever Occurrence in Kenya and Mapping Risk Areas

Gladys Jebiwot Mosomtai[1], Magnus Evander[2], Per Sandström[3], Clas Ahlm[4], Rosemary Sang[1], Osama Ahmed Hassan[2], Hippolyte Affognon[1], Tobias Landmann[1]

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Rift Valley Fever (RVF) is a zoonotic disease affecting both humans and livestock with a large impact on the economy in countries affected by outbreaks. Since its identification in Kenya in 1930s, the disease has been expanding and new outbreaks are reported from new regions. The disease is caused by RVF virus (RVFV), which is transmitted by mosquito bites and through handling of infected livestock. The transmission and maintenance of virus depend on the vector mosquito, infected livestock and environmental factors. Understanding the ecology factor of RVF outbreaks is key in managing the disease. Therefore, this study aimed at mapping spatially explicit risk zones using remote sensing and other geographic data at landscape level in eastern and central Kenya. The sensitivity of fourteen selected ecological variables to RVF occurrence were assessed using generalized linear modeling (GLM). Seasonality parameters from Normalized Difference Vegetation Index (NDVI) and principal component analysis from evapotranspiration (ET) were extracted from 0.25-1 km MODIS satellite data for 13 year observations period. Livestock density (N/km2), animal count by type, topographic wetness index (TWI) ratio and soil ratio (aerial coverage of RVF occurrence relevant soil types and TWI per county) were used as co-variants. The number of RVF outbreaks a county has recorded was analyzed in a negative binomial model, while presence or absence of an outbreak during the 2006/2007 outbreak in a county was analyzed in a binomial model. In both models, animal density, seasonal parameters - base and small integral, number of goats and sheep, soil ratio and TWI ratio were significant determinants (p value <0.05) for RVF occurrence, with high RVF risk areas in the counties of Tana River, Garissa, Isiolo and Lamu. Evapotranspiration was only significant in the binomial model. The size and the number of animals found in a county played a major role in RVF occurrence. Furthermore, presence of goats and sheep were highly significant in regions with RVF occurrence, compared to cattle and camels. Future outbreaks can be better managed if relevant RVF variables are integrated into early warning systems.

Urban Greenspace dynamics and socio-environmental (in)justice in Kumasi, Ghana

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Urban greenspaces are crucial for urban sustainability and resilience to environmental vulnerabilities. Yet in many cities in Africa, green spaces are marginalized in urban plans and their distribution uncertain. This paper analyzed the spatio-temporal change in green cover, examined its composition and extent and highlighted possible distributional inequities associated with greenspaces in Kumasi, Ghana. Spatio-temporal dynamics were analyzed using GIS and remote sensing techniques whereas distributional equity at the submetro level was assessed with multiple approaches including GINI sustainability index.

Greenspace area decline in the last five years (2009-2014) was 3.5 times greater than that of the first 15 years since 1986. Shannon entropy for built-up sprawl for 1986 and 2014 were respectively 0.8 and 0.99 with high built-up density proportion of at least 0.75 (1986) and 0.62 (2014) respectively spreading to 4 km and 8 km from the city center. Mean per capita green space was 25 m2 and ranged between 6 m2 in Tafo and 52 m2 in Oforikrom. Housing quality index, a surrogate of socioeconomic standards of living, had a somewhat weak relationship with per capita greenspace area for 2009 (r2 = 0.50, p=0.049) and 2014 (r2 = 0.53, p=0.0398) at the submetro level. A GINI coefficient of 0.26 was estimated for each of vegetation and tree cover distribution in Kumasi. At least 8 green spaces were identified with home gardens accounting for roughly 50% of vegetation cover in the city.

These findings are essential to government officials, traditional leaders, urban planners, and private individuals as they seek solutions to current and potential future urban vulnerabilities to climate change and other environmental setbacks. Ample availability and strategic planning for greenspaces can ensure equity in access and minimize the impact of climate related vulnerabilities such as floods, extreme heat, diseases, and food security.

The Geospatial Approach of Carbon Sequestration in Oluwa Forest, Ondo State, Nigeria

Esther Oluwafunmilayo Makinde, Ahmed Abiodun Womiloju, Michael Oluwatoyin Ogundeko

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The study assessed the amount of carbon been sequestrated in the Ondo State Afforestation Project (OSAP) in Oluwa Forest, south west of Nigeria. This was with the view to determining the above and below ground biomass; estimates the total carbon content and evaluate the CO_2 sequestered. Geospatial technique was used. This was complemented with Non-Destructive Field Observation method. A total of 10 random Sample plots of 20m × 20m were located in the field using a Garmin GPS device. In each of the plots, all trees with diameter at breast height (i.e. diameter at 1.3m) exceeding 5cm were measured. Tree major dominant tree-specie groups namely Tectona Grandis, Gmelina arborea and indigenous species (such as Mahogany, Obeche and Opepe etc.) were observed in the forest reserve and were also used as ground-truth parameters for the satellite imagery classification. Trees were grouped in diameter classes of diameter at breast height (DBH). The Total Organic Carbon (TOC) of soil matter was determined by collecting soil samples from the sub-plot within the main sample plots. A total of 20 samples at 0-15cm and 15-30cm were collected and tested for TOC (% Carbon). Landsat imagery acquired for this study was Landsat TM (1984, 1991), Landsat ETM+ (2002, 2008) and Landsat 8 OLI (2015). Land cover area estimation was obtained from the supervised classification of Landsat imagery of 2015. The Aboveground biomass for the tree species strata was estimated from measured diameter at breast height (DBH) and tree height using a generalized tree biomass regression equation for the specific precipitation zone: $y=e^{((-3.1141+0.9719 \ln(DBH \times H))}$ where y is the aboveground biomass in kg; DBH, diameter at breast height in cm; H is the height of tree in m and this was converted ton $(ha)^{-1}$ by multiplying with 0.001. The regression equation with $r^2 = 0.97$ was adopted. Summarily, the total above-ground biomass of trees per sampled plots was multiplied by the number of trees per plot. The Below Ground Biomass (BGB) was measured as BGB=20%×AGB, where, 20% is the non-destructive approach of the belowground biomass values for vegetation in forest of the aboveground biomass. The results showed that a total of 359 Mega ton/ha of C02 was estimated to have being sequestered in the OSAP, Oluwa Forest using the non-destructive field measurements. The change in Land use Land cover of the area from 1984-2015 reveals that Gmelina Plantation suffered a drastic reduction from 269.56% to -97.65% and also, Tectona Grandis from 78.33% to -50.37% except an increase observed between 1991-2002 from 22.46% to 77.14% evidently as a result of the Tectona Grandis re-plantation of 1996, while Built up area increased from -15.68% to 131.53%. However, the Natural forest continued to flourish

throughout the period considered from -47.83% to 88.44%. The study concluded that the afforestation project sequestered carbon and should be resuscitated.

SESSION 04 – OVERVIEW

SE - 04: LAND ICE AND SNOW

Time: **Monday, 20/Jun/2016: 4:00pm - 5:30pm**
Location: **S 30/32**

Session Chair: **Prof. Matthias Braun**, Friedrich-Alexander Universität Erlangen-Nürnberg, Germany
Session Chair: **Dr. Ulrike Falk**, University of Bremen, Germany

First Snow Avalanche Inventory in the Romanian Carpathians Based on Very High-Resolution Satellite Images

Exploiting Sentinel-1 Sar Imagery for Glacier Surface Velocity Field Measurements: First Experiment on Baltoro Glacier

Mass budget estimates for the northern Antarctic Peninsula

Assignment of Probabilities to Ship Detections from Satellite SAR Imagery Based on Ice Cover and Satellite AIS Density Maps

First Snow Avalanche Inventory in the Romanian Carpathians Based on Very High-Resolution Satellite Images

Marcel Torok-Oance[1], Florina Ardelean[1], Mircea Voiculescu[1], Narcisa Milian[2]

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Snow avalanches represent one of the most important winter season natural hazard in the Romanian Carpathians. Although past snow avalanches are present in the statistics of meteorogical stations, there is a lack of information and no consistent database exists for the entire mountain area. Avalanche occurrence is frequent in the highest areas of the Romanian Carpathians (~4000 sqkm), regions that are not permanently inhabited and with rough topography. Although there are few ski domains in the Romanian Carpathians, only two of them are located in areas frequently affected by snow avalanches. A permanent service for monitoring the snow parameters and snow avalanches exist from 2004, but the information is sparse for the mountain areas, the observations and measurements being provided only by 4 meteorological stations located in Bucegi and Făgăraș Mountains.

The purpose of this study is to generate an avalanche inventory based on satellite images that can be used for an objective evaluation of the location and magnitude of this phenomenon.

Past records from meteorological stations showed that avalanches have generally lengths of 500-800 m, thus we used VHR satellite images that allow the delineation of small and medium size avalanche deposits. Digital Globe and Airbus Defence and Space archives have been checked for the dates when avalanches have been observed in the field. Because of high percentage values of nebulosity in the analyzed images, we selected two representative GeoEye-1 scenes from April 11, 2012, that cover central part of Făgăraș Mountains, the highest sector from Romanian Carpathians.

The images were orthorectified using a digital surface model (DSM) at 0.5 m spatial resolution generated using an unmanned aerial vehicle (UAV). In several areas, beside spectral information, we used as additional information the terrain parameters derived from DSM. Spectral signature of avalanche deposits is similar with the deposits of undisturbed snow which makes it difficult to delineate. The avalanches were easily detected in panchromatic band, based mainly on texture, with the exception of shaded and overexposed areas. For a better visual detection and delineation of snow avalanche deposits, we used several bands combination, image differencing and PCA analysis. The best visualization was achieved using false-color images generated using panchromatic band, the difference between NIR and blue bands and PCA, which made possible the identification of two generation of avalanches produced on the same avalanche-path.

In total 542 avalanches were identified and delineated with an area of 55 sqkm and a density of 9.85 avalanches/sqkm. For each feature, spectral, dimensional (length and

width, shape index) and morphometric characteristics (altitude, slope, aspect, curvature) have been extracted. The features length varied between 34 and 2644 m with a mean value of 445 m.

The resulted avalanche inventory is the first approach for the Romanian Carpathians based on GeoEye-1 images and represents an improved objective statistic. In the same it can be used as input data for the avalanche warning service. This inventory represents also an important spatial database that is currently used for development of an avalanche detection algorithm and for its validation.

Exploiting Sentinel-1 Sar Imagery for Glacier Surface Velocity Field Measurements: First Experiment on Baltoro Glacier

Andrea Nascetti, Flavia Nocchi, Andrea Camplani, Clarissa Di Rico, <u>Mattia Crespi</u>

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The glaciers are a natural global resource and one of the principal climate change indicator at global and local scale, being influenced by temperature and snow precipitation changes; moreover the glaciers are the largest freshwater reservoirs on the Earth. Starting from 1894, thanks to the foundation of the International Glacier Commission at the 6th International Geological Congress in Zurich, several investigations have been carried out to study the complex glaciers dynamics. Nowadays, the World Glacier Monitoring Service (WGMS http://www.wgms.ch) in collaboration with the Global Land Ice Measurements from Space (GLIMS http://www.glims.org), collects observations on time changes in mass, volume, area and length of glaciers (glacier fluctuations), as well as statistical information about the perennial ice distribution (glacier inventories). Among the parameters used for glacier monitoring, the glaciers surface velocity is an important element, since it influences the events connected to glaciers changes (mass balance, hydro balance, glaciers stability, landscape erosion). In particular, the surface glacier velocity can be measured using both in-situ survey (mainly based on GNSS, but also on laser scanner and close range photogrammetry) and remote sensing geomatic techniques based on optical or radar satellite imagery.

The leading idea of this work is to continuously retrieve glaciers surface velocity field through SAR imagery, in particular using the amplitude data coming from the new ESA satellite sensor Sentinel-1 imagery. These imagery key aspects are the free access policy, the very short revisit time (down to 6 days with the launch of the Sentinel-1B satellite) and the high amplitude resolution (up to 5 m).

In order to verify the reliability of the proposed approach, a first experiment has been performed using Sentinel-1 imagery acquired over the Baltoro Glacier, that is one of the world's largest debris-covered glaciers (about 66 km long) located on the south side of the Karakoram Range (Pakistan).

During this study, a stack of 12 images acquired during the 2015 has been used in order to investigate the potentialities of the Sentinel-1 SAR sensor to retrieve the glacier surface velocity every month. The aim of this test was to measure the glacier surface velocity between each subsequent pair, in order to produce a time series of the surface velocity fields along the investigated period. The necessary co-registration procedure between the images has been performed and subsequently the glacier area taken from the free available glacier cadastral database has been sampled using a regular grid with a posting of 100m. Finaly the velocity has been measured, for each image pair, using a template matching procedure, and an outlier filtering procedure based on the signal to noise ratio values has been applied, in order to exclude from

the analysis unreliable points. The achieved velocity values range from 10 to 25 meters/month and they are coherent to those obtained in previous studies carried out on the same glacier with other techniques, and the results highlight that it is possible to have a continuous update of the glacier surface velocity field through free Sentinel-1 imagery, that could be very useful to investigate the seasonal effects on the glacier fluid-dynamics.

Mass budget estimates for the northern Antarctic Peninsula

__Matthias Braun[1]__, __Thorsten Christian Seehaus[1]__, __Sebastian Marinsek[2]__, __Veit Helm[3]__, __Jan Melchior van Wessem[4]__, __Pedro Skvarca[5]__

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The Antarctic Peninsula is currently undergoing considerable climatic and glaciological changes. Widespread glacier retreat and surface lowering has been reported. Several ice shelves have disintegrated or considerably retreated. Subsequently, glacier acceleration and mass loss have been reported for the Prince-Gustav-Channel, Larsen Inlet, Larsen-A/B and Wordie ice shelf regions. We analyse time series of synthetic aperture radar (SAR) data in regard to surface velocities using SAR intensity offset tracking. Optical satellite data as well as data from various altimetry missions (ICESat, CryosSat-2, NASA Operation IceBridge) as well as from the German bi-static SAR mission TanDEM-X are analysed in regard to surface elevation changes. We compile those data sets to time series in order to study the adaptation of the glacier systems to ice shelf break-up and glacier retreat north of 65°S. We provide geodetic glacier mass balance estimates since 1993. Using ice thickness estimates from Huss & Faronitti (2013) as well as surface mass balance output from the recent refined RACMO-2 runs for the Antarctic Peninsula, we estimate the mass loss by the flux gate approach (also referred to as input-output method). Our analysis reveal a quite distinctive response patterns of the glacier systems depending on the prevailing conditions. We estimate a mass budget of −40.7±3.9 Gt (1995-2014) for the Dinsmoor-Bombardier-Edgeworth glacier system (DBE, formerly draining into Larsen-A), -50.9±8.3 Gt (1993-2014) for Sjögren Inlet (formerly draining into Prince Gustave-Channel Ice Shelf). We will also show analyses for the Western Antarctic Peninsula glaciers in this region. For DBE, the contribution to sea level rise was estimated to be 18.8±1.8 Gt, corresponding to a 0.052±0.005 mm sea level equivalent, for the period 1995–2014 and for Sjögren Inlet 0.0798±0,0145 mm SLE in 1993-2014. While modern satellite observations can constrain the adaptation in surface velocity and surface elevation reasonably well, our analysis shows that still largest uncertainties result from unknown ice thickness – in particular before ice shelf collapse – as well as surface mass balance.

Assignment of Probabilities to Ship Detections from Satellite SAR Imagery Based on Ice Cover and Satellite AIS Density Maps

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SAR-satellites have extensively been used in vessel monitoring under varying environmental conditions. In this sense, SAR-based vessel detection approaches have shown a great potential to cover large areas independent of cloud cover. However, they have also shown some limitations when dealing with difficult conditions imposed mainly by tough climatic circumstances such as those prevailing in Polar Regions. There, it is quite common that SAR-based detection methods cannot discriminate between vessels and ice structures such as icebergs or drifting ice blocks with similar reflection and geometric properties with the result that a high number of false detections are generated. This is especially true with medium to low resolution SAR sensors, which are widely used for those tasks. In order to address this issue, this study analyses the use of additional data sources in a probabilistic approach in order to help differentiate ships from non-ship objects. This work is part of the research project PASSAGES (Protection and Advance Surveillance System for the Artic: Green, Efficient, Secure). The proposed method consists essentially of two stages: a) ship-like object detection and b) probability assignment to each detected ship candidate. Ship detection is automatically performed using a classical CFAR and K-distribution method on the SAR images, where bright small areas are highlighted and separated from sea clutter as vessel candidates. Subsequently, some detected ship candidates are discarded based on their size. The probability assignment stage is performed individually on every ancillary information layer. Daily ice maps from the IMS (Ice Mapping System; Daily Northern Hemisphere Snow and Ice Analysis) database and ship traffic density maps (DM) are utilized as auxiliary data sources. The DMs are calculated based on satellite-AIS data collected over available months prior to the SAR image acquisition date. Probability values are assigned for the ice layer based on the assumption that ice polygons are unlikely to contain vessels whereas ice-free sea areas will present a high probability of vessel presence. Interpolations are performed in transition areas between both classes. For the calculation of the probabilities from the density-map layer, an accumulative exponential function is used to transform the original values into probabilities. Preliminary results on a single dataset show that many false detections can be discarded on the basis of calculated probabilities. Thus, on the ice-layer around 85% of 730 evaluated candidates exhibit a probability smaller than 0.1 and 89% smaller than 0.5. Only 7.5% show probabilities greater than 0.9 and they include the only correct vessel detection according to the ground truth provided by satellite AIS. On the other side, DM-based probabilities are smaller than 0.1 for 96% of the candidates and larger than 0.5 for only 2% of the candidates. In this case, the detection corresponding to the ground truth exhibited a probability of 0.9. Even though these results are promising, it can also be expected that some correct detections will

fall in areas covered by ice or showing low traffic density, as is the case of ice-breakers or ships not following common movement patterns (e.g. research vessels). False detections might still appear in situations in which ice blocks drift within areas of high vessel traffic density or in the middle of open sea.

SESSION 05 – OVERVIEW

SE - 05: COPERNICUS: DATA, TOOLS, APPLICATIONS AND GERMAN CONTRIBUTIONS (ICW DLR)

Time: **Tuesday, 21/Jun/2016: 11:00am - 1:00pm**
Location: **S 29/31**

Session Chair: **Dr. Jörn Hoffmann**, DLR, Germany
Session Chair: **Dr. Bianca Hoersch**, ESA's European Space Research Institute (ESRIN), Germany

German national EO Programme and contributions to Copernicus

The Copernicus Sentinels and Data Access

The Sentinel Toolboxes for Scientific Exploitation of Operational Missions

An Operational Data Handling and Processing Environment for Copernicus Sentinel 1,2 and 3 Data

Temporal resolution counts - Examples of successful Sentinel-1 applications to land monitoring

Copernicus Satellites Data: Delivering Sentinel Data to Users

Copernicus Satellites Data: Delivering Sentinel Data to Users

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The advent of new, freely accessible European remote sensing data sources covering the globe is at the same time exciting and challenging in terms of data processing and data provision to the users. In 2014, the first earth observation satellite "Sentinel-1A" of the EU program "Copernicus" was launched, followed by "Sentinel-2A" in 2015. Since both systems continuously provide high resolution RADAR and Optical/SWIR data. Copernicus addresses several thematic areas including land, marine, atmosphere, climate change, emergency management and security. The Sentinel data allow to derive a wide range of thematic data layers including land use, forest structure, vegetation stages, or urban structure, just to name a few examples. While the Copernicus program is well perceived in the remote sensing community, the new data sets are still widely unnoticed in the GIS community as well as in the public administration. What is currently lacking, likely due to the sheer amount of available data and the need of notable computational power, is an easy access to information derived from these raw data.

In our talk we will present an open source approach of providing standardized OGC Web Services by GeoServer and MapProxy software. The backend of the system is able to timely deliver postprocessed and analysed Sentinel data in an automated way using the ESA SNAP software and GRASS GIS. We have developed a Web portal architecture that allows the user to automatically derive thematic data layers based on algorithms provided in the portal. The allows the users to generate their own topical layers without the need of deep technical knowledge of software and hardware. We believe that this approach likely widens up the potential user group of the Copernicus program. At the same time it connects two worlds that are often unnecessarily disentangled: the GIS and the remote sensing communities.

For the users the proposed portal eliminates the barrier of complex data collection and management, long download times and the necessity of providing computing and storage resources. Expert tools turn the raw Sentinel data into the standardised OGC WMS (Web Map Service) protocol, directly usable for own GIS applications.

The presentation is completed by some examples and practical use cases, illustrating the idea of the workflow and the architecture of the portal.

SESSION 06 – OVERVIEW

SE - 06: EARTH OBSERVATION IN PEACE & CONFLICT STUDIES

Time: **Tuesday, 21/Jun/2016: 11:00am - 12:30pm**
Location: **S 30/32**

Session Chair: **Prof. Klaus Greve**, University of Bonn, Germany
Session Chair: **Lars Wirkus**, Bonn International Center for Conversion - BICC, Germany

Earth Observation for Conflict Mitigation and Peacekeeping – From Humanitarian Relief to Supporting Peace and Conflict Studies

Resource exploitation in conflict regions – the benefit of Earth observation for peace and conflict studies

Satellite Imagery Processing for the Verification of Nuclear Non-proliferation and Arms Control

Earth Observation to Explore Organized Violence – A Review of Methods and Use Cases

Monitoring Agricultural Large-Scale Land Investments in the Republic of South Sudan

Earth Observation for Conflict Mitigation and Peacekeeping – From Humanitarian Relief to Supporting Peace and Conflict Studies

Olaf Kranz[1,2], Kristin Spröhnle[3], Elisabeth Schoepfer[3], Stefan Lang[1]

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Conflict situations all over the world lead to humanitarian emergencies, forced migration as well as political, social and economic instability. Among the more than 60 million forced migrants in 2014 about one third were refugees, and two thirds were internally displaced people (IDPs). With respect to camps hosting refugees or IDPs, natural resources are an important source of supply for food, water and shelter but at the same time are a significant driver for instability and conflict. Besides the Democratic Republic of Congo (DRC) and other countries in the Great Lakes region, also Chad and Sudan (including South Sudan) suffer from protracted regional crises where since decades national and international aid organisations strive for humanitarian relief. Satellite Earth observation (EO) can provide reliable and up-to date information of the actual situation, which deems to be critical for humanitarian organisations in setting up and maintaining refugee or IDP camps. They require – amongst others – information on population figures, the availability of water resources and the assessment of wood resources in the vicinity of refugee or IDP camps. To meet these information requirements, EO techniques can detect reliably the environmental conditions and changes related to conflict situations over large areas and allow detailed analysis of certain areas of interest. The results being integrated in an overall assessment of the in-field situation can provide support to conflict mitigation strategies in the broader context of humanitarian aid, conflict and peace research.

The overall methodological framework of this study follows a multi-scale approach providing information at different scales starting with a macroscopic overview for large areas derived from medium and high resolution (MR/HR) satellite data. For particular area of interests more detailed and fine-scale assessments are conducted by analysing very high resolution (VHR) satellite imagery. In addition, the EO-based assessment is linked with auxiliary information (e.g. population data, hydrological and geological information). The application of remote sensing techniques and methods from geospatial analysis is a promising approach especially in inaccessible regions that are remote for field surveys or too insecure. Results comprise estimations of population figures for certain refugee and IDP camps, water probability measures for areas of interest and hotspots indicating human-induced environmental impact in conflict regions. The outcomes of the presented study demonstrate that the underlying EO approaches are an important monitoring and documentation source for organisations active in humanitarian assistance as well as for the peace and conflict research

community. The proposed multi-scale approach contributes to relief actions as well as to conflict mitigation and peacekeeping activities.

Resource exploitation in conflict regions – the benefit of Earth observation for peace and conflict studies

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With the growing global population the need of land and its natural resources like water, plants, timber or minerals is continuously increasing. The exploitation of those resources, if not properly managed, can lead however to spoiling natural habitats as well as to threatening people's health, livelihoods and security. In this context, environmental factors are rarely, if ever, the sole cause of violent conflict, but can become significant drivers of violence and instability. Together with other influencing factors such as weak governance structures, fragile political systems and poverty it can fuel and prolong crisis. The investigation of the origins, dynamics and resolution of conflicts is among others subject of peace and conflict research. In contrast, Earth observation (EO) allows monitoring and observing processes and changes of our planet via remote sensing technologies. Thus, the main objective of the presented study is to bridge the gap between these two complementary disciplines. It aims at supporting peace and conflict research by means of satellite-based analysis and monitoring of processes on Earth from a bird's eye view.

Different case studies analysing natural resource exploitation in the Democratic Republic of the Congo (DRC) are presented and discussed. Mining in the DRC is mainly carried out by civilians using artisanal and small-scale mining techniques (ASM) which in fact means working with shovel, pickaxe and hammers or even using bare hands. Thus, the focus of EO techniques lies primarily on the detection of mining-related small-scale land cover changes. In order to be able to cover large regions of interest the conducted work is performed at different observation scales - ranging from regional to local - by using high and very high resolution optical satellite data. The method used for monitoring core features of interest combines object-based image and spatial analyses. The objective of the object-based image analysis (OBIA) approach is the development of robust and transferable algorithms. This is strongly supported by the object-based environment, which allows not only for the use of the spectral image information but also the integration of spatial, textural and contextual features. Detecting land cover changes related to the aforementioned mining activities provides indications about the situation on the ground in the insecure and often remote areas of interest which in turn supports peace and conflict studies in their assessments of conflict situations. Thus, the proposed monitoring and documentation of mineral exploitation may contribute to focused reactions during crises and yield rapid

identification of affected areas and its dynamics and finally significantly supports the development of recommendations for conflict mitigation and peace building.

Satellite Imagery Processing for the Verification of Nuclear Non-proliferation and Arms Control

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In the last few decades, the international community has negotiated a number of multi-or bilateral agreements on nuclear non-proliferation and arms control, some of which have provisions for the verification of compliance. Among the different verification measures, earth observation (EO) by scientific or commercial satellite imaging sensors has been established as an important source of information for verification.

In the context of the Nuclear Non-proliferation Treaty (NPT), very high resolution satellite imagery (SI) is routinely used by the International Atomic Energy Agency (IAEA) as a reference source to aid in inspection planning for in-field activities, to verify the accuracy and completeness of State declared information and to monitor activities at nuclear sites. In contrast, the verification regime of the Comprehensive Nuclear Test Ban Treaty (CTBT) does not include SI as verification measure yet. However, the treaty text considers satellite monitoring as an additional technology whose verification potential should be examined. The CTBTO investigated the application of airborne and space-borne imagery in the preparation of on-site inspections. SI proved to be helpful in order to determine the inspection area, point of entry for inspection, and to focus activities during inspections. In addition, SI can also complement the CTBTO's International Monitoring System (IMS) by confirming the information collected by the IMS which includes seismic, hydroacoustic, infrasound and radionuclide monitoring sensors. For verifying compliance with a potential future Fissile Materials Cut-off Treaty (FMCT), SI should be considered as one tool among other verification measures in order to monitor declared shut-down facilities or undeclared facilities, and to prepare or initiate on-site inspections.

By reviewing the technical progress in the field of EO sensors, this paper highlights the spatial, spectral and temporal aspects of high resolution EO sensors and demonstrates how EO sensors provide relevant information for nuclear non-proliferation and arms control verification. The variety of EO solutions continues to expand and diversify, with more States launching EO satellites. For nuclear related treaty verification, feasibility studies on the application and benefits of SI are required in order to keep track of emerging developments in data. When monitoring nuclear facilities and activities using SI, specific object features related to the nuclear fuel cycle need to be surveyed.

With these international verification regimes in mind, this paper also explores recent advances in SI processing and proposes some analysis techniques based on pixel- and object-based feature extraction, change detection and image classification. Such techniques assist imagery analysts to identify objects regarding size, shape, height, color, texture, surface temperature, surroundings, facility functions, and/or temporal changes, and ultimately assist in determining the significance of observable features.

Earth Observation to Explore Organized Violence – A Review of Methods and Use Cases

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Organized violence in its multifaceted forms is omnipresent, ultimately reaching into the capillaries of society. Ongoing wars such as in the Ukraine, Syria and Afghanistan; violent conflicts kindled by terror groups such as the Islamic State in the Middle East or Boko Haram in Nigeria; conflict-induced flight and migration to European border countries as well as continuously increasing military expenditures and trade of military goods and weapons, serve as examples of this diversity. Organized violence refers not only to armed conflicts between two or more groups, but also includes military and security structures. It encompasses the planned and coordinated practices of violence by social and political groups without distinguishing between legal violence and illegal violence or, for that matter, between state and non-state violence. Organized violence continually changes and varies depending on time and place.

Due to its unique point of view from space, Earth Observation (EO) is increasingly playing an important role in studying organized violence. Remote sensing methods and tools allow for a birds-view assessment and monitoring of spatial footprints of violence and its impacts. In so doing, it enables researchers to put seemingly isolated incidents into a larger context, which contributes to a better understanding of the spatiality of organized violence. In an ideal case, such EO-based assessments and analyses would be combined with local field research for the provision of ground truth to verify the information derived thereof. However, due to steadily improving satellite sensors and the related provision of continuously advancing imagery and analysis methods, field verification is no longer absolutely necessary. Remote sensing, thus, can facilitate the monitoring and analysis of areas affected by war or violent conflict when these are no longer safe or accessible for field research, allowing for data collection despite the lack of presence on the ground.

The primary objective of this literature review is to determine how Earth Observation has been utilized for the investigation of organized violence in its diverse facets since the early 2000s. Within peace and conflict studies, attention is increasingly being paid to spatiality and the spatial analysis of parameters, which play decisive roles either for the onset of, or in the course of violent conflicts, but also in post conflict situations and peacebuilding. By linking space with various manifestations, patterns and processes of organized violence, peace and conflict scholars aim to achieve a better understanding of the dynamics of violent conflicts and related impacts. To be able to also develop and provide policymakers with suitable tools to, at best, prevent or, at least, better manage violent conflicts, more robust and reliable data and sound information is needed. Besides presenting successful approaches and use cases, the paper identifies current limitations of EO approaches in regard to the exploration of

multifaceted forms of organized violence. It concludes by indicating how new developments in EO Science might help to overcome impeding barriers of conflict early warning and to support conflict prevention and peacebuilding. Ultimately, it serves as an important step towards integrating EO methods into the methods toolbox of peace and conflict studies.

Monitoring Agricultural Large-Scale Land Investments in the Republic of South Sudan

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More land is in the hand of fewer. In times, where human population growth is unprecedented, dietary patterns change to a more meat-based nutrition, and cultivable land is negatively impacted by climate change, the interest of financial institutions in arable land is growing.

Since 2000 the 'rush' of investors for agricultural land has dramatically increased. However, even though the phenomenon has received much attention from the media and from Non Governmental Organizations (NGO), the quantitative assessment and localization of the factual investments remains a core challenge. Africa is regarded as the prime target continent and is the focus of the largest deals as well. The Republic of South Sudan is listed by scientific reports, reports in the media or from NGOs as one of the major target countries of large-scale land investments (LSLI) worldwide.

Large-scale land use changes have the potential of high impacts on people and societies especially in areas where small-scale farming and herding is prevalent. In most target countries agriculture is the main employment and income source for the population. Case studies show that the impact of agricultural LSLI often stay behind of what has been promised e.g. on employment or food security. Moreover, these investments often come along with evictions without adequate compensation. Linkages between the right to access land and evictions and conflicts have been shown.

The survey on LSLI in the Republic of South Sudan (RoSS) published in 2011 is a rare example of a baseline study. The survey is particularly meaningful as it investigates investments in a country which - at that time - was in transition towards independence, and later stumbled into war.

Earth Observation (EO) has the potential to monitor large areas at relatively low cost and offers tools to quantify land-cover changes. The use of EO data to monitor land-cover changes has been established by many studies. Based on the survey the usability of the significance of the NDVI time series trend for the detection of agricultural LSLI in the RoSS was determined. For this, NDVI time series from 2002 to 2012 were analyzed. The identified areas were quantified using multi-temporal true-color composites from the Landsat program.

The potentials of the methods applied in this study can be shown in one case. Pixels of a predefined area could be aggregated according to their significance of Mann-Kendall's Tau. The aggregation led to identifying an area with a change of land-cover change from natural vegetation to agricultural that was visual interpretable and quantifiable. As the NDVI patterns from the other analyzed areas did not show a definitive change, the conclusion can be drawn that the investments where not realized

on the ground. This implies that reports calling large numbers can distort the global picture of LSLI if no follow up investigation on the realization on the ground is being done. Localizing and monitoring LSLI may help peace and conflict researchers in analyzing the nature and thus providing new insights into this global phenomena and its impacts on societies.

SESSION 07 – OVERVIEW

SE - 07: COPERNICUS: DISASTER RISK MANAGEMENT 2 (ICW UN-SPIDER)

Time: **Tuesday, 21/Jun/2016: 2:00pm - 3:30pm**
Location: **S 29/31**

Session Chair**: Dr. Juan Carlos Villagran de Leon**, UNOOSA / UN-SPIDER, Germany
Session Chair: **Dr. Joachim Post**, United Nations Office for Outer Space Affairs, Germany

Near real-time multisource satellite mapping of the 2015 Chennai floods, India

Impact of DEM Quality and Resolution on Risk Assessment of Coal Waste Heap Stability

Land-use change modelling for sustainable risk management in Belgium

Analysis on Open Source Compression Algorithms for Efficient Storage of Remote Sensing Images

Near real-time multisource satellite mapping of the 2015 Chennai floods, India

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This article discusses the near real-time (NRT) satellite mapping activities in response to the recent Chennai floods in India by IWMI as well as other institutions around the globe. This study demonstrates that data from current SAR satellites can already be processed and delivered in near real-time to support post-disaster response and emergency management. IWMI in cooperation with Sentinel Asia System (SAS) has activated disaster charter to provide rapid images from ALOS-2 PALSAR-2 interferometric pairs. In addition freely available images from Sentinel-1/2, EO-1, Landsat-8 were obtained to provide operational flood progressive information to end users. Freely available SENTINEL-1 Toolbox and ArcGIS was used to derive rapid emergency response flood mapping products. The study shows that the mapping products can be released 6-7 hours after the post-event image is acquired using Sentinel Asia System, with the direct mapping activities such as Sentinel-1, JAXA and GIS processing typically taking 2-3 hours only. Subsequently the maps has been disseminated back to SAS, disaster management authorities and academic institutions. Further the maps have been used by insurer to estimate the flood insured losses. This study also discusses the urgent need for internationally coordinated development and deployment of SAR satellite constellations in order to greatly reduce the latency in NRT mapping of disasters, which will benefit a range of other satellite remote sensing applications as well. Moreover, it is suggested that the near real-time responses be coordinated across the globe in order to improve the effectiveness of rapid disaster mapping in order to mitigate the effects of floods and other natural disasters.

Impact of DEM Quality and Resolution on Risk Assessment of Coal Waste Heap Stability

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The present study compares the impact of Digital Elevation Model (DEM) quality and resolution on the outcome of simplified geotechnical stability analyses conducted on four coal waste heaps located in Western Wallonia (Heribus, 14-17 et Siege Social, Crachet 7-12 and Saint-Placide). This initiative is part of the Walloon response to Directive 2006/21/EC, requiring Member States to set up an inventory of the waste facilities liable to have a serious impact on the environment and/or human health. Institut Scientifique de Service Public (ISSeP) has established such a quantitative inventory. The four waste heaps studied here were pre-selected as needing further analysis. The protocol adopted for detailed geotechnical risk assessment includes geotechnical modelling, field observations and visual interpretation of ortho-photos and historical aerial photography. The assessment of the susceptibility of slope failure is quantified using a factor of safety, F. This factor corresponds to the ratio of the maximum admissible load and the load value actually applied on the slope. It is computed on a pixel basis using a simplified infinite-slope geotechnical model for two DEMs (Light detection and Ranging LiDAR and ERRUISSOL, available on the Walloon geoportal http://geoportail.wallonie.be/WalOnMap). Several factors may affect the quality of a DEM. Among these, data collection, density of points and interpolation techniques are key features. In this study, we concentrated on evaluating the performance of two techniques for generating DEMs from raw LiDAR data: natural neighbor Binning and Triangulation techniques. Additionally, various DEM spatial resolutions were used in order to improve the understanding of raw data processing's impact on risk assessment Finally, several supplementary datasets have been used in the analysis of the susceptibility of slope failure (field observations, historical aerial photography and ortho-photos). Our results show that interpolation techniques and spatial resolution can significantly affect DEM quality and geotechnical risk assessment. In particular, by removing striped patterns resulting from data acquisition errors, the Triangulation technique improves stability analysis. We also found that a minimum spatial resolution of 10 m was required for risk assessment. Conducting stability analyses using DEMs with a resolution of 1 m yielded multiple small (i.e. smaller than 10 m²) isolated areas that were susceptible to be unstable, but not posing any actual threat. The use of a DEM with a resolution of 1 m erroneously overestimates the risk of slope failure. While both LiDAR and ERRUISSOL data have the resolution proposed by the Protocol of the Directive (10 m), LiDAR data improve the stability assessment by comparison with ERRUISSOL even when it is aggregated at 10 m resolution because of a better precision of this technique.

Land-use change modelling for sustainable risk management in Belgium

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Floods, urban heat islands, mobility issues and other environmental and health risks increase with urban growth. In Belgium, these risks are supported by high current and projected urbanization rate. Sustainable territory planning requires decision support tools providing a holistic and dynamic vision of the fast changing environment. Current and historical land-use/cover can be assessed using geodata and remote sensing within geographical information systems. Possible future impacts of policies can be simulated by means of model-based scenarios. This paper considers the application of a constrained Cellular Automata (CA) land-use change model within both the Walloon and Flanders region in Belgium. As natural hazards are not stopped by regional borders, homogenizing risks studies between both Belgian regions is interesting for integrated planning.

Transposing the Flanders CA-based land-use model to Wallonia implies some particular contextual and methodological choices and decisions that are described in this paper. First of all different modelling goals, and geographical and social-economic contexts create a need for different parameter sets and scenarios. Secondly, availability, limited access, quality or semantic differences in existing data induce some model adaptations such as calibration, parameters and/or validation phases. Finally, knowledge of local and regional LU processes is required.

Firstly, identifying end-users and involving them closely in the model development process helps to precisely define the specific goals and outcomes for the Walloon region. This project created an implementation group including scientists and decision makers from several administrations. The second step is gathering and homogenizing model inputs across regions. Each region in Belgium is responsible for its own geodata production and management. By consequence, data availability and properties differ between regions. As an example, an important model input is a land-use map for the start year of the model simulation. The semantic adaptation between the existing land-use maps for Flanders and Wallonia is necessary to define the classes that are simulated by the model. A survey is currently being carried out to assess the users' satisfaction regarding the existing Walloon LU map as well as the expectation towards the modelled products. During model implementation, additional decisions must be taken together with end-users. These include calibrating the model and defining future scenario(s), e.g., using historical and projected LU or population data, as well as assessing model flexibility (i.e. what consequences if new data/studies/directive is published). Validation step will be discussed in detail, e.g., field work or use of authentic data sources such as buildings.

Generic and common land-use change model will be key decision support tool for sustainable spatial planning in the whole of Belgium. Involving end-users in the model

development and application guarantees future valorization and use of this model. Land-use change simulation will help drawing policies that limit risks caused by further urbanization.

Analysis on Open Source Compression Algorithms for Efficient Storage of Remote Sensing Images

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The space era has been started long time ago from the launch of the Sputnik that is the first artificial satellite which orbited around the Earth in 1957, which was the milestone of both space technologies development and all the other subjects of space exploration either planetary or deep space. In terms of planetary exploration, owing to the rapid development of high-tech space-borne sensor systems, we can now reach sub-meter ground sampling distances on Earth. However, the higher the resolution gets, then the more amount of data is to be transmitted to ground station. It may become a problem for archiving stations which store higher amount of satellite telemetry and data products that are being produced after the acquisition with some image enhancement and post-processing algorithms, as a result, file sizes increase even more with these steps and the processed data becomes harder to transfer and store. In the end, time needed to transfer increase and satellite telemetry requires more space.

Data compression algorithms are mainly divided into three sequences as lossy, near-lossless and lossless compression algorithms. The main aim of this study is to reveal the most efficient/optimal open-source lossless compression algorithms and in order to reveal those, several compression algorithms are taken into account for comprehensive comparison for efficient storage of Sentinel 1 & 2, SPOT 6 & 7, Pléiades 1A & 1B satellite products in several formats (GeoTIFF, ENVI, ERDAS Specific, etc.). These lossless open-source compression algorithms include Lempel and Ziv (LZ), LZB, LZSS, Adaptive Huffman (AH), LZMA (Lempel Ziv Marcov chain Algorithm) and PPMd (Prediction by Partial Matching). Most of the compression algorithms are aimed to reduce bit density of the data by reducing the redundant information in the stream of data. LZMA of this, uses a delta filter to achieve more compression ratios. Another algoritm which is PPMd, uses the very few characters at the end of the input stream to generate continuation of the stream to reduce the amount of extra information. After compression, there must be also a decompression for these compressed data in order to retrieve all the information to its initial, original state. These lossless compression algorithms, included in this research basically reduces the amount of data and retrieves the compressed bits without any losses.

Every algorithm have some trade-offs like different time intervals elapsed during compression, different compression ratios and compression efficiencies, so that, there have been an examination process for these compression techniques in order to evaluate the most efficient and best one to achieve the highest performance for satellite imagery. To acknowledge this, multi-temporal satellite images having different spatial

resolutions and GSD's acquired by different sensors and acquired at different seasons are used in order to evaluate the best data compression algorithm. These satellite images are preferred from different land covers, such as forestry, residential, agricultural etc. to asset if surface density properties of the satellite images affect the compression efficiency. The satellite imagery selected in research have been produced with two different processing levels as orthorectified and primary sensor data and images that are produced have been compressed by using different open-source lossless data compression algorithms to compare according to their performance in order to reveal which lossless compression algorithm is the best for very high resolution satellite imagery.

Sentinel 1 & 2 images are kindly provided by ESA Copernicus Sci-hub, while SPOT and PHR constellation images by ITU Center for Satellite Communications and Remote Sensing of Turkey.

SESSION 08 – OVERVIEW

SE - 08: LAND DEGRADATION

Time: **Tuesday, 21/Jun/2016: 2:00pm - 3:30pm**
Location: **S 30/32**

Session Chair: **Dr. Tobias Landmann**, International Centre for Insect Physiology and Ecology (ICIPE), Kenya
Session Chair: **Dr. Olena Dubovyk**, University of Bonn, Germany

Bush Encroachment Mapping for Africa – A Multi-Scale Analysis with Remote Sensing and GIS

Assessing land-cover change and degradation in the Central Asian deserts using satellite image processing and geostatistical methods

Remote Sensing Assessment of the Condition of Alpine Swards on the Example of Tatra National Park (Poland).

Do vegetation indices provide a reliable indication of vegetation degradation? A case study in the Mongolian pastures

Assessing different remote sensing based methods for mapping post-Soviet abandoned cropland in Central Asia

Bush Encroachment Mapping for Africa – A Multi-Scale Analysis with Remote Sensing and GIS

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Bush encroachment describes a global problem which is especially facing the savanna ecosystem in Africa. Invasive species and woody vegetation spread out in areas where they are not naturally occurring and suppress endemic vegetation, especially grasses. Livestock is directly affected by decreasing grasslands and inedible invasive species which are a result of the process of bush encroachment. For many small scale farmers in developing countries livestock represents a type of insurance in times of crop failure and droughts. Among that bush encroachment is also becoming more and more a problem for crop production. Studies on the mapping of bush encroachment so far focus on small scales using high-resolution data such as mainly aerial photography, and rarely provide information that goes beyond the local or national level. Therefore a process chain was developed using a multi-scale approach to detect bush encroachment for the whole African continent. This bush encroachment map is calibrated with field data provided by experts in Southern, Eastern and Western Africa. Supervised classification links location data, which represent the training samples for the up-scaling, to the respective pixel of remote sensing data. The location specific information is up-scaled with the integration of remote sensing imagery from two different sensors. The first level uses Landsat 5 and Landsat 8 with 30m resolution. For the second level the MODIS surface-reflectance product (MOD09A1) with 500m resolution is taken into account. Based on these data a map is developed that shows potential and actual areas of bush encroachment in Africa and thereby provides an innovative approach to map bush encroachment on the regional scale. The classification technique is based on random forests and regression trees, a machine learning classification approach which is programmed in R. In addition to the map on bush encroachment a second output is generated which focuses on the probability of bush encroachment occurrence based on possible causes such as fire occurrence based on MODIS data (product MCD14DL) or soil moisture information by ESA (CCI SM v02.1). By this, possible areas for bush encroachment occurrence based on their pre-conditions and risk factors are identified.

This innovative approach includes multiple datasets derived from earth observation data to detect bush encroachment in Africa, a severe and ongoing global problem. The identification of bush encroachment and the probability of its occurrence can help to prevent further grassland decrease and identify those regions where land management strategies are of high importance to sustain livestock keeping and thereby also secure livelihoods in rural areas.

Assessing land-cover change and degradation in the Central Asian deserts using satellite image processing and geostatistical methods

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Soil and vegetation degradation around watering points has been observed in many drylands around the world. It can be recognized in spaceborne imagery as radial brightness belts fading as a function of distance from the water wells. The primary goal of the study was to characterize spatial and temporal land degradation/rehabilitation in the Central Asian drylands. Tasseled Cap's brightness index was found to be the best spectral transformation for enhancing the contrast between the bright-degraded areas close to the wells and the darker surrounding areas far from and in-between these wells. Semi-variograms were derived to understand the spatial structure present in the spaceborne imagery of two desert sites and in three key time periods (mid-late 1970s, around 1990, and 2000). A geostatistical model, namely the kriging interpolation technique, was applied for smoothing brightness index values extracted from 30 to 80 m spatial resolution images in order to assess spatial and temporal land-cover patterns. Change detection analysis, based on the kriging prediction maps, was performed to assess the direction and intensity of changes between the study periods. These findings were linked to the socio-economic situation before and after the collapse of the Soviet Union that influenced the grazing pressure and hence the land-use/land-cover state of the study sites. The study found that degradation occurred in some areas due to recent exploration and exploitation of the gas and oil reserves in the region. Another area was subject to rehabilitation of the rangeland due to a dramatic decrease in the number of livestock due to socio-economical changes after the independence of Kazakhstan in 1991.

Remote Sensing Assessment of the Condition of Alpine Swards on the Example of Tatra National Park (Poland).

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In high mountains environment main stressors include too high light intensity, lack of water, changing weather conditions or trampling due to increased tourist traffic. Too much intensity of stressor causes irreversible cellular changes, sometimes leading to death of the plant cell. Studies in a non-invasive manner can be carried out by methods of remote sensing and fluorescence. During field research in August 2013 following measurements were performed: spectrometric measurements with ASD spectrometer FieldSpec 3, bio-radiometric measurements of chlorophyll content, plants surface radiation temperature (ts) and thermodynamic air temperature (ta), accumulation of photosynthetically active energy and the projection surface of the leaves. Spectrometric measurements allowed to obtain spectral characteristics of tested alpine swards species. Remote sensing vegetation indices were calculated to show various parameters of plants, including chlorophyll, carotenoids, the amount of light used in the process of photosynthesis, or the water content in the plant. Bio-radiometric measurement were used to verify information obtained from the spectrometer and to show correlation between biometric measurements and vegetation indices. Chlorophyll fluorescence informs of the state of photosynthetic apparatus and the dynamics of the processes of photosynthesis. The aim of combining such research methods is to estimate the proportion of energy used for photosynthesis (photochemical quenching) to energy emitted in the form of heat (non-photochemical quenching) and on this basis to evaluate how effectively the energy of light radiation was consumed by PSII. The correlation of fluorescence (t1/2; Fv/Fm) with values of indices determines the state of plant and the impact of stress factors on vegetation.

Studies were conducted in the area of Kasprowy Peak and Red Peaks in Tatras (UNESCO M&B Reserve and National Park). Measurement points were located in a 5 meters buffer from the trail for analysis of the most damaged vegetation, as well as over 10 meters for reference plants. In studies were also used multispectral WorldView-2 image acquired 7 September 2013, capturing wavelengths from 400 nm to 1040 nm, with a spatial resolution of 2 meters. WV-2 images were geometrically and atmospherically corrected and used to calculate vegetation indices: NDVI, SAVI, OSAVI, ARVI, GNDVI, EVI, PSRI, TCARI, MCARI, TVI, WARI, NCPI, CRI1 (carotenoid content), ARI2 (anthocyanin content). As a validation ASD FieldSpec, fluorescence, chlorophyll measurements were used.

The study showed statistically significant differences between indices calculated for the same species in two studied buffer zones. The vegetation alpine swards in the 5 m buffer had less dense cover and poorer condition, which partially enhanced the process of erosion and destruction of the trails. In addition, it was observed that the vegetation located near the trails produces less products of photosynthesis, however, stress has not destroyed completely plant cells. The maximum differences of NDVI between buffer were 0.2 and the minimum 0.05. The differences between indices values of analyzed and reference buffers were statistically significant ($p < 0.05$) for NDVI, ARVI, GNDVI, EVI, PSRI, TCARI, MCARI values. Mean difference between buffers was 0.2 for field measurements and 0.15 on satellite image. The applied remote sensing and fluorimetric methods allows to analyze the state of vegetation in a multi-year period.

Do vegetation indices provide a reliable indication of vegetation degradation? A case study in the Mongolian pastures

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Space and ground observations were applied to explore the ability of remote sensing techniques to assess the effect of grazing on vegetation degradation. The steppe biome of Mongolia was used as the study area, in which several pairs of sites were investigated – each pair comprised an ungrazed (fenced-off) area and a heavily grazed area. For each pair, the enhanced vegetation index (EVI), computed from Landsat-7 Enhanced Thematic Mapper Plus (ETM+) data, along with field-observed biophysical variables (e.g. plant density, species composite, above-ground biomass (AGB), and percentage cover) and plant spectral reflectance data were collected. As expected, plant density, AGB, and percentage cover values were significantly higher in the ungrazed areas than in the adjacent grazed ones. However, unexpectedly, the grazed areas had significantly higher EVI values than the ungrazed areas. It was found that unpalatable species had invaded into the grazed areas, substituting the native grasses. These invasive species, mostly characterized by denser leaf structure, induced higher spectral responses in the near infrared (NIR) region of the electromagnetic spectrum. EVI is the preferred vegetation index to use for detecting this phenomenon, since it is more sensitive to variations in leaf cellular structural as expressed in the NIR (rather than the red) portion of the spectrum. The current study contradicts the general assumption that the higher the vegetation index value, the better the grazing conditions.

Assessing different remote sensing based methods for mapping post-Soviet abandoned cropland in Central Asia

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The surging demand of the former Soviet Union to become independent from cotton imports and to satisfy the demands for its fast growing growing population had to be met by immense increases of domestic production. This succeeded, but predominantly by extending irrigated agriculture in countries currently located in Central Asia, and concurrently at the expense of an unsustainable use of land and water resources in this region. These resources were over-exploited and even reaching an ecological tipping point as substantiated by a widespread soil degradation and consequent cropland abandonment. Driven by growing environmental concerns, fear for food insecurity of a growing population and the hostile projections of climate change for the region, the productivity enhancement of degraded and abandoned croplands has been placed on the political agenda again. Such croplands do not only represent a potentially valuable resource, even when realizing the potentially lower crop yields, but it is recognized concurrently as an effective means in levering previous investments to extend the irrigation and drainage infrastructure. Latest research findings point additionally at the potential for implementing alternative sustainable land management options such as e.g. afforestation and renewable energy production.

The current lack of robust data and information, needed to identify abandoned croplands rapidly and over a wide area, can be counterbalanced by satellite earth observation (EO) data. The availability of repetitive and objective EO data can be used to assess alterations in surface characteristics and consequently map large territories. Yet, current remote sensing methods have each (dis)advantages, which a priori cannot be assessed for the situation in Central Asia. Therefore, the findings of abandoned cropland mapping by six common methods were compared and assessed. The comparison followed a step-wise procedure: First an agricultural land mask was produced to separate agricultural from non-agricultural land. Secondly, NDVI time series from the MODIS Terra and Aqua platforms for 2003-2014 were compiled. These were consequently subjected to one unsupervised method based on thresholds, two different supervised methods, two trend based methods and a fusion method based on majority voting. The results of the six methods were then fused once more, but based on a weighted fusion algorithm that accounted for the performance of each method. To summarize patterns of abandoned cropland across Central Asia, the percentage of abandoned cropland relative to the sum of abandoned plus active

cropland was estimated. Abandonment rates were grouped by biophysical suitability for agriculture, using a crop suitability index from FAO.

Overall accuracies of the methods ranged from 0.678 – 0.825. The weighted fusion increased the accuracy even more (0.858), whilst the difference between the weighted fusion and the single best approach was statistically significant ($p < 0.05$). Overall, the magnitude of abandoned cropland varied between 10%-35% of the total agricultural land, depending on the method used. None of the methods was exclusively superior in all irrigated regions across Central Asia. Consent across methods occurred on the primary location of abandoned croplands in the lowland regions, typified by water deficits and were land abandonment is driven predominantly by land degradation. In some regions, abandonment was detected also in places with highest recorded suitability for crops. The assessment revealed overall that no individual method can be promoted as the most accurate one across the entire irrigated landscape in Central Asia. Yet, due to the fusion of the different methods, a first reliable and unified abandoned cropland layer in Central Asia was elaborated, which should be of interest to local practitioners, land users and political decision-makers alike.

SE - 09: FORESTRY

Time: **Wednesday, 22/Jun/2016: 11:00am - 12:30pm**
Location: **S 29/31**

Session Chair: **Dr. Frank Thonfeld**, University of Bonn, Germany
Session Chair: **Christina Eisfelder**, German Aerospace Center (DLR), Earth Observation
Center (EOC), Germany

Forest cover loss in Paraguay and Ecosystem Service Approaches: An Upper Parana Forest Study Case.

Remote Sensing based Modelling of Net Primary Productivity for China – Analysing trends, monitoring human impact and forest disturbance

Phenological Changes in 2014-2015 Vegetative Periods of UNESCO's World Heritage Bialowieza National Park Tree Species

Potentials and Limitations of ALS-based Tree Detection and Segmentation Concepts for an Object-Based Forest Characterization

The impact of drought in 2015 in Poland on the condition oak and pine forests using remote sensing indicators from very high resolution aerial images and OLI

Forest cover loss in Paraguay and Ecosystem Service Approaches: An Upper Parana Forest Study Case.

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Tropical forest cover has fluctuated greatly over recent decades. The continuous advancement of agricultural crops, cattle ranching, and illegal logging has resulted in the conversion of the majority of the world's forest into isolated patches; endangering not only their continuity but the biodiversity within them. Despite that rates of deforestation have decreased in comparison to previous years, it still remains a crucial concern. The latest studies conducted on a global scale identified Paraguay as one of the countries in Latin America with the highest deforestation rates in the globe. The rapid growth of deforestation has resulted in the loss of 91% of the forest cover in the eastern region of the country (Alto Parana Atlantic Forest). In order to halt the predation of forest, several strategies, decisions, conventions, and monitoring programmes were carried out in an international context. One of the most promising alternatives is the Payment for Ecosystem Services (PES). The programme establishes a mechanism in which forests owners receive compensation to preserve their forest reserves and other natural environments. Within this context, the present research provides a characterization of the ecosystems service value derived from the Atlantic Forest Region in Paraguay (BAAPA). The results were obtained from the combination of Earth Observation-based mapping and an extensive household survey, to assess the value of direct and indirect ecosystems services provided by the BAAPA forest and their correlation to a socio-economic scale. Remotely sensed data obtained from Landsat images from 2003 and 2013 were utilized in order to derive the extent of the forest cover and deforestation rates over the past decade. Household surveys provided a comprehensive understanding of the perception of the ecosystems service influence on the preservation of the forest in regards to a mixture of landowners, such as: indigenous communities, small/large soy bean producers, and crop companies. Preliminary results demonstrate a lack of understanding regarding the value of natural resources, if no direct income is generated among the communities. Further differences between communities were observed when dealing with perceptions and general understanding of the importance of maintaining their forests. Indigenous communities are considered to be more concerned with protection of the forest for cultural purposes, whereas small and large soy bean producers expressed their willingness to obtain economical profits from the forest in a sustainable matter. Values obtained from the field surveys in combination with remote sensing data allow us to identify and characterize the value of ecosystems services in the BAAPA region. Recognizing and valuing ecosystem services is of great importance to the contribution towards planning measures aimed at preserving these very precious natural resources.

Remote Sensing based Modelling of Net Primary Productivity for China – Analysing trends, monitoring human impact and forest disturbance

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The Republic of China is the world's third largest and most populous country. It shows immense and rapid development. Economic growth and migration trends put pressure on ecological resources. In this context, observation of Net Primary Productivity (NPP) dynamics helps to understand possible impacts on the environment and to observe changes in productivity of natural vegetation and agricultural areas.

In this study, we present results of monthly and annual NPP calculated with the Biosphere Energy Transfer Hydrology (BETHY/DLR) model for China for 14 years from 1999–2012. The model results are based on meteorological and remote sensing derived input data. BETHY/DLR makes use of remote sensing derived leaf area index (LAI) as one of nine major input parameters. As our study shows, this allows analysing not only meteorological effects, but also human impact on vegetation productivity and temporary effects, based on the NPP results from BETHY/DLR.

We present annual NPP distribution for 1999–2012 and monthly NPP patterns for China. The NPP time-series of 14 years with 1 km spatial resolution allows analysing relevant environmental changes, patterns, and trends for large areas, but on a regional scale. Investigation of inter-annual NPP variability reveals considerable differences in the development of annual vegetation productivity within the analysed time period for different provinces.

The NPP results are then used for analysing changes in NPP in the surroundings of Shanghai. We observe a decrease in NPP especially for Shanghai, but also in the close-by provinces. A closer look at Shanghai and the neighbouring districts reveals that a strong impact on NPP can be observed for the districts around Shanghai. These results show that calculated NPP time-series can be used for quantifying the impact of urban sprawl on the environment.

The NPP data were also analysed for a region in the North of China, which has been effected by forest fires and clearances. The analyses show that NPP data can be used to identify areas of forest disturbance. Moreover, they can also be used for monitoring of forest regrowth. This information is important for understanding the status of forests after disturbance events.

As our examples show, the 14-year NPP time-series based on remote sensing input data for China provides important information for understanding environmental change

in this fast-changing country. The retrieved information is important for understanding impact of urban growth and ecological disturbances. We demonstrate the usability of remote-sensing based NPP time-series for monitoring the impact of human activities and permanent or temporary disturbances on vegetation productivity on a regional scale.

Phenological Changes in 2014-2015 Vegetative Periods of UNESCO's World Heritage Bialowieza National Park Tree Species

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Narrowband vegetation indices can show detailed, even minuscule changes in vegetation condition, especially regarding amount of chlorophyll and other pigments, water content or use of light in process of photosynthesis. Proper application of such data can provide information on plants phenology as well as changes between vegetative periods.

The research was devoted to analysis of changes in tree species phenology on the area of the UNESCO's World Heritage Bialowieza National Park in Poland. The Park being a remnant of Central European lowland forests is characterized by high biodiversity and is under strict protection. The data were collected in 2014 and 2015 on the beginning (May), during (July) and at the end of the vegetative period (September) using ASD FieldSpec 3 and 4 spectroradiometer with Plant Probe (information on spectral response) and Dualex Scientific+ Polyphenol & Chlorophyll-Meter (chlorophyll content). The data were acquired on 8 homogenous areas for the following tree species - deciduous: hornbeam (Carpinus betulus), oak (Quercus robur), alder (Alnus glutinosa), birch (Betula pubescens) and coniferous: spruce (Picea abies) and pine (Pinus sylvestris). The aim of the research was to assess changes undergoing in plants phenology during two vegetative periods (one in 2014 and the other in 2015) and to compare plant's condition between years, taking into consideration strenuous atmospheric conditions of 2015 (European drought of 2015). Spectral response curves were used to calculate vegetation indices while chlorophyll content was applied to verify accuracy of collected data.

Statistical analysis with ANOVA and Kruskal-Wallis ANOVA allowed to determine which parts of the electromagnetic spectrum and which vegetation indices showed significant changes between measurement periods both in 2014 and 2015 as well as between years. The most common changes during each vegetative period were observed along all wavelengths, varying between species. Changes between years were noted in blue and red visible light spectral ranges, cell structures, yet rarely in ranges dependent on water content.

Potentials and Limitations of ALS-based Tree Detection and Segmentation Concepts for an Object-Based Forest Characterization

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The preservation of natural resources and the coordination of competitive interest groups (e.g. timber production, recreation, natural protection) is a major task of a sustainable forest management. A detailed knowledge of present forest conditions, forest ecosystem functions and services is necessary to plan relevant decisions. Precision forestry assists forest management and planning by using geospatial information. Remote sensing data has been proven suitable to determine key forest parameters (e.g. tree species, biomass, carbon sequestration, leaf area index) on different scales and even on a single tree level.

A bottom-up concept using single tree objects as the smallest unit promises to cover the whole variability for each superordinate object (e.g. patch of trees). Object-based modeling approaches deliver localized information, which also increases the comparability to terrestrial reference measurements of individuals, because an explicit assignment to the corresponding reference trees is facilitated.

Today, airborne laser scanning (ALS) is the measurement technique of choice for an identification and structural characterization of single trees due to its high spatial resolution and its ability to record the vertical structure by penetrating the canopy. Other remote sensing data, like multispectral, hyperspectral or radar data, is suited for further characterizations of the trees and stands to derive various forest parameters.

A conceptional comparison of ALS-based single tree detection and segmentation concepts will be given and the general strengths and weaknesses will be addressed. The enhancement of ALS systems with increasing spatial resolutions and point densities enabled the recording of dominated trees and structural details (like tree trunks). Thus, newly developed single tree detection and segmentation methods tend to use the more detailed point clouds as base data rather than gridded data. The increasing data amount and a demand of automated large-scale processing results in an increasing importance of efficient spatial analyses. To characterize spatial relationships as well as to analyze 2D/3D topology spatial indices (e.g. k-d tree, R-tree or Quadtree) solve the performance problem efficiently. A combination of complementary detection methods, which focus on different features (e.g. crown shape, tree trunk, point density), is proposed to improve the detection rate while maximizing the precision. The derived tree positions can be used as initial points for a crown segmentation approach, whose quality is defined by its ability to separate neighbored trees correctly while preserving the 3D shape for each tree.

The static character of ALS data – usually caused by a low repetition rate of measurement campaigns – and the limited spectral resolution makes ALS insufficient

for deriving biochemical or phenological parameters. Therefore, the potential of data-fusion concepts to improve the estimation of such parameters will be highlighted.

Since the accuracy assessment of tree detection and segmentation approaches requires detailed and accurate reference data, some limitations of measuring the 3D-structure terrestrially will be discussed.

On the basis of the given overview, the potentials and limitations of a single-tree-based evaluation of forest ecosystems will be summarized. Finally a research perspective for newly opening fields of application – due to newly derivable parameters (e.g. trunk leaning angle) caused by increased point cloud densities – will be given.

The impact of drought in 2015 in Poland on the condition oak and pine forests using remote sensing indicators from very high resolution aerial images and OLI

Mariusz Kacprzak, Jan Kotlarz, <u>Sylwia Agata Nasilowska</u>

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The paper presents an analysis of the set of aerial and satellite multispectral images in aim to detect the impact of drought on forest tree condition. Aerial imagery were taken within HESOFF project, aiming to cover chosen forests in western Poland with very high resolution data. Images are performed by specially designed for the project multispectral camera QUERCUS, coupled with 6 lenses for recording images in different spectral lengths of light with maximal 25 cm spatial resolution. Images were gathered since 2013. Every year few flights were conducted during growing season. In addition similar analysis using OLI Landsat 8 were conducted for parallel period to compare results and indicate the best methods for drought monitoring.

Tree forests sites were selected for overflights, localized near Krotoszyn, Leszno and Piaski (Wielkopolska region). Two types of forest were analysed: decidiuous with a predominance of oak, and coniferous (mainly pine trees). During flights some field experiments were conducted by foresters in aim to collect trees condition parameters. Weather parameters were acquired from ground meteorological stations.

The paper presents a methodology for comparing remote sensing indicators and condition of the trees in the groving season in 2015 in the context of previous years. The 2015 year was outstanding, due to the amount and incidence of precipitation. It was few time lower in comparison to previous years, and to average in this region. The drought has influence on the forests conditions, thus also on remote sensing indices.

During HESOFF observing cycle, for oak forest and between April to June, few changes were observed. NDVI index were lower than average during this time. In next months (July - August) correlation between trees conditions and low rain amount were not observed. Results for pine forest shows their higher resistance for supply of water, due to the differences in the specificity of the root system.

Monitoring of the range and amount of damages caused by drought is important due to assessing of future potential forests threats (eg. defoliation, lower resistance to fungal diseases). Thus several aerial flights are planned in 2016, which may show the drought effect on trees condition.

SESSION 10 – OVERVIEW

SE - 10: GEOLOGICAL APPLICATIONS 1

Time: **Wednesday, 22/Jun/2016: 11:00am - 12:30pm**
Location: **S 30/32**

Session Chair: **Dr. Christian Rogass**, Helmholtz Centre Potsdam GFZ German Research
Centre for Geosciences, Germany
Session Chair: **Prof. Konstantinos Nikolakopoulos**, University of Patras, Greece

Drill core mineral analysis by the hyperspectral imaging spectrometer HySpex, XRD and ASD in the area of the Mýtina maar, Czech Republic

Sentinel-2 and Landsat-8, Global Mapping Missions for Mineral Resource Exploration and Mine Waste Monitoring, Examples from Southern Africa.

Rare Earth Element Mapping of Outcrops using the EnGEOMAP approach

GeoMAP-trans – a processing chain for geocorrected at-surface reflectance retrieval for translational laboratory scans

UAV-MEMO project – Bringing the Finnish UAV Businesses and Mining Industry Together

Drill core mineral analysis by the hyperspectral imaging spectrometer HySpex, XRD and ASD in the area of the Mýtina maar, Czech Republic

Friederike Magdalena Koerting[1], Christian Rogass[1], Horst Kaempf[1], Christin Lubitz[1], Ulrich Harms[1], Nina Boesche[1], Christian Mielke[1], Uwe Altenberger[2], Michael Schudack[3], Raymond Kokaly[4]

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The study used samples from a recently discovered maar system in Mýtina, Czech Republic to compare different analysis techniques in order to create a surface cover map which includes the volcano-clastic overprint of the area. This goal is to be achieved by focusing on using remote sensing techniques. Hyperspectral images are increasingly in demand for geological surface mapping purposes and therefor a range of expert systems established to satisify that demand. Their performances have to be qualified and verified to ensure a correct classification and by that to ensure the correctness of the resulting surface cover maps. In this work, several steps were taken: First, samples from 7 drill cores from the adjacent area of the maar were analysed by X-Ray diffractometry (XRD) and the hyperspectral imaging spectrometer HySpex. Secondly, in-situ measurements of soil samples were taken in the field by an analytical spectral device (ASD) and by the HySpex system in the laboratory. Third, the resulting data was analysed by a material characterization algorithm (MICA) and the produced classificiation was compared to the XRD-analysis which effectively acts as a validation. Fourth, for a semi-quantitative analysis a spearman-rank correlation was carried out and fifth, the MICA-results of the ASD measurements were compared to the measurements of the soil samples in the laboratory.

This comparison provides the possibility to create a volcanic map based on the in-situ soil in the area of Mýtina. A good correlation of detected minerals by the two methods of XRD and the solaroptic remote sensing was found. We also found a correlation in the semi-quantitative analysis, regarding the soil samples but it has to be kept in mind that the minerals which lack identifiable features in the visible to short wave infrared range (e.g. quartz, feldspar) had to be taken out of consideration for that. The analyses of soil samples by XRD and HySpex showed a lack of mineral identification and rather the detection of vegetation or no detection at all. This is due to the method of analysis. This work developed an operable process chain which simplyfies the analysis of drill cores, drill core samples and soil samples. It provides the groundwork for a spatially extensive analysis of hyperspectral remote sensing data of the area.

Sentinel-2 and Landsat-8, Global Mapping Missions for Mineral Resource Exploration and Mine Waste Monitoring, Examples from Southern Africa.

Christian Mielke[1], Christian Rogass[1], Nina Boesche[1], Yu Li[1], Karl Segl[1], Christoph Gauert[2], Maarten de Wit[3]

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Sentinel-2 and Landsat-8 OLI are unique optical sensor assets to the geoscientific community worldwide. Previous work showed the potential of Southern Africa as natural laboratory for testing and developing new applications for the geoscientific community from global mapper missions as South Africa and Namibia have large mining and tailings landscapes near densely populated areas together with large-scale mineral deposit sites. Here Landsat-8 OLI has already proven its capability for gossan detection and mine waste monitoring at test sites in Namibia and South Africa complementing the data of the hyperspectral sensor Hyperion. ESAs new Sentinel-2 sensor with its enhanced spectral resolution in the visible and near infrared will deliver improved results (e.g. in the Iron Feature Depth) at those test sites, previously covered only by Landsat-8 data.

Here we present a comparison of the results from ESRINs python code for at ground reflectance retrieval with the GFZ in-house code for Sentinel-2 at ground reflectance retrieval at the mine waste and mineral deposit sites of Southern Africa. In addition results from Iron Feature Depth (IFD) and Normalized Iron Feature Depth (NIFD) over gold mining and platinum tailings in South Africa are shown from Landsat-8 OLI and Sentinel-2 data. Mineral exploration test site results from gossans at the Aggeneys Cu-Pb-Zn deposits of Bushmanland are shown, together with data from gossans at the Haib River Cu-Mo deposit.

Rare Earth Element Mapping of Outcrops using the EnGEOMAP approach

Nina Kristine Bösche[1], Christian Mielke[1], Christian Rogass[1], Christin Lubitz[1], Maximilian Brell[1], Sabrina Herrmann[1], Anne Papenfuß[1], Friederike Körting[1], Uwe Altenberger[2], Luis Guanter[1]

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The increasing demand of rare earth elements for global industry and the potential risk of supply disruptions leads to an intensification of global exploration. Besides classic exploration methodologies, such as sampling in combination with geochemical analyzes and geophysics, remote sensing techniques are more and more utilized. In this study, a recently published rare earth mapping tool of the EnGEOMAP approach is applied to map the mineral distribution of surface of outcrops and to highlight rare earth element indicative pixel. The EnGEOMAP is a two-step approach, developed to classify the images of the future EnMAP imager. The first step is an automatic continuum removal and a signal-to-noise ratio adapted feature definition and retrieval. The second step consists of a signal-to-noise-ratio weighted averaging of multitemporal acquired images, an adaptive filtering for the rare earth element related absorption bands and a correlation of the pixel spectra with an artificial spectral library. EnGEOMAP is applied to three outcrops of slightly different mineralogy (Fen Carbonatite Complex, Norway). The characteristic rock types at the Fen Complex are Ca-carbonatites (sovites), Mg-carbonatites (rauhaugites) and Fe-carbonatites (rodbergites). The resulting maps show the different rock types overlaid with the ore zone indicative pixels. The validation of the results were achieved with geochemical analyses on field samples and in-situ point measurements. Surface mineral mapping and ore zone detection in outcrops is feasible using the EnGEOMAP approach.

GeoMAP-trans – a processing chain for geocorrected at-surface reflectance retrieval for translational laboratory scans

Christian Rogass, Maximilian Brell, Christian Mielke, Nina Boesche, Yu Li, Friederike Koerting, Maria Bade

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Hyperspectral imaging becomes more and more important for a variety of remote sensing applications. Different applications rise the quantity of different sensor platforms, scanning environments and scanning principles. This copes with an increase of proximal sensing applications such as in the laboratory using object translating stages of object line scanning systems that utilize the push broom technique.

In this work we propose a processing chain to retrieve geometrically and atmospherically corrected at-surface reflectance that is a necessity for succeeding analysis. It consists of a set of hybrid approaches for assisted SIFT and affine FFT sub pixel precise co-registration, spatial polynomial irradiance estimation and automatic norm plate detection. It has been already used in numerous applications and its validity for HySPEX VNIR/SWIR scans will be shown by comparisons with point wise derived at-surface reflectance data retrieved using an ASD FieldSpec on different objects.

It is named as GFZ GeoMAP-trans and is part of the GFZ GeoMAP (Geosphere MAPping) framework that combines multiple remote sensing sensors, analysis modules (Minerals and Rare Earth Elements) and application purposes (EnGeoMAP – EnMAP GeoMAP). It is primarily used for geological prospection purposes, but might be utilized also for other applications because of the overall performance of the processing chain.

UAV-MEMO project – Bringing the Finnish UAV Businesses and Mining Industry Together

Maarit Middleton[1], Heikki Salmirinne[1], Jukka Konnunaho[1], Tuomo Karinen[1], Maija Kurimo[1], Jouni Lerssi[2], Mika Larronmaa[2], Tero Niiranen[1], Hannu Panttila[1], Antti Pasanen[2], Heikki Pirinen[2], Raija Pietilä[1], Pertti Turunen[1], Mikko Huttunen[3], Lotta Viikari[3], Vesa Nykänen[1]

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Expanding mineral exploration and mining operations in northern Finland require developing environmentally neutral techniques which are cost and time-efficient. The project 'Unmanned Aerial Vehicles in Mineral Exploration and Mining Operations in the Arctic Areas of Finland' (UAV-MEMO, 2015-2016) was initiated by the Geological Survey of Finland (GTK) and University of Lapland to study the applicability of UAVs in mineral exploration and monitoring environmental issues on mine sites from the technological and legal points of view. The project is funded by the Finnish Funding Agency for Innovation (Tekes) and several locally operating mining companies.

New UAV startups might not have the required competence regarding the technical applicability of UAVs and the regulations allowing them to provide the necessary services to mining sector. The goal of the UAV-MEMO project is to promote business in northern Finland, networking of companies, new drone applications and the development of drone technology and regulations. The project was set up to create new business opportunities for the UAV companies to complement the growing and traditional mining operations. In the UAV-MEMO project, GTK studies the technical suitability of the UAVs, surveys the customer needs in the sector and carries out test measurements. University of Lapland's Faculty of Law researches the current regulations concerning the use of UAVs in Finnish airspace.

In the first year, two magnetic UAV surveys were carried out in summer and winter conditions. The project is also allowed to utilize data acquired in a photogrammetric survey of a rock quarry to estimate the volume and quality of the quarried rock and storage piles. A questionnaire sent to potential service buyers showed that the mining and exploration companies are interested in the low-priced UAV surveys if the data has high quality, the UAV technology speeds up the data acquisition, or there is a safety component involved. Hyperspectral, thermal camera and radiometric surveys are planned for the coming summer for monitoring purposes of currently operating and abandoned mine sites. A profound overview of the UAV regulations will be summarized into a concise guidebook. The results will be published in a UAV-MEMO handbook which will be freely available at http://hakku.gtk.fi/fi/reports in the early 2017.

SESSION 11 – OVERVIEW

SE - 11: IMAGING SPECTROSCOPY 1

Time: **Wednesday, 22/Jun/2016: 4:00pm - 5:30pm**
Location: **S 29/31**

Session Chair: **Prof. Lena Halounova**, Czech Technical University in Prague, Czech Republic
Session Chair: **Dr. Bogdan Zagajewski**, University of Warsaw, Faculty of Geography and Regional Studies, Poland

A New Vertex Component Analysis Approach Based on Support Vector Data Description for Linear Hyperspectral Endmember Spectra Extraction

Application of HySpex Hyperspectral Image in Analyse Trees on Urban Areas: Tree Species Identification and Monitoring of Tree Damages

Tree species classification of Karkonoski National Park using artificial neural networks and APEX airborne hyperspectral data

Assessment of field hyperspectral remote sensing in heavy metal contamination analyses of forests in SW Poland

A New Vertex Component Analysis Approach Based on Support Vector Data Description for Linear Hyperspectral Endmember Spectra Extraction

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In the framework of remote sensing, optical hyperspectral imaging systems are currently among the most important tools. Hyperspectral sensors measure reflected energy in hundreds narrower bands of the electromagnetic spectrum.

Spectral unmixing (SU) is one of the most used techniques for analyzing hyperspectral images. SU, in its first step, aims at extracting the endmember spectra (contained in a mixed form in the analyzed data). In the simplest and most popular situation, the mixture is assumed to be linear and instantaneous, thus linear spectral unmixing (LSU) techniques are applied to linearly extract a collection of endmember spectra.

Well-known LSU techniques are based on geometric formulation, and most of them aim at retrieving the optimal simplex, which circumscribes the hyperspectral data scatter space. The vertices of the retrieved simplex correspond to the endmembers. The first reported of these approaches assume that hyperspectral data contain at least one pure pixel per endmember. These methods need to know the number of endmembers a priori. Recently, other sparse-based approaches are developed that do not require such knowledge. These approaches necessitate the existence, in the observed scene, of at least one pure pixel zone per endmember. In this work, a new Vertex Component Analysis (VCA)-based approach is proposed. This method does not need to know in advance the number of endmembers, and only requires one pure pixel per endmember.

The proposed approach uses the Support Vector Data Description (SVDD) algorithm, which is able to automatically extract the desired endmember spectra. This algorithm is one of the most well-known one-class Support Vector Machines (SVM) algorithms. In the current work, the whole hyperspectral image pixels are considered as one class, and the SVDD algorithm is applied in order to automatically select the Support Vectors (SVs) among these pixels. The selected SVs lie along the boundary of the optimal description model that encloses the data cloud. The SVs of this description model are expected to match the vertices of the optimal simplex circumscribing the pixels. Therefore, in this work, these SVs are considered as the desired endmember spectra.

The basic idea behind the SVDD algorithm is to find a hypersphere with minimum volume that encloses the whole data. Moreover, by introducing a kernel function, the SVDD gets a much more flexible model instead of a hypersphere. In the proposed approach, the SVDD algorithm is used with a Gaussian kernel. The common limitation, when using such a kernel, is the precise setting of the Gaussian width parameter. This limitation is crucial to obtain properly the number of the endmembers. In this investigation, this parameter is set to the mean of the standard deviations of the spectral bands of the considered hyperspectral image.

Experiments using synthetic and real data are conducted to evaluate the performance of the proposed approach. Globally, this approach yields very satisfactory results and slightly better than those obtained by tested literature methods, but with a substantial advantage, which is the automatic determination of endmembers number.

Application of HySpex Hyperspectral Image in Analyse Trees on Urban Areas: Tree Species Identification and Monitoring of Tree Damages

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Urban vegetation is an important part of the city. It is changing the microclimate in the city, provides a great amount of oxygen and isolates from the dust and the noise. It is also exposed to stress caused by many factors like air pollution, higher temperatures, especially in the summer, strong winds and soil salinisation during winter. Because of that it is important to develop a method to monitor the plant communities and to monitor the state of the plants.

The aim was assessment of the possibility to use hyperspectral HySpex data to analyze trees in the city. The analyses were conducted in Bialystok city in North-East Poland. The data were used to detect dominant tree species and to analyze the biophysical parameters of trees: discoloration and defoliation and to discover the changes caused by drought.

Firstly, the hyperspectral image was acquired by MGGP Aero aircraft on 3rd July and during the drought on 27th of August 2015 using HySpex scanners (with 451 spectral bands from VNIR 400-1000 nm and SWIR 930-2500 nm) with spatial resolution 0.5 in VNIR and 1 m in SWIR. In the same time field measurements were done – 233 polygons with tree species and values of discoloration and defoliation. The same trees were measured in July and August. Also was acquired reference spectrum using ASD FieldSpec 4 for object spectrally stable and flat like concrete, asphalt, sand and water. ALS data was collected from The National Geodetic and Cartographic Resources. On the basis of 12 point/meter point cloud the digital surface model was generated with cell size of 0.5 meter.

Hyspex images were ortho-rectified using flight parameters and digital surface model. Parametric geocoding was performed in PARGE software. Imagery from both VNIR and SWIR sensors was resampled to 1 m spatial resolution and combined into one cube. Atmospheric correction was done using ATCOR4 software and assessed with ground spectral reflectance measurement.

Mask for trees was created using height for the object based on ALS data and NDVI calculated from HySpex images. Based on field measurements were created spectrally pure training pixels for each species. Next, Spectral Angle Mapper classification was performed. The accuracy was tested using reference data.

The values of vegetation indices were calculated to find the correlation between image and biophysical parameters. From the image from 3rd July were acquired values of vegetation indices from the test polygons and were correlated with the values of discoloration and defoliation. Using estimated regression models the values of discoloration and defoliation were calculated for whole trees on the image. The accuracy was tested using RMSE values based on reference values of discoloration and defoliation. Using developed model the discoloration and defoliation was calculated for the image from 27th of August. The damages were verified based on field measurements. The last step was the analysis of the changes in damages between two dates.

Tree species classification of Karkonoski National Park using artificial neural networks and APEX airborne hyperspectral data

Edwin Raczko, Bogdan Zagajewski

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APEX 288 band hyperspectral airborne images and artificial neural networks were used to classify six dominant tree species of Karkonoski National Park, south-western Poland. Classified tree species were beech, spruce, pine, larch, alder and birch. APEX processing and correcting of data consisted of geometric, radiometric and atmospheric correction of raw image using DSM of KPN and MODTRAN 4 radiative transfer model. Corrected data were then delivered for further processing. APEX images were corrected by VITO.

First step was to resample all APEX scenes to one common spatial resolution of 3,35 meter. After this step a band selection was conducted. Noisy bands and bands located in water vapour absorption range were taken out of whole dataset before selection of best bands. This procedure receded 288 original bands to 222. Remaining bands went thought PCA analysis to find out bands with highest information load. Each band had its information load assessed and was later sorted based on amount of information it held. Finally 40 most informative bands were selected for final classification.

It this work we used feed forward multi-layered-perceptron with single hidden layer. To simulate such network we used R statistical program and one of R software "packages" called nnet, developed at Oxford University. This package is dedicated tool for simulation and development of ANN in R software. In this work we have used neural network consisting of 40 input neurons, 24 hidden and 6 output bands. Number of neurons in hidden layer was determined experimentally in process on iterative assessment of classification accuracy in relation to number of neurons in hidden layer. Next spectral data coming from selected 40 bands were extracted for training polygons. This dataset was later split into two parts from whom one was used in training of neural network (2/3 of all pixels) and other was used to calculate classification accuracy of trained network. This step resulted with neural network that had overall classification accuracy of 85%.

To further measure the ability of neural networks to generalize (that means the ability of neural network to classify datasets that were not used in network training) we classified APEX scenes with trained neural network. Scenes covering whole area of KPN were classified, resulting in classification image of six selected tree species with overall classification accuracy of 80%. Presented method shows the potential of ANN in field of imaging spectroscopy.

Assessment of field hyperspectral remote sensing in heavy metal contamination analyses of forests in SW Poland

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Hyperspectral remote sensing techniques allow to detect physiological and chemical properties of plants. Narrow-band techniques register detailed biophysical properties, which have direct impact on spectral responses of plants in different wavelengths (350-2500 nm). The proposed researches were conducted along the Polish part of the Beskid Żywiecki and Karkonosze National Park, mountain ranges in southern Poland. It is characterized by beech-fir forest intermixed with Norway spruce. Field campaigns were undertaken in May, June and September 2014 at 24 sites along an environmental gradient dominated by spruce (Picea abies) and beech (Fagus sylvatica). The following data were acquired from these two species:

• hyperspectral leaf characteristics (using ASD FieldSpec 3 hyperspectral spectrometer with a direct contact ASD PlantProbe + ASD LeafClip),

• bioradiometric data: surface and air temperatures (IRtec MiniRay pyrometer); content of chlorophyll, protective pigments (anthocyanins), flavonoids and nitrogencontent (Dualex Scientific+™) and chlorophyll fluorescence values (OS1p OptiSciences),

• leaves samples for measurements of heavy metals. The collected samples were cleaned and dried in laboratory conditions, then homogenized and mineralized in a microwave mineralizer (Speedwave Four Berghof, DE). Concentrations of Mn, Ni, Cu, Zn, Cd and Pb were determined.

Spectral characteristics were used to analyze spectral response curves and to calculate selected vegetation indices (mNDVI705, VOG1, SIPI, NDLI, ARI1, NDWI, NDII). Bioradiometric data and content of heavy metal were used as a reference data. The results were validated by statistical tests. In case of both species significant differences were observed in spectral characteristics of the near-infrared spectral region and in the short-wave infrared region, which is due to differences in coniferous and deciduous cell structures and water content. Overall, the measurements clearly suggest that both species were in a good condition at all sites, and there were no indications of water stress. The applied hyperspectral remote sensing tools and methods proved to be appropriate for analysis of forest tree conditions at a detailed level; the acquired data precisely depicted vegetation phenology. Detailed results will be presented during the conference.

SESSION 12 – OVERVIEW

SE - 12: URBAN 1

Time: **Wednesday, 22/Jun/2016: 4:00pm - 5:30pm**
Location: **S 30/32**

Session Chair: **Prof. Derya Maktav**, Istanbul Technical University, Turkey
Session Chair: **Dr. Roland Goetzke**, Federal Ministry of Transport and Digital Infrastructure, Germany

Extraction of Building Footprints and Classification of Basic Building Typologies using Pléiades Satellite Imagery

Assessing and analyzing the spatial pattern of different urban vegetation height classes in Berlin using a TanDEM-X DEM

Detection of Warsaw's ventilation corridors using a spatio-temporal approach

Units of Uniform Green Valuation – Integrating Biophysical and Telic Aspects of Urban Green

An unsupervised approach for building change detection in VHR remote sensing imagery

Extraction of Building Footprints and Classification of Basic Building Typologies using Pléiades Satellite Imagery

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Dynamically changing urban agglomerations in developing and emerging countries suffer from social and environmental challenges, due to a growing population and socioeconomic developments. As a basis for the planning of supply and disposal infrastructure, frequent information on qualitative and quantitative changes in settlement structure is necessary. High-resolution multispectral imagery offers the possibility to identify buildings and infrastructure on a frequent basis.

The objective of the presented study is to determine the applicability of Pléiades tri-stereoscopic imagery to identify and extract building footprints in the City of Kigali (Rwanda). For the delineation of land-use and buildings, an object based image analysis approach was chosen. It utilizes the height information from a DSM, processed from the Pléiades data, multispectral data, as well as relational properties. Since the processing of a bare earth model proved to be not possible in unplanned settlements with a high building density, topographic derivatives were applied to identify specific characteristics of different quarters. The classification of the image segments was conducted with Support Vector Machines (SVMs). After a post-processing of the resulting building footprints, a rule-based approach was applied to distinguish between basic building typologies.

The extraction of building footprints by multispectral and height information of a Pléiades satellite scene led to promising results with an accuracy of 93 % (true positive) compared with > 300 ground reference points. Unplanned squatter settlements with a high building density and relatively small share of bare ground made it difficult to delineate between single buildings and to identify the building heights. In addition, dark roof materials (mainly asbestos) of single-family detached buildings showed a spectral overlap to shadowed vegetation. Since trees often surround this building type, the positive matches were low.

The methodological approach will be transferred and validated with other case study cities: DaNang (Vietnam) and Asyut (Egypt). The results are made available to the planning administrations of all three case study cities.

Assessing and analyzing the spatial pattern of different urban vegetation height classes in Berlin using a TanDEM-X DEM

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Large-area urban ecology studies often miss information on vertical parameters of vegetation, even though they represent important constituting properties of complex urban ecosystems. Very high resolution remote sensing data offers great potential for deriving accurate height information on urban vegetation from optical sensors or active systems such as airborne Light Detection And Ranging (LiDAR) [1]. However, data availability is limited to a few cities and countries due to high data acquisition and processing costs. To alleviate these restrictions, current developments of satellite-based sensors with global homogeneous coverage may provide new opportunities for comparable assessments on small-scale objects like urban vegetation. The new globally-available Digital Elevation Model (DEM) of the spaceborne TanDEM-X mission has an unprecedented spatial resolution (12 x 12 m) that allows us to derive height information within urban areas. Initial studies produced promising results for the applicability of an intermediate DEM (iDEM) of the TanDEM-X mission for height assessments within a normalized digital surface model (nDSM) of buildings in urban areas [2]. On that positive outcome, the authors previously proved the suitability of the iDEM to derive urban vegetation heights by the use of additional vegetation information and produced a normalized canopy model (nCM) for urban- and forest-like conditions [3].

The ongoing work aims to improve the final results for Berlin within a different approach and to use the outcome for a spatial analyses. In greater detail, we answer the following questions: 1) What level of detail and goodness of information of a city-wide normalized Canopy Model (nCM) can we derive for different vegetation types (bushes, trees) using TanDEM X? 2) How are the identified vegetation types distributed across the city and across biotope types? Finally, we summarize the potentials and limitations of using such remote-sensing derived vegetation information for analyzing ecosystem service information for urban areas on a global scale.

To answer these questions, we focus on the case study of Berlin using the following datasets: a Tan-DEM-X intermediate DEM, a LiDAR digital terrain model (DTM), UltraCamX data and a biotope map. We apply a workflow based on techniques of data integration and raster algebra, including the following main steps: preprocessing of the iDEM, processing of a mask for non-vegetated areas, nCM processing, nCM classification in two vegetation groups (<5 m: bushes and shrubs; >5 m: trees) and deriving of vegetation heights per biotope. Accuracies of the nCM are assessed using a nCM.

In result, we receive an area-wide nCM and a layer for trees and shrubs/bushes including the respective height values. The accuracy assessment reveals a slight

underestimation of heights, but nevertheless a good accuracy of the produced nCM for all vegetation classes in comparison to the validation nCM, expressed in a similar mean height (TanDEM-X nCM: 10.46 m; validation nCM: 12.02 m). Similar results are shown for the nCM for trees as well (TanDEM-X nCM: 13.17 m; validation nCM: 15.40 m). Findings for the spatial distribution show a distinct pattern with increasing heights to the suburban areas. For the distribution across the biotope types we can identify a large standard deviation for 12 main types.

The derived findings offer a large asset for a comparable and most likely transferable assessment of vegetation heights in urban areas. Such information is of high importance for further assessing biomass information to analyse carbon storage in cities or to investigate the biodiversity based on heterogeneity of vegetation, for example.

[1] J. Schreyer, J. Tigges, T. Lakes, and G. Churkina, "Using Airborne LiDAR and QuickBird Data for Modelling Urban Tree Carbon Storage and Its Distribution - A Case Study of Berlin," Remote Sensing, vol. 6, pp. 10636-10655, 2014.

[2] C. Geiß, M. Wurm, M. Breunig, A. Felbier, and H. Taubenböck, "Normalization of TanDEM-X DSM Data in Urban Environments with Morphological Filters," IEEE transactions on geoscience and remote sensing, vol. 53, pp. 4348 - 4362, 2015.

[3] J. Schreyer, C. Geiß, and T. Lakes, "TanDEM-X for Large-Area Modeling of Urban Vegetation Height: Evidence from Berlin, Germany," Ieee Journal of Selected Topics in Applied Earth Observations and Remote Sensing, pp. 1939-1404, 2016, accepted for publication

Detection of Warsaw's ventilation corridors using a spatio-temporal approach

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The initial idea of air regeneration and the ventilation system in Warsaw dates back to early 19th century. The task was to aid the horizontal air exchange through the city and enable the free air flow from remote (suburb) areas to the city centre, aiding the Vistula River as a natural ventilation path. A system of corridors was designated taking into account wind direction, its topography, land use and planned urban development. So far its functionality was not the subject of a comprehensive study. As a result of proceeding expansion of many Warsaw's districts, the system was gradually diminished. Moreover, each successive development plan reduced their area. The aim of this study is to detect ventilation corridors in three epochs (between 1992 and 2010) to prove, if initial plans distributed the paths correctly and if they still play their assigned role in Warsaw's air exchange. Based on the results, their extent can change or new areas might be designated, where the local government might be forced to re-evaluate them for the citizen's comfort and urban climate.

Units of Uniform Green Valuation – Integrating Biophysical and Telic Aspects of Urban Green

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'Urban green' has recently turned into a multi-dimensional, integrative concept comprising at least the following aspects: (1) urban ecosystems and biodiversity, manifested in the physical green, i.e. vegetative environment, (2) the psychological well-being and quality-of-life including restorative effects and recovery of attention (Kaplan 1995), induced by green structures and non-monotonous urban landscapes; (3) green mobility as well as production and consumption including resource maintenance and efficiency in the sense of the 'green' city. Due to this multi-faceted significance, green policies established in European and international strategies for sustainable urban neighbourhoods under global change dynamics, with cities being likewise the main cause and the main solution driver for these sustainability challenges. Satellite-based Earth observation (EO) is a key enabler to realize area-wide mapping and monitoring of urban green, in multiple nested scales, including the strategic scale(s) of urban planning and management. Urban green can be mapped as biophysical land-cover types of specific green objects or composite structures in its formal or constitutive dimension. With respect to the functional and purpose-related dimension a park, a green belt, green infrastructure, etc. represent telic (ibid.) land-use features of city planning. Urban land cover/use classification has recently gained from the 3rd dimension (green volume) using auxiliary LiDAR data or DSM data derived from stereo imagery.

Complementary, urban green and its beneficial effect may be subjectively conceived by the citizens. In this respect, EO and spatial analysis coupled with qualitative survey-based assessments increase capacity to address specific aspects of urban green that go beyond functional land use. In previous studies we performed a detailed mapping of 29 types of green structures and derived a weighted green index, GIw . In this paper we advance the representation of the telic dimension of urban green by deriving scale-adapted, policy-relevant units, a.k.a geons. These units represent areas of uniform green valuation under certain size and homogeneity constraints. The geons representing green valuation were derived by variance-based regionalization techniques based on GIw assigned to 50x50m grid cells. They were also quality-assessed through local auto-correlation measures and field-validated by 360° photo-documentation at the intersection of the units. The average size of the generated units was 13.15 hectares, with a range between 2 and 50 hectares and a left-skewed frequency distribution.

The approach to be repeatable and transferable utilizes semi-automated OBIA class modelling for calibrated and ortho-rectified VHR data. The study was carried out in the

urban municipality of the city of Salzburg, Austria, applying a 5-year monitoring scheme in 2005, 2010 and 2015 using QuickBird, WorldView-2, and Pléiades imagery. The 2015 study was complemented by a DSM derived from Pléiades triple-stereo data for improved volumetric analysis of the respective green structure types. Currently the approach is being transferred to a similar-sized urban setting at the city of Szeged, Hungary, with a comparative EO data repository.

An unsupervised approach for building change detection in VHR remote sensing imagery

Tobias Leichtle[1,2], Christian Geiß[2], Michael Wurm[2], Klaus Martin[1], Tobia Lakes[3], Hannes Taubenböck[2]

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Continuous monitoring of changes is one of the intrinsic capabilities of remote sensing. With respect to the increasing availability of very high resolution (VHR) remote sensing imagery, the capabilities become more and more relevant for rapidly changing complex urban environments. Therefore highly automatic concepts for analysis of changes are more and more required. In addition, appropriate unsupervised change detection approaches should be capable of handling VHR remote sensing data acquired by different sensors with possibly deviating viewing geometries and varying solar illumination angles. Especially concerning the high level of detail present in VHR imagery over urban areas, object-based methods facilitate change detection in this context. Another asset of the object-based analysis is that it inherently tackles discrepancies in exact spatial, spectral and radiometric matching of VHR image pairs.

The aim of this paper is to present a novel object-based approach for unsupervised change detection with focus on individual buildings. The object-based paradigm allows the characterization of image objects by a large number of features that can be derived from the multi-temporal VHR image pairs. Modern VHR space-borne sensors like QuickBird, GeoEye, WorldView or Pléiades offer at least four multispectral image channels at spatial resolutions of approximately 50 centimeters. Different groups of features (e.g. 1st and 2nd order statistics of image channels) are compared regarding their discriminative power for building change detection. Principal component analysis is used as a feature extraction technique which compensates redundancies among features and enables proper data representation in the multi-dimensional feature space. For discrimination of changed and unchanged buildings, a comprehensive number of clustering algorithms from different methodological categories are evaluated regarding their capability of handling this two-class change detection problem. Overall, the proposed approach returned viable results which show the general suitability of clustering for object-based change detection. In detail, highest consistent accuracies were achieved using the algorithms k-means, partitioning around medoids, genetic k-means and the self-organizing map (SOM) clustering technique. We conclude that the proposed approach offers new benefits for building change detection particularly in rapidly changing urban settings, such as in Chinese cities.

SESSION 13 – OVERVIEW

SE - 13: IMAGING SPECTROSCOPY 2

Time: **Thursday, 23/Jun/2016: 11:00am - 12:30pm**
Location: **S 29/31**

Session Chair: **Prof. Luis Guanter**, Remote Sensing German Research Centre for Geosciences
(GFZ), Germany
Session Chair: **Prof. Joachim Hill**, Trier University, Germany

**Measuring and understanding the dynamics of sun-induced fluorescence -
Background on the FLEX satellite mission - the 8th Earth Explorer of ESA**

**Phenological Changes in Chlorophyll Content and Fluorescence Values in
Forest Species**

Mapping subalpine and alpine vegetation using APEX hyperspectral data

**The EnMAP-Box – advanced tools for environmental monitoring with imaging
spectroscopy data**

Preparing the future: the HYPXIM Mission

Measuring and understanding the dynamics of sun-induced fluorescence - Background on the FLEX satellite mission - the 8th Earth Explorer of ESA

Uwe Rascher[1], Luis Alonso[2], Roberto Colombo[5], Alexander Damm[4], Matthias Drusch[3], Elizabeth Middleton[6], Franco Miglietta[8], Gina Mohamed[7], Jose Moreno[2], Ladislav Nedbal[1], Francisco Pinto[1], Micol Rossini[5], Anke Schickling[1], Dirk Schüttemeyer[3]

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In November 2015, the FLuorescence EXplorer (FLEX) was selected as the 8th Earth Explorer mission of the European Space Agency (ESA). The tandem mission concept will provide measurements at a spectral and spatial resolution enabling the retrieval and interpretation of the full chlorophyll fluorescence spectrum emitted by the terrestrial vegetation.

With this contribution we will provide a mission concept overview of the scientific goals, the key objectives related to fluorescence, and the requirements guaranteeing the fitness for purpose of the resulting scientific data set. We present the mission design, which relies on a single payload, FLORIS, covering the spectral range from 500 to 780 nm. In the oxygen absorption bands its spectral resolution will be 0.3 nm with a spectral sampling interval of 0.1 nm. The swath width of the spectrometer is 150 km and the spatial resolution will be 300 x 300 m2. The satellite will fly in tandem with Sentinel-3 providing different and complementary measurements with a temporal collocation of 6 to 15 seconds.

The FLEX launch is scheduled for 2022.

Direct measurements of actual photosynthesis are of high importance as variations in photosynthesis still cause substantial uncertainties in predicting photosynthetic CO_2 uptake rates and monitoring plant stress, which are difficult to measure by reflectance based optical remote sensing techniques. Sun-induced fluorescence in contrast is directly emitted from the core of the photosynthetic apparatus and is a direct indicator for plant health and the effciency of photosynthettic energy conversion.

We present several validated maps of sun-induced fluorescence, employing the novel airborne imaging spectrometer HyPlant. HyPlant has an unprecedented spectral resolution, which allows for the first time quantifying sun-induced fluorescence emission in physical units according to the Fraunhofer Line Depth Principle that exploits solar and atmospheric absorption bands. HyPlant serves as both an airborne demonstrator for the FLEX satellite mission, and it also is valuable for strategically focused activities in the validation and interpretation of space-based fluorescence signals at the field scale. Maps of sun-induced fluorescence show a large spatial variability between different vegetation types, which complement classical remote sensing approaches. Different crop types largely differ in emitting fluorescence that additionally changes within the seasonal cycle and are related to the seasonal activation and deactivation of the photosynthetic machinery. Additionally, we show

examples how fluorescence can track acute environmental stresses and can be used to improve our forward modelling of actual photosynthesis.

Phenological Changes in Chlorophyll Content and Fluorescence Values in Forest Species

Karolina Orłowska[1,2], Adrian Ochtyra[1,2], Zbigniew Bochenek[3], Bogdan Zagajewski[1], Marlena Kycko[1]

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Variations in plant's abiotic conditions, such as accessibility to light, water or nutrients, frequently results from seasonal changes. Non-contact identification of plant stressors and condition is possible through remote sensing techniques. While plant's physiological processes are highly dependent on external factors, their alterations can be observed through variations in plant's spectral characteristics, thus enabling to observe, using remote sensing, growth and senescence.

During photosynthesis vegetation uses chlorophyll to absorb blue and red ranges of visible light and create chemical energy (Adenosine triphosphate - ATP). Two types of chlorophyll participate in this process - chlorophyll a, which is the main factor in this mechanism and chlorophyll b, which plays supporting role. High amount of chlorophyll is associated with healthy vegetation. Excess light absorbed by vegetation can be re-emitted as chlorophyll fluorescence.

The study used hyperspectral remote sensing to assess variations of the amount of photosynthetic pigments and efficiency of fluorescence photosystems in plants at the beginning, during and at the end of a phenological period. Six tree species underwent analysis: arborescent species - deciduous: hornbeam (Carpinus betulus), oak (Quercus robur), alder (Alnus glutinosa), birch (Betula pubescens) and coniferous: spruce (Picea abies) and pine (Pinus sylvestris). The study was conducted in May, July and September of 2015 in protected forest areas of north-eastern Poland - Bialowieza National Park, Borecka Wilderness and Knyszynska Wilderness. Following data were collected: spectral signatures (ASD FieldSpec 4 spectroradiometer), chlorophyll content (Dualex Scientific+ Polyphenol & Chlorophyll-Meter) and chlorophyll fluorescence in non-adapted and dark-adapted states (OS1p Chlorophyll Fluorometer).

Spectral signatures allowed calculating amount of chlorophyll a and b (RARS, REP, MTCI and others). The data were compared to chlorophyll content measured with hand-held chlorophyll-meter and fluorescence values in both states. The highest amount of chlorophyll was found in plants in July and September while the smallest at the beginning of the phenological period. The highest performance of the photosystem was observed at the end of the period (September) and the lowest at the beginning (May). All data were characteristic for healthy vegetation. The data showed significant differences between species in amount of photosynthetically active pigments. Correlation between amount of chlorophyll and efficiency of photosystems was

observed as well as between field-acquired chlorophyll amounts and those calculated from spectral signatures.

Mapping subalpine and alpine vegetation using APEX hyperspectral data

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Every plant species have a specific properties, which can be analysed using imaging spectroscopy. With hyperspectral scanners acquiring data in a large number of narrow, contiguous, spectral bands at high spatial and spectral resolution the discrimination of vegetation communities becomes possible. The aim of the study was to classify mountain vegetation communities based on APEX hyperspectral data using two methods: Support Vector Machine (SVM) in ENVI 5.3 software and Random Forest (RF) in R package. The study area covers the subalpine and alpine vegetation area of Karkonosze National Park (M&B Reserve of the UNESCO) in Poland.

The APEX data characterized by 288 bands in the wavelength range 0.4-2.5 µm were acquired on 10th September 2012 by DLR in the framework of the EUFAR HyMountEcos project. APEX images were calibrated radiometrically and corrected atmospherically at VITO. After that the assessment of bands quality was performed and were removed water vapor affected bands.

For reference patterns the vector map of non-forest vegetation distribution in 1:10 000 scale provided by the National Park were used. The object of the study were following classes of subalpine and alpine vegetation communities: spruce forest of the association Calamagrostio villosae-Piceetum, ruderal vegetation of the class Artemisietea vulgaris, meadows of the class Molinio-Arrhenatheretea, a dwarf shrub-dominated vegetation (Empetro-Vaccinietum association and Vaccinium myrtillus community), closed alpine grassland of the assoc. Carici (rigidae)-Nardetum, subalpine dwarf mountain pine shrubs (Pinetum mugo sudeticum assoc.), subalpine tall grassland of the association Crepido-Calamagrostietum villosae, tall-grass vegetation of the alliance Calamagrostion, subalpine tall-forbs of the assoc. Adenostyletum alliariae, subalpine tall-ferns of the assoc. Athyrietum distentifolii, subalpine deciduous scrub and woodland (assoc. of Salicetum lapponum and Pado-Sorbetum), mountain pine bog woods (Pino mugo-Sphagnetum assoc.), open bog vegetation of the class Oxycocco-Sphagnetea, mire vegetation of the class Scheuchzerio-Caricetea nigrae, spring vegetation of the alliance Cardamino-Montion, epilithic lichen communities of alliances Rhizocarpion alpicolae and Umbilicarion cylindricae, Calluna vulgaris comm., Peucedanum ostruthium comm., Urtica dioica comm., Deschampsia flexuosa comm., Deschampsia caespitosa comm., Molinia caerulea comm., early stages of succession, lakes and areas without vegetation.

Using created test polygons the SVM and RF classifiers were performed and then, a post classification maps of subalpine and alpine vegetation were obtained. The terrain

validation was based on field walks with a GPS receiver which allowed to create validation polygons of all of vegetation communities. Based on them the accuracy assessment was lead which allowed for obtaining classification statistics as: total, user, producer accuracies, kappa coefficient and error matrix. Next, test polygons with different number of pixels for each class were created. It allowed for testing classifications and for checking the best input dataset.

Overall accuracy and accuracies for each class showed that almost all the classes were recognised properly. Most of them were classified with more than 80% of accuracy. It shows that imaging spectroscopy and used methods are very useful for the classification of the dominant plant communities of mountain areas.

The EnMAP-Box – advanced tools for environmental monitoring with imaging spectroscopy data

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New possibilities for spaceborne environmental monitoring will arise with the launch of the spaceborne EnMAP (Environmental Monitoring and Analysis Program) imaging spectrometer. Imaging spectroscopy data of unprecedented quality will be available for multi-temporal studies, comparative analysis of biomes from arbitrary places on the Earth's surface, or synergistic approaches with data from Landsat-8, the Sentinels or similar.

Such analyses require sophisticated data processing approaches, for which the provision of latest developments from computer science in useful and standardized frameworks as well as a constant exchange and improvement of adapted methods within the imaging spectroscopy community are needed. The development of the cost-free and open-source EnMAP-Box was driven by the aim of offering latest applications to all users and a platform for the exchange of new algorithms to developers. All existing applications follow a standardized framework with pre-programmed dialogues and data I/O routines that enable external developers to easily include their own developments. After several years of development the EnMAP-Box (currently Version 2.2) includes advanced applications for classification (SVC, RF), regression (SVR, PLSR, RF), unmixing approaches (ISMA, synthetic mixture SVR) as well as a range of other algorithms specifically for imaging spectroscopy data.

The EnMAP-Box functionality is explained along a sophisticated mapping approach of gradual shrub encroachment with simulated EnMAP-data from southern Portugal. Class probabilities from an adapted support vector classification are used to map class fractions, after selecting the model that best represents mixed pixels.

The presentation ends with an outlook on the future EnMAP-Box development that includes the conversion into a Python plug-in for Q GIS. This way, an even greater amount of image processing approaches becomes available in a commonly used, open source platform for GI data processing.

Preparing the future: the HYPXIM Mission

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The HYPXIM phase A took place mid-2012 but was frozen in early 2013 for financial reasons and until the conclusions of the Scientific Prospective Seminar of CNES (SPS). In March 2014, the SPS decided to plan this mission at "middle term horizon (2023-2025)" and recommended to focus this hyperspectral mission, in priority around the needs for a few environment scientific problematic and their social benefits.

Five projects were selected in the frame of 2014-2016 TOSCA (1) program. They cover the following topics: Tropical Forest biodiversity (Hypertropik), River sedimentology (SAMSAT2), Soil degradation (Humper/MiHySpecSol), Coastal biotopes and water quality (HyperCoral) and Urban planning (UrbHyp / Hyep). Complementary projects, supported by other research programs, are focusing on industrial environments, covering industrial waste pollution and chemicals, gases and aerosols in the urban area. Each project is based on field studies, on physical modeling and on different experimental airborne campaigns, with the main aim to analyze GSD vs SNR needs.

These new requirements have been compared with those which have been drawn previously by a broad federation of the hyperspectral dual users community and clearly approved. This strengthened us around the key drivers to design a high resolution hyperspectral space mission which would assume the following characteristics: spectral domain [0.4-2.5 microns), spectral resolution (10-15 nm depending of the band), signal-to-noise ratio (depends on the range), high spatial resolution (~ 8 m), swath (> 10 km) and revisiting period (3-5 days).

To meet these requirements, two systems (a challenging class with GSD: 15m and a high performance class with GSD: 8m) were preliminary considered by CNES with industrial support from Airbus Defense & Space (ADS) and Thales Alenia Space (TAS). During phases 0 studies, our team has designed three different system scenarii which are presented in this paper:

- HYPXIM-C (C for Challenging) spatial segment is composed of 2 identical satellites orbiting on a sun-synchronous orbit at 650 km. Both accommodate the same hyperspectral payload (80 kg/110w). The instrument's TMA telescope diameter (150mm) being limited due to the small size of the platform (200kg at launch); the satellite has to "slow down" when taking hyperspectral images so as to enhance the number of collected photons in all illuminated spectral bands; this particularity reduces the number of acquisitions at 280 images/day/satellite (63000km2). Expected lifetime in orbit is 5 years, including end-of-life operations;

- HYPXIM-P (P for performance) weighs around 605 kg at launch, so is in the frame of a so called "mini-satellite" and is compatible with Soyuz or Vega. The spatial segment is composed of a solo satellite orbiting on a sun synchronous orbit at 660 km with an expected lifetime of 10 years, including end-of-life operations constraints. The payload (115 kg/ 150w) is made up with an hyperspectral sensor composed of a Korsch telescope (diameter 450 mm) and a separate panchromatic channel (PAN), using the same telescope. The number of acquisitions depends of the image quality and could vary from 270 to 400 images/day (~100000 km2)

- HYPXIM-D (D for Demonstrator) accommodates the same instrument than HYPXIM-C (80kg/110w) but its performance is like HYPXIM-P (8 m spatial resolution in Hyperspectral, 1,8m in panchromatic) for a swath of 8-10km due to his lower orbit altitude at 360 km. This particular orbit induces also a limited coverage of ~110 images/days (7000km2) due to a high "slow down" constraint but preserves the revisit capabilities of 3-5 days with 35° across-track imaging.

(1) TOSCA scientific Committee annual selection

SESSION 14 – OVERVIEW

SE - 14: THERMAL REMOTE SENSING 1

Time: **Thursday, 23/Jun/2016: 11:00am - 12:30pm**
Location: **S 30/32**

Session Chair: **Dr. Claudia Kuenzer**, German Aerospace Center (DLR), Germany
Session Chair: **Dr. Corinne Myrtha Frey**, DLR, Germany

Real Data Assessment of Thermal Sharpening Algorithms Exploiting Multitemporal Heterogeneous Data

Calibration of DART Radiative Transfer Model with Satellite Images for Simulating Albedo and Thermal Irradiance Images and 3D Radiative Budget of Urban Environment

Multitemporal Analysis of Urban Surface Temperature Dynamics in the City of Basel, Switzerland

"Spatial and temporal air temperature variability in the city. Case study in Tel-Aviv"

Real Data Assessment of Thermal Sharpening Algorithms Exploiting Multitemporal Heterogeneous Data

Paolo Addesso[1], Riccardo Garella[1], Maurizio Longo[1], <u>Rita Montone</u>[1], Rocco Restaino[1], Gemine Vivone[2]

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One of the key parameters controlling many physical, chemical and biological processes of the Earth is the Land Surface Temperature (LST). Many applications, from agriculture to climate models, require the estimation of LST image sequences from satellite Thermal InfraRed (TIR) data, with both High Spatial Resolution (HSR) and high temporal rate (htr). Unfortunately, data provided by a single satellite system are often not adequate and the fusion of information collected by multiple sensors is needed.

In fact a high frequency of observation is possible for satellites in geostationary orbit (e.g. Meteosat Second Generation - MSG). For example, the Spinning Enhanced Visible and Infrared Imager (SEVIRI) aboard MSG is a spectral radiometer that can retrieve new data every 15 minutes, thus providing 96 images per day. However the spatial resolution is about 4-6 kilometers. On the contrary, the Moderate Resolution Imaging Spectroradiometer (MODIS), operating on-board the sun-synchronous and near-polar orbiting Terra (also called EOS-AM) and Aqua (also called EOS-PM) satellites, has a spatial resolution of 1 km and collects data with time intervals greater than three hours between successive acquisitions. Similar features are shown by the Visible Infrared Imaging Radiometer Suite (VIIRS) instrument that was launched in October 2011 as part of the Suomi National Polar-orbiting Partnership and is referred to as the next-generation Earth observation instrument. Actually, VIIRS was designed to provide observation continuity with MODIS since both are whiskbroom sensors with a large number of spectral bands and large fields of regard. VIIRS is characterized by an improved spatial quality (a 375 m spatial resolution for the Imagery bands) and a slightly decreased temporal accuracy, since it observes the same point of the Earth one or two times a day.

The potential of approaches based on the combination of thermal image sequences acquired by the mentioned satellites is the focus of this work, that investigates several algorithms for implementing this methodology. We firstly examine some approaches for obtaining, at each instant, an enhanced measurement by fusing the available data by means of simple deterministic procedures. More specifically, the enhanced sequence is achieved through classical interpolation methods and by combination algorithms borrowed from the pansharpening literature. Subsequently, we assess the further application of Bayesian estimation methods to the described combined sequences; both sequential and batch processing procedures, aimed to real-time and

non-real-time applications, respectively, are employed for taking into account the temporal correlation among the consecutively acquired images.

Starting from the results obtained in previous studies with simulated data, in this paper we test the algorithms on real SEVIRI data in conjunction with both MODIS and VIIRS images. Leave-One-Out procedures are employed to validate the proposed algorithms in real scenarios, focusing on the improvements achievable by introducing data collected by the sensor mounted on the recent NPP satellite.

Calibration of DART Radiative Transfer Model with Satellite Images for Simulating Albedo and Thermal Irradiance Images and 3D Radiative Budget of Urban Environment

Lucas Landier[1], Nicolas Lauret[1], Jean-Philippe Gastellu-Etchegorry[1], Ahmad Al Bitar[1], Zina Mitraka[2], Christian Feigenwinter[3], Eberhard Parlow[3], Wieke Heldens[4], Simone Kotthaus[5], Sue Grimmond[5], Fredrik Lindberg[6], Nektarios Chrysoulakis[2]

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Remote sensing is increasingly used for managing urban environment. In this context, the H2020 project URBANFLUXES aims to improve our knowledge on urban anthropogenic heat fluxes, with the specific study of three cities: London, Basel and Heraklion. Usually, one expects to derive directly 2 major urban parameters from remote sensing: the albedo and thermal irradiance. However, the determination of these two parameters is seriously hampered by complexity of urban architecture. For example, urban reflectance and brightness temperature are far from isotropic and are spatially heterogeneous. Hence, radiative transfer models that consider the complexity of urban architecture when simulating remote sensing signals are essential tools. Even for these sophisticated models, there is a major constraint for an operational use of remote sensing: the complex 3D distribution of optical properties and temperatures in urban environments. Here, the work is conducted with the DART (Discrete Anisotropic Radiative Transfer) model. It is a comprehensive physically based 3D radiative transfer model that simulates optical signals at the entrance of imaging spectro-radiometers and LiDAR scanners on board of satellites and airplanes, as well as the 3D radiative budget, of urban and natural landscapes for any experimental (atmosphere, topography,…) and instrumental (sensor altitude, spatial resolution, UV to thermal infrared,…) configuration. Paul Sabatier University distributes free licenses for research activities.

This paper presents the calibration of DART model with high spatial resolution satellite images (Landsat 8, Sentinel 2, etc.) that are acquired in the visible (VIS) / near infrared (NIR) domain and in the thermal infrared (TIR) domain. Here, the work is conducted with an atmospherically corrected Landsat 8 image and Bale city, with its urban database. The calibration approach in the VIS/IR domain encompasses 5 steps for computing the 2D distribution (image) of urban albedo at satellite spatial resolution. (1) DART simulation of satellite image at very high spatial resolution (e.g., 50cm) per satellite spectral band. Atmosphere conditions are specific to the satellite image acquisition. (2) Spatial resampling of DART image at the coarser spatial resolution of the available satellite image, per spectral band. (3) Iterative derivation of the urban surfaces (roofs, walls, streets, vegetation,…) optical properties as derived from pixel-wise comparison of DART and satellite images, independently per spectral band. (4) Computation of the band albedo image of the city, per spectral band. (5) Computation of the image of the city albedo and VIS/NIR exitance, as an integral over all satellite

spectral bands. In order to get a time series of albedo and VIS/NIR exitance, even in the absence of satellite images, ECMWF information about local irradiance and atmosphere conditions are used. A similar approach is used for calculating the city thermal exitance using satellite images acquired in the thermal infrared domain. Finally, DART simulations that are conducted with the optical properties derived from remote sensing images give also the 3D radiative budget of the city at any date including the date of the satellite image acquisition.

Multitemporal Analysis of Urban Surface Temperature Dynamics in the City of Basel, Switzerland

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Due to predictions of the WHO, the future population worldwide will progressively change to an urban society with a majority of people living in an urban environment, especially in developed countries. In combination with future climate change and more intense heat waves, the study of thermal comfort and urban heat distribution will gain ever more importance. As a main reason for the urban heat island, the different thermal behavior of artificial urban materials (in comparison to the natural surroundings) controls the diurnal heating and reduces the nocturnal cooling. This causes enhanced heat stress during extreme heat waves and inhibits the recovery of the human circulation. Satellite data are therefore used to derive information about the surface temperature distribution as a hint for the urban heat island dynamics, using thermal infrared remote sensing. In this study, multitemporal Landsat 8 images including 19 different days (dual-path) with explicit seasonal variations during the years 2013-2015 are used to evaluate the differences in urban surface temperatures within the city of Basel, Switzerland. The calculated land surface temperatures are combined with a land use/land cover analysis derived by combining several maximum likelihood classifications with a modal classification algorithm based on pan-sharpened Landsat 8 VIS, NIR and SWIR data. The investigation was conducted across different scales (large neighborhood, medium residential districts and small housing blocks) according to the administrative units of the city. A statistical analysis of the land surface temperature reveals clear tendencies of the surface temperature distribution within the city and shows obvious connections with the land cover distribution. Thereby, regions with higher imperviousness show higher mean land surface temperature with less variance (seasonal), compared to regions with a bigger amount of natural surfaces. The small scale analysis was used for multiple linear regression models surveying the dependence of land surface temperature on the land use/land cover and showed seasonal variations with higher correlation coefficients during warmer months. The methods used present an advanced application and combination of GIS- and remote sensing data, with a large and high quality data set. The results could be useful for urban planners to reduce heat stress in specific areas, large industrial companies optimizing the energy use or individual dwellers as criteria for habitation.

"Spatial and temporal air temperature variability in the city. Case study in Tel-Aviv"

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This study applies remote sensing technology to assess and examine the spatial and temporal Brightness and Air Temperature profiles in the city of Tel-Aviv, Israel. We used satellite imagery, from the late 80s and present time, provided by Landsat 5 and 8. We determined: 1) the LST spatial distribution pattern of Tel-Aviv over the last 30 years; 2) where changes have taken place and what type of change has occurred; 3) we applied mixed regression models with daily random slopes to correlate Landsat BT data with monitored air temperature (Tair) measurements using 54 images for 1989-2015. Our analysis shows that there is fairly consistent spatial distribution of air temperature that can be related to land use/cover, with specific areas consistently warmer than others over the course of the last 30 years. Notably, the spatial distribution and horizontal variability of LST follows the physical layout of the city and can be highly variable due to the different urban morphology and surface properties. We conclude that on a diurnal scale, Air temperature is mainly due to physical properties of the various urban elements, the Sky View Factor (SVF), street geometry and anthropogenic activity, whereas on a temporal scale, its variability can be mainly attributed to land cover/use change. Finally, in spite of urban renewal projects and redevelopment of certain neighborhoods and industrial zones, the effect of high LST had not been mitigated.

SE - 15: EDUCATION & TRAINING

Time: **Thursday, 23/Jun/2016: 11:00am - 12:30pm**
Location: **S 34/35**

Session Chair: **Prof. Alexander Siegmund**, University of Education & University Heidelberg,
Germany
Session Chair: **Dr. Andreas Rienow**, University of Bonn, Germany

SAR - EDU - The online learning portal for radar remote sensing

Observe the Earth from Space in Schools – How to Use ISS Live-Imagery for Educational Purposes –

An Adaptive Learning Environment for the Application of Remote Sensing in Schools – Implementation and Evaluation Outcomes

BLIF 2.0 – An Enhanced Version of the Web-based Remote Sensing Software for Students with New Features and a New Look

Education in Remote Sensing (RS) for agriculture experts

SAR - EDU - The online learning portal for radar remote sensing

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Radar remote sensing has a long and prosper tradition in the Earth observation sciences. Past, present and future satellite missions provide vast amounts of data for the analysis of the condition and development of the Earth surface as well as natural and anthropogenic habitats. The application of radar data is rife in nearly all fields of geoscientific research, decision making and the creation of commercial geographic products.

The project SAR-EDU is a joint education initiative of the Friedrich-Schiller-University of Jena (FSU), the German Aerospace Center (DLR) and numerous partners in radar-related scientific institutions. In a previous project phase two main cornerstones for education in the field of applied radar remote sensing were established. Since 2013 the FSU is hosting a yearly summer school on applied radar remote sensing. Furthermore DLR and FSU published the SAR-EDU learning portal in late 2014 (https://saredu.dlr.de). This web portal is designed to provide access to a vast range of teaching material regarding the basics, methods and applications for radar remote sensing.

In a future project phase it is planned to equip the existing web portal with further interactive functionality in order to create a vital online community for radar remote sensing education. The teaching material is available under a creative commons license (CC BY-SA 4.0) allowing for the usage, adaption and distribution of the material.

Future visions for this education platform include the creation of Massive Open Online Courses and innovative ways to provide, share and communicate application oriented SAR knowledge.

Observe the Earth from Space – How to Use ISS Live-Imagery for Educational Purposes

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The project 'Columbus Eye – Live-Imagery from the ISS in Schools' has published a learning portal for earth observation from the ISS including a large educational portfolio (www.columbuseye.uni-bonn.de). Columbus Eye is carried out by the University of Bonn, funded by the German Aerospace Center (DLR) Space Administration and exclusive European partner of Nasa´s High Definition Earth Viewing (HDEV) experiment. Four commercial of the shelf cameras are recording the earth 24/7 and providing imposing image material of our earth. Main objective of this project is to make pupils curious about space flight and raise their attention for scientific remote sensing analysis tools using this video material. Besides a video live stream, the portal contains an archive providing spectacular footage and a school section with interactive learning materials.

The presentation gives an extensive overview about how ISS live videos are received, preprocessed (e.g. image enhancement), archived, tagged with geoinformation (WebGIS, for convenient and interactive access) and finally utilized for school lessons. Based on the ISS videos three different learning material types are developed. Worksheets represent the simplest learning material as they have a low degree of interactivity. Alongside, a short didactical commentary for teachers is included. Additionally, videos, ancillary information, maps, and instructions for interactive school experiments (for instance to demonstrate Rayleigh and Mie scattering) are provided. The observatory represents the second type of the Columbus Eye learning materials. It requires a high degree of self-organization and responsibility of the pupils. Thus, the observatory provides an opportunity for pupils to freely construct their own hypotheses based on spatial analysis tools which are similar to those provided by commercial software. Thirdly, Columbus Eye provides comprehensive learning modules with a high degree of interactivity. These, include background information, interactive animations, quizzes and various analysis tools (e.g. image correction using statistical methods). All materials and modules are developed considering the school curricular. The material can be used in lessons that are mainly based on self-reliant learning and require only minimal instruction by the teacher. The learning material covers a wide range of subjects mainly natural sciences but also applied sciences such as geography or biology. Besides the existing modules and tools, we present future and upcoming extensions of the Columbus Eye learning material which include annotating videos with additional information, the production of ISS 3D videos, and new m-learning materials integrating Augmented Reality smart phone applicable animations. Consequently, our presentation exhibits the complete processing chain from receiving and archiving ISS videos through development of current and future interactive learning modules.

An Adaptive Learning Environment for the Application of Remote Sensing in Schools – Implementation and Evaluation Outcomes

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Remote sensing offers great educational potential for geography teaching and has been integrated within Germany's national educational standards and an increasing number of federal curricula. However, the implementation of satellite images in class is still reluctant due to the thematic complexity, the lack of education material and know-how of the teachers. The project "Learning to understand the Earth – Using modern satellite image technology for earth observation for adolescents" (Space4Geography) funded by the German Aerospace Center (Space Administration) seeks encouraging, facilitating and increasing the application of satellite imagery in the classroom. This aim is achieved by the development of a web-based learning platform enabling students to work with original satellite images in various geographical topics.

The platform consists of ten learning modules dealing with key issues of geography education which have been identified in a comprehensive curricula analysis and addresses students from 5th to 13th grade. Each module presents the topic content (e.g. natural hazards, deforestation, globalisation) as well as the possibilities of remote sensing in the given field of application in a modern, intuitive and responsive design featuring interactive multimedia elements.

The integrated web-based remote sensing software "BLIF", especially developed for education and training of students, provides an educationally based toolset to import, enhance, explore and interpret satellite images. The software is fostering the competence of students to work on geographical questions without requiring prior knowledge of remote sensing. The functional range of "BLIF" can be adapted to the grade level and covers basic operations such as the creation of false-color composites as well as sophisticated supervised classification algorithms. A broad satellite data contingent of 50 RapidEye and 15 TerraSAR-X images and the possibility of importing Landsat 5-8 acquisitions ensure a diverse spectrum of investigation areas and a global coverage of the learning modules.

To support individual learning, the platform features personalised learning paths with different level contents through an adaptive web-based learning environment to fit the capabilities and preferences of the student. The learning process is recorded by knowledge tests and interactive tasks which regulate the further learning paths of the students depending on their individual skills. A successful module completion is rewarded with a personalised certificate. Registered teachers can easily manage class and student accounts and are able to supervise their students' progress.

After technical implementation of the learning contents an evaluation and testing phase ensures the platform's educational and scientific quality. This evaluation is carried out with approximately 800 test students at the "GIS-Station, Klaus Tschira Competence Centre for digital Geomedia"at the Department of Geography – Research Group for Earth Observation (rgeo) of the Heidelberg University of Education as well as at the DLR_School_Lab in Oberpfaffenhofen. Furthermore, the platform's development is scientifically accompanied by two dissertation projects, focusing on the identification of general design principles for the platform and the evaluation of different implementations of adaptive learning.

The current version of the platform will be presented, giving an impression of exemplary learning modules and discussing the results of the evaluation process.

BLIF 2.0 – An Enhanced Version of the Web-based Remote Sensing Software for Students with New Features and a New Look

Vera Fuchsgruber[1], Guido Riembauer[1], Nils Wolf[1], Alexander Siegmund[1,2]

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The application of satellite images and their analysis are represented in an increasing number of German curricula and at the national educational standards for Geography for several years now. The presence of aerial and satellite imagery in educational material, e.g. school books and satellite image atlas, has increased ever since but hardly ever surpasses a visual interpretation in an "analog" (printed) settings. Thus the full potential of the information out of remote sensing data is not exploited. Several studies prove positive effects on motivation and learning efficacy of students working with satellite images.

Since 2008, the software "BLIF" (Blickpunkt Fernerkundung) has been developed by the Research Group for Earth Observation (rgeo), Department for Geography at Heidelberg University of Education and widely evaluated. It represents a freely available remote sensing software that runs online without installation. Implemented in an educational core concept, it enables problem- and action-oriented working with original satellite images to answer geographical and environmental questions. Different levels to use "BLIF", from beginners to experts meet individual needs and prior experiences of students. The students perform main (pre-)processing steps of satellite image analysis such as histogram stretching, image enhancement, colour composites, vegetation indices, unsupervised and supervised classification and change detection.

"BLIF 2.0" has been extensively revised and technically renewed, now including additional features with regard to new data types (e.g. RapidEye and TerraSAR-X data) and remote sensing applications (e.g. threshold filtering) as well as a new, up-to-date user interface. A guided mode simplifies performing processing steps for less or unexperienced users, supplementary to the beginner level. The new layout combines responsive web design with improved usability and shorter loading times. Users can upload original satellite images to the integrated webserver and teachers have the possibility to provide images via the server for his/her class.

Additionally to Landsat 5-8 and RapidEye satellite data, version 2.0 of "BLIF" enables the upload and analysis of TerraSAR-X data. With speckle and threshold filtering algorithms, typical SAR-applications like oil spill detection or urban footprint delineation are possible. A further new feature is the band calculator: a tool for creating individual indices, extending the automated calculation of the NDVI and EVI. Also, a layer menu will be implemented providing an easy way to compare several images among one another and with OpenStreetMap-basemaps.

"BLIF 2.0" is developed further in the course of the project "Learning to understand the Earth – The application of modern satellite image technology for earth observation for students (Space4Geography)". Ten learning modules are developed, providing curricula-relevant topics as geographic questions that can be answered by processing, analysing, and assessing satellite images. "BLIF" will be integrated in the platform with a single sign-on but will also be available as standalone online-software as before.

Education in Remote Sensing (RS) for agriculture experts

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During last decades wide range of modern satellites that can be used for solving of different tasks in the agricultural domain was launched. Such satellites as Landsat-8, Proba-V, Sentinel-1 and Sentinel-2 allow to get free satellite data with spatial resolution up to 20 meters and weekly guaranteed revisit for each territory.

Thus such type of data is eventually good enough for integration in agricultural enterprises management workflow. The most challenging problem in this area is lack of RS experts within representatives of agricultural enterprises (at least at the moment). This area of knowledge requires special skills and expertise in both geospatial data processing (RS) and agricultural activities. Because of this the process of creation new remote sensing experts in this area is time consuming task (especially without highly specialized educational courses and practical trainings aimed to the most urgent topics).

Taking this into account makes high quality educational materials aimed to forming of new skills in geospatial data processing for agriculture even more important.

Ukrainian SME Integration-Plus Ltd. develops such educational and training courses. Our "GIS and satellite monitoring for agricultural enterprises" course aimed to developing of new skills in use of open-source GIS-system QGIS for solving different monitoring and satellite data processing tasks for agriculture. Within cooperation with Ukrainian World Data Center (based in Kiev Polytechnic Institute) and Vancouver Island University this course will be easy extendable and available for wide range of experts in agriculture domain and will be helpful for intensification of integration of RS data in agriculture management.

SESSION 16 – OVERVIEW

SE - 16: LAND USE & LAND COVER

Time: **Thursday, 23/Jun/2016: 2:00pm - 3:30pm**
Location: **S 29/31**

Session Chair: **Dr. Ursula Gessner**, German Aerospace Center, Germany
Session Chair: **Dr. Sebastian van der Linden**, Humboldt-Universität zu Berlin, Germany

Assessing land surface dynamics in an emerging region - Novel products for the Yellow River Basin in China

Analyses of semi arid natural vegetation in the Negev, Israel along a climate gradient using multitemporal RapidEye and WorldView2 data

Monitoring Land Use/ Land Cover Changes in Konya Closed Basin Area with the Integration of Geographic Information Systems and Remote Sensing.

Pan-European Land Cover Classification with Landsat Data – Preliminary Results

Validation of Regional Retrospective Land Cover Maps

Assessing land surface dynamics in an emerging region - Novel products for the Yellow River Basin in China

Christian Wohlfart[1], Gaohuan Liu[2], Chong Huang[2], Claudia Kuenzer[3]

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The second largest river basin in China – the Yellow River Basin (Chinese: Huang He) – is densely populated and currently one of China's most dynamic regions, with abundant natural resources and intense agricultural production. The basin is facing tremendous socio-economic pressure through population expansion, urbanization, economic growth, agricultural encroachment, and rising affluence, that have intensively shaped the landscape characteristics. Besides, recent major land polices and management plans have greatly modified the Yellow River Basin watershed during the last decade. As complex systems river basins require holistic management perspectives and for effective and sustainable river basin management reliable, comprehensive, and multi-temporal "wall-to-wall" information are essential. Despite the urgent need to better understand the prevailing land cover dynamics and underlying factors influencing the current processes, there is a surprising lack of such comprehensive land use/cover information for the entire basin. In this study, we addressed this existing research gap and derived novel land cover and land use products for the Yellow River Basin for the years 2003 and 2013 and reveal the major dynamics during this decade. For that, we used optical high-temporal medium spatial resolution MODIS MOD09Q1 time series at 250 m spatial resolution. The inherent noise was eradicated by filtering and smoothing the MODIS time series applying the adaptive Savitzky-Golay filter. Based on the processed data we computed a large variety of phenological and annual metrics. The final classifications (2003 and 2013), where we took spectral, phenological, temporal, and ancillary data into consideration, were built on a Random Forest classifier, trained by reference samples from high and very high-resolution imagery (Landsat, Quickbird, IKONOS). In total, 18 regionally adapted thematic land use/cover classes were defined, representing the basin's landscape structure. A 30 % reference data split served as basis for assessing thematic accuracy. The final classified maps for this spatially complex and heterogeneous landscape yielded an overall accuracy of 87 % and 84 % for 2003 and 2013, respectively. The results reveal major land cover and land use changes during the last decade: (1) Sprawl of urban and peri-urban areas; (2) Agricultural encroachment, particularly in arid areas; (3) Expansion of mining areas; (4) Recent land restoration and conservation programs triggered large-scale recovery of natural vegetation in degraded areas. The novel and precise land use and land cover products possess a large potential for e.g. climate, hydrology, and biodiversity modelling and can serve as valuable basis for decision making processes of river basin and regional governmental authorities.

Analyses of semi arid natural vegetation in the Negev, Israel along a climate gradient using multitemporal RapidEye and WorldView2 data

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Natural vegetation in semi-arid environment is very sensitive in relation to meteorological variability of precipitation and long term changes. Phenological shifts are connected with climate changes and have many applicative, economic, and environmental impacts. Monitoring and assessment of this vegetation type is very important as an indicator for land use changes. The availability satellite data, like Rapid Eye with high repetition time capability and high spatial resolution as well as the red edge band offers new possibilities of change detection of these land cover types, characterized by highly heterogenous distribution and typical life time cycle.

The test site is located in Shaked Park and is part of the Negev Long Term Ecological Research (LTER) site, Israel. It is a slightly hilly area and consist loessial soils. The long term annual average of precipitation of 200mm and occurs only in the winter season. The area is characterized by scattered perennial shrubs, and patches of annual plants. The soil surface is covered by biological soil crusts, lichens, and mosses, which are extremely sensitive to climate changes. The climatic changes are influencing heavily these ecosystems. Based on ground spectral measurements we could use a data set of RapidEye data for three different phenological seasons (2010/11, 2012/2013, 2013/2014) with clear differences in annual amount and distribution of the rainfull. We selected there different vegetation indices, which are best fitted to the characteristic vegetation types (crusts, annual and perennial vegetation). For each vegetation type we analysed the time series of Rapid Eye data (11- 14 scenes per season). For each index we selected the scene with highest index which is compared with the maximum of the photosynthetic activity for this vegetation type. The results were discussed in relation to the meteorological differences (temperature, precipitation, and haze). Only with the time series of the RapidEye data we could integrate the phenological aspects and define the best time windows in the different years to detect the typical life cycle of the vegetation. The mapping of the distribution of the different vegetation types needs three different index maps of different time windows. Finally we produced a colour composition from the results of this three different best fitted index/time window. To enhance the results we integrated into the RapidEye series Worldview2 data. First we proofed different fusion methods related to geometrical and spectral aspects. Finally we used the SVM for the RapidEye time series and the RE/WV time series and show the increasing of the accuracy of the results.

We could produce first time for this area a distribution map of the vegetation. Finally we can separate between "seasonal variability" and "changes". The results were integrated in a climatic gradient within the country and are the database for the

assessment and monitoring of the land use changes of natural vegetation. The developed algorithm can be transformed to long term satellite data sets from the past and continued in the future and will transformed to different scales.

Monitoring Land Use/ Land Cover Changes in Konya Closed Basin Area with the Integration of Geographic Information Systems and Remote Sensing.

Raziye Hale Topaloglu[1], Semih Ekercin[2], Elif Sertel[1]

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The detection of the multitemporal land use/cover changes occur in the Konya Closed Basin Area which is the largest basin in Turkey is essential for the sustainable management of both the basin and wetlands located in it (especial for the Salt Lake).This paper is an attempt to assess the changes in land use/cover in Konya Closed Basin Area over a 25 year period. For this purpose, 1984, 2002, and 2011 dated Landsat imageries were used as base data which were processed using ArcGIS and ERDAS software. In image processing stage, processes of image enhancement, geometric and radiometric correction, classification for visual interpretation, creating and interpretation to change analysis table (exchange matrix) were carried out.

The multitemporal changes of land use/cover were carried out by exchange matrix. Obtained accuracies were 80.14 % for 1984, 79.22 % for 2002 and 76.87 % for 2011 years. According to obtained exchange matrix, it was seen that there was increase in salt covered areas located inner part of the Salt Lake and around the Salt Lake, there was decrease water covered areas. At the same time, there was contractions in all wetlands of the Salt Lake Basin. On the other hand, it was obtained decrease in bare areas of Konya Closed Basin in big percentage. The reason of this decrease was the increase of the green vegetation in Konya Closed Basin. This paper highlights the importance of remote sensing and GIS techniques in comprehending the situation in Konya Closed Basin area.

Pan-European Land Cover Classification with Landsat Data – Preliminary Results

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Knowledge about land cover and land use (LULC) is important for advancing in earth system science, for decision making and natural resource management and for environmental monitoring and reporting obligations. Such information is particularly required in high spatial resolution (<= 30m) at national and regional scales. The data and acquisition characteristics of the Landsat and Sentinel-2 missions both following free and open data policies enable the derivation of high-resolution LULC information over large areas from optical remote sensing data.

We present first results on our efforts to derive a European land cover classification for 2014 at 30m resolution using Landsat 7 and Landsat 8 imagery with <60% cloud coverage. The results were derived based on our fully automated processing chain, TimeTools, that integrates methods from data acquisition, preprocessing, feature extraction, classification, and post classification editing. ATCOR 3 has been used for atmospherically correct all images and FMask for the calculation of cloud/cloud-shadow masks. Using the clear observations only we derived spatially contiguous spectral-temporal variability metrics (e.g. percentiles) for all layers, i.e. the surface reflectance bands, brightness temperature, and spectral indices. We also consider auxiliary layers as input features for the classification, e.g. the number of clear observations, elevation, slope, etc. A Random Forest classifier is used for the land cover classification due to its good performance in terms of computational cost and accuracy. For training the classifier we use the micro data of the LUCAS survey conducted by EUROSTATS.

The first goal of the presented study is to determine which features to use for the classification and how to best utilize the reference data. For example, using the extreme values of the spectral-temporal distributions might contain unique information for better class discrimination. On the other hand, extreme values are most likely affected by noise, such as undetected clouds or cloud shadows and can therefore negatively affect the classification. Also auxiliary layers can have positive and negative effects on the classification result. Therefore, we consider different sets of features and determine the best set for the classification. Furthermore, we investigate how to best utilize the reference data since for large areas different approaches are reasonable. First, the reference data of the whole region can be used to train a single classification model. Second, the whole region can be subdivided in sub-regions for each of which a different classification model is trained, e.g. a spatial subset of the reference samples or all reference samples but applying different weights related to the distance between a reference sample and the region to be classified.

Findings of this study contribute towards the advancement and enhancement of the TimeTools workflow, which is directed towards the provision of operational products such as land-cover maps or land change maps, being of central importance to related land monitoring and reporting services.

Validation of Regional Retrospective Land Cover Maps

Mykola Lavreniuk[1,3,4], Nataliia Kussul[1,2], Andrii Shelestov[2,1,3], Bohdan Yailymov[1], Tamara Oliinyk[1,4], Daria Yashchuk[1], Alexander Kosteckyi[1], Ruslan Basarab[1,3]

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A lot of applied satellite monitoring problems are solved using land cover and land use (LCLU) maps. That is why, it is extremely important to assess the maps' accuracy and reliability. We have built high resolution land cover maps for the whole territory of Ukraine for three decades: 1990s, 2000s and 2010s. For this, atmospherically corrected time-series of Landsat-4/5/7 images were classified using a neural network ensemble. These maps contain six main land cover classes of the European Land Use and Cover Area frame Survey (LUCAS) nomenclature: artificial surface, cropland, grassland, forest, bare land and water.

In this study, we consider three most common methods for reference data generation: pseudo-random sampling, systematic sampling on a regular 10 km grid and the approach on the base of segments. During first approach, an expert selects samples that can be interpreted by him with minimal errors. In such a case, the accuracy of the map could be overestimated. Systematic sampling approach is more objective for reference data selection, but might be more difficult and resource consuming for photo-interpretation. Taking into account the impact of human subjectivity, two independent experts participated in reference data collecting within the second approach. Within photo-interpretation, they provided a linguistic measure of reliability along with identified classes. Then a more experienced expert ("chief analyst") determined the final value of reference class for each sample based on two experts' results. This technique allows us to provide independent validation for land cover map and to compare it with the results based on random selection of reference samples. With the first pseudo-random sampling approach, the overall classification accuracy is approximately 95% for three different time periods (1990, 2000 and 2010) [1]. Within the second approach (regular grid), the overall accuracy of 84.5% was achieved. We think this result is more objective due to regularity of grid and more independent selection of validation set. Third approach on the base of segments is the most difficult to realize because of a lot of so called "unknown" polygons which should be interpreted by expert with a low probability.

For retrospective validation we don't need to collect ground truth data [2]. At the same time, using systematic sampling on a regular 10 km grid based on photo-interpretation acquired RMSE = 11.6. So, the approach on the base of segments has the closest area proportions to statistics. Regular grid sampling based on photo-interpretation has almost the same classes' distribution as a ground surveys approach.

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SESSION 17 – OVERVIEW

SE - 17: GEOLOGICAL APPLICATIONS 2

Time: **Thursday, 23/Jun/2016: 2:00pm - 3:30pm**
Location: **S 30/32**

Session Chair: **Prof. Konstantinos Nikolakopoulos**, University of Patras, Greece
Session Chair: **Dr. Christian Rogass**, Helmholtz Centre Potsdam GFZ German Research
Centre for Geosciences, Germany

Photogrammetric Study of Rock Fracture Roughness: Validation and Examples.

FOSS DATE Plug-in for DSMs Generation from Tri-stereo Optical Imagery: Development and First Results

Detection and discrimination of complex thrust and salt tectonics structures using field and remote sensing data around the Emirhan region (Sivas Basin, Turkey)

Morphological Analysis Using Modern Techniques (Tinos Island, Aegean, Greece)

Surface deformation and human-made exposure based on SAR interferometry and GIS: The case of Etna's SE slope.

Photogrammetric Study of Rock Fracture Roughness: Validation and Examples.

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Fluid flow in fractured rock media depends on fracture network properties such as fracture density, connectivity and aperture. In situ fracture aperture is mostly dependent on fracture roughness, fluid pressure and ambient stress. Roughness measurements give possibility to estimate in situ fracture aperture, which is important with regard to transport processes of e.g. water or hydrocarbons in fractured rock media.

In this study, photogrammetric method was applied down to sub millimetre scale, which is needed to describe fracture roughness. To assess the accuracy of our photogrammetric routine, we have designed the following synthetic test:

1) Two synthetic roughness models with 1000 x1000 points were generated, with prescribed values of the standard deviation, correlation length and the Hurst exponent.

2) Synthetic models were texturized by medium grain granite texture and printed on 3d printer using Color Jet Printing technology, which allows to create 3d colour printouts with a precision of 0.089mm.

3) Multiple images of the 3d printed models were captured using Nikon d800, 36 Mpx camera.

4) VisualSFM and PMVS/CMVS photogrammetric software was used to create 3d point clouds from photo sets of each printed model.

5) Using our own scripts in MATLAB, the point clouds were quantitatively compared to the input models to estimate the accuracy of the photogrammetric method. The analysis was focused on the misfit between both the point locations in the input and output models and surface characteristics such as the standard deviation, correlation length and the Hurst exponent.

The misfit of the standard deviation (sigma) and correlation lengths (lx and ly) is below 1 – 3 %. At this stage of our study, we have experienced some difficulties while estimating the Hurst exponent for the reconstructed point clouds, and further work is needed to constrain this parameter. Prior to the analysis, the surface is smoothed with a low-pass filter to eliminate point highly deviating from the reconstructed surface. Filtering shows that 5 % of the reconstructed points deviate more than 0.06 mm from the local average. After filtering, the misfit between the reconstructed and input surfaces was lower than 0.1 mm for 94 % points, maximally reaching 0.22 mm. Our results show that our photogrammetric method could be useful in imaging fracture roughness features with amplitudes exceeding 0.1 mm. We present some preliminary models of fracture morphology measured in the Karkonosze and Strzegom-Sobótka granitoid massifs, with intention to use them to study deep water circulation.

FOSS DATE Plug-in for DSMs Generation from Tri-stereo Optical Imagery: Development and First Results

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In the last years a quick increase of satellite sensors able to acquire three images for a given area, taken from the same orbit at along track forward, nadir and backward view, has been witnessed. These satellites are able to scan a target area from three different viewing directions during one pass, thus resulting in a triplet (also called tri-stereo imagery). Tri-stereo acquisition potential of new satellite systems may give important contribution in terms of Digital Surface Models (DSMs) generation considering their capability, especially over steep terrain and dense urban areas, to reveal elevation that would otherwise remain hidden in stereo acquisitions. Occlusion and mismatches can be reduced by combining the redundant information of three images.

It is in this context and following an open source vision that the present work has been conceived.

In this paper DATE (Digital Automatic Terrain Extractor) software upgrade is presented: the existing processing workflow has been extended in order to be able to exploit tri-stereo imagery for DSMs generation. DATE is a FOSS developed at the Geodesy and Geomatics Division, University of Rome "La Sapienza", and conceived as an OSSIM (Open Source Software Image Map) plug-in. It has been developed within the framework of 2014 Google Summer of Code, having as early purpose a fully automatic DSMs generation from high resolution optical satellite stereo imagery acquired by the most common sensors. DATE key features include: the epipolarity achievement in the object space (ground "quasi-epipolar" images) thanks to the images ground projection and the coarse-to-fine pyramidal scheme adopted; the use of computer vision algorithms in order to improve the processing efficiency and make the DSMs generation process fully automatic; the free and open source aspect of the developed code; the capability to handle a large amount of data, since it manages to process different images in a sequential and totally automatic way.

Multiple disparity maps obtained through the processing of the acquired images are fused in order to optimize and merging 3D information achievable from the optical triplet. In general, the use of multiple stereo-pairs and the fusion of multiple matching results is a succesful approach to increase the 3D reconstruction quality. As a matter of fact, exploiting tri-stereo derived information image matching is facilitated, since the images are more similar from a geometric point of view due to a smaller intersection angle, than in standard stereo image acquisitions. Furthermore, despite the weak stereo geometry between the single image pairs (due to the small intersection angles), geometry robustness is guaranteed by the redundancy of a third image, that lead to a more reliable photogrammetric processing.

As the first results achieved demonstrate, the workflow defined in DATE plug-in can be efficiently applied to tri-stereo images, confirming the approach validity to generate DSMs also from triplets. As a matter of fact some DMSs have been generated over Trento and Bolzano area (Northern Italy) through triplets acquired by Pléiades and ZiYuan-3 satellite sensors. The obtained DSMs have been assessed using a suited reference LiDAR DSM and also statistical parameters have been computed. These preliminary results are promising and further tests and analysis are expected for a more complete assessment of DATE application to tri-stereo optical imagery.

Detection and discrimination of complex thrust and salt tectonics structures using field and remote sensing data around the Emirhan region (Sivas Basin, Turkey)

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The Sivas Basin is one of the most well-known Tertiary Basins after Upper Cretaceous closure of northern branch of the Neotethys Ocean along the Izmir-Ankara-Erzincan Zone in Turkey's eminent geology. It is surrounded with three different crustal domains as Pontides, Anatolide-Tauride Block and Central Anatolian Crystalline Complex (CACC). Basin has a length of approximately 250 km from east to southwest and 50 km width from north to south at the widest profile. Sivas Basin also contains a lot of folds and thrusts connected with compressional regime. Therefore, tectonic evolution of the Sivas Basin has been evaluated dominantly under the effect of only thrust tectonics. This situation has led to confusion geologic assessment of the basin. Whereas, it should be also considered under the effect of the salt tectonics structures such as minibasins, welds and canopies.

Emirhan region is located in the central part of the Sivas Basin. Salt structures which developed in Mid-Oligocene in this region allow to researchers creating an analogical tool between land and undersea salt structure examples such as Gulf of Mexico. It is known that these types of geomorphological structures have also great importance for hydrocarbon exploration. Salt structures in Sivas Basin can be counted in worldwide well-known examples (e.g. La Popa Mexico, Great Kavir Iran and Axel Heiberg Canada) conveniently.

ASTER and high resolution images were used to detect both thrust and salt tectonics structures as a reliable geologic mapping tool in this research. As a geographical transition plateau between Inner and Eastern Anatolian region, Sivas Basin doesn't show hampering vegetation on geologic outcroppings for detailed hybrid remote sensing analyses. This feature also allow healthy interpretation possibilities.

The results show that both of visual interpretations and digital image processing methods spectrally provide healthy discrimination power between different rock lithologies in not covered with vegetation areas. Image fusion methods were also contributed to reveal these subtle tectonic and geomorphologic evidences that developed in and between salt and clastic lithologies. On the other hand, it should be also appraised potential value of these types of regions in terms of geological heritage.

Morphological Analysis Using Modern Techniques (Tinos Island, Aegean, Greece)

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The morphological analysis of the topographic features constitutes a basic tool prior every geological study (stratigraphy, tectonics, hydrogeology, geophysics and others) of an area. The present work focuses on the geomorphologic study of the southern part in Tinos island, using high resolution topographic data and geological data from previous studies updated with data that have been collected during a geological field trip in Tinos. It is well known that the morphology of Tinos island is strongly related to its stratigraphy, the current tectonic regime and the climate.

Concerning the methodology applied, initially the derivative maps (gradient, aspect, curvature) from the digital terrain model (1:5000) have been combined with the results from the application of a recent algorithm (Panagiotakis and Kokinou, 2014, 2015). This algorithm has been developed in order to automatically detect the geomorphologic features, with special emphasis on the faults, using elevation data. Next, the automatic detected geomorphologic structures have been compared with the data collected in the field.

The pre-mentioned methodology has been proved successful, yielding high-performance results concerning the study area. More specifically, the geomorphologic structures and especially the normal faults seem to be detected with sufficient accuracy concerning their location and orientation.

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Surface deformation and human-made exposure based on SAR interferometry and GIS: The case of Etna's SE slope.

Sofia Mitoulaki[1], Athanasia-Maria Tobolidi[1], Alessandro Bonforte[2], Francesco Gulielmino[2], Isaak Parcharidis[1], Pierre Briole[3]

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Surface deformation has become increasing concerns in modern life, affecting both population and infrastructures. It could lead to serious economic loss through damaged building, roads, gas/water pipes, utilities and telecommunication cables and in cases may indirectly threaten human live.

In general, structures are less affected by uniformly distributed ground displacements compared to differential ground motion. A uniform displacement of a region may not be even noticeable in some cases. Similarly, uniform displacement, at relative low rates, of a structure, does not damage the construction itself. It is mainly the differential displacements that might cause damages to structures. For instance, for rigid structures, if their tilt is considerable, it can result in overturning or in buildings can make the building uninhabitable. Lifelines, such as pipelines, bridges or dams are also a typical example.

During the last years, the monitoring of surface deformation at centimeter to millimeter resolution with space-borne Synthetic Aperture Radar (SAR) Interferometry reached some maturity and the technique has become a very useful remote sensing tool. Interferometric SAR (InSAR) techniques exploit the phase difference between two or more coherent complex-valued images in order to derive path-length differences in the scale of the carrier wavelength and bellow. By moving from InSAR to Persistent Scatterers Interferometry (PSI), in late nineties, obstacles related to the so-called temporal and geometric decorrelation as well as atmospheric artefacts have been overcome allowing a considerably wider spectrum of applications. This last achievement was mainly due to the plethora of SAR data available at ESA's ERS and Envisat archives.

The Tre Castagni fault system is a discontinuity developed in the southeastern slope of Mt. Etna. It is an active structure with a NNW-SSE trend crossing a densely inhabited area of Etna. The structure is characterized morphological scarps and displacement of normal and right lateral that directly could affect the building stock as well as lifelines and critical infrastructures.

The present work concerns correltion in terms of spatial and rate of surface deformation and human-made exposure in the SE flank of Etna (Tre Castagni fault area) combining PSI results plus interferometric stacking results (so point type mainly in the urban areas and continuous spatially interforomentric data for the broader area) to correlate with the human-made exposure (urban centers, lifelines etc produced in a GIS

environment) in order to contribute to risk assessment focusing mainly, based on SAR results, along the zones where abrupt differential deformation exists.

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SESSION 18 – OVERVIEW

SE - 18: SAR

Time: **Thursday, 23/Jun/2016: 2:00pm - 3:30pm**
Location: **S 34/35**

Session Chair: **Prof. Steffen Kuntz**, Airbus DS GmbH, Germany
Session Chair: **Dr. Roland Perko**, Joanneum Research, Austria

DEM-based Epipolar Rectification for Radargrammetry

Fusion of the Sentinel-1 and Sentinel-2 Data for Mapping High Resolution Land Cover Layers

Processing Concepts and Use of Multi-Temporal Sentinel-1 SAR Backscatter at Cross-Polarization for Thematic Applications

Processing and Exploration of 12-Day Repeat-Pass Coherence from Dual-Polarization Sentinel-1 C-Band Data

Multi-temporal SAR and optical satellite data fusion for land cover clasification in boreal zone

DEM-based Epipolar Rectification for Radargrammetry

Roland Perko, Karlheinz Gutjahr, Hannes Raggam, Mathias Schardt

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Radargrammetry is a well-established technique for deriving digital surface models (DSMs) from synthetic aperture radar (SAR) images [Toutin and Gray, 2000; Raggam et al., 2010]. To increase the quality of the image matching step and thus the quality of the desired DSM the epipolar constraint should be incorporated in the radargrammetric workflow [Gutjahr et al., 2014]. Here the main idea is to rectify the images onto a local tangential plane [Wang et al., 2011] which is rotated such that all stereo parallaxes are aligned in horizontal direction. Then the image matching step is reduced to a 1D search problem, i.e. a correspondence has only to be searched along an axis-parallel line. However, SAR specific geometric effects, in particular foreshortening, remain in these epipolar images, which cause major problems in image matching. This work focuses on a novel epipolar rectification method for SAR images, that rectify the images using a coarse DEM (e.g. SRTM, ASTER, ALOS-PRISM). Since the images are not rectified on a single plane but on a given surface, the images are non-linearly scaled in epipolar direction and thus the local scaling changes in range direction is reversed. In contrast to [Meric et al., 2011] who proposed a local scaling of the cross-correlation kernel for each pixel, our method is (1) much faster, as the non-linear scaling effects are removed in the rectification step and (2) more elegant, since we calculate the local scaling from a given DSM instead of trying a range of scales. The following up image matching procedure does not need to take the SAR geometry into account. Therefore, already existing very efficient implementations can be applied (e.g. CUDA-based stereo matching algorithms). The presented work describes the whole radargrammetric processing chain with emphasis on the novel DSM-based epipolar rectification. For several test sites TerraSAR-X images with varying imaging mode, including Stripmap and Staring Spotlight, are processed. The resulting DSMs are compared to reference airborne LiDAR DSMs in order to evaluation the accuracy gain of the presented methodology.

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Fusion of the Sentinel-1 and Sentinel-2 Data for Mapping High Resolution Land Cover Layers

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SAR data can bring high added value to optical data in Earth Observation applications, however, requires methodological adaptation, given considerably different nature of SAR compared to optical data. Results achieved in land cover surveys as well as the broadening and uninterrupted availability of Sentinel-1 data gives a reason for investigation of the possibilities of its usage regarded to land cover type classification.

In this presentation the contribution of Sentinel-1 and Sentinel-2 data fusion for distinguishing land cover categories is evaluated, as these categories show unique spectral as well as geometrical structural characteristics (e.g.: forest, grassland, wetland, imperviousness, water bodies).

For this purpose a study area was selected in Hungary (vicinity of Lake Tisza) having complex characteristics and fairly rich in different types of land cover categories. For mapping of HRLs we used time series of Sentinel-1 dual polarisation (VV+VH) SLC format data and Sentinel-2 optical data. Different types of spectral indices (NDVI, NDWI) were derived from radiometric calibrated optical satellite images. Polarimetric descriptors (Shannon Entropy and its I component) were generated based on the H/A/Alpha decomposition of covariance matrix for Sentinel-1 satellite images. Maximum likelihood classification was performed in case of optical data while temporal profile classification in case of SAR data.

Comparative analysis was carried out, focused on the efficiency in distinguishing land cover categories by using time series of Sentinel-1 and Sentinel-2 satellite images for classification. Accuracy assessment of the outcomes were performed by comparing of the classified image to the reference data.

Based on the preliminary results of our case study, it can be declared that SAR images have notable relevance for each layer of Copernicus HRLs. Fusion of radar and optical images can improve the quality of results in identification of HRLs. The abundance of time series of Sentinel-1 and Sentinel-2 images provides improvement of HRLs identification. It was demonstrated that the contribution of Sentinel1 time series in HRLs mapping is significant, especially in case of grassland and imperviousness.

Processing Concepts and Use of Multi-Temporal Sentinel-1 SAR Backscatter at Cross-Polarization for Thematic Applications

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The Sentinel-1 SARs are designed to achieve global coverage with short repeat intervals. Using a constellation of two satellites and operating these in a special ScanSAR mode permits providing excellent multi-temporal data. Most of the acquisitions are in dual-polarization. As a consequence multi-temporal C-band data are for the first time becoming widely available.

While multi-temporal processing techniques and retrieval concepts have been developed for co-polarization C-band data much less related experience exists for cross-polarization. In our contribution we first address processing related aspects that are particularly relevant at cross-polarization, such as the effects of the system noise and its partly mitigation using the noise characterization data provided with the Sentinel-1 data, and the combined use of co- and cross-polarization data in advanced multi-scene image filtering concepts. Then we compare the cross-polarization backscattering and parameters as polarization ratios and multi-temporal metrics, with the corresponding parameters at co-polarization and assess its potential for land applications.

Over smooth targets as water surfaces C-band backscatter at cross-polarization is very low and therefore affected by the system noise which is up to -24 dB for Sentinl-1. For Sentinel-1 information on the system noise is provided with the data and therefore a part of the effect can be mitigated. As a result higher contrast between the low backscatter areas (water, wet snow) and other areas is achieved (Fig. 1) which also improves the contrast in the often used RGB composite of the co-pol. backscatter, the cross-pol. backscatter, and the co- to cross-pol. ratio (Fig. 2).

The usefulness of cross-pol. backscatter for vegetation and in particular forest mapping is well known. Less known are the good potential of multi-temporal metrics as the temporal average (Fig. 3) and the temporal variability (Fig. 4) of cross-pol. C-band data. At cross-pol. the temporal variability of agricultural fields is even higher than at co-pol. – consequently the contrast between forest and urban areas on one hand with low values and cultivated areas on the other hand is increased as compared to co-pol. These parameters and further ones (Fig. 5) have an obvious potential to support landuse classification and mapping applications. Besides, cross-pol. C-band data of Sentinel-1 also shows also a good potential for the retrieval of bio- and geophysical parameters as indicated by the backscatter time series shown for an open area near Sodankyla, Finland (Fig. 6).

Sentinel-1 cross-polarization backscattering data are widely available and are found of comparable high quality as the corresponding co-polarization data. When using Sentinel-1 data we strongly recommend that the system noise information available in

the meta data is used to mitigate some of the limitations at very low backscatter levels which is particularly relevant at cross-polarization over smooth areas (water, smooth bare soils) and other targets with very low backscattering (such as wet snow and dry sand). Based on the findings we conclude that Sentinel-1 cross-polarization data have a good potential to improve both mapping and parameter retrieval applications. Sentinel-1 cross-polarization backscattering clearly complements Sentinel-1 co-polarization backscattering data.

Wegmüller, U., M. Santoro, and C. Werner, "Multi-temporal SAR data filtering for land applications," ESA Living Planet Symp., Edinburgh, UK, 9-13 Sep., SP-722, 2013.

Processing and Exploration of 12-Day Repeat-Pass Coherence from Dual-Polarization Sentinel-1 C-Band Data

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The interferometric coherence of short repeat-pass C-band SAR observations from the ERS-1/2 tandem mission (1995-2000) was shown to be strongly related to land cover and vegetation attributes (e.g., biomass). The exploitation of coherence for mapping land cover also represents a potential application for Sentinel-1 (S1), which acquires C-band data with repeat intervals of 12 days. However, limited knowledge exists about the usefulness of coherence in the case of 12-day repeat intervals. While the repeat interval is significantly increased compared to ERS-1/2, and hence the risk of the loss of land cover related information due to extensive temporal decorrelation (e.g., due to rain), land cover applications may benefit from i) the acquisition strategy of S1, which allows for the computation of many coherence images per year, and ii) dual-polarization observations. In this paper, we address aspects of the interferometric processing specific to S1 TOPS imagery, followed by a discussion of land cover information contained in S1 coherence based on coherence images calculated from S1 Interferometric Wide Swath TOPS data acquired over central Europe since January 2015.

The interferometric processing of S1 TOPS SLCs, which are provided per sub-swath/polarization, each containing several bursts, comprised co-registration, mosaicing of sub-swaths/bursts, differential interferogram computation, range common band filtering, coherence estimation, and geocoding based on DEM and orbit information. Co-registration accuracies of few thousands of a pixel in azimuth are required to avoid phase jumps between subsequent bursts because across each burst the doppler centroid runs through a steep spectral ramp. Such co-registration accuracy can be achieved through a combination of cross-correlation and spectral diversity methods, with the latter considering the interferometric phase in the overlap area of adjacent bursts.

The analysis of coherence images as function of land cover showed that coherence was high over built-up areas (Fig. 1). Over forests, coherence was generally low (<0.2) except for one image pair acquired in March and low density forests (according to a canopy density map), indicating some potential for distinguishing forest density classes. The temporal variability of coherence was most pronounced for croplands, with high coherence before and after the growing season when fields are bare and decreasing coherence throughout the growing season due to field work and crop growth. Cross-polarization coherence showed similar trends as co-polarization coherence, albeit at somewhat lower level. Differences between polarizations were primarily observed for crops (Fig. 1,2), indicating potential applications of cross-polarization over cropland. Regardless of land cover and across all coherence images,

spatially inconsistent temporal decorrelation could be observed, which may be explained with changing snow conditions limited to parts of the study area or local rain events (Fig. 2). Limitations due to spatially variable temporal decorrelation may be overcome by calculating multi-temporal coherence metrics (Fig. 3). The minimum coherence across all images, for instance, maximizes the contrast of built-up areas with respect to other cover types whereas the maximum coherence maximizes the contrast between forest and non-forest classes. We conclude that time series of S1 coherence carry a wealth of information on land cover. Single S1 coherence images will, however, be of limited use.

Multi-temporal SAR and optical satellite data fusion for land cover clasification in boreal zone

Oleg Antropov[1,2], Yrjö Rauste[1], Tuomas Häme[1]

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The aim of this study was to develop and implement an effective land cover classification approach for the boreal forest zone by using multi-temporal SAR and optical data.

Satellite data were collected from the area around Hyytiälä forestry station, in the centre of southern Finland. A time series of Spot 5 data takes acquired during summer season of 2015, and a time series of Sentinel-1 data spanning over a year since October 2014 were used.

A very high resolution (VHR) reference image was manually interpreted to form training and validation data. Also CORINE Land Cover 2012 data of 25m resolution produced by Finnish Environment Institute were used for cross-validation.

Time series signatures from both sensors were analysed. Multi-temporal features were extracted from both data sets and reduced using different feature selection and reduction strategies. A land cover classification with 5 classes was then performed separately on each data set and with a fused data set. Different features were tested to find an optimal combination. The classifications were performed with the nearest neighbor rule and the maximum likelihood classifier. This resulted in several classification maps which were validated with the test plots and compared against CORINE. The multi-sensor classifications with the fused data improved the results significantly. The best classification was reached with a fused data set of four SAR based features and four optical features, which gained a final accuracy of over 90%.

SE - 19: AGRICULTURE

Time: **Thursday, 23/Jun/2016: 4:00pm - 5:30pm**
Location: **S 29/31**

Session Chair: **Dr. Tobias Landmann**, International Centre for Insect Physiology and Ecology (ICIPE), Kenya
Session Chair: **Dr. Valerie Annemarie Martine Graw**, Center for Remote Sensing of Land Surfaces (ZFL), Germany

Estimating Stem Borer Density in Maize Using RapidEye Data and Generalized Linear Models

Using Historical Knowledge to Classify Crop Types: Case Study in Southwest Kansas

The use of RapidEye observations to map cropping systems in highly fragmented agro-ecological landscapes in Africa

Multi-Data Approach for Crop Classification Using Multitemporal and Dual-Polarimetric TerraSAR-X Data

Biophysical Parameters Mapping from Optical and Sar Imagery for Jecam Test Site in Ukraine

Estimating Stem Borer Density in Maize Using RapidEye Data and Generalized Linear Models

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Maize (Zea mays L.) is a major staple food crop in Africa, particularly in the eastern region of the continent. The maize growing area in Africa spans over 25 million ha and 84% of rural households in Africa cultivate maize mainly as a means to generate food and income. Average maize yields in Sub Saharan Africa are 1.4 t/ha as compared to global average of 2.5–3.9 t/ha due to biotic and abiotic constraints. Amongst the biotic production constraints in Africa, stem borers are the most injurious. In East Africa, maize yield losses due to stem borers are currently estimated between 12% to 40% of the total production. The objective of the present study was to estimate stem borer larvae density in maize fields using RapidEye reflectance data and generalized linear models (GLMs). RapidEye level 3A images (5 m spatial resolution) were captured for a test site in Kenya (Machakos) in January and in February 2015. Field data on stem borer larvae were collected from 64 fields (N = 64) following stratified random sampling. We inspected 100 plants in each field (within an area of 25 m by 25 m) for any stem borer damage signs (dead heart leaf damage, bored holes and exit holes etc.) and the number of infested maize plants was recorded. A maximum of 12 infested plants per plot were then randomly selected and dissected. The number of stem borer larvae in these 12 plants was recorded. Stem borer larva numbers were modeled using GLMs assuming Poisson (Po) and negative binomial (NB) distributions with an error log arithmetic link. Root mean square error (RMSE) and ratio prediction to deviation (RPD) statistics were employed to assess the performance of the models using a leave one-out cross-validation approach. Results showed that NB models outperformed Po ones in all study sites. RMSE and RPD ranged between 0.95 and 2.70, and between 2.39 and 6.81, respectively for NB models. Overall, all models performed similar when using the January and the February image data. We conclude that reflectance variables from RapidEye data can be used to estimate site specific stem borer larvae density. The developed models could improve decision making regarding control of maize stem borers using various integrated pest management (IPM) interventions.

Using Historical Knowledge to Classify Crop Types: Case Study in Southwest Kansas

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Purpose:

To classify the crop types using remote sensing data, the training samples of the classification year are always obtained by field survey. While, if the crop distribution map is needed at annually frequency, the ground reference data will be collected every year, which is time and labor consuming. On the other hand, some governments do not pay major attention to collect the field data, which even lead to the deficiency of ground reference data.

Apart from field survey, maybe an alternative strategy is using historical crop classification products to collect training samples. We could acquire two kinds of knowledge from historical remotely sensed crop maps: (1) remote sensing classification features of each crop and (2) crop type frequency. We could then have a simple assumption: for each pixel, if the crop frequency for one crop is higher than 50% in the historical data records, the pixel could be labeled as crop with high frequency, and then used as training samples. In this study, we tried to test the assumption and tried to acquire training samples in Kansas of 2014 using historical knowledge.

Study area and Data:

We select southwest Kansas as study area in this study because Kansas is a crop dominant state in the U.S. and the southwest Kansas contain all major crop types of the state. Data in this study can be divided into two parts: data used for obtaining training samples and data used for classify crops in 2014. Two dataset were used to acquire the training samples: multi-year MODIS data and Crop Data Layer (CDL) data. MODIS data was selected to convey the knowledge from the historical data to the classification year because MODIS data has 250m spatial resolution, good temporal resolution which is density enough to describe crop growth characters, and long data records as the data is available since 2001. The Crop Data Layer (CDL) of Kansas between 2006 and 2013 is selected as historical crop data products because this product has 30m spatial resolution, and high classification accuracy for the major crops. To classify crop types at 30m resolution in 2014, Landsat NDVI and EVI time series were employed. The classification result was validated by CDL data in 2014.

Method:

The methodology of acquiring training samples was composed of four main parts: (1) collecting 'pure MODIS pixels' using corresponding CDL data of the major crops between 2006 and 2013; (2) extracting EVI time series profiles from the 'pure' pixels; (3) collecting the 'possible training pixels' in 2014 based on the crop type frequency;

(4) comparing the EVI profile of the 'possible training pixels' in 2014 with the historical EVI profiles, and removing the mismatch pixels.

We could obtain training samples from the proposed method, and then classify crop types in 2014 using the training samples. Landsat NDVI and EVI were obtained, and Random Forest was employed to classify the crop types at 30m resolution. The CDL data in 2014 was used to verify the result.

Result and conclusion:

The results showed that the training samples obtained from historical knowledge had good potential to classify crop types at 30m resolution. The overall accuracies achieved by Landsat NDVI and EVI data were 93.29% and 94.36%, respectively. Producer's accuracy and user's accuracy of the dominant crops (corn and wheat) were higher than 90% for both NDVI and EVI results. Additionally, the crop distribution map achieved by historical data was similar to that obtaining from training data in 2014.

Generally, the method proposed in this study use historical knowledge to acquire the training samples; the crop classification type distribution could be obtained using this method when we cannot acquire ground reference data.

The use of RapidEye observations to map cropping systems in highly fragmented agro-ecological landscapes in Africa

Richard Kyalo[1], Tobias Landmann[1], Elfatih Abdel-Rahman[1,3], Sevgan Subramanian[1], Johnson Nyasani[1], Michael Thiel[2], Hossein Jozani[2]

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Information on the spatial distribution of crops and cropping systems is imperative for understanding agricultural productivity and constraints as well as food supply projections and the overall sustainability of cropping systems. In addition, spatial explicit information on the distribution of crops and cropping patterns provides a baseline dataset for better understanding of pest and disease propagation mechanisms. This study explored the utility of multi-temporal RapidEye data, acquired during two maize phenological growth stages in Kenya, to map maize growing areas under mixed cropping and monocropping. A machine learning (random forest; RF) classifier was optimized and employed within a 2-step hierarchical classification approach. Non-cropland was masked out prior to discriminating the two cropping systems. Inclusion of the most important spectral indices, selected using RF backward feature elimination, gave an overall accuracy of 85%. The results confirmed the capability of multi-temporal RapidEye data for cropping systems mapping in a complex and highly fragmented agro-ecological landscapes in Africa.

Multi-Data Approach for Crop Classification Using Multitemporal and Dual-Polarimetric TerraSAR-X Data

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Annually updated crop classification maps are highly demanded for regional agro-ecosystem modelling, crop monitoring or crop yield estimations. The remote sensing-based derivation of regional scale land use information is usually done using optical remote sensing data of moderate spatial resolution. However, spectral or radiometric characteristics of contemporary sensor systems, as well as differences in crop phenology, hamper a straight forward crop differentiation. One way to compensate for such issues is to incorporate multitemporal remote sensing data of different sensors, ancillary data or expert-knowledge. In this regard, our Multi-Data Approach (MDA) was successfully used and further developed since 2007 to generate annul land use datasets for the Rur catchment, located in the West of Germany. Nevertheless, even when using multiple optical data sources, an appropriate data coverage for optimal crop differentiation is rarely available, due to cloud coverage and large revisiting cycles. With contemporary satellite-borne SAR sensors with high revisiting rates, like the TerraSAR-X/TanDEM-X/PAZ system, such obstacles can be overcome. In this contribution we investigate which crop mapping results are achievable by applying the MDA using multitemporal SAR data only. For this study, six TerraSAR-X dual polarimetric (HH/VV) stripmap scenes from May to August 2013 were acquired for a subset of the Rur catchment (ca. 280 km²). The area is dominated by intensive agriculture where winter wheat, sugar beet, winter barley, maize, rapeseed, winter rye and potato are the main crops. For the analysis, a total of 61 fields were selected and equally divided into independent training and validation datasets. Initially each TerraSAR-X scene was classified individually for a principle classification of specific crops. Absolute backscatter values for each polarization and polarimetric features, based on the coherency matrix, were derived from each radar scene and used for classifying each scene with the best kappa approach (BKA). The key aspect of the BKA is the automatic extraction of bands that improve the kappa of the classification by automatic repetitive classification and accuracy assessment. Subsequently, expert knowledge-based production rules incorporating information on crop phenology are applied to a data stack of all classifications to extract the most valuable information for each crop and to produce the final classification. In the final classification, winter and summer crop areas were almost perfectly separated (kappa > 95% in a four class classification). However, classification results for winter wheat and winter rye had to be merged into one class. The final kappa for the classification of six crop types then was beyond 79%. In addition, the reflection of barley revealed high similarities with winter wheat/rye. The merging of all winter cereal classes increased the kappa again to 89%. Moreover, rapeseed was perfectly classified. Potatoes were satisfyingly separated from other root crops. Yet, the error matrix showed high similarities for sugar beet and

maize. Our results show that multitemporal TerraSAR-X data and the integration of knowledge on crop phenology is a promising way to obtain parcel-based crop maps, without any optical data. However, especially the distinction of maize/sugar beet and winter cereals remains challenging. Further studies should incorporate even more datasets to find the best point in time during the growing period to better separate these classes.

Biophysical Parameters Mapping from Optical and Sar Imagery for Jecam Test Site in Ukraine

Andrii Shelestov[1,2,3], Nataliia Kussul[1,2], **Mykola Lavreniuk**[1,3], Oleksandr Kostetsky[1]

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Leaf area index (LAI) and fraction of absorbed photosynthetically active radiation (FAPAR) are important land biophysical parameters that enable monitoring and quantitative assessment of vegetation state. In situ estimation of biophysical parameters is a time and resource consuming task even with the aid of automation systems. Remote sensing data from space is the only source of information in order to enable regular and consistent estimation of biophysical parameters at regional, national and global scale. Currently, coarse resolution images acquired by SPOT-VEGETATION, MODIS, and PROBA-V are used to provide regular products on biophysical parameters at global scale. Direct comparison of low resolution imagery at 1 km pixel size and point ground measurements is not possible since a 1 km pixel represents a mix of different vegetation types and states. Therefore, an up-scaling protocol using high-resolution satellite imagery should be established as proposed by the CEOS Land Product Validation sub-group. With the availability of large amount of high resolution optical images from Landsat-8, Sentinel-2, SPOT-4/5 as well as Proba-V it is possible to provide the high resolution biophysical maps in the regional level and regular basis.

During the 2013-2015 it was acquired a lot of ground observations followed the VALERI protocol in which the measurements were made for the elementary sampling units (ESUs) in the Ukrainian JECAM (Joint Experiment for Crop Assessment and Monitoring) test site. A pseudo-regular sampling was used within each ESU of approximately 20×20 m. The Digital Hemispheric Photographs (DHP) images acquired during the field campaign were processed with the CAN-EYE software to derive LAI, FAPAR and FCOVER estimations. The in situ biophysical values were used for producing LAI, FCOVER and FAPAR maps for maize and winter wheat from high resolution optical satellite images and providing cross-validation of these products. The NDVI vegetation index was used as a main variable to derive biophysical values using regression model. Obtained results are compared to available coarse resolution global biophysical products such as MODIS and SPOT-Vegetation.

One of the problems in dealing with optical images is the presence of clouds and shadows that result in having missing values in the products. In some regions period of cloudiness continue during long time of the grown season. For solving this issue, we propose an approach for estimation biophysical parameters for winter wheat and maize using multi-temporal satellite synthetic-aperture radar (SAR). The Sentinel-1A SAR satellite (launched in April 2014) is available under a "full, free and open" data license.

It allows to provide the regular high resolution biophysical maps despite of weather and cloudiness.

The validation of global low resolution products with crop specific maps showed a good agreement of the MODIS LAI products. At the same time Copernicus SPOT/VGT GEOV1 products overestimate the biophysical parameters and more close to LAI true than to LAI effective.

More detailed results based on optical and radar data we will present during the symposium.

[1] A. Shelestov, A. Kolotii, F. Camacho, S. Skakun, O. Kussul, M. Lavreniuk, and O. Kostetsky, "Mapping of biophysical parameters based on high resolution EO imagery for JECAM test site in Ukraine," in: 2015 IEEE International Geoscience and Remote Sensing Symposium (IGARSS), pp. 1733–1736, 26-31 July 2015.

SESSION 20 – OVERVIEW

SE - 20: URBAN 2

Time: **Thursday, 23/Jun/2016: 4:00pm - 5:30pm**
Location: **S 30/32**

Session Chair: **Prof. Carsten Juergens**, Ruhr-University Bochum, Germany
Session Chair: **Dr. Andreas Rienow**, University of Bonn, Germany

Transferability of the Generic and Local Ontology of Slum in Multi-Temporal Imagery, Case Study: Jakarta

Mapping Singapore by Pleiades Stereo Data: Carbon Reporting and more

Geospatial Assessment of the Impact of Urban Sprawl in Akure, Southwestern Nigeria

Mapping impervious surface change and testing imperviousness indicator for Budapest, Hungary using multi-temporal Landsat imagery

Automated Province Assignment for SPOT Satellite Images Based on Hybrid k-NN and PiP Algorithm: A Case Study of Turkey

Transferability of the Generic and Local Ontology of Slum in Multi-Temporal Imagery, Case Study: Jakarta

Jati Pratomo, Monika Kuffer, Javier Martinez Martin

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The Generic Slum Ontology (GSO) was developed to assists the detection of slums in Geographic Object-based Image Analysis (GEOBIA). However, the GSO has three main challenges. The first challenge is due to local variations of slums, slums having their own unique spatial and temporal characteristics. The second challenge is the different conceptualizations of the term slum. Therefore, the GSO has to be adapted to each local context, by combining local expert knowledge and visual interpretation of the image. The third challenge is due to the dynamics of slum settlements, which require adaptation of GSO to be able to perform properly in a multi-temporal data set. Therefore, as an effort to develop a more robust approach for slums detection, this study focuses on the study of the transferability of the GSO across different conceptualizations of slums, spatial and temporal conditions. The case of the city of Jakarta, Indonesia was selected for several reasons. Firstly, approximately 60% of its residents, mostly low-income people, are living in informal settlements called kampungs. Secondly, several local definitions of slums are used in this area. Thirdly, the existence of kampungs blurs the line between slums and non-slums.

We developed two rulesets according to the definition of slums from GSO and one based on the Local Slum Ontology (LSO) to analyse the different results of slums detection. The LSO was developed according to the definition of local experts. We applied both rulesets to multi-temporal Pleiades imagery (2012 to 2015) for two purposefully selected subsets. We selected two subsets according to their spatial pattern to ensure the rulesets can work in various conditions. In the first subset, we chose an area where the slums are easy to distinct. In the second subset, we choose an area where the slums are difficult to identify. The transferability of the slum ontology to different spatiotemporal subsets was analysed using the quantitative and qualitative approach. For quantitative approach, we employed three measurements, i.e., spatial comparison, temporal comparison and spatiotemporal pattern comparison. For qualitative approach, we compared the applicability of the ruleset, which measured by three indicators, i.e., utility, generality and reusability.

For the quantitative approach, the GSO ruleset is better performed than LSO, in term of spatial transferability. Meanwhile, for the LSO resulted in better temporal transferability than GSO. The spatial metrics comparison showed both ruleset only resulted in similarities in particular measurements and time, which indicated the GSO and LSO result in the different interpretation of the spatiotemporal change of slums. Regarding qualitative measurement, the GSO is more transferable than LSO in term of utility, according to the number of characteristics that can be used for slum extracting. Meanwhile, for the generality, the LSO is more transferable than GSO,

according to the less number of adaptation needed. In the reusability measurement, we conclude some source of uncertainties has resulted in an unexpected results. For instance, different agreement of slum boundary between local expert contributed to the low accuracy of classification quality.

This research has contributed to measuring the transferability of the GSO and LSO across different conceptualization and spatiotemporal condition. However, further research needs to be done. Firstly, development of automated tools to estimate the appropriate smoothness and compactness parameter, in multiresolution segmentation algorithm. Secondly, the application of fuzzy classification method, to overcome the uncertainties of slum concept. Lastly, the incorporation of different data, e.g., the usage of active sensor, or testing the transferability for the multi-temporal image with the different sensor.

Mapping Singapore by Pleiades Stereo Data: Carbon Reporting and more

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Singapore launched a project for the carbon accounting covering both the historic development over the last 20 years and also the development of a system for mapping and reporting in the upcoming years. In the frame of this project, land use, land use change and forestry (LULUCF) is one important issue, which is covered by remote sensing technology. While the historic mapping is performed using SPOT and LANDSAT data, the hereby presented current and future mapping is based on Pléiades stereo data.

From such Pléiades stereo pairs, several products are generated: digital surface models (DSMs), digital terrain models (DTMs), normalized digital surface models (nDSMs) and pansharpened true orthophotos. These products serve as input for land use change mapping. Change mapping is especially challenging since in urban regions skyscrapers tilt to different directions in the stereo images obscuring the neighbouring areas. Thus, for the DSM generation, a two-step interpolation scheme was developed that fill holes in the matching result. First, small areas are filled by an area-based linear interpolation. Second, larger gaps that most frequently occur due to occlusions are filled towards the ground height level. Thus, instead of artificially introducing smooth transitions, the novel method yield sharp edges in the matching result and therefore also in the final DSM. For gathering a DTM from a given DSM an improved method has been developed by the authors [1] and has been applied on the Pléiades data. This method proposes a simple filtering that can be applied to DSMs in order to extract DTMs. From both DSM and DTM, an nDSM is generated including the heights of buildings and vegetation. While building heights are irrelevant for carbon accounting, the height of the vegetation gives an important parameter of the carbon content of the vegetation. In the true orthophoto generation the previously extracted DSM is used within the ortho-rectification step together with a direct rectification procedure. In contrast to the standard indirect ortho-rectification method this processing does not yield duplication of elevated structures (e.g. buildings). This ensures that tall buildings are correctly located and not tilted and occluded areas are specifically marked as nodata (void) areas. This processing is done for both Pléiades stereo images, so occluded areas in one image can be filled by using the other. The same procedure is also applied for clouded areas. Then, the nDSM together with the spectral information of the true orthophoto are the basis for the classification of land cover and then follow-up land use categories. These categories are ultimately combined with a set of permanent carbon sample plots, which are measured in the field, to estimate the carbon stock and carbon emissions from LULUCF for the whole area of Singapore.

[1] Perko, R.; Raggam, H.; Gutjahr, K. & Schardt, M.: Advanced DTM generation from very high resolution satellite stereo images. ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 2015, II-3/W4, 165-172.

Geospatial Assessment of the Impact of Urban Sprawl in Akure, Southwestern Nigeria

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This study analyzed trend and examined the factors responsible for urban sprawl in Akure with a view to developing a user-friendly geospatial database for monitoring urban sprawl in the study area. Medium resolution satellite imageries derived from Landsat (TM) and (ETM+) comprising of four dates (1986, 1991, 2002 and 2011) were analyzed. The results revealed that built up area increased rapidly by 43.31% from 5,857.54 hectares in 1986 to 8,394.21 hectares in 1991. It further increased by 72.02% from 8,762.76 hectares to 15,073.7 hectares in 2011. Field study conducted in 2013 involved In-depth interviews and questionnaires to stakeholders and residence respectively. The analysis showed that there was a weak negative relationship ($r = -0.189$, $p < 0.01$) between gender and 'house ownership', a weak positive relationship ($r = 0.343$, $p < 0.01$) between marital status and 'house ownership' and a weak negative relationship ($r = -0.159$, $p < 0.05$) between 'number of children' and 'house ownership' in the sprawl location. Geo-spatial database modeled was tested by subjecting it to spatial analysis to show its capability to answer question pertaining to all the entities of the database. The study concluded that urban sprawl increased and if not reversed might constitute greater social and environmental problems in the future.

Mapping impervious surface change and testing imperviousness indicator for Budapest, Hungary using multi-temporal Landsat imagery

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In the context of Copernicus Land Monitoring Services five High Resolution Layers (HRL) were prepared for the 39 member and collaborating countries of European Environment Agency (EEA). HRL's are raster-based datasets with 20 m spatial resolution and provide information about five land cover types (imperviousness, forests, natural grasslands, wetlands, and permanent water bodies) for the reference year 2012.

Data and indicators on the extent and change of soil sealing or imperviousness (used as synonyms) are important for a number of highly policy-relevant issues related to biodiversity, pollution, water management, runoff and climate change. Imperviousness status layers serve information about the spatial distribution of artificially sealed areas, including the degree of impervious surface (1-100%) for each pixel. Besides the 2012 status layer two additional status layers exist for the reference years 2006 and 2009. Currently, two imperviousness change layers (aggregated to 100m) are available between reference years (2006-2009 / 2009-2012).

Imperviousness indicator is part of the EEA core set of indicators and defined as the yearly average imperviousness change between two reference years, aggregated for a certain reference unit and relative to the size of reference unit. The indicator was first published in 2015 based on the only available 2006-2009 change data, knowing that the quality of source layers introduces several uncertainties to indicator values.

The aim of this study was to test alternative methods to produce improved quality imperviousness change information and based on that calculate imperviousness indicator for a selected test area in the central region of Hungary including large part of the capital Budapest. An independent time series of imperviousness status layers were produced for the reference years 2001, 2006 and 2013 on the basis of freely available Landsat satellite imagery. Status layer for the year 2001 was produced based on a time series-analysis of multi-temporal satellite imagery collected in different seasons within the same reference year. Changes were mapped using multi-temporal NDVI subtraction and multi-temporal image classification procedure. Further status layer for the reference years 2006 and 2013 were created by adding the changed pixels to previous impervious surface status layer. The accuracy of status layers and change detection procedure were checked using large-scale aerial photos from 2000, 2005 and 2013.

Automated Province Assignment for SPOT Satellite Images Based on Hybrid k-NN and PiP Algorithm: A Case Study of Turkey

Alper Akoguz[1], Gizem Sacihan[2], Mehmet Ortak[2], Ibrahim Ozsahin[1], Elif Sertel[3]

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Geographic Information Systems help mankind on decision making from spatial analysis with using of geographic data since 1970s. In recent years, GIS has been increasingly used in several scientific areas, involving domain specific crucial problems, where Remote Sensing (RS) shall be seen the most relevant case.

One of the most important problems experienced in GIS projects (agricultural projects, etc.) is automated province assignment for the RS satellite imagery. Since it can be seen as a computational geometry problem, it can be extended to the case of multiple ground control points (GCP) and the polygon based on the corner coordinates (RS satellite images consist five pair of coordinates which are north-east, north-west, south-east, south-west and center coordinates), included in metadata file of RS satellite image with the assignment of relevant points that lie inside the polygon where it is called as Point-in-Polygon (PiP) analysis.

In this project firstly it is generated 31676 grid based GCPs with 5 km distances over Turkey caring with province tagging (with the total number of 81 cities) and for the speed-up k Nearest Neighbor (kNN) algorithm is used in order train by the centroid points of 81 cities in Turkey and the "k" of cities are selected to use in the second stage, so points of the database that do not belong to one of the selected "k" cities are eliminated and the main PiP classifier works with the selected amount of points. With this cascaded application, main classifier can work with fewer points and with using less time and memory.

Metadata of SPOT 6 & 7 constellation images are kindly provided by ITU Center for Satellite Communications and Remote Sensing of Turkey.

SESSION 21 – OVERVIEW

SE - 21: OBIA & GEOBIA

Time: **Thursday, 23/Jun/2016: 4:00pm - 5:30pm**
Location: **S 34/35**

Session Chair: **Prof. Volker Hochschild**, University of Tübingen, Germany
Session Chair: **Dr. Stefan C. Lang**, University of Salzburg, Austria

Pansharpening of VHR Satellite Images with Sliding Window Fourier Approach

Comparison of Pixel-based and Object-based Image Classification Algorithms for Improved Agriculture Land Use Mapping: A Case of Irrigated Croplands.

Understanding, Quantifying and Analyzing Dynamics in Multitemporal Remote Sensing Data - an Object-based Approach Realized in the RoiSeries IDL Library

Local Spatial Autocorrelation of Very High Resolution Imagery – Causes and Effects on Image Segmentation

Object based image analysis and detection of surface stoniness for mass-flow deposits from airborne LiDAR

Pansharpening of VHR Satellite Images with Sliding Window Fourier Approach

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Remote Sensing is the science of acquiring information about an object or phenomenon without actually being in physical contact with the object. Being done by sensing and recording reflected or emitted energy and processing, analyzing and applying that information. During the last decade, the coverage of the Earth in space, time and the electromagnetic spectrum is improving relatively fast. In the satellite sensors with different wavelengths of the electromagnetic spectrum and different points of view measurements provide complementary information. The first type of sensor gives high spatial resolution image which is named Panchromatic (PAN) image, and other type gives high spectral resolution images which are named Multispectral (MS) images.

Image fusion to combine data from several sources is becoming more important in Remote Sensing applications and one image can have both high spatial and high spectral resolution with pansharpening.The important goal of image fusion of remote sensed images (Multispectral and Panchromatic) aims to reach greater quality. Therefore, there are some developed algorithms to combine spectral and spatial information from multiple images of the same coordinate based area in pansharpening. These high quality obtained data from pansharpening can be applicable for analysing in different areas such as Remote Sensing, Geographical Information Systems, civil and millitary applications. They can be categorized into three methods: modulation-based, component substitution and Fourier-based.

Modulation-based methods such as Brovey are dealing about color transformation which modulates the high spatial resolution Pan scene, by using intensity modulation ratio. Component Substitution (CS) Method is mainly regarded pixel based method on adding some high frequency information into MS scenes with making use of a transformation, such as Principle Component Analysis (PCA), Intensity-Hue-Saturation (IHS), and Gram-Schmidt (GS).

Gram-Schmidt transformation or Gram-Schmidt orthogonalization is a sophisticated statistical coordinate transformation which is a procedure to produce a set of uncorrelated variables from a set of correlated random variables. This transformation can be applied for any number of band in fusion process. Principle Component Analysis tries to transform the multispectral data to a new domain that have perpendicular axis lines and the effect of these domain lines are determined with larger eigenvalues. In order to get higher quality image with PCA, the first principle component with histogram matched Pan scene should be swapped and applied an inverse PCA to these data set to obtain fused scene. Intensity-Hue-Saturation transform uses upscaled MS bands

and their IHS space values, then change Intensity image with histogram matched Pan image, and applying an inverse IHS to obtain fused image.

Image Fusion in Fourier domain is based on Discrete Fourier Transform (DFT) is called is called Fourier based pansharpening. As for usage both MS and Pan image is taken into 2D Fourier domain and complementary 2D FIR filters are applied in Fourier domain (LPF and HPF respectively) and finally the resulting pansharpened image was obtained with an inverse 2D DFT of the sum of the filter outputs.

In this study, there has been examined the Fourier-based pansharpening methods with different types of 2D FIR filters with not only global DFT, but also a sliding window approach of different window sizes. The performances of Fourier algorithms are compared with well known traditional methods such as Brovey, Intensity-Hue-Saturation (IHS), Principle Component Analysis (PCA) and Gram-Schmidt (GS) as mentioned above.

Experiments of pansharpening methods on MS and Pan images were performed on several interpolation methods, histogram stretching as pre-processing and non-stretching.The observation on several interpolation techniques in the pre-processing, best results could be obtained with bilinear interpolation.

By the mentioned pansharpening methods results were obtained by the quality assessment metrics which are Spectral Angle Mapper (SAM), Mean Square Error (RMSE), Root Relative Average Spectral Error (RASE), Erreur Relative Adimensionelle de Synthése (ERGAS) and it is shown that best method could be provided with FFT based methods on SPOT6 multispectral images.

Comparison of Pixel-based and Object-based Image Classification Algorithms for Improved Agriculture Land Use Mapping: A Case of Irrigated Croplands.

Amit Kumar Basukala[1], Carsten Oldenburg[1], Jürgen Schellberg[2], Gunter Menz[1,3], Olena Dubovyk[1]

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An accurate agricultural land use map is essential for many agro-environmental assessments such as irrigated water management. Enhancement of the accuracy of remote sensing based land use maps is still an ongoing process, since the development of the first classification algorithms for satellite datasets in the 1970s. With the rapid advances in computer technology, Earth Observation sensors and geographical information system, object based (OB) image analysis evolved along with the development of many machine learning algorithms. Studies showed that regardless of availability of different classification methods and algorithms no particular method has universal applicability and acceptability. This study aimed to compare different classification methods (object-based and pixel based (PB) algorithms) to contribute to improve agriculture land use mapping using a case study in the arid irrigated croplands of Khorezm in northern Uzbekistan. The comparison is made using two robust non-parametric machine learning algorithms, random forest (RF) and support vector machine (SVM), and a classical parametric algorithm, maximum likelihood (MLC) based on the freely available multitemporal Landsat 8 OLI imagery and open source software EnMAP Box (www.enmap.org), Interactive Data Language (IDL) Program (www.exelisvis.com) and ENVI. Accuracy assessment showed a significant higher overall accuracy (OA) of the machine learning OB-RF algorithm (87.69%) and OB-SVM algorithm (89.23%) over the PB-RF algorithm (78.28%), PB-SVM (79.23%) and PB- MLC (78.51%). The lowest OA occurred with OB-MLC (66.87%). The OB-RF produced visually appealing agricultural land use map of the area. The results indicate that the OB based machine learning robust non-parametric algorithms have good potential for extracting land use information from satellite imagery captured over spatially heterogeneous irrigated croplands.

Understanding, Quantifying and Analyzing Dynamics in Multitemporal Remote Sensing Data - an Object-based Approach Realized in the RoiSeries IDL Library

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Geographic data on land cover and the ecological status of biotopes is relevant for administrative tasks from local to EU level; i.e. EU reporting obligations (NATURA 2000, CAP-Cross Compliance), biotope monitoring and landscape planning of regional and local government. Within the scope of the project NATFLO (Landscape Objects from remotely sensed data for Nature Conservancy) seamless and state-wide land cover data of sub-meter resolution has been created for the federal state of Rhineland-Palatinate in Germany. This data was created within an automated object-based (GEOBIA) workflow using aerial imagery and normalized digital surface models. Special focus is placed on the object-based detection and quantification of temporal dynamics in RS data of high temporal and spatial resolution requiring the following four steps: a) Understand the different factors influencing the data via an object-based exploratory data analysis (EDA); b) Derive temporal metrics: Use the gained knowledge to quantify those factors and mathematically describe the temporal dynamics; c) Calculate these metrics per object d) Analyze the resulting metrics with e.g. machine learning algorithms to classify e.g. target indicators in compliance with accepted trans-national vocabularies (EAGLE, EUNIS). The "RoiSeries" library for IDL developed within the scope of this research aims to streamline these steps. Functionality from existing libraries for temporal analysis of e.g. RS data will be incorporated in addition to the algorithms developed in the project. Upon initialization of a RoiSeries object, an object-based extraction of spatiotemporal arrays (3D) is carried out on a temporal stack of RS data using vector geometries. Metadata and further background information is then attached to those objects including pre-classification, time of acquisition of images and events like mowing or felling. Step a) and b): For EDA a set of tools to visualize and manipulate the data is provided. Manipulations include e.g. filtering, interpolation and arithmetic operations between time series. Step c): For the operational calculation of the parameters multithreaded batch processing has been implemented. Step d): For the machine learning analysis an interface to existing python packages is currently under development. RoiSeries works on individual pixel values per object over time (spatiotemporal) as well as aggregated values (e.g. mean, GLCM) per object over time (temporal). It was tested on multitemporal RS data including TerraSAR-X. RoiSeries has been in operational use for monotemporal RS data for the state-wide calculation of textural and spectral parameters for Rhineland-Palatinate. With the current implementation the following performance was achieved while processing over 5000 DOPs with 10 000 X 10 000 pixels, each covered by on average 20 800 vector objects: For the calculation of 7 spectral (mean, standard deviation etc.) and 44 GLCM parameters (11 X 4 directions) the average processing time per DOP per core was below 10 minutes on a 3.5 GHZ

Xeon CPU. In the next step the library will be applied on Sentinel 1 and 2 data and enhancements will be made to solve additional requirements discovered within the scope of the NATFLO project.

Local Spatial Autocorrelation of Very High Resolution Imagery – Causes and Effects on Image Segmentation

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In the last decades, geographic object-based image analysis (GEOBIA) has received considerable attention for analyzing and interpreting very high resolution (VHR) remote sensing imagery. GEOBIA is devoted to developing automated methods to partition remote sensing imagery into meaningful image objects and assessing their characteristics through spatial, spectral and temporal scales, thus generating new geographic information in a GIS-ready format. With increased spatial and radiometric resolution of VHR imagery the effects of spatial autocorrelation on image segmentation is of growing importance. Thus, an exploration of the local spatial structure may help to understand the dependency and relations within the image with respect to the segmentation processes.

One approach to explore the spatial structure of an image is to make use of spatial autocorrelation statistics, to quantify the overall spatial relations of the scene, or local indicators of spatial autocorrelation, which focus on local variation of spatial dependency within the scene. Many GEOBIA studies, which dealt with image segmentation, made use of local indicators of spatial autocorrelation in order to objectively parameterize the segmentation process or to assess the accuracy of segmentation results. Only few studies, however, had a closer look to the spatial structure of the image, in order to understand the information encoded within the data and how the segmentation process could be influenced by that. In this study, we are focusing on analysis and modelling of local spatial autocorrelation of VHR imagery to assess the suitability of spatial autocorrelation indices to support the segmentation process.

We focus on Local Moran's I, Local Geary and G statistics, as inherent features of VHR imagery. These measures indicate local spatial relations within the scene, as well as outliers. Since local indicators of spatial autocorrelation reflect the relation of a pixel with his neighborhood, we use different kernel sizes when computing them, starting from direct neighborhood (3x3), in order to better represent and understand the appropriate scale of indicators that would have an impact in the segmentation process. Segmentation experiments were conducted using the multiresolution segmentation algorithm, as implemented in the eCognition software (Trimble Geospatial), on datasets of QuickBird, Pleiades, WorldView-2 and a Digital Surface Model (DSM).

The indicators reveal discontinuities in the image that are not obvious in the original scene. Since the multiresolution segmentation tends to be influenced by outliers, the usage of LISA can help identify appropriate segmentation levels. Also, local indicators of spatial autocorrelation can highlight multi-scaled features in the same segmentation level (e.g. in the case of DSM, extraction of buildings and high forest trees in the same

segmentation step). The study underlines the importance of spatial structure of VHR imagery and its effects on the segmentation process.

Object based image analysis and detection of surface stoniness for mass-flow deposits from airborne LiDAR

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Mass-flow deposits are potential construction aggregates because their sediments are moderately sorted diamictons with a fine-fraction conten less than 12%. Mass-flow morphologies occur as fields of ridges varying in elongation and in surface stoniness and boulder clusterings. Their sedimentation is linked to conduit infill sedimentation which was presumably initiated by the subglacial earthquake event(s) associated with lithospheric plate stresses and glacial isostatic adjustment.

The goal of the project was to develop a semi-automated pattern recognition approach to map mass-flow deposits as potential new aggregate materials using the airborne laser scanning (ALS) data. The study was conducted in the Kemijärvi mass-flow field, northern Finland, which has regional significance for aggregate production.

The first pattern regocnition stage involved delineation of all hummocky features with a convex topographic form from the ALS derived digital elevation model and its tilt derivative with an Object-Based Image Analysis algorithm developed in the eCognition software. Then field campaign was conducted to provide validation and calibration data for classification of the delineated hummocky landforms into mass-flow deposits and other landforms based on their surface stoniness. The presence of stones was detected from the last-return point cloud ALS data by producing a surface triangulation with a limited spatial angle on every point. The signal was then amplified by a neighborhood voting and cumulated to grid points for classifying each mass-flow polygon. The classification with logistic regression was successful (AUC= 0.85) and presents the first attempt to semi-autimatically map aggregate deposits from ALS data in Finland.

SESSION 22 – OVERVIEW

SE - 22: WETLAND MONITORING

Time: **Friday, 24/Jun/2016: 9:00am - 10:30am**
Location: **S 29/31**

Session Chair: **Prof. Gunter Menz**, Bonn University, Department of Geography, Germany
Session Chair: **Dr. Frank Thonfeld**, University of Bonn, Germany

Monitoring the spatio-temporal dynamics of a semi-arid wetland based on linear spectral unmxing and change vector analysis technique in the Ordos Larus Relictus National Nature Reserve, China

Using imaging spectroscopy to map Leaf Mass per Area in a wetland under water stress

Identification of Dynamic Cover Types in wetlands by using multitemporal cross-polarized SENTINEL-1 images

Assessing socio-economic and climate-related impacts on natural resources in rural areas of West Africa

Monitoring the spatio-temporal dynamics of a semi-arid wetland based on linear spectral unmxing and change vector analysis technique in the Ordos Larus Relictus National Nature Reserve, China

Di Liu[1,2,3], Chunxiang Cao[1,2], Gunter Menz[3,4], Olena Dubovyk[3], Wei Chen[1,2], Yunfei Xu[1,2]

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It has been an indisputable fact that a constellation of saline wetlands in northern China are subject to increasing pressures from climate change and human activities. Among these wetlands, the wetland in the Ordos Larus Relictus National Nature Reserve, which is the only reserve in the world that protects Larus relictus, is the sole wetland in the semi-arid and arid region of China on the "RAMSAR List" (the List of Wetlands of International Importance). Against a background of continued degradation, dynamic monitoring and analysis of the wetland's state and changes have an irreplaceable role in its protection and management, which have rarely been performed systematically. In this study, the dynamic change of wetland was analysed by using an integrated method, which combined linear spectral unmixing (LSU) method and change vector analysis (CVA) method. According to the methodology, three land-cover components (vegetation, soil and water) in the wetland were acquired through LSU method firstly. Then, the object object-oriented segment method was implemented to get the mean value of each component within a parcel for minimizing the variability. Finally, the temporal ecological changes in the wetland degradation were analysed by using the CVA method. Additionally, main driving factors and the impacts of wetland degradation were discussed. The results showed that the wetland is suffering continuous degradation as a result of both natural and anthropogenic effects. During 2000-2010, a dramatic change occurred in the wetland, as characterized by the rapid reduction in the water area and the significant increase in the vegetation coverage: the water surface area continued to decrease (from 9.64 km2 in 2000 to 1.68 km2 in 2010) and slightly increased in 2014 (1.74 km2, an increase of 0.06 km2 compared with 2010); these changes may, result from the extremely large amounts of rainfall in 2012 (673.1 mm) and 2013 (439.4 mm) that alleviated the water surface reduction. Meanwhile, the soil area has a sudden increase of 6.22 km2 occurred in 2000-2010. The vegetation area has had a significant upward trend since 2000 (from 5.52 km2 in 2000 to 7.88 km2 in 2014). As the dynamic change of wetland, the ecological functions are degrade, particularly the provision of breeding habitat for Larus relictus.

Using imaging spectroscopy to map Leaf Mass per Area in a wetland under water stress

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Leaf Mass per Area (LMA) is a functional plant trait that describes the thickness of plant leaves. LMA is related to relative growth rate and the investment of a plant in its leaves. Richness in resources leads in general to decreasing LMA values. Differences in LMA between species as well as among individuals of a single species can thus be used as an indicator for the response of plants to the prevailing environmental conditions. LMA is further closely linked to the spectral signal in the NIR and SWIR region and can be recovered from optical remote sensing data. In the present study we aim to test the potential of LMA for the quantification of plant responses to environmental stress in a drying wetland.

The study took place in the wetland of Las Tablas de Daimiel, a national park in Central Spain. Over the past five decades, human induced activities led to decreasing water levels in the wetland. During the most recent drought period in the 21st century, the wetland was almost dry with no surface water lamina in 2009. In 2010, heavy rainfalls and management actions allowed for a rewetting that stopped the degradation process. In a field campaign in 2009 we sampled the vegetation (species composition, structural parameters and biochemistry) and soils (standard morphological and physicochemical parameters) in 37 plots covering the northern part of the park. Simultaneously, imaging spectroscopy data were acquired with the airborne HyMap sensor operated by the German Aerospace Center. The data cover the solar electromagnetic spectrum from 455 nm to 2445 nm in 115 spectral bands with a spatial resolution of 5m x 5 m on the ground. Pre-processing of the data included radiometric, atmospheric, and geometric corrections, resulting in at-surface reflectance values. These data allowed to analyze the spatial distribution of LMA across the study site.

To quantify the relation between the spectral signal and LMA, an approach based on a statistical inversion of the PROSAIL model was employed. First, the PROSAIL was used in the forward mode to build a large lookup table for canopy reflectance signals of LMA in combination with varying mesophyll structure, leaf pigment and water concentrations, as well as LAI values. This lookup table covered LMA values from 0.002 g*cm^-2 to 0.018 g*cm^-2, meeting the expected range for the study site. Subsequently, a subset of the lookup table was used to train a random forest regression model for the retrieval of LMA values from the spectral signal. The predictive power of this model was tested using the remaining spectra of the table, resulting in R^2=0.93 and a RMSE = 0.0013 g*cm^-2.

To map the LMA distribution across the study site, the random forest model was then applied onto the image data for a pixel-wise prediction of LMA. The predicted values were well within the range of the model calibration. For plants in good vigor, the

predicted values further met the published LMA values for the respective species. The mapped LMA patterns allowed for additional analyses regarding (i) the LMA distribution across different types of wetland vegetation (ii) differences within these types that are related to resource stress, and (iii) relations between soil properties and LMA. We conclude that imaging spectroscopy is a powerful tool for LMA mapping and that the remotely sensed LMA distribution provides valuable and spatially explicit information on plant responses to environmental stress.

Identification of Dynamic Cover Types in wetlands by using multitemporal cross-polarized SENTINEL-1 images

Javier Muro[1], **Mort Canty**[4], **Allan Nielsen**[2], **Knut Conradsen**[2], **Christian Hüttich**[3], **Gunter Menz**[1], **Henning Skriver**[2], **Adrian Strauch**[1], **Frank Thonfeld**[1]

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Monitoring of long-term land-use and land-cover change patterns may be biased by seasonal changes of different surface properties (e.g. hydrology, phenology, etc.) which become even more prominent in highly dynamic ecosystems such as wetlands (Crews-Meyer, 2008; McClearly, Crews-Meyer and Young 2008; Dronova et al. 2011). These surface dynamics produce transitional states and fine-scale mixtures of classes that may hinder classifications and long-term change detection. Dronova et al. (2015) proposed the term "Dynamic Cover Types" (DCT) to refer to such areas of regimes of periodic or seasonal change. Examples of DCT in the context of wetlands would be seasonally inundated forests, temporal water bodies and waterways, or harvests of reeds and crops such as rice.

We assess the spatio-temporal extent of DCT in two study sites; The Camargue, a large coastal wetland in Southern France, and the Lagoon of Fuente de Piedra, a small wetland in Southern Spain. For that we use a multitemporal change detection procedure for polarimetric SAR imagery based on the Complex Wishart distribution developed recently by Conradsen et al (2015), (to be published) and an innovative open source software implementation which makes use of Ipython Notebooks and Docker containers (http://mortcanty.github.io/SARDocker/). The procedure carries out a series of change detection processing routines for the whole time series with a desired significance level. It uses multilook, geocoded and terrain corrected intensity images in C2 matrix. These were generated in the Sentinel Application Platform (SNAP) using 12 Sentinel-1 images (Interferometric Wide, Single Look Complex and cross-polarized) with a monthly resolution.

The methodology proposed here for change detection is relatively easy to use and utilizes only open source and free data. It enables an operational monitoring service of short-term change detection. No calibration or validation needed, only interpretation of changes using local knowledge. This has important implications for operational standardized monitoring service such as the ones developed in the –Satellite-based Wetland Observation Service (SWOS) Horizon 2020 project.

Besides its easiness to use, this methodology has other important advantages: First, the fine spatial and temporal resolutions of Sentinel-1 SAR data allow us to detect short-time changes for a complete water year regardless of the cloud cover. Second, change detection methods based on classification are affected by classification errors, whose probability of occurrence increases in dynamic and transitional landscapes (Powell et al. 2003). Our approach does not rely on classification and thus is free from

such errors. Third, DCT are complex landscapes that often give rise to unique species assemblages (Parrot & Meyer 2012; Watson et. al 2014), and knowing their spatio-temporal extent will assist in biodiversity management. Fourth, annual stable features can be identified and used for training areas, which may facilitate the classification process and improve accuracies. And fifth, estimating the spatio-temporal extent of DCT might shed some light on the wide array of options in classification methodologies available and their different results (Object vs. Pixel based, Support Vector Machines, Random Forest Classifiers, and other algorithms).

Assessing socio-economic and climate-related impacts on natural resources in rural areas of West Africa

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In many regions of Africa, high population growth rates and the related accelerating need for food, water, energy, and construction materials have led to considerable human impacts on natural resources. Agricultural areas, urban areas, and dispersed rural settlements for example are expanding at the expense of natural forest, grassland, and savanna systems. Dams, reservoirs, and irrigation systems have been constructed, affecting the availability of water and the dynamics of lakes, rivers, and wetlands, to give just few examples. In addition to these anthropogenic transformations, climate variability and change do increasingly impact natural resources, ecosystem services, and human livelihoods, particularly in the arid and semi-arid zones of Africa.

This presentation gives an overview over a range of remote sensing based studies disclosing the impacts of socio-economic development and climate variability on natural resources in West and Southern Africa. We put a particular focus on rural areas which are, despite high urbanization rates, still home to a considerable part of the African population. The presented analyses utilize satellite remote sensing time series of different sensors at high to medium spatial resolution, including Landsat, MODIS, QuickBird, ASAR, TerraSAR-X, and Sentinel-1/-2. Information on land use and land cover, tree fractional cover, waterbody dynamics, fire and vegetation phenology are derived based on methods incorporating multi-sensor, multi-temporal satellite data.

Analyses in the savanna biome of West Africa show for example a thinning of woody vegetation in intensively used cropland and rangeland areas, where the configuration of rural settlements and population density clearly influence the observed spatio-temporal patterns. Agroforestry systems, with a mixture of crops and trees, prevail in rather remote and scarcely populated regions but their spatial distribution is at the same time clearly influenced e.g. by climatic conditions. Well noticeable is also the increasing number of reservoirs in semi-arid regions of Africa which are constructed to meet the demand for drinking water, irrigation water, and proteins in form of fish for the growing population. Further studies will be presented that analyze natural wetland ecosystems based on the multi-sensor earth observation time series. Here, a special focus is put on the combined impact of climate variability and human modifications such as irrigation and dam construction on water availability and vegetation productivity. The presentation finally gives an outlook on the potential and added value of new and upcoming earth observation sensors for improving future analyses of socio-economic impacts in data scarce regions such as rural Africa.

SE - 23: THERMAL REMOTE SENSING 2

Time: **Friday, 24/Jun/2016: 9:00am - 10:30am**
Location: **S 30/32**

Session Chair: **Dr. Claudia Kuenzer**, German Aerospace Center (DLR), Germany
Session Chair: **Dr. Doris Klein**, Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Germany

Sharpening of VIIRS Thermal Images Based on Blind Filter Estimation

TIMELINE 1-km AVHRR basis parameters: reflectance, clouds, LST

The usage of thermal remote sensing in the field of crisis information - examples from the European PHAROS project and the thermal analysis of the 2014/15 Holuhraun fissure eruption

Combining Satellite, In-situ and Modeling Approaches to Reconstruct the Diurnal Sea Surface Temperature Variation in the Mediterranean Sea: Impact on the basin heat budget

Sharpening of VIIRS Thermal Images Based on Blind Filter Estimation

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Remote sensing thermal images quantify the at-sensor Brightness Temperature (BT), which is relevant for several applications, as, for example, agriculture, fire hazard monitoring and climate models. Such applications often require spatial and spectral resolutions greater than the native ones, thus motivating the use of data fusion approaches. Thermal Sharpening (TS) procedures perform a disaggregation of the pixels at a finer scale, using a companion high resolution image: e.g., the popular TsHARP algorithm employs NDVI (calculated using VNIR bands) to improve the spatial resolution of the thermal bands.

An alternative approach is viable for the Visible Infrared Imaging Radiometer Suite (VIIRS) sensor, mounted on the NPP-Suomi satellite, due to the peculiar band design in the Long Wave InfraRed (LWIR) domain. Specifically, VIIRS acquires a spectral band (named I5) characterized by a 375 m spatial resolution and a large bandwidth (10.500 – 12.400 microns). This frequency range includes the bandwidths of the M15 and M16 channels that are centered on 10.8 and 12 microns and have a 750 m spatial resolution. These characteristic allows the use of classical techniques developed in the Pansharpening field. Indeed, I5 (from now on I) plays the role of the PANchromatic (PAN) image and the couple M = {M15 – M16} corresponds to the MultiSpectral (MS) image. Products employing the M15 and M16 channels, as for example the Land Surface Temperature (LST) derived through the classical split-windows algorithm, are expected to experience a significant improvement through this enhancement procedure.

In particular, this work is focused on the application of pansharpening techniques based on the estimation of the sensor's Modulation Transfer Function (MTF) via blind image deblurring. These algorithms, that belong to the MultiResolution Analysis (MRA) family, are useful when the MTF characterization of the sensor is unreliable (e.g. due to the aging of the sensor) or not available at all. In the case of VIIRS, only a few studies have faced the characterization of the sensor MTF after the launch.

There exist three main approaches for implementing the MTF estimation procedure, each characterized by peculiar advantages and drawbacks: Filter Estimation (FE), Filter Estimation with Multi-Spectral optimization (FE MS) and Multi-Band Filter Estimation (MBFE).

We evaluated their performance on the TIR bands of VIIRS via a Reduced Resolution (RR) assessment, based on the Wald's protocol, in which the available data are spatially degraded under the hypothesis of scale invariance and the original couple of

images acts as ground truth. More in detail, the results are quantified by using several indices, such as:

- The Erreur Relative Globale Adimensionelle de Synthèse (ERGAS), that is a generalization of the Root Mean Square Error (RMSE)

- The Spectral Angle Mapper (SAM), useful to test if the relationships among the bands of M are pixel-wise preserved

- The Spatial Correlation Coefficient (SCC) computed between the details of the ground truth and the fused one, useful to assess the correct rendering of the details in the fused image

Several datasets acquired by the ReSLEHM Ground station of the University of Salerno are employed to validate the effectiveness of the tested algorithms according to these indices, allowing the separate assessment of the spatial quality and of the spectral fidelity of the final product.

TIMELINE 1-km AVHRR basis parameters: reflectance, clouds, LST

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In order to re-process DLRs 1km AVHRR data archive to different geophysical and descriptive parameters of the land surface and the atmosphere, a series of scientific data processors are being developed in the framework of the TIMELINE project. The archive of DLR ranges back to the 80ies. The data is preprocessed to L1b and harmonized for sensor effects. The detection of clouds and the processing of cloud properties are done using APOLLO_NG (APOLLO_NextGeneration), which is a probabilistic interpretation of the classical APOLLO scheme, building on its physical principles. Cloud detection is expressed as cloud probability for each satellite pixel. Furthermore, the probabilistic approach of APOLLO_NG allows the retrieval of cloud properties (optical depth, effective radius, cloud top temperature and cloud water path) along with their uncertainties. The radiative transfer solution is approximated by a two-stream approach, which allows the online calculation of the radiative transfer. Further processing of the visible bands includes the TAC (TIMELINE Atmospheric Correction) step, in which atmospheric correction is done on the basis of LUTs. BRDF is corrected using a temporal moving window approach. The thermal bands of the L1b product are used for LST estimation with SurfTemp. Its development included the selection of statistical procedures suitable for time series processing. In a round robin approach, the selected algorithms are tested on the basis of a large number of TOA radiance/LST pairs, which were generated using a radiative transfer model and the SeeBorV5 profile database. The algorithm comparison includes measures of precision, as well as the sensitivity of a method to the accuracy of its input data. Besides the implementation into SurfTemp, first cross-validation results between the AVHRR LST and MODIS LST are shown.

The usage of thermal remote sensing in the field of crisis information - examples from the European PHAROS project and the thermal analysis of the 2014/15 Holuhraun fissure eruption

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Thermal remote sensing is providing valuable information in the context of modern crisis information applications supporting disaster management. At the German Remote Sensing Data Center (DFD) of DLR, a wide variety of different sensors are used for the near-real time detection of thermal hot spots over Europe (e.g. MODIS, MSG Seviri) and also for the reprocessing of historic time series (AVHRR). In addition, high resolution satellite imagery (optical/radar) is used by the Center for Satellite Based Crisis Information (ZKI) of DFD to create rapid information (maps and services) about the geographic reference, the disaster extent, the damage assessment and in some cases also for monitoring disastreous fires over time. This paper focuses on two specific crisis related use cases of thermal remote sensing, namely the development of an early warning system for wildfires in Europe and satellite based volcano monitoring in Iceland.

The early warning system was developed in the PHAROS project (Multi-Hazard Open Platform for Satellite Based Downstream Services) which aims at the design and development of a modular and scalable multi-hazard open service platform. While this service platform is designed to be multi-hazard, the use case for the pre-operational system was restricted to the forest fire scenario. One of the main concerns is to provide fire hot spots (MODIS, MSG Seviri) as an input for the PHAROS simulation service. Furthermore, EO-based rapid mapping products are used on the short term in support of the fire fighters and in long term for mitigation and preparedness tasks.

For the volcano monitoring the Holuhraun fissure eruption in 2014/15 is described. This eruption was one of the largest volcanic events in modern Icelandic history. It is a dike intrusion, that originated from the Islandic Bardarbunga Volcano. Landsat-8 night time acquisitions, MODIS imagery and data from DLR's TET-1 (Technology Experiment Carrier) are analysed to measure the temperature of the lava over time to show the temporal evolution of such a potentially catastrophic fissure eruption.

Upcoming satellite missions like the European Copernicus Sentinel-3 will provide valuable information for both use cases, for forest fire and volcano monitoring.

Combining Satellite, In-situ and Modeling Approaches to Reconstruct the Diurnal Sea Surface Temperature Variation in the Mediterranean Sea: Impact on the basin heat budget

Salvatore Marullo[1], Peter Minnett[2], Rosalia Santoleri[3], Vincenzo Artale[1]

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Several studies have focused on the role of the diurnal Sea Surface Temperature (SST) cycle on air-sea feedbacks and its influence on climatology energy and water budgets at global scale (e.g. Clayson & Bogdanoff, 2013). The Mediterranean Sea is the largest semi-enclosed sea on Earth, a basin where a wide range of oceanic processes and interactions of global interest occur. Even more importantly, the Mediterranean Sea is a laboratory basin for the investigation of processes of global importance, being much more amenable to observational surveys because of its location at mid-latitude and its dimensions. Since the Mediterranean Sea is also one of the world ocean areas where the diurnal warming is more intense and frequent (Gentemann al., 2008), it represents an unique opportunity to evaluate the impact of resolving the SST diurnal cycle, including extreme events, on its heat budget and to test diurnal warming models.

This work focuses on the SST diurnal cycle reconstruction by combining numerical model analyses and satellite measurements (Marullo et al. 2014) to evaluate the impact of resolving the SST diurnal cycle, including extreme events, on the heat budget of the Mediterranean Sea over an entire annual cycle. For the year 2013, the mean annual difference in the heat budget derived using SST's with and without diurnal variations is -4 Wm-2 with a peak of -9 Wm-2 in July. The order of magnitude of these differences is not negligible considering that the Mediterranean Sea is a concentration basin where evaporation exceeds the sum of precipitations and river runoff. This deficit is compensated by water exchanges at the Strait of Gibraltar where fresher Atlantic enters near the surface and saltier water, of Levantine origin, exits at intermediate depths. In terms of heat budget this implies a mean heat loss of -6±3 Wm-2 from the ocean to the atmosphere. This indicates that even small errors in the determination of the SST, including neglecting the diurnal cycle, can modify the estimate of the Mediterranean Sea heat budget changing its sign with implications on water budget at the Strait of Gibraltar and on the global thermohaline circulation.

From March 27th to April 15th the oceanographic cruise COSIMO 2015 took place on the R/V Minerva Uno in the Mediterranean Sea to further validate the reconstruction method and investigate the diurnal evolution of the ocean water temperature profile from the ocean skin to the foundation temperature depth. Measurements were taken using CTD casts, M-AERI measurements and near-surface thermistors instruments along several transects in an area that includes the Ionian and the Adriatic Seas. Meteorological parameters including direct radiative air-sea fluxes were also recorded

continuously during the whole cruise. A 37 h experiment at a fixed position was done from April 8th 22:00 UTC to April 10th at 11:00 UTC. A preliminary analysis of the data shows an reassuring agreement between measured and modeled temperatures, simulated using locally recorded atmospheric forcing, and clearly describes the attenuation of the temperature wave with depth.

SESSION 24 – OVERVIEW

SE - 24: TEMPORAL ANALYSIS

Time: **Friday, 24/Jun/2016: 11:00am - 12:30pm**
Location: **S 29/31**

Session Chair: **Prof. Eberhard Parlow**, University Basel, Switzerland
Session Chair: **Prof. Mattia Crespi**, University of Rome "La Sapienza", Italy

Gap Filling of RapidEye Time Series with Landsat 8 Using the Ehlers Fusion

Spline-Based Modelling of Vegetation Index Time Series to Characterise Land Use Systems in the Tarim Basin

Using the full depth of the Landsat archive to analyze post-war forest cover dynamics in Angola

Monitoring Land Cover Dynamics at Varying Spatial Scales: High to Very High Resolution Optical Imagery

Land Surface Dynamics in Ukraine from 1982 to 2013: Towards an Improved Environmental Understanding Based on Multi-source Remote Sensing Time-series Datasets

Gap Filling of RapidEye Time Series with Landsat 8 Using the Ehlers Fusion

André Baldauf, Stefan Conrads, Kevin Fries, Johanna Moellmann, Jannes Schofeld,
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Time series (TS) analysis of satellite data can be used for various challenging tasks such as agricultural classification and monitoring. However, a lack of data availability to create seamless TS can be caused by several reasons such as missing imagery on a specific date, high cloud coverage or a small budget. Combining satellite data from different sensors could be a solution to fill existing gaps in TS by using free data from Landsat or Sentinel satellites. In our paper, we present the results of our investigation if classifications of RapidEye (RE) TS fused with Landsat 8 (L8) data can improve the classification of RE-TS containing temporal gaps. For an agricultural study site in North Israel close to Haifa bay (N32°47'; E35°04'), a region with a large number of fields with many different crops and a temporally very dense RE-TS, data gaps were artificially created and then filled with fused L8 images using the Ehlers Fusion. The Ehlers Fusion was developed especially for a spectral characteristics preserving image merging. It is based on an IHS (intensity, hue, saturation) transform coupled with a Fourier domain filtering. A high-resolution image (RE, 5 m GSD) has to sharpen the multispectral image (L8, 30 m GSD) without adding new grey level information to its spectral components. The selected data include imagery in the period of October 2014 to February 2015. Close acquisition dates were selected for both, RE and L8: RE_24-10-14 / L8_27-10-14, RE_01-01-15 / L8_30-12-14, RE_01-02-15 / L8_31-01-15. A field campaign was conducted in March 2015 to create training and validation data. In order to apply the Ehlers Fusion, an artificial RE-PAN (RE_01-02-15) image was created (as spatial information) to fuse it with the L8_30-12-14 image (as spectral information) for filling the gap in the RE-TS. It was validated firstly by calculating the spectral angle between the original and the fused L8 image, and secondly by comparative classifications of different TS constellations using Random Forest algorithm (RF). Validation of the fusion led to a mean spectral angle of approximately 0.086 RAD (4.927°) for the L8 fusion using an artificial RE-PAN image. That can be considered as a very good result, in particular when considering that the spatial information of the artificial RE-PAN image has a temporal off-set of 33 days. Additionally, a visual interpretation by expert knowledge confirmed the good results. In order to validate the different TS constellations by RF classification, overall accuracies (OAA) were calculated. The result of the gap filling with fused L8_31-12-14 data (91.27%) is nearly as good as the OAA of the pure RE-TS (consisting of all RE images) without a gap (92.53%). Classification of the RE-TS with a gap (RE_24-10-14, RE_01-02-15) shows an OAA of 88.01%. Furthermore producer and user accuracies were compared. The results indicated that it is useful to produce fused L8 imagery with an artificial RE-PAN to replace missing images in a TS.

Spline-Based Modelling of Vegetation Index Time Series to Characterise Land Use Systems in the Tarim Basin

Sebastian Mader, Guilin Liu, Joachim Hill

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The oases in the catchment area of the river Tarim in northwest China experience major land use changes and transitions. Population growth and improving socioeconomic conditions have led to a rapid expansion of cultivated land, along with an intensification of agricultural practices. To a large part, agricultural and even previously unused land is transformed into irrigated cotton monoculture. Precipitation being sparse, the Tarim and its tributaries, which are fed by melting snow and glaciers of the mountain ranges surrounding the Tarim basin, remain as the only water supply for the intensive agriculture. The increasingly high demand for irrigation water in combination with strong evapotranspiration has led to a number of environmental problems, such as water shortage, salinisation of soils, and decreasing water quality in the river Tarim. Large scale cotton monocultures in state-owned farms concur with the traditional land use practices of the native population for the scarce water resources. Traditional land use practices rely on a system of mixed cropping with fruit trees and winter wheat or maize growing simultaneously on the same piece of land.

Today, there is a clear trade-off between generating income from irrigation agriculture, mainly cotton, at the cost of Ecosystem Functions (ESF) and Ecosystem Services (ESS) provided by the natural ecosystems. The present study was conducted within the project SuMaRiO (Sustainable Management of River Oases along the Tarim River), sponsored by the German Federal Ministry of Education and Research as part of their research program on "Sustainable Land Management"

We developed a new method based on B-spline analysis to derive phenological parameters from a MODIS enhanced vegetation index (EVI) time series at 250m resolution. Based on these metrics it has been possible to distinguish between different land use systems and intensities in the oases along the Tarim river. For example, mixed cropping systems could be distinguished from cotton monoculture by a considerably earlier start of the growing season. This was attributed to the fact that tree cultures have access to groundwater and do not depend as strongly on irrigation as cotton, whereas the start of growth of cotton is well defined in time due to the close relation of growth to irrigation and fertilisation. The results were verified using ground-based land cover samples.

The new B-spline-based method for de-noising and parameterizing EVI/NDVI observation sequences represents an efficient and powerful alternative for phenological time series analysis. It can also handle time series with irregular or duplicate observations, e.g. from combined MODIS Aqua and Terra observations, without requiring substantial pre-processing steps.

Using the full depth of the Landsat archive to analyze post-war forest cover dynamics in Angola

Achim Röder[1], David Frantz[1], Anne Schneibel[1], Marion Stellmes[1], Manfred Finckh[2], Valter Chissingui[3], Joachim Hill[1]

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After more than two decades of civil war, Angola is presently experiencing dramatic socio-economic changes. The richness in natural capital (e.g. oil, uranium, diamonds) has promoted one of fastest-growing economies in Southern Africa, with growth rates of 8% in 2014. As part of the efforts to recuperate from the war, massive investments into infrastructure and building are being made, resulting in the establishment or upgrade of transportation networks, urban building schemes and plans to establish dams for electricity production along the streams. While urbanization is one major process reflecting this, the return of people to their former settlement areas has promoted increasing conversion rates of Miombo woodlands to cropland and the extraction of trees for charcoal production. In addition to this, Angola is expected to become a major producer of food for national and international markets, and large irrigation schemes are beginning to appear along major streams.

To date, a consistent, exhaustive assessment of deforestation dynamics, in particular after the end of the civil war, is still missing, and only isolated case studies exist. To achieve a synoptic view across the Miombo-Savanna transition zone, we employed the full Landsat archive available for Angola. Rigorous radiometric pre-processing has been applied, including automated cloud detection and masking, as well as spatially explicit modeling of the radiative transfer based on date-specific estimations of optical thickness and water vapor concentrations. To account for topography-induced illumination variations, a C-correction was employed.

Multi-seasonal, pixel-based composites were generated based on time-related seasonal breakpoints to derive large-area image datasets covering coincident phenological states of vegetation. Based on these composites, we mapped forest cover distribution and its temporal dynamics using hybrid classification and iterative spectral mixture analysis. Results of this were related to information on population density, hierarchical road network layers and the distribution of land mines, clearly illustrating spatial gradients of these drivers.

To understand the dynamics of shifting cultivation, in particular with respect to fallow dynamics, we used a time series segmentation algorithm (LandTrendr) on the full series of available Landsat data. This allows identifying the year when fields were established and quantifying regrowth or reactivation dynamics afterwards, which is an important input to analyses on carbon stocks, biodiversity or ecosystem services that may be obtained from these areas.

These results are essential to understand how post-war demographic developments continue to affect the distribution and spatial configuration of forests, and subsequently support land management schemes facilitating the protection of Miombo forests and woodlands as major hubs of biodiversity as well as important sinks of carbon in southwestern Africa.

Monitoring Land Cover Dynamics at Varying Spatial Scales: High to Very High Resolution Optical Imagery

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Activities have focused on using the Landsat-8 Operational Land Imager (OLI) and Sentinel-2 MultiSpectral Instrument (MSI) to monitor land cover dynamics. Landsat-8 was chosen because it offers a significantly improved spatial resolution compared to medium resolution sensors e.g., MODIS and VIIRS that have pixel sizes from 0.25 to 1 km. OLI also has high Signal-to-Noise Ratio (SNR) values that are important for mapping surfaces with low reflectances, such as inland waters, because otherwise variations can be lost in the noise. With Sentinel-2 data also becoming available, the temporal frequency can be improved and MSI has a higher spatial resolution for the visible / Near Infrared (NIR) multispectral wavebands (10 m as compared to 30 m) that enhances the fidelity of high resolution features. In addition, for specific applications, such as agricultural mapping of individual fields these datasets are supplemented with commercial imagery; such as Worldview and Kompsat.

The applied Atmospheric Correction (AC) is based on an ocean colour 'dark pixel' NIR / Shortwave Infrared (SWIR) approach combined with vegetation SWIR 'dark targets' (Masek et al. 2006) used to create an above-water and above-land correction, respectively (Lavender, 2014). The focus has been on making the AC operationally robust, which aids the choice when multiple solutions are considered equally valid. When sensors have no SWIR waveband, especially for missions like Kompsat-2 and -3 where there are only 4 wavebands, the aerosol component is significantly simplified. For simplistic band-ratio algorithms, such as the Normalized Difference Vegetation Index (NDVI), the assumption is that the algorithm itself is relatively insensitive to the remaining atmospheric artefacts.

An OLI dataset was selected to have minimum cloud cover followed by similar acquisition dates to minimise phenological changes, and hence scene to scene mosaicking discontinuities. This is being processed using a cloud-based infrastructure to create a UK-wide mosaic that provides the baseline mapping. Current work involves the processing and analysis of complimentary multi-sensor matchups (over short periods of time, i.e. a few days) so the effects of sensor differences (such as spatial resolution, radiometric calibration, SNR and positioning / width of the wavebands) on the atmospheric correction and NDVI algorithm can be studied. The ultimate aim is to quantify, for the end user, the uncertainty within a time-series land cover product derived from data originating from multiple missions.

Lavender, S.J. 2014. Multi-sensor ocean colour atmospheric correction for time-series data: Application to LANDSAT ETM+ and OLI data, EARSeL eProceedings, 13(2): 58-66.

Masek, J G, E F Vermote, N Saleous, R Wolfe, F G Hall, F Huemmrich, F Gao, J Kutler, & T K Lim, 2006. A Landsat surface reflectance data set for North America, 1990-2000, Geoscience and Remote Sensing Letters, 3: 68-72

Land Surface Dynamics in Ukraine from 1982 to 2013: Towards an Improved Environmental Understanding Based on Multi-source Remote Sensing Time-series Datasets

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During the last three decades, Ukraine has experienced immense environmental and institutional changes. In order to estimate the land surface dynamics caused by these changes and to explain the possible causes, we conducted the study in two consecutive steps. First, we employed Mann Kendall trend analysis of AVHRR Normalized Difference Vegetation Index (NDVI3g) time series to analyze monotonic changes. The gradual and abrupt changes were studied by fitting season-trend model and detecting the breakpoints. Second, essential environmental variables: Essential Climate Variable (ECV) soil moisture product from European Space Agency (based on active and passive microwave sensors) and gridded air temperature and precipitation from Climate Research Unit (CRU) were used to quantify their effects on land surface dynamics. For this, we used partial rank correlation analysis based on annually aggregated time-series. The results showed that around one third of Ukraine was characterized with positive trends in the NDVI3g time-series, clustered mainly in northern and western areas, while negative trends occurred less, and were scattered across the country. The monotonic trends were rare and trends with shifts were prevailing. Greening with the trend shifts were the dominant type covering 28% of Ukraine and the main changes occurred during the recent years with the peak in 2008. Based on correlation analysis, we found that vegetation dynamics and climate variability were functionally interdependent, but the drivers were influential in different locations. Among all analyzed factors, air temperature explained most of the vegetation variability. The impacts of air temperature with high correlation coefficient ($r = 0.78$) were observed all over the country, whereas the soil moisture content was influential in eastern ($r = 0.66$) (mainly croplands) and precipitation ($r = 0.68$) in central regions of the country. The results enhance the detection of trends and add knowledge in understanding of ecosystem responses to climatic changes and anthropogenic activities.

SESSION 25 – OVERVIEW

SE - 25: SAR FOR GEOLOGICAL APPLICATIONS

Time: **Friday, 24/Jun/2016: 11:00am - 12:30pm**
Location: **S 30/32**

Session Chair: **Dr. Christian Rogass**, Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, Germany
Session Chair: **Dr. Karsten Jacobsen**, Leibniz University Hannover, Germany

Title Case: Preliminary results from active landslide monitoring using multidisciplinary surveys

Height models by ZiYuan-3 – systematic errors and accuracy figures

Centimeter Displacements Detection: Application with COSMO-SkyMed Amplitude Data

Results of ground deformation monitoring in the Upper Silesia Coal Basin (Southern Poland) on the basis of the TerraSAR – X and Sentinel interferometric data

Accuracy Characteristics of ALOS World 3D – 30m DSM

Title Case: Preliminary results from active landslide monitoring using multidisciplinary surveys

Konstantinos Nikolakopoulos, **Katerina Kavoura, Nikolaos Depountis, Aggeliki Kyriou, Nikolaos Argyropoulos, Ioannis Koukouvelas, Nikolaos Sabatakakis**

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An active landslide can be monitored using many different methods: Classical geotechnical measurements like inclinometer, topographical survey measurements with total stations or GPS and photogrammetric techniques using airphotos or high resolution satellite images. For a proper displacement identification all the above methods need a high resolution and very accurate representation of the relief. Performing repeated surveys is necessary for an active landslide monitoring as the geomorphology of a landslide must be analyzed and the changes over time should be mapped precisely. Taking into account that a single technique is not always sufficient to perform a reliable and accurate survey, this study presents the synergy of multidisciplinary surveys for the study and monitoring of an active landslide in Western Greece. The final aim of this paper is to highlight and validate a methodology based on multiple sensors data integration, useful to obtain a comprehensive GIS (Geographic Information System) which can successfully be used to manage natural disasters or to improve the knowledge of a specific phenomenon in order to prevent and mitigate the risk. Photogrammetric and interferometric processing has been applied to a complex set of remote sensing data used in this study, such as high resolution satellite images, digital airphotos, aerial photos acquired from a UAV and radar data. Global Navigation Satellite System (GNSS) measurements and continuous inclinometer measurements are being performed. The multifunctional technology of Geographic information Systems is used in order to collect, storage, manage, process, analyze and cartographically represent the above described complex geoscientific information

Height models by ZiYuan-3 – systematic errors and accuracy figures

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The Chinese remote sensing satellite ZiYuan-3 (ZY-3) with three high resolution panchromatic cameras, forward and backward viewing with +/-22° nadir angle and 3.4m ground sampling distance (GSD) and nadir view with 2.1m GSD, allows with a 51km swath the generation of large area covering height models. An attitude registration just with 4 Hz leads to some uncertainties of the viewing direction which cannot be determined by bias-corrected RPC-orientation with the used 12 ground control points. This leads to systematic errors of generated height models. In the literature some possibilities are described to improve the attitude information of ZY-3 by matching of the panchromatic bands with bands of the lower resolution colour camera having 6° nadir angle. Colour images as well as detailed satellite orientation information was not available for the investigated test data set of the ISPRS Sainte-Maxim benchmark test data set. An accurate reference digital surface model (DSM) from French survey administration IGN-DRE allowed a detailed analysis. The bias corrected RPC-orientation could not level the DSM satisfying, causing a tilt in X-direction of 3m over 50km and in Y-direction 10m over 55 km. In addition an averaging of height model differences in 30 groups as function of X and Y show after DSM levelling root mean square differences of averaged Z-differences in X-direction of 1.0m and in Y-direction 0.6m. A correction by smoothed averaged height differences in X- and Y-direction was able to eliminate such clearly visible systematic errors. The levelling and correction of undulating systematic errors can also be made with the free available SRTM height model, leading to very similar results.

The same investigation has been made with a Pleiades height model having a base to height relation of just 1:9, enlarging small systematic orientation errors strongly; and some Cartosat-1 height models. It is necessary to investigate especially the undulating systematic height errors in detail to avoid an influence of forest areas which may have a changed elevation since data acquisition of the SRTM height models and also a different definition of canopy level determined by C-band radar and optical images.

It is not so easy to describe the geometric quality of a height model. For the ZY-3 DSM accuracy figures from 5.23m down to 2.35m can be used. In general the accuracy depends upon the terrain slope, requiring a description by the function A + B * tan (terrain slope). If the DSM accuracy is just described by one figure, the accuracy of flat terrain (e.g. slope < 0.1) should be used; otherwise it is not possible to compare different methods of height model generation for different test areas. The root mean square error is influenced by the bias (average height error), while the standard deviation is related to the average. The square sum nature of the standard deviation enlarge the influence of large discrepancies or not eliminated blunders as also the influence of larger terrain inclination leading to larger accuracy numbers. The normalized median absolute deviation (NMAD) is not so much influenced by such facts

and usually describes the frequency distribution of the height discrepancies better as the standard deviation. Important is also the threshold for accepted height differences. For the investigated ZY-3 DSM for slope > 0.1 the standard deviation of the height (SZ) is 3.41m if a threshold of 20m is used (0.6% of values not accepted) and 2.54m if a threshold of 10m is used (4% of values not accepted). The corresponding NMAD values are 2.83m respectively 2.35m, demonstrating that NMAD is not so sensitive for larger height differences.

Centimeter Displacements Detection: Application with COSMO-SkyMed Amplitude Data

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Several deformation phenomena impact the Earth surface (e.g. landslides, subsidence, volcano deformations and glacier motions) and infrastructures (e.g. buildings, dams, bridges); their monitoring is strictly necessary.

The high resolution SAR imagery, represent an efficient alternative to the classic monitoring techniques since they allow the continuous observations of the wide areas of Earth's surface with short revisit times, providing information independently from logistic constraints on the ground and from illumination and weather conditions. The main remote sensing technique to extract sub-centimeter information from SAR imagery is the Differential SAR Interferometry (DInSAR), based on the phase information only. However, it is well known that DInSAR technique may suffer for lack of coherence among the considered stack of images. Currently, SAR images, acquired by the last generation sensors as COSMO-SkyMed, TerraSAR-X and PAZ, have a high amplitude resolution (up to 1 m on the ground in the SpotLight mode), and the satellite are equipped by dual frequency GPS receivers on board that allow to determinate the orbit trajectory with the accuracy in the centimetre range; this allows to achieve positioning accuracies in a global reference frame in the decimeter range and even better without any need about information on the ground. The accurate range measurements, however, can be obtained only correcting and compensating the SAR signal by the largest sources of ranging errors, such as the signal propagation delay of the electromagnetic waves in the troposphere and ionosphere, and by the deformation of the Earth due to the gravitational force of the Sun and the Moon, known as Solid Earth Tide.

The goal of work is to exploit the potentialities of the amplitude information of high resolution SAR imagery for the centimeter displacements detection of well identifiable and stable natural and man-made Persistent Scatterers (PS's) along the SAR line in order to monitor the deformation phenomena.

Some experiments using natural PS's, were carried out by our research group with interferometric stacks of TerraSAR-X SpotLight imagery obtaining a slant-range measurements accuracy reached is about 10 cm of bias and about 2-3 cm of standard deviation.

Thanks to the encouraging results, the core of this work is to test this methodology on COSMO-SkyMed data acquired over the Corvara area (Bolzano – Northern Italy), where, currently, a landslide with relevant yearly displacements, up to decimeters, is monitored, using GPS survey and DInSAR technique. The evaluation of displacements through slant-range measurements is ongoing, being based on a stack of twenty three COSMO-SkyMed StripMap images, acquired between September 2010 and

September 2011, with an incidence angle of about 47 degree, moreover, a cross test on benchmarks monitored with GPS will be also developed.

Results of ground deformation monitoring in the Upper Silesia Coal Basin (Southern Poland) on the basis of the TerraSAR – X and Sentinel interferometric data

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The paper presents application of satellite interferometric methods (differential interferometric synthetic aperture radar – DInSAR) for observation of ground deformation above underground mines in the Upper Silesian Coal Basin (USCB). The area of interest is about 460 km² and is located between the cities of Zabrze, Sosnowiec, Mysłowice and Katowice. The basin comprises a thick sequence (up to 8 500 m) of upper carboniferous sediments. The thickness of the seams can be up to 6 – 7 m. Subsidence hazard and risk within the Upper Silesia Coal Basin are usually connected with the deep coal mining. In such cases, the surface becomes pitted with numerous collapse cavities or basins which depth may even reach tens of meters. They may remain dry or be filled with water (land surface inundation) depending on the local hydro geological conditions. The subsidence is particularly dangerous because of causing severe damage to gas and water pipelines, electric cables, and to sewage disposal systems. In Upper Silesia it is common to find houses strengthened with iron bars anchored in the walls in order to prevent further damage or collapse, but even such reinforced buildings could show cracks and joints on their walls. Collection of systematic information on the ground instability in these parts of the mining basin is very important because of the ongoing changes in spatial planning politics. Part of the presented interferometric data were obtained during DORIS project (EC FP 7, Grant Agreement 242212). They included 30 TerraSAR – X satellite images from 2011 – 2012, which were processed by Tele-Rilevamento Europa-T.R.E. Italy. Time span of the interferograms was 44 days. The other, newer part of the data contained Sentinel - 1A satellite images from 2015 (TOPSAR Acquisition IW SLC products), gathered from European Space Agency Data Hub https://scihub.copernicus.eu/. Sentinel-1A is a radar imaging satellite launched in 3rd April 2014. It is the first satellite launched as part of the European Union's Copernicus programme. The satellite carries a C-band Synthetic Aperture Radar. These data were processed in PGI using ESA software (Sentinel-1 Toolbox). Time span of the created interferograms was 48 days, therefore comparable to TerraSAR – X interferograms. Satellite Differential Synthetic Aperture Radar Interferometry (DInSAR) proved to be an attractive technique for detecting and monitoring bigger (several centimeters to decimeters) ground surface deformations arising from regional scale processes e.g. seismic, volcanic, tectonic etc. Comparison of two interferometric data sets from the same area revealed two times more fringes at the TerraSAR – X images. There are several explanation of this interpretation result. The first one could be related to lower activity of the mining during last five year. The second one could be probably connected with different wavelength of two radar system X and C and better resolution of TerraSAR – X. In several places interpreted fringes are overlapped each other or are slightly shifted due to the changes of underground

mining exploitation fronts. Such situation has happened in the following hard coal mines: KWK Budryk, KWK Sośnica – Makoszowy, KWK Pokój, KWK Bobrek Centrum and KWK Halemba – Wirek. Taking this under consideration, the new Sentinel – 1 data proved to be very useful for monitoring mining activity nearly in real time.

Accuracy Characteristics of ALOS World 3D – 30m DSM

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The Japanese ALOS satellite, active from January 2006 up to May 2011, with PRISM had a three-stereo sensor with 2.5m ground sampling distance and a height to base relation between forward and backward view of 1:1.0. Based on all usable ALOS PRISM images the Japanese space organization JAXA generated for the area range from -82° southern up to 82° northern latitude a DSM under the name ALOS World 3D (AW3D). The image quality was not optimal, but this did not influence the height accuracy. The stereo scene orientation was improved by ICESat profile points. From the nearly complete commercial AW3D with 5m point spacing the first part of a reduced version with 1 arcsec point spacing (approximately 31m at the equator) is available free of charge as AW3D30. The first parts of this digital surface model (DSM) are available now.

JAXA is announcing AW3D with a standard deviation of 5m, but this is just a rough estimation. The accuracy depends upon the number of used stacks (images) varying from DSM area to DSM area. The number of used stacks is available for any DSM point as additional file and as general information in a quality file. For some fields in France, Turkey and Jordan the accuracy and characteristics of AW3D30 has been analyzed. As it is the case for ASTER GDEM the accuracy is slightly depending upon the number of used stacks. As in general, there is a dependence of the quality from the terrain slope and the system accuracy, the accuracy of the individual height value, from the accuracy of the description of the surface from the terrain roughness.

The achieved accuracy is promising – for areas with a slope < 0.1 standard deviations of the height between 3.0m and 3.7m, respectively a NMAD between 2.4m and 2.7m have been reached. Even in the mountainous area Zonguldak the overall standard deviation is just 3.4m if the height model has a point spacing of 2m. An interpolation over 27m, corresponding to 1 arcsec in that area, results in an overall standard deviation of 6.4m and in areas with slope <0.1 in 3.9m, demonstrating the influence of terrain roughness which is dominated by the point spacing and not the system accuracy. In the quality information files, belonging to the height models, the root mean square height differences against SRTM DSM are listed as between 3.4m and 5.4m, while the root mean square differences against ASTER GTED2 is listed as between 7.1m and 9.6m. It has to be mentioned, that the SRTM DSM, with exception of Near East, is now available also with 1 arcsec point spacing. The linear standard deviation regression depending upon the number of stacks is quite different for the test areas, but in any case an improvement by a higher number of stacks for the individual points is shown. The accuracy reached with AW3D30 is better as for the SRTM DSM, demonstrating the improvement of the now available free of charge height models.

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Turbidity from Space: Integration of Satellite Data into an Operational Sediment Monitoring

Multi-Source Remote Sensing Observation of Land and Water Surface Dynamics of the Yellow River Delta

Meteorological phenomena from view of the International Space Station (ISS)

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Satellite-based earth observations and photographic records by astronauts have shown that the earth's atmosphere is dominated by clouds. According to multi-year observations, about 67% of the earth is covered by clouds while oceans are cloud-free by less than 10%. Clouds describe atmospheric processes and meteorological phenomenons which are discussed in this presentation. Their analysis is based on earth observation data derived from cameras at the ISS.

The project 'Columbus Eye – Live-Imagery from the ISS in Schools' has published a learning portal for earth observation from the ISS (www.columbuseye.uni-bonn.de). Columbus Eye is carried out by the University of Bonn and funded by the German Aerospace Center (DLR). The NASA's High Definition Earth Viewing (HDEV) experiment possess four cameras and records the earth 24/7. The NASA is testing the HDEV cameras for possible missions to the moon and mars in the near future. The cameras are mounted statically and cover three viewing directions. The camera in nadir sight, angle of view in perpendicular direction, is beneficial for satellite-based remote sensing. The ISS crosses the earth 16 times a day within an orbital period of 90 minutes. The operating altitude is 410 kilometers, resulting in an image resolution of about 500 meters. The main goal of Columbus Eye is to make pupils curious about space flight and to make them familiar with scientific remote sensing analysis tools. Besides a video live stream, the portal contains an archive providing spectacular footages, a Web-GIS and an observatory with interactive materials for school teaching. The Columbus Eye archive stores data from 09/23/2014 until today.

The presentation shows how the ISS is used as earth observation platform and how the archived video footage can be implemented as innovative image products. In addition to remote sensing challenges by the cameras onboard, also meteorological phenomena can be detected, and will be discussed here. These include phenomena such as dynamic low-pressure areas, tropical cyclones, hubbubs (sandstorms), volcanic ash clouds after explosive eruptions, smoke plumes from bushfires and cloud genera. The possibilities for using the video material is multi-faceted.

Besides the nowcasting in meteorology or aspects in climate research, such as the determination of the degree of coverage and the global observation of contrails, applications can also be operated for disaster management.

Exploration of Raw Materials in Dump Sites – A New Hyperspectral Approach

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The importance of raw materials and their availability for the industry and economy is an ongoing issue in many levels of society. In addition to more efficient recycling strategies, it is possible to address shortages not only by exploring new deposits but also by reusing materials that were discarded as waste products during former quarrying and mining extraction and processing like spoil heaps and industrial dump sites. Now, as costs increase and production workflows improve, it has become economically viable to revisit these anthropogenic deposits. However, at present, the distribution and quantities of reusable materials are not known, and must first be assessed.

In this study, aiming for the detection of economically important materials, we applied an innovative combination of geochemical analysis, hyperspectral measurements as well as laser scanning to explore and analyse a dumpsite of an electric steelwork with a long history of iron and steel production by an integrated metallurgical plant since the 1870s which is located in Unterwellenborn, Thuringia, Germany.

Hyperspectral images of an outcrop with multiple layers of slags and sludges from different iron and steel production phases were acquired using a HySpex SWIR-320m (1.300-2.500 nm). The hyperspectral images are integrated with a high resolution LIDAR model from the same outcrop. In addition, samples were collected for laboratory measurements with the imaging spectrometer and an ASD FieldSpec Pro (350-2.500 nm). Afterwards the sample spectra were collected in a spectral library, analysed for distinctive features and used for different classification approaches. Results from X-Ray-diffraction und chemical analysis serve as the basis for the spectral interpretation.

The results show that hyperspectral methods are suitable non-invasive tools that can be used to quickly detect, distinguish and map several by-products from the current steel production as well as slags, sludges and dusts from past production phases, which may aid the exploration of dump sites and sampling strategies within the context of urban mining.

Further information:

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Usage of Indices for Extraction of Land Use and Land Cover Classes: A Case Study of Sazlidere Basin, Istanbul

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Protecting and improvement of water resources is a quite important phenomenon to supply clean drinking water demands currently. Population growth and consequent urbanization causes land use and land cover (LULC) changes seriously. It is significant to produce up to date thematic maps for preparing effective basin management plans for decision makers. Sazlidere Basin, which covers approximately 157 km2 area and supplies 2 % of drinking water demand, is one of the seven most important basins of Istanbul, Turkey. Sazlidere Basin is located inside Arnavutkoy District. The district has been growing quicly in parallel to the realization of planned transportation network like the Northern Marmara Motorway (NMM) access for the 3rd bridge named as Yavuz Sultan Selim on the Istanbul Strait joining the two continents, Europe and Asia and the third international airport of Istanbul as well. Therefore, it is clear that the basin is under fairly strong urban pressure.

In this study, 2015 dated LANDSAT 8 OLI image was used and it is aimed to find out current LULC classes and to produce present thematic map of the Sazlidere Basin area by using image processing methods. By operating red, green and infrared bands, four different spectral indices, Modified Normalized Difference Water Index (MNDWI), Normalized Built – up Area Index (NBAI), Normalized Difference Vegetation Index (NDVI) and Soil Index, were used to determine thematic classes CORINE Level 1, water bodies, forest and semi-natural areas, agricultural areas and artificial surfaces, inside basin area and the results compared with supervised classification results.

Differential Block Lift and Tilt Estimations in the Southern Margin of the Corinthian Gulf, Greece, Using Gis and Freely Available DSM

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Rift tectonism in the Corinthian trough started probably in the Upper Miocene or Lower Pliocene and resulted in a significant rise of the land with consequent withdrawal of the coastline and the emergence of coastal sediments. This rise may be associated with the rising blocks of normal faults and the deposition of sediments of the Greek trough and has interacted with the changes in the sea level, so as to create a stepped topography of the terrain, defined by flat marine terraces which developed over almost the entire northern Peloponnese. Overall, there are more than 20 marine terraces, while only ten (10) are thoroughly mapped and dated. These terraces reflect the interaction of tectonic uplift of the northern Peloponnese and global eustatic changes in sea level during the last 500,000 years. The southern coast of the Corinthian Gulf is a good example of a coastal, tectonically active region, characterized by a sequence similar to that of continental margins.

The subject of the present paper is to study and compare differential block lift and tilt, caused by rift tectonism, in the southern land margin of the Corinthian Gulf (North Peloponnese, Greece), using GIS, conventional means (topographical maps) and the new freely available digital elevation data such as ASTER GDEM and SRTM DEM.

Our study area is a section of the NE part of the Peloponnese, specifically the zone between the villages of Velo and Vrachati. In our study area, a system of seven (7) marine terraces appear, which have been mapped in detail and which correspond to isotopic stages of interglacial periods of the Pleistocene.

Correlation of Onshore and Offshore Topography to Detect Similar Geomorphologic Features in the Proximity of the Land and the Sea

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The geomorphology of both the offshore and onshore environment is strongly related to the past and modern geodynamics-tectonics. It is well known that onshore geological structures are easier detected and analyzed in relation to the geological structures in the marine environment. This is because the access to land is easier. On the contrary, the investigation of the marine environment is more complex, time consuming and more expensive.

Scope of this study is to analyze digital elevation data and bathymetric data from the onshore and offshore region of Tinos island in Aegean, based on modern processing techniques in order to qualitatively estimate the similar geomorphologic features in both the land and the marine environment. Digital elevation and bathymetric data have been processed by applying a new algorithm for the automatic enhancement and the identification of the linear patterns, relating to important geomorphologic features. According to this method (Panagiotakis and Kokinou, 2014, 2015; Kokinou 2015) the slope and aspect images, as well as their derivatives are initially computed. Rotation and scale-invariant filter and pixel-labeling methods are then applied to enhance the detection of the geomorphologic features.

Concerning the evaluation and interpretation of the detected land and seabed geomorphologic features, previous geological studies have been used.

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Application of Selected Vegetation Indices in Assessing Arborescent Species Condition in UNESCO's World Heritage Bialowieza National Park, Poland

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The aim of the research was to estimate which vegetation indices are most applicable in assessing condition of coniferous and deciduous arborescent species. The radiometric and biometric data for this research were collected in May, July and September of 2014 using ASD FieldSpec 3 spectroradiometer (with Plant Probe) and Dualex Scientific+ Polyphenol & Chlorophyll-Meter. Test area was Bialowieza National Park in Poland, located along the Polish-Belarusian border with an area of 10 517 ha, of which 5725 ha are under strict protection. It is the remnant of Central European lowland forests, placed on UNESCO's World Heritage list, distinct for its high biodiversity. The data were collected on 8 homogenous polygons (10 measurements of spectral reflectance curves and chlorophyll content each) on dominant arborescent species - hornbeam (Carpinus betulus), oak (Quercus robur), alder (Alnus glutinosa), birch (Betula pubescens), spruce (Picea abies) and pine (Pinus sylvestris).

Spectral reflectance curves were statistically analyzed for each species using ANOVA test to determine on which wavelengths changes occurred between measurement periods (May, July, September). The spectra were used to calculate remote sensing vegetation indices: narrowband general condition indices (mSR705, NDVI705, VOG), chlorophyll content (TCARI, MCARI, TVI, NPCI), anthocyans (ARI 1, 2) and carotenoids content (CRI 1, 2), nitrogen content (NDNI), amount of dry material (CAI, NDLI, PSRI), amount of water (WBI, MSI, NDII, NDWI), and use of light in the process of photosynthesis (PRI, SIPI).

Calculated vegetation indices were verified with biometric data (chlorophyll content). Correlation of vegetation indices with amounts chlorophyll showed strong positive correlation with mSR705, NDVI705, NDLI and strong negative correlation with VOG 2, TCARI, MCARI and CRI2. A non-parametric Kruskal - Wallis ANOVA was applied to assess which indices showed statistically significant changes between measurement periods (May, July, September) with regard to type of vegetation (deciduous or coniferous). The most appropriate in analysis of condition of dominant arborescent species in Bialowieza National Park proved to be mSR 705, NPCI, CRI1, ARI1, NDNI, NDLI, WBI, PRI. Where relevant, normalized vegetation indices were selected, to create basis for a further long-term remote sensing of the area.

Land use changes around UNESCO heritage sites in SE Asia - remote sensing approach

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UNESCO Heritage Sites spread around the World, differ in the actual condition and potential risk of several damage due to artificial and natural processes. Some of them, located in developed countries, can be highly influenced by overall urbanization and transportation only, thus sites in developing countries are mostly endangered by rapid touristic and intense population growth influences, as well as natural hazards. Among these hazards, earthquakes, volcanos eruption, woodland cutting, floods and forest fires should be highlighted. In this research, selected UNESCO Heritage Sites in SE Asia are analyzed on the base of Remote Sensing data from available sources (mostly satellite data) and ground observations, with use of GIS techniques to assess the overall risk of the hazardous changes. Such analyses, prepared uniformly for the Sites, prepared every few years, can be invaluable for UNESCO as a tool for monitoring the current condition of the Sites, detection of hazardous changes in their vicinity and for preparation of recommendations for local authorities.

The main common and unified source of data for all the UNESCO Sites located around the world is a satellite imagery, like EO satellites, Landsat, Ikonos, Sentinel, others, and old CORONA hi-resolution imagery. High geometrical resolution data can be used for direct analyses of changes, although medium resolution, multi- or hyperspectral data can be also used for indirect analyses. Remote Sensing data preparation and analyses can be unified and operationally used by specialized UN organizations.

The functionality of GIS systems enables to draw several boundaries and buffer zones related to natural and human-related risks. The frequent analysis of changes in the vicinity of the Sites can result in highly valuable early reconnaissance of interested objects. Human-induced threats, like transportation stress, urbanization, agriculture or water drainage system can be presented mostly like areas or linear features, boundaries (buffers) and points, and natural hazards can be presented mostly like areas, extend boundaries or, rarely, as points (when the threat has stable position). Common analyses of changes in landuse/land cover features and natural hazards can result in maps of risk related to do preserved Heritage Sites. In many cases, such map can be a good base for planning activities focused on the monitoring of the current state, emergency actions and restoration plans of the Sites.

Common remote sensing data and GIS technology use together with field work, made in last years, gives good opportunity to make an detailed overlook on the interested object, place, in the wide context of adjacent areas and simply track the changes inside the object area and around. Areas affected by the decreasing natural pressure with parallel increasing human (urbanization, tourism, agriculture) pressure, like in Angkor Wat, Cambodia, can be an example of this methodology. Other sites located in SE Asia will also be discussed.

A New Unmixing-Based Approach for Unsupervised Band Selection of Remote Sensing Hyperspectral Images

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Hyperspectral imaging sensors simultaneously acquire images from hundreds of narrow and contiguous bands of electromagnetic spectrum. Obtained image cube increases the opportunity for better identification of spectrally unique materials.

The detailed spectra lead to an increase in the dimension of the data, which brings the "Hughes phenomenon" for classification and the computational complexity. Reducing the dimensionality of hyperspectral data is a simpler way to address such problems.

Feature extraction and feature selection are the most popular ways for dimensionality reduction. Feature extraction approaches transform the spectral bands of a hyperspectral image to a low-dimensional feature through projection techniques. The obtained features lack physical interpretability. On the contrary, feature selection (also referred to as band selection) approaches choose some representative spectral bands that preserve the physical information of the original data, making them preferable than feature extraction ones.

Depending on the availability of labeled reference data, band selection can be performed within both supervised and unsupervised ways. Supervised methods need a training set to perform selection of bands, whereas unsupervised methods do not assume the availability of such labeled data.

In these investigations, a new unmixing-based approach is proposed for unsupervised band selection of hyperspectral images. Most unmixing techniques consist in linearly extracting, from remote sensing data, a collection of pure endmember spectra contained in a mixed form.

The proposed approach operates in two principal stages. The first one consists in linearly extracting endmember spectra, after automatically estimating their number, while the second stage aims at selecting decisive spectral bands in optimality sense (described hereafter) in order to represent the original data. More precisely, the extracted spectra are analyzed according to the considered wavelengths. At each wavelength, the variance of the extracted spectra samples is calculated. The selected spectral bands are those which correspond to wavelengths where the variance is maximum. Indeed, in this case the differences between the samples of the endmember spectra are significant, and thus a better discrimination is possible. However, this strategy is not sufficient, because it can result in the selection of very close spectral bands. To overcome this issue, the computed variances are segmented to a fixed number of clusters with a sequential clustering algorithm. For each obtained segment, only one spectral band is selected. This one corresponds to the wavelength where the variance is maximum.

Experiments, based on different real hyperspectral datasets, are conducted to evaluate the performance of the proposed approach and other methods from the literature. Two evaluation measures, overall classification accuracy and Kappa are calculated. Globally, the proposed approach yields very satisfactory and encouraging results and outperforms the used literature methods.

Hyperspectral imaging and full-waveform LiDAR data fusion for surface classification

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Hyperspectral imaging (HSI) is a commonly used remote sensing method that allows to retrieve many parameters from an observed scene, based on the narrow spectral sampling interval of the sensor. The basic step of coupling HSI data with LiDAR data is to use products of the discrete returns, allowing to complete the hyperspectral data with surface information. A step ahead is to take into account the entire waveforms (full-waveform, FWF) recorded by the LiDAR system to provide information on the structure and the density of the surface composition.

In this study, the HSI and FWF LiDAR coupled data sets have been acquired together during the same airborne campaign in early September 2015 over Western France. Two observed scenes have been analyzed: One over a coastal dune in Vendée (France) and the other in the surroundings of the city of Nantes (France). The hyperspectral data have been acquired using a HySpex VNIR-1600 (Visible and Near Infra Red) camera and a HySpex SWIR-320m-e (Short Wave Infra Red) camera. The FWF LiDAR data come from an Optech Titan airborne laser scanner. The VNIR HSI data range covers the 400 – 1000 nm spectral region with a spectral resolution of 3.5 nm while the SWIR HSI data ranges from 1000 to 2500 nm with a resolution of 6 nm. The FWF data has a 10 points/m² density.

Although data have been simultaneously acquired, the HSI images still have to be registered so that each pixel of the images has a corresponding LiDAR information. As the HSI data are based on 3D grids, a waveform voxelization approach needs to be taken to be able to compare both data sets. The method used here consists in creating a 3D grid of voxels (volumes) divided into slices. All georeferenced waveforms samples along each LiDAR scan ray are assigned to the corresponding voxels thanks to a fast ray-volume intersection algorithm. The synthesized intensity is then computed (by e.g. mean, maximum, minimum) to recreate a regularly spaced waveform.

When both data sets are gridded, one can process them with the aim of classifying the elements of the observed scene. Regarding the HSI data, a set of leave color indexes and a Spectral Angle Mapper are used to identify the different parts of the image. The approach to classify the LiDAR synthesized waveform can be based on the number of returns and their shape as well as using their height.

The data fusion performed here shows that FWF LiDAR data voxelization allows to retrieve more information on the surface state and therefore improve the scenes classification.

Simulating Trees Reflectance in Primary Forest Using HySpex Images and PROSAIL Model

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Monitoring of vegetation cover, especially on protected areas, is an important indicator of local and global changes, because it shows interactions of different abiotical components, which shouldn't be interrupted by anthropopressure.

Bialowieza forest is partly protected natural forest and holds Bialowieza National Park (BNP) which is Biosphere Reserve and World Heritage Site since 1979. This area is the last remnant lowland primeval forest of mixed temperate deciduous and coniferous ecosystem. Mainly occurred type of the forest is Galio silvatici-Carpinetum and it occupies 47% of all forest space. Coniferous forest covers 37% and deciduous and mixed forest covers 14.5% of the forest. In all stands older than 100 years no forest management is carried out as well. The forest is quite diverse and the trees are different in age. In the study were analysed trees from 10 species: birch, oak, hornbeam, ash, maple, alder, linden, elm, pine and spruce.

The aim of the study was to check the possibility to use Radiative Transfer Model to simulate the reflectance of different tree species from Bialowieza Forest. Radiative Transfer Models are physically based models which describe the interactions of radiation with the object. Models are often applied to vegetation modelling. After successful inversion of the model it is possible to retrieve biophysical variables. In the study PROSAIL was used. It is one of the most commonly used model to simulate the reflectance and to retrieve biophysical parameter.

During field measurements gathered from 1st till 5th July 2015 were identified tree species and measured chlorophyll content using CCM-300 Chlorophyll Content Meter as an input parameter to the PROSAIL model. Also was acquired reference spectrum using ASD FieldSpec 4 for objects spectrally stable and flat like concrete, asphalt, sand and water. The HySpex images were acquired on 2nd and 4th July 2015 with spatial resolution 2.5 m for VNIR image and 5 m for SWIR image. The images have 451 bands spectral reflectance in range from 400 to 2500 nm. On HySpex images radiometric, geometric, atmospheric and topographic correction was done, the images were resampled to 5 meters resolution. The correction was verified using spectral reflectance from field measurements.

Each tree or group of trees were identified on the image and the spectrum was collected. Then, PROSAIL model was used to simulate the spectrum for each polygon. The version in Python – PyProSAIL, was used. Parametrization was done based on acquired biophysical parameters and literature. Then simulated spectral reflectance

were compared with HySpex spectrum. To check the accuracy were calculated RMSE values for whole spectrum 400-2500 nm and at specific ranges: 400-600, 400-800, 800-1500 and 1500-2500 nm.

The results showed that the PROSAIL model can be used for simulation reflectance trees in natural forest. The parameters were different for each tree species. The differences were noticed between coniferous and deciduous trees and between species.

The use of AISA and HySpex hyperspectral images for analysis changes in water properties

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Monitoring lakes properties is an important issue, because of the pollution. Traditional measurements are time-consuming and expensive. This is a reason, why remote sensing techniques are very useful in water monitoring.

The aim was assessment of the possibility to use hyperspectral images to analyze water properties and changes on Zegrzynskie Lake. Based on images were discover changes between two periods. Also was analysed the relationship between Hyperspectral images and in-situ water properties.

Analysis were done on artificial Zegrze Reservoir. The lake is on confluence of two major Polish lowland rivers: Bug and Narew. Bug discharging to the reservoir deposit large volumes of sediments transported as a bedload and in water column. Water flow at the confluence of the rivers is controlled by the discharge and suspended sediments concentration.

The analysis were basing on images from hyperspectral scanners: AISA Eagle and HySpex. The spectral range for AISA scanner is 400-1000 nm with 129 bands and for two combined HySpex scanners – 400-2500 nm with 451 bands. The images were acquired by MGGP Aero aircraft on 5/08/2013 (AISA) and 2/10/2015 (HySpex). During both overflight were acquired reference data about water properties: amount of chlorides, sulphates, bromides, fluorides, sodium, ammonia, potassium, magnesium, calcium, colour, dissolved oxygen and conductivity.

Images were geometrically and radiometrically corrected using PARGE software. The atmospheric correction was conducted for HySpex data using ATCOR4 software. On both images were calculated hyperspectral indices to estimate water parameters: Secchi Disk Depth (SSD), Turbidity, chlorophyll-a content, Total Suspended Solids (TSS), Dissolved Organic Matter (DOM), Total Phosphorus (TP) and phytoplankton. Apart from that were calculated vegetation indices (like Red Edge Normalized Difference Vegetation Index) to estimate chlorophyll content. The information about water properties were correlated with in-situ water properties. As a result were the relationship were analysed. To analyse changes in water properties were compared values of indices calculated from AISA and HySpex.

Mapping abandoned cropland in Central Asia - what can trends in satellite sensor time-series tell us?

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An approach was developed to better understand the specific information from satellite sensors used for trend analysis to map abandoned cropland. The approach was tested at the example of three study sites in the irrigated landscape of Central Asia, which has been extended to one of the largest artificial irrigation system in the world during the Soviet epoch. After the break-up of the Soviet Union, the processes of irrigated cropland degradation and abandonment continued in Central Asia, reportedly in the lowlands of Uzbekistan and southern Kazakhstan.

Basically, cropland abandonment can be mapped in two ways when using satellite remote sensing: (i) by classifying a series of images from different years and in turn analysing land cover changes post-classification (LCC), or (ii) by assessing trends in multi-annual time series (TS) of vegetation indices (VI). However, trend attribution remains critical, because negative trends are not inherently a reliable indicator for land abandonment. In addition, mixed pixels can further impact the assessment. To shed more light on this issue, trend analysis was combined with LCC, based on MODIS Terra and Aqua enhanced vegetation index (EVI) over 2003-2014, and the effect of pixel purity on both methods was investigated. A reference data set for validating the abandoned cropland map by the LCC analysis was created with Google Earth.

Based on LCC, i.e. by assessing the frequency of fallow years in each pixel, abandoned cropland was identified with 85.4% overall accuracy on average for the three study sites (81.8% class-wise accuracy for abandoned land). The analysis revealed that indeed in one of the three investigated study sites, positively trending pixels characterized best abandoned cropland. In the remainder two sites, negative trends in the EVI time series were found to be a reliable cropland abandonment indicator. The impact of landscape heterogeneity, which is common in the study region, on trend analysis was investigated by calculating the fraction of trend classes as a function of pixel purity. In two landscapes, mixed pixels tended to be correlated more with negatively trending pixels, whilst positive trending pixels prevailed in purer pixels. In one landscape, the share of positively trending pixels increased from 20% to 30% of all significantly trending pixels (p≤0.01 and p≤0.05) when the purity increased. The dominant pattern emerging from the combined analysis of LCC and trends in the observed landscapes is one of (i) agricultural de-intensification across the irrigated area in southern Kazakhstan, with abandonment rates of almost 50%, and (ii)

agricultural "monoculture" in Uzbekistan where 2-3 crops dominate and where cotton is cultivated in rotation with winter wheat.

The value of a combined trend and LCC analysis is the partitioning of land use trajectories from the land use classification that indicate agricultural land abandonment. Without LCC, trend analysis alone can be insufficient to identify the total area of abandoned cropland, e.g. when changes in cropping pattern are characterized by negative or positive trends or due to the effect of pixel purity.

Land cover monitoring for water resources management in Angola

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Water resources management has become a challenging problem worldwide, especially in developing countries. The lack of information on land cover monitoring has a huge impact on the water resources management, since it may hamper the collection, treatment and

distribution of water for human consumption and agricultural development. To fulfil this demand, Earth Observation data has been used in African countries to map land cover of large and often inaccessible areas, providing useful information on qualitative and quantitative land cover changes. Although optical data methods for land cover classification are well established and almost operational, these data are not applicable to regions where the cloud coverage is

frequent. In these regions, the use of Synthetic aperture radar (SAR) data is an alternative due to its ability to acquire data regardless of weather conditions and day/night cycle. The aim of this study is to assess the complementarity and interoperability of optical and polarimetric SAR

data to map and monitor crops of an agricultural area in Wako Kungo, Cela municipality, South Kwanza province, Angola. For this purpose, 28 SPOT 5-Take 5 images (April, 10 to September, 12), 9 Sentinel-1 dual polarisation (VV+VH) images (March, 26 to October, 10) and field data

(April, 15-30) acquired during the 2015 growing season are used. SPOT5 Take 5 experiment images are used, as a proxy of Sentinel-2 data, to evaluate the potential of its enhanced temporal resolution for agriculture applications. SPOT Normalized Difference Vegetation Index (NDVI) and VV and VH polarization backscattering time series were plotted, for the crops parcels identified in the test area, to evaluate the discrimination among the different crops.

The field data collection and classification focused on the main crops grown in the region, which include: maize, soybean, bean and pastures. Average NDVI values are also used to compute the basal crop coefficients (Kcb) for each crop growth stage and to estimate the respective length of each phenological growth stage. Both are then used to compute the crop evapotranspiration and subsequently to estimate the crop irrigation requirements based on a

soil water balance model. The integration of optical and SAR data is assessed by comparing the classification results from different algorithms under 2 different scenarios: SPOT time series and mixed SPOT-Sentinel 1 time series. The SAR inputs include VV and VH backscatter intensity channels, VV and VH ratios and VV and VH differences. Preliminary results show that the combination of images from different sources provides the best information to map

agricultural areas and also that the use of multi-temporal data can successfully classify crops due to spectral information for the complete growing season. The study was developed in the scope of the ESA Alcantara initiative project (Ref: 14-P13) and Spot-take 5 project ID: 29142.

Applying the Change Vector Analysis Technique for Assessing Spatio-Temporal Dynamics of Land-Use and Land-Cover in the Mu Us Sandy Land, China

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Considerable attention has been given to sandification processes in China since vast areas of sandy deserts are located in the north of the country within arid and semi-arid climatic zones where the annual precipitation is below 500 mm. By the end of 2009, the desertified land area of China was estimated to be 2,623,700 km2 (27.33% of the national territory), and the sandified land area to be 1,731,100 km2 (69% of the total desertified land area). The temporal dynamics of the northern China sandy landscapes can be roughly separated into two periods, from 1950 to 1980, and from the 1980s onward. During the 1950s, 1960s, and the 1970s, the sandification in northern China was the result of interaction between environmental and physical conditions and climatic and anthropogenic factors. These trends of anthropogenic activities have been reversed since the 1980s. The rate of increasing sandified land has reduced in northern China mainly due to the great amount of attention paid to this matter by the central government since the end of the 1970s. The basic state policy was to "plant trees everywhere and make the country green". Actions to combat sandification, undertaken by the government and local residents, including ground and air-seeding of trees, bushes, and grasses over large areas, the construction of long windbreaks, shelterbelts, and barriers, pastureland enclosures, as well as chemical mulching and hydrologic solutions. There is compelling evidence that, during these years, the area of grassland and woodland biomass production enlarged.

Mapping and Monitoring Paddy Rice in Asia - A Multi-Resolution, Multi-Sensor Approach

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Rice is the most important food crop in Asia and the mapping and monitoring of paddy rice fields is an important task in the context of food security, food trade policy and greenhouse gas emissions modelling. Two countries where rice is of special significance are China, the largest producer and importer of rice, and Vietnam, where rice exports contribute a fifth to the GDP. Both countries are facing increasing pressure in terms of food security due to population and economic growth while agricultural areas are confronted with urban encroachment and the limits of yield increase.

Despite the importance of knowledge about rice production the countries official land cover products and rice production statistics are of varying quality and sometimes even contradict each other. Available remote sensing studies focused either on time-series analysis from optical sensors or from Synthetic Aperture Radar (SAR) sensors – the studies using optical sensors faced problems due to either the spatial or temporal resolution and the persistent cloud cover while SAR studies found the limited data availability and large image size to be the biggest drawbacks. We try to address these issues by proposing a paddy rice mapping approach that combines medium spatial resolution, temporally dense time-series from the optical MODIS sensors and high spatial resolution time-series from the recently launched Sentinel-1 SAR sensor.

We used the 250m resolution MOD13Q1 and MYD13Q1 products as a basis for our medium resolution rice map. Prevalent cloud cover introduces noise into these time-series which we reduced by applying a Savitzky-Golay filter. We then derived a number of time-series temporal and phenological metrics for multiple years and classified rice areas with One Class Support Vector Machines. In a next step we used this medium resolution rice map to mask Sentinel-1 Interferometric Wide Swath images and create SAR time-series from which we again derived temporal and phenological metrics and classified rice areas with machine learning algorithms to arrive at a 10m resolution rice map.

This method allows concurrent, accurate and high resolution mapping of paddy rice areas from freely available data with limited requirements towards processing infrastructure and can be used as a basis for greenhouse gas and crop modelling as well as providing viable information for decision makers regarding food security, food trade, bioeconomy and mitigation after crop failure. Results of our paddy rice classification will be presented for selected study sites in China and Vietnam.

Assessment of Optical and Radar Data Fusion Techniques Used for Crop Classification

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Satellite data fusion is one of techniques which is used in various studies related to land cover monitoring. Combining various spectral bands allows to increase the differentiation of objects on the Earth's surface and improve e.g. classification accuracy. One of an application fields example where data obtained from different types of sensors are used is monitoring of agricultural lands. However the development of various techniques of crops recognition with use of satellite imagery is still in progress, monitoring of agriculture lands is still a challenge especially in regions with complex mosaic of cultivated fields.

In our study, we focused on crops recognition with optical and SAR data. Our main objective here was to assess influence of data fusion levels on accuracy of crops classification. The study area was located in the Żywiec Basin, a part of the Polish Carpathians. The advantage of this small agriculture region was that it is covered by a mosaic of different size cultivated fields (from 0.01 to 36 ha), with a predominance of small and very small fields. We used Landsat 8 multispectral images from OLI sensor (7 June 2014) and Sentinel-1A SAR images (2 August 2014) here. In first step of our workflow we pre-processed both images, then we integrated optical and radar data using Ehlers method. The next step was to apply Random Forest algorithm on pixel- and object-based classification level. We assumed that in studies using integrated optical and SAR images and for such specific region like Żywiec Basin, the use of per-parcel classification is a better solution than traditional per-pixel classification. Finally, we assessed accuracy using information about agriculture activities in the study region collected during the field survey in 2014 (interviews with farmers). The results demonstrated that use of integrated optical and SAR imagery is successful in crop classification. Although a wide variety of factors can greatly affect achieved accuracies, especially in specific region like Żywiec Basin: fields size and their fragmentation.

Rule-based object-oriented land cover classification of RapidEye multispectral satellite images for dasymetric mapping

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Land cover data obtained by means of remote sensing were used for the production of a thematic map of the population density of the City of Zagreb in Croatia. A binary method of dasymetric mapping was selected for this task. An object-oriented land cover classification was conducted on RapidEye multispectral satellite imagery for the entire administrative area of the City of Zagreb with the total area of 641 sq. km. Trimble's eCognition 9.0 and ESRI's ArcGIS 10 computer software have been utilized for the research. Minimal pre-processing of satellite imagery was performed in order to avoid any unnecessary data transformation. Coordinate systems had to be transformed for the five RapidEye satellite image tiles used in research, and had to be co-registered as well to match the vector data layers of administrative units and reference images in GIS software. Rule-based method used for the land cover classification was based on range of statistical data on image segments, arithmetic features, vegetation indices, datasets acquired by principle component analysis, and spatial relations of image segments. Ruleset applied for the classification comprised of threshold values for the selected features and has resulted with crisp classification of image segments. Ridd's V-I-S (vegetation – impervious surface - soil) model was used as a reference for land cover classification. Dataset created by land cover classification in this research consists of four final classes: vegetation, impervious or built-up surfaces, bare soil, and water. Such classification allows further geographical research of apparent dichotomies of the urban versus rural, or artificial versus natural surfaces. Classification accuracy was assessed by using methods of error matrix and kappa statistic. Aerial imagery and other satellite imagery of higher spatial resolution were used as reference data for the creation of the error matrix. Accuracy assessment resulted with the overall accuracy of classification at 92.06% and kappa statistic of 0.89. Data acquired by land cover classification was used for the production of dasymetric thematic map of population density and distribution for the City of Zagreb. Population data has been obtained from the Republic of Croatia's Census of Population, Households and Dwellings 2011 at the administrative level of the Local committees. The City of Zagreb is comprised of 218 Local committees. RapidEye satellite images from 2011 were intentionally used for the land cover classification in order to optimally match remote sensing data with official census data. Contributions made by this research involve development of land cover classification ruleset, production of land cover map and land cover GIS layers for the area of the City of Zagreb, and production of dasymetric map.

Wetland change detection by Using Image Classification and Water Indices

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Wetlands are well-known with their rich biological diversity and economic value beyond their significant functions like serving as nesting and breeding areas for the migrating birds and maintaining partial treatment of waste water. There are more than 300 wetlands in Turkey and 135 of them are holding an international significance. Akgol Wetland is one of them. Akgol Wetland is located within the borders of Konya Watershed of Turkey. The total surface area of Akgol till 1960's had been around 21.500 ha, but most of this amount had been lost until now basically due to water cuts as a result of the dams that have been built and to other human-induced activities such as fighting against malaria disease, and gaining more agricultural land. The area has been declared as Class1 Natural Protection Area in 1992 and as Nature Reserve Area in 1995.

In this study temporal change of the wetland borders examined by using 1987 dated LANDSAT 5 TM and 2015 dated LANDSAT 8 OLI satellite images. For this aim, classification methods and water indices have been applied and results were compared. Multispectral images are used to delineate Land Surface Water (LSW) using the methods of images classification, single-band density slicing and water indices. Image classification methods are highly dependent on human expertise and have difficulty in producing rapid and reproducible extractions of LSW information. But, water indices can extract LSW information more accurately, quickly and easily than classification methods. For this study Normalized difference water index (NDWI), modified water index (MNDWI) water ratio index (WRI) and automated water extraction index (AWEI) were used.

Supervised classification method is applied by using Maximum Likelihood Algorithm to obtain CORINE Level 1 classification that has been established by the European Union (EU) as a land-use/cover definition hierarchy. According to classification results, there has been a dramatic change in the wetland's land-use distribution. On the classification of satellite images, it is clearly observed that the lake has been largely dried within a time scale of 28 years. Wetland area has decreased to 360 ha in 2015, while it was 5478 ha in 1987 indicating a decline by 93.4%.

Multi-sensor data approach for vegetation condition research: case study – Tatras, Poland

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Multi-sensor data give an advantage to obtain more information than can be derived from each of the single sensor data alone. Different sensors give different information about the same object. Integration of an information collected by satellite sensor (Landsat OLI), airborne sensor (LiDAR scanner) and remote sensing field instruments to assess vegetation condition was the objective of this research. The study area is located in Tatra Mountains in south Poland and it is protected by Tatra National Park which is enlisted on UNESCO M&B program. This area were selected due to the natural value and sensitivity to changes caused by nature and human.

Airborne Laser Scanning data were acquired in 2011 and Landsat OLI image in 2013 (September). Landsat image were atmospherically corrected using ATCOR 3 software and resized to National Park border area. Terrain measurements were carried out in second half of August 2013 and 120 polygons were obtained in lower and upper montane, subalpine and alpine zones of Tatra Mountains. For each polygon were measured spectral curves using ASD FieldSpec 3 JR spectrometer, Leaf Area Index using LAI-2000 Plant Canopy Analyzer (for meadows) and hemispherical camera (for forests) amount of photosynthetic active radiation using AccuPAR ceptometer (for meadows) and coordinates using Trimble GeoXT GPS receiver. Based on spectral characteristics vegetation indices were calculated: Normalized Difference Vegetation Index, Simple Ratio Index, Soil Adjusted Vegetation Index, Optimized Soil-Adjusted Vegetation Index, Wide Dynamic Range Vegetation Index, Atmospherically Resistant Vegetation Index, Green Normalized Difference Vegetation Index, Enhanced Vegetation Index, Plant Senescence Reflectance Index, Normalized Pigment Chlorophyll Ratio Index, Visible Atmospherically Resistant Index, Normalized Difference Infrared Index and Moisture Stress Index. The same indices were calculated using corrected Landsat OLI image. Values of indices from terrain measurements and satellite data were correlated. It allowed to select the best correlated indices from both of levels. Then indices calculated on Landsat were correlated with LAI and APAR for meadows and with LAI only for forests which allowed to obtain maps of distribution of these parameters. LiDAR data were additionally used to find out gaps in forests.

Landsat image was divided into non-forest and forest area by masking them in order to obtain the results for them separately. Based on maps of calculated indices including also LAI and APAR values distribution the Support Vector Machine classification of non-forest and forest vegetation condition was performed. The classes of both vegetation types were divided into poor, medium and good condition. To assess the classification accuracy 40 polygons measured in the terrain were used. The overall

accuracy of classification for non-forest vegetation was 81.8 % and for forests 91.7%. Proposed approach was also verified using Landsat data from August and September 2015 and field data as spectral characteristics and hemispherical photographs collected in August 2015.

Spatial Data Based Multicriteria Analysis for Vineyard Site Selection

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Having high economical and societal values, viticulture is an important agricultural practice for several countries including Turkey, with the fourth largest vineyard areas among the leading grape producing countries. Selection of suitable vineyard areas is outmost important to increase the yield and quality of grapes. There are several factors such as topography, soil type, meteorology etc. that impact the yield and quality and most of these factors are depend on geography. Therefore, applying a Geographic Information System based decision rule is a common approach for agricultural site selections. In this research, multi-criteria analysis was applied to Sarkoy region of Turkey in order to find out the best locations for vineyard planting. Several parameters such as land cover, meteorology, elevation, aspect, slope were considered during the analysis. Land cover maps, meteorological data, vegetation index map, slope and aspect maps were used as input to conduct spatial analysis. Different weights were assigned to different parameters based on their importance for viticulture activity. The weighting is defined as ratings of parameters in order of importance for a particular assessment. Weights of the criteria can be calculated by either ranking method, rating method, trade of analysis method or binary comparison method. Effects of weighting in the multi-criteria analysis for determination of suitable lands for vineyards were also examined. Current vineyard areas were determined using Worldview-2 imagery and spatial distribution of vineyard areas were compared with the resulting maps of multi-criteria analysis to find out if the current vineyards are planted in suitable locations and to give suggestions on alternative sites for new vineyard plantation.

Earth observation supported monitoring of oil field development in conflict-prone regions in South Sudan

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Several studies have found a positive correlation between the dependence on oil exports and violent conflicts in developing countries. Such conflicts are often linked with questions of cost-benefit distribution between central governments and the local population living near oil production areas. The conflicts are further fueled by grievances stemming from environmental destruction and social dislocation caused by oil exploration and exploitation activities. Oil is the most important source of revenue for the South Sudanese government. The development of the oil fields took place against the backdrop of Sudan's second civil war which lasted from 1983 to 2005. The history of oil exploration and production in the area was characterized by bloodshed, displacement and other grave human rights violations. Apart from the violence, oil field development led to big-scale environmental problems. Crop patterns changed, poorly constructed roads led to drain blocks which caused draughts and floods and polluted ponds posed a danger for humans and animals alike.

A case study on monitoring oil-related developments in Melut County, located in the Upper Nile region, in South Sudan for the period from 1999 to 2011 is presented. Conflict history of the region was visualised by conflict data taken from two conflict databases: Armed Conflict Location & Event Data Project (ACELD) and Uppsala Conflict Data Program (UCDP). Six points in time – 1999, 2002, 2004, 2006, 2009 and 2011 – were chosen to map human activity in the context of oil extraction and to assess its impacts in the area of interest. In order to document the spatio-temporal development of the oil fields and impacts on their surroundings, Landsat-5 and -7 satellite data was analysed with regard to land cover changes as well as the evolution of transportation and oil field infrastructure. Two very high resolution scenes (WorldView-2, QuickBird-2) from 2004 and 2012 were also analyzed to explore reported population growth in the town of Paloich. Feature extraction consisted of onscreen digitization as well as classification approaches. With regard to the latter, pixel- and object-based classification of land cover was performed as a base for further object-based classification of cropland areas and oil well pads. The interplay between the features of interest was investigated by applying geospatial analysis operations.

Apart from a sharp decline in cropland areas between 1999 and 2002, agricultural lands increased steadily over time and more than doubled in size. Oil infrastructure grew enormously in size throughout the whole time series with 555 oil well pads identified in 2011, compared to a single one in 1999. Geospatial analysis revealed that causal connections between the increase in all three types of features is likely, but cannot be assessed solely from satellite data. Remotely sensed information and its geospatial analysis added not only an additional perspective to developments on the ground but also proofed to be a valuable analysis tool for conflict researchers.

Ground Based InSAR Monitoring of a Landslide Affecting an Urban Area

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Ground-Based DInSAR systems can be used to monitor the deformation of single slopes and the most commonly used configuration consists in leaving installed the apparatus in situ, acquiring data with a cadence of tens of minutes, and processing sets of GBSAR images acquired without moving the system. This is called continuous GBSAR (C-GBSAR). In this case the instrumentation is dedicated to a single site for the whole survey period. In this paper a different methodology is applied, which is called discontinuous GBSAR (D-GBSAR): the radar is installed and dismounted, performing single one-day measurement campaigns, and revisiting the site periodically, with a period that is chosen according to the estimated velocity of the observed phenomenon. With respect to the continuous approach this choice is rarely used due to some potential drawbacks as the phase unwrapping complexity, the loss of coherence and a difficult estimation of the atmospheric effects. In some cases, as the one reported in this paper, the experimental conditions can be more favorable and the discontinuous monitoring can demonstrate to be fairly effective.

Data here reported are the results of an experimental campaign aimed at monitoring a landslide in an urban area, spanning four years and visiting the site almost yearly. A set of images was acquired for each campaign using a commercial interferometric radar system, and processed with software deevoped at CTTC: interferograms were generated and the associated coherence calculated. A pixel selection was performed, which aimed at separating the pixels that contain information (deformation measurements) from those that are dominated by noise, according to the Persistent Scatterers rationale. Atmospheric Phase Screen (APS) was also estimated for each campaign, making use of known stable areas located in the observed scene. Finally, the APS-cleaned phases were converted in Line-Of-Sight (LOS) displacements and geocoded, obtaining the two main GBSAR products: the geocoded accumulated deformation maps and the geocoded deformation time series. The monitored area is an urban area: the village of Barberà de la Conca (Catalonia, Spain). This small village has experienced deformations since 2011 that have caused cracks in several buildings. Five D-GBSAR campaigns were performed from November 2011 to December 2015. The radar was installed outside the village at an average distance of 500 m. The data analysis was based on 10 SAR images for each campaign, from which four coherently averaged images were derived. The goal of the monitoring was to detect the deformation affecting the slope based on the discontinuous GBSAR (D-GBSAR) configuration. This acquisition mode is apt to monitor slow deformation phenomena in urban areas. It offers the advantage of reduced monitoring costs by using the same instrument over several sites. However, it requires a more complex data processing and, yields reduced measurement density, precision and reliability.

Thanks to its physical and geometrical features, the urban case study here discussed represents a fine example, which was derived in a fully remote mode, a relevant aspect for applications where the accessibility to the area of interest is difficult or risky.

Assessment of coastal aquaculture ponds in Asia with high resolution SAR Data

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Aquaculture is one of the fastest-growing animal food production sectors worldwide and is the main source of valuable animal protein in many countries. The farming of fish, crustaceans and mollusks generated income and employment for many people in rural coastal areas and has attracted considerable attention for its high export value and potentials in terms of protein supply and global food security. Rising demand for fish, crustaceans and mollusks, and international trade has driven the rapid expansion of the total global aquaculture production with an increase from 17.8 Mio tones in 1993 to 70.2 Mio tones in 2013. Farmed aquatic products account for 43 percent of the total volume of aquatic food produced in 2013 and it is foreseen that aquaculture will be the main source of aquatic animal food in human consumption since capture fisheries production stagnated over the past years.

Asia alone generates nearly 90 percent of the total aquaculture production worldwide – and China is by far the largest producing country with a share of more than 65 percent of the global aquaculture production. Aquaculture has mainly been developed in valuable fertile environments along the coasts in Southeast Asian and East Asian countries and caused large-scale land use changes, destruction and loss of coastal wetlands and pollution of waters and soils. Quantitative assessment of the spatial extent and distribution of aquaculture is of utmost importance for a sustainable management of land and water resources. Such information can further be used to identify and investigate environmental impacts which might deserve special attention in terms of future human and ecosystem health. However, inventory data barely exists on national or regional level but is crucial to analyze current status and trends of aquaculture development around the globe. Here, earth observation can effectively support the planning and management of aquaculture practices and the implementation of adequate regulations and protection measures.

In this presentation we address the potentials of radar data processing to map large-scale coastal aquaculture areas in Asia, highlighting the opportunities to delineate coastal pond structures using advanced SAR data. Radar instruments provide all-weather capabilities obtaining cloud-free imagery which increases capabilities to monitor and map aquaculture structures – such as ponds – and is therefore a promising data source for aquaculture research. As part of the established European Copernicus program, the Sentinel-1A C-band SAR satellite has been launched in 2014 imaging the earth's surface at high spatial resolution for more than a year now. The free and open access data policy of the Sentinel fleet opens up new opportunities to process large-scale and timely data to analyze aquaculture on local, regional and even global scale.

In our study, Sentinel-1A interferometric wide swath mode imagery is being used to test the capabilities of radar imagery to delineate aquaculture ponds in coastal test areas in China and Vietnam.

Rainfall Maps from Medium Resolution Satellite Data – A Key to Understand Long-term Dynamics in Hyper-Arid Environments

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In water-limited arid ecosystems understanding long-term plant-water-climate relations are one of the primary keys to fundamental knowledge about ecosystem dynamics. Governed, as they are, by slow dynamics yet exposed to comparatively fast environmental changes, dryland ecosystems are at risk of irreversible changes. In environmental and ecological research, however, they have not in some respects, received the attention they require. The dynamics, mechanisms, and long-term effects of the variability of this part of the xerosphere remain poorly known, and climatic records are virtually non-existent.

In this paper the potential of Earth Observation data is explored as a source of information about rainfall events in a hyper-arid desert environment. This is based on the correlation between growth of ephemeral vegetation and rainfall events. Low resolution satellite data from, e.g., NOAA AVHRR and MODIS have been successfully applied to monitor spatio-temporal dynamics and changes in the Sahel. In the hyper-arid parts of North-Africa, however, the contracted vegetation pattern requires at least medium resolution imagery for ephemeral vegetation monitoring. Landsat imagery has long been recognized as an efficient tool to monitor and map changes in ecosystems due to its fine spatial resolution and over 40 year long history of records. Its presently free availability and improved data processing capacity make it possible to exploit this material in multi-temporal analyses that earlier were too expensive and computationally-intensive.

In this paper a method to derive rainfall maps from Landsat is tested along an aridity gradient. Rainfall-pulse maps are derived based on the spatio-temporal size and extent of greening events in watersheds. The workflow includes 1) assessment of geometric accuracy and radiometric comparability 2) multi-temporal change/trend analyses and 3) classification and visualisation of duration and magnitude of ephemeral greening pulses.

Successful computation of rainfall pulse maps from hyper-arid areas will be a breakthrough as a proxy for rainfall in dry areas that lack meteorological observations. Hence they will be a key for understanding long-term dynamics and natural versus human-induced changes in arid ecosystems.

Urban Anthropogenic heat flux estimation from space: first results

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While Earth Observation (EO) has made significant advances in the study of urban areas, there are several unanswered science and policy questions to which it could contribute. To this aim the recently launched Horizon 2020 project URBANFLUXES (URBan ANthrpogenic heat FLUX from Earth observation Satellites) investigates the potential of EO to retrieve anthropogenic heat flux, as a key component in the urban energy budget. The anthropogenic heat flux is the heat flux resulting from vehicular emissions, space heating and cooling of buildings, industrial processing and the metabolic heat release by people. Optical, thermal and SAR data from existing satellite sensors are used to improve the accuracy of the radiation balance spatial distribution calculation, using also in-situ reflectance measurements of urban materials are for calibration. EO-based methods are developed for estimating turbulent sensible and latent heat fluxes, as well as urban heat storage flux and anthropogenic heat flux spatial patterns at city scale and local scale by employing an energy budget closure approach. Independent methods and models are engaged to evaluate the derived products and statistical analyses provide uncertainty measures as well. Ultimate goal of the URBANFLUXES is to develop a highly automated method for estimating urban energy budget components to use with Copernicus Sentinel data, enabling its integration into applications and operational services. Thus, URBANFLUXES prepares the ground for further innovative exploitation of European space data in scientific activities (i.e. Earth system modelling and climate change studies in cities) and future and emerging applications (i.e. sustainable urban planning) by exploiting the improved data quality, coverage and revisit times of the Copernicus data. The URBANFLUXES products will therefore have the potential to support both sustainable planning strategies to improve the quality of life in cities, as well as Earth system models to provide more robust climate simulations. More information on the project can be found at http://urbanfluxes.eu/.

Innovative Approach to Retrieve Land Surface Emissivity and Land Surface Temperature in Areas of Highly Dynamic Emissivity Changes by Using Thermal Infrared Data

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The land surface temperature (LST) is an extremely significant parameter in order to understand the processes of energetic interactions between the Earth's surface and the atmosphere. This knowledge is significant for various environmental research questions, particularly with regard to climate change. The current challenge is to reduce the higher deviations during daytime especially for bare areas with a maximum of 5.7 Kelvin. These temperature differences are time and vegetation cover dependent. This study shows an innovative approach to retrieve land surface emissivity (LSE) and LST by using thermal infrared (TIR) data from satellite sensors, such as SEVIRI and AATSR.

So far there are no methods to derive LSE/LST particularly in areas of highly dynamic emissivity changes. Therefore especially for regions with large surface temperature amplitude in the diurnal cycle such as bare and uneven soil surfaces but also for regions with seasonal changes in vegetation cover including various surface areas such as grassland, mixed forests or agricultural land different methods were investigated to identify the most appropriate one.

The LSE is retrieved by using the day/night Temperature-Independent Spectral Indices (TISI) method, while the Generalised Split-Window (GSW) method is used to retrieve the LST. Nevertheless different GSW algorithms show that equal LSEs lead to large LST differences. For bare surfaces during daytime the difference is about 6 Kelvin. Additionally LSE is also measured using a NDVI-based threshold method (NDVITHM) to distinguish between soil, dense vegetation cover and pixel composed of soil and vegetation. The data used for this analysis were derived from MODIS TIR.

The analysis is implemented with IDL and an intercomparison is performed to determine the most effective methods. To compensate temperature differences between derived and ground truth data appropriate correction terms, by comparing derived LSE/LST data with ground-based measurements, are developed. One way to calibrate LST retrievals is by comparing the canopy leaf temperature of conifers derived from TIR data with the surrounding air temperature (e.g. from synoptic stations).

Prospectively, the derived LSE/LST data become validated with near infrared data obtained from an UAV with a TIR camera (TIRC) onboard, and is also compared with ground-based measurements.

This study aims to generate an appropriate method to eventually obtain a high correlation between LSE/LST, TIRC and ground truth data by integrating developed correction terms.

Earthquake Anomalies Recognition Through Satellite and In-Situ Monitoring Data

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Medium- to short-term earthquake prediction is becoming ever more essential for safeguarding man, but till now there have been no verifiable methods of reliable earthquake prediction developed. As one of the most seismically active area in Europe, Vrancea region in Romania presents a relatively high potential of seismic risk mainly due to the subcrustal earthquakes located at the sharp bend of the Southeast Carpathians. Earthquake prediction has two potentially compatible but distinctly different objectives: (a) phenomena that provide information about the future earthquake hazard useful to those who live in earthquake-prone regions and (b) phenomena causally related to the physical processes governing failure on a fault that will improve our understanding of those processes. Cumulative stress energy in seismic active regions under operating tectonic force manifests various earthquakes' precursors. This energy transformation may result in enhanced transient thermal infrared (TIR) emission, as well as of local magnetic field variations, electromagnetic emissions over a wide range of frequencies, a variety of atmospheric and ionospheric phenomena, clear evidenced from optospectral satellite recordings. For seismic hazard analysis in Vrancea area, Romania have been selected the earthquake precursors detectable from space which can also be observed by ground-based monitoring experiments: surface deformation provided by GPS and SAR imaging, land surface temperature anomalies as possible precursors provided by time-series satellite which can be detected through satellites equipped with thermal sensors like MODIS (Terra/Aqua) and AVHRR (NOAA), Landsat TM and ETM, electromagnetic and ionospheric anomalies, radon gas emissions in the faults areas prior to earthquakes, as well as seismicity. The joint analysis of geodetic, seismological and geological information on the spatial distribution of crustal deformations is revealing new insights in the understanding of the kinematics and dynamics of the complex plate boundary system present in the Eastern Carpathians. Fusion of satellite (LANDSAT TM, ETM, SAR-ERS, and ASTER), GPS and field data on Vrancea area including radon (Rn222) concentrations variation provides a better monitoring of different geophysical parameters and long-term deformation in relation with earthquake activity. Multispectral and multitemporal satellite LANDSAT TM/ETM, MODIS (Terra/Aqua) and AVHRR (NOAA) time-series data over 2000-2014 period have been analyzed for recognizing the continuity and regional relationships of active faults as well as for geologic and seismic hazard mapping. GPS Romanian network stations data revealed a displacement of about 5 - 6 millimeters/year in horizontal direction relative motion, and a few millimeters/year in vertical direction. Spatio-temporal radon (Rn222) concentrations variation as well as land surface temperature and latent heat flux are well correlated with seismic events of moment magnitude Mw >4.5. As Vrancea zone

has a significant regional tectonic activity in Romania and Europe, the survey and joint analysis of geospatial and in-situ geophysical information of land surface and outgoing long-wave radiation reveal new insights in the field of seismic hazard assessment.

Combined Use of Radar Data, Optical Data and GIS Techniques for Flood Expansion.

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Floods are suddenly and temporary natural disasters and one of the most common hazards all over the world. They influence equally important the society and the natural environment, hence flood propagation mapping is crucial. Floods are affecting areas which are normally dry by overtopping the natural boundaries of the river due to the due to reduced capacity of the river channel to deal with the increasing accumulation of rainwater or snow melt water. The laboratory of Hydrogeology of the department of Geology can contribute to flood research with conventional hydrogeological methods as well as with modern remote sensing methods, extracting satisfactory and effective results in both cases. This work is focused on expansion of water bodies of the river Evros, North Greece, as they overtopped the natural levees of the river and they invaded in the surroundings areas converting them in flooded, as a result of the intense rains. In that context different remote sensing techniques may be exploited with sufficient and effective results. In particular, radar data from Sentinel-1 mission as well as optical data from Landsat-8 were utilized. Concerning, Sentinel-1 data before flood events, named "archived images", were treated with respectively during flood, called "crisis images", yielding images which reflect the spread of the flood event. On the other hand, regarding optical data, Landsat-8 data were acquired in order to identify and map the flooded areas, utilizing the Normalized Difference Water Index calculation and Modified Normalized Difference Water Index calculation, where the exploitation of different band combination leads to slightly variegated results. Both methods for flood propagation mapping were compared to each other and the flooded areas were estimated quantitatively. In addition, aiming to verify the results of two techniques DEMs were imported in a GIS environment. Initially, it was materialized an automatic drainage network extraction. The procedure contains the following steps DEM Fill, Flow Direction, Flow Accumulation, Threshold value selection, Stream Link, Stream Order and Stream to Feature. The results of that procedure were associated with the flooded areas, which were extracted from the two other techniques. Observations were mentioned and conclusions were recorded. The results are presented in the current study.

Time-Series Satellite Imagery for Assesment of Urban Green Changes

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Urban vegetation, known as green space that includes vegetated areas such as parks or forest stands, and isolated trees growing along streets, in street medians, or private property, is a critical issue for both a healthy population as well as for city economy. Urban vegetation cover in cities is constantly changing due to various natural and anthropogenic pressures. Natural forces for change include natural regeneration, vegetation growth and vegetation mortality from insects and diseases or old age. Anthropogenic factors that influence urban vegetation cover include tree planting and tree mortality or removal from either direct or indirect human actions such as development and air pollution. The combination of these factors through time determines existing and future vegetation cover levels. Accurate information is essential for estimation of changes in surface energy balance and atmospheric greenhouse gas emissions, and Urban Heat Island function at local and regional scale as well as urban land cover/use dynamics in frame of global warming. Through reducing air pollution, and providing recreational places, green spaces play important functions in urban environments. With the rapid change of Bucharest metropolitan area in Romania, during the past decades, urban green was fragmented and dispersed causing impairment and dysfunction of these important urban elements. Climate variability and change can exert profound stresses on urban green environment, which are sensitive to heat waves, droughts, and changes in the frequency of precipitations. As future climate trends have been predicted to increase the magnitude and negative impacts of urban heat waves in metropolitan areas, there is an urgent need to be developed adequate strategies for societal vulnerability reducing. This study explored the use of time-series MODIS Terra/Aqua Normalized Difference Vegetation Index (NDVI) and Leaf Area Index (LAI), data to provide vegetation change detection information for metropolitan area of Bucharest in Romania. Training and validation are based on a reference dataset collected from IKONOS high resolution remote sensing data. The mean detection accuracy for period 2002- 2015 was assessed to be of 88%, with a reasonable balance between change commission errors (20.3%), change omission errors (25.7%), and Kappa coefficient of 0.71. Annual change detection rates across the urban/periurban areas over the study period (2002–2015) were estimated at 0.79% per annum in the range of 0.46% (2002) to 0.86% (2014).Vegetation dynamics in urban areas at seasonal and longer timescales reflect large-scale interactions between the terrestrial biosphere and the climate system. This paper demonstrates the potential of moderate-and high resolution, multispectral imagery to map and monitor the evolution of the physical urban green land cover.

Turbidity from Space: Integration of Satellite Data into an Operational Sediment Monitoring

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The applications of remote sensing in hydrology are divers and offer significant benefits for water monitoring. Up to now, river monitoring and sediment management in Germany mainly rely on in-situ measurements and results obtained from numerical modelling. Remote sensing by satellites has a great potential to supplement existing data with two-dimensional information on near-surface turbidity distributions at greater spatial scales than in-situ measurements can offer. Within the project WasMon-CT (WaterMonitoring-Chlorophyll/Turbidity), the Federal Institute of Hydrology (BfG) aims at the implementation of an operational monitoring of turbidity distributions based on satellite images (Sentinel-2, Landsat7 & 8). Initially, selected federal inland and estuarine waterways will be addressed: Rhine, Elbe, Ems, Weser. WasMon-CT is funded within the German Copernicus activities. Within the project, a database of atmospherically processed, geo-referenced turbidity data will be assembled. The collected corresponding meta-data will include aspects of satellite data as well as hydrological data, e.g. cloud cover and river run-off. An important part of the project is the validation with in-situ data and the assessment of uncertainties. The database will include past as well as recent satellite images and is designed with a long-term perspective to optimize the existing in-situ measurement network. Here, turbidity is used as proxy for corresponding suspended sediment concentrations. Derived products as e.g. longitudinal profiles or virtual measurement stations will be developed to specifically match requirements of operational monitoring tasks and to allow for a better integration into the existing monitoring system. This new approach will be of great value to assess, evaluate and monitor the status or the change of large-scale sediment processes at the system level. Accordingly, the satellite-derived turbidity data will strongly enhance federal consulting activities and thus ensure a high quality river monitoring of Germany's federal water ways.

Multi-Source Remote Sensing Observation of Land and Water Surface Dynamics of the Yellow River Delta

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River deltas globally are home to a growing population. Already today 550 million people live in deltas which cover only 5% of Earth's surface. Generally, river deltas and coastal environments are rich in natural resources such as natural oil and gas, fresh water, fertile soils, and are rich in biodiversity.

The dynamically changing surface of the Yellow River Delta at the Bohai Sea, China, serves as a test case for this study. The Yellow River Delta has been undergoing extensive man-made modifications of the landscape since the exploitation of large oil and gas resources has started at the end of 1960s. This main influencing factor has caused rapid urbanization during the last few decades and puts the deltas ecosystems under strong anthropogenic pressure. From the natural perspective the Yellow River Delta is surrounded by water, influenced and affected by precipitation, river runoff, inundation, and increasingly threatened by sea level rise. In view of this, the observation and mapping of water surfaces is central to most monitoring activity in river deltas, e.g. monitoring of environmental dynamics, wetland changes, and land use developments. Satellites provide a cost effective way for deriving periodical and area wide information on water and land surfaces.

For water surface mapping especially satellite data from active SAR systems that can be used to monitor the Earth's surface independently of prevailing cloud coverage provide highly valuable sources of information. In the presented study surface water is detected with the easy-to-use satellite data analysis tool WaMaPro – which stands for Water Mask Processor. It is capable of utilizing any kind of radar data, such as Envisat ASAR, TerraSAR-X, and Sentinel-1. A knowledge-driven threshold-based approach combined with morphological operations separates surfaces with very low backscatter, i.e. water surfaces from those with high backscatter, i.e. land surfaces. With respect to the analyses of coastal dynamics, the surface water of the Yellow River Delta was monitored since 2005 until today.

Secondly, the land surface area of the delta was analysed with regard to land use change. Based on change detection of land cover maps derived from 1995 Landsat 5 and 2013 Landsat 8 data 18 years of change were quantified. Vast changes due to aquaculture and agriculture expansion were detected caused by population increase and strong urban expansion. The results furthermore show that natural coverages such as meadows, shrubs (e.g. Tamarisk), broadleaf forests, and tidal flats were unrecoverably destroyed in the delta.

The land and water surface conditions of the Yellow River Delta were analysed with multi-source Earth observation data from optical and SAR sensor sources for the last two decades. Derived information can serve as information sources to support scientists and decision makers in their respective activities towards a sustainable development of the Yellow River Delta.

EARSeL Young Scientist Days
Bonn 2016

YOUNG SCIENTIST DAYS

YSD – OVERVIEW

YSD - 01: Optical Remote Sensing & SAR
Location: S 25/26
Lecturer: **Dr. Francesco Sarti**, ESA's European Space Research Institute (ESRIN), Italy

YSD - 02: Optical Remote Sensing
Location: S 25/26
Lecturer: **Dr. Thomas Bahr**, Harris Corporation, Germany

YSD - 03: Optical Remote Sensing
Location: S 25/26
Lecturer: **Dr. Samantha Jane Lavender**, Pixalytics Ltd, United Kingdom
Chair: **Adriana Marcinkowska-Ochtyra**, University of Warsaw, Faculty of Geography and Regional Studies, Poland

YSD - 04: Big Data with MATLAB
Location: S 25/26
Lecturer: **Dmitrij Martynenko**, Mathworks, Germany
Chair: **Edwin Raczko**, University of Warsaw, Faculty of Geography and Regional Studies, Poland

YSD - 05: SAR
Location: S 25/26
Lecturer: **Dr. Chris Stewart**, ESA's European Space Research Institute (ESRIN), United Kingdom
Chair: **Dr. Anna Jarocinska**, University of Warsaw, Faculty of Geography and Regional Studies, Poland

YSD - 06: Optical Remote Sensing & SAR
Location: S 25/26
Lecturer: **Dr. Chris Stewart**, ESA's European Space Research Institute (ESRIN), United Kingdom
Chair: **Adrian Ochtyra**, University of Warsaw, Poland

YSD – 01, 05, 06: Optical Remote Sensing & SAR

Practical sessions will be provided by the European Space Agency (ESA) on the processing of Earth Observation (EO) data for a number of applications. The sessions will utilise the Sentinels Application Platform (SNAP) software to process and analyse optical and radar satellite datasets acquired by the Sentinel satellites and ENVISAT.

SNAP is a free and open source toolbox developed by ESA for the scientific exploitation of Earth Observation missions. The software, documentation and user forum can be accessed through the Science Toolbox Exploitation Platform (STEP) website (http://step.esa.int/main/). The ESA toolboxes support ERS-ENVISAT, Sentinels 1/2/3 and a range of National and Third Party missions.

The sessions will demonstrate the main techniques for optical and Synthetic Aperture Radar (SAR) data processing, from image preparation to analysis, and will reveal ways to extract the spectral and spatial information content of all the sensors introduced. Participants will be shown how to import datasets, perform radiometric calibration and geometric correction, carry out spectral analysis, calculate indices such as the Normalised Difference Vegetation Index (NDVI), and export datasets for visualisation and data comparison in other software. The full SAR processing chain for various applications will be applied using both Ground Range Detected (GRD) and Single Look Complex (SLC) data types.

By the end of the sessions participants will have gained a thorough familiarity with the SNAP toolbox and an exposure to satellite data of various types and processing levels from a range of sensors.

YSD - 02: Optical Remote Sensing

New ENVI technologies for spatio-temporal analysis and photogrammetry

In this interactive workshop you will learn a) the latest techniques of the ENVI platform for spatio-temporal analysis and b) the generation and evaluation of photogrammetric point clouds, both on the basis of selected exercises.

We will create a time series of images acquired from different Landsat sensors and use advanced features such as animation, context information, linking with other time series, and video export. The pre-processing of these data will also be considered.

With the Photogrammetry Module you will generate point clouds in LAS format from high resolution Pléiades stereo data. The LiDAR tools will be used to derive surface and terrain models from these point clouds.

IDL code examples will show you how to easily automate such tasks by using the ENVI API. And by the interplay of IDL and Python, these workflows can be seamlessly inserted into your GIS workflows.

YSD - 03: Optical Remote Sensing

The aim of the training course is to provide a practical session where the participants can experiment with using the European Space Agency (ESA) Sentinel Application Platform (SNAP) toolbox alongside Quantum GIS (QGIS). It will provide both a theoretical and practical understanding of remote sensing by following the contents of the following chapters from 'The Practical Handbook of Remote Sensing' (https://www.crcpress.com/Practical-Handbook-of-Remote-Sensing/Lavender-Lavender/p/book/9781498704335):

- Chapters 6 & 7: Image Processing and Geographical Information Systems

- Chapter 8: Urban Environments and their Signatures: including spectral and thermal signatures.

- Chapter 9: Landscape Evolution: including vegetation indices and image classification.

Chapters 6 and 7 will presented as a short (15 minute) introductory presentation, and then the participants will undertake practical exercises to put the knowledge gained into practice. These exercises are from Chapters 8 and/or 9 depending on their personal interests, e.g. use of SNAP and/or QGIS, with the tutor providing support. Pre-downloaded example data will be available from the Landsat and MODIS missions alongside Sentinel-2, which was not included in the book due to the public release occurring after publication.

Participants should bring their own laptop, and have SNAP
 (http://step.esa.int/main/download/)
and QGIS (http://www.qgis.org/en/site/forusers/download.html) installed in advance of the practical.

YSD - 04: Big Data with MATLAB

Data is everywhere; every year we store more of it. Huge data sets present an amazing opportunity for discovering new things about our world, about the products we make and how people interact with them. However, big data sets also present some challenges regarding analysis, interpretation and intelligence leading to data-driven decision making.

A primary driver for collecting data on a broader scale is the ever increasing digitization of information. The number and types of acquisition devices and other data generation mechanisms are growing continuously. Big data sources include streaming data from instrumentation sensors, satellite or medical imagery. Those applications alone generate gigabytes or terabytes of data, which may grow on the order of megabytes or gigabytes per day.

Big data represent opportunities for analysts and data scientists to gain better insights and the ability to make data-driven decisions. It equally presents a number of challenges. Big data sets may not fit into available memory, may take too long to process, or may stream too quickly to store. Standard algorithms are usually not designed to process big data sets in reasonable amounts of time or memory.

There is no single approach to big data. Therefore, MATLAB provides a number of tools to tackle these challenges.

This talk looks at the tools that MATLAB provides for dealing with data-sets of all sizes with focus on scientific data formats like HDF/NetCDF and big satellite image data.

FLOOR PLAN
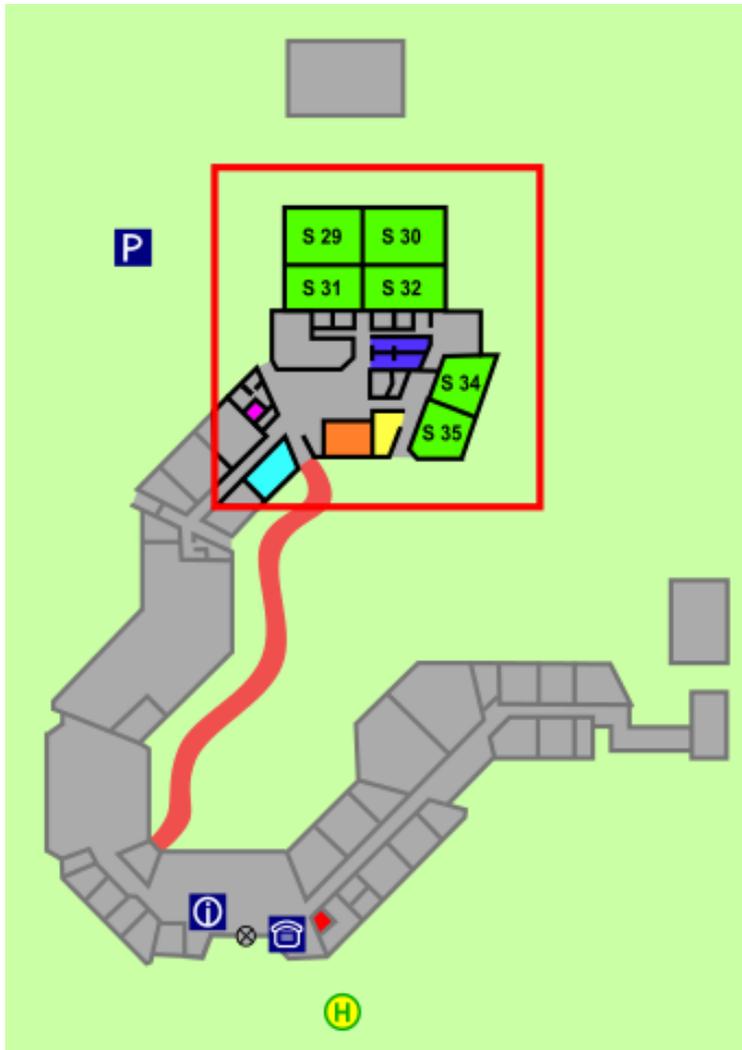
🟩 Session Rooms	🟦 WC	🅿 Parking
🟧 Conference Office	🟪 Disabled WC	☎ Telephon
🟦 Exhibition	🟨 Stairs	ⓘ Information
	🟥 Lift	Ⓗ Bus Station