Foreword to the Special Issue on Analysis of Multitemporal Remote Sensing Images

THE motivation for this Special Issue was the opportunity to solicit contributions from papers presented at the 9th International Workshop on the Analysis of Multitemporal Remote Sensing Images (MultiTemp 2017), hosted by VITO Remote Sensing on June 27–29, 2017. The MultiTemp biannual conference's primary objective is to advance the knowledge on the methodologies and the applications related to EO time series. Since its foundation in 2001, the scientific development in multitemporal analysis has evolved from bitemporal change detection methods to signal-processing methods for the analysis of long image time series of multidimensional data, and from single-sensor approaches to multisensor methods based on data fusion. This evolution not only originates from the technological development of sensor systems and the availability of a multitude of high quality EO data from a wide range of instruments, but also from evolving societal challenges that require different approaches and are reflected in more stringent user requirements.

These evolutions demand both the development of advanced methodologies for the analysis of EO time series and the establishment of suitable EO time series derived from various instruments. Harmonization of the datasets from different sensors is, therefore, often needed. Another emerging requirement is the traceability and uncertainty characterization of the information derived from the time series. To be able to assess whether user requirements are met, appropriate validation strategies and adequate fiducial reference measurements are a prerequisite. MultiTemp 2017 placed the methodological improvements within the different application fields central, in order to facilitate the cross fertilization between different approaches.

This special issue of the IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing (JSTARS) contains papers that were presented at the 9th MultiTemp workshop as well as regular papers that were received from a general call for papers published in JSTARS.

A number of contributions focus on methodological improvements related to change detection and deep learning using multitemporal datasets. Unsupervised change detection methods are investigated for different application fields such as environmental monitoring of natural resources, disaster assessment, and detection of human-induced changes, such as urbanization ([item 11) in the Appendix], [item 13) in the Appendix], [item 9) in the Appendix], and [item 1) in the Appendix]). Novel change detection methods are presented for SAR data [item 13) in the Appendix], polarimetric SAR [item 1) in the Appendix], and optical data ([item 9) in the Appendix] and [item 11) in the Appendix]). The emerging area of deep learning is addressed by a number of authors for a variety of purposes. Item 2) in the Appendix applied and compared various machine learning methods to crop monitoring and yield estimation and prediction. To improve land cover classifications based on multitemporal images, [item 5) in the Appendix] used convolutional neural networks and [item 6) in the Appendix] included NDVI statistic and phenology features from a fused Landsat 8 and MODIS data set.

Other authors examine the use of multitemporal datasets in a large number of application domains. Item 12) in the Appendix analyze the area of lakes that have been seriously affected by economic development and urbanization using a long time series of MODIS data. Item 4) in the Appendix develops an unsupervised clustering technique for long time series of MERIS data to obtain an optical classification of one of these lakes. Both analyses provide critical information for future environmental conservation planning. Long time series were also used to investigate the impact of climate change on vegetation. Item 7) in the Appendix analyzed the changes of wheat vegetative growth response to climate change using phenological algorithms in order to improve regional crop growth monitoring and management. Item 8) in the Appendix investigated the influence of altitude on the relationship between vegetation (presented as net primary production derived from NDVI) and climate variability to obtain a better understanding of impacts of climate change on vegetation. Item 3) in the Appendix explore data from the NASA Airborne Microwave Observatory of Subcanopy and Subsurface (AirMOSS) mission to repeatedly map high-resolution root-zone soil moisture fields, which are needed for accurate estimation of grid-scale fluxes of water, energy, and carbon. Item 10) in the Appendix evaluated a five-year dataset of SMOS soil moisture data with *in-situ* data.

A number of the papers contained in this Special Issue were presented at the MultiTemp 2017 workshop. They represent a sampling of the cross-cutting science issues associated with the exploitation and application of multitemporal imagery data. The Guest Associate Editors would like to thank the Belgian Science Policy Office for its workshop sponsorship.

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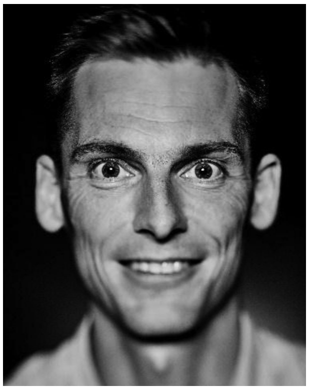
APPENDIX
RELATED WORK

1) Ghanbari and Akbari, "Unsupervised change detection in polarimetric SAR data with the hotelling-Lawley trace statistic and minimum-error thresholding," vol. 11, no. 12, Dec. 2018.
2) Aghighi *et al.*, "Machine learning regression techniques for the silage maize yield prediction using time-series images of landsat 8 OLI," vol. 11, no. 12, Dec. 2018.
3) Crow *et al.*, "Spatial and temporal variability of root-zone soil moisture acquired from hydrologic modeling and airmoss P-band radar," vol. 11, no. 12, Dec. 2018.
4) Guan *et al.*, "Optical classifications of Poyang lake water and long-term dynamics based on meris observations," 2018, vol. 11, no. 12, Dec. 2018.
5) Kim *et al.*, "Convolutional neural network-based land cover classification using 2-D spectral reflectance curve graphs with multitemporal satellite imagery," vol. 11, no. 12, Dec. 2018.
6) Huang *et al.*, "Comparing the effects of temporal features derived from synthetic time-series NDVI on fine land cover classification," vol. 11, no. 12, Dec. 2018.
7) Liu and Wang, "Detecting changes of wheat vegetative growth and their response to climate change over the North China plain," vol. 11, no. 12, Dec. 2018.
8) Guan *et al.*, "Climate control on net primary productivity in the complicated mountainous area: A case study of Yunnan, China," vol. 11, no. 12, Dec. 2018.
9) Shao *et al.*, "Indicator-Kriging-integrated evidence theory for unsupervised change detection in remotely sensed imagery," vol. 11, no. 12, Dec. 2018.
10) Walker *et al.*, "A five-year evaluation of SMOS level 2 soil moisture in the corn belt of the United States," vol. 11, no. 12, Dec. 2018.
11) Du *et al.*, "Unsupervised scene change detection via latent Dirichlet allocation and multivariate alteration detection," vol. 11, no. 12, Dec. 2018.
12) Xu *et al.*, "Dynamic monitoring of the lake area in the middle and lower reaches of the Yangtze river using MODIS images between 2000 and 2016," vol. 11, no. 12, Dec. 2018.
13) Zhang *et al.*, "SAR image change detection using saliency extraction and shearlet transform," vol. 11, no. 12, Dec. 2018.

Lorenzo Bruzzone (S'95–M'98–SM'03–F'10) received the Laurea (M.S.) degree in electronic engineering (*summa cum laude*) and the Ph.D. degree in telecommunications from the University of Genoa, Genoa, Italy, in 1993 and 1998, respectively.

He is currently a Full Professor in telecommunications with the University of Trento, Trento, Italy, where he teaches remote sensing, radar, and digital communications. He is the founder and the Director of the Remote Sensing Laboratory, Department of Information Engineering and Computer Science, University of Trento. He has authored and coauthored 218 scientific publications in referred international journals (157 in the IEEE journals), more than 290 papers in conference proceedings, and 21 book chapters. He is an Editor/Co-Editor of 18 books/conference proceedings and 1 scientific book. His papers are highly cited, as proven from the total number of citations (more than 25 000) and the value of the h-index (74) (source: Google Scholar). His current research interests include the areas of remote sensing, radar and SAR, signal processing, machine learning, and pattern recognition. He promotes and supervises research on these topics within the frameworks of many national and international projects. He is the Principal Investigator of many research projects. Among the others, he is the Principal Investigator of the *Radar for Icy Moon Exploration* instrument in the framework of the *JUpiter ICy Moons Explorer* mission of the European Space Agency.

Dr. Bruzzone was invited as a Keynote Speaker in more than 30 international conferences and workshops. He was a Guest Co-Editor for many Special Issues of international journals. Since 2003, he has been the Chair of the SPIE Conference on Image and Signal Processing for Remote Sensing. Since 2009, he has been a member of the Administrative Committee of the IEEE Geoscience and Remote Sensing Society (GRSS). He is the co-founder of the IEEE International Workshop on the Analysis of Multi-Temporal Remote-Sensing Images series and is currently a member of the Permanent Steering Committee of this series of workshops. Between 2012–2016, he was a Distinguished Speaker of the IEEE Geoscience and Remote Sensing Society. He has been the founder of the IEEE GEOSCIENCE AND REMOTE SENSING MAGAZINE for which he was the Editor-in-Chief between 2013–2017. He is currently an Associate Editor for the IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING. He ranked first place in the Student Prize Paper Competition of the 1998 IEEE International Geoscience and Remote Sensing Symposium (IGARSS), Seattle, WA, USA, July 1998. Since 1998, he has been the recipient of many international and national honors and awards, including the recent IEEE GRSS 2015 Outstanding Service Award and the 2017 and 2018 IEEE IGARSS Symposium Prize Paper Award.



Bart Deronde has been the Programme Manager with VITO's Remote Sensing unit, Mol, Belgium, since September 2008. VITO Remote Sensing develops and operates space- and airborne-based earth observation systems that translate raw data into consumable information about population, growth, urban development, agriculture and vegetation, natural disasters, etc. In his Ph.D., he investigated the use of airborne hyperspectral remote sensing and LiDAR for beach morphodynamics. Next to this area, he gained expertise in the use of air- and spaceborne remote sensing for vegetation mapping.

Since 2005, he has been combining scientific work with project management and team coordination. In autumn 2008, he joined the management team of the remote sensing unit, VITO, as the Operations Manager of the SPOT-VEGETATION and PROBA-V satellite missions. In the same year, he managed the operations of ESA's hyperspectral APEX sensor and started a new team on spatial data infrastructures. Since August 2015, he has been the Programme Manager and a Team Leader of the Remote Sensing Applications team. This team develops a wide variety of remote sensing applications ranging from commercial services to the agriculture sector to climate-impact monitoring for institutional users and a range of drone-based very high-resolution products and services.

Else Swinnen received the Ph.D. degree in geography from the Université Catholique de Louvain, Louvain-la-Neuve, Belgium (Vegetation dynamics in Southern Africa from NOAA-AVHRR and SPOT-VGT time series) and the Master's degree in applied biological sciences from Katholieke Universiteit Leuven, Leuven, Belgium.

In 1999, she joined VITO, where she is currently a Senior Scientist with the Remote Sensing Unit and an R&D project manager of the Image Quality Team focusing on the validation and improvement of remote sensing products. Her research interests include definition of algorithms for the preprocessing of medium- to low-resolution sensors, the validation of various remote sensing products, the harmonization of time series from various low-resolution sensors, and analysis of terrestrial ecosystem dynamics using time series of remotely sensed data. She coordinates the scientific support team of the PROBA-V processing centre, the ESA-funded projects PV-LAC, and TerrA-P. She is currently the Principal Investigator of a data provision contract for the Copernicus Climate Change Service and the Data Quality Manager in the Copernicus Global Land Service (Lot1). She is the Co-Leader of the CEOS LPV subgroup on vegetation indices, a member of the Quality Working Group of PROBA-V, and a member of the Mission Performance Centre of Sentinel-3.