4th International Conference
on the Status and Future of the
WORLD's LARGE RIVERS


Ob


Murray-Darling


Congo


Amazon


Mississippi


Volga

WORLDs LARGE RIVERS
MOSCOW 2021

3.-6. August 2021,
Moscow, Russia // Online

CONFERENCE PROGRAMME

RUSSIAN GEOGRAPHICAL SOCIETY · FOUNDED IN 1845 ·

IAHR AIRH International Association for Hydro-Environment Engineering and Research
Hosted by Spain Water and IWHR, China

IAHS AISH

SIL

WASER

IAG GEOMORPHOLOGY GEOMORPHOLOGIE AIG

1755

UNESCO
United Nations Educational, Scientific and Cultural Organization
Intergovernmental Hydrological Programme

BOKU

Contents

Welcome to the International Conference on the Status and Future of the World's Large Rivers

On behalf of the Local Organizing Committee and the International Scientific Committee we want to warmly welcome you to the 4th International Conference on the Status and Future of the World´s Large Rivers which will be held as online event hosted by Moscow State University, Russia.

The pressures and impacts on the World's Large Rivers have increased greatly in recent years, as a consequence of their exploitation to meet human needs. Large rivers are particularly exposed to problems of multiple uses, often with conflicting aims. At the global scale, there is no overview assessment of the current status of the World's Large Rivers, the conflicting demands on such rivers, and likely future anthropogenic impacts, as well as the potential for restoration and the associated problems.

In 2011 the first International Conference on **„The Status and Future of the World's Large Rivers"** in **Vienna, Austria**, provided a global forum for a wide-ranging discussion of key issues related to research on large rivers and to their effective and sustainable management, involving both scientists and decision makers. This successful event was continued in **Manaus, Brazil** at the fascinating Amazon River in 2014 and then in **New Delhi, India** in 2017. Now, we have the pleasure to meet again – even though it is only virtually this time – hosted by Moscow State University.

We wish you interesting scientific talks and discussions and hope that you will also join our online social events like Ice Breaker and the World's Large Rivers Initiative Meeting!

Nikolay Kasimov
Co-Chair of Local Organizing Committee

Sergey Dobroliubov
Co-Chair of Local Organizing Committee

Natalia Frolova
Co-Chair of Local Organizing Committee

Sergey Chalov
Co-Chair of Local Organizing Committee

Helmut Habersack
Initiator and Chair of the Scientific Committee

Bernhard Schober
Conference Secretariat

Michael Tritthart
Conference Secretariat

Martin Schletterer
Co-Organiser of the Scientific Committee

Local Organizing Committee

Nikolay Kasimov (LOC-Chair)
Lomonosov Moscow State University, Russian Geographical Society

Sergey Dobroliubov (Vice-Chair)
Lomonosov Moscow State University - Faculty of Geography

Natalia Frolova (Vice-Chair)
Lomonosov Moscow State University - Faculty of Geography

Sergey Chalov (Vice-Chair, General Secretary)
Lomonosov Moscow State University - Faculty of Geography

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Russian National Committee IHP

Maxim Yakovenko
Federal Service for Hydrometeorology and Environmental Monitoring of Russia

Artem Manukyan
Russian Geographical Society

Alexander Bedritsky
Russian Hydrometeorological Society

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Russian Academy of Sciences - Water Problems Institute

Endon Garmaev
Russian Academy of Sciences - Baikal Institute of Nature Management

Olga Solomina
Russian Academy of Sciences - Institute of Geography

Nikolai Koronkevich
Russian Academy of Sciences - Institute of Geography

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Perm State University - Department of Hydrology and Water Resources Protection

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Tomsk State University - Department of Hydrology

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Vladislav Rumyantsev
Limnological Institute SB RAS

Anatoly Tsyplenkov (secretary)
Lomonosov Moscow State University - Faculty of Geography

Daria Litovchenko (secretary)
Lomonosov Moscow State University - Faculty of Geography

Local Co-Organisers

Russian Geographical Society

Pan Eurasian Experiment

Russian Hydrometeorological Society

Russian National Committee IHP

International Scientific Committee

Prof. Helmut Habersack (ISC-Chair & Initiator)
Bernhard Schober (Organizing Secretary)
Michael Tritthart (Organizer & IT Coordinator)
BOKU - University of Natural Resources and Life Sciences, Vienna, Austria

Martin Schletterer
TIWAG-Tiroler Wasserkraft and
University of Natural Resources and Life Sciences, Vienna, Austria

Gado Djibo Abdourahmane
Hydrology Expert, Mali

Luna Bharati
International Water Management Institute, Nepal

Ian Campbell
Monash University, Melbourne, Australia

Ali Chavoshian
Regional Centre on Urban Water Management, Iran

Francis Chiew
Water Resources Assessment and Prediction, Australia

Naziano Filizola
Federal University of Amazonas, Manaus, Brazil

Jerker Jarsjo
Stockholm University, Sweden

Daniel Karthe
German-Mongolian Institute for Resources and Technology, Mongolia, Germany

Joong Hoon Kim
Korea University, Seoul

Mathias Kondolf
Lyon Institute of Advanced Studies / University of California Berkeley, USA

Gil Mahé
Institute of Research for Development, IRD, France / FRIEND

Erik Mosselman
Delft University of Technology and Deltares, The Netherlands

Jeffrey Nittrouer
Rice University, Houston, United States of America

Chantha Oeurng
Faculty of Hydrology and Water Resources Engineering, Institute of Technology of Cambodia

Hervé Piégay
National Centre for Scientific Research, France

Des Walling
University of Exeter, UK

Frank Winde
North West University South Africa, IGU Water Commission, SAR

Wang Xiaojun
Nanjing Hydraulic Research Institute, Ministry of Water Resources, China

Department of Land Hydrology
Faculty of Geography
Lomonosov Moscow State University

Study at Hydrology Department, MSU

Department of Land Hydrology offers a unique blend of water-related subjects. Broadly-based topics prevail during first year of studying, but greater specialization in branches of hydrology increase in later years of curricullum.
Main : River hydrology, limnology, hygrometry, water quality, flow hydraulics, hydrological predictions, fluvial processes, hydrophysics, hydrogeology, water management, water ecology.

Studying at Hydrology Department gives unique possibility to get involved into various hydrological programs at various rivers and lakes of the vast territory of Russia during the field training. 2-nd year students have the general summer field practice on hydrology at vivid Oka river (Volga basin), Mojaisk lake (Moscow river basin) and mountain rivers of Caucasus, Altai, Kamchatka, Alps, Tien-Shan. 3-r and 4-th year students work for 2-3 months at various hydrological organizations, national parks at different places of Russia – from Kamchatka peninsula and Amur river basin till Baikal lake and Kolsky peninsula.

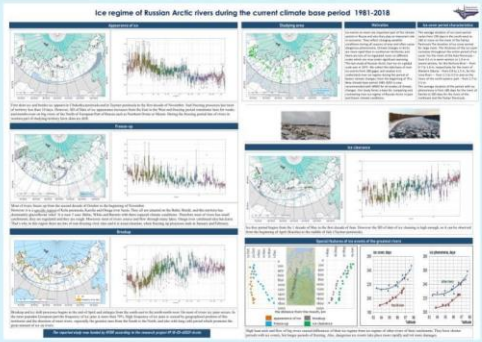
Students work with up-to-date computer equipment, hydrometric and water quality field measurement devices, hydrochemical laboratory. Introduction to the special hydrological software for hydrodynamic modeling, hydroinformatics, channel morphology analysis is the core in studying.

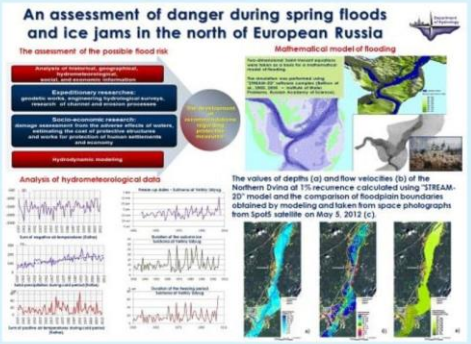
Winter field training courses – unique experience in hydrological research under Polar conditions

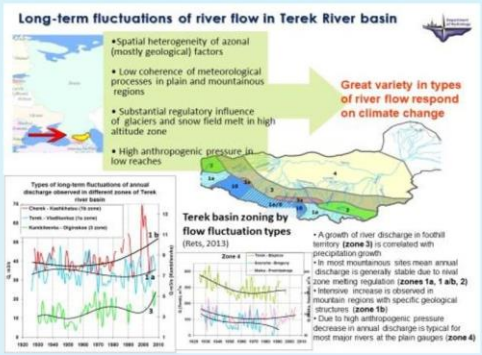
Department of Land Hydrology
Faculty of Geography
Lomonosov Moscow State University

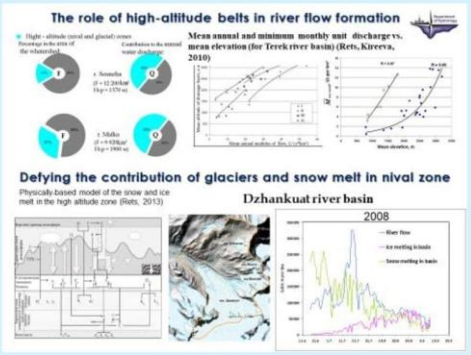
Department of Hydrology

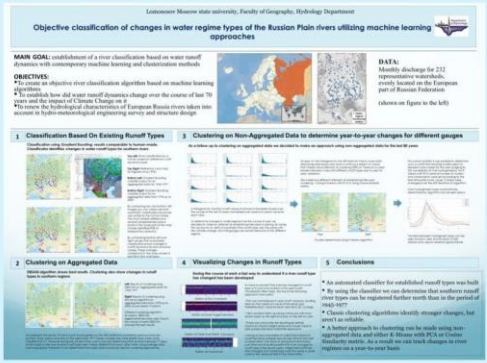
Fields of Research







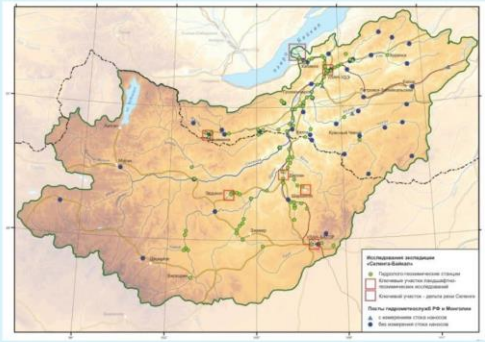




Faculty of Geography
Lomonosov Moscow State University

Selenga – Baikal research

Catchment

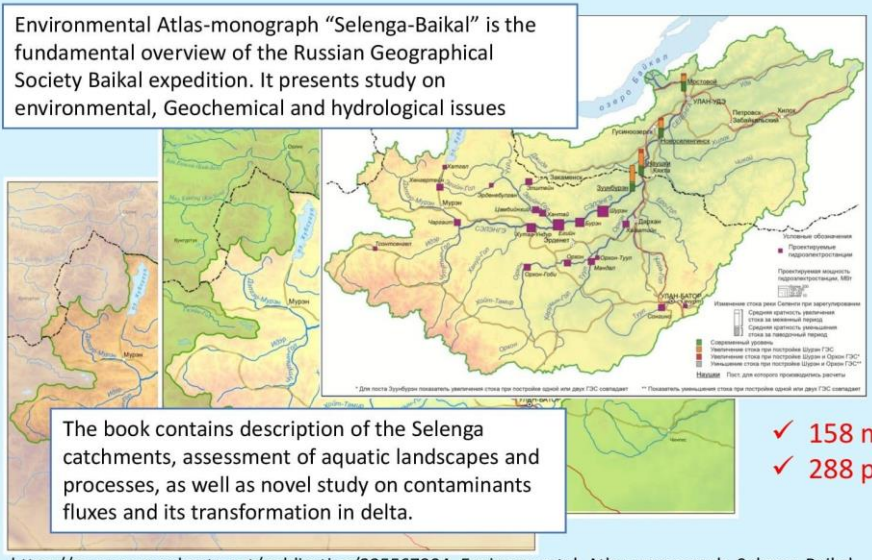


Delta

- Multidisciplinary research over large (447 000 km^2) transboundary catchment of Lake Baikal main tributary – Selenga river.
- 8 years of comprehensive catchment-scale hydrogeochemical monitoring
- Over 100 monitoring stations throughout river basin

Environmental Atlas-monograph "Selenga-Baikal"

Environmental Atlas-monograph "Selenga-Baikal" is the fundamental overview of the Russian Geographical Society Baikal expedition. It presents study on environmental, Geochemical and hydrological issues

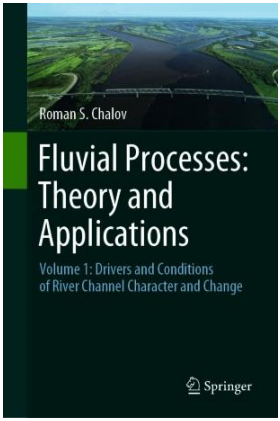


The book contains description of the Selenga catchments, assessment of aquatic landscapes and processes, as well as novel study on contaminants fluxes and its transformation in delta.

- ✓ 158 maps
- ✓ 288 pages

https://www.researchgate.net/publication/335567904_Environmental_Atlas-monograph_Selenga-Baikal

LOC is proud to bring your attention to the book recently published at Moscow State University and which might be of great interest to scientists and decision makers dealing with large rivers.



Roman S. Chalov

Fluvial Processes: Theory and Applications

Volume 1: Drivers and Conditions of River Channel Character and Change

ISBN 978-3-030-66182-3
ISBN 978-3-030-66183-0 (eBook)

https://www.springer.com/gp/book/9783030661823

The book presents an overview of the fluvial processes theory which was developed in former USSR at Lomonosov Moscow State University for the last 50 years since the famous book by Prof. Makkaveev was published in 1955.

The book demonstrates basics of fluvial geomorphology and hydromorphology and its links to ecosystem approach in river analysis and management. The fluvial processes theory accepted in USSR was separated from English-language World during the long period of development of the English-language literature.

Descriptions and quantitative measures of channel pattern of Northern Eurasia rivers (Russia and former USSR territory, China, Poland) are most interesting to international reader having much different compared to those described in classical English-language works and devoted to European and USA rivers.

The book presents overview on the hierarchy and classification of the channel patterns. Based on the impressive empirical datasets on the most of large Russian rivers which have collected by the author since 1957 and are related to channel evolution, sediment transport and adjustments of channel form, which are almost unknown to international reader. The book contains variety of classifications and illustration of various theoretical and field-based descriptions of river channels insights.

Roman S. Chalov is Professor of the Department of the Land Hydrology, Faculty of Geography, Moscow State University; Head of the Makkaveev's Laboratory of Soil Erosion and Fluvial Processes (Faculty of Geography, Moscow State University). He is World's Leading Scientist in fluvial geomorphology and fluvial processes.

Conference Information

Virtual Conference Desk
For any kind of requests or problems, please, contact our Virtual Conference Desk via email (worldslargerivers@boku.ac.at). Your messages will be answered on every conference day in the times between 8:30 and 18:30 (Moscow Time = GMT+3).
Further, each Zoom Session will be accompanied by a technical assistant. In case of technical questions, you can contact this assistant directly via the chat function (during the presentations) or by activating your microphone (in the breaks).

Recording of Sessions
All oral presentations will be recorded (video and audio) by the conference organizers. These video files will be available for download to all registered participants for one month after the conference.

Posters
All posters will be available for download a couple of days before the conference starts. This will give attendees the opportunity to take a look at these posters and then contact their authors directly in the poster zoom sessions.

Pictures of the Conference
Pictures / screenshots of the online conference can be made only by the conference organizing team at any time.
Any other recording or making of screenshots by unauthorized persons violates the personal rights of the attendees and is therefore strictly prohibited.

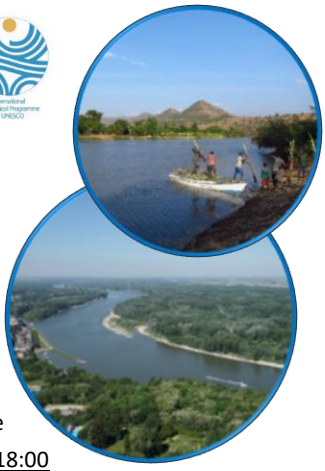
Certificate of Attendance
A personalized Certificate of Attendance in pdf format will be provided to registered participants via email *after* the conference.

Certificate of Presentation
A personalized Certificate of Presentation in pdf format will be provided to presenters via email *after* the conference.

Announcement: World's Large Rivers Initiative Meeting

World's Large Rivers Initiative

WLRI Meeting – AGENDA



4th of August 2021

Dear participant of the World's Large Rivers Conference!

We cordially invite you to take part in the World's Large Rivers Initiative Meeting, which will be held on Wednesday, 4th of August 2021 at 18:00 Moscow Time (15:00 UTC) as an online event in the framework of the World's Large Rivers Conference.

The **World's Large Rivers Initiative (WLRI)** was approved by the Intergovernmental Council of the Intergovernmental Hydrological Programme (IHP) of UNESCO in 2014 and has been prolonged in 2018.

This Initiative fosters the linkage between research at and management of large river basins by bringing together scientists and practitioners from all fields of river related research. Beside organising the World´s Large Rivers Conferences, a main activity is the organization of a joint international project at large rivers. This core project is an integrated assessment of the status and future of the World's Large Rivers. The kick-off project for this started with the assessment of three large rivers – Danube, Mekong and Niger – of which first results will be presented during this meeting.

Now, the objective is to extend this assessment to a larger number of rivers. Hence, this meeting will discuss the next steps of the future implementation of this global assessment and is looking for researchers who are interested to be part of a network by representing their river / country. The network will consist of scientists and researchers coming from different river basins and fields of research.

Take the chance and become part of this Initiative!

I am looking very much forward to welcoming you at this meeting,

Helmut Habersack
Chair of International Scientific Committee (ISC)

Announcement: World's Large Rivers Initiative Meeting

WLRI Meeting – PROGRAMME

4th of August 2021

18:00 **Welcome** by our host ***Michael Tritthart*** (BOKU University of Natural Resources and Life Sciences, Vienna, Austria)

18:05 **Introductory presentation** about the World's Large Rivers Initiative by ***Helmut Habersack*** (BOKU University of Natural Resources and Life Sciences, Vienna, Austria)

- UNESCO & the World's Large Rivers Initiative
- Intergovernmental Council of UNESCO and the
- The ninth phase of the Intergovernmental Hydrological Programme 2022-2029
- Project "RiBaM" – Test assessment on three rivers (Danube, Niger, Mekong)

18:15 **Panel discussion** with highly ranked scientists:

Anil Mishra (Chief of Hydrological System and Water Scarcity Section, UNESCO)
Expert on UNESCO water initiatives and international cooperation

Sergey Chalov (Faculty of Geography, Lomonosov Moscow State University, Russia)
Expert on Arctic / Siberian rivers and geomorphology

Gil Mahé (Institute of Research for Development IRD, France / Tunisia)
Expert on African rivers under changing climatic conditions

Francis Chiew (CSIRO Land and Water, Canberra, Australia)
Expert on hydroclimate, modelling and integrated water resources management

Luna Bharati (IWMI, Nepal / Germany)
Expert on water resources management and policy engagement

Helmut Habersack (BOKU University of Natural Resources and Life Sciences, Vienna, Austria)
Expert on hydrology, sediment research and integrated river management

18:45 **Live questions** from the audience will be discussed among the panelists

19:10 **Summary** by our host ***Michael Tritthart***

19:15 End of the WLRI meeting

Keynote Speakers

We are happy and proud to announce a highly ranked line-up of **Keynote Speakers**:

Dr. ***Alexander GELFAN***

Dr.Sci. in Phys. & Math, Director
Water Problems Institute of Russian Academy of Sciences, Russia

Keynote Topic: **Climate change and threats to water security**

Dr. ***Ellen WOHL***

Professor of Geology and University Distinguished Professor
Dept of Geosciences, Colorado State University, USA

Keynote Topic: **Messy Rivers are Healthy Rivers: the Role of Spatial Heterogeneity in Sustaining River Ecosystems**

Dr. ***Jim BEST***

Professor of Geography and Geographic Information Science, Mechanical Science and Engineering; Department of Geology, University of Illinous Urbana-Champaign

Keynote Topic: **Anthropogenic stresses on large rivers: Types, timescales and triage**

Dr. ***Nikolay KASIMOV***

Professor at Lomonosov Moscow State University and Full Member of the Russian Academy of Sciences

Keynote Topic: **Terrestrial particulate and dissolved flux by largest Russian rivers**

Co-Authors: Sergey Chalov (C.V.), Mikhail Lychagin, Galina Shinkareva & Vasily Efimov

Invited Speakers

We also thank our **Invited Speakers** for giving us insight in their current fields of research:

Ulrich Looser

Global Runoff Data Centre (GRDC) at the German Federal Institute of Hydrology (BfG), Koblenz, Germany

Invited Lecture: **The Global Runoff Data Centre (GRDC)**

Liudmila Lebedeva

Melnikov Permafrost Institute, Yakutsk, Russia

Invited Lecture: **River streamflow in permafrost environment: complicated relations and recent changes**

Natalia Frolova

Lomonosov Moscow State University, Russia

Invited Lecture: **Modern water regime of Russian European rivers: Analysis and mapping**

Gil Mahé

IRD and INSTM Carthage, Tunisia

Invited Lecture: **The impact of dams on the reduction of solid transports to the sea in north Africa: Evidence from sediment cores and suspended time series**

Sergey Chalov

Lomonosov Moscow State University, Faculty of Geography, Russia

Invited Lecture: **Sedimentation processes in the Russian large river deltas: North to South variations**

Franz-Josef Maringer

BOKU – University of Natural Resources and Life Sciences Vienna, Austria; TU Wien – University of Technology Vienna, Austria

Invited Lecture: **Radioactive contamination of the Danube - 50 years of research**

Erik Mosselman

Deltares, Delft, the Netherlands; Delft University of Technology, Delft, the Netherlands

Invited Lecture: **River training using surface screens: the legacy of M.V. Potapov**

Helmut Habersack

BOKU – University of Natural Resources and Life Sciences Vienna, Austria

Invited Lecture: **On the Status and Future of World´s Large Rivers: a comparison of the Danube, Niger and Mekong - a contribution to the UNESCO WLRI**

Instructions for Presenters

Both, oral and poster presentations will be given via Zoom Meeting.

The links to these meetings will be provided in due time before the conference.

All presentations will be given in English language!

Oral presentations:

Oral presentations will be done via a professional Zoom Conference Meeting.

As presenting author you will be able to share your screen and to show your presentations slides. Please, find a template of the presentation slides for 4:3 or 16:9 on our webpage.

You will have 12 minutes for your presentation + 3 minutes for answering questions from the audience. The questions (posed either in the Q&A-Box or by digitally raising the hand) will be managed by the Session Chair.

Please, make sure that your technical equipment (audio and microphone) is working correctly. In case that you should not be familiar with the Zoom Meeting Software, we will provide a testing possibility with tutors who will assist you on Monday, 2nd of August (detailed information about this will follow in due time).

IMPORTANT NOTE: as presenting author (either for oral or poster presentation) it is required that you will enter the online zoom meeting 15 minutes before your session starts!

Instructions for Presenters

Poster presentations:

Poster presentations will be given via a professional Zoom Conference Meeting in separated break-out-rooms.

As presenting author you are asked to stay in your break-out-room during the entire duration of the poster session (45 min). Interested attendees can switch between the different break-out-rooms (posters) and directly ask questions and discuss with the author.

IMPORTANT NOTE: we will publish your poster one week before the conference on our webpage, so that interested attendees can already read them. Therefore, please, send us your digital poster as PDF not later than 25th of July to worldslargerivers@boku.ac.at.

A template for poster presentation can be downloaded from our webpage.

Please, make sure that your technical equipment (audio and microphone) is working correctly. In case that you should not be familiar with the Zoom Meeting Software, we will provide a testing possibility with tutors who will assist you on Monday, 2nd of August (detailed information about this will follow in due time).

IMPORTANT NOTE: as presenting author (either for oral or poster presentation) it is required that you will enter the online zoom meeting 15 minutes before your session starts!

Important Note

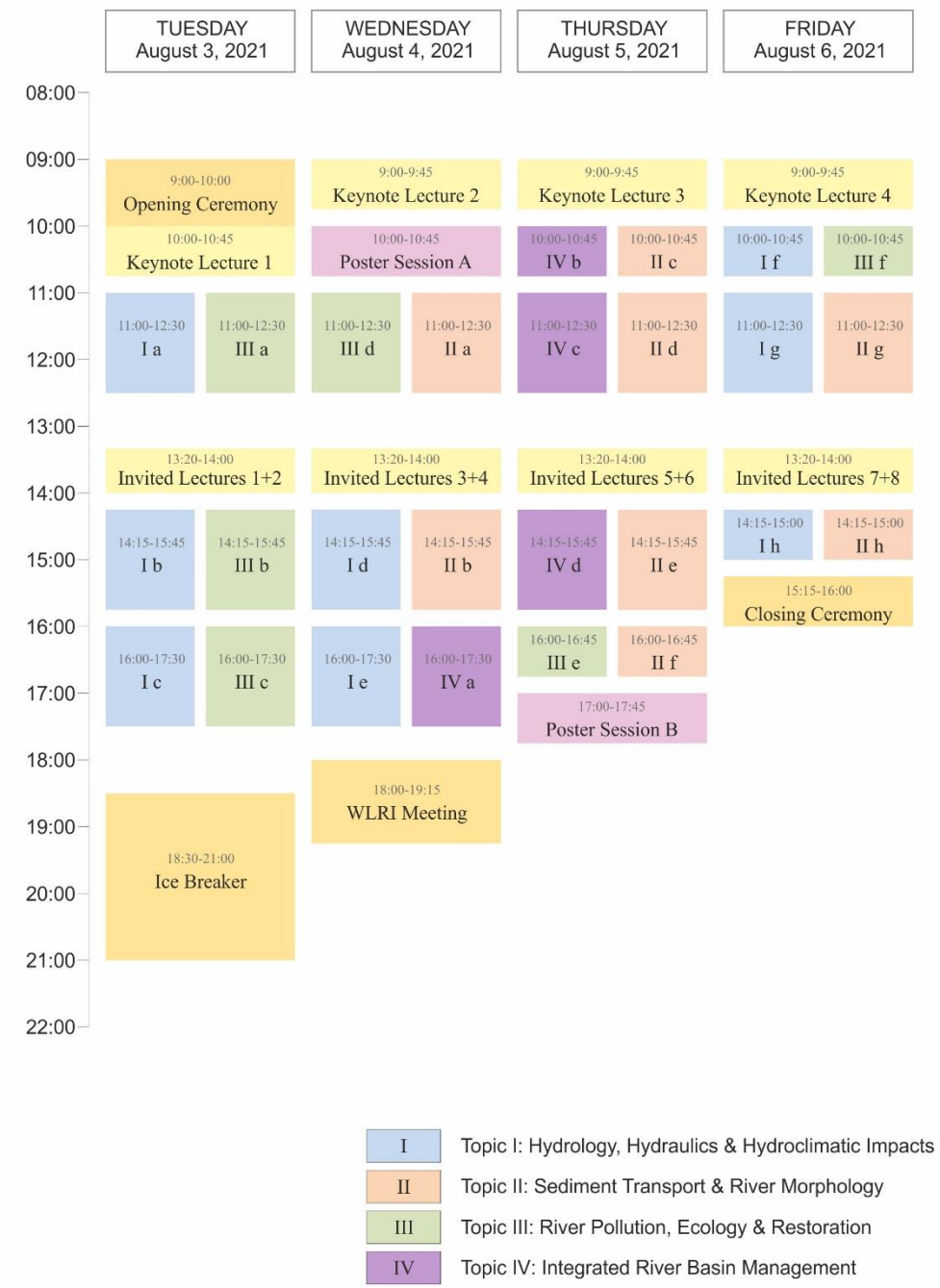
Important information:

all indicated times refer to Moscow Time (MSK - Time zone UTC+3)

Conference Topics

Topic I	**Hydrology, Hydraulics & Hydroclimatic Impacts**
Topic II	**Sediment Transport & River Morphology**
Topic III	**River Pollution, Ecology & Restoration**
Topic IV	**Integrated River Basin Management**

Conference Programme Overview



Daily Conference Programme

Tuesday, August 3, 2021

9:00 – 10:00	**Opening Ceremony** (Zoom Session A) Welcome speeches	
10:00 – 10:45	**Keynote Lecture 1** (Zoom Session A) "Climate change and threats to water security" *Gelfan, A.*	
11:00 – 12:30	**Oral Presentations I a** "Hydrology under changing environmental conditions (Part I)" (Zoom Session A)	**Oral Presentations III a** "Biodiversity, bioindication & conservation in Russian rivers (Part I)" (Zoom Session B)
13:20 – 13:40	**Invited Lecture 1** (Zoom Session A) "The Global Runoff Data Centre (GRDC)" *Looser, U.*	
13:40 – 14:00	**Invited Lecture 2** (Zoom Session A) "River streamflow in permafrost environment: complicated relations and recent changes" *Lebedeva, L.*	
14:15 – 15:45	**Oral Presentations I b** "Hydrology under changing environmental conditions (Part II)" (Zoom Session A)	**Oral Presentations III b** "Biodiversity, bioindication & conservation in Russian rivers (Part II) / Chemical water quality" (Zoom Session B)
16:00 – 17:30	**Oral Presentations I c** "Catchment-wide / large scale hydrological assessments" (Zoom Session A)	**Oral Presentations III c** "River ecology & restoration" (Zoom Session B)
18:30 – 21:00	**Ice Breaker**	

Daily Conference Programme

Wednesday, August 4, 2021

9:00 – 9:45	**Keynote Lecture 2** (Zoom Session A) "Messy rivers are healthy rivers: the role of spatial heterogeneity in sustaining river ecosystems" *Wohl, E.*	
10:00 – 10:45	**Poster Session A**	
11:00 – 12:30	**Oral Presentations III d** "River pollution" (Zoom Session A)	**Oral Presentations II a** "Morphology under changing environmental conditions" (Zoom Session B)
13:20 – 13:40	**Invited Lecture 3** (Zoom Session A) "Modern water regime of Russian European rivers: Analysis and mapping" *Frolova, N.*	
13:40 – 14:00	**Invited Lecture 4** (Zoom Session A) "The impact of dams on the reduction of solid transports to the sea in north Africa: Evidence from sediment cores and suspended time series" *Mahé, G.*	
14:15 – 15:45	**Oral Presentations I d** "Hydraulics - experiments, measurements & modelling (Part I)" (Zoom Session A)	**Oral Presentations II b** "Measurement and modelling of sediment transport" (Zoom Session B)
16:00 – 17:30	**Oral Presentations I e** "River ice & thermal regime / Hydraulics (Part II) (Zoom Session A)	**Oral Presentations IV a** "Hydropower / flood management / conflicting demands" (Zoom Session B)
18:00 – 19:15	**WLRI Meeting** (Zoom Session A)	

Daily Conference Programme

Thursday, August 5, 2021

9:00 – 9:45	**Keynote Lecture 3** (Zoom Session A) "Anthropogenic stresses on large rivers: Types, timescales and triage" *Best, J.*	
10:00 – 10:45	**Oral Presentations IV b** "Transboundary management" (Zoom Session A)	**Oral Presentations II c** "Morphological stabilization measures (Part I)" (Zoom Session B)
11:00 – 12:30	**Oral Presentations IV c** "Integrated water management (Part I)" (Zoom Session A)	**Oral Presentations II d** "Morphological stabilization measures (Part II) / Big Data" (Zoom Session B)
13:20 – 13:40	**Invited Lecture 5** (Zoom Session A) "Sedimentation processes in the Russian large river deltas: North to South variations." *Chalov, S.*	
13:40 – 14:00	**Invited Lecture 6** (Zoom Session A) "Radioactive contamination of the Danube - 50 years of research" *Maringer, F.*	
14:15 – 15:45	**Oral Presentations IV d** "Integrated water management (Part II)" (Zoom Session A)	**Oral Presentations II e** "Management of sediment and river morphology" (Zoom Session B)
16:00 – 16:45	**Oral Presentations III e** "Ecology under changing environmental conditions / Fish ecology (Part I)" (Zoom Session A)	**Oral Presentations II f** "Sediment transport under changing environmental conditions" (Zoom Session B)
17:00 – 17:45	**Poster Session B**	

Daily Conference Programme

Friday, August 6, 2021

9:00 – 9:45	**Keynote Lecture 4** (Zoom Session A) "Terrestrial particulate and dissolved flux by largest Russian rivers" *Kasimov, N.*	
10:00 – 10:45	**Oral Presentations I f** "Hydrological extremes: floods" (Zoom Session A)	**Oral Presentations III f** "Fish ecology (Part II)" (Zoom Session B)
11:00 – 12:30	**Oral Presentations I g** "Hydrological extremes: low flows & droughts" (Zoom Session A)	**Oral Presentations II g** "Large scale river morphology (Part I)" (Zoom Session B)
13:20 – 13:40	**Invited Lecture 7** (Zoom Session A) "River training using surface screens: the legacy of M.V. Potapov" *Mosselman, E.*	
13:40 – 14:00	**Invited Lecture 8** (Zoom Session A) "On the Status and Future of World´s Large Rivers: a comparison of the Danube, Niger and Mekong - a contribution to the UNESCO WLRI" *Habersack, H.*	
14:15 – 15:00	**Oral Presentations I h** "Impact of dams on hydrology" (Zoom Session A)	**Oral Presentations II h** "Large scale river morphology (Part II)" (Zoom Session B)
15:15 – 16:00	**Closing Ceremony** (Zoom Session A) Best Poster Award Final speeches ▪ *Sergey Chalov*, XXXX (Local Organizing Committee) ▪ *Helmut Habersack* (International Scientific Committee Chairman & Initiator)	

Oral Sessions, Tuesday, 3 August 2021

	Oral Presentations I a **"Hydrology, Hydraulics & Hydroclimatic Impacts"** ***Hydrology under changing environmental conditions (Part I)*** (11:00 – 12:30, Zoom Session A) Chaired by *Krylenko, I.*	**Oral Presentations III a** **"River Pollution, Ecology & Restoration"** ***Biodiversity, bioindication & conservation in Russian rivers (Part I)*** (11:00 – 12:30, Zoom Session B) Chaired by *Schletterer, M.*
11:00 – 11:15	Climate change and water management in the Murray-Darling Basin *Chiew, F.*	Environmental problems of the Arctic territories of the Yenisei River *Bondareva, L.*
11:15 – 11:30	Climate change impact assessment on the Syr Darya River runoff *Ayzel, G.V.*	Spatial modelling for conservation of ecosystem for the Novosibirsk Reservoir *Tskhai, A. & Ageikov, V.*
11:30 – 11:45	Flow prediction using future scenarios in the Chéliff catchment, North West Algeria: Case of the Sidi M'hamed Ben Aouda dam *Zaibak, I., Meddi, M. & Mahé, G.*	Water quality in the Volga headwaters *Kuzovlev, V.V., Grigoryeva, I.L., Komissarov, A.B., Chekmareva, E.A. & Schletterer, M.*
11:45 – 12:00	Model-based assessing the Selenga Basin runoff sensitivity to climate change *Millionshchikova T. & Gelfan A.*	Factors affecting bloom outbreaks in the Gorky Reservoir *Erina, O., Tereshina, M., Vilimovich, E. & Sokolov, D.*
12:00 – 12:15	Projecting changes in water balance components of Arctic river basins *Nasonova, O.N., Gusev, Y.M., Kovalev, E.E.1 & Ayzel, G.V.*	The hydrological conditions of fish reproduction in Lower Don River *Goncharov, A., Georgiadi, A., Semenova, A. & Kireeva, M.*
12:15 – 12:30	The world's large rivers' runoff: natural variations and forecast *Dobrovolski, S.*	Nature reserves (zapovedniks) in the Volga catchment: Protection and management *Schletterer, M., Kuzovlev, V., Zheltukhin, A. Litvinov, K., Osipov, V. & Ruchin, A.*

Oral Sessions, Tuesday, 3 August 2021

	Oral Presentations I b **"Hydrology, Hydraulics & Hydroclimatic Impacts"** ***Hydrology under changing environmental conditions (Part II)*** (14:15 – 15:45, Zoom Session A) Chaired by *Glas, M.*	**Oral Presentations III b** **"River Pollution, Ecology & Restoration"** ***Biodiversity, bioindication & conservation in Russian rivers (Part II) / Chem. water quality*** (14:15 – 15:45, Zoom Session B) Chaired by *Schletterer, M.* & *Kuzolev, V.*
14:15 – 14:30	Improving historic flood reconstruction using a detailed 1D-2D coupled hydraulic model approach *Ngo, H., Bomers, A., Augustijn, D.C.M et al.*	The impact of anthropogenic transformation of the watershed on the ecological condition of the river *Trifonova, T.*
14:30 – 14:45	Water regime transformation in downstream of European Russia's large Rivers *Kireeva, M., Rets, E., Samsonov, T. et al.*	Sources of pollution of the Volga River within the Republic of Mari El *Goncharov, E., Anufriev, M., Obukhov, A., Malyuta, O., Yarantseva, E. & Ivashechkin, A.*
14:45 – 15:00	Modeling of the River Lena floodplains inundation under changing climate *Krylenko, I. & Kornilova, E.*	Discharge-related fluxes of particle-reactive elements in Swedish rivers *Weimar, N.E., Schmidt, K., Kurahashi, E. & Bau, M.*
15:00 – 15:15	The impact of regional climate changes on the emergence of extreme hydrological situations … *Sidorova, M.V. & Kashutina, E.A.*	Iron in the waters "Don River – Azov Sea" megaprofile *Fedorov, Y.A., Dotsenko, I.V. & Dmitrik, L.Y.*
15:15 – 15:30	Modeling current and future hydrologic processes in Bouregreg River Catchment *Brouziyne, Y., Abouabdillah, A., Chehbouni, A. & Benaabidate, L.*	Biogeochemistry of metals in Amur River and Yangtze River estuaries *Shulkin, V. & Zhang, J.*
15:30 – 15:45	Climatic and man-induced hydrological changes *Koronkevich, N.I., Georgiadi, A.G., Barabanova, E.A., Dolgov, S.V. et al.*	Pesticide administration strategies for hazards on farms in the Caribbean *Shah, M.*

Oral Sessions, Tuesday, 3 August 2021

	Oral Presentations I c **"Hydrology, Hydraulics & Hydroclimatic Impacts"** ***Catchment-wide / large scale hydrological assessments*** (16:00 – 17:30, Zoom Session A) Chaired by *Eder, M.*	**Oral Presentations III c** **"River Pollution, Ecology & Restoration"** ***River ecology & restoration*** (16:00 – 17:30, Zoom Session B) Chaired by *Pavluk, T.*
16:00 – 16:15	Stable isotopes of water in the Indus River Basin, Northwest Himalayas *Bhat, M.A., Zhong, J. & Li, S.-L.*	Country-wide statistical modelling of flow-ecology relations in Polish rivers *Keller, A., Piniewski, M., Chattopadhyay, S. & Baldan, D.*
16:15 – 16:30	Application of GRACE mission to study the watersheds water balance *Grigorev, V. & Frolova, N.*	Water table dynamics and surface water chemistry patterns of north-eastern drained part of Great Vasyugan Mire *Kharanzhevskaya, Yu.A.*
16:30 – 16:45	Hydrological predictions for poorly gauged basins: case study of Mereb-Gash River Basin in Eritrea *Ghebrehiwot, A.A. & Kozlov, D.V.*	Transfer of artificial radionuclides by biota of the Yenisei River *Zotina, T., Dementyev, D. Alexandrova, Yu. & Melgunov M.*
16:45 – 17:00	The Pechora Estuary – Greatest microtidal delta of Russia? *Alabyan, A., Vasilenko, A., Demidenko, N., Krylenko, I., Panchenko, E. et al.*	Restoring the Rhine: Feedbacks of gravel augmentation and bank (re-)erosion *Chardon, V., Schmitt, L., Piégay, H., Arnaud, F. & Clutier, A.*
17:00 – 17:15	Soft variables can explain uncertainties in discharges of South-American large rivers *Navarro, F.A.R., Rápalo, L.M.C., Guzmán, D.A. & Mendiondo, E.M.*	Restoration of Ichamoti River in Bangladesh *Chowdhury, A.I.A. & Rahman, M.R.*
17:15 – 17:30	A Resource Nexus perspective on water management in the transboundary Selenga River Basin *Karthe, D.*	Floodplain restoration project along a Danube stretch in Bavaria (Germany) *Cyffka, B., Stammel, B., Betz, F. & Gelhaus, M.*

Oral Sessions, Wednesday, 4 August 2021

	Oral Presentations III d **"River Pollution, Ecology & Restoration"** ***River pollution*** (11:00 – 12:30, Zoom Session A) Chaired by *Erina, O.*	**Oral Presentations II a** **"Sediment Transport & River Morphology"** ***Morphology under changing environmental conditions*** (11:00 – 12:30, Zoom Session B) Chaired by *Wagner, B.*
11:00 – 11:15	Evolution of the Rhine River's industrial pollution: Historical and legal approach *Ly Keng, C., Badariotti, D. & Berrod, F.*	Influence of fluvial environment evolution on the dynamics of groundwater *Bujakowski, F., Falkowski, T., Podlasek, A. & Ostrowski, P.*
11:15 – 11:30	The Global 100 Plastic Rivers project: Investigating microplastic contamination in over 100 river systems around the world *Nel, H.A., Krause, S., Drummond, J. et al.*	Anthropogenic, climatic impacts on The Medjerda delta and coastal dynamic *Zahar, Y., & Albergel, J.*
11:30 – 11:45	GPS tracking of plastic items in the Austrian Danube River *Liedermann, M., Pessenlehner. S., Gmeiner, P., Tritthart, M. & Habersack, H.*	Large rivers on the permafrost zone at the past *Sidorchuk, A.Y., Panin, A.V. & Borisova, O.K.*
11:45 – 12:00	Abundance of microplastics in the water of the Volga River: the results of a summer 2020 field survey *Lomakov, O.*	Climate and human activities impact on Russian large rivers channels *Chalov, R.S.*
12:00 – 12:15	Microplastics in the surface waters of Russian rivers: A first glance *Frank, Y., Vorobiev, E., Kulinicheva, K., Kayler, O., Trifonov A. & Vorobiev, D.*	Climate change and human influences on the future sediment budget of the Rhine Meuse Delta *Cox, J.R., Dunn, F.E., Nienhuis, J.H. et al.*
12:15 – 12:30	Pollution transfer by microparticles in urban water bodies *Yasinsky, S., Kashutina, E. & Sidorova, M.*	Historical changes to the geomorphic character and distribution of waterholes *Pearson, M.R., Reid, M.A., Miller, C. & Ryder, R.*

Oral Sessions, Wednesday, 4 August 2021

	Oral Presentations I d **"Hydrology, Hydraulics & Hydroclimatic Impacts"** ***Hydraulics - experiments, measurements & modelling (Part I)*** (14:15 – 15:45, Zoom Session A) Chaired by *Grigoriev, V.*	**Oral Presentations II b** **"Sediment Transport & River Morphology"** ***Measurement and modelling of sediment transport*** (14:15 – 15:45, Zoom Session B) Chaired by *Krylenko, I.*
14:15 – 14:30	Integrated methodology of linking hydraulic structure images to numerical simulation *Carvalho, R.F. & Santos, A.*	Testing of suspended sediment concentration measurement techniques in the Danube *Pomázi, F. & Baranya, S.*
14:30 – 14:45	Simulation of flow structure in an asymmetric compound channel *Sahoo, S., Devi, K. & Khatua, K.K.*	Bedload flux modeling in large global rivers *Cohen, S., Syvitski, JMP. & Ashley, T.*
14:45 – 15:00	Influence of channel-scale secondary circulation on mixing processes downstream of river junctions *Lyubimova, T., Lepikhin, A. et al.*	Measurements and calculations of bed load transport in the Lower Amur *Petrovskaya, O. & Maltsev, A.*
15:00 – 15:15	Streamflow simulation and comparison over Volta and Oueme watershed in Togo and Benin *Kodja, D., Koubodana, H. et al.*	Characteristics of bedload transport measurements in alpine catchments *Rindler, R., Schwarz, S., Liedermann, M., Gmeiner, P., Shire, D., Kreisler, A. et al.*
15:15 – 15:30	Experiment to compare evaporation reducers in reservoirs *Hernández, M., Rosales, S., Arganis, M., Osnaya, J. & Carrizosa, E.*	Study of the sediment flux origin of Yenisei and Ob' *Ivanov, V.A. & Chalov, S.R.*
15:30 – 15:45	SonTek RS5: Advancements in ADCP technology for measuring streamflow *Fan, X. & Pimble, L.*	Coupling topographic airborne lidar and photo-sieving methods for grain-size mapping *Piasny, G., Chardon, V., Garambois, P. et al.*

Oral Sessions, Wednesday, 4 August 2021

	Oral Presentations I e **"Hydrology, Hydraulics & Hydroclimatic Impacts"** ***River ice & thermal regime / Hydraulics (Part II)*** (16:00 – 17:30, Zoom Session A) Chaired by *Moreydo, V.*	**Oral Presentations IV a** **"Integrated River Basin Management"** ***Hydropower / flood management / conflicting demands*** (16:00 – 17:30, Zoom Session B) Chaired by *Liedermann, M.*
16:00 – 16:15	River ice thickness in the North-East of Russia in the current climate *Zemlianskova, A., Makarieva, O., Nesterova, N. & Ostashov, A.*	Hydropower developments in selected large river basins *Wagner, B., Lasinger, N., Leutgöb, E., Kainz, M., Hauer, C. & Habersack, H.*
16:15 – 16:30	Aufeis in large river basins of Russia in current climate *Makarieva, O., Alexeev, V., Shikhov, A., Nesterova, N., Ostashov, A. et al.*	Floodplains along the Danube River and their importance for flood risk reduction, ecology and socio-economics *Eder, M., Scheuer, S. & Habersack, H.*
16:30 – 16:45	Assessment of ice jam formation for the Northern Dvina River *Semenova, N.K. & Sazonov, A.A.*	Modeling of urbanized territory flooding at a large rivers confluence *Sazonov, A., Krylenko, I. & Rumyantsev, A.*
16:45 – 17:00	Contemporary climate change impact on Kamsky Reservoir ice formation dates *Kalinin, V. & Mikova, K.*	Catastrophic floods in large river basins: dynamic complex natural processes of the surface water and groundwater interaction *Arakelian, S., Abrakhin, S., Bukharov, D. et al.*
17:00 – 17:15	Thermal regime of Russian Arctic big rivers under climate changes *Vasilenko, A., Magritskiy, D. & Frolova, N.*	Adjustment of chemical industrial along the mainstream of Yangtze River *Wang, X. & Liao, C.*
17:15 – 17:30	Secondary flow effect in discharge prediction for smooth and rough open channel flow *Khuntia, J.R., Devi, K., Das, B.S. et al.*	Methods and technologies of space monitoring of the condition of river water areas in the event of emergencies *Akovetsky, V., Afanasyev, A., Sizov, O. et al.*

Oral Sessions, Thursday, 5 August 2021

	Oral Presentations IV b **"Integrated River Basin Management"** ***Transboundary management*** (10:00 – 10:45, Zoom Session A) Chaired by *Rindler, R.*	**Oral Presentations II c** **"Sediment Transport & River Morphology"** ***Morphological stabilization measures (Part I)*** (10:00 – 10:45, Zoom Session B) Chaired by *Tritthart, M.*
10:00 – 10:15	Legal framework of management of the transboundary Amur River (Heilong Jiang) *Janusz-Pawletta, B. & Solntsev, A.*	Morphological characteristics and riverbed stabilization mechanism of Nujiang River, China *Zhang, C., Xu, M., Lin Y., Huang K. & Wang Z.*
10:15 – 10:30	Climatic and anthropogenic changes in transboundary Ural River water regime *Magritsky, D., Yumina, N., Kenzhebaeva, A., Efimova, L. & Goncharov, A.*	Design to avoid sedimentation at Magdalena River mouth *Bateman, A., Sosa, R., Osorio, A. & Marín-Esteve, B.*
10:30 – 10:45	Integrated water management in Bulgarian and Romanian transboundary basin cooperation *Bournaski, E. & Bardarska, G.*	Macro roughness to mobilize sediment at the Buenaventura Bay *Bateman, A., Sosa, R. & Marín-Esteve, B.*

Oral Sessions, Thursday, 5 August 2021

	Oral Presentations IV c **"Integrated River Basin Management"** ***Integrated water management (Part I)*** (11:00 – 12:30, Zoom Session A) Chaired by *Wagner, B.*	**Oral Presentations II d** **"Sediment Transport & River Morphology"** ***Morphological stabilization measures (Part II) / Big Data*** (11:00 – 12:30, Zoom Session B) Chaired by *Liedermann, M.*
11:00 – 11:15	Research to help manage the Murray-Darling Basin, Australia *Post, D.A.*	Geomorphic responses of restored frequently flowing side channels along the Rhône River *Tissot, N., Riquier, J. & Piégay, H.*
11:15 – 11:30	Water-sediment regulation scheme of the Yellow River: A review *Wang, H., Bi, N., Wu, X. & Nittrouer, J.*	Sustainable side channel reconnection at the Austrian Danube *Tritthart, M., Binder, J., Liedermann, M. & Habersack, H.*
11:30 – 11:45	Optimization approaches to water resources management in the Lower Kuban *Buber, A.L., Bondarik, I.G. & Buber, A.A.*	Numerical modelling of groynes and bed degradation at the Austrian Danube *Glas, M., Tritthart, M. & Habersack, H.*
11:45 – 12:00	Problems of water resources regulation in the basins of Lake Baikal, the Angara, and the Yenisei *Nikitin, V.M., Abasov, N.V. & Osipchuk, E.N.*	Protective characteristics of different bank-protection types in the Yangtze River *Ding, B., Wang, X.X., Qu, G. & Fang, J.J.*
12:00 – 12:15	Integrated hydrolgocial modelling for integrated water resources management in Drava River floodplain *Salem, A., Dezső, J. & Lóczy, D.*	Dredged channel as a flood mitigation measure *Yadav, S.M. & Kapoor, N.*
12:15 – 12:30	Management evaluation and optimization of dispatching schedules of Irkutsk reservoir *Buber, A. & Buber, V.*	Assessment of available geoenvironmental observations from large Latin American rivers *Gutierrez, R., Escusa, F., Maturana, A. et al.*

Oral Sessions, Thursday, 5 August 2021

	Oral Presentations IV d **"Integrated River Basin Management"** ***Integrated water management (Part II)*** (14:15 – 15:45, Zoom Session A) Chaired by *Glas, M.*	**Oral Presentations II e** **"Sediment Transport & River Morphology"** ***Management of sediment and river morphology*** (14:15 – 15:45, Zoom Session B) Chaired by *Tritthart, M.*
14:15 – 14:30	Rivers of power *Smith, L.C.*	Sediment management throughout the Meuse River *Barneveld, H.J., Frings, R.M., Dewals, B.J., Melsen, L.A. & Hoitink, A.J.F.*
14:30 – 14:45	Adaptative and participatory management on the Rhine fluvial hydrosystem. Learning from the past to optimize future scenarios *Osorio-Gomez, A., Meinard, Y. et al.*	The Grand-Ethiopian-Renaissance-Dam impact on the Blue Nile discharges and sediment loads *Osman, M. & Osman, M.A.*
14:45 – 15:00	Social consequences of extreme hydrological events within large river drainage basins *Bondarev, V.P.*	Evaluation of a novel sediment management approach – case study Danube/Austria *Krapesch, M., Hauer, C., Haimann, M. et al.*
15:00 – 15:15	Oka River channel transformation and its recovery perspective *Berkovich, K.M., Zlotina, L.V. & Turykin, L.A.*	Predicting water and sediment partitioning in a delta channel network under varying discharge conditions *Dong, T.Y., Nittrouer, J.A., McElroy, B. et al.*
15:15 – 15:30	Integration of biological levels to assess impacts in river systems *Colin, N., Górski, K., Manosalva, A., López, R., Maceda-Veiga, A. & Habit, E.*	Stabilizing the Brahmaputra River in Bangladesh: Morphological modelling for planning *Thompson, A., Oberhagemann, K. & Haque, A.*
15:30 – 15:45	Improving seasonal streamflow forecasts in the Volga and Amur basins *Moreydo, V. & Gartsman, B.*	A global practicable screening tool to compare morphological characteristics in connection with anthropogenic influences *Fuhrmann, M., Habersack, H. et al.*

Oral Sessions, Thursday, 5 August 2021

	Oral Presentations III e **"River Pollution, Ecology & Restoration"** ***Ecology under changing environmental conditions / Fish ecology (Part I)*** (16:00 – 16:45, Zoom Session A) Chaired by *Schletterer, M.*	**Oral Presentations II f** **"Sediment Transport & River Morphology"** ***Sediment transport under changing environmental conditions*** (16:00 – 16:45, Zoom Session B) Chaired by *Rindler, R.*
16:00 – 16:15	Bird nesting success in the conditions of climate change *O'Keeffe, J., Bukacinski, D., Bukacinska, M., Piniewski, M. & Okruszko, T.*	Is suspended sediment transport in large German rivers decreasing back to prestine levels? *Hoffmann, T., Baulig, Y., Blöthe, J. et al.*
16:15 – 16:30	CO_2 Outgassing during the historic Mississippi River flooding of 2019 *Xu, Y.J. & Xu, Z.*	Long-term changes of geo-flux components in Russian Arctic rivers *Georgiadi, A.G., Milyukova, I.P., Kashutina, E.A. & Danilenko, A.O.*
16:30 – 16:45	Impacts of regionalization strategy on the fish community structure in Polish rivers *Chattopadhyay, S., Baldan, D., Prus, P., Keller, A. & Piniewski, M.*	Forecasting sediment transport and morphological response in the Mississippi River *Soar, P., Cox, A., Thorne, C., Little, C. et al.*

Oral Sessions, Friday, 6 August 2021

	Oral Presentations I f **"Hydrology, Hydraulics & Hydroclimatic Impacts"** ***Hydrological extremes: floods*** (10:00 – 10:45, Zoom Session A) Chaired by *Sidorova, M.*	**Oral Presentations III f** **"River Pollution, Ecology & Restoration"** ***Fish ecology (Part II)*** (10:00 – 10:45, Zoom Session B) Chaired by *Fuhrmann, M.*
10:00 – 10:15	The impact of instantaneous spring floods on the extreme functioning of undeveloped basins: case of the Ouaoumana catchment *Lahlou, N. & El Ghachi, M.*	The effect of attraction flow at fish passes in the epipotamal of the Drava River *Brandl, A., Käfer, S. & Mader, H.*
10:15 – 10:30	Extreme summer rainfall and floods in the mountains of Irkutsk region *Kichigina, N. & Voropay, N.*	Adaptive management of Włocławek Reservoir Dam to improve fish habitat in Vistula River *Parasiewicz, P., Suska, K. et al.*
10:30 – 10:45	Variability of high flood flows in southern Quebec *Assani, A.A. & Zeroual, A.*	Aquatic habitats in the Inn River: Correlations to river morphology *Kopecki, I., Schneider, M., Hubmann, M., Reindl, R. & Schletterer, M.*

Oral Sessions, Friday, 6 August 2021

	Oral Presentations I g **"Hydrology, Hydraulics & Hydroclimatic Impacts"** ***Hydrological extremes: low flows & droughts*** (11:00 – 12:30, Zoom Session A) Chaired by *Kireeva, M.*	**Oral Presentations II g** **"Sediment Transport & River Morphology"** ***Large scale river morphology (Part I)*** (11:00 – 12:30, Zoom Session B) Chaired by *Krapesch, M.*
11:00 – 11:15	Regional frequency analysis of meteorological drought duration within Comoe watershed *Ismaïla, O., Léréyaha, C., Amidou, D. et al.*	Bedrock impact on the course of lowland rivers fluvial processes *Falkowski, T., Ostrowski, P. & Bujakowski, F.*
11:15 – 11:30	Changes in the frequency of heat waves and extreme climate events in the Chaliyar and Periyar River Basin, India *Vijay, A. & Varija, K.*	Morphological dynamics of a large sand bed braided river system *Chembolu, V., Dubey, A.K. & Dutta, S.*
11:30 – 11:45	Phase of precipitation as a factor of low-flows increase in the basins of large Siberian rivers *Nesterova, N. & Makarieva, O.*	Sediment transport and morphological characterisation for a large braided river using hydrodynamic modeling *Nandi, K., Pradhan, C., Khatua, K. & Dutta, S.*
11:45 – 12:00	Low flow in the Oued el Abid basin (Morocco): better understand it to better manage it (Oum Errbia Basin - Morocco) *Nafia, K. & El Ghachi, M.*	Assessing the river freedom space along the continuum of braided channel patterns using advanced geo-spatial analysis *Pradhan, C., Bharti, R. & Dutta, S.*
12:00 – 12:15	Contribution to the study of low water levels in North-West Algeria using the IEB *Toumi, S. & Meddi, M.*	The uniqueness of the river-mouth systems of the Baikal tributaries *Ilicheva, E. & Pavlov, M.*
12:15 – 12:30	Climate change and low flow in the Don river basin: bayesian evaluation and prediction *Bolgov, M.*	Development of river deltas in permafrost zone illustrated by example of mouths of the rivers Lena and Mackenzie *Dolgopolova, E.N. & Isupova, M.V.*

Oral Sessions, Friday, 6 August 2021

	Oral Presentations I h **"Hydrology, Hydraulics & Hydroclimatic Impacts"** ***Impact of dams on hydrology*** (14:15 – 15:00, Zoom Session A) Chaired by *Sidorova, M.*	**Oral Presentations II h** **"Sediment Transport & River Morphology"** ***Large scale river morphology (Part II)*** (14:15 – 15:00, Zoom Session B) Chaired by *Fuhrmann, M.*
14:15 – 14:30	Changes in land use/ land cover and water balance components before and after dam construction in the Mono RiverBasin *Koubodana, H.D., Atchonouglo, K. et al.*	Investigation of planform change of the Amazon River near Iquitos, Peru *Garcia Angulo, K. & Kwan Tun, L.*
14:30 – 14:45	Estimating the flow of the structures of a sub-basin of the Grijalva River *Domínguez, R., Mendoza, A., Arganis, M. & Carrizosa, E.*	Birthplace Amazon River, a confluence of meandering and anabranching rivers *Guerrero, L., Flores, G., Valverde, H., Chicchon, H., Estrada, Y., Naito, K. et al.*
14:45 – 15:00	Impact of damming on the regime of the Jaguaribe River *Lima, T., De Araújo, J., Medeiros, P. & Mamede, G.*	Flow regime and bank erosion of the Anadyr River, Chukotka *Tsyplenkov, A., Shkolnyi D. & Antoniuk, A.*

Poster Session A, Wednesday, 4 August 2021

Poster Session A ***Hydrology, Hydraulics & Hydroclimatic Impacts*** (10:00 – 10:45)	
A Hydro 01	Characterisation of the sources of Volga, Dnieper & Daugava *Kuzovlev, V.V. & Schletterer, M.*
A Hydro 02	Estuaries of the White Sea: Northern Dvina, Onega and Mezen' – great and different *Panchenko, E., Alabyan, A., Demidenko, N., Krylenko, I., Lebedeva, S. et al.*
A Hydro 03	Spatial distribution of the water flow at the Ili Delta *Isupova, M.V.*
A Hydro 04	Modern patterns of space-time transformation of Kolyma River hydrological regime *Frolova, N.L., Magritsky, D.V., Agafonova, S.A., Sazonov, A.A., Vasilenko, A.N. et al.*
A Hydro 05	Natural flow modeling of the Volga River during its regulation *Kalugin, A. & Motovilov, Y.*
A Hydro 06	Future projections of the Amur and Lena River runoff *Kalugin, A.*
A Hydro 07	Hydrological elements quantitative relationship betw. Dongting Lake and Yangtze *Li, C.W., You, Z.Q., Xu, Z.M. & Li, A.Q.*
A Hydro 08	Effect of roughness on apparent shear force in diverging channel *Bodapati, S.S.P., Khatua, K.K., Pinakana, L.R. & Sharma, A.*
A Hydro 09	A numerical hydrodyn. 2D model of the Amur and Zeya Rivers and the Amur Liman *Glotko, A.V., Aleksyuk, A.I., Borisova, N.M., … Fedorova, T.A. … & Belikov, V.V.*
A Hydro 10	Impact of HPP on the hydrological regime of large rivers *Vinogradova, N. & Ruleva, S.*
A Hydro 11	Relationship betw. hydrological variability & climatic fluctuations in the Chellif Basin *Khedimallah, A., Meddi, M. & Mahé, G.*
A Hydro 12	The Volga and the Don water flow in warm climatic epochs *Georgiadi, A.G. & Milyukova, I.P.*

Poster Session A, Wednesday, 4 August 2021

A Hydro 13	Transformation of the Lower Don runoff *Nazarenko, O.*
A Hydro 14	Role of snow cover properties for ice freezing on watersheds *Frolov, D.*
A Hydro 15	Application of the LSM SWAP for hydrological simulations and projections *Gusev, Y.M., Nasonova, O.N., Kovalev, E.E., Dzhogan, L.Y. & Aizel, G.V.*
A Hydro 16	Water balance changes in the Western Dvina River Basin *Kazachuk, A. & Terskii, P.*
A Hydro 17	Hydrological regime of the Lower Ob River under modern condition *Agafonova, S., Magritsky, D. & Banshchikova, L.*
A Hydro 18	Correction method of reanalysis wind field in estuarine areas *Tao, Z., Chu, A. & Chen, Y.*
A Hydro 19	Declining water resources in Western Mediterranean associated with climatic changes *Labrousse, C., Ludwig, W., Pinel, S., Sadaoui, M. & Lacquement, G.*
A Hydro 20	Rating curves with a closing water balance in the bifurcating Rhine River in the Netherlands *Gensen, M.R.A., Warmink, J.J., Berends, K.D., Huthoff, F. & Hulscher, S.J.M.H.*
A Hydro 21	Evaluation of DEMs on GIUH-Nash Model-based direct surface runoff prediction *Ghebrehiwot, A.A. & Kozlov, D.V.*

Poster Session A, Wednesday, 4 August 2021

Poster Session A ***River Pollution, Ecology & Restoration*** (10:00 – 10:45)	
A Ecol 01	Diffuse biogens flow from the catchment to the Cheboksary Reservoir *Yasinsky, S.V., Kashutina, E.A., Sidorova, M.V. & Narykov, A.N.*
A Ecol 02	The environmental risk for the ecosystem of the Yenisei River *Bondareva, L. & Fedorova, N.*
A Ecol 03	Oxygen regime of the rivers of European Russia *Goncharov, A., Lobchenko, E., Agafonova, S., Semenova, A. & Vasilenko, A.*
A Ecol 04	Danube water quality dynamics: Review of web of science articles *Manoiu, V.-M. & Craciun, A.-I.*
A Ecol 05	Geological state of the Osetr River Basin *Yurova Yu.D. & Shirokova V.A.*
A Ecol 06	Chem. indicators of water quality in Pyasino river system after diesel fuel spill *Bezmaternykh, D., Puzanov, A. & Kotovshchikov A.*
A Ecol 07	Sources of nutrient pollution in the Cheboksary reservoir *Tereshina, M., Erina, O., Sokolov, D. & Vilimovich, E.*
A Ecol 08	Microparticle contribution to element transport in major river systems of Russia *Tereshina, M., Erina, O., Chalov, S., Shinkareva, G., Efimov, V. & Sokolov, D.*
A Ecol 09	Mercury behavior on boundary of natural environments in rivers estuaries *Fedorov, Y.A., Mikhailenko, A.V., Dotsenko, I.V. & Solodko, D.F.*
A Ecol 10	Hydrochemistry research of downstream of Amur River and Amur Liman *Anisimova, E.V. & Tishchenko, P.Ya.*
A Ecol 11	Characteristics of macroinvertebrate assemblages in Alpine headwater streams Schletterer, M., Lechthaler, W., Scotti, A. & Bottarin, R.

Poster Session A, Wednesday, 4 August 2021

A Ecol 12	Impact of riparian forest on EPTs dispersion across European biogeographical regions *Peredo Arce, A., Palt, M., Kail, J. & Schletterer, M.*
A Ecol 13	Macroinvertebrates reveal environmental gradients *Yanygina, L.V. & Schletterer, M.*
A Ecol 14	Nematode fish parasites in the Danube River - Belgrade section *Djikanović, V., Vasiljević, B., Cakić, P. & Lenhardt, M.*
A Ecol 15	Spatial movement of wels catfish (Silurus glanis) in the Danube *Smederevac-Lalić, M., Lenhardt, M., Spasić, S., Hont, S., Paraschiv, M., Iani, M. et al.*
A Ecol 16	Holistic fish-diversity assessment in the Volga Basin *Askeyev, I., Shaymuratova, D., Askeyev, O., Askeyev, A., Monakhov, S. et al.*
A Ecol 17	Climate change affects under-ice dynamics of phytoplankton *Erina, O., Kalenichenko, V. & Puklakov, V.*
A Ecol 18	Phytoplankton diversity dynamics of Danubian floodplain lake in the context of global CC *Mihaljević, M., Špoljarić Maronić, D., Stević, F. & Žuna Pfeiffer, T.*
A Ecol 19	Environmental guiding principles for alpine rivers: case study Biya River *Schmalfuß, L., Hauer, C., Yanygina, L.V. & Schletterer, M.*
A Ecol 20	Actual issues of rivers bioindication: Russian experience and prospective *Pavluk, T.E.*

Poster Session B, Thursday, 5 August 2021

Poster Session B ***Sediment Transport & River Morphology*** (17:00 – 17:45)	
B Sed 01	Physical modelling of sediment management scenarios with bottom outlets *Sandberger, J., Lichtneger, P., Sindelar, C. & Habersack, H.*
B Sed 02	Water and sediment budget of Casiquiare channel linking Orinoco and Amazon *Laraque, A., Yepez, S., Lopez, J.L. & Georgescu, P.*
B Sed 03	Lena delta suspended sediment budget revealed from satellite imagery *Prokopeva, K. & Chalov, S.*
B Sed 04	Hydrogeochemical flow distribution in the Volga River Delta *Zavadskaya, M., Zavadskiy, A., Kasimov, N., Lychagin, M., Golovlev, P. & Terskii, P.*
B Sed 05	Evolution of the sedimentary dynamics of the Cheliff wadi (Algeria) *Hadour, A., Mahe, G. & Meddi, M.*
B Sed 06	Contemporary sediments of water ecosystems as indicators of the Anthropocene *Fedorov, Yu.A., Kuznetsov, A.N., Dotsenko, I.V. & Mikhailenko, A.V.*
B Sed 07	Sediment transport and bathymetric changes in the Mississippi-Atchafalaya Rivers *Xu, Y.J. & Wang, B.*
B Sed 08	Bore in branches of Yangtze, Ganges and Amazon rivers deltas *Dolgopolova, E.N.*
B Sed 09	Large-scale hydromorphological characteristics of the glacial river Katun *Seidl, F., Reisenbüchler, M., Rutschmann, P., Yanygina, L.V. & Schletterer, M.*
B Sed 10	Morphological change detection using time series analysis of satellite images *Arfa, A., Ayyoubzadeh, A., Mianabadi, H. & Shafizadeh, H.*
B Sed 11	Analyzing morphodynamics of lower Indus River using GIS *Suhail, T., Allahditta, S., Siyal, A.A. & Ansari, K.*
B Sed 12	Modern changes in morphometry and morphodynamics of large Rivers' Deltas *Mikhailova, M.*

Poster Session B, Thursday, 5 August 2021

B Sed 13	Channel processes on the rivers of the West Siberian *Kurakova, A.A.*
B Sed 14	Certain aspects of the Selenga River Delta modern morphodynamics *Zakharova, E.D., Belyaev, V.R., Chalov, S.R. & Harchenko, S.V.*
B Sed 15	The river bed deformation in the permafrost zone *Debolskaya, E., Ivanov, A., Maslikova, O. & Gritsuk, I.*
B Sed 16	Erosion at the turn sector of a river in permafrost *Maslikova, O., Gritsuk, I., Debolskaya, E. & Debolsky, V.*
B Sed 17	Transitional bedform and velocity instabilities at the Solimões-Negro confluence *Gutierrez, R., Escusa, F. & Gualtieri, C.*

Poster Session B, Thursday, 5 August 2021

Poster Session B ***Integrated River Basin Management*** (17:00 – 17:45)	
B Int 01	Understand. Peruvian Amazon rivers to develop BMP for infrastructure: Amazon Waterway *Barreto, C.D., Guerrero, L., Flores, G., Estrada, Y., Velarde, J., Calderon, E. et al.*
B Int 02	Dynamics of land use and productivity indicators of the Lena River Basin *Repkin, R., Trifonova, T., Mishchenko, N. & Shutov, P.*
B Int 03	Assessment of flooding risk in medical facilities in Tokyo lowlands *Gotoh, H., Ishino, K. & Takezawa, M.*
B Int 04	Study on emergency drawdown capability of dams in Korea *Son, K.I. & Kang, S.W.*

Keynote Lectures

CLIMATE CHANGE AND THREATS TO WATER SECURITY

Gelfan, A.[1,2]

[1] *Water Problems Institute of Russian Academy of Sciences, Moscow*
[2] *Lomonosov Moscow State University, Faculty of Geography, Moscow, Russia*

The subject of the lecture is the current understanding of the impact of climate change on threats to water security in the world and particularly in Russia. The lecture focuses on the issues related to changes in physical water scarcity as well as in frequency and magnitude of disastrous floods. Economic or social phenomena affecting water security are not discussed. The lecture consists of four parts. The first one briefly discusses the current thinking on the mechanisms of the influence of anthropogenic climate change on water resources and flood risk. The second part discusses the methodological aspects of constructing assessments of the ongoing changes of the river regimes and reviews some of the assessments of water resources change and the maximal river runoff in the world and, particularly in Russia. The third part is devoted to the global and regional projections of the future changes of the river runoff regimes in the 21th century and discusses the methodological challenges of constructing such projections. Finally, the fourth part assesses socio-economic consequences of the current and projected hydrological changes and their influence on water security.

MESSY RIVERS ARE HEALTHY RIVERS: THE ROLE OF SPATIAL HETEROGENEITY IN SUSTAINING RIVER ECOSYSTEMS

Wohl, E.[1]

[1] *Colorado State University, Fort Collins, Colorado, USA*

Perceptions of river health are strongly influenced by expectations regarding a natural river. Many observers expect clear water, a slightly sinuous river with pools and riffles, and some riparian trees. River health, however, is much more complicated and multifaceted. The physical appearance of a river, for example, depends strongly on geomorphic context and river history. Complexity can be described with respect to the stream bed, banks, cross-sectional form, and planform of the river and floodplain. The configuration of each of these components of a riverine system has implications for habitat abundance and diversity, sensitivity and resilience of the river to natural and human-induced disturbances, retention of water, sediment and nutrients, and connectivity within the riverine system and between the river and adjacent uplands. Many types of resource use simplify rivers to the point that the river undergoes a metamorphosis, or a thorough, sustained change in channel form and function. Loss of beaver dams and channel-spanning logjams in mountainous headwater streams in Colorado, for example, has resulted in metamorphosis of physically complex, anastomosing channels that were highly connected to adjacent floodplains. These rivers have assumed an alternate stable state as single-thread channels with limited retention and resilience. The world's large rivers, especially in the mid-latitudes, have undergone analogously thorough changes in form that have compromised their ecosystem functions. Effective, sustainable river restoration involves (i) characterizing the magnitude of different forms of physical complexity naturally present in a particular river segment, (ii) understanding the effects of physical complexity on river ecosystem function, and (iii) assessing the degree to which this level of physical complexity can be restored or mimicked. An important part of this process may be educating stakeholders regarding the importance of physical complexity – messiness – in healthy rivers.

ANTHROPOGENIC STRESSES ON LARGE RIVERS: TYPES, TIMESCALES AND TRIAGE

Best, J.L.[1]

[1] *University of Illinois at Urbana-Champaign, Urbana, IL, USA*

The world's great rivers are facing increasing pressures on their ecosystem functioning and services as a result of growing anthropogenic stresses. These stresses are linked principally to population growth, urbanization and changing agricultural practices and the reliance society consequently places on a diverse set of resources – from fish protein to silica building sand.

This talk will present a broad overview of the range of anthropogenic stresses influencing the world's large rivers, using insights from recent studies sourced from across a wide and thriving research community and presenting examples from selected large rivers. Major riverine stressors include climate change (influencing flooding and drought), damming, pollution from a diverse range of sources, sediment mining/dredging, water diversions/river interlinking, non-native species, subsidence related to subsurface fluid withdrawal, land-use change, ecosystem fragmentation, and sea-level rise. In addition, the trade of virtual water sets a background that may influence the patterns, and rates, of water abstraction. Societal, political and economic shocks place additional stresses on river basins, and governance frameworks can provide avenues towards, or barriers to, successful river basin management.

Not only are these stressors, and their interactions, vital to identify and model within river basin management, but the timescales of their effects must be quantified. These assessments are vital to permit river basin triage: the need to identify and prioritize the actions, interventions and treatments needed by large rivers. Triage for selected rivers reveals that climate change may not be the stressor that demands priority attention. In addition, many physical, chemical and biological changes that large rivers are undergoing centrally involve humans, sediment and landscape change. This simple realization highlights the importance of sociogeomorphology as a central tenet within river basin management, and that underlies attainment of many of the UN Sustainable Development Goals within the world's large river basins.

TERRESTRIAL PARTICULATE AND DISSOLVED FLUX BY LARGEST RUSSIAN RIVERS

Kasimov, N.[1], Chalov, S.[1], Lychagin, M.[1], Shinkareva, G.[1] & Efimov, V.[1]

[1] *Lomonosov Moscow State University, Moscow, Russia*

Northern rivers transport huge quantities of water and constituents from the continents to the Arctic Ocean. Characteristics of the transport mode of chemical flow are poorly monitored, and the existing estimates of river flux are characterized by high uncertainty both in term of water (Lappalainen et al. 2018), sediment (Chalov et al. 2017) and chemicals (Raymond et al. 2007).

This lecture demonstrates recent outputs of comprehensive monitoring campaign established by Lomonosov Moscow State University and collaborators at the 4 largest Siberian rivers (Ob, Enisey, Lena and Kolyma) outlets. Multiple times per year at the most downstream river cross-sections flux estimates for dissolved organic matter (DOM), inorganic nutrients, heavy metals and metalloids were done and combined with ADCP acquisitions of sediment depth profiles. The model of the annual flux of the particulate and dissolved flux of the trace metals and POC into Arctic seas is discussed. These estimates are important to learn how changes in inputs from the major rivers will have widespread impacts on biogeochemical cycling in the ocean and led to major revisions of terrestrial flux knowledge into the Arctic.

Invited Lectures

THE GLOBAL RUNOFF DATA CENTRE (GRDC)

Looser, U.[1] & Dornblut, I.[1]

[1] *Global Runoff Data Centre (GRDC) at the German Federal Institute of Hydrology (BfG), Koblenz, Germany*

The Global Runoff Data Centre (GRDC) was established in 1988 at the Federal Institute for Hydrology (BfG) under the auspices of the World Meteorological Organization (WMO). It is a contribution of the Federal Republic of Germany to the World Climate Programme of the WMO. The WMO mandates and directly supports the GRDC through its Resolution 21 (Cg XII, 1995: Request to the member states to provide GRDC with river discharge data) and Resolution 25 (Cg XIII, 1999: Free and unrestricted exchange of hydrological data).

The Global Runoff Database at GRDC is a unique collection of river discharge data collected at daily or monthly intervals from more than 10,300 stations in 159 countries. This adds up to around 470,000 station-years with an average record length of 45 years. The GRDC archives international data of up to 200 years old, and fosters multinational and global long-term hydrological studies. The aim of the GRDC is to help earth scientists analyse global climate trends and assess environmental impacts and risks.

The GRDC maintains a number of specialised databases such as the Arctic-HYCOS quality assured discharge database for hydrological, climatological and oceanographic studies in the Arctic region. The data for this dataset are freely available and are supporting Climate and Cryosphere Projects of the WMO. In addition products such as GIS maps on the Major River Basins of the World and watershed boundaries for more than 7,000 GRDC stations are available.

Positioned as a facilitator for exchanges between data providers and data users, the GRDC has become a focal point for international cooperation. National Hydrological Services are encouraged to supply suitable river discharge data and associated station metadata so that GRDC can provide the available discharge data and data products to the scientific and research community via its website and data portal.

RIVER STREAMFLOW IN PERMAFROST ENVIRONMENT: COMPLICATED RELATIONS AND RECENT CHANGES

Lebedeva, L.[1]

[1] *Melnikov Permafrost Institute, Yakutsk, Russia*

Permafrost controls the movement, storage, and exchange of surface and subsurface water in most of the Russian territory. Available subsurface water storage and position of the frozen aquifuge change seasonally due to summer thawing and winter freezing of the active layer. Seasonal and perennial ground ice could be additional water storages in the basin and affect streamflow distribution between seasons and years. Water transport and water constituents dramatically vary across diverse permafrost landscapes. Recent hydrologic change has been causally linked to climate warming and nonuniform permafrost thaw, but the mechanisms of such changes have not been revealed yet.

Our research aims at better understanding of permafrost-hydrology interplay in Eastern Siberia, assessment of the current hydrological changes and investigation of its causes.

In Central Yakutia river basins dominated by thermokarst terrain have extremely low streamflow (1-10 mm/year) due to the absence of water discharge of thermokarst lakes and their local catchments into the river and increased evaporation from the lake surface. Another permafrost landscape, pine forest on sand massifs, has high fraction of permanently thawed subsurface ground water storage (taliks) that could potentially sustain groundwater contribution to rivers in permafrost domain.

We analyze changes of monthly discharges (104 gauges), the lowest winter discharges (62 gauges) and timing of the freezing period (absence of flow, 43 gauges) of small, medium and large permafrost-covered river basins in Eastern Siberia. The river runoff tends to increase and redistribute over the seasons. At half of the gauges, streamflow increase is happening in winter while most of the gauges show the absence of any trend in summer. The duration of the complete river freezing decreases at the fourth part of all analyzed data samples. The heterogeneity of the found trends could relate to fundamentally different runoff generation processes in different permafrost landscapes.

The study was partly supported by Grants Council of the President of the Russian Federation, project No MK-5330.2021.1.5 and by RFBR, projects No 20-55-71005, 20-35-70027 and 20-05-00670.

MODERN WATER REGIME OF RUSSIAN EUROPEAN RIVERS: ANALYSIS AND MAPPING

Frolova, N.[1], Kireeva, M.[1], Samsonov, T.[1], Grigorev, V.[1], Entin, A.[1] & Sazonov, A.[1]

[1] *Lomonosov Moscow State University, Moscow, Russia*

The results of the study of modern spatial and temporal patterns of the water regime characteristics of the rivers and their cartographic and geographic information generalization for the European territory of Russia (ETR) are presented. Based on the analysis and the developed criteria of the river flow parameterizing characteristics, the transformation of the types of water regime during the period of climatic changes is estimated in comparison with the previous steady period. The zoning of the territory according to the direction and scale of the modern climatic changes effect on the water regime of rivers was carried out, new methods of zoning the territory according to the degree of hydrological processes danger, as well as new technologies for summarizing the hydrological information to generate thematic maps for assessing the risk of dangerous hydrological phenomena for modern and future water use. The results obtained give an idea of the reaction of river basins to the ongoing processes of climate change in various natural and geographical zones. The created series of maps includes analytical, synthetic, and complex maps of the characteristics of the water regime and various parameters averaged over two periods: "historical" (until 1977) and "modern" (from 1978 to the present).

Based on the generated maps, a number of spatio-temporal trends have been revealed: intensification of the hydrological cycle; increase in the annual runoff in the central part of the ETR; an increase in the absolute irregularity of the runoff during summer low flow period and a decrease in its relative irregularity; reduction of maximum water discharges; a significant change in the ratio of the shares of feed sources for most of the rivers, the most important feature of which is a decrease in the proportion of snowmelt.

The reported study was funded by RFBR according to the research project №18-05-60021.

THE IMPACT OF DAMS ON THE REDUCTION OF SOLID TRANSPORTS TO THE SEA IN NORTH AFRICA: EVIDENCE FROM SEDIMENT CORES AND SUSPENDED TIME SERIES

Mahé, G.[1], Amrouni, O.[2], Hzami, A.[2,3], Kotti, F.[4], Ben Moussa, T.[2,3], Habeieb, H.[4], Meddi, M.[5], Hadour, A.[5], Hallouz, F.[6], Khedimallah, A.[5], Hout, R.[7], Maleval, V.[7], Kacimi, I.[8], Emran, A.[9], El Aoula, R.[10], Mhammdi, N.[10], Achab, M.[10], Hara, F.[10], Ezzaouini, M.[11], Dezileau, L.[12], Rouche, N.[13] & Heggy, E.[14]

[1] *IRD and INSTM Carthage, Tunisia*
[2] *INSTM Carthage, Tunisia*
[3] *Univ Tunis, Tunisia*
[4] *INAT Tunis, Tunisia*
[5] *ENSH Blida, Algeria*
[6] *Univ. Khemis Miliana, Algeria*
[7] *Univ Limoges, France*
[8] *Univ Rabat, Morocco*
[9] *CRASTE-LF, Rabat, Morocco*
[10] *Scientific Institute Univ Rabat, Morocco*
[11] *Bouregreg Agency ABHBC, Ben Slimane, Morocco*
[12] *Univ Rouen, France*
[13] *IRD Montpellier, France*
[14] *USC Los Angeles, USA*

The largest rivers of North Africa have been studied regarding how the dams built on the river basins since decades have reduced the solid transport to the sea. The main rivers studied are the Bouregreg River in Morocco, the Cheliff River in Algeria and the Medjerda River in Tunisia. Sediment cores have been sampled in the downstream parts of the rivers, downstream of the main dams to be sure to sample sediment deposits released by the river to the sea, and just before the estuaries to avoid the tidal effects. Solid transport has been monitored on the Bouregreg and Cheliff Rivers, which can be compared to the sediment cores deposits. For the sediment cores the measures concern the geochemistry, granulometry and Cesium 137 –which allow datation, in combination with discharges time series at the nearest hydrological gauging station, which serve as proxies to help in the interpretation of the sediment cores. For the rivers the data used are rainfall and discharges time series, which help identifying climatic signal, and when available, solid transport, from water samples collected during floods and throughout all the year.

The main result is that in all three cases, the dams construction resulted in a drastic reduction of solid transport to the sea. The coarse fraction of the sediments, sand, is the most affected by this sediment trapping in dams reservoirs. Since many decades the quantity of sand reaching the coastal areas is negligeable. This has great impacts on the stability of the morphology and dynamics of the littoral, as

it can be demonstrated in Tunisia. Economic and social impacts are major on coastal areas where the vulnerability to coastal risk is very high, and will worsen in the future if no action is undertaken to redesign a more natural river regime on the whole continent-litoral continuum.

SEDIMENTATION PROCESSES IN THE RUSSIAN LARGE RIVER DELTAS: NORTH TO SOUTH VARIATIONS.

Chalov, S.[1], Efimov, V.[1] & Kasimov, N.[1]

[1] *Lomonosov Moscow State University, Faculty of Geography*

Massive northern rivers transport huge quantities of water and constituents from the continents to the Arctic Ocean. Particularly within the Russian sector, they are least studied regarding quantitative characteristics of the transport mode of sediment grain size and particulate heavy metals. The existing datasets (e.g. ArcticGRO) rely on suspended sediment samples taken at the surface of the river channel, at one single sampling time. They do not provide integrated hydrogeochemical knowledge regarding drivers and spatial-temporal variability of particulate flux due to complex range of size, density, shape, mineralogy, and chemical composition of solid products of erosion which are hydrodynamically sorted in large river channels during their transport.

Since 2018 the monitoring campaign ArcticFlux has been sampling the 4 largest Siberian rivers (Ob, Enisey, Lena and Kolyma) multiple times per year at the most downstream river crossection selected as unaffected by river mouth processes (tides, surges etc). Particulate heavy metals are collected at different water depths (9 locations within a crossection) and are characterized as a function of grain size and sediment concentration. Using Acoustic Doppler Current Profiler (ADCP) acquisitions with sediment depth profile sampling we build a simple model to derive the bed and suspended seasonal fluxes, grain size and particulate heavy metals distributions. Study demonstrates the significance of the hydraulic control for the metal partitioning within river as well as explains spatial (inter-basin) variations in particulate flux due to local hydrology, erosion rates and catchment lithology. Based on the modeling techniques and application of erosion models for all four Arctic catchments the project will also focus on the novel quantitative assessment of bank and catchment erosion contribution into chemical flux.

RADIOACTIVE CONTAMINATION OF THE DANUBE - 50 YEARS OF RESEARCH

Maringer, F.J.[1, 2]

[1] BOKU – University of Natural Resources and Life Sciences Vienna, Austria
[2] TU Wien – University of Technology Vienna, Austria

This radioecological research review gives a complete overview on the spatial and temporal radioactive contamination development of the Danube River from its spring in the German Black Forest to its estuary delta at the Black Sea from the nineteen sixties until present.

In the 20th century, spacious environmental radioactive contamination due to atmospheric nuclear weapons testing as well as nuclear reactor accidents have had their radioecological impact on the ecosphere and this includes, quite prominently, freshwater resources. Radioecological research in the Danube region began in the nineteen sixties by monitoring ^{90}Sr, ^{137}Cs and other man-made radionuclides. Simultaneously, monitoring of ^{137}Cs and ^{90}Sr in drinking water, soil and agricultural food products (e.g. crop, milk) had been established in all countries of the Danube river basin, as important part of the monitoring program on environmental radioactivity. Very early, also naturally occurring radionuclides such as ^{210}Pb, ^{210}Po, ^{226}Ra, ^{228}Ra, ^{228}Th and ^{238}U originated from industrial plants processing natural materials (e.g. mineral raw materials, building materials) were also included in the environmental monitoring programmes.

The essential objective of the spacious and long-term radioecological monitoring is the full protection of the environment against harmful radioactive exposure in the future to manage sustainable use and conservation of the Danube freshwater resources. Elevated levels of radionuclide concentration in rivers lead to increased health risks for the public drinking processed river water or consuming water animals. The use of contaminated river water for irrigation can also increase health risks by consumption of the agricultural products produced in the irrigated areas. Therefore, it is of importance to monitor continuously the radioecological status of the Danube River ecosphere and to evaluate the impact of artificial and natural radionuclides on the health of the population living in the basin.

Currently, ^{137}Cs activity concentration (half-life of 30.05 ± 0.08 years) in Danube water and riverbed sediments originated primarily from the nuclear power accident in Chernobyl (April-May 1986) and secondarily from atmospheric nuclear weapons testing during the 1950s and 1960s. ^{90}Sr (half-life of 28.80 ± 0.07 years) originates primarily from atmospheric nuclear weapons tests and, to a much lesser extent, from Chernobyl fallout.

In this paper, a complete review on radioecological research and radioactivity monitoring carried out in the Danube freshwater ecosystem in the last 50 years is presented. Results of radiometric analysis of Danube water and bottom sediment, collected continuously by sediment traps and additionally by grab sampling during Danube research cruises, are given and discussed. Sample collection techniques, sample preparation and radio-analytic methods, developed and applied in radioecological studies on the

Danube River, are shown comprehensively. Additionally, this paper aims to evaluate and visualise the spatial and long-term temporal development of ^{40}K, ^{90}Sr, ^{137}Cs, ^{226}Ra, ^{228}Ra, ^{228}Th, ^{238}U and ^{210}Pb radionuclides in Danube riverbed sediments. Finally, the health risks on the population due to the radioactive contamination of the Danube ecosystem is assessed.

RIVER TRAINING USING SURFACE SCREENS: THE LEGACY OF M.V. POTAPOV

Mosselman, E.[1,2]

[1] *Deltares, Delft, the Netherlands*
[2] *Delft University of Technology, Delft, the Netherlands*

River training structures such as groynes, guide banks, longitudinal training walls, bottom vanes and surface screens all act on the primary flow field. Bottom vanes and surface screens, however, act on the secondary flow field too by inducing a helical water motion. This "transverse circulation" displaces sediment in another direction than the main flow direction. India already used surface screens in the 19th century, originally calling the screens "jhámps" and today referring to them as "bandals". This usage relied mainly on practical experience, without systematic research. It was M.V. Potapov who, in the first half of the 20th century, carried out systematic experimental research and realized field applications in large rivers of the former Soviet Union. As he published in Russian only, his work became only known in other countries thanks to translations by R.I. Batalin. It still merits wider acknowledgement but now risks falling into oblivion. The present contribution therefore recalls Potapov's work and presents recent field tests and research in Bangladesh and in the Netherlands. In Bangladesh, floating surface screens and high-water bandals were tested in the Brahmaputra-Jamuna River at Katlamari. In the Netherlands, the effects of a surface screen on water motion and riverbed morphology were tested in the laboratory and in a secondary channel of the river IJssel. The ensemble of experiences allows drawing conclusions on the practical suitability of fixed and floating surface screens.

ON THE STATUS AND FUTURE OF WORLD'S LARGE RIVERS: A COMPARISON OF THE DANUBE, NIGER AND MEKONG - A CONTRIBUTION TO THE UNESCO WLRI

Habersack, H.[1], Wagner, B.[1], Hauer, C.[1], Liedermann, M.[1], Glas, M.[1], Haimann, M.[1], Krapesch, M.[1], Flödl, P.[1], Holzapfel, P.[1], Gmeiner, P.[1], Schober, B.[1], Stelzer, S.[1], Leutgöb, E.[1], Lasinger, N.[1], Schütz, P.[1], Lehner, D.[1], Kainz, M.[1], Fuhrmann, M.[1], Scheuer, S.[1], Abdouramane, G.[2] & Lim, S.[3]

[1] *Institute of Hydraulic Engineering and River Research*
Department of Water, Atmosphere and Environment
BOKU – University of Natural Resources and Life Sciences, Vienna, Austria
[2] *Wetlands International Africa*
[3] *Mekong River Commission*

The overall aim to analyze large rivers based on a common / standardized and replicable methodology has been developed in accordance with the UNESCO IHP World's Large Rivers Initiative's (WLRI) vision to improve the knowledge on the status of large rivers, and to better understand developments, synergies and challenges in large river basins holistically. In a first step of a multi-level approach, conceptualized in the frame of the WLRI, three rivers as pilot rivers – Danube, Mekong and Niger – were studied, whereby this contribution focuses on an integrative assessment of the status of the Danube, Niger and Mekong rivers. By applying a common methodology of analysis to each of the rivers, for the first time, comparable analyses enable a uniform assessment of the respective river and its basin. It became clear that all three rivers are undergoing major changes with different focus. For the Danube, flood protection, navigation and hydropower have been developed for a long time. As a consequence, the sediment regime is totally disturbed with only 10 % of the river length to be in equilibrium, the rest shows erosion or sedimentation. The Niger river is very sensitive to changes in the flow regime. Discharge amount as observed before 1970's has not been reached in 2001. Climate change impact seems to be apparent. At the Mekong the long-term seasonal discharge within the last 75 years showed an increase of dry discharge by 7 % and a reduction of wet discharge by -11 %. For all three rivers a significant reduction of the suspended load transported to the Delta and the Sea can be observed, however with different temporal and spatial extent. In the contribution also a need for improved monitoring in various topics is elaborated.

Oral Presentations I a

"Hydrology under changing environmental conditions (Part I)"

CLIMATE CHANGE AND WATER MANAGEMENT IN THE MURRAY-DARLING BASIN

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The Murray-Darling Basin covers one million square kilometres of south-eastern Australia. The Murray-Darling River is Australia's largest, most economically important and politically complex river system. Water resources in the Basin support over two million people, about two-thirds of Australia's irrigated agriculture, and significant cultural and environmental assets.

The first part of this paper will present the climate and hydrological characteristics of the Basin. The paper will describe (i) the high inter-annual and decadal variability in river flows, (ii) the very severe 1997–2009 Millennium drought, (iii) the significantly lower cool season rainfall over the past 30 years, (iv) attribution of the decline in cool season rainfall to anthropogenic climate change, (v) projections of a drier future, and (vi) the amplification of rainfall reduction in the runoff and river flow characteristics. The paper will discuss developments in climate change science, challenges in linking and interpreting climate projections and hydrological modelling to predict water futures, and the need to adapt hydrological models to incorporate new dominant processes to robustly predict hydrological characteristics in a changing climate.

The second part of this paper will present the significant water reforms and initiatives in the Basin to redress over-allocation of water, which have been accelerated by the Millennium drought and projections of a drier future. These include returning water to the environment through purchase of irrigation water entitlements and infrastructure projects, improving irrigation water use efficiency, enhancing provision of water information, and establishing active water markets. These initiatives are helping buffer the system against droughts and will facilitate adaptation. However, the extreme dry end of future water projections would threaten agriculture production, ecosystems and rural communities and would require transformative adaptation and solutions.

CLIMATE CHANGE IMPACT ASSESSMENT ON THE SYR DARYA RIVER RUNOFF

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In the present study, we have developed and extensively validated the hybrid model for the Syr Darya River basin based on a combination of state-of-the-art hydrological and machine learning models. Climate change impact on the Syr Darya River runoff for the projection period 2007-2099 has been quantified based on the developed hybrid model and bias-corrected and downscaled meteorological projections simulated by four General Circulation Models (GCM) for each of three Representative Concentration Pathway scenarios (RCP). The developed hybrid model reliably simulates runoff on the historical period with Nash-Sutcliffe efficiency of 0.72 and Kling-Gupta efficiency of 0.77. Results of the climate change impact assessment showed that the runoff projections produced by different GCMs are misleading by providing contradictory results on the projection period. However, we identified that the relative runoff changes are expected to be more pronounced in case of more aggressive RCP scenarios. The simulated projections of the Syr Darya River runoff provide a basis for further assessment of climate change impacts on hydrological and ecological conditions of the Small Aral Sea in the 21st century.

FLOW PREDICTION USING FUTURE SCENARIOS IN THE CHÉLIFF CATCHMENT, NORTH WEST ALGERIA: CASE OF THE SIDI M'HAMED BEN AOUDA DAM (SMBA)

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The spatio-temporal variability of flows caused by climate change has a significant impact on hydrological processes and the quantities of water mobilized at the watershed scale. The prediction of flows upstream of the Sidi M'hamed Ben Aouda dam (SMBA), in the Chéllif basin in north-western Algeria, was carried out on the basis of RCA4 regional climate simulations of historical precipitation and temperatures over the period 1981-2005 and then projected for the near future 2025-2050 with an evaluation of two concentration pathways RCP4.5 and RCP 8.5.

The SMBA dam is of great importance for the region, commissioned in 1978 with a capacity of more than 235 million cubic meters, it stores the waters of Oued Mina (main tributary of the Chéliff) and serves both to supply drinking water to three main cities of the region with a population of more than 150,000 inhabitants and to ensure the irrigation of the perimeter of the Mina with an area of more than 10,600 ha.

The generated climate sequences were used as input to the Soil and Water Assessment Tool (SWAT) to simulate the projected changes in hydrological processes in the basin over the period 2025-2050.

The model performed very well at the hydrometric station upstream of the SMBA dam with a coefficient of determination (R2), Nash-Sutcliffe efficiency (NSE) and percentage bias (PBIAS) of 0.80, 0.80 and 0.02, respectively for the calibration period (1983-1988) and 0.70, 0.70 and -1.5, respectively for the validation period (1988-1992). We found that flows will decrease in the future as a result of reduced rainfall in future horizons. These projections will provide a decision support tool for water resource managers in the region.

MODEL-BASED ASSESSING THE SELENGA BASIN RUNOFF SENSITIVITY TO CLIMATE CHANGE

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The Selenga River is one of the largest undammed rivers in the world and it is the most substantial source of inflow into Lake Baikal. It is an important basin for studying due to exclusive hydrological conditions in transboundary region. Since the mid-1990s the longest long-term low-flow period has been observed. This study presents assessments of the Selenga runoff sensitivity to climate change based on numerical experiments with the ECOMAG hydrological model adopted for the entire basin (including Russian and Mongolian parts). The model parameters were determined using global databases of the spatially-distributed underlying surface characteristics. The developed model has proved to be robust enough in order to be used to assess climate change impact for Selenga River basin. The runoff sensitivity to climate change was assessed using two sets of climate projections in the XXI century as inputs to the hydrological model: (1) derived from an ensemble of Global Climate Models (GCMs); (2) calculated through a linear transformation of meteorological series of reanalysis EWEMBI («delta-change»-method). It is shown that for both sets of climate projections, the mean annual runoff is almost equally sensitive to variations of mean annual of air temperature and total precipitation: an increase in the basin-average air temperature by 1°C leads to a decrease in the mean annual runoff by -8% using GCMs data and by 10% using transformed data; an increase in the basin-averaged total precipitation by 10% leads to an increase in the mean annual runoff by 21% using GCMs data and by 21 using transformed data. Thus, the main contribution to the observed -35% runoff decrease over the past 20 years was mainly due to a decrease in the annual mean precipitation by 10% and, to a lesser extent, due to an increase in the mean air temperature by 0.4°C.

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PROJECTING CHANGES IN WATER BALANCE COMPONENTS OF ARCTIC RIVER BASINS

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Climate change impact on the water balance components (including river runoff, evapotranspiration and precipitation) was investigated using a physically-based Land Surface Model SWAP developed in the Institute of Water Problems of the Russian Academy of Sciences. The Northern Dvina, Indigirka, Lena, MacKenzie and Taz river basins were used in this study. For simulating runoff at the river basin outlets, schematization of each basin as a set of 0.5°x0.5° computational grid cells connected by a river network was carried out. Model parameters for each grid cell were taken or derived from the ECOCLIMAP data set after its aggregation for 0.5 degree grid cells. Soil parameters were derived from the values of Clay and Sand given in ECOCLIMAP. Meteorological forcing data (including precipitation, air temperature and humidity, shortwave and longwave downward radiation, wind speed, and air pressure) for historical period (1969–2001) needed for model calibration and validation were taken from the WATCH data set with a daily time step.

For hydrological projections, meteorological simulations performed by five General Climate Models (GCMs) under four RCP-scenarios for the period of 2005–2100 were used. All GCMs' projections were bias-corrected to WATCH within the framework of the ISI-MIP. First of all, historical simulations of streamflow for five river basins were carried out with making use of the SWAP model and meteorological outputs from the five GCMs. Comparison of simulated and measured river runoff has shown a satisfactory agreement for all rivers. Then, for each river basin, 20 projections of changes in climatic values of the water balance components were obtained for three climatic periods of the 21st century. The projected changes in climatic river runoff were analyzed together with the projected changes in climatic precipitation, incoming shortwave and longwave radiation, and evapotranspiration. Analysis of the obtained hydrological projections made it possible to estimate their uncertainties resulted from application of different GCMs and RCP scenarios.

THE WORLD'S LARGE RIVERS' RUNOFF: NATURAL VARIATIONS AND FORECAST

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Changes in the annual, maximal, and minimal runoff within the basins of 30 most important rivers of the world were investigated. All-in-all, about 4,000 long-time series of the river discharges was processed. A new classification of watersheds with the respect to the type of river feeding was proposed and tested. A new system of statistical and stochastic estimations was proposed by the author, based on a new algorithm of generating pseudo-Gaussian random numbers. Thus, new formulas for calculating standard deviations and autocorrelations were proposed – as well as new criteria for assessing the order of autoregressive models (needed for the implementation of the Maximum Entropy Method) and new two-sided criteria for the verification of the zero-hypothesis on the stationarity of series with the respect of mathematical expectation, standard deviations, and autocorrelations. Fundamental natural phenomena were discovered (or highlighted) within the basins of largest rivers: a "-1/2 law" (in bilogarithmic scales) of the coefficient of variation as a function of the annual runoff depth for relatively small sub-basins, and the same "minus half law" describing the relationships between the coefficient of variation of the annual runoff and the watershed area/annual discharge for large sub-basins. Also, a phenomenon of a "bifurcation" of the autoregressive models' orders of the maximal runoff series on one side, and minimal runoff series on another side, with the growth of basins area was studied.

Chronological forecasts of the annual runoff of the main world rivers during the 21th century were proposed on the basis of the results obtained on 21 climatic models. Following 4 uncertainties of forecasting were taken into consideration: differences between 6 scenarios of the greenhouse gases emission, differences between climatic models, errors in estimating the mean runoff values during the test period of instrumental observations, possible natural changes in the global climate.

Oral Presentations I b

"Hydrology under changing environmental conditions (Part II)"

IMPROVING HISTORIC FLOOD RECONSTRUCTION USING A DETAILED 1D-2D COUPLED HYDRAULIC MODEL APPROACH

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The 1374 flood event is considered the largest flood of the last millennium in the Rhine River. Herget and Meurs (2010) used a simple one-dimensional approach to reconstruct peak discharges of historic Rhine River flood events at Cologne, Germany, including the 1374 flood event. They found a 1374 peak discharge of around 23,200 m^3/s with an uncertainty range of between 18,800 m^3/s and 29,000 m^3/s. Recently, using one-dimensional–two-dimensional (1D-2D) coupled hydraulic models to solve complex hydraulic has become popular thanks to its advantages regarding the accuracy of model results and computational efficiency (Dasallas et al., 2020, Leandro et al., 2016). This study sets up a 1D-2D coupled hydraulic model in HEC-RAS for a study area stretching from near Andernach to Haus Burgel (Germany) to reconstruct the discharge magnitude of the 1374 flood event. A high-resolution palaeo-DEM for the Lower Rhine catchment (van der Meulen et al., 2020) and hydraulic roughness for landscape classes corresponding to the palaeo situation were used as the input data for this model. We performed an uncertainty analysis with different river bed levels and roughness values to estimate the influence of these uncertainties on the reconstructed peak discharge. The upstream discharge wave was also varied, with discharge peak values ranging from 12,000-24,000 m^3/s. The simulated flood water levels were then compared with the 1374 flood marks at Cologne and Haus Burgel. Based on this comparison, the discharge magnitude was determined to be between 12,800-21,400 m^3/s, with a best estimate between 14,000-18,300 m^3/s. These best estimate values were used in a flood frequency analysis to determine the design discharges corresponding to different return periods (Bomers et al., 2019). A significant reduction of 2000 m^3/s in the design discharge was found corresponding to a 100,000 year return period compared to the previous 1374 peak discharge estimations (Herget and Meurs, 2010).

Keywords: historic flood event, flood mark, 1D-2D coupled hydraulic model, flood reconstruction

Reference:
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WATER REGIME TRANSFORMATION IN DOWNSTREAM OF EUROPEAN RUSSIA'S LARGE RIVERS

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Changes in the water regime of large rivers in the European territory of Russia have a key impact on the economic activity of the entire region. This is especially evident during periods of occurrence of extreme hydrological events and leads to restrictions on economic activity and economic losses. Climate changes significantly transform the water regime of a given territory and the assessment of these changes is a key step in adapting strategies to them.

In this work, we analyzed changes in the main hydrological characteristics of the seasonal and extreme runoff of the largest rivers in the region. To do this, for the lowest cross-sections of these rivers, a hydrograph separation was realised using the automated GrWat algorithm. This made it possible to conduct a comprehensive analysis, rather than isolating individual seasonal and genetic components. For the western and southwestern parts of the region (the Oka and Don basins), changes in the seasonal redistribution of runoff are most pronounced. Here, the hydrograph becomes smoother during the year. The maximum discharges and volumes of spring snowmelt wave are most significantly reduced. At the same time, the number of occasional flood peaks that are now observed throughout the year is growing. Most likely this is due to milder winters and increased losses on infiltration. Heat waves, which are observed more often in the cold season, lead to an increase in infiltration losses and the formation of subsurface runoff.

In the northeast of the region (Pechora, Kama basins), these tendencies are weakly expressed, and in the Mezen basin and the left-bank large tributaries of the Volga (Vetluga, Unzha), they are reversed. Most likely this is due to the reverse effect of moisture-bearing flows and the influence of climate continentality.

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MODELING OF THE RIVER LENA FLOODPLAINS INUNDATION UNDER CHANGING CLIMATE

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The estimations of possible river Lena runoff changes near city Yakutsk (hydrological gauge Tabaga, basin area 897 000 km^2) was done using runoff formation model ECOMAG (author Yu. Motovilov), based on data of global climate models projections for 21c. Further, based on the two-dimensional hydrodynamic model STREAM_2D (author V. Belikov) possible changes in the inundation with the expected changes in runoff were determined.

Both, runoff formation and hydrodynamic models were calibrated and validated using observed data for the historical period from the year 1980 until nowadays. Runoff formation model calibrated using daily data of weather stations and reanalysis WATCH and WFDEI, has showed good correspondence of observed and simulated hydrographs, Nash - Sutcliffe criteria (NSE) for water discharges was above 0.87. Results of hydrodynamic modelling have shown good coincidence of modeled and observed daily water levels (NSE criteria for all sub-periods for water levels was above 0.90) and inundations zones.

For the forecast period, runoff simulations based on the data of five global climate models, provided by the ISI-MIP2 project, have demonstrated positive mean and maximum runoff anomalies and shift of the flooding period to the earlier time. On average by the ensemble, modeling has showed an increase in the average long-term maximum water discharges from 13% under the rcp2.6 scenario to 25% under the most severe climate change scenario rcp8.5 to the middle of the 21st century. An analysis of scenario calculations based on the STREAM-2D hydrodynamic model, has shown that the expected increase in the maximum water discharges may lead to an increase in flooding area by 5-6%; the intensity of flow, which determines the risk of flooding may increase by 7% to 18% depending on the climatic scenario.

The research was supported by the RFBR №https://kias.rfbr.ru/index.php18-05-60021.

THE IMPACT OF REGIONAL CLIMATE CHANGES ON THE EMERGENCE OF EXTREME HYDROLOGICAL SITUATIONS IN THE EUROPEAN TERRITORY OF RUSSIA IN THE 21ST CENTURY

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We estimate possible changes on the emergence of extreme hydrological situations in the European Russia (ER) in the 21st century. Large rivers catchments - Volga, Don, Terek, Severnaya Dvina, etc. are situated on the ER. We use data on precipitation and temperature from AOGCMs (atmospheric and ocean general circulation models) of the CMIP5 project, selected based on the best reproduction of the current climate.

We estimate possible changes in the average annual maximum snow reserves and flood runoff and the possible changes of the probability of occurrence of extremely shallow years in the 21st century in ER.

We show that multidirectional changes in the maximum snow reserves and flood runoff are expected in ER, although there is a tendency in the southern territories towards a decrease in these characteristics; this intensifies near the end of the 21st Century and when using data from the 'hard' scenario of greenhouse gas emissions.

Based on the estimates of possible changes in the variability index of precipitation and humidification conditions, according to the data of AOGCM, changes in the runoff variability index (Cvy) were calculate. Then we calculate the change in the runoff of extremely dry years (95% of supply) or the change in the probability of their occurrence by the probability distribution function (three-parameter gamma distribution), taking into account the predicted annual normal flow and variability index.

According of the calculations made by the AOGCM, an increase in the number of extreme shallow years will be characteristic of the southern and southeastern parts of the Russian Plain. The most unfavorable situation is predicted on the Lower Volga. North of 55 ° N, i.e. in the middle of the 21st century the runoff of dry years is practically unchanged, while by the end of the century the frequency of dry years can increase.

The study completed according to the state assignment № 0148-2019-0007.

MODELING CURRENT AND FUTURE HYDROLOGIC PROCESSES IN BOUREGREG RIVER CATCHMENT

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Precipitation changes and water use patterns are two factors affecting the water quantity; obviously, hydrologic processes are always linked to many elements in the catchment scale, so to understand water management issues it is fundamental to analyze the different elements of hydrologic processes occurring in the catchment.

In this study, the "SWAT" model (Soil and Water Assessment Tool) has been used to study water balance in one of the strategic river catchments in Morocco (Bouregreg). The study catchment is covering an area of 9656 km^2, with farming, pasture and forestry as key local activities and is securing the drinking water for the country's capital (Rabat) and some surrounding cities. SWAT model was first run and calibrated under current climate at 3 different discharge gauges; and was driven with downscaled climate data to generate future hydrological projections for Bouregreg catchment in the 2031 to 2050 and 2080 to 2100 horizons under two Representative Concentration Pathways (RCPs): 4.5 and 8.5.

Results of the study showed that the water balance in Bouregreg catchment is dominated by evapotranspiration and water resources distribution within the watershed is uneven and follows a decreasing gradient matching the flow direction. The main results of climate change simulations showed that Bouregreg catchment will undergo significant decrease of water resources availability (more than -20%) in some scenarios with uneven impact across the different sub-basins. This study provided high resolution modeling approach in predicting climate change impacts on hydrology and can be dependably used to simulate potential adaptation strategies in Bouregreg or any large river catchments with similar context.

Keywords: Bouregreg Catchment, SWAT model, Climate change, water yield

CLIMATIC AND MAN-INDUCED HYDROLOGICAL CHANGES

Koronkevich, N.I.[1], Georgiadi, A.G.[1], Barabanova, E.A.[1], Dolgov, S.V.[1], Zaitseva, I.S.[1], Kashutina, E.A.[1] & Shaporenko, S.I.[1]

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The correlation of climatic and anthropogenic factors in the change of river flow and runoff from catchment areas, as well as water quality in various natural and economic conditions, is considered. Climatic and man-induced changes of hydrological characteristics are closely interrelated and often affect the runoff not directly, but indirectly through relief, soil, and biota. That is why it is impossible to separate definitely the contribution of climatic and anthropogenic factors to changes of hydrological characteristics and one has to be satisfied with relative estimates, which are generally performed by the deviations from some basic values (for example, from the normal annual discharge, the average long-term runoff or runoff of some other period, from the MPC, background characteristics of the environment and target quality indicators) calculated by different methods, among which water balance methods, methods of water management statistics, reconstruction of conditionally natural runoff for a period of intensive anthropogenic impacts and its comparison with the actual runoff.

The contribution of climatic and anthropogenic factors to changes in the annual and seasonal runoff of a number of Russian rivers, the surface slope runoff in the southern part of Russia, as well as the water quality of the Russian rivers and reservoirs, are estimated.

It is shown that the role of natural and man-induced factors in modern changes in the quantity and quality of water resources varies widely depending on specific conditions. But in general, in most cases, the contribution of both of them is significant, which is important to keep in mind performing hydrological and water management calculations. Some measures, mainly preventive, aimed to reduce the negative anthropogenic impact on water resources are proposed.

The study completed according to the state assignment № 0148-2019-0007

Oral Presentations I c

"Catchment-wide / large scale hydrological assessments"

STABLE ISOTOPES OF WATER IN THE INDUS RIVER BASIN, NORTHWEST HIMALAYAS

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The Indus River (length 3100 km), is one of the largest rivers of the Indian sub-continent, rises from Mount Kailash near Mansarovar Lake in Tibet and flows through Tibet (China), India, Pakistan, and Afghanistan, and then drains into the Arabian sea. Various types of water samples across the headwater region of the Indus River were collected in summer 2019 for isotopic analysis to understand the moisture sources and hydrological processes. The local water line for the IRB was found to be $\delta D = 8.3\ \delta^{18}O + 19.9$, which suggests the meteoric origin of water and minimal evaporation in the river water. The $\delta^{18}O$ values of river water vary from -15.7‰ to -6.9‰ with a general enrichment in $\delta^{18}O$ from source to sink. In the upper reaches of the Indus River, δD decreased longitudinally, due to ice melting and an increasing amount of glacier meltwater as elevation decreases. Mean d-excess values (6.1‰ to 15.6‰), suggested that the main source of moisture in the Indus River basin was mainly from westerlies and southwest monsoons. A mass balance shows that the Mediterranean Sea contributed the maximum share (70±15%) of moisture, and the remaining came from the southwest monsoon. The surface water originates from not only atmospheric precipitation but also glacial/snow meltwater, especially in the Zankar river, Suru river, and Drass river. The results of this study provide a baseline for hydrological research in the Indus River Basin.

Keywords: Stable isotopes, d-excess, River water, Indus River Basin, Moisture sources, Himalayas

APPLICATION OF GRACE MISSION TO STUDY THE WATERSHEDS WATER BALANCE

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In 2002–2019, GRACE mission data have been widely used in hydrology. They enabled calibration and validation of hydrological models, including data assimilation in them, monitoring of groundwater and soil water reserves, snow water reserves and, in some cases, even river water reserves and river sediment runoff. The independence of the results of measurements of the GRACE mission from the properties of the underlying surface gives it a unique advantage compared to classical remote sensing systems using electromagnetic radiation of objects. The contribution of GRACE data to the study of the flow of the rivers of the Arctic Ocean is significant. It is shown that the increase in the flow of Arctic rivers in the 21st century is not associated with permafrost thawing, and the existing network of ground-based precipitation observations underestimates the amount of solid precipitation by 20-25%. The GRACE mission is the only source of information on the groundwater variability at the regional and global level.

The low rate of change in underground water reserves and significant long-term variability of these reserves, in comparison with surface waters, enable using GRACE data not only to monitor, but also to forecast underground water reserves.

However, the practical application of GRACE data is very limited. The low resolution does not allow to use GRACE data for the study of small and medium river catchments. Floods associated with heavy rainfalls or large amounts of water in the snow, even on large rivers, form within a few weeks, and data available in two-month delay are useless for forecasting.

Currently, the practical use of satellite gravimetry data in hydrology is possible only within the framework of a system that assimilates both altarnative remote sensing data and model solutions.

One example of such a system is the EGSIEM Hydrological Service.

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HYDROLOGICAL PREDICTIONS FOR POORLY GAUGED BASINS: CASE STUDY OF MEREB-GASH RIVER BASIN IN ERITREA

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Streamflow data helps to estimate the reliability of water supply to satisfy human and environmental needs and assess anthropogenic and climate change impacts on water resources. Nonetheless, obtaining reliable long-term data have never been easy in many arid and semi-arid regions due to economic, technological, and political constraints. Under such circumstances, development and management of water resources have been a major challenge. Among the various approaches, remote sensing and satellite-based topographic and climate information are used extensively for hydrological predictions. Thus, the present work attempts to investigate the suitability of global climate reanalysis datasets as forcing variables and geomorphologic watershed characteristics for streamflow simulations from poorly gauged Mereb-Gash River basin, in Eritrea. To this end, statistical evaluations of long-term climatic variables and intercomparison of physically-based semi-distributed and conceptual precipitation-runoff models are investigated. Results exhibit the presence of persistent dry conditions over the period 2000 to 2013 and predominantly humid conditions from 1979 through the end of 1990s. The presence of significant trends in most of the climatic variables and persistent drought conditions in recent years seem to be ultimately associated to human and climate influences on the ecosystem. The subjective and objective goodness of fit results for single-event based hydrographs indicate that GIUH-Nash model produced acceptable values in most cases, irrespective of sources and resolutions of digital elevation models. However, the results from physically-based mathematical models suggest that a considerable overestimation of most of the precipitation values in the reanalysis datasets, which in turn has a significant effect on other variables such as potential evapotranspiration, leads to a significant discrepancy between water balance values which are simulated and observed hydrographs. While there is no substitute for strengthening and enhancing the expansion of ground observation networks, further intensive research that aims at identifying effective mechanisms to properly utilize reanalysis datasets are also suggested.

THE PECHORA ESTUARY – GREATEST MICROTIDAL DELTA OF RUSSIA?

Alabyan, A.M.[1,2], Vasilenko, A.N.[1], Demidenko, N.A.[3], Krylenko, I.N.[1,2], Panchenko, E.D.[1], Platonov, S.V.[1] & Popryadukhin A.A.[1]

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The Pechora River flowing into the Barents Sea is the greatest river of Russian European Arctic. According to the most estuarine typifications the delta of Pechora belongs to microtidal ones. However, the relatively low tides (less than 1 m in average) play a vital rule for flow pattern and runoff distribution among delta branches during low-water seasons. In August 2020 a hydrological expedition took place at the Pechora estuary, the results of which make it possible to rethink radically the flow dynamics there. An uneven change in water levels along the sea border of the delta as the tidal wave moves westward along the Korovinskaya Bay leads to the appearance of reverse currents in essential delta branches and significant runoff redistribution among them. Under the total Pechora runoff of 1.5-2.0 thousand m^3/s and a tide of about 1 m at Cape Bolvansky Nos, reversible currents in the Bolshaya (Major) Pechora were observed, reaching a maximum of 4.11 thousand m^3/s towards the river at the flood tide and 4.76 thousand m^3/s towards the sea at the ebb. The main runoff redistribution occurs at the Andeg distributary hub by reverse currents, where the arms Tundrovyi Shar and Srednii Shar branch off the Malaya (Minor) Pechora to the left side. The flow dynamics in this node during the tidal cycle is of extremely complex behavior and represents the key control of the watering for the western part of the Pechora delta. The tidal fluctuations of water level penetrate up to the top of the delta and upstream, where the hydrological station Oksino is located, and could change the water discharge almost two-fold there. The research of flow dynamics in the Pechora updates the problem about criteria for classification of estuaries according to the importance of tides for their flow regime.

SOFT VARIABLES CAN EXPLAIN UNCERTAINTIES IN DISCHARGES OF SOUTH-AMERICAN LARGE RIVERS

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Long river basins may be shared by countries, states, or municipalities. Climate and anthropological effects in non-stationary regimes can modify the basin responses and the hydrological cycle over time in these different geographic scales. Added to this, the many legislation uses and interests along its course can have impacts on discharge on the rainy and dry season, increasing uncertainty in streamflow. Soft variables derived from the political and economic environment, and governance structures to manage the water resource, could explain in part these uncertainties in long transboundary rivers, an approach that has been dismissed due to focus on the hydrologic factors. The objective of the work is to use political, social and economic information to explain part of the uncertainties of the discharge curve of long transboundary rivers, applied to two large South American rivers (Amazonas at Óbidos, Brazil, and the Parana at Corrientes, Argentina). For this, it was related information of multidimensional indexes, such as the Blue Peace Index (BPI) or the Biodiversity and Ecosystem Services Index (BESI), coupled with citizen science information gathered through serious games application for river users, and the uncertainties in discharges in the two large transboundary rivers. The results show that soft variables can explain changes in the maximum, average and minimum discharge, since they are highly related to anthropological elements, such as land use and cover, illegal water consumption and basin regulation, as well as explaining the influence of climate change on hydrological regimes and ecosystems. Common politics are required between stakeholders in order to improve water management, which also leads to new opportunities for sustainable human activities and increase resilience against natural disasters.

Keywords: Risk Perception, Climate Change, BPI, Natural Disasters, Gamification, Transboundary Politics

A RESOURCE NEXUS PERSPECTIVE ON WATER MANAGEMENT IN THE TRANSBOUNDARY SELENGA RIVER BASIN

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The Selenga River system contributes most of the inflow into Lake Baikal, which is not only the world's oldest and largest lake by volume but also a world natural heritage site. Water management in its basin is linked to several dimensions of the Resource Nexus that impact hydrology, water quality and the state of aquatic ecosystems:

- Biosphere: Land use change is a major driver of hydrological change, particularly with regard to forest losses in the headwater zones due to forest fires, logging and conversion of forests into pasture.
- Soil: Land cover change (particularly the conversion of grassland into agricultural land and forests into pasture) and mining are important causes of soil erosion. High livestock densities in the floodplains accelerate riverbank erosion. In strongly affected stretches, this negatively impacts the aquatic ecosystem.
- Resources: Mining is a major water consumer and polluter. Bio-accumulation of heavy metals has been detected in several freshwater fish species.
- Food: In the Mongolian part of the basin, a strive to increase domestic food production has led to massive increases in agricultural land and animal husbandry, resulting in soil erosion and sediment and nutrient inputs and a deterioration of microbiological water quality.
- Energy production in the basin is mostly coal-based, with combustion by-products polluting soils and potentially also water resources.

Despite a history of Integrated Water Resources Management in the region, synergies and tradeoffs between water and other resource objectives require an even greater attention in the future.

Oral Presentations I d

"Hydraulics - experiments, measurements & modelling"

INTEGRATED METHODOLOGY OF LINKING HYDRAULIC STRUCTURE IMAGES TO NUMERICAL SIMULATION

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Motivated by a culture of cooperation between infrastructure managers, scientific communities, industries and policy makers there is a need to promote and discuss the use of hydraulic numerical models to evaluate the response of hydraulic harbour structures in fluvial and coastal areas to the action of extreme, combined and cumulative events in a changing climate, which is important to understand flows and changes. Currently, there is the ability to model a wide range of conditions, as well as to study uncertainty in the performance of hydraulic structures, to be prepared for new occurrences.

On the other hand, Earth Observation data is a rich source currently under development as well as other recent technologies such as UAV, both able to register occurrences, which can able and validate models.

In this paper, a workflow will be presented along with examples to motivate the various actors dealing with hydraulic infrastructures to look for numerical models. The workflow is based on several tasks, starting by linking of field and/or pilot studies images to identify geometry and to construct models, perform simulations and evaluate their results and finally compare results with experiments, in situ sensors and images.

SIMULATION OF FLOW STRUCTURE IN AN ASYMMETRIC COMPOUND CHANNEL

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During flood, water moves from main river stream to its both adjacent flood plains and vice versa. If the river has only one flood plain either side of it, then it is called as asymmetric compound channel. The difference in hydraulic resistances between the main channel and flood plain subsections causes the exchange of momentum between them. The article reports the turbulence measurements undertaken in an asymmetric compound channel flow in the hydraulics laboratory, NIT, Rourkela. In the present study, variation of secondary flow for six different flow depths are analyzed. The principal focus in this study is on the nonlinear nature of flow structures in the shear layer region between the main channel and flood plain. The variation of secondary flow in lateral direction and influence of relative flow depths on flow structure were also investigated using MATLAB programming. The same has been compared with the results from ANSYS. From the available turbulence models in ANSYS, *k-omega* model is used as it takes less computing time and provides satisfactory results for steady flow condition. In all the areas three types of circulations are found. Two circulations are found at variable flow depth domains, which is located at each side of main channel with counter clockwise rotation and one circulation found at central main channel of constant flow depth domain with clockwise rotation. All the three circulations are found opposite in nature with respect to consecutive circulations. The interaction phenomenon at junction between two subsections has been explored with respect to relative depth. The work will be of interest to hydraulics engineers associated with compound open channel flow in particular.

INFLUENCE OF CHANNEL-SCALE SECONDARY CIRCULATION ON MIXING PROCESSES DOWNSTREAM OF RIVER JUNCTIONS

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A rapid downstream weakening of the processes that drive the intensity of transverse mixing at the confluence of large rivers has been identified and attributed to the progressive reduction in shear driven mixing with distance downstream from the junction. This may be reinforced by the presence of secondary circulation of the second kind identified by Prandtl that maintains two separate circulation cells as compared with situations where channel scale secondary circulation driven by pressure gradients in the flow maintain the mixing process. These processes are investigated in this paper using a three-dimensional computation of the Reynolds averaged Navier Stokes equations combined with a Reynolds stress turbulence model for the confluence of the Kama River and Vishera rivers in the Russian Urals. Results show that when the rivers are represented as an idealized junction with rectangular channels, the initial vortices that form due to channel-scale pressure gradients decline rapidly with distance downstream. Mixing is slow and incomplete at more than 10 multiples of channel width downstream from the junction corner. However, when the real bathymetry is introduced, rates of mixing increase dramatically, both at the junction corner and maintained with distance downstream. The latter is associated with formation of a single channel-scale vortex aided by curvature in the post junction channel. This effect is strongest when the discharge of the tributary that has the same direction of curvature as the post junction channel is greatest.

The study was carried out with the financial support of the Russian Foundation for Basic Research (Grant No. 16-41-590005) and the Government of the Perm Krai (Project No. C-26/788 for the support of International Research Teams).

STREAMFLOW SIMULATION AND COMPARISON OVER VOLTA AND OUEME WATERSHED IN TOGO AND BENIN

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In the context of global climate changes associated with extreme events, most tropical watersheds have been affected in recent decades by climatic variability with many repercussions on the hydrological dynamics of the basins and this involves consequences on the socio-economic activities linked to water. Faced with this, simulation of stremflows is an important issue for better management of water resources. Thus, the study aims to analyze the performance of GR4J (daily hydrological model GR4J) and IHACRES (Identification of unit Hydrographs and Component flows from Rainfall, Evapotranspiration and Stream data) conceptual models following the simulations of average flows in the watersheds of the 'Ouémé at Bétérou and Mono at Athiémé in Benin (West Africa). To achieve this, the daily precipitation, evapotranspiration (ETP) data from Penman-Monteith, Oudin and the daily discharge of Bétérou and Athiémé hydrometric stations are used and finally are implemented in the GR4J and IHACRES conceptual models over the period of 1971 to 2010. The results indicate that the values of modified Nash the objective function in calibration vary from 75 to 90% at Bétérou and Athiémé, while in validation period, its balance is between 61 and 80 % at Bétérou and at Athiémé stations. The study also showed that the model gives better optimization in calibration than over the validation period and the performance of the two models during this hydrological modeling is less sensitive to the variation of the ETP computed from different methods in the two watersheds.

Keywords: Simulation; discharge; GR4J; IHACRES

EXPERIMENT TO COMPARE EVAPORATION REDUCERS IN RESERVOIRS

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Knowledge of materials and procedures that help reduce evaporation in reservoirs is considered extremely useful since it is known that this element of the hydrological cycle is important in the analysis of the operation of dams located in large rivers. An experiment was conducted to identify possible mechanisms to reduce evaporation in water containers placed outdoors. For this, four samples were considered, one in which the container tank was left with the free surface uncovered to measure natural evaporation at the site; another container whose surface was covered by plastic bottles pet, with minor water disturbance numbering; an air inclusion mechanism with the help of a pump and a plastic tube and a water mixing mechanism with the help of a submersible pump. The tests were carried out during the time when there is no rainfall in central Mexico. After 83 days of measurements, it was obtained that covering the surface of the tank with the help of a pet bottle, helped to reduce the total natural evaporation in 139 mm, managing to prevent 38.61 % of the lamina from evaporating, followed by the incorporating mechanism of air with which a reduction in the lamina of 26 mm, that is, a 7.22 % of non-evaporated lamina, and finally with the recirculation of the water, a reduction in the evaporation lamina of 8 mm was obtained, that is, a 2.22 % of non-evaporated lamina, additionally the option of covering the water surface with pet plastic is a low-cost procedure and only a few cleaning maneuvers are needed to avoid the proliferation of unwanted aquatic fauna.

SONTEK RS5: ADVANCEMENTS IN ADCP TECHNOLOGY FOR MEASURING STREAMFLOW

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In 2020, SonTek released the world's smallest Acoustic Doppler Current Profiler (ADCP), the SonTek RS5, capable of measuring discharge in slow-flowing flood plains as well as high-velocity flood peaks in streams and canals. This presentation will use data examples to highlight the latest innovations that will help optimize discharge measurements during flooding events. The RS5 is a self-contained, five-beam, GNSS-enabled, shallow-water ADCP developed to optimize moving-boat (and soon, stationary) discharge measurements in streams up to 6 meters depth. New acoustic signal processing combines both Broad-band and Pulse-Coherent acoustic technologies, creating a system that reliably profiles streams in high resolution. The new velocity algorithm automatically selects and merges acoustic pulse types to optimize the return signals for a given sampling depth and velocity, and adapts to changes in conditions in real-time. Software advancements enable the user to perform unique data processing, including 3-beam solutions to extend the range of data and sub-sectioning of the data. Other improvements with respect to existing ADCP systems include a compact, wireless form factor, more reliable bottom-tracking, finer resolution velocity profiles, decreased error (variance) in the velocity measurements, and the ability to measure closer to the transducer head.

Oral Presentations I e

"River ice & thermal regime"

RIVER ICE THICKNESS IN THE NORTH-EAST OF RUSSIA IN THE CURRENT CLIMATE

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In the Arctic regions, winter roads provide the means of communication to remote places which are hard to reach in other seasons of the year. Winter road functioning depends on the thickness of the river ice. In the North-East of Russia, winter roads are laid along the Kolyma, Yana and Indigirka rivers. The historical data (1951-2018) of 24 hydrological gauges located in the basins of these rivers were investigated. The maximum river ice thickness, its date and the time of 60 and 90 cm ice thickness establishment required for driving wheeled vehicles weighing 15 and 35 tons, respectively were analyzed.

At 11 gauges, maximum ice thickness has decreased by 40 cm (28%) at a significance level of $p < 0.10$, but the date of maximum value remained almost constant. At 5 gauges, the ice thickness has increased in average by 50 cm (33%). Such changes are observed in the basins of the Yana and Indigirka rivers due to the increased intensity of river aufeis formation. Over the past fifty years, the formation of ice thickness of 60 cm has delayed in average by 24 days (at 13 gauges), and the formation of the thickness of 90 cm delayed by 38 days (at 9 gauges). The earlier formation of 90 cm of ice was observed at two gauges, but it is due to the formation of aufeis, which complicates the functioning of winter roads.

According to the results of the work, the period of winter roads operation at the rivers of the North-East of Russia may decrease by a month or more. Reducing the operating time of winter roads can lead to significant economic damage and should be accounted in future planning.

The research is supported by the RFBR-Project No. 19-55-80028.

AUFEIS IN LARGE RIVER BASINS OF RUSSIA IN CURRENT CLIMATE

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Aufeis characterize the dynamic reserves of groundwater, they regulate surface and underground runoff and are an essential element of water exchange processes in the permafrost zone. The cataloging of aufeis in the basins of large rivers of the North-East was carried out more than 70 years ago. Since then, extensive aerospace information has appeared, which makes it possible to significantly correct the knowledge about the dynamics of aufeis phenomena and their role in the formation of the geological and geographical environment. The following tasks were achieved in the study: create a modern geoinformation database on aufeis distribution and processes based on the study of Landsat images; compile an Atlas of giant aufeis of the North-East of Russia; calculate the amount of aufeis resources, assess their spatial and temporal variability. The satellite-derived total area of aufeis in the basins of three large rivers – the Yana, Indigirka and Kolyma (total area > 1.2 mln km^2) is 2167 km^2 of 3429 aufeis fields, while historical Cadastre (1958) contains data of 2561 aufeis fields with total area of 4009 km^2. In total for three basins, 1803 aufeis fields from the Cadastre (1958) were found by the Landsat images and 1043 aufeis fields from the Cadastre (1958) with total area 620 km^2 were missing in recent images. 2066 new aufeis fields with total area of 522 km^2 were discovered on recent images in the study area. The comparison of recent and historical data has shown that aufeis conditions have changed since the mid-20th century indicating the changes of hydrological regime and permafrost conditions in studied area. Compiled geodatabase is the useful tool for the assessment of hydrological changes in remote permafrost regions.

This study is supported by RFBR (projects 20-05-00666, 19-55-80028) and Russian Geographical Society ("Atlas of giant aufeis-taryn of the North-East of Russia").

ASSESSMENT OF ICE JAM FORMATION FOR THE NORTHERN DVINA RIVER

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Floods are one of the most dangerous natural disasters in Russia, especially in the northern regions. The melting of ice and snow and the appearance of ice jams have a primary impact on the flooding of rivers in the spring. The possibility of early predicting the occurrence of ice jams using machine learning, together with the use of STREAM-2D two-dimensional hydrodynamic model and ECOMAG physico-mathematical model of flow formation, allows to assess the zone of possible flooding. The absence of long observation series does not allow the use of classical statistical methods of machine learning. Another approach in machine learning is application of combinatorial-logical and metric methods such as k-nearest neighbors algorithm (KNN).

In this paper, on the basis of the KNN method, an attempt is made to predict the ice-jam-induced water level rise at the confluence of the Sukhona and Yug rivers near the city of Veliky Ustyug.

The model based on the 10 most significant features, such as the maximum ice thickness, the features of the temperature regime during the freezing period, and others, used meteorological and hydrological data of 6 gauging stations and 3 weather stations for the period 1956–2016. The optimal model parameters were selected using the cross-validation method for the period 1956–1999. The model was tested using the period 2000–2016. Forecast success rate during the model verification was 82%. It should be noted that during the verification period, the model never made a mistake in the years of ice jam formation.

The study was supported by the RFBR grant 18-35-00498 mol_a.

CONTEMPORARY CLIMATE CHANGE IMPACT ON KAMSKY RESERVOIR ICE FORMATION DATES

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Climate changes observed in recent decades largely determine the features of the hydrological regime of water bodies. The most sensitive to changes in air temperature are the processes of the ice formation on rivers and reservoirs.

The aim of the work is to analyze the long-term fluctuations of the Kamsky reservoir's ice formation dates. Analysis of the long-term average of the ice formation dates over the period 1956–2017 showed a tendency to shift the studied periods to more late dates in recent decades.

A comparison of the periods before and after 1975 showed that for the Kamsky reservoir, there are no significant differences in the ice formations dates. Furthermore, if we consider the periods of the last 30 (1986–2017) and 20 (1996–2017) years in comparison with the previous periods. The moving average method for detection of the period beginning of stable ice formations date's changes was used. An analysis of the smoothed fluctuations for periods of 5, 7, 9, 11, 21, and 31 years with 1 year step was done.

The results show the heterogeneity in time series and possibility to identify the inflection point – as the beginning of apparent changes. This point was detected as the middle of the corresponding n-year interval. In addition in the results for 9, 11 and 21-year periods, the inflection point is clearly distinguished. While at 5, 7 and 31-year periods this point is hard to identify. For each gauge station and for each n-year interval, the repeatability of the years at which the inflection point observed was calculated. An analysis of these data showed that the highest repeatability corresponds to the year 1992.

Thus, the influence of contemporary climate changes on the stable ice formation's dates of the Kamsky reservoir is most apparent in the last 25 years.

THERMAL REGIME OF RUSSIAN ARCTIC BIG RIVERS UNDER CLIMATE CHANGES

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Thermal regime of rivers controls different chemical and biological processes in lotic ecosystems. Climate changes in the northern part of Russia are more intense compared with southern regions as in Russia as in the whole world. Heat flux of the biggest rivers of Russia increases now, on most of them, as it shown in some papers. However, it is a gap, connected with water temperature annual dynamic and it changes in past decades. Water temperature data was collected from Russian hydrology and meteorology service (ROSHIDROMET) gages on big rivers, which have drainage area more than 50000 sq. km. The biggest river is Enisey, and the smallest is Anadyr River. There is not Koluma river in this list due to the absence of data after 2014, when Ust-Srednekansk reservoir was built.

We use monthly data from 35 gages in our investigation. Trends in our data was tested with Spearman rank-test. Homogeneity of data rows were tested with Mann-Whithey U-test. Averages and SD of 2 periods 1961-1990 and 1991-2012 was compared to determine changes of water temperature regime. Annual water temperatures were counted as like average from May to October, as like avereges during the period with water temperatures higher than 0°C.

Due to our investigation, we show, that in big rivers annual water temperature become higher for 0,5-1°C, and on 30% of rivers these changes are significant. The highest warming is on Olenek River and on Severnaya Sosva River (Ob river left tributary). Although, maximum of annual water temperatures detected after 1990 on more than 40% of gages. Maps of different aspects of thermal regime was also build.

The reported study was funded by RFBR according to the research project № 18-05-60021-Arctic.

SECONDARY FLOW EFFECT IN DISCHARGE PREDICTION FOR SMOOTH AND ROUGH OPEN CHANNEL FLOW

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Secondary flows are considered as an important aspect in river engineering. Secondary flows are commonly present in open channel flows and create complexity in flow prediction methods. Secondary flow is generated and modified due to the anisotropy of turbulence, caused by the boundary conditions of the bed, side wall and the free surface, as well as the aspect ratio of the cannel. The secondary flows have less contribution to the total flow as compared to the primary flow but producing three-dimensional flow structures. Experimental investigations have been performed in a tilting flume, to perceive the influence of secondary flow in channels having smooth and rough boundaries at Hydraulic Engineering Laboratory, NIT, Rourkela. Various flows are sampled using three dimensional Acoustic Doppler Velocimeter (ADV). The turbulence intensifies over rough bed surfaces and inhibit over smooth surfaces. The sign of secondary flow, Γ, will be demonstrated from the location and rotation of the secondary current cells. The variations of this secondary flow structure across the cross-channel distance for each flow depth and roughness have been observed. In this paper, mathematical relationships have also been developed for accurate estimation of secondary flow coefficients for constant and variable flow depth domain of an open channel flow under different flow and geometry conditions which cover the ranges of Reynolds number from 8923 to 3.69×103 and aspect ratio ranging from 2.13 to 30.61.

Oral Presentations I f

"Hydrological extremes: floods"

THE IMPACT OF INSTANTANEOUS SPRING FLOODS ON THE EXTREME FUNCTIONING OF UNDEVELOPED BASINS: CASE OF THE OUAOUMANA CATCHMENT (MARCH 2010 FLOOD) (OUM ER-RBIA BASIN, MOROCCO)

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It is difficult to prevent floods from happening, but it is possible to prepare for it. The knowledge of flood phenomena, their genesis and their operation are the starting point in risk management. In Morocco, the floods are characterized by the rising of water, which constantly causes more and more damage. Many areas have been deeply affected by this type of hazard, causing particularly significant damage.

The study area is located in the great basin of Oum Er-Rbia (second largest basin on the scale of Morocco). The Ouaoumana catchment covers an area of 173 km^2, it is part of the friable Triassic formations of the eastern depression of the plateau central foot of the middle Atlas. It is equipped with hydrometric station, Taghzout downstream the catchment. The altitudes are between 2235 m and 681m.

This basin is subject to harsh climatic conditions marked by high precipitation aggressively concentrated and irregular in time and space. This paper aims to characterize the instantaneous floods recorded over the 1971-2015 period, with a focus on the spring flood of 2010. The main objective is to understand the course and behaviour of this flood. To do this, we propose a range of hydrological methods for the study and analysis of this important flood.

Keywords: instantaneous floods, undeveloped basins, instantaneous flows, statistical analysis, Ouaoumana catchment (basin the Oum Er-Rbia – Morocco)

EXTREME SUMMER RAINFALL AND FLOODS IN THE MOUNTAINS OF IRKUTSK REGION

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Rainfall floods are the most dangerous among all floods in the Irkutsk region. The ability to forecast such floods is determined by the success in rainfall forecasting which is quite low. There is an increase in the frequency of extreme precipitation from the 1990s to 2000s here.

The data of daily runoff, water level and precipitation at Roshydromet gauge stations on Angara, upper Lena and Lake Baikal river basins were used. The majority of Roshydromet weather stations are located in the downstream flat areas and do not allow to estimate the amount, intensity and area of precipitation in the zones of its forming in the mountains. We used also high-precision experimental data obtained by using automated precipitation and water level gauges (IMCES, Tomsk, Russia). Devices are installed within experimental mountain catchments. Precipitation gauges are installed in the mountains at different heights, and measurements are carried out once every 30 minutes. The method of superimposed epochs was used to determine the time delay of the flooding after extreme precipitation for floods for the period 2001-2015. Precipitation gradient has been studied.

The time lag between precipitation and floods events varies from 2 to 7 days. Analysing the daily sums of precipitation at a Roshydromet weather station located not more than 10 km from a runoff gauge station this time lag is 3 days on average. Flooding occurs two days after the observation of the maximum of precipitation in five days (R5d) at neighbouring weather stations. The catchment area covered by precipitation and the intensity of precipitation affect the onset of flooding. The daily precipitation falling in the catchment of a small river can be used to analyse and forecast floods. The medium river basins require analysis of the five-day precipitation total observed at weather stations. Floods usually occur after the accumulation of an extreme amount of precipitation R5d (at least 40-50% of the monthly rainfall norm) at most weather stations located in the catchment area. The maximum number of rainfall floods events was observed at the Roshydromet gauge stations Iya-Tulun and Vitim-Bodaibo.

VARIABILITY OF HIGH FLOOD FLOWS IN SOUTHERN QUEBEC

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We compared the characteristics (magnitude, duration, frequency and variability) and stationarity (long-term trends and shifts) of annual maximum daily flows in 15 tributaries of the St. Lawrence River in southern Quebec (Canada) measured during the period from 1930 to 2019. Regarding flow characteristics, the variance analysis (ANOVA) revealed that the tributaries on the north shore, which are located in a continental climate, are characterized by flooding of less magnitude but of longer duration than those located on the south shore. On the south shore, tributaries located south of 47°N are characterized by flooding of shorter duration than flooding of tributaries located north of this parallel. No difference in flood flow frequency and variability was observed between the tributaries on two banks. Regarding stationarity, application of various Mann-Kendall tests revealed a statistically significant long-term trend in annual maximum daily flows for all rivers on the north shore, unlike rivers on the south shore. Applying the Lombard test revealed that this long-term trend is reflected in a significant increase in the mean magnitude of these flows occurring during the second half of the 1960s, which preceded the wettest decade of the 20th century (1970s) in the St. Lawrence River watershed. The observed difference in flood magnitude, frequency and duration between tributaries on two banks is attributed to area of the wetlands, the average slope of the watersheds and the morphology of the valleys, which is linked to the lithologic characteristics of the watersheds.

Oral Presentations I g

"Hydrological extremes: low flows & droughts"

REGIONAL FREQUENCY ANALYSIS OF METEOROLOGICAL DROUGHT DURATION WITHIN COMOE WATERSHED

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Drought is a stochastic natural hazard caused by an intense and persistent shortage of precipitation. These subsequent impacts are realized on agriculture and hydrology. Droughts vary in multiple dynamic dimensions, including severity and duration. To manage drought, characterization of drought is essential allowing to planning. This study focused on the prediction of meteorological drought duration within the *Comoe* transboundary basin (West Africa). SPI (Standardized Precipitation Index) have been calculated for the period 1960 to 2000. Then, regional frequency analysis based on L-moments using the LmomRFA package allowed us to predict meteorological drought duration. Classification and homogeneity tests based on *Di* and *H1* indexes applied to give four groups. Group R2 is characteristic of the Equatorial transition climate in the south. Group R4 is typical of the Sudanese climate in the northern part. The other two groups (R1 and R3) are contrasted climatically. Many distributions have been applied to describe drought duration. The results show that the *Wakeby* distribution (5 parameters) is the most suitable. Thus, the average drought duration within almost the entire area of the basin should be 2, 3 or 4 months respectively for return periods of 2, 5 and 10 years, while it should be 4, 6 and 8 months for the extreme northern part of the basin. For return periods of 20 and 50 years, drought length should be 7 to 3 months on average. While in the northern part, duration should be between 11 and 15 months, respectively for the same return periods.

Keywords: Meteorological drought, Duration, SPI, lmomRFA, Wakeby, Comoe watershed

CHANGES IN THE FREQUENCY OF HEAT WAVES AND EXTREME CLIMATE EVENTS IN THE CHALIYAR AND PERIYAR RIVER BASIN, INDIA

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Estimating the impact of climate change and urbanization on heat waves (HW) and extreme climate indices are crucial for the ecosystem restoration and human health. In this study, the long term trends and spatiotemporal variability of heat waves and extreme climate events were studied using daily maximum and minimum temperature data (1951-2019) in the Chaliyar and Periyar river basin, India. These two river basins are highly sensitive to extreme climate events like floods, heat waves etc. Eight heat wave characteristics were analyzed to access the long-term changes of heat wave in the study area. The major findings of the study showed that heat wave in the river basins became more and more frequent, longer and intense. Thirteen temperature indices were selected and results indicated that mean of annual minimum (TNm) and maximum temperature (TXm), warm temperature extremes are significantly increasing in the study area. The increase in the monthly maximum temperature (TXx) in the Chaliyar river basin was 0.13 °C/decade while the value was 0.15 °C/decade in the Periyar river basin. Change point detection applied for the temperature indices revealed an abrupt change for all during either the 2000s or 2010s.

PHASE OF PRECIPITATION AS A FACTOR OF LOW-FLOWS INCREASE IN THE BASINS OF LARGE SIBERIAN RIVERS

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Numerous studies have shown that river low-flows in permafrost basins of Eurasia and North America are increasing. Most hypotheses link the changes of hydrological regime to permafrost degradation and groundwater conditions transformation. In this study we analyzed monthly streamflow and meteorological data in the basins of four large rivers of Siberia – the Lena, Yana, Indigirka and Kolyma. Our analysis reveals statistically significant ($p < 0.05$) positive trends in the monthly streamflow time series during the autumn–winter period for most of the gauges. The data also shows that the rise of annual air temperature led to an increase of rainfall in transition months when temperatures are close to the melting point (September, October) at most meteorological stations. Both, the streamflow and precipitation phase changes occur in a stepwise pattern in a common period. We conclude that warmer temperatures due to climate change are impacting the hydrological regime of these rivers via changes in precipitation type (rain replacing snow). The revealed dependences of monthly streamflow on the amount of rainfall in transition months for small catchments confirm that hypothesis. Other factors, such as the melting of permafrost, glaciers, and aufeis or changes in groundwater conditions, are likely to amplify the impact of rainfall; however, no direct observations of these changes are available. As the reduction of snowfall in the Arctic is projected by most of climate models, new climate conditions will continue heavily impacting Arctic hydrology and ecology.

LOW FLOW IN THE OUED EL ABID BASIN (MOROCCO): BETTER UNDERSTAND IT TO BETTER MANAGE IT (OUM ERRBIA BASIN - MOROCCO)

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In a context where the pressures exerted on aquatic environments and the water needs of populations continue to increase, to which are added the impacts of global changes, knowledge of low water flows is a major issue.

Low flow is defined as a natural, seasonal phenomenon, generally resulting from a more or less long and more or less severe rain deficit, likely to vary in time and space and leading to a decrease in flow in the streams.

The Oued El Abid watershed (BVOA) is a sub-basin of the Oum Er Rbia wadi (30,600 km^2). The Oued El Abid is the most important tributary of the Oum Er Rbia, with an average annual flow of 32 m^3/sec. A maximum average flow rate of 77 m^3/sec. A minimum average flow of 10 m^3/sec (Regional Atlas region Tadla Azilal Morocco, 2015). The regime of this watercourse alternates between brutal floods and low flow supported by water from the karst hydrosystems of the central High Atlas.

The objective of this study is to characterize the low water flow rates of the Oued El Abid (upstream) watershed with a view to better management of the water resources of this basin.

The methodology used consists in extracting the lowest flows to be calculated and analyzing the low-flow severity thresholds (QMNA), the QMNA, the lowest average monthly flow of the year, low water flow rates calculated from the flows monthly averages, and we will calculate the values of QMNA for return periods.

Monthly flow data from two hydrometric stations in our study area (Ait Ouchéne, Tizi Nisly) were used and cover the period from 1976 to 2018.

Keywords: Management, Flow, Low water flow, Low flow, Statistical approach, Oued El Abid

CONTRIBUTION TO THE STUDY OF LOW WATER LEVELS IN NORTH-WEST ALGERIA USING THE IEB

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The low water flow is an important hydrological parameter, as much at the level of the human economic activity, as from the point of view of the preservation of the ecosystems. The low water level occupies a very important place in the cycle of the variations of the flows of a river and one could say that it is as well important as the flood flow. The consequences of drought, which are expressed in low water flows, are often wide-ranging. The renewal of this resource depends directly on the effective infiltration of precipitation (water reaching the water tables), which is obviously the result of total precipitation, but also of its intensity, duration, distribution in time and temperature, which influences evapotranspiration rates. In this context, the present work aims to study the low water flows in the North-Western region of Algeria and summarises the importance and the spatial and temporal distribution (trend) of the base flow due to groundwater discharge in the context of the quantification and management of water resources. Base flow (low flow) is often determined using a graphical or mathematical process known as base flow separation. This process uses recorded hydrographs. For this study, the Base Flow Index (BFI) technique originally proposed by the Wallingford Institute of Hydrology (Institute of Hydrology, 1980) was used. The base flow index is defined as the average base flow rate compared to the total flow rate and varies from 0 to 1. This technique is an automatic process of decomposition of a daily flow hydrograph. The interest of this index lies in its automatizability and controllability (computer program), while being able to process long data sets very quickly.

Our results show that the values of the base flow index (ratio of base flow to total flow) for a given month or year are closely linked to the amount of rainfall during the month or year, but that this parameter alone is not sufficient to adequately predict the value of the base flow of a wadi. On a chronological level, the BFI is obviously sensitive to climatic events and in particular to rainfall; it decreases at the time of floods and increases during low water periods. Its annual and monthly evolution over several years highlights the major climate trends. The study of monthly trends using linear regressions over the entire data period showed that the BFI values for several months (8 out of 12) had decreasing trends and very few increases for the months of December, January, February and March. For total precipitation, the trends were either increasing (spring and summer) or decreasing (December to June). The decrease of the BFI in recent years can be attributed to several factors.

Keywords: base flow index, low flow, trend, climate change, Northwest Algeria

CLIMATE CHANGE AND LOW FLOW IN THE DON RIVER BASIN: BAIESIAN EVALUATION AND PREDICTION

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The stationary disturbances observed in the time series of the minimum flow of rivers are largely due to climatic changes.

The increase in winter air temperatures led to changes in the conditions for the formation of river runoff: the number of thaws increased and the share of runoff formed by underground runoff increased. These effects led to a redistribution of runoff between seasons, and, accordingly, to a violation of the homogeneity of the time series of some runoff characteristics.

The hypothesis discussed in the report, in relation to the problem of substantiating the stochastic model of minimum runoff in non-stationary conditions, is to describe the observed runoff fluctuations in the framework of semi-Mark models of random processes.

In the statistical processing of non-stationary sequences of this kind, the task of determining the points in the time series to which the process state changes occurs arises.

To characterize and then take into account the moments at which the state change occurred, it is necessary to consider these points as a parameter of the non-stationary stochastic model, and use one of the known estimation methods, for example Bayesian.

This setting of the task is known in the scientific literature as the task of finding a CPD (change point detection) change point or a stop point. Several ways are known to solve this problem, including in climatological research.

The problem of finding a point of change in rows of minimum runoff in a non-stationary case is considered on the basis of the approach proposed in [Smith, 1975], which allows, at certain points in time, a change in the state of a random process, and the observed sample is a set of homogeneous time sequences characterized by a random change of states.

Bayesian estimate of fracture point is obtained for minimum flow of rivers of the Don basin by calculation by Bayes formula at given uniform a priori distribution of this parameter. As an estimate of the fracture point, it is proposed to take the average date value determined by numerical calculation of the moments of the distribution of the posterior distribution density.

Oral Presentations I h

"Impact of dams on hydrology"

CHANGES IN LAND USE / LAND COVER AND WATER BALANCE COMPONENTS BEFORE AND AFTER DAM CONSTRUCTION IN THE MONO RIVERBASIN, WEST AFRICA

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The Intergovernmental Panel on Climate Change has predicted sub-tropical region to be more vulnerable to the negative effects of climate change (CC). Additionally, to climate change, land use and land cover changes (LULCC) and dam construction often neglected, plays an important role on the spatial and temporal distribution of water balance components for agricultural production and socio-ecological equilibrium. The aim of this study was to analyze and compare the changes in land use/cover and water balance components for the period before Nangbeto dam construction (1964-1986) and the period after its construction (1988-2010) in the Mono River Basin (MRB). To this end, the study used mainly water balance components extracted from the validated Soil and Water Assessment Tool and land use/cover data of the years 1975 and 2000 in the MRB to explore their temporal distributions and the link in their changes. The results showed that mean monthly actual evapotranspiration, percolation, water yield, surface runoff, groundwater and lateral flow represent 51.05%, 17.53%, 15.93%, 9.43%; 5.67% and 0.42%, respectively of total water balance between 1964 and 1986. The same components represented 51.02%, 9.17%, 20.43%, 6.30%; 10.56% and 2.59%, respectively between 1988 and 2010. The contribution of these water balance components in mean-annual (1964-1986) period were for actual evapotranspiration (31.33%), water yield (25.95%), percolation (17.67%), groundwater (14.71%), surface runoff (9.94%) and lateral flow (0.40%). Meanwhile between 1988 and 2010, the contribution of actual evapotranspiration, water yield, percolation, groundwater, surface runoff and lateral flow are 49.85%,19.97%, 11.17%, 10.34%, 6.15%, and 2.52%, respectively. The results showed that the peaks of the actual evapotranspiration, surface runoff, percolation and water yield appeared in September corresponding to a month after the maximum of rainfall in August. However, our more detailed analysis showed that a significant decrease of forest and savanna and increase of croplands led to a decrease in precipitation, actual evapotranspiration and lateral flow over the second period of simulation compared

to the first period of simulation over MRB scale. Therefore, LULCC amplified by dam construction, have impacts on water balance components in MRB. These findings showed that sustainable management and conservation of natural vegetation is crucial for integrated water resource management and conservation in MRB.

Keywords: Water balance components, land use/ cover changes, dam construction, temporal analysis**,** Mono River Basin

ESTIMATING THE FLOW OF THE STRUCTURES OF A SUB-BASIN OF THE GRIJALVA RIVER

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The basin located between the Peñitas and Malpaso dams, in the Grijalva River basin is complex to manage since the reach between the beforementioned dams is divided in two reservoirs interconnected by two tunnels and one open channel. The management of the dams require a precise computation of the discharge in the tunnels and the channel. The estimation of the discharge can be on hydraulic basis, however there is not a proper bathymetry of the channel for such effort. Instead, we propose to use a statistical approach to estimate the combined discharge of the tunnels and the channel. An analysis was made of the outflow discharged by existing structures in such sub-basin. Based on the historical information of inflow volumes to the Peñitas Dam which we consider reliable, and based on the known operation of the dam (withdraws for generation for example), we propose different models for the estimation of the combined discharge of the structures. Two models were obtained with regression approaches and their parameters were optimized later with Genetic Algorithms (GA); another two models were calculated with a Genetic Programming (GP). The results obtained show that the GP achieves a higher correlation than the linear regression approach.

IMPACT OF DAMMING ON THE REGIME OF THE JAGUARIBE RIVER

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This work aims to analyze the impact of reservoirs on the discharge of the Jaguaribe River. The Jaguaribe River Hydrographic Basin (JRB) occupies an area of 75000 km², located in the Brazilian Semiarid Region (a million km² zone), drained by one of the largest intermittent rivers in the world, with an average flow of around 110 m³/s. Historically, an important number of reservoirs was established in the region to enable the establishment and development of cities in this area characterized by high rainfall variability and frequent occurrence of droughts. The examination of the hydrological dynamics of the JRB was conducted using the hydrological model WASA (Water Availability in Semi-Arid environments). The method used in the present paper to investigate it was simulation and validation of the model in the Upper Jaguaribe Basin (one third of the JRB area) considering the dams and withdrawals; simulation in JRB without dams and with dams, disregarding withdrawals aiming to assess the impact of the dams only; and comparing these previous simulations in terms of average discharge, floods and droughts (intermittency). The volume stored in the Orós Reservoir (outlet of the Upper Jaguaribe Basin) was the variable analyzed for the validation of the model, compared with measured values, using the Nash-Sutcliffe efficiency index (NSE). The result of NSE of 0.58 indicates the satisfactory performance of WASA in representing the hydrological dynamics in the Upper Jaguaribe Basin. Moreover, the implantation of reservoirs in JRB produced a reduction around 15% in the discharge. This contraction of the discharge occurs due to the increase in the water surface, a consequence of the implementation of dams, subject to the high evaporation rates in the region.

Oral Presentations II a

"Morphology under changing environmental conditions"

INFLUENCE OF FLUVIAL ENVIRONMENT EVOLUTION ON THE DYNAMICS OF GROUNDWATER

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The influence of the erosive base of the river valley on the course of geomorphological processes, exposed in a lot of scientific research, can be associated with the occurrence of specific erosion and deposition structures in the floodplain zone.

This impact is reflected particularly in the geological structure of the proximal part of the floodplain, which undergoes the strongest transformation during subsequent flood events. In many cases, during rapid flows in the floodplain area, the packet of low-permeable flood facies covering the river terrace is cut, and sandy material is deposited in the resulting gutters. Such zones are collectors of privileged groundwater flow.

This paper presents the results of groundwater flow dynamics tests performed in the filled erosional channel zone and untransformed terrace area (covered by river muds) using remote sensing methods and digital recorders allowing for the measurements of water level, electrical conductivity and temperature. The tests were carried out during the transition of the flood wave on the Vistula River in the zone of the full embankment system occurrence.

Presented studies allowed for the verification of the occurrence of zones susceptible to the risk of embankment failure resulting from the initiation of the suffosion process.

ANTHROPOGENIC, CLIMATIC IMPACTS ON THE MEDJERDA DELTA AND COASTAL DYNAMIC

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Medjerda (Arabic: مجردة) is a river whose source is located in Algeria and whose bed is mainly on Tunisian territory. Flowing over 460 kilometers, 350 in Tunisia, it is both the longest and the only perennial river in Tunisia. The average annual flow in its downstream part is 29 m^3/s, with great seasonal contrasts, in particular due to the influx of very irregular flows of wadis leading to a maximum solid transport capacity of more than 30 gl^{-1}. The low-water flow can be reduced to less than 1 m^3/s, whereas for floods with a ten-year periodicity it can reach 1,000 to 1,200 m^3/s. The Medjerda is equipped with two dams: Sidi Salem (the largest dam in the country) and El Aroussia which has a hydroelectric power station and a 50,000 hectares water intake for irrigation.

In 2008, we published a paper showing the impact of dams on solid transport and changes in river delta. The regulation of the Medjerda floods and the Sidi Salem Dam de-silting maintenance releases results in an extremely rapid aggradation and an alarming narrowing of the downstream channel-bed which were the major causes of the large floods experienced in the North of the country since 1996.

In this presentation, we update the results published in 2008 and show a modelling that allows to consider the geomorphological future of the Medjerda Delta under the constraints of climate change. For this we use new data on dam management and silting, coastal sediment dynamics (before and after dams) and considering INM-Météo France scenarios on climate change for 2050 and 2100.

LARGE RIVERS ON THE PERMAFROST ZONE AT THE PAST

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The area of permafrost at the end of the Valdai era occupied in Eurasia a wide belt from the edge of the drained shelf in the north to about 39 N. in south. In this area, on the plains (Great Poland, Pannonian, East European, West Siberian), fragments of meandering paleochannels 16-19 thousand years old are widely developed. The width and depth of these paleochannels, as well as meander wave-lengths, are significantly larger than that of modern rivers with the same catchment areas. It is assumed that large rivers in cold climates were formed due to atmospheric precipitation, without the runoff from melting continental glaciers. Significant water discharge was generated during the spring flood due to melting snow, which accumulated over the long winter. Losses of spring runoff due to evaporation and infiltration were minimal. During the transition to the Holocene, snow depth decreased, and the losses increased. This led to a decrease in the size of river channels (up to 15 times in width). At the same time, sediments washed away from the catchments were accumulated in the over-deepened channel network. As a result, the geometry of large channels of the end of the Valdai era largely control the modern morphology of river channels and floodplains, as well as the sediment budgets.

CLIMATE AND HUMAN ACTIVITIES IMPACT ON RUSSIAN LARGE RIVERS CHANNELS

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Global environmental change leads to increase / decrease of river water runoff. Such changes have an impact on river channels, which in the long term adjust to new conditions through changes in river morphology and channel patterns shifts. Human impacts associated with water management or water transport use of rivers also affect such changes and in some cases are crucially important.

Based on a retrospective analysis of largest river channels of Russia - Northern Dvina, Mezen', Pechora, Ob', Lena, Yenisei, Volga, Amur - we formulate the following typical scenarios of large rivers channel pattern adjustments driven by natural or anthropogenic impacts:

1. Driver: increase of water runoff rate. Typically evolution of steep bends and cut-off bends, flattening of bends, reduction of bends development degree and increasing of bends parameters can be seen. Braided channels typically shift from conjugated braided channel reaches to sub-parallel braided channel; straight unbraided channels – to single unbraided channels, one-sided or sub-parallel braided reaches; formation of braided channel patterns of the second order or formation of islands on the limbs or tops of meanders is observed.

2. Driver: decrease of water runoff rate. The sequence of shifts is opposite compared to previous scheme.

3. Driver: increase in sediment runoff and channel aggradation leads to evolution of braided channel pattern or their formation in a previously unbraided channel; steep bends tend to from cut-offs.

4. Driver: dams. Below dams braided channels of any type are typically formed. Upstream from the reservoirs bends tend to form cut-offs; straight unbraided or slightly sinuous channel → single or one-sided braided reaches; runoff recovery in old (previous) river channels, cut-off bends development.

5. Driver: in-channel dredging works: Typically meanders and braided reaches of any type are formed instead of straight unbraided channel, and conjugated braided reaches – instead of single or one-sided braided reaches.

Implemented under support of the Russian Science Foundation (project 18-17-000860) and according to the plans of the research work of the Department of Hydrology and the Laboratory of Soil Erosion and Channel Processes of the Lomonosov Moscow State University

CLIMATE CHANGE AND HUMAN INFLUENCES ON THE FUTURE SEDIMENT BUDGET OF THE RHINE MEUSE DELTA

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Deltas require sufficient sediment to maintain land area and elevation. Sediment budgets are a tool to indicate if deltas will net gain (positive budget) or lose sediment (negative budget). In this study, we aim to quantify the future sediment budget of the Rhine-Meuse delta, which is located in the west of the Netherlands and hosts the Port of Rotterdam, Europe's largest seaport. Using climate predictions, measurement data, 1D modelling and new predictive dredging relations, we estimate the future sediment budget and sediment distribution in the RMD in 2050 and 2085. By 2050 -18±8 Mt/yr will be lost annually from the delta, and -12±4 Mt/yr by 2085. The extensive dredging undertaken in the RMD, driven by port development and accommodation of larger ships completely outweighs any climatic or other effects on the sediment budget of the RMD in the coming century. Despite increased sediment supply from the coast and upstream rivers, current sediment management practices will continue to cause a sediment deficit in the future. The sediment distribution in the system is also uneven, with the majority of additional sediment transported to the major shipping fairways, which will increase dredging costs in future, cause enhanced erosion in some branches risking bank stability and infrastructure (e.g. underground cables and wires) and place intertidal (nature) areas at risk.

HISTORICAL CHANGES TO THE GEOMORPHIC CHARACTER AND DISTRIBUTION OF WATERHOLES

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Waterholes are an important biophysical feature of dryland river systems. They provide habitat for aquatic biota during unfavorable conditions and are a critical water supply to local communities in an otherwise arid environment. Despite their importance, waterholes are increasingly being impacted by human activity. These impacts result from deliberate, direct modifications to the river channel as well as via indirect processes linked to broadscale landscape change.

This study has examined changes to the physical character and spatial organisation of waterholes on the Barwon-Darling River, a dryland river in south-east Australia. Historical longitudinal profiles from the late 1800s were compared with contemporary profiles derived from high definition side scanning sonar.

Comparisons revealed a dramatic change in the physical character of waterholes over a 120-year period. Waterhole depths and the distance between deep waterholes (> 4 m in depth) have been altered significantly. The magnitude and trajectory of change was, however, scale dependent with the greatest observable change attributed to the presence or absence of low-level weirs. As expected, localized impoundment created deeper waterholes in areas immediately upstream of the weir structures which, corresponded with a decline in distance between deep waterholes. In contrast, the maximum depth of waterholes located outside of the weir pools influence declined by 1.6 m and the distance between deep waterholes has more than doubled in most locations. This decline in depth is hypothesised to be due to sediment accumulation associated with anthropogenic increases in sediment flux.

In this study the use of historical data created several challenges due to a small sample size and suspected sample bias in the historical data. However, this study demonstrated that such issues are not insurmountable providing the limitations and uncertainties with the data are acknowledged and data analysis is limited to parameters that can distinguish these issues from genuine landscape change.

Oral Presentations II b

"Measurement and modelling of sediment transport"

TESTING OF SUSPENDED SEDIMENT CONCENTRATION MEASUREMENT TECHNIQUES IN THE DANUBE

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A harmonized monitoring of the suspended sediment transport along such a large river as the world's most international river, the Danube River, is a rather challenging task. The conventional monitoring method in Hungary is obsolete but using indirect measurement devices and techniques could provide a fast and efficient alternative option of direct methods. We performed a comparative analysis of the filtration method and different indirect methods – optical devices: i) infrared turbidimeter (VELP TB1), ii) laser diffraction (LISST-Portable|XR), and acoustic methods: iii) acoustic backscatter sensor (LISST-ABS) and iv) ADCP backscatter calibration. A reasonably wide flow range could be covered during the measurement campaigns, i.e. from low water (~1100 m^3/s) to a 1-year-flood (~4600 m^3/s), which provided a wide range of detected suspended sediment concentration values. We found that there is a strong relationship between the direct and indirect methods indeed. However, indirect methods are highly sensitive to the characteristics of the suspended sediment particles (i.e. size, shape, material). We investigated the advantages and limitations of optical and acoustic devices, with the aim of quantifying the uncertainties and providing a comprehensive comparative assessment of the investigated indirect methods. Furthermore, we illustrated the additional information content that can be retrieved from the indirect measurements, for instance obtaining the cross-sectional suspended sediment concentration distribution from moving-boat ADCP measurements and information about the particle size distribution easily determined by the LISST-Portable|XR.

BEDLOAD FLUX MODELING IN LARGE GLOBAL RIVERS

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Bedload flux is notoriously challenging to measure and model. The dynamics of bedload sediment transport mechanisms therefore remains largely unknown in most fluvial systems worldwide. That is a persistent issue in fluvial geomorphology given the importance that bedload transport rate and distribution in geomorphological, ecological and engineering functioning of rivers, reservoirs and costal systems. We present a global scale bedload flux model as part of the WBMsed hydro-geomorphic modelling framework. We test three bedload equations and analyze the importance of particle size, water discharge, river slope and stream power on the model predictions. While offering fairly coarse-scale and first order estimate of bedload flux, the model enables the study of large-scale universal dynamics and it offer a pathway for alleviating the acute scarcity in bedload flux data. As an example, we will present an analysis of the dynamics between suspended sediment and bedload fluxes along major rivers.

MEASUREMENTS AND CALCULATIONS OF BED LOAD TRANSPORT IN THE LOWER AMUR

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Despite the large number of studies on the problem of bed load transport, it is still calculated with a fairly large error. The reason of this is the insufficient knowledge of the bed load transport process, which is the result of a rather low measurement accuracy. The problem is particularly acute for lowland rivers. Among the existing methods of bed load measurements an iterated lengthwise echo sounding method is relatively reliable, however, it also gives an error of up to 30-50%. The most accurate method was and still remains a volumetric method, when bed load transport is determined by the actual sediment accumulation in reservoirs, ditches, borrows, etc.

Exactly such measurements were made in the Lower Amur during the construction of the reserve line of the ESPO-II oil pipeline. Due to the high intensity of bed load transport and in order to clarify the estimated value of bed load, the amount of sediments accumulated in the ditch over several periods at the beginning of the ditch digging were measured. On the base of this data a comparison of more than hundred bed load formulas was made, and the most reliable ones for these and close to them hydraulic conditions were determined.

CHARACTERISTICS OF BEDLOAD TRANSPORT MEASUREMENTS IN ALPINE CATCHMENTS

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Sampling of bedload transport and its processes is a major challenge in river research that has occupied researchers around the world for decades. In Austria, bedload transport has been recorded at seven sites, from high-altitude Alpine regions down to the Danube River, for more than ten years. The size of the investigated catchment areas ranges from 52 km² at the Johnsbach to 104.177 km² at the Danube.

The measurements are carried out by means of direct measurement methods (various bedload samplers and traps) and indirect measurement methods (geophones) and thus the bedload transport is mostly recorded integratively. Bedload transport as well as bedload load yield itself can be determined station-specifically by Bedload Discharge Integrated Calculation Approach (integrated approach) and/or by the Bedload Rating Curve Approach.

With the help of the measurement methods used, all relevant extreme events could be sampled during the study period. For example, maximum bedload transport rates of 131 kg/s were observed in Dellach/Drau on 31.10.2018, or a maximum of. 312 kg/s on 6 June 2013 at the Danube near Hainburg.

The mean annual bedload at the investigated monitoring sites ranges from about 4800 t at the Drau/Falkensteinsteg site to about 380,000 t at the Danube in Hainburg, whereby the annual loads are partly subject to high fluctuations depending on hydrology and catchment size. Due to an intensive flood event in October 2018 induced by a pronounced snowmelt, the annual load at the Falkensteinsteg measuring station, for example, was six times higher than the average annual load.

Owing to the long-term monitoring, good statements can be made about the bedload yield and the bedload transport behavior. For instance, it could be observed that the dependence of bedload transport on flow decreases with decreasing catchment size and with fluctuating sediment availability.

STUDY OF THE SEDIMENT FLUX ORIGIN OF YENISEI AND OB'

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This abstract presents the results of the study, in which the main goal was to investigate the composition and origin of river sediments of Great Arctic Rivers. On the one hand, MSU expedition collected sediment samples in different flow periods per cross-section in Ob' and Yenisei channels at last gauging stations (Salekhard and Igarka), where estuary flow changes are marginal. The matter, which income to rivers can be from three main places: from the watershed (rain and snow melted water soil erosion) and from the channel changes. These incomes were estimated by RUSLE and MUSLE model. Thus, the comparison of total erosion, quantity and composition of suspended sediments in two rivers allows making assumptions about processes, which are valuable for sediments transport in Arctic region.

COUPLING TOPOGRAPHIC AIRBORNE LIDAR AND PHOTO-SIEVING METHODS FOR GRAIN-SIZE MAPPING

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Quantification and spatialization of grain size distribution (GSD) of riverbed surfaces is crucial for morpho-sedimentary survey and modeling, as well as ecological studies. Recently, new remote sensing methods were tested as UAV-Sfm and terrestrial LiDAR by using roughness metrics. However, these methods are not usable for river reaches of several tens of kilometers.

In this paper, we tested the capacity of an airborne topographic LiDAR to estimate the bed GSD using both roughness metric (rh) and return pulse intensity on two large gravel bed rivers with different grain size properties: the Old Rhine River (D_{50} = 27 to 130 mm and D_{84} = 33 to 180 mm) and the Moselle river (range D_{50} = 38 to 56 mm and range D_{84} = 44 to 64 mm). Field manual measurements (Wolman, 1954) were simultaneously performed to build statistical models between the two proxies and the field GSD. Photo-sieving was also used to calibrate Lidar data and to compare results of continuous and discontinuous GSD mapping.

Our results showed that both metrics can be used as proxies to accurately estimate the GSD on the two rivers. Photo-sieving can also be used to calibrate the airborne LiDAR surveys. Nevertheless, when automatic image treatment is aimed, particular attention should be paid to environmental conditions during field sampling, especially solar conditions (intensity and angle) and shooting distance.

The use of topographic LiDAR method offers the opportunity to map the GSD of emerged channel bars in addition to classical use of LIDAR i.e. accurate channel morphological characterization and sediment balance. These maps can be used for morphodynamic survey, hydraulic and sediment transport modelling, as well as riverine habitat characterization in order to integrate the variability of GSD in both longitudinal and lateral dimension.

Oral Presentations II c

"Morphological stabilization measures (Part I)"

MORPHOLOGICAL CHARACTERISTICS AND RIVERBED STABILIZATION MECHANISM OF NUJIANG RIVER, CHINA

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Nujiang River, called as Salween River in the downstream, is a typical incised river located in the topographic steep zone at the eastern edge of Qinghai-Tibet Plateau, in Southwest China. In the Nujiang Grand Canyon, river incision of the mainstream has triggered frequent geological hazards such as collapses, landslides and debris flows and formed hundreds of barrier dams in the mainstream, which effectively restrain river incision and stabilize the riverbed in turn. The objective of our present study is to build further understanding for the stabilization mechanism of the mainstream riverbed by barrier dam development in the Nujiang River. We collected data from satellite images and field investigations conducted in three years. The geomorphological characteristics of the main stream and barrier dams in the Nujiang River were summarized. The barrier dams were classified by hierarchical cluster analysis, in which 9 geomorphological and hydraulic parameters were used. The stability and energy dissipation properties of the barrier dams were evaluated quantitatively for each category of barrier dams. The results show that the distribution density of barrier dams is high and positively correlated with unit width stream power. The barrier dams can be classified into two categories, barrier dams formed by collapses or landslides, and formed by debris flows. The former type can remain stable during historic exceptional floods while the latter stays stable in ordinary floods. The energy dissipation ratio of the barrier dams by collapses or landslides increases with unit width stream power. In contrast, the unit width stream power increases relatively slowly owing to the larger transverse valley for the other barrier dam type. The barrier dams in the mainstream exhibit the stability and energy dissipation ratio matching the local unit width stream power, and therefore, can dissipate flow energy enduringly and efficiently, and increase the riverbed stability.

DESIGN TO AVOID SEDIMENTATION AT MAGDALENA RIVER MOUTH

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Bocas de Ceniza is the name of the mouth of the Magdalena River, few kilometers upstream an important big river harbor is located. During the last one hundred years, the morphology of the river has been modified in order to transform its depth from 30 feet into 40 feet. Nevertheless, the river exhibits a continuous sedimentation in the mouth of the river, which has to be dredged periodically. A huge amount of money has to be expended each year in order to maintain the functionality of the harbor. Thus, the administration has decided to make a study to explore the possibility to arrange the sedimentation problem.

The Magdalena River has a mean dominate discharge about 7400 m^3/s, is a sinuous river of average width of 500 m and the depth at this discharge is slightly lower than 40 feet. The drainage area of the Magdalena River is about 250000 km^2.

In order to explain the sedimentation problem in the mouth of the Magdalena river two aspects where detected. The first one is related to the plant configuration geometry; the river was designed in such a way that the river is completely straight, this configuration produces unstable Thalweg, that generates that Thalweg position changes; over a year, some months it may be found on the right side, while others on the left side. This continuous changing of the Thalweg gives sedimentation problems, producing bars that change in height and position frequently. The second aspect is the problem related to the salt wedge that intrudes several kilometers upstream. The salt wedge generates zones in which the flow has nearly zero velocity, inhibiting the turbulence, thus sedimentation starts, especially near the mouth.

A curve solution has been designed, in which is proposed that the straight final part of the river will change into a curve. This solution creates a stable and deep Thalweg and fights against the salt wedge. The settlement considers changing the final curvature of the river and demolishing some spur dikes that gives some flow problems, especially with sedimentation behavior. Furthermore, river shores will be moved with the help of submerged vanes.

MACRO ROUGHNESS TO MOBILIZE SEDIMENT AT THE BUENAVENTURA BAY

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Buenaventura Bay connects the pacific sea to the east coast of Colombia, to provide goods from Asia and east of USA to the interior of Colombia; Bogota, Cali, Medellin and other cities through the Buenaventura port, moving millions of tons throughout the country, in this fact relies its importance.

A channel dragged in the bay surface allows the entrance of certain ships with draft until Post Panamax, but the Buenaventura Regional Port Society wants to increase the manage volume including the super Post Panamax ships. The problem lies in the sedimentation phenomenon that exists in the outlet of the Bay controlled by a natural gorge. Millions of tons per year of material deposited by the flow near the entrance fill the channel of sediment.

This paper presents a structure to generate turbulence that moves the sediment outside the bay using only the water energy, the Rocker. The behavior of the flow in the bay is asymmetric giving a net sediment flow in the outside direction, allowing the Rocker to stimulate the turbulence keeping the sediment into suspension.

The configuration of the Rocker and the turbulence behavior and influence of the Rocker in the flow are presented. Practically, a suspended plate with enough weight generates enough turbulence to maintain the sediment in suspension. The density of rockers is important to keep the turbulence active, because turbulences have a very fast decay. The Rockers are mobile elements that can be changed from one place to another or re-accommodate if they move by some heavy storms. The channel surface is covered by those rockets to permit the flow to transport the sediment to a deeper zone and keep the channel free of sediment.

Oral Presentations II d

"Morphological stabilization measures (Part II)"

GEOMORPHIC RESPONSES OF RESTORED FREQUENTLY FLOWING SIDE CHANNELS ALONG THE RHÔNE RIVER

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From early stages to more mature conditions, temporal patterns of fine sedimentation are well known in side channels that have been restored along the Rhône River. Since the beginning of the restoration program in the 1990s, a scientific monitoring has been performed to provide data from a set of restored channels along the river continuum to understand how they adjust to their new conditions after restoration. However, there is still a lack of knowledge regarding the geomorphic processes in the active side channels (i.e., upstream and downstream frequently connected with the main channel) and their bedload transport conditions. We can observe in some of them a terrestrialization pattern (i.e., gradual water lowering) that can be linked to: (i) bedload input from the main channel which in turns is controlled by geometric characters of the channel or its entrance as bifurcation angles, and/or (ii) morphological adjustments of the main channel or the side-channel itself. we show here the results of a multi-technical approach which aim at characterizing terrestrialization patterns, in time and space, of five restored active side-channels located on three bypassed reaches of the Rhône River. We first characterized conditions prior artificial disconnection from historical data and archives. Then, geomorphic trajectories since the first implementation of longitudinal dykes [1850's-1930's] and flow diversion due to by-passing [1948-1986] until restoration (for over a century since cutoff) and then from restoration to the present day (i.e., from 3 to 16 years after restoration works), are assessed from a combination of existing topo-bathymetric data and new acquisitions. These new acquisitions consist on in situ measurements of bed grain size characteristics by underwater imagery, bedload transport assessment using RFID technology, interstitial clogging by volumetric analysis and evaluation of hydraulic conditions in channels with limnimetric data series. Finally, geomorphic responses of active side channels and their life span are discussed with regard to the evolution of the main channel itself over the last two centuries.

SUSTAINABLE SIDE CHANNEL RECONNECTION AT THE AUSTRIAN DANUBE

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The Austrian Danube East of Vienna passes through a National Park with an alluvial forest that serves both as habitat for many different species and as important recreation zone for humans. Originally an anabranching system, river regulation dating back over a century has cut off former side channels from the main river branch, which are often only connected for less than half a typical hydrological year. The long-term river management strategy is therefore to reconnect the side channels at lower discharges to improve the overall ecological functioning of the river system. In the approximately 7 km long side channel system between the municipalities Haslau and Regelsbrunn, restoration measures in the 1990s aimed at improving the flow conditions in the oxbows and increased the connection to over 200 days per year. However, sedimentation and morphodynamics processes caused the connection duration to drop to 140 days today. The aim of the study as part of a larger restoration project is therefore to determine which parameters contribute to the long-term sustainability of a side channel reconnection.

Hydrodynamics and morphodynamics constitute the key parameters for assessing (i) general functionality and (ii) sustainability of a reconnection measure. In our study, these were investigated using a modelling approach involving 3D hydrodynamics coupled with a sediment transport and morphodynamics model. In particular, different angles of the branch junction were tested as well as a variation of width and depth. It was found that a connection angle between main river branch and side channel entrance of less than 40° substantially improves the inflowing discharge. Moreover, sedimentation in the side channel downstream the junction was found to be smaller when the channel geometry was homogeneous, avoiding larger variations of width and depth. A side channel reconnection considering these constraints is therefore expected to exhibit an improved long-term sustainability.

NUMERCIAL MODELLING OF GROYNES AND BED DEGRADATION AT THE AUSTRIAN DANUBE

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Bed degradation is occurring in many large rivers, as a result of e.g. channelization of rivers and sedimentation in reservoirs upstream. 1 to 2 cm/year degradation was observed in the free-flowing Austrian Danube east of Vienna. Recently, the optimization of groynes was found to be a successful instrument to reduce the sediment transport in the main stream and, thus, to decrease bed degradation, while keeping a sufficient fairway depth for navigation. Those findings were reached within variant studies using numerical models up to one month simulation time and during the monitoring of the application of the numerically optimized geometries in field experiments. These studies were applied in two reaches up to 3 km length in the Danube showing a local improvement of the morphodynamic equilibrium. However, effects of adaptations of a higher number of groynes at longer reaches and longer simulation times remained unclear. Therefore, in a further numerical investigation, all groynes in a reach of 10 km were removed (scenario B) and compared to the current state including groynes (scenario A). A 3D hydrodynamic model (RSim-3D) coupled with a sediment transport model (iSed) was applied considering a simulation time of two months mean flow followed by a flood event with a 1-year return period. Scenario A showed no change in mean bed levels in the main stream, whereas scenario B increased sedimentation in the main stream by around +6 cm on average. Those sedimentations are expected to interfere with navigation in the long run. The difference in the morphodynamic state between the scenarios clearly underlines the strong impact of groynes in terms of a morphodynamic equilibrium in large free-flowing rivers. Thus, the optimization of groynes in terms of hydrodynamics and sediment transport serves as an important tool to manage river bed degradation and sufficient fairway depths for navigation.

PROTECTIVE CHARACTERISTICS OF DIFFERENT BANK-PROTECTION TYPES IN THE YANGTZE RIVER

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Under the condition of the clear water flow due to the Three Gorges Project (TGP), the bank collapse frequently occurs in the Yangtze River. In order to protect bank against scouring, engineers have designed and used many different types of countermeasures, such as riprap, wire mesh stone cage, tetrahedral frame, flexible mattress and so on. Armoring countermeasures, such as riprap stones, are the primary method used to protect river bank against scouring; however, these methods have not had definitive success. In order to study the effects and mechanism of new protection countermeasures, some laboratory experiments have been carried out. However, in natural rivers, especially rivers with large flows such as the Yangtze River, little research on protective characteristics of different bank protection countermeasures has been carried out.

This paper presents a comparative test of different bank protection countermeasures in the natural reach of the Yangtze River. Based on the new water and sediment conditions and characteristics in the Anqing Reach which is facing into the major flow, the protective characteristics of three types of bank protection countermeasures, such as riprap, wire mesh stone cage, and flexible mattress, are investigated under almost the same flow condition. Comparative analysis of the changes of incoming water and sediment, riverbed level, river cross-section and bed sand grading indicate that: (I) the edges of wire mesh cage and flexible mattress are easy to be washed away, even if the protective layer boundary is protected by stones, (II) fine particles under the wire mesh stone cages will occur the winnowing phenomenon, when the thickness of the cages is less than 0.5m which is almost twice the average particle size of the stone, (III) the flexible mattress is not suitable for the banks which are facing into the major flow and steeper than 1:2.5.

DREDGED CHANNEL AS A FLOOD MITIGATION MEASURE

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The rivers flowing in the central part of India have flat slopes. These rivers originate from Himalayas and carry high discharges and huge amounts of suspended sediments with it during rainy season. Rivers flowing through lower reaches have shallow depth and continuous deposition of sediment lead to changes in the course of river often. This results in to erosion of the banks. The lives of people staying on this river banks get adversely affected due to erosion of banks and recurrent floods. The conventional structural flood measures like levees, spur, guide bunds, bed pitching or bank revetments though effective but costly affairs. In this research the effect of dredged channel in the Ghaghara River reach to divert flood water and prevent erosion of bank has been discussed. The areas surrounding to this dredged channel was flooded for days prior to the construction of dredged channel. At this river reach right bank of the river was attacked by flood waters and villages on the right bank of the river was at the risk. The dredged channel was constructed in the middle of the river reach by excavating deposited sediments forming an island. The length of dredged channel was 10.5 km, width 40 m and at this location width of river was approximately 4 km. The dredged channel worked well during rainy season of year 2018 and passed heavy discharges safely. It has protected erosion of the right bank and served purpose of flood mitigation. In last two years a river course has been developed and water is passing through the middle part of the river instead of attacking right bank of the channel due to this dredged channel.

ASSESSMENT OF AVAILABLE GEOENVIRONMENTAL OBSERVATIONS FROM LARGE LATIN AMERICAN RIVERS

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Disaster risk reduction requires scientific support based on scientific observations. A large body of compelling evidence suggests that hydroclimatic hazards (i.e., floods and storm events) are the most frequent natural hazards in the Latin American sphere. This contribution reports a large assessment of the existing geoenvironmental observations that describe the dynamics of Latin American rivers, which encompasses several large neotropical fluvial systems. Thus, we present a conceptual and engineered database that is aimed to deliver centralized information that can be used in hydroclimatic hazards management in the short term, and for improving the scientific understanding of the processes associated to the rivers in question in the medium term.

The database has the following technical characteristics: [1] a decentralized administration, which enables any interested party to partake in the data management without requiring specialized hardware; [2] in-built platform tools that properly cross-reference different datasets and address proper assessment of regions with poor information, and [3] a taxonomical system that allows for easily performing complex queries from both a frontend platform and an application programming interface. Finally, an application to the Cesar River, one of the largest rivers of the Magdalena system (Colombia), is also described.

Oral Presentations II e

"Management of sediment and river morphology"

SEDIMENT MANAGEMENT THROUGHOUT THE MEUSE RIVER

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The catchment of the Meuse River measures 34,347 km^2 and is shared by France, Belgium, the Netherlands, Luxembourg and Germany. The main river is 905 km long and flows from France through Belgium and the Netherlands towards the North Sea. Since the 19th century large engineering works have been carried out to serve navigation, power generation and flood safety.

The International Meuse Commission (IMC) was established in 2002 with the signing of the Meuse Treaty (Ghent Convention). The treaty aims at achieving sustainable and integrated water management by addressing transboundary issues such as flood management, water quality and nature and water availability. In this way rules and requirements of the European Water Directive and the Floods Directive are implemented in a coordinated way. Although erosion and sedimentation processes are important for ecology as well as a potential threat for structures and navigation, the directives do not provide clear guidance for sediment management.

In this research we made an inventory of sediment related problems in the countries and national sediment management strategies, which until now aim at safeguarding navigation and flood safety through maintenance dredging. However, national sediment research programs started recently including river system aspects and long-term effects of human interference and climate change. France started the program "Know the River" to understand the sediment loads, morphological development and impact of human activity and climate change. In the Netherlands the morphological system is assessed in the "Story of the Meuse", the "Story of the Sediment" and the Integrated River Management program. In both countries the results will be used for improved management and planning new interventions.

The national programs are not coordinated at this stage. This provides a challenge for international cooperation, aiming at understanding of basin wide sediment sources, sinks and fluxes and ultimately recommendations for transboundary sediment management.

THE GRAND-ETHIOPIAN-RENAISSANCE-DAM IMPACT ON THE BLUE NILE DISCHARGES AND SEDIMENT LOADS

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This paper addresses the issue of downstream impacts of the Grand Ethiopian Renaissance Dam GERD, which is under construction on the Blue Nile in Ethiopia, in terms of water quantity and its distribution throughout the year, and it also studies how the dam could affect the sediment concentration at Eldeim station downstream the Sudanese-Ethiopian border. This research is conducted considering both the initial filling state and steady operation state.

The effect of water impoundment at GERD reservoir on sediment load entering Sudan is estimated by using an analytical method to calculate sediment trap efficiency of the dam. The method used is the sediment index method.

According to the result of the developed model, the reservoir of GERD loses 0.76 Bm^3 of its storage capacity by the end of the initial filing period. The steady operation of GERD reservoir was studied considering two scenarios. The first scenario uses the measured sediment data of an average hydrological year; this shows that GERD reservoir loses 10% (i.e. 7.4 Bm^3) of its capacity after 55 years, and 20% (i.e. 15 Bm^3) after 119 years of steady operation. In the second scenario, the data used is the sediment concentration series generated from the developed general sediment rating curve, in this case, the 10% loss of the GERD reservoir capacity occurs after 95 years.

EVALUATION OF A NOVEL SEDIMENT MANAGEMENT APPROACH – CASE STUDY DANUBE/AUSTRIA

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Sedimentation in impounded sections of run-of-river hydropower plants in large rivers is gaining growing public awareness because of its associated impacts on flood protection and inland navigation. While increasing riverbed levels pose risks for the maintenance of high-water levels and waterway parameters, the morphological and ecological diversity suffer from the presence of impounded river sections. Current management strategies are often rather expensive and unsustainable, and eventually include adverse effects for ecology in downstream river sections (e.g. during flushing). A novel approach on sediment management by Zauner et al., was implemented at the study site Danube in Austria consisting of two main steps: (i) local dredging in areas of the impoundment that are problematic in terms of flood levels, (ii) re-deposition of dredged bedload material by constructing artificial gravel structures. The present study evaluated this implemented sediment management approach by considering the long-term morphological processes in the impoundment and their effects on aquatic habitats. Bathymetrical surveys from the years 1965 – 2016 were analysed by a "cross-section based analysis" and supplemented by the construction of digital terrain models. Results showed that the impoundment can be divided into sections of bedload and fine sediment depositions with decreasing sedimentation rates in upstream direction. In general, the structures remained stable even after flood events. However, there is room for optimization regarding their shape, height and location. The novel approach on sediment management represents a cost-efficient measure for hydropower companies that includes considerable improvements for flood protection, navigation, and the morphological and ecological status of the river. For a successful implementation, knowledge on the sediment dynamics in the impoundment is required in order to identify both problematic areas in respect of flood protection and areas that provide bedload material for ecological structures. Moreover, the definition of appropriate locations for the re-deposition, which depend on morphological, navigational and ecological criteria, is crucial in order not to diminish flood protection.

PREDICTING WATER AND SEDIMENT PARTITIONING IN A DELTA CHANNEL NETWORK UNDER VARYING DISCHARGE CONDITIONS

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Channel bifurcations control the distribution of water and sediment in deltas and the routing of these materials facilitates land building in coastal regions. Previous studies on channel bifurcations have used numerical models that couple downstream branches to an upstream branch via a nodal relation that describes flow partitioning. However, few field measurements are available to evaluate what hydraulic variables best predict flow partitioning at a channel bifurcation. Herein, multiple nodal relations utilizing various hydraulic and channel planform parameters are evaluated to assess their predictability of flow partitioning using field data collected from the Selenga River delta, Russia. The data set includes 2.5 months of time-continuous, synoptic measurements of water and sediment partitioning covering a flood hydrograph. Results show that nodal relations utilizing channel geometry, length, and sinuosity have the best qualities for predicting water and sediment partitioning. Flow partitioning is determined to be highly variable over the flood hydrograph. Moreover, a stability analysis shows that bifurcations are morphodynamically stable at flood conditions and unstable during low discharge, indicating that flood intermittency impacts bifurcation stability. The best nodal relations are incorporated into a channel network model, based on graph theory, to yield a framework that predicts distribution of water and sediment fluxes in deltas. This framework tests well with data from the Wax Lake, Selenga, and Lena River deltas. Variables from this framework can be easily measured by remote sensing, thus it has the potential to evaluate both water and sediment fluxes for deltas globally.

STABILIZING THE BRAHMAPUTRA RIVER IN BANGLADESH: MORPHOLOGICAL MODELLING FOR PLANNING

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The Brahmaputra is one of the largest and most complex rivers in the world. It exhibits a braided planform in the lower half of its basin, which is strongly influenced by annual monsoons, as well as infrequent but very large earthquakes. The last major earthquake in 1950 destabilized the river and widened it by an average of 50%. Today some locations exceed 20 km in width. On average 350 km of riverbanks are eroded annually along the 1,100 km long Lower Brahmaputra. The erosion not only causes devastation to the densely populated floodplain, it also inhibits development.

In order to eradicate this problem, Bangladesh is currently attempting to stabilize the river under the Flood and Riverbank Erosion Risk Manage Implementation Program (FRERMIP). FRERMIP has developed a river stabilization plan, which proposes to fix a more meandering planform along a reach of 150 km. Long guiding geobag revetments stabilize outer bends, creating a "backbone" for the river, fixing a boundary between river and land.

Successful stabilization efforts are dependent on a comprehensive understanding of the rapidly changing morphological riverine situation. Two-dimensional morphological models have been employed in order to assist in the understanding of the ever-changing channel patterns, as well as predict future developments. Delft3D has been used to model a 60 km reach (upstream of the Ganges confluence) over four flood seasons. The model focused on bifurcation dynamics, deep channel scour migration (for identification of erosion prone locations) and channel closure scenarios. While the modelling activities have proved to be extremely useful, they have had their limitations. Unpredictable monsoons, uncoordinated dredging actives, large spacial scales and limited data make modelling the already complicated braided river extremely difficult.

A GLOBAL PRACTICABLE SCREENING TOOL TO COMPARE MORPHOLOGICAL CHARACTERISTICS IN CONNECTION WITH ANTHROPOGENIC INFLUENCES

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For the evaluation and subsequently for the comparison of different morphological characteristics of large rivers it is necessary to develop and apply a standardized methodology based on worldwide freely available data. In the methodology presented here, all that is needed is a digital terrain model with the highest available resolution and aerial photographs that are as up-to-date as possible.

The methodology, which is to be understood as a screening tool, uses a hybrid assessment approach, containing 1D-Hydrodynamic-Numerical (1D-HN) model data and aerial photography. It compares the ratio of water level widths for three morphologically representative and standardized discharge values: The wetted width within bankfull width, the width of the active channel and the morphological floodplain width.

The evaluations are cross sectionally-based and were carried out with the 1D-HN model software HecRas on the basis of an edited digital terrain model as well as aerial photographs. The wetted width within the bankfull is modelled with standardized discharge variables from HecRas, the width of the active channel and the morphological floodplain width are created with the help of the aerial photographs.

The results show that due to the anthropogenic influence on the rivers, such as through hydropower use, settlement pressure and flood protection, natural boundary conditions such as slope and valley width do not always lead to the expected morphological characteristics: e.g. in heavily populated areas with large valley width and low gradient, where a large difference between the widths would be expected, flood protection results in a small difference as would be expected in very steep sections.

With the help of this screening methodology, sections can be identified which, contrary to their natural boundary conditions, show morphological characteristics caused by strong anthropogenic changes of the rivers in their planform and width development.

Oral Presentations II f

"Sediment transport under changing environmental conditions"

IS SUSPENDED SEDIMENT TRANSPORT IN LARGE GERMAN RIVERS DECREASING BACK TO PRESTINE LEVELS?

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Suspended sediment transport is an integral part of large river systems and constitutes an important component of riverine ecosystems. Suspended sediment transport has been disturbed by human intervention in most river systems around the world, inducing changes in both directions: While deforestation and conversion to agricultural land increases suspended sediment loads in many rivers of the world, dam construction and the recent implementation of soil conservation measures reduce suspended sediment loads. Thus, recent trends in suspended sediment transport may vary from region to region based on the prevailing driving forces and the configuration of their contributing catchments. Here we report on trends in suspended sediment transport in large German rivers between 1990 and 2010 CE and evaluate various driving forces.

Our analysis is based on 65 monitoring stations of the suspended sediment monitoring network conducted by the German Water and Shipping authority. The majority of the monitoring stations (e.g. 52 of 65) show a significant reduction up to 50% in suspended sediment concentration and transport since the early 1990ies (at $p < 0.05$). While none of the station shows an increasing trend, 13 stations are characterized by no significant change. Suspended sediment concentrations for most stations decline somehow slightly stronger during summer months, however there is no congruent picture; as for some stations winter-concentrations decline stronger than summer concentrations. Our analysis indicates that decreasing suspended sediment concentrations seem to be unrelated to changes (e.g. decreases) in discharge, for which no significant trends could be found for most stations.

In this talk, we discuss various causes for the declining trend of suspended sediment. We will evaluate, weather declining SSC levels is either caused due to reduced catchment scale soil erosion (e.g. due to soil conservation measures) or the reduced sediment connectivity due to implementation of buffers and barriers within the contributing catchment or within the river channels. We will stress the importance of small-scale measures that retain small amounts of sediment per single measure, but may have large scale effects in sediment flux, due to their large number within the contributing catchments.

LONG-TERM CHANGES OF GEO-FLUX COMPONENTS IN RUSSIAN ARCTIC RIVERS

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Long phases (more than 10-15 years) of decreased and increased river water flow, heat flux, suspended sediment load and major ions flux of the Ob', Yenisei, Lena and Northern Dvina Rivers at their outlets during the period of observation from 1930-1940 till 2000 have been revealed by statistical criteria as well as with normalized cumulative deviation curves. The contrasting phases of naturalized (i.e., excluding anthropogenic changes, mainly due to the river flow regulation by reservoirs) geo-flux components have been evaluated. The identified phases display statistically significant differences in average values for the considered geo-runoff components. Their long-term changes are mainly characterized by two major long phases with a border between the 1970-1990s on all rivers under consideration with the exception of the Ob' River, where such contrasting long-term phases for suspended sediment load were not identified. The difference between the average values of geo-flux components for contrasting phases varies from 10 to 20 % reaching its 40 % maximum in the Yenisei River winter water flow and 50% in the Lena River suspended sediment load. Anthropogenic factors (mainly river flow regulation by reservoirs) have significantly decreased the differences between average values of geo-flux components for contrasting phases.

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FORECASTING SEDIMENT TRANSPORT AND MORPHOLOGICAL RESPONSE IN THE MISSISSIPPI RIVER

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The Mississippi delta is being degraded at an unsustainable rate with serious potential to undermine the benefits the delta provides to wildlife, people and the U.S. economy unless action is taken to address the long-term decline in sediment load delivered by the Lower Mississippi River. Understanding the likely future evolution of the river in response to its changing sediment budget is imperative but remains a vision beyond the capabilities of conventional river engineering models that focus on short-term investigations of hydraulics, flooding, habitats and channel morphological response, typically within reaches of interest and over project-design time-scales.

A new type of model is currently in development for the lower Mississippi River, tasked with revealing uncertainty-bounded trends in sediment transport and channel morphology over annual, decadal and centennial time-scales. The FRAME (Future River Analysis & Management Evaluation) tool is being designed with river managers and planners in mind where results will offer exploratory insights into plausible river futures and their potential impacts. A unique attribute of the tool is its hybrid interfacing of traditional one-dimensional hydraulic and sediment transport modelling with a rules-based expert system for characterising the nature of morphological response. The tool employs probabilistic annual flow duration curves to define ensembles of hypothetical average years, wetter than average years and drier than average years that in sequence enable the design of long-term hydrological storylines.

A testbed model for a 200-mile reach of the Mississippi River upstream of Vicksburg currently provides a platform for FRAME's development, testing and, critically, for realising the multiple benefits that such a tool would deliver. While the lower Mississippi River provides a prominent case where long-term forecasting of sediment transport and morphological response would be invaluable, such a tool would be transferable to other river settings and management programs seeking to mitigate against undesirable future outcomes.

Oral Presentations II g

"Large scale river morphology (Part I)"

BEDROCK IMPACT ON THE COURSE OF LOWLAND RIVERS FLUVIAL PROCESSES

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The maturity of lowland rivers is usually manifested by formation of valley with considerable thickness of alluvial deposits. This kind of structure provides river with freedom to adapt channel pattern in respond to hydrological regime changes. In case of Polish Lowlands postglacial area, changes of contemporary fluvial environments including enlarging differences between extreme discharges (considered as effect of development of drainage basin and climate changes) caused increase in significance of alluvial bed-rock as a factor determining rivers behaviour.

Although under conditions of medium and low river discharges the surface of alluvial bed-rock is hidden under the channel alluvia, during a flood the depth of deep erosion increases. In zones where the alluvia substratum forms morphological protrusions (their origin is linked with glacial genesis of the area and proves apparent maturity of valleys), its surface could be then revealed from under alluvia cover. The outcrops of substratum of the alluvia are usually insusceptible to erosion, so their morphology can affect the currents lines distribution not only in the channel, but also on the floodplain area. During subsequent floods, the recurrence of spatial differentiation of erosion and deposition leads to the transformation of alluvial layer and e.g. causes changes in groundwater flow conditions inside the certain valley section. The trends in the flood courses conditioned by the geological structure could be the cause of repeated failures of hydrotechnical structures. It should be expected that due to the progressing climate change the influence of the alluvial bed-rock protrusions on the course of floods will be increasing.

The presentation contains results of research carried out in large Polish lowland river valleys: Vistula, Narew and Bug. Presented work includes geological mapping, drilling in the channel and on floodplain surfaces, remote sensing analysis, sonar measures under various discharge conditions as well as hydrogeological modelling.

MORPHOLOGICAL DYNAMICS OF A LARGE SAND BED BRAIDED RIVER SYSTEM

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Braided network of the Brahmaputra River consists of hierarchical channels carrying varying discharge and sediment load, planform and cross-section geometry, and location. The river is characterized by high flow and energy making several morphological adjustments. The presence of nodal and multi-thread locations along the river network generates complex morphological processes making it important to understand the river hydraulic characteristics. The understanding of the braided-morphology of the river has become a challenging task because of limited *in-situ* hydrologic, hydraulic and morphological dataset. The limited data collection is due to its large-width (1.2 km-18 km), highly-variable-discharge (3,000-40,000 cumecs) and multiple-channels during low-flow season. The present work reports the findings from flow structure and morphological adjustments at multiple-channel network of the Brahmaputra River. A number of field observations conducted with acoustic Doppler current profiler (ADCP) at hierarchical river channels integrated with satellite imagery analysis showed dynamic flow and sediment characteristics in critical zones. The analysis of ADCP data revealed the variability in velocity core and its distribution depending on channel geometry and width to depth ratio. The generation of secondary circulations in the river is observed to be controlled by planform characteristics and bed morphology. Short-term morphological changes including planform and cross-section changes at hierarchical channels were influenced by upstream morphological changes and local flow structures, which is dependent on width to depth ratio. The results of the present works address the need of field investigations in the Brahmaputra river system to develop appropriate river-training-works, short and long-term mitigation for flood and bank-erosion issue, and also to provide stable river navigation.

SEDIMENT TRANSPORT AND MORPHOLOGICAL CHARACTERISATION FOR A LARGE BRAIDED RIVER USING HYDRODYNAMIC MODELING

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Hydrodynamic and sediment transport models are extensively used for flood monitoring, water quality modelling, designing of channel navigation system, as well as sediment transport variability study. The spatio-temporal sediment transport variability for a river like the Brahmaputra is of highly complex braided river and becomes a challenging task due to the hydro-bio-morphological heterogeneity. The river is one of the large sand-bed braided river systems, frequently associated with planform alteration owing to erraticism in seasonal-flow, sediment dynamics, channel migration and macroturbulences. In this study, an attempt has been made to simulate HEC-RAS hydrodynamic and sediment model to understand the complex sediment regime for the middle reach (200 km) of the river. Therefore, hydrological dataset (stage and discharge), limited river bathymetry data, and geospatial dataset (optical satellite imagery, digital elevation model and altimetry) have been integrated to a quasi-steady simulation (extreme events) in the hydrodynamic model. The results show, confined reaches (nodal sections) possess a suspended sediment concentration (SSC) up to 500 mg/L, where the percentage change in average SSC with respect to the maximum values along upstream and downstream reaches are 83% and 62%, respectively. This further indicates a relationship between braided belt width and sediment generation in the morphologically active channels. Reaches with significant lateral migration potential are subjected to intense sediment re-mobilization, bed-elevation change (4 m to 10 m) as compared to the confined reaches which may operate as a connecting segment for the oscillated morphological zones. Finally, this research will develop a hierarchical energy dissipation model (in terms of unit steam power) to comprehend the braided-belt instability of the Brahmaputra.

ASSESSING THE RIVER FREEDOM SPACE ALONG THE CONTINUUM OF BRAIDED CHANNEL PATTERNS USING ADVANCED GEO-SPATIAL ANALYSIS

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Large alluvial rivers are increasingly subjected to anthropogenic stresses and fluvial disturbances, further developing transitional channel planforms and variable freedom spaces. The present study is focused on understanding such spatio-temporal dynamics along the continuum of braided segments. The study area encompasses (i) an unregulated, highly braided segment (active channel width: 2000 m) of the Brahmaputra River, India, and (ii) a regulated, weakly braided reach (active channel width: 100 m) of the Brahmani River, India. Google earth engine (*GEE*) cloud computing system is used to comprehend the temporal surface water dynamics between two epochs (1984-1999 and 2000-2019). The advanced geo-spatial data (JRC global surface water) analysis shows the Brahmaputra exhibits significant alteration in mean braided belt width (up to 9000 m) and hierarchical absolute change (*AC*) in surface water occurrence from nodal points (*AC*=0), low-flow (*AC*~0), floodplain (*AC*<0), and islands (*AC*>0). In contrast, the Brahmani River possesses a compound channel form, and surface water dynamics signals lateral fluctuation of low-flow (*AC*<0) with an aggradational regime on the bar surface (*AC*>0). This concludes that the Brahmaputra has maximum freedom space in the floodplain due to lateral migration of braided width, whereas the Brahmani has with-in macrochannel freedom space attributed to the vertical growth of instream geomorphic units.

THE UNIQUENESS OF THE RIVER-MOUTH SYSTEMS OF THE BAIKAL TRIBUTARIES

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The hydrological and geomorphological analyses of the river mouths of the Baikal tributaries are presented. The research is aimed at assessing the development of river mouth systems (RMS) at different periods of water availability. Particular attention is paid to the natural prerequisites for the relief formation of river mouth areas, the most important of which is the morphostructural features of the coasts generated under seismotectonic activity of Baikal rift, which determine the morphogenetic and dynamic type of the coastal zone. There are more than 470 river-mouths along the Baikal coast, 230 - permanent rivers with various morphogenetic types of RMS. The river mouths develop through the interaction of fresh waters of rivers and lake and in the absence of tidal processes, at the regulated level within the range of 2.3 m. The determining natural factors of the formation of various morphogenetic types of RMS are considered: there are the morphostructural features of the coastal zone. Positive structures are distinguished - horsts, represented by ridges, spurs and slopes of mountains. The deposits composing are generally very resistant to abrasion. The negative morphostructural units include grabens - depressions of the Baikal type filled with Neogene-Quaternary loose well-eroded deposits. And small intermontane depressions filled with Neopleistocene-Holocene sediments. Various morphogenetic types of RMS are confined to certain morphostructural elements, and under some geological and tectonic conditions there are no mouths. Six main morphogenetic types of RMS are identified: simple; multi-channel on proluvial mudflow cones with phytogenic shore; estuarine and estuarine-deltaic; protruding delta. The hydrological factor catalyzes the development of RMS, as a closing link of a river system, due to seasonal and long-term fluctuations in water and sediment runoff. In general, the river mouth geosystems will develop striving for their equilibrium state under different hydrological conditions.

DEVELOPMENT OF RIVER DELTAS IN PERMAFROST ZONE ILLUSTRATED BY EXAMPLE OF MOUTHS OF THE RIVERS LENA AND MACKENZIE

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The paper is devoted to comparison of hydrological characteristics of the rivers Lena and Mackenzie, and their impact on development of the largest deltas of Polar region. Both delta channel flows have small ground feeding and winter water discharge often resulting in complete freezing of a delta channel, regular ice jams formation during spring break up and abundance of lakes at the river delta. The main river factors involving water and sediment flow, water level of the river and ice conditions were compared for two deltas. It was found that the river discharge, governing delta processes, increases considerably at the Lena delta head during last 50 years, while the similar trend at the Mackenzie delta head is much smaller. Comparison of average annual sediment flows W_s at the river mouths of the rivers shows that W_s at the Mackenzie delta is 5 – 6 times larger than that at the Lena delta. Further analysis of the causes of this distinction revealed great impact of permafrost grounds properties at the watershed of the rivers.

The slope of the Mackenzie delta plain is one order of magnitude less than that of the Lena delta plain, while suspended sediments concentration in the channels at the Mackenzie delta is one order of magnitude larger than that at the Lena delta. The most active suspended sediment flux at both deltas is observed in the North – East direction.

Deep score holes revealed in the channels of the Mackenzie delta were formed, apparently, as a result of conjunction of the channel with the delta's lake filled of easily erodible fine sediment.

Demolishing of the banks of Laptev and Beaufort seas constructed of icy rocks results in retreat of the sea boundary of Mackenzie and Lena deltas.

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Oral Presentations II h

"Large scale river morphology (Part II)"

INVESTIGATION OF PLANFORM CHANGE OF THE AMAZON RIVER NEAR IQUITOS, PERU

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The Amazon River is a mega river in South America. The river shows an anabranching planform type with a remarkably high migration rate and a very dynamic morphology. In 2012, the Amazon River was hit by a historically large flood event, bringing record water levels and affecting several towns along the river. The aim of this study is to determine the anabranching planform change due to this severe flood in the Peruvian part of the Amazon River. The study area is located at Muyuy which is 20 km upstream of the city of Iquitos. Images of Landsat 5 and Landsat 7 from the years 2008, 2009, 2012 and 2013 were collected for analysis to investigate the river planform change affected by the annual flooding, that is the period from the wet season (from January to March) to dry season (September). The analysis of planform changes was accomplished by performing the NDVI calculation. The image cells were classified into three types of land cover as water, bare soil, and vegetation and others. The results of this analysis show that the bank erosion was more intensive due to the 2012 flood with an erosion area of 5.15 km^2 compared to a smaller bank erosion of 1.54 to 2.85 km^2 in the years of 2008, 2009 and 2013. Moreover, significant deposition of 14.36 km^2 was found in 2013 after the 2012 flood year, and the deposition varied between 5.64 and 8.92 km^2 in the years of 2008, 2009 and 2013.

Keywords: River planform change, Amazon River, NDVI calculation, bank erosion, deposition

BIRTHPLACE AMAZON RIVER, A CONFLUENCE OF MEANDERING AND ANABRANCHING RIVERS

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River confluences are defined as a point where two or more rivers merge. It is typical that one of them is considered as a main channel. At the confluence of Maranon and Ucayali rivers, however, the difficulty remains as to which river is the main one since they are two large rivers but with different morphodynamic characteristics; one is anabranching and the other is meandering. At the confluence, these two rivers form the largest river in the world, the Amazon River. In this work we consider these two rivers both as main channels, and focus on their interaction in order to to identify which river defines the point of confluence and dominates the morphodynamic behaviour of the Amazon River. We study the birthplace of Amazon River on the basis of planimetry and altimetry analyses using remote sensing techniques and a series of field measurement. In the remote sensing analyses, we focused on the planimetry assessment to describe arc length, sinuosity, width, and main and secondary channels. Altimetry analyses based on field measurements included velocity distribution, river bed morphology, concentration and size distribution of sediments. Preliminary results show higher migration activity in meandering Ucayali River than anabranching Maranon River, and that wash load and suspended bed load in Ucayali River is higher than Maranon River with finer size distribution. In contrast to the suspended sediment, bed load transport is higher in Maranon River. The location of the birth of the Amazon River depends on Ucayali River due to its higher channel dynamics, and the morphodynamic behavior depended on Maranon River due to its higher sediment load. This study is decisive not only to understanding geomorphological aspects of the confluence of two large rivers. In the case of the Amazon Basin, confluence represents crucial nodes for fish diversity and productivity.

FLOW REGIME AND BANK EROSION OF THE ANADYR RIVER, CHUKOTKA

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Anadyr is the second largest river emptying into the Bering Sea, with an annual water discharge of 68.2 km^3 and a catchment area of 191 000 km^2. The minimal number of gauging stations in the basin with only water stage measurements available since the 1990s make it one of the poorly studied rivers in the Arctic region. Water discharge and turbidity measurements made in June 2021combined with remote sensing approaches shed some light on the flow regime and sediment budget of the middle reach of the Anadyr River (Markovo – Ust-Belaya section).

The bulk of the discharge (60-70%) is supplied during flooding in June. Due to the minimal slopes and the relief of the territory surrounding the depression, the flooded area in high floods can exceed 3000 km^2. At the same time, the share of the floodplain of alluvial genesis does not exceed 10%. The rest of the floodplain is inherited, representing the bottom of the former lake basin. The Anadyr River in the middle reach has an anabranching channel. The water flow distributes almost evenly (from 15 to 30%) among branches during spring floods.

A distinctive feature of Anadyr is the interchange of rifts and deep (up to 35 m at low-water levels) stream pools. The small distance between rift crests and minor changes in the stream pools' morphometry over the last 50 years (according to sailing directions of the 1970s) suggests their pre-fluvial origin.

The bank erosion rates within the section are highest in the semi-mountain branches, where the high sediment load leads to significant changes in the bed topography, and the average rate of change in channel position reaches 60% over 50 years. In the downstream part, the maximum rates are up to 2.6 m/year at the convex banks of the blocked bends. The total area of eroded banks in the studied section of the Anadyr is more than 14 km^2 over the 2000-2019 period.

Oral Presentations III a

"Biodiversity, bioindication & conservation in Russian rivers (Part I)"

ENVIRONMENTAL PROBLEMS OF THE ARCTIC TERRITORIES OF THE YENISEI RIVER

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Climate change and its social implications are among the most important challenges of the twenty-first century. Climate change affects human health in a number of ways. In recent years, climate change has become one of the leading negative factors to human health alongside traditional risk factors such as air pollution, drinking water pollution, smoking and drug abuse. Climate change increases health risks and mortality on days with unusually high or low temperatures. While the accumulation of persistent toxic substances (PTS) in Arctic ecosystems has long been observed, its implications for human health with Arctic climate change remain largely unstudied.

We carried out long-term studies (2011-2017) of water sources located in the Arctic and Subarctic territories of the Krasnoyarsk Territory (Central Siberia), including the Yenisei River (lower reaches), with water sampling. All water samples were analyzed: metals and non-metals, petroleum products, methanol, radionuclides, phenols and its derivatives. The relationship between the level of anthropogenic pollutants and the toxicity of water sources has been investigated.

The water of the Yenisei River in the lower reaches is moderately toxic (polluted), since the sum of pollutants belonging to hazard classes 1 and 2 is 2.086 MPC, and the sum of pollutants of hazard classes 3 and 4 is 16.1328.

Consequently, the ecological state of the Arctic territory of Central Siberia is defined as critical, the consequences of which will have a negative result for the health of the population living permanently or on a rotational basis in the studied territories. Due to their dilapidation, abandoned geological and military facilities are considered as an additional and, at times, a significant source of pollution. Surface water bodies flowing through the northern territories cannot be used as a source of drinking water supply.

SPATIAL MODELLING FOR CONSERVATION OF ECOSYSTEM FOR THE NOVOSIBIRSK RESERVOIR

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In current model approaches, the dynamics of ecosystems are considered, as a rule, within the framework of the equilibrium approximation, which makes it impossible to characterize new, significantly non-equilibrium cases for the biogeocenosis, such as degradation or restoration of the state of the aquatic ecosystem. Tools that allow to flexibly reproduce the changes in internal structure of the ecosystem under intensive impacts, are needed. A structural change is understood as the species composition variability for links in the trophic chain of the aquatic biogeocenosis. The structural-dynamic models that appeared at the end of the 20th century in the search for a possible response of an ecosystem to a violation of stability, use the assumption of non-equilibrium thermodynamics about the preference for a development trajectory that corresponds to the possible maximum order of a living system in specific conditions. Only time changes have been taken into account on this path without the role of spatial mechanisms that determine the internal mass and energy flows of substances that occur in real ecosystems. The novelty of the result lies in the synergy of methods: structural-dynamic modeling and reproduction of cycles of biogeochemical transformation for limiting elements in spatially heterogeneous ecosystems of water bodies. This study simulation reproduces the trend of long-term eutrophication of the Novosibirsk reservoir; the mechanism of cases of unusual spatial distribution of phytoplankton is explained and evaluated; the reaction of the studied ecosystem to the implementation of known methods of conservation for trophic status is predicted.

This study was executed in framework of the Research Program of the Institute for Water and Environmental Problems, SB RAS, and supported by the Russian Foundation for Basic Research and the government of the Altai region of the Russian Federation, grant № 18-41-220002.

WATER QUALITY IN THE VOLGA HEADWATERS

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The Volga River is the largest river in Europe in terms of water content (annual flow 254 km^3), basin area (1,36 mio. km^2) and length (3531 km) in Europe. We conduct long term water quality studies in the Volga headwaters: in the Upper Volga Lakes, the free-flowing section as well as in the Ivankovskoe and Uglich reservoir.

At the source of the river the water is very soft, slightly mineralized, characterized by high color indicators (up to 400 degrees Pt-Co scale), permanganate oxidation (60.3-72 mgO/dm^3). In the Upper Volga Lakes, water mineralization increases to 110 mg/dm^3, the color of the water decreases significantly. In the waters of the Ivankovo reservoir higher concentrations of manganese and BOD_5 are noted than in the Volga water above Tver.

By the concentration of total phosphorus, the waters of the Upper Volga Reservoir (Lake Volgo) and the unregulated section of the Upper Volga (from Selizharovo to the city of Tver) belong to the "mesotrophic" class, and the waters of the Ivankovo reservoir belong to the "eutrophic" class. In the water of the Uglich reservoir higher concentrations of phosphates and sulfates are observed than in Ivankovo.

Based on physico-chemical parameters as well as biological quality elements phytoplankton, phytobenthos as well as macroinvertebrates we characterize the Volga headwaters. Especially the free-flowing section comprises an important reference section for lowland rivers, thus monitoring of different aspects is an important issue.

FACTORS AFFECTING BLOOM OUTBREAKS IN THE GORKY RESERVOIR

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The Volga River is the largest waterway in the European part of Russia and is inhabited by 40 percent of the country's population. The water resources of the river and its tributaries are actively used for many purposes. Due to this, the quality of the river water has been seriously affected by the huge inflow of domestic wastewater. In addition, the construction of a cascade of reservoirs on the Volga and its tributaries has resulted in further degradation of the river water quality due to outbreaks of algal bloom.

The Gorky Reservoir is located in the central part of the Volga River basin, and the outbreak of blue-green algae blooms is higher here than in any of the other Volga Reservoirs. There is no temperature stratification in the deepest parts of the reservoir due to the strong winds disturbing the water, which causes nutrients from the bottom sediments to enter the water and become a source for algae growth.

The present study is aimed at understanding the main factors that control the intensity of bloom in the Gorky Reservoir. The study is based on our observations and water sampling in the Gorky Reservoir between 2017-2019, with varying weather conditions and inflow rates. We determined the content of dissolved and suspended forms of nutrients, organic carbon and chlorophyll a in the collected samples.

Bloom outbreaks occurred in the reservoir over the 3-year period, but their start was influenced by the weather conditions. During cold summers blooming began in August, while in hotter summers blooming occurred as early as June. We found that chlorophyll concentrations were most closely related to the content of nitrogen rather than phosphorus. The ratio of total nitrogen to phosphorus in the water indicates that both of these elements limit the growth of algae in the reservoir.

THE HYDROLOGICAL CONDITIONS OF FISH REPRODUCTION IN LOWER DON RIVER

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The Don River is an important river for its fishing resources. The current climatic changes result in reduction of spring floods. The areas of floodplain spawning regions where phytophilous fish species spawn on flooded vegetation are decreasing. Fish reproduction is affected, and commercial fishing decreases.

To characterize the occurring changes, we evaluated the conditions for spawning of phytophilous fish species by duration of the spawning period (DSP). DSP is the time of flooding of a plain with water more than 20 cm high and its temperature higher than that at which fish begin to spawn. DSP should last about a month for spawning of many phytophilous fish species. As a model object, the bream was chosen, beginning to spawn at water temperature 8 °C. The river section was chosen below of Tsimlyanskoye reservoir (151 km from the river mouth).

DSP showed that in the period of 1936-2018 only 16 years were beneficial for spawning, when DSP was longer than 30 days. During the first 15 years of observations before the appearance of Tsimlyanskoye reservoir in 1951), 9 years were beneficial, and in the following 66 years, only 7 years were good. In 51 cases (out of 83), water did not even enter the flood plain. That was due to the reservoir-caused spring runoff reduction and prolonged reduced runoff, which appeared beginning with the early 1970s.

Ivanchenko demonstrated close connection between the water level in the river and the number of bream fingerlings. In our evaluations, if water rises 1 m above the channel edge, the number of fingerlings doubles, and if it rises 2 meters, their number increases fivefold (compared to the unflooded plain). This is related to increased spawning areas.

Thus, fish spawn under hard conditions, worsened by low water and runoff regulation.

NATURE RESERVES (ZAPOVEDNIKS) IN THE VOLGA CATCHMENT: PROTECTION AND MANAGEMENT

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Our case studies from the Volga Basin exemplify the structure and function of nature reserves and highlight their contribution to research, protection and management of aquatic ecosystems.

In the Central Forest Reserve, in the Volga headwaters, up to now no invasive fish species were recorded. Due to regular inspection rounds poaching was reduced and nowadays only occurs in the buffer zone with about 6 cases per year (mainly during spring-summer). Hydrobiological monitoring is conducted since 2006 in the framework of the long-term environmental research and monitoring programme "REFCOND_VOLGA". In 2017 an environmentalDNA survey was used to analyze fish diversity in the Volga headwaters, which exemplifies the high potential for biodiversity monitoring.

The Volga can be recognized as one of the main corridors for alien fish species, e.g. in the Kuybyshev reservoir the share of invasive fish is 30.5 % and in the Gorky and Cheboksary reservoirs up to 37.7%. Along the Volga reservoirs (Volga-Kama Reserve and Samarskaya Luka National Park) fish are studied well, but information on alien species in the water bodies of nature reserves and national parks located far from the Volga channel is scarce. The most widespread alien species in small water bodies are Perccottus glenii (spread by fishermen) and Carassius auratus, the spread of both species is related to human activities. In the last 5 years an expansion of Eupallasella percnurus was observed. Aquatic ecosystems in protected areas are vulnerable to biological invasions, thus monitoring is the key to understand the status and development of fish populations.

The Astrakhanskiy Biosphere Reserve in the Volga delta is a hotspot for fish biodiversity. Here the state nature reserve security service plays an important role to avoid poaching. The growth of aquaculture in the region increases the possibility of invasion of new fish species into the ecosystems of the Volga delta. The monitoring of ichthyofauna has been conducted in the reserve for more than 50 years and allows to identify long-term trends in the number of fish.

Oral Presentations III b

"Biodiversity, bioindication & conservation in Russian rivers (Part II) / Chemical water quality"

THE IMPACT OF ANTHROPOGENIC TRANSFORMATION OF THE WATERSHED ON THE ECOLOGICAL CONDITION OF THE RIVER

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It is known that in the world some large rivers served as centers of gravity for people living on their banks - the Nile, the Ganges, the Danube, the Volga.... These waterways provided the very existence of life on their banks, i.e. the river itself was life supporting. We have, however, paid attention to another peculiarity, which is as follows. Almost the entire land can be represented as a set of different watersheds. The whole river system plays the leading system-forming role here; it also forms the ecosystem of the river basin through the distribution of water resources, relief and climate features, etc. And here, an important role begins to be played by the territory - watershed, which, as a unified circulatory system, is covered by the river with all its tributaries. As a rule, the state of the river is determined by the processes that take place on this territory. It is obvious that all man-caused loading on the river water begins with a land. From this point of view, we have developed a methodology and made an ecological atlas of the Klyazma river basin, a part of the Volga basin, where a rich material on geology, geomorphology, hydrology, flora and fauna, social and cultural features of the territory is collected. The Atlas clearly shows how the river system is gradually degrading under the anthropogenic pressure. Usually, watersheds of large rivers occupy huge areas, which are often heterogeneous in their structure and nature. Therefore, it is advisable to study their condition "piecemeal", i.e. separate watersheds of lower orders in order to then obtain a complete picture of the ecological condition of the entire watershed. Such methodology is presented in the present work.

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SOURCES OF POLLUTION OF THE VOLGA RIVER WITHIN THE REPUBLIC OF MARI EL

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Ecological problems of one of the largest freshwater ecosystems - the Volga River, have been observed for a long time. About half of Russia's industrial and agricultural production industries are concentrated in the river basin, which has worsened water quality and contributed to the degradation of coastal areas. A significant contribution to the pollution of the Volga is made by its tributaries. The river network of the Republic of Mari El belongs to the Volga River basin and includes 169 rivers with a length of more than 10 km and more than 300 small rivers. Monitoring studies indicate both natural and anthropogenic sources of pollution of the tributaries of the Volga River, and, as a result, her own.

According to the chemical composition, the waters of the rivers of the Republic of Mari El are hydrocarbonate-calcium with a salinity of 0.1–0.5 g / dm³, with the exception of the Ilet River, the salinity of which increases in low-water periods to 1.4 g / dm³. Monitoring of the majority of river sources shows stable excess of water quality standards for the content of iron, manganese and copper, which are of natural origin.

Wastewater is discharged on the territory of the republic into 22 water bodies and on average is 56 million m³ / year (or 1.2% of the local river flow), while the volume of insufficiently treated wastewater reaches 84%. 50–56% of discharges occur on the Malaya Kokshaga River. The composition of pollutants is dominated by chlorides and sulfates, suspended matter and organic matter. The main pollutants are also ammonium nitrogen, nitrates, phosphates, oil products, synthetic surfactants. Significant quantities of specific pollutants are present in the discharges of Yoshkar-Ola (fluorides) and Volzhsk (sodium).

The upper reaches of the Malaya Kokshaga, Nemda, Buy and Urzhumka rivers, and the river basins on the right bank of the Volga River are undergoing significant anthropogenic impact due to diffuse pollution from agricultural lands, settlements not connected to centralized sewerage systems, discharge onto the terrain (on average 4.6 million m³ / year), as well as watercourses within cities and at areas of discharges from municipal sewage treatment plants.

The federal project «Improvement of the Volga», developed within the framework of the national project «Ecology», is intended to significantly improve the ecological state of the Volga and its tributaries.

DISCHARGE-RELATED FLUXES OF PARTICLE-REACTIVE ELEMENTS IN SWEDISH RIVERS

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The net flux of Rare Earths and Y (REY) into the ocean is determined by their association with different "physical pools" in river water, i.e. suspended particles (>0.2 µm), nanoparticles and colloids (NPCs; 1kDa – 0.2 µm) and the truly dissolved fraction (<1KDa).

The Swedish rivers Kalix, Rane and Pite were sampled 2017 during low discharge (base flow) and in 2019 after the first snow melt (high discharge). The rivers are sourced in the Caledonian mountains (400-1000 Ga) and drain into the Baltic Sea.

Boreal rivers show usually flat REY patterns, but may display strong seasonal changes [1]. While total dissolved fractions (<0.2 µm) of the Kalix, Råne and Pite rivers show such flat patterns, albeit with negative Ce and Eu anomalies, the NPCs and the truly dissolved fraction reveal strong fractionation between heavy and light REY. This is reflected by increasing Yb/La and Y/Ho ratios with decreasing filter pore size. Independent of the discharge, our results support recent studies suggesting that the REY patterns of the truly dissolved pool of river water is very similar to the REY distribution in seawater [2,3], implying that the major REY fractionation between the REY in seawater and upper continental crust occurs during *terrestrial* weathering and REY mobilisation.

The Nd isotope compositions reflect the respective catchment geology. The truly dissolved ƐNd values for the Pite river (-19.4 for <1KDa) with its catchment of younger rocks is more radiogenic than those of the Kalix (2017: -25.5; 2019: -24.1 (2019) for <1KDa) and Rane (2017: -20.9; 2019: -23.9 for <1KDa) rivers. The ƐHf values are decoupled from ƐNd and vary depending on the „size fraction ". In all three rivers the dissolved fraction (< 0.2 µm) is more radiogenic compared to the suspended particles (> 0.2 µm), possibly due to the "zircon effect".

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IRON IN THE WATERS "DON RIVER – AZOV SEA" MEGAPROFILE

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Iron plays an important physiological, biochemical role in the organism's life. Iron compounds are running to the surface waters as a result of chemical weathering of rocks with underground, surface runoff, industrial and agricultural sewage waters. Don River basins is a unique cascade geo-system that traces the accumulation and dispersion of iron compounds in the water along the continuum "surface waters - Azov Sea". It`s important, because the Don Rivers estuary area is influenced by anthropogenic over a century and the iron is a pollutant for the river basin. The report will present the results of enduring studies of migration forms of iron in underground, mine waters, storage ponds, small rivers of coal mining areas, the Don River and the Taganrog Bay. Experimental, full-scale and laboratory studies, regression dependencies between the content of iron migration forms and physicochemical characteristics, as the created cartographic schemes of the distribution of the total dissolved iron will give an idea of the features formation of its flow into the Taganrog Bay. Much attention is given to the description of the conjugate cycles of iron and sulfur in time space. The data are used to insight the physico-chemical characteristics of the water and isotopic composition of sulfur of iron sulphide, sulfur and oxygen of sulfate ions by profile "Don River-Azov Sea". Isotopic and hydrochemical indicators of the existence in the nature of "pure genetic type" in acidic waters and the participation of microorganisms in their formation, transformation mixing with river waters will be presented. The role of microparticles representing iron compounds as one of the phases-carriers of heavy metals in the estuary waters will be shown.

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BIOGEOCHEMISTRY OF METALS IN AMUR RIVER AND YANGTZE RIVER ESTUARIES

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Similarities and differences in trace metal behavior in estuaries of biggest rivers of China and the Russian Far East have been analyzed. High suspended solid concentrations, elevated pH, and relatively low dissolved trace metal concentrations are characteristics of the Yangtze R. Elevated dissolved Fe and Mn concentrations, neutral pH, and relatively low suspended solid concentrations are characteristics of the Amur R. The transfer of dissolved Fe to suspended forms is typical in the Amur estuary, though Cd and Mn tend to mobilize to solution, and Cu and Ni are diluted in the estuarine system. Metal concentrations in suspended matter in the Amur estuary are controlled by the ratio of terrigenous riverine material, enriched in Al and Fe, and marine biogenic particles, enriched in Cu, Mn, Cd, and in some cases Ni. Besides the usual removal of dissolved Fe at the beginning of estuarine mixing, the increase in dissolved forms of Mn, Ni, Cu, Cd, and Pb compared with river end-member is unique to the Yangtze R. estuary. Particle–solution interactions are not reflected in bulk suspended-solid metal concentrations in the Yangtze R. estuary due to the dominance of particulate forms of these metals. Cd is an exception in the Yangtze R. estuary, where the increase in dissolved Cd is of comparable magnitude to the decrease in particulate Cd. Despite runoff in the Amur R. being lower than that in the Yangtze R., the fluxes of dissolved Mn, Zn and Fe in the Amur R. exceed those in the Yangtze R. Dissolved Ni, and Cd fluxes are near equal in both estuaries, but dissolved Cu is lower in the Amur estuary. The hydrological and physico-chemical river characteristics are dominated at the assessment of river influence on the adjoining coastal sea areas despite differences in estuarine processes.

PESTICIDE ADMINISTRATION STRATEGIES FOR HAZARDS ON FARMS IN THE CARIBBEAN

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Recent studies have shown that pesticide administration strategies affect hazard and risk management on farms. The two hypotheses to be derived in this study were, that high concentrations of pesticides exist in the agricultural runoff and surface water used by farmers for irrigation, and, that farmers demonstrate a lack of awareness of pesticide management strategies for pesticide use, hazards and risks on farms. Water quality tests were performed and statistical analyses were explored through a case study.

The aim of this study was to improve the quality of surface water for irrigation and reduce associated hazards and risks on farms, accomplished using the following objectives:

1. Identification of Pesticide Use, Hazards and Risks
2. Evaluation of Farmers' Awareness of Pesticides Hazards and Risks
3. Determination of the pesticide content in surface water and agricultural runoff
4. Recommendation of Pesticide Management Strategies for reduction of hazards and risks on farms

The findings of this study would aid the design of effective policies to address health problems and environmental issues.

The structured methodology approach used in this study incorporates the determination of pesticide content, water quality and discharge flow rates by laboratory testing, screening and analysis and evaluation of farmers' awareness of pesticide hazards and risks using SPSS statistical analysis and questionnaire surveys.

The findings of this study were that farmers of the Orange Grove Estate, Tacarigua did not demonstrate a lack of awareness of pesticide management strategies for pesticide use, hazards and risks on farms, and that a low concentration of pesticides existed in the agricultural runoff and surface water used by farmers for irrigation. Increased awareness and recommended hazard and risk management strategies for pesticide use would improve food quality, water quality and reduce environmental degradation associated with the hazards and risks on farms.

Keywords: Pesticide, Surface Water, Hazards, Risks, Water Quality, Runoff, Statistical Analysis

Oral Presentations III c

"River ecology & restoration"

COUNTRY-WIDE STATISTICAL MODELLING OF FLOW-ECOLOGY RELATIONS IN POLISH RIVERS

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Flow variability is a fundamental factor affecting riverine biota. The objective of this study is to quantify the responses of biota to the flow variability, especially extreme events such as droughts or floods. The focus is placed on the riverine macroinvertebrates, as they seem to be more vulnerable and less resilient to the extreme hydrological events. The proposed modelling will collate a large dataset of Poland-wide biomonitoring of macroinvertebrates and model it against the flow variability measurements from the neighbouring flow gauges. The biomonitoring data obtained from the Chief Inspectorate of Environmental Protection in Poland contains results of macroinvertebrate sampling for the years 2012-2020 from over 3,200 sites. Most of the sites were sampled once. Upon a spatial coupling conducted in ArcGIS, 309 sampling sites (with 520 unique sampling instances) were paired with 290 flow gauges based on three criteria: location on the same stream, proximity (<10 km), and difference in the upstream catchment area (<20%). The river flow data available online at the Polish hydrometeorological service (*Instytut Meteorologii i Gospodarki Wodnej)* was downloaded in R with "climate" package. As the ecologically relevant flow index, the indicators of hydrologic alteration previously used in this context in Poland, were computed in R using "IHA" package. Time series of ecological metrics derived from biomonitoring data (macroinvertebrates indices) will be analysed along with observed streamflow data (expressed in IHA parameters) in order to establish new, empirical flow-ecology (or species-discharge) relationships. It will be decided after a thorough investigation of the subject literature which modelling approach to apply, however, hierarchical logistic regression model (combined with Huisman–Olff–Fresco biological response models) is the most likely one. This will be the first country-wide modelling of flow-ecology relationships in Poland. The results could benefit practitioners and decision-makers especially in the context of developing environmental flows concept in the country.

WATER TABLE DYNAMICS AND SURFACE WATER CHEMISTRY PATTERNS OF NORTH-EASTERN DRAINED PART OF GREAT VASYUGAN MIRE

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According to the IPCC report (Ciais et al., 2013), inland waters (rivers, lakes) are a very significant component of the global carbon cycle with significant CO_2 emissions, which is 2 times higher than the runoff of organic carbon into the World Ocean from the global river network.

Hydrological studies were carried out in 2015-2019 on a drained pine-shrub-sphagnum area of the Great Vasyugan bog (GVM) in the Gavrilovka River basin (56°53'25.25 "82°40'46.93") and on a similar natural site in the Klyuch River basin (56°58'24.3"82°36'41.2"). The observations of the water level within GVM were carried out using an autonomous differential pressure sensor (Bazarov et al., 2018). Water sampling of bog and river waters for the determination of dissolved organic carbon (DOC) was carried out from April to September in 2015-2019.

The analysis showed that on the drained GVM site, the water levels were 28 cm bgl which is 8 cm lower than in natural conditions, and the amplitude of level fluctuations is almost 1.5 times higher. As a result of drainage, a significant decrease in water table level is noted; the minimum value for the study period was 51 cm bgl, which is 13 cm lower than in the pristine area. Peak water table depth for the drained area is on average 2 times lower than for the pristine area of the GVM. The analysis showed 12 h and 24 h recession rates averaging 0.42 cm/h and 0.25 cm/h, which is 2.5-3 times higher than the data for the natural GVM site.

The content of DOC in the waters of the drained part of GVM is 68.6 mg/L, which is 22% higher than the concentration for pristine area. The total DOC release from the Gavrilovka River basin for the period April-September 2019 amounted to 7250 kg/km^2. In the seasonal dynamics, April and May stand out, when an increase in the removal of DOC with river waters is noted. The principal component analysis confirmed the conclusions that the leading condition determining the content of DOC in bog and river waters is the thermal factor; therefore, in drought periods there is an accumulation of DOC in the peat deposit and in waters in rewetting periods.

TRANSFER OF ARTIFICIAL RADIONUCLIDES BY BIOTA OF THE YENISEI RIVER

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The Yenisei River is contaminated with artificial radionuclides due to the operation of the Mining and Chemical Combine (MCC), which has been producing weapon grade plutonium since 1958. We investigated long-term trends of artificial radionuclides in bottom sediments and biota inhabiting the Yenisei River in the vicinity of the radioactive discharge site: macrophytes (*Potamogeton lucens* and *Fontinalis antipyretica*), zoobenthos (amphipods and caddisfly larvae), fish (Northern pike, Arctic grayling, and Siberian dace), before and after the shutdown of the reactor plant at the MCC, in 2006-2020. Activity concentration of radionuclides in samples was measured by gamma- and alpha-spectrometry. From our research, we learned that concentrations of radionuclides (^{51}Cr, ^{54}Mn, ^{58,60}Co, ^{65}Zn, ^{141,144}Ce, ^{152,154}Eu et al.), whose discharges to the Yenisei either stopped or decreased after the shutdown of the reactor plant at the MCC, decreased in biota samples soon as well. Concentration of ^{137}Cs did not decrease in biota of the Yenisei after the shutdown of the last reactor plant because the discharges of this radionuclide to the Yenisei continued at the same level. Contents of ^{238}Pu and $^{239+240}$Pu and their ratios in environmental samples of the Yenisei increased significantly following the increasing volume of discharge of these isotopes to the river since 2018. Based on the data obtained in our study we estimated effective half-life of ^{54}Mn, ^{65}Zn, ^{60}Co, ^{152}Eu, and ^{137}Cs for different biota species. Concentration factors of artificial radionuclides in biota were calculated. Indicative potential of biota species for monitoring of radioactive contamination of the Yenisei was estimated from the correlations of radionuclides in samples of biota with the volume of annual discharge of the radionuclides to the Yenisei.

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RESTORING THE RHINE: FEEDBACKS OF GRAVEL AUGMENTATION AND BANK (RE-)EROSION

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Gravel augmentation and bank (re-)erosion are increasingly performed by managers of regulated rivers to enhance bedload transport, recreate pioneer units, rejuvenate channel forms, and diversify aquatic and riverine habitats. This paper aims providing feedbacks from unprecedent restoration actions conducted along the Upper Rhine river downstream of the Kembs dam (France/Germany): three gravel augmentations (GAs) and one controlled bank (re-)erosiontest. The restored sites were monitored over a period varying from 1 to 8 years. Topo-bathymetric surveys, bedload tracking, grain size measurement, and hydraulic modelling have been performed to evaluate both efficiency and sustainability of the restoration actions.

At short term, a bathymetric simplification occurred downstream of the GAs due to sediment transfer, mostly along the thalweg with few lateral sediment mobility in the stable and narrow channel. Grain size fining was observed, but only over 3 years, due to the downstream propagation of the sediment waves. Local habitat diversification occurred due to the fragmentation of the sediment wave, with preferential sediment deposition on riffles. This potentially favors spawning habitats for salmonid fish species. Sediment starvation conditions reappeared a few years after GAs in absence of repeated upstream bedload supply.

Results of the controlled bank (re-)erosion test showed that the sediment supply (from bank erosion) was low (about 1,500 m^3) even after a 15-year flood, notably due to unexpected buried riprap blocks at bank toe.

Combining bank (re-)erosion and GAs as management strategy to restore geomorphic processes, aquatic and riverine habitats, and limiting sediment starvation conditions are discussed in term of cost-benefit and efficiency compared to potential other options (e.g., channel widening or narrowing).

RESTORATION OF ICHAMOTI RIVER IN BANGLADESH

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Ichamoti river is a medium sized river connecting two major rivers - the Ganges and the Brahmaputra within Bangladesh. The flood flow from these two mighty rivers used to flow through the Ichamoti river and inundate surrounding areas. In the 1980s, as part of a large-scale flood control project, regulators were placed at the outfalls of Ichamoti river at the Ganges and Brahmaputra. Through these regulators flood flow was totally eliminated through Ichamoti river. Construction of a closure to store water for irrigation at the downstream has seized the river flow in the section between these two human interventions. Rainwater during the monsoon is the only source of water for this section otherwise the river is dead for rest of the year. The Pabna city is situated within this blocked stretch of the river where the no flow condition coupled with the indiscriminate dumping of solid waste and sewage and river encroachment have rendered the river water unusable for any purpose. Recently, Bangladesh Water Development Board (BWDB) has initiated a study with an objective to evaluate the feasibility of resuscitation of the Ichamoti river. The benefits of flow restoration are judged considering the current socioeconomic benefits that the people of the study area are receiving from the flood control, drainage and irrigation facilities. Re-establishing the connection with the Ganges and the floodplains is expected to increase flow in Ichamoti to near pristine condition and increase the lost inland open water fisheries population. The Ichamoti river has a unique feature in the sense that it connects two major rivers – Ganges and Brahmaputra which have different ecological characteristics. Therefore, if restored, it will be benefited by the ecological contributions from both Ganges and Brahmaputra and well serve the people in its watershed.

FLOODPLAIN RESTORATION PROJECT ALONG A DANUBE STRETCH IN BAVARIA (GERMANY)

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The straightening and embankment of the Danube in the middle of the last century has separated the floodplain from its river and the natural water dynamics are inhibited by hydropower generation. Despite the hydropower dams, this restoration project aims to bring back water dynamics to the floodplain by a new floodplain stream, by ecological flooding and by temporary groundwater drawdown during the summer months. Connected with these measures are expectations of the different stakeholders:

- For the Water Management Authority longitudinal connectivity for migrating species has first priority (requirement of the European Water Framework Directive). So, fish and flowing waters are in focus and therefore, more or less stable conditions are required.
- Nature Conservation Authorities are aiming at dynamics in hydrology, ranging from no water to high water to imitate the conditions on a natural floodplain. Phases of ecological flooding and groundwater drawdown in high/low extremes and of long duration are welcome.

The groundwater drawdown can serve as an example. It aims to enhance the abiotic conditions for pioneer species of muddy streambanks. But due to the new floodplain stream, former fluctuating water zones which are habitats for target species, e.g. *Oenanthe aquatica* (water dropwort), have changed to aquatic habitats which are required for fish.

The monitoring compares the situation before restoration with the effects of three different types of groundwater drawdown. For these types, the hydrological situation was investigated and the effects on the occurrence of *Oenanthe aquatica* were mapped. The outcome is that one type can enhance germination of *O. aquatica*, but is detrimental to fish. The other type is able to provide the same suitable conditions for *O. aquatica*, without severely harming the aquatic habitats. The third type cannot reach the required low water levels and is therefore not a comparable option.

The results show that an interdisciplinary monitoring is able to develop a measure suitable for both competing habitat types.

Oral Presentations III d

"River pollution"

EVOLUTION OF THE RHINE RIVER'S INDUSTRIAL POLLUTION: HISTORICAL AND LEGAL APPROACH

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The development of an important fluvial transport axis has made the Rhine River one of the most important European rivers. The river is used for different needs, but the purposes of this study focus on the disposal of industrial and urban releases. In the past, anthropic pressures were not regulated by law and important pollution occurred in the Rhine River whether constant or accidental pollution. The Rhine River was so polluted that it was once called "the open sewer of Europe". The initial factors of industries development on the Rhine were the flourishing of chemical and heavy industries, especially the production of coal in order to supply industries along the Rhine River. Thus, legal acts such as international agreements, European Union's directives and intern laws, have been adopted in order to reduce water's pollution by industries. Indeed, the transboundary water cooperation which is based on shared historical legacy of water governance allowed the improvement of the Rhine river's water quality over the time. The main goals of this study are to reconstruct the geo-history of industrial pollutions and assess the effectiveness of law with the help of digital tools. First, the results of researches in archives which represent precious information for tracing the history of industrial pollution in the Rhine will be lay out. Then, quantitative analysis of European pollutant emission register's databases and quality of water's data will be presented in order to complete the first results. Lastly, water policies and industrial policies will help to discuss the evolution of the pollution in the Rhine by studying the trajectories of the pollutants which are regulated by different scale of law over the time. We conclude that the understanding of interaction between law and industrial releases allows to anticipate new regulations in order to protect the Rhine River.

THE GLOBAL 100 PLASTIC RIVERS PROJECT: INVESTIGATING MICROPLASTIC CONTAMINATION IN OVER 100 RIVER SYSTEMS AROUND THE WORLD

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Our ability to assess global risks of microplastics (MP), particles < 5mm, on environmental and public health is critically limited by the lack of knowledge of their transport, fate and ecotoxicological impacts in freshwater ecosystems. Despite, regulators and industry stakeholders recognising the global threat of MPs as critical emerging pollutants, they have been studied almost exclusively in marine ecosystems. Understanding the transport, fate and environmental impacts of MP on freshwater ecosystems is crucial for the assessment of their global impacts, given that the majority (70-80%) of all MPs reaching the sea have been transported by rivers. The absence of systematic freshwater MP surveys impedes our understanding of how their concentration, composition and properties vary globally. How are MPs distributed in rivers globally, and how do their physical (size, shape, density) and chemical properties differ in relation to catchment properties, prevalence of primary and secondary MP sources, hydrodynamic and sediment conditions? The Global 100 Plastic Rivers programme utilises global partnerships, who sample sediment and water using a custom-made sampling kit from a range of sites. Samples are sent back to the University of Birmingham whereby microplastic contamination is quantified using various novel techniques; such as Nile Red and Thermo-Gravimetric-InfraRed-Gas Chromatography/Mass Spectrometry (TG-IR-GC/MS). Targeted high-frequency sampling also took place in various globally important rivers, for example River Ganga and Red River. Results suggest that river corridors are more than pure conduits and in fact pronounced hotspots exist leading to a high risk of legacy pollution. This project provides the first set of comparable microplastic data in freshwater environments globally and has been used in conjunction with lab-based stream and river simulations to highlight mechanistic drivers of MP in river corridors.

GPS TRACKING OF PLASTIC ITEMS IN THE AUSTRIAN DANUBE RIVER

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Due to the longevity of plastics in our environment and the not yet assessable impact on the biota, research on these materials in the environment becomes more and more relevant. Rivers are considered the main pathways of plastic into the world's oceans, yet there is still very little research in this sector in particular. In Austria, the PlasticFreeDanube project focused on the issue of macroplastics in the Danube. Although Austria has very good waste management paths, a large amount of plastic still ends up in the national park downstream from Vienna. One of the most important questions in the project was therefore where the plastic comes from, how it is transported in the river and where it is deposited.

To clarify this question, plastic items were equipped with GPS transmitters and their transport was tracked within the system. The developed method worked excellently and yielded a number of important findings. All of the tagged macro plastic items stayed on the side they were launched at all discharges therefore it became clear that an input on the right side leads to higher accumulation on right river banks and flood plain areas. Items stranded mostly at fixed banks and groyne fields and the average distance until stranding was found at 10.4 km. A higher stranding rate was detected with rising discharge. Furthermore, it could be shown that the Freudenau hydropower plant is able to remove a part of the plastic, but a certain proportion of the plastic items (at certain times) pass the power plant. The observed particle paths could also be reproduced very well by means of hydrodynamic numerical modelling.

DESCRIPTION OF FLUVIAL MACRO PLASTIC TRANSPORT PROCESSES USING NUMERICAL SIMULATION

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Rivers are nowadays considered the main sources of plastic waste into the ocean. Due to their longevity and unknown long-term effects on biota, these contaminants pose a risk to our environment. Furthermore, despite established waste management systems in the Upper Danube catchment, large amounts of macroplastics are frequently found during waste collection campaigns in the National Park Donau-Auen downstream of Vienna. In order to systematically investigate these contaminants in and along the Danube, the PlasticFreeDanube project was launched.

To improve the process understanding of fluvial macro plastic transport, numerical simulations were performed. For this purpose, hydrodynamic models were created for different flows at different scales using RSim software. High-resolution models were used to characterise flow fields near river structures such as groynes and guiding walls, while large-scale models were used to describe accumulations in the floodplain. Furthermore, a particle tracing tool was implemented and adapted to the floating properties of macro plastics. Modelling results were then combined with hydrologic and field data to quantify plastic deposition along the shoreline, providing a methodology for upscaling plastic accumulations. The results clearly show that floating macro plastics interact with hydraulic structures; in particular, a tendency for the highest accumulation potential was observed in the center of the groyne field. Hydrological conditions must also be considered. While overflowing of groynes leads to remobilisation, the falling limb of hydrographs can be associated with accumulation processes. In addition to instream accumulation processes, both sampling and modelling results show that floodplains act as filters for plastic debris during flood events. The results of this study aim to reduce future collection efforts for macro plastics in riverine environments.

MICROPLASTICS IN THE SURFACE WATERS OF RUSSIAN RIVERS: A FIRST GLANCE

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Research groups all over the world are focused on identifying sources of the world's oceans pollution by microplastics (MPs). Significant transport routes for the entry of MPs into the oceans and inland seas include land transport via rivers. To date, little is known about the actual concentrations of MPs in the waters of Russian rivers and their role in the short and long distance transport of particles.

Surface waters of Russian large rivers and tributaries, including the Irtysh, Ishim, Tobol, Tura, Kama, Chusovaya, Vyatka, Vychegda, and Pechora were sampled in August-September 2020 to study MPs abundance before the autumn rise of levels. For the preliminary screening, we sampled surface water by Mantra trawl and visually analyzed extracted synthetic particles concentrated on the 0.45 μm membrane filters using stereomicroscope equipped with a digital camera. Average concentrations of MPs were counted, particles were categorized by size and shape.

Average MPs concentrations varied from 4.56±1.50 pcs/m^3 in the Ishim, second-order tributary of the Ob River, to 76.0±44.0 pcs/m^3 in the Vychegda, tributary of the Northern Dvina. All studied samples were dominated by particles ranging in size from 300 to 1000 μm which accounted for 51 to 94 % of all detected particles with the exception of the Tobol, where smaller particles prevailed. Microfragments of irregular shape were the most abundant category of particles in the water of most of the rivers studied. While the water of the Irtysh, Vychegda and Kama were dominated my microfilms that may reflect differences in sources of MPs.

Further analyses of the morphology of particles and their polymer composition will help identify sources of pollution of rivers by MPs. Understanding MPs flows carried by Russian rivers requires spatial-temporal studies.

POLLUTION TRANSFER BY MICROPARTICLES IN URBAN WATER BODIES

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Water bodies almost always contain suspensions of different sizes. A decrease in the size of suspended particles leads to an increase in their specific surface area and an increase in their sorption capacity. Microparticles carry other components, including pollutants, bacteria and viruses. Depending on the chemical composition, both the microparticles themselves and the pollutants sorbed by them can be harmful to health. Microparticles do not, in practice, settle in the flow. The smaller the particle is, the longer will be the path of its migration, both in water and in biota.

In recent years, there has been research into the contribution of both natural and anthropogenic microparticles to pollution transfer in the environment. However, there is a limited number of publications that address the processes of transport of pollutants by microparticles in surface water.

We presented the first results of our study in 2020-2021: the contribution of microparticles to the transport of pollution by rivers and groundwater in Nizhny Novgorod, a large industrial Russian centre. Urban water bodies are subject to strong anthropogenic pollution from both point and diffuse sources. Together with the runoff of small urban rivers and groundwater, pollution enters the Volga.

Water samples taken from water bodies were sequentially filtered, through filters with different pore sizes. Initial water samples taken, sequential filtrates, and filter cakes (Prodigy High Dispersion ICP, etc.) were all analysed.

During the summer-autumn low-water period, at least half of the total transfer of priority pollutants in urban rivers is carried out by suspensions. About a quarter of the flow of these pollutants is associated with the transfer of microparticles with a size of 0.22-2 microns (for iron - about a third).

The reported study was funded by RFBR, project number 19-05-50082.

Oral Presentations III e

"Ecology under changing environmental conditions / Fish ecology (Part I)"

BIRD NESTING SUCCESS IN THE CONDITIONS OF CLIMATE CHANGE

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This research combines knowledge from the field of hydrology, ecology and nature protection and uses modelling to analyze the impact of climate change on habitats relevant for waterbirds. The following were defined as research objectives: (1) diagnosis and analysis of hydrological regime characteristics important for waterbirds nesting on Vistula river islands and sandbanks, (2) projection of changes in the hydrological regime characteristics in the future using climate change scenarios and the SWAT model, (3) analysis of impact of climate change on the functioning of selected habitats relevant for waterbirds. Common gull (*Larus canus*), little tern (*Sternula albifrons*) and black-headed gull (*Chroicocephalus ridibundus*) are threatened in Poland by the loss of breeding habitats as a result of changes in the hydrological regime of rivers, changing the frequency and length of inundation in river valleys. Exploring the hydrological regime of the Vistula allowed to determine the beneficial or unfavorable conditions for birds. Analysis of daily flows generated from the SWAT (Soil & Water Assessment Tool) model, allowed to obtain the values of hydrological characteristics expressed as Indicators of Hydrological Alteration (IHA) and find the relationship with collected data on nesting success from 2004 until 2018. For each bird species a set of key IHA was selected. The same key IHA were obtained for future scenarios for the years 2021-2050 and 2071-2100. The projections were prepared on the basis of EURO-CORDEX and contain two scenarios of changes in greenhouse gas concentrations: RCP4.5 and RCP8.5. Projected data enabled the assessment of the significance of changes in the value of key IHA under the conditions of climate change. This allowed to undertake the assessment whether these changes will be beneficial or unfavorable for the species concerned.

CO_2 OUTGASSING DURING THE HISTORIC MISSISSIPPI RIVER FLOODING OF 2019

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In 2019, the Lower Mississippi River (LMR) experienced the largest flood that surpassed by far the 1927, 1973, and 2011 mega floods. River water at Baton Rouge, located 357 kilometers upstream of the river's mouth at the Gulf of Mexico, stayed above flood stage consecutively 212 days from the 6th of January through the 5th of August. The extremely long-lasting flood discharged 632 km^3 freshwater, 33% more than the annual average discharge in the past three decades (i.e., 474 km^3). This unprecedented event provided an opportunity to test the hypothesis that summer floods increase carbon dioxide (CO_2) outgassing from river surface due to higher terrestrial carbon inputs and warmer temperatures. To test the hypothesis, we conducted intensive river sampling and in-situ measurements on partial pressure of CO_2 (pCO_2) and other water physical, chemical and biological parameters in 5-day intervals during the entire flood period. Water samples were analyzed for the concentration of dissolved organic carbon (DOC), dissolved inorganic carbon (DIC) and their carbon–13 isotopes. Compared to reported average pCO_2 from the past (1500 μatm±743), we found significantly elevated pCO_2 in the river water during the flood period (2214 μatm±812; max: > 7000 μatm), which was positively correlated with water temperature (r^2=0.82). During the flood period with sustained high pCO_2, the LMR released 230 Gg C from its last 357-km reach, which is 18% greater than the annual CO_2 emission (195 Gg C) reported for the past three years. A total of 3.71 Tg DOC and 14.3 Tg DIC was transported to the Gulf of Mexico during the flood period, which were close to or greater than the previously reported average annual DOC (3.95 Tg) and DIC (12.25 Tg) exports. The findings support the initial hypothesis and suggest that future climate change may intensify carbon cycling in world's large rivers.

IMPACTS OF REGIONALIZATION STRATEGY ON THE FISH COMMUNITY STRUCTURE IN POLISH RIVERS

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Freshwater bioassessment programs yield valuable information to quantify the diversity and the distribution of freshwater organisms, and can be linked to environmental variables through the use of multivariate methods. In this regard, regionalization strategies are widely used, but the effects on the discerned relationships have not been sufficiently explored. This study employed a permutational analysis of variance to investigate the influence of various environmental variables on the fish community structure in river networks of Poland. The analysis was conducted at the national level and for five different regionalization strategies: a) ecoregion b) elevation zone c) river basin d) ichthyological river type and e) water region. The database included data on fish abundance and environmental variables from 768 sampling points covering the years 2011 – 2019. For the national assessment, elevation and depth were the two most important variables explaining the community dissimilarities. Our findings elucidate that combined effect of seemingly non-correlated factors such as topography, hydraulics and substrate can explain a substantial fraction of the variance of fish community dissimilarity. Regionalization scenarios had higher explanatory power, compared to the national scale benchmark for majority of the environmental variables investigated, with higher improvements noted for smaller regions. The rankings of the variable's importance changed significantly for different regionalization strategies, implying the choice of the spatial extent to significantly impact the determination of community structuring factors. Overall, hydrological variables including velocity, slope and depth gained importance at the smallest spatial resolution units defined by water region. Findings from this study would be helpful for environmental flow regulations from the fish community perspective. Our results can assist water resource planners and managers towards improving fish-based tools for river ecological status assessment.

Oral Presentations III f

"Fish ecology (Part II)"

THE EFFECT OF ATTRACTION FLOW AT FISH PASSES IN THE EPIPOTAMAL OF THE DRAVA RIVER

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In the course of eliminating continuum breaks at watercourses, the findability of the entrance to fish passes continues to be a relevant research topic. In addition to the positioning, the functionality of the entrance is defined in various guidelines, primarily by the flow or flow impulse. This publication, which is part of a research project at various fish passes at the power plant chain of the river Drava, examines the influence of flow parameters on the findability of the entrances, using technical, fish-ecological and statistical methods. Based on the time accurate recording of each ascending fish individual, the relationship between flow parameters and the ascent rates in the fish pass were examined. In addition to the FishCam system for 24/7 accurate detection of fish movements and the FishNet software, statistical methods for variable selection based on penalized regression models with different penalty terms such as LASSO, SCAD and MCP were used. As a result of more than 45.000 observed fish on three different fish passes, re-establishing the Drava river continuity over a length of 48 km, flow parameters like attraction flow and the discharge in the fish pass do not show any significant effect on the ascent rates, which is in clear contrast to various publications, whereas other investigated parameters like water temperature and daylight have significantly positive effects on the findability of the fish pass entrance, and should therefore be further investigated.

ADAPTIVE MANAGEMENT OF WŁOCŁAWEK RESERVOIR DAM TO IMPROVE FISH HABITAT IN VISTULA RIVER

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The River Vistula is the longest Baltic river (1,020 km). The size of its basin is 194,000 km^2 and the average streamflow is 1,046 m^3/s. It was historically a main migration path in Poland for several diadromous fish species. A key moment was the construction of a dam across the River Vistula in Włocławek, 266 km from its estuary with a reservoir of approximately 60 km of length. Populations of sea trout, vimba and potamodromous species, like asp and barbell, declined after dam construction. The fishpass at Włocławek dam was reconstructed in 2014 into vertical slot type for better passability parameters provided some improvement of fish migration. Yet, fish habitat availability study documented that the large impoundment beyond Włocławek dam has significant impact on up- and downstream habitats. The modification of habitat structure leads to alteration of fish communities from riverine to pond preferring species. The fish community structure strongly resembles the habitat structure of the impounded area. The study recommended adaptive management strategy in the following chronological steps:

1.) Introducing flow augmentation scheme for the time of drought, thus mitigating the impact of climate change.

2.) Improve downstream habitats for riverine fish with the river restoration measures that will create more sidearm and braided channel forms downstream of the dam also combating the channel incision.

3.) Lowering of the dam to a third of its height shortening the impoundment to 20 km. At this point reduction of the augmentation scheme can be considered.

The study was a part of Adaptive Management of Barriers on European Rivers (AMBER) project funded by European Commission.

AQUATIC HABITATS IN THE INN RIVER: CORRELATIONS TO RIVER MORPHOLOGY

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The presented study analyses the results of habitat modelling for the ten river stretches along the Tyrolean part of the Inn River, one of the largest Danube tributaries. The modelling sites are situated in two biocoenotic regions: hyporhithral (grayling region) between the Swiss border and the confluence of the Fagge and downstream of Landeck (Sanna confluence) until Innsbruck; and metarhithral (= lower trout region) in the middle part downstream of the tributary Fagge towards the Sanna confluence. In addition to a strong natural change of flow and gradient conditions along the river, the Inn is heavily affected by anthropogenic impacts and construction measures of the last 300 years. Land reclamation, flood protection and infrastructure measures (e.g. railway, motorway) have changed the originally branched river with wide gravel banks and alluvial forest to the channelized stream with cut off floodplains. Nowadays there is also hydropower utilization, i.e. run-of-river HPP as well as discharge from high alpine reservoirs (hydropeaking).

Between 2005 and 2015 numerical habitat investigations have been performed in ten different river sections using the fuzzy rule - based simulation model CASiMiR. Habitats of grayling (*Thymallus thymallus*), brown trout (*Salmo trutta*) and mayfly *Baetis alpinus* have been studied and flow dependent variations of habitat availability and quality have been analysed. Although investigation reaches show the same species range and are situated relatively close to each other, habitat amount, habitat quality and their flow dependent changes are different.

The study shows that the potential of physical habitat in the Inn River is closely related to the river morphology. The morphological features which govern habitat characteristics are not fully covered by standard assessment methods such as structural quality mapping. Thus, for the elaboration of flow management and river restoration measures, physical habitat modelling is considered being a suitable tool. Integrating hydraulics and morphology and targeting habitat as crucial component of the river ecosystem, it allows finding operational recommendations that support river resilience under local anthropogenic pressures.

Oral Presentations IV a

"Hydropower / flood management / conflicting demands"

HYDROPOWER DEVELOPMENTS IN SELECTED LARGE RIVER BASINS

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Large river basins are often characterized by the interaction of different land use demands and natural river functions. As one of these uses, hydropower represents an important renewable energy source in many river basins. However, the increasing development of hydropower often leads to ongoing interactions with the environment. Using the three major rivers Danube, Mekong and Niger as examples, the status of hydropower is comparatively investigated on three scales. At the first scale, hydropower development on the three rivers is analyzed over time. In addition to a historical review, an overview of future planned hydropower projects is also provided. At the second scale, by mapping hydropower plants, the technology is presented in its spatial dimensions. Thereby, the view is extended to the entire river basins. Moreover, different types and sizes of hydropower plants are also analyzed. The third scale addresses the often mutual interaction of hydropower with its environment. Synergetic interactions as well as conflicts and challenges are discussed. Furthermore, a linkage to the importance of hydropower to basin's population and possible impacts due to predicted demographic trends are explored. The results show that the development of hydropower is strongly dependent on basic framework conditions, and therefore a spatially differentiated view is necessary to adequately assess the status of hydropower in its river basin.

FLOODPLAINS ALONG THE DANUBE RIVER AND THEIR IMPORTANCE FOR FLOOD RISK REDUCTION, ECOLOGY AND SOCIO-ECONOMICS

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Floodplains are highly endangered ecosystems, despite their multiple benefits for flood risk reduction, ecology and socio-economics. 90% of floodplains in Europe and North America are already impaired by anthropogenic activities. The ongoing urbanization and economic growth put a lot of pressure on the remaining active floodplains, although they filter and store water which lead to natural flood protection and a healthy functioning of the river ecosystem, and provide the biological diversity on floodplains with the essential water. For demonstrating the multiple benefits of active and potential floodplains along the Danube, the Floodplain Evaluation Matrix (FEM) was applied. This method was developed to determine highly relevant floodplains in terms of flood protection, ecological and socio-economic reasons where efforts of floodplain preservation or restoration should be taken first. The Floodplain Evaluation Matrix has a flexible design and different sets of parameters can be determined and used for the evaluation. In this study, hydrological (e.g. peak reduction), hydraulic (e.g. water level change), ecological (e.g. protected species) and socio-economic (e.g. affected buildings) parameters were used for the evaluation of active and potential floodplains along the Danube. At the Austrian Danube in total six active floodplains (>500 ha) and two potential floodplains, which are extensions of two active floodplains, were identified and evaluated. For the determination of the hydrological and hydraulic parameters, a 2D hydrodynamic-numerical model and different flood events (e.g. 2002, 2013) were used and the results of the different events were compared with each other. Analyses with a Geographic Information System (ArcGIS) were used to calculate the ecological and socio-economic parameters. The results of the Floodplain Evaluation Matrix demonstrated the high importance of the floodplains for the whole Danube and specifically for the Austrian reach under investigation for flood risk reduction, ecology and socio-economics and showed the need for their preservation and restoration.

MODELING OF URBANIZED TERRITORY FLOODING AT A LARGE RIVERS CONFLUENCE

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Floods are one of the most dangerous natural disasters in Russia, both in terms of impact area and frequency of occurrence, and in the amount of damage caused. To assess possible damage, identify possible flood zones and the influence of different factors affecting the river during the flood, methods of mathematical modeling are increasingly used.

The object of the study was the confluence of two large Russian rivers: the Sukhona and the Yug. This region is one of the most prone to flooding, including ice-jam-induced.

As part of this study, an attempt to adapt the STREAM-2D two-dimensional hydrodynamic model to a spatial resolution comparable to the size of residential buildings was made. Open Street Map data were used as initial information on residential and household buildings located within the city.

To generate a mesh on the territory of the city, Automesh-2D software, developed at Jinan University, was used. The mesh generation was carried out in several stages: dividing the modeling area into separate sections, splitting into nodes, meshing, manual adjustment.

The obtained detailed mesh was used to calculate the flooding zone for the two largest floods of the last decade in the city of Veliky Ustyug: 2013 and 2016. The model calculation was visualized as a depth map and a velocity map; a comparison with the actual data was also made.

The computational mesh generation was supported by RSF No. 17-11-01254, the flood simulation was carried out with the financial support of the RFBF grant as part of scientific project No. 18-35-00498 mol_a.

CATASTROPHIC FLOODS IN LARGE RIVER BASINS: DYNAMIC COMPLEX NATURAL PROCESSES OF THE SURFACE WATER AND GROUNDWATER INTERACTION – FORECASTING AND PRESENTATION OF FLOOD CONSEQUENCES

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Motivation of the paper is to discuss the knowledge level for catastrophic mudflow/debris and floods in mountain conditions in a river basin. The problem is that more than 60 years history to study the processes, but still many questions and not reasonable forecast for the process development to prevent the catastrophic consequences do exist. In fact, even in roughly estimation of water balance for catastrophic floods (great river basin in USA, India, Russia, e.g. for the last 10 years) – especially in mountain country – results in a strange factor when even a small river, being the river tributary, discharge becomes comparable with discharge of great world river. And next factor often occurs, that fantastic localization of the water mass in a small channel for strongly dissection of relief takes place.

Our idea is not to downplay the role of precipitation in the flood emergence and development but to consider the whole complex dynamic system of river basin in the close interconnection of its parts where groundwater is an important factor as a precipitation, especially while we consider disastrous floods.

The approach (and the conception around) results in more reasonable forecast and early warning for the natural water hazard/disaster taking into account the groundwater dominant role. For practical verification of proposed approach and numerical forecast based on the discussed model, we need a vital information about both the groundwater hydrostatic/hydrodynamic pressure distribution and the water flows, carried out by the water crack 3D-map in the mountain massif. The necessary condition for dramatic development of the phenomena is the breaking down the impermeable rock due to sudden opening of the crack-ways (preliminary blocked), that become active by some reasons (e.g. due to the shower runoff action and/or geo-thermal stream influence) and due to earthquake as well in principle.

ADJUSTMENT OF CHEMICAL INDUSTRIAL ALONG THE MAINSTREAM OF YANGTZE RIVER

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The over-exploitation, disorderly development, and inefficient use of water resources issues have been occurred in mainstream of Yangtze River due to the large numbers of chemical industrial parks and the high-density distribution of chemical companies set in this area. Aiming to solve these issues, we analyzed water resources and the chemical engineering industry in places along the Yangtze River. The water resource and water environmental carrying capacity of the Yangtze River mainstream were comprehensively evaluated and their influencing factors were well hackled. We also analyzed the rationality of the distribution of the chemical engineering industry within water resources constrains, the compatibility with water source conditions, and other existing problems in this area. Moreover, we have divided the thirty-nine major cities along the mainstream into types of low-capacity and high-pressure zones, low-capacity and low-pressure zones, high- capacity and high-pressure zones, high-capacity and low-pressure zones and others. Finally, suggestions on optimization and adjustment of the chemical engineering industry and policy recommendations for improving access to the chemical engineering industry along the Yangtze River were explored and formed. The results prospects to provide references for further optimizing the chemical industrial distribution along the Yangtze River.

METHODS AND TECHNOLOGIES OF SPACE MONITORING OF THE CONDITION OF RIVER WATER AREAS IN THE EVENT OF EMERGENCIES

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The tasks of assessing the geoecological risks of sustainable development of states at the beginning of the XXI century come to the fore in the research of scientists from many countries. An important place among them is given to the tasks of assessing and forecasting risks in the implementation of projects of the fuel and energy complex and its important component of the oil and gas complex. Their source is accidents at oil fields, water crossings of pipeline systems, oil refineries (refineries), storage of oil and oil products. First of all, this concerns emergency spills of oil and oil products occurring in river basins. Examples of these are accidents:

- at the Komineft oil pipeline in July 1994 near the city of Usinsk (Komi), where 94 thousand tons of oil spilled into the Kolva River;
- at the oil depot in the city of Lensk on the Lena River in 2001, where 89 out of 148 oil reservoirs were destroyed during the spring flood;
- failure of one of the oil gathering pipelines of the Ust-Balykskoye field in the city of Nefteyugansk, when 200 tons of oil got into the channel of the Ob River (23.06.2015);
- at the fuel reservoirs in the city of Norilsk, when 21 thousand tons of diesel fuel got into the Ambarnaya river basin (05.29.2020).

To ensure the safety of the territories where the oil and gas facilities are located, it is necessary to assess and neutralize the impact of the emerging hazardous. This is achieved through the implementation of environmental in areas of increased geoecological risk. The effectiveness of their implementation depends on the completeness of the information picture characterizing the state of the territory for the period associated with the investigated negative impacts, and, accordingly, on the choice of optimal control decisions based on it.

The complexity of accounting for geoecological risks is associated with an assessment of the uncertainty caused by the random nature of the activation of the manifestation of hazardous natural and technogenic processes. This involves establishing:

- of sources of hazardous natural and man-made processes in the study area;
- of frequency of manifestation of hazardous processes;
- of vulnerability of the facility in the event of hazardous impacts;
- of the cost of eliminating the consequences of hazardous impacts.

The aim of the work is the development and practical testing of methods for assessing the state of water areas of river basins in the event of emergencies of natural and manufactured origin using space monitoring technologies, as well as geoinformation modeling systems.

In the course of fulfillment the work, was development out:

- model of the geoinformation environment of territorial objects;
- forecast of areas of emergencies of natural and technogenic origin;
- search system for zones of potentially dangerous processes;
- methods of interpretation of images obtained by space systems the Landsat-8; Sentinel-2A and Resource-P3 in the tasks of assessing the state of water areas of river basins in emergencies.

Oral Presentations IV b

"Transboundary management"

LEGAL FRAMEWORK OF MANAGEMENT OF THE TRANSBOUNDARY AMUR RIVER (HEILONG JIANG): ISSUES OF ENVIRONMENTAL, SOCIAL AND ECONOMICAL DEVELOPMENT UNDER THE IMPACT OF CLIMATE CHANGE

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Management of transboundary rivers is very complex and requires combined approach to link water resources as such with the sectors using water for the sake of food and energy production. The Water-Food-Energy sectors are inextricably linked and of great importance for securing of human rights to water and food. On the other side NEXUS approach is necessary for achieving sustainable development, in particular of SDG 6 (water and sanitation), SDG 2 (food security and sustainable agriculture), SDG 7 (access to energy), and SDG 15 (protection and sustainable use of ecosystems).

International water law as well as international law regulating soil management and energy management as well as Multilateral Environmental Agreements, set up a legal basis for framing interstate obligations towards implementing NEXUS approach in the management of transboundary rivers.

In this study, we would like to consider the problem of joint management of the transboundary Amur River by the two largest countries of the world - Russia and China. Comparative analysis of water use in the Russian and Chinese parts of the Amur River basin shows a drastic disproportion in its intensity and structure. The reason for this is obvious: differences in population, degree and course of economic development of the territories. The consequences of the Amur River flow regulation with the reservoirs can be traced both for the Russian and the Chinese part of the basin. This requires a substantive analysis the existing international legal applications of both, Russia and China, to share the Amur River flow for guarantee its sustainable development.

CLIMATIC AND ANTHROPOGENIC CHANGES IN TRANSBOUNDARY URAL RIVER WATER REGIME

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The Ural River is the third in the list of European rivers by its length. Its length is 2428 km and basin area is 237 000 km^2. The basin occupies the territory of Russia and Kazakhstan. The Ural River is considered a transboundary water body, which didn't escape problems due to sharing water resources. Main problems are a decrease in water levels and maximum discharges during spring flood, a decrease of annual water runoff and polluting river water. They negatively affect the living conditions of fish, productivity of floodplains and possibility of using river water for settlements. The authors found that the current long-term low-water period began in 2006-2008 and continues to this day, despite an increase in precipitation in the winter and spring seasons in the 21st century. Runoff and maximum discharges of spring flood in the Lower Ural has decreased by 27 and 55-43%. Now the flood season begins and ends 9 and 5 days earlier. Runoff of the summer-autumn and winter low-water seasons has increased by 56-42 and 70-61%, the winter duration - by 18 days. Intra-annual fluctuations of water discharges and levels have decreased significantly. Large inundations have not been since the mid-1990s. There are several reasons. These are obvious regional climatic changes: an increase of air temperature, frequency and duration of winter thaws, and a change in precipitation regime and snow cover during November-March. It is also a consequence of the regulation of Ural River by the Iriklinskiy reservoir and 3130 smaller reservoirs and numerous ponds; irrevocable intake of river waters (~2.38 km^3/yr in 1985-1990 and ~1.1 in 1999-2007); wastewater discharges; man-made landscape changes. Problems in the transboundary water use are compounded, although it is regulated by several international documents. The authors offer their assessment of the current situation, the contribution of each of the factor and ways to solve these problems.

The investigations were carried due to theme 121051400038-1 and an agreement with the Atyrau region.

INTEGRATED WATER MANAGEMENT IN BULGARIAN AND ROMANIAN TRANSBOUNDARY BASIN COOPERATION

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The presentation is relevant to UN SDG indicator 6.5.2. The Bulgarian-Romanian Commission and working groups about Danube River have been established in 2004. The data about transboundary surface and groundwater bodies are part of the River Basin Management Plans 2016-2021. Nevertheless, there are some problematic issues that will be discussed, given the data on calculation of the freshwater resources in other Danube countries. Proposals will be made to harmonize the water balances not only in the two transboundary countries but also throughout the Danube basin based on integrated water resources management.

Oral Presentations IV c

"Integrated water management (Part I)"

RESEARCH TO HELP MANAGE THE MURRAY-DARLING BASIN, AUSTRALIA

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The Murray-Darling Basin in south-eastern Australia is one of the world's largest rivers, draining an area of just over 1 million square kilometres. The basin drains about one-seventh of the Australian land mass and is the 16th longest river in the world. However, being located on the driest continent on Earth, its discharge is relatively small, averaging just 767 m^3/s, far smaller than the discharge from any other similarly sized river worldwide.

Despite the relative lack of water, the Murray-Darling Basin is one of the most significant agricultural areas in Australia. In order to manage the water in the basin, in 2008 the Murray-Darling Basin Authority was formed with a mandate to manage the Murray-Darling Basin in an integrated and sustainable manner. Water reform in the basin has been a world-first in terms of the scale of intervention, but it has led to numerous conflicts in terms of access to water. The ability to manage the basin adequately relies on appropriate research being carried out in order to determine how much water is currently available, where it is currently being used, and how water availability and use are likely to change into the future.

Like much of southern Australia, the Murray-Darling Basin is already feeling the impacts of climate change, with more hotter days, fewer cold days, and a reduction in cool-season precipitation. These changes are only likely to increase over the coming decades. Additionally, as of October 2019, the Murray-Darling Basin finds itself in the grip of the worst drought in 120 years of records. This follows on the back of the second worst drought on record, the Millennium drought from 1997-2009.

This presentation will summarise the research being carried out by CSIRO in order to assist the MDBA to appropriately manage the water resources of the basin.

WATER-SEDIMENT REGULATION SCHEME OF THE YELLOW RIVER: A REVIEW

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The Water-Sediment Regulation Scheme (WSRS), beginning in 2002, was an unprecedented engineering effort to manage the Yellow River with the hydrological aims to mitigate the siltation both in the lower river channel and within the Xiaolangdi Reservoir employing dam-regulated floods. Ten years after its initial implementation, multi-disciplinary indicators allow us to offer a comprehensive review of human intervention on a river-coastal system. The WSRS generally achieved its hydrological objective, including bed erosion in the lower reaches with increasing capacity for flood discharge and the mitigation of reservoir siltation. However, the WSRS presented unexpected disturbances on the delta and coastal system. Increasing grain size of sediment and decreasing sediment concentration at the river mouth resulted in a regime shift of sediment transport patterns that enhanced the disequilibrium of the delta. The WSRS induced an impulse delivery of nutrients and pollutants within a short period (~20 days), which together with the altered hydrological cycle, impacted both the terrestrial and aquatic ecosystem in the delta region. The sediment yield from the loess region is expected to decrease due to soil-conservation practices, and the lower channel erosion will decrease as the riverbed armors with coarser sediment. These, in combination with uncertain water discharge concomitant with climate change, increasing water demands and delta subsidence, put the delta and coastal ocean at high environmental risks. In the context of global change, we depict a scenario of human activities in the river basin that have been transferred along the hydrological pathway to the coastal system and remotely transformed different components of coastal environment. The synthesis review of the WSRS indicates that an integrated management of the river-coast continuum is crucially important for the sustainability of river-delta system. The lessons learned from the WSRS in the Yellow River provide insights to the integrated management of large rivers worldwide.

OPTIMIZATION APPROACHES TO WATER RESOURCES MANAGEMENT IN THE LOWER KUBAN

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The Lower Kuban River Basin experiences an acute shortage of water resources during the growing season. Every third year is a low-water period. The complex layout of rice irrigation systems requires reliable forecasting and skilful management. This article presents the results and methodology for optimal operation for the Lower Kuban irrigation and drainage systems based on multi-criteria analyses and trade-off theory that ensure the reliable functioning of the water resource system taking into account contradictory requirements of water users and restrictions aimed at preserving the Kuban River Basin ecosystem.

Water management systems (WMS) have multiple purposes: economical, ecological, social, etc. They also provide reliable operations for water users (agriculture and fisheries, ecology, energy, navigation, drinking water supply, flood protection, recreation, etc.). To assess the effectiveness of the system, various criteria are used that determine the quantitative assessment of the reliability of the WMS operation.

The methodology is based on multi-criteria analysis and hydrodynamic modelling with the application of the 'operating structures' module, which, according to a given hierarchy of priorities, allows the water users to fulfil the requirements for discharges and water levels during the determined time period at water intake sites and outlets within the river network. The developed computational technology allows a reasonable compromise to be reached in the process of negotiations between water users and water basin authorities.

For the creation of the hydrodynamic model, a calculation scheme was developed in MIKE 11 that included the hydrographic/water source network of the Lower Kuban River, four reservoirs (Krasnodarskoe, Shapsugskoe, Kryukovskoe, Varnavinskoe), the Fedorovsky and Tikhovsky hydrounits/hydraulic structures, and the sites of the outlets and intakes of the pumping stations within the Kuban (KIS), Ponuro-Kalininskaya (PKIS), Petrovsko-Anstasievskaya (PAIS), Maryano-Cheburgolskaya (MCIS), Chernoerkovskaya and Fedorovskaya (FIS) irrigation systems.

Different scenarios for hydrodynamic calculations with a possible hierarchy of priorities were formed. A multi-criteria analysis of the decision matrix was performed, and CT that supports the negotiation process was formulated and demonstrated to choose the "optimal" compromise solution for the operating modes of the Lower Kuban WMS using the example of a low-water year, 2013.

PROBLEMS OF WATER RESOURCES REGULATION IN THE BASINS OF LAKE BAIKAL, THE ANGARA, AND THE YENISEI

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The Yenisei is the most abundant river in Russia, the fifth in the world. The area of the river basin is 3.62 million km^2 (including the Baikal and Angara basins) with an average water content of 591 km^3 per year. The basin has a relatively high level of flow regulation. The nine largest reservoirs have a total volume of 469 km^3, useful - 174 km^3. Irretrievable water consumption is insignificant - less than 1% of the annual flow. With significant water resources of the basins and the storage capacities of reservoirs, the requirements of water users are fully met only in years of average water content and close to it. Problems in water resources management accompanied by socio-economic and environmental damage arise with the onset of high-water and, especially, low-water periods.

Two groups of factors behind the problems should be noted. The first are natural and climatic factors. The probabilistic nature of river runoff changes does not allow obtaining reliable long-term (up to 1 year) forecasts of water inflow into reservoirs and, therefore, making effective advance decisions on managing the operation of reservoirs. The second group includes changes in socio-economic and technical conditions, as well as current legislation. Most of the hydrosystems and reservoirs were built and put into operation 30-60 years ago. Over the years, socio-economic conditions in Russia have changed significantly, and for some hydroelectric facilities, technical characteristics have changed relative to the design ones. The unified state property ceased to exist. Hydroelectric power plants have been transformed into joint-stock companies in which private individuals (in some of them, only private persons) are shareholders along with the state. The sphere of water use currently does not have economic management criteria, which does not stimulate the rational use of water resources. Many legislative documents have become outdated, including the Rules for the Use of Water Resources in Reservoirs. The development and construction of the adjacent territories require clarification of the marks of the upper and lower ponds of the hydrosystems, the permissible water flow rates. Whereas previously of priority were the interests of the energy sector, now the top priority is environmental and social requirements and restrictions. First of all, this applies to the Irkutsk reservoir and Lake Baikal (a UNESCO World Heritage Site).

Thus, to increase the efficiency of water resources in the Baikal, Angara, and Yenisei basins, it is appropriate to amend the current legislation; introduce economic methods to stimulate rational water use (including the introduction of water charges); formulate environmental and socio-economic requirements; develop methods for long-term forecasting of water inflows into reservoirs.

INTEGRATED HYDROLGOCIAL MODELLING FOR INTEGRATED WATER RESOURCES MANAGEMENT IN DRAVA RIVER FLOODPLAIN

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Growing awareness about the benefits of more sustainable management and allocation of water resources has highlighted the need to manage surface water and groundwater systems as a single integrated system. Hydrological models are a simplified representation of hydrological processes and can be applied for water and environment resources management and gain an integral view of the status of Integrated Water Resources Management (IWRM). A reliable and accurate simulation of both land surface and groundwater hydrological processes represents the most essential step in IWRM. Coupling surface and groundwater models is the only way to achieve such a purpose. It has become imperative that surface and groundwater resources be managed as a holistic system. In this study, an integrated surface water (Wetspass-M) and groundwater model (MODFLOW-NWT) is developed and calibrated with an eight-year data series to improve the long-term stressor simulation of WetSpass-M standalone for a highly-regulated river floodplain, the Drava River basin in Hungary. The Drava river floodplain region is highly affected by human activities and it suffers from water stress and intensification of drought hazard. Integrated water resources management is necessary, particularly in a system where considerable interactions exist between surface and groundwater resources. The integrated model is applied to examine the human interventions within natural hydrological systems, and to evaluate the feasibility of water replenishment under different management scenarios. The research approach of the integrated models can generally be applied to any catchment and inspired by the need of considering all aspects related to hydrological models for IWRM to bridge the gap between stakeholder involvement and natural hydrological processes in building and applying integrated models to ensure acceptability and application in decision-making for IWRM.

MANAGEMENT EVALUATION AND OPTIMIZATION OF DISPATCHING SCHEDULES OF IRKUTSK RESERVOIR

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In the process of flow regulation in the basins of large rivers with a large number of riverbed hydropower reservoirs, it is necessary to make operational decisions on the interconnected feeding of flood waters through the hydroelectric units, while ensuring the appropriate water supply to consumers. It is necessary to withstand the demands of the water system expenses and water levels in pools of the waterworks, taking into account the inflow to reservoirs of the cascade. In modern practice, such decisions are usually made on the basis of dispatching control schedules developed on the basis of long-term hydrological series and experience of basin water resources management in the past years. Rules for the use of reservoirs water resources provide compliance of requirements for the guaranteed return of the reservoir to the main consumers to the values of a number of standards for providing normal consumption for the number of uninterruptible years in the range of 75-99 percent (depending on the standard).

The aim of this study is to develop methods for assessing the quality of dispatching schedules, without using the principle of dispatching, as well as methods for optimizing dispatching schedules taking into account the requirements of interested water users on the basis of a hierarchy of consumers demands priorities and the theory of trade-offs.

Oral Presentations IV d

"Integrated water management (Part II)"

RIVERS OF POWER

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This talk introduces my book Rivers of Power, which explores the timeless and often underappreciated breadth of humans' relationship with rivers.

These natural geographical features are of course important in many practical ways (e.g. municipal water supply, transportation, irrigation), but the historical scale of their influence is sometimes less obvious. The many ways that humans use rivers have varied by region and changed over time. Yet their value has persisted because they provide us with at least five fundamental benefits: access, natural capital, territory, well-being, and a means of projecting power. The manifestations of these benefits have changed, but our underlying needs for them have not. Rivers define and transcend international borders, creating migrant barriers while forcing cooperation between nations. Human explorations and the repeated colonizations of continents were guided by rivers. Wars, politics, and urban demography are occasionally shaped by floods. We massively engineer rivers to sustain cities, agriculture, and energy production. The territorial claims of nations, their cultural and economic ties to each other, and the migrations and histories of people trace back to rivers, river valleys, and the topographic relief they carve upon the world. Today, rivers remain a powerful political force and are critical as ever to our future.

ADAPTATIVE AND PARTICIPATORY MANAGEMENT ON THE RHINE FLUVIAL HYDROSYSTEM. LEARNING FROM THE PAST TO OPTIMIZE FUTURE SCENARIOS

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The need to manage aquatic and riparian habitats in an integrated and participatory manner is increasingly seen as crucial regarding the implementation of environmental policies, particularly in a context of global change. This talk focuses on protected natural areas in the Upper Rhine fluvial hydrosystem, including the main channel, the floodplain and side channels. The protection and restoration of these wetlands and riparian habitats is a major issue on both national and European scales, because of the importance of the ecosystem services they provide, (e.g. food mitigation, groundwater resource renewal, biodiversity and adaptation to climate change). We began by investigating the methodological tools that are supposed to guide the managers in an efficient way. This analysis was based on the application of an evaluative framework based on three criteria: (i) Scientific foundations, (ii) Operationality, (iii) Legitimacy. We then discussed the way managers use methodological tools in the field and how managers are responding to the current increase demand of integrated and participatory management. Our results highlight important methodological weaknesses which may significantly impair the manager's actions. Our results also show that current management practices do not fully incorporate the concepts of "integration of different stakeholders" and "adaptation", which may weaken the effectiveness and sustainability of management actions. Lastly, we propose a set of conceptual and methodological recommendations aimed at clarifying the procedures for an integrated management of natural areas. These recommendations focus on the main stages of management and involve a procedure for carrying out the diagnosis and evaluation phases through a participatory approach, as well as the proposal of a control and surveillance system that allows the adaptability of actions throughout the execution of the management plan. We conclude by arguing that these recommendations can be reproduced and transposed to other natural aquatic and riparian areas, in France and elsewhere.

SOCIAL CONSEQUENCES OF EXTREME HYDROLOGICAL EVENTS WITHIN LARGE RIVER DRAINAGE BASINS

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Extreme hydrological events can be grouped into three categories: high water (mainly flooding), low water, and a sharp change in the quality of natural water [Koronkevich, Barabanova, Zaitseva (eds.), 2010]. Any of them has a wide range of social consequences. Despite the abundance of various data on extreme hydrological events, it is not always clear how these events affect the transformation of local communities and their continued existence. The problem is which social effects should be taken into account first of all.

Among the most dangerous extreme hydrological events both in Russia and in the world are floods on large rivers caused by high water levels of rare recurrence. To identify the actualization degree in the scientific literature of these consequences, a content analysis of publications on five major events in different countries (Pakistan (2010); Thailand (2011); Australia (2011); Russia (2012); the USA (2013)) was conducted [Bondarev, Bolkhovitinova, 2019]. It was shown that the most discussed social consequences were the human losses, social solidarity and management problems. The problems of psychological state of the population, horizontal and vertical mobility caused the medium interest. The problems of social conflict, adaptation, health losses were the least described.

Generally, we can expect a similar set of social consequences for any extreme hydrological events. However, the range of the problems is determined by the specifics of a particular extreme hydrological event.

It is important to note that social consequences of extreme hydrological events can be divided into negative (human and sanitary losses, the deterioration of social and psychological state, etc.) and positive (the activation of social adaptation processes, the growth of social solidarity and the improvement of crisis management tools of the community).

OKA RIVER CHANNEL TRANSFORMATION AND ITS RECOVERY PERSPECTIVE

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Oka River is one of the largest rivers in European part of Russia, draining the East European Plain's central part. Watershed area is 245.000 km^2, mean long-term water discharge is 1300 m^3/s. The river is as long as 1500 km. The river flows through the most populated and economically developed part of Russia, there are many cities and industrial facilities in its water basin. The river underwent the changes of channel morphology, river and floodplain ecosystems, due to human activity.

Oka River in its upper and middle course is used as a source of sand and gravel materials for constructing purpose greatly required in the region as long as since the early 1950ies. More than 100 mln. m^3 sand and gravel was mined from the riverbed during 6 decades. Taking into account the current bed sediment yield, river could transport such amount of material for 500 years. Meanwhile, no more than 12-15% of removed material was compensated on account of river sediment yield.

Riverbed is substantially transformed. It consists of shallow ripples and overdeepened pools sequence. The last are the former mines which are as deep as up to 13 m and as long as several tens kilometers. Mean bed degradation is about 1,9 m. Bed degradation within mines occurred because of manmade material removing while vertical erosion developed in the sections between the mines. Erosion rate reached as much as 3-5 cm $year^{-1}$. Longitudinal water surface profile became stepwise.

Riverbed transformation has continued. It reveals itself in widespread low-water level drop which has the linear trend and exceeds at present 2 m. Level drop is the most serious effect to ecosystem. Riverbed recovery is probably impossible. To recover the riverbed, the increase of sediment yield from bank erosion and tributary influx is needed along with complete mining stop. Both sediment sources give little possibility to refill sediment yield. Alternative way to restore the water level and ecological situation could be low-head dams construction.

INTEGRATION OF BIOLOGICAL LEVELS TO ASSESS IMPACTS IN RIVER SYSTEMS

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Exacerbation of human activities have caused multiple stressors in running waters that often negatively affect aquatic organisms. These effects can be detected at different biological organisation levels: from molecular to ecosystems, while ecological relevance of indicators increases at superior levels. However, a high quantity of studies is concentrated on inferior levels and studies that integrate organism's response at several levels of biological organisation are scarce and are needed to understand complex responses of ecosystems to stressors. In this study we evaluated riverine ecosystem response to interplay of multiple stressors (pollution, hydrological alteration, non-native species) in two basins in Chile (Biobio and Valdivia) at three levels of biological organisation: molecular (lipids concentration), individual (body condition) and community (diversity and structure). At individual level, response of a common native fish, Chilean silverside (*Basilichthys microlepidotus*) as a sentinel species was evaluated. We found significant changes in fish community at contaminated sites in both river systems and these effects were more severe in the Biobío River characterised by more intensive flow management due to hydropower development. At individual level, silverside body condition decreased in the polluted zone in Valdivia River and increased in Biobio River in warmer season. At inferior levels DHA, an essential fatty acid, increased in the most polluted zone in the Biobío River, possibly due to bioaccumulation of pollutants. More significant alteration in summer suggests a stronger influence of stressors due to loss of self-depuration capacity of river system during low flows. The assessment of different level of biological organization is primordial to understand effects on organisms, because each level could respond differentially depending on stressor type, as well as number and interplay of stressors. Such multilevel assessment allows more accurate evaluation of health status of the river ecosystems that is essential for efficient management.

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IMPROVING SEASONAL STREAMFLOW FORECASTS IN THE VOLGA AND AMUR BASINS

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We explore the possibilities for improving the long-term (up to 4 months) mean monthly streamflow forecasts skill by constructing cumulative distributions (CDF) of the observed streamflow conditioned on the predicted streamflow and weather conditions, namely mean monthly air temperature and precipitation, taken as predictors. We overcome the limitation of short time-series of the observed variables by multivariate modelling procedure allowing for the time-series extension. The extended time-series are then classified by their quartile values into 64 bins each containing the unique combination of the predictors, and the conditioned streamflow CDFs are constructed. The forecasting procedure was tested in the Volga and Amur River basins for two case study catchments with different streamflow conditions. The ensemble forecasting system was built around the ECOMAG model, for the weather predictions in the Volga River basin we used seasonal ECMWF forecasts, and for the Ussuri river basin – the SL-AV model monthly forecasts. Given the combination of the predicted future monthly streamflow, air temperature and precipitation, we determined the appropriate CDF bin and interpreted its 90% confidence interval and mean value as probabilistic forecast of the streamflow. We tested the developed approach against the observed streamflow and the raw ensemble streamflow forecasts and show its advantage by improving the confidence interval and resolution. We also show that the approach is highly dependent on the weather forecast accuracy.

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Poster Session A

"Hydrology, Hydraulics & Hydroclimatic Impacts"

CHARACTERISATION OF THE SOURCES OF VOLGA, DNIEPER & DAUGAVA

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In the Valdai Hills the sources of three large east European rivers are located close together, within a radius of 85 km. The catchment area is characterized by dense forests that are parts of the ancient "Okovsky Forest" and also rich in swamps and mires. The paludified catchment is typical for the rivers in this region and it is also determining the physico-chemistry of the water.

The source of Volga (228 m asl), Europe's longest river (3551 km), is a limnokrene located near the village Volgoverkhovje. Several meters downstream of its source the Volga River forms a small runnel not wider than half a meter, but soon it is becoming a creek. Downstream of the Upper Volga Lakes the free-flowing section towards Tver evolves. The Dnjepr, which is Europe's 4th longest river (2201 km), emerges at the village Bocharovo (220 m asl) near Smolensk, before flowing through Belarus and Ukraine to the Black Sea. Daugava or Western Dvina (1020 km) emerges near the village of Koriakino (221 m asl) and soon after enters Lake Okhvat, a humic lake, wherefrom the river emerges. The Western Dvina flows through the territory of three countries (Russia, Belarus and Latvia) and discharges into the Gulf of Riga (Baltic Sea).

The water at the sources of all three rivers has a low mineralization (less than 100 mg/l) with a predominance of bicarbonate and calcium ions. Due to mire feeding, the water is highly saturated with organic substances and has high chromaticity and low pH. Official monitoring points along the three rivers indicate good quality in their headwater sections. We also investigated diatom communities at the three sources and analysed species diversity and common biological indices. Our study characterises the sources of three large rivers and contributes to the knowledge about the biggest East European drainage devide.

ESTUARIES OF THE WHITE SEA: NORTHERN DVINA, ONEGA AND MEZEN' – GREAT AND DIFFERENT

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The Northern Dvina, Onega and Mezen' rivers form the largest estuaries of the White Sea basin. They are very different according to their geomorphological structure, tidal wave range (1 to 9 m), salt-fresh water mixing processes and sediment transport features. The intensive field investigations were undertaken in 2015-2020 in both summer and winter seasons to investigate the hydrodynamic regime of the estuaries using acoustic Doppler current profilers, barometric water level loggers and differential global positioning system together with water sampling for salinity and sediment load. Some new features of the reversible flow dynamics in tidal estuaries were identified, in particular, variations of hydraulic parameters in the Saint-Venant equations during the tidal cycle, such as hydraulic resistance and Coriolis and Boussinesq velocity corrections. The lands within estuarine areas of the most dangerous manifestations of hydrological processes were identified. The obtained field data were used for development, calibration and verification of 2D hydrodynamic models for the Northern Dvina, Onega and Mezen' estuaries. The models allow reproducing typical or unique hydrological situations, including dangerous hydrological phenomena, such as extreme snow-melt flood or wind surge, as well as analyzing variations of the main hydrodynamic parameters of water masses within the area under modeling. Possible changes in estuarine regime of the Northern Dvina and Onega have been simulated for various scenarios of river runoff and sea level alteration as a result of climatic changes.

SPATIAL DISTRIBUTION OF THE WATER FLOW AT THE ILI DELTA

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The paper is devoted to the analysis of contemporary spatial distribution of the water flow at the Ili delta and flooding of this delta during the floods. The Ili delta development (including today's evolution) pertains to the regular formation of new branch systems following water breakthroughs and subsequent abandoning of the old ones. The Ili delta runoff is concentrated in three branch systems (Ili, Topar and Zhideli). In the first half of the 20th century, the runoff was distributed between these systems in the following way: the Ili and Zhideli branch systems received 42 and 40% of the runoff in the delta head respectively, while the Topar branch system received 18%. In the second half of the 20th century water runoff distribution and re-distribution between the branch systems was changing. Currently the Zhideli branch system, the youngest one in the delta, concentrates nearly the entire Ili delta head runoff (up to 96–98%). This branch system was formed by swift river inflow to the irrigation canal and rapidly eroded. This caused water supply to new parts of the delta and formation of new branches, for example the most active Kugaly (Kokozek) branch. This branch system feeds multiple watercourses, lakes, and wetlands.

During the high water period, the Ili delta flooding area amounts to more than 13% of the whole delta area, and the greatest flooding is observed in the Zhideli branch system which has the greatest water supply. In addition, delta areas in the lower reaches of the Naryn branch, in the systems of coastal lakes, and in the upper reaches of the Topar branch get submerged.

Hydrological parameters of the Ili delta will be determined by the mode of flow regulation at Kapchagay Reservoir and reservoirs located in China, by long-term climate changes and by hydro-engineering measures at the delta.

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MODERN PATTERNS OF SPACE-TIME TRANSFORMATION OF KOLYMA RIVER HYDROLOGICAL REGIME

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Kolyma is the main river of the East Siberian Sea. Its length is 2129 km, the basin area is 643000 km^2. However, the Kolyma River and its tributaries are the least studied rivers in Russia. The shortage of hydrological information increased in the 21st century, when the number of gauges in the Kolyma basin (measuring water flow) have decreased from 50 to 12. Gauges in the lower reaches and the mouth of the Kolyma, with measuring water discharges and turbidity, the suspended sediment load, were closed. In the Kolyma River Delta, water flow measurements are sporadic now.

At the same time, since the mid-1990s, the hydrological regime of the Kolyma River and its tributaries began to change due to increasing air temperature, mitigation of winter conditions, changes in precipitation regime, permafrost degradation, construction of the Kolymskoe and Ust-Srednekanskoe reservoirs, continuing large-scale mining. A notable increase in Kolyma water runoff (+14% in 1995-2015) is one of the major results of these processes. It is important to note that this increase covers all rivers of the Laptev Sea and the East Siberian sea. Their total water runoff has increased by 13%, the share of river inflow to the Arctic Ocean coming from the territory of the Russian Federation has increased from 37.7 to 39.2%. A significant decrease of water turbidity of the Kolyma River downstream the reservoirs (1.5-2 times) is the second result, while the opposite trend is recorded on unregulated rivers of the Kolyma basin. Water temperature increase during the warm season, changes in the winter ice regime and intensity of thermal abrasion of the banks is the third main result.

We record these and other large-scale changes due to a few stationary hydrological stations and data obtained by indirect methods. Results of long hydrological expedition of Moscow University to the mouth of the Kolyma river in the summer of 2019, new hydrological materials and remote sensing data open up new prospects for studying these and other reactions of the Kolyma flow and regime to hydro-climatic and water management changes in the region.

The reported study was funded by RFBR according to the research project №18-05-60021.

NATURAL FLOW MODELING OF THE VOLGA RIVER DURING ITS REGULATION

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Runoff formation model for the Volga River basin was developed using the ECOMAG software. Global databases of the underlying surface (DEM, soil, landuse) and monitoring network daily data at weather stations were the initial information for the model. Due to the regulated flow by the Volga-Kama cascade of reservoirs, the model was verified over multiyear period by comparing the observed and calculated daily discharges at the outlet gauging stations of the main tributaries of the Volga and Kama rivers with a catchment area of 18,500 to 244,000 km^2. This approach of spatial calibration of the hydrological model, in contrast to the calibration for each gauging station, allows, within the framework of a one runtime of model, to take into account the features of runoff formation in different parts of the basin. The total runoff of the Volga River was estimated as the inflow to the Kuibyshev reservoir (the largest in the Volga-Kama cascade system) with a total catchment area of almost 90% of the Volga basin. A quantitative assessment of the accuracy of river flow calculations was carried out using the NSE and BIAS criteria. As a result the developed model satisfactorily reproduces the daily flow in the Volga River basin. At the next stage, natural flow modeling of the Volga River during its regulation by the Volga-Kama cascade of reservoirs was carried out using data from a monitoring network at weather stations and meteorological reanalysis.

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FUTURE PROJECTIONS OF THE AMUR AND LENA RIVER RUNOFF

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According to calculations of regional models of runoff formation, developed on the basis of the ECOMAG software with global databases of the underlying surface and monitoring network data at weather stations, using data from an ensemble of general atmospheric and ocean circulation models (ISIMIP project), the change in the probability of formation of extreme high and low annual and seasonal runoff of the Amur and Lena rivers during the 21st century under various RCP scenarios is compared to the historical period. To assess the spatio-temporal variability of climatic and hydrological characteristics, maps of spatial distribution of average annual air temperature and precipitation, as well as average annual runoff rate, were constructed based on the calculation of runoff formation models for elementary catchments in the Amur and Lena basins in the middle and end of the 21st century. Hydrological models with a daily time step according to the GCMs data successfully reproduce the average annual and seasonal river runoff at the outlet gauging stations. Calculations of changes in the annual and seasonal runoff of the Amur and Lena rivers according to hydrological models for the 21st century were carried out with the same parameters that were calibrated for the historical period. Thus, only the natural response of the river system to possible climate changes was studied excluding flow regulation by hydraulic structures.

HYDROLOGICAL ELEMENTS QUANTITATIVE RELATIONSHIP BETWEEN DONGTING LAKE AND YANGTZE RIVER

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Dongting Lake is the second largest freshwater lake in China. The interaction between the Yangtze River and Dongting Lake is extremely complicated. Based on the measured hydrological data of controlling stations before and after the operation of reservoir group at the upper reaches of the Yangtze River, the transition water levels between fluviatile facies and lacustrine facies of Dongting Lake were analyzed. Based on the flood and dry water characteristics, the water level and discharge relationships between Dongting Lake and Yangtze River were quantified. The results show obvious phenomenon of lacustrine facies under high water level and fluviatile facies under low water level of Dongting Lake, the critical water level of fluviatile phase and lacustrine phase is 24m and 28m at Qilishan Station, respectively, and the water level range of 24~26m and 26~28m is the main area of fluviatile facies and lacustrine facies, respectively. The end time of lacustrine phase has been advanced and the critical water level has changed little after the water storage of upstream reservoirs. The relationship between the water level of Qilishan Station of Dongting Lake and the discharge of Luoshan Station of Yangtze River is rope-shaped, the difference between the rising and falling periods is large, and the loop discharge rating curve has increased since the upstream reservoirs were put into operation. The water level of East Dongting Lake is greatly affected by the Yangtze River, showing a linear relationship between them, and the water level of West and South Dongting Lake is less affected by the Yangtze River, showing a rope-case relationship between them. The research results can understand the connotation of river - lake relationship between Yangtze River and Dongting Lake, and provide scientific basis for the refined operation of upstream reservoirs of Yangtze River and governance of Dongting Lake.

Keywords: Quantitative relationship, Dongting Lake, Yangtze River, Fluviatile facies, Lacustrine facies

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EFFECT OF ROUGHNESS ON APPARENT SHEAR FORCE IN DIVERGING CHANNEL

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In rivers, error in estimation of discharge leads to huge loss of property and life. This error in estimation of discharge is due to neglecting turbulent flow structures such as helical secondary currents and momentum vortices between main channel and floodplain. In literature, numerous researches are carried out to estimate discharge in prismatic channels. However, river sections are non-prismatic and often behave as diverging channels in case of floods etc. In prismatic channels, researchers expressed shear force carried by floodplains (%Sfp) as an empirical equation obtained from regression analysis of flow parameters. But in case of non-prismatic channels, that shear force carried by sub sections is also affected by geometrical parameters as well as flow parameters. In case of rough bed flows, bed roughness also influences shear force carried by sub sections. In the current study, experiments are carried out in 14.57° diverging channel for both smooth bed (Perspex sheet) and rough bed (Gravel bed) for medium relative flow depth and apparent shear force is calculated by using force equilibrium between sub sections. From experimental results of both cases, apparent shear stress is calculated by dividing compound channel into sub sections by using Horizontal Division Method (HDM), Vertical Division Method (VDM). Effect of roughness on apparent shear force is evaluated and models available in literature for prediction of %Sfp are compared with experimental values and a new model is developed for non-prismatic channels.

A NUMERICAL HYDRODYNAMIC 2D MODEL OF THE AMUR AND ZEYA RIVERS AND THE AMUR LIMAN

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A numerical two-dimensional hydrodynamic model of the Amur River is built based on the stretch from Chernyaevo village (454 km upstream of the city of Blagoveshchensk) up to (and including) the Amur Liman of the Okhotsk Sea. The Zeya River from the Zeya hydroelectric dam to the confluence with the Amur River was also taken into account. The beginning of the model is located at a distance along the riverbed of approximately 2500 km from the mouth.

At the riverbed of the Amur River and its tributaries, predominantly quadrangular cells are used (the cells are elongated along the riverbed). Triangular cells are utilized at geometrically complex sections of the riverbed. An unstructured triangular mesh is applied at the floodplain. The model also takes into account flood control dams (more than 80), which are placed along the Amur riverbed and on its floodplain on the territory of the Russian Federation and especially in the part of the People's Republic of China. Additionally, the roads and railways that run along the Amur riverbed and cross its floodplain are included in the model.

As a result, about 2000 polygons are used in the computational domain. Each of them is discretized using triangular or quadrilateral cells. In total, the computational mesh of the Amur numerical model, taking into account the Amur Liman, contains more than 700000 cells.

As the initial data for describing the terrain, the model uses the WorldDEM4Ortho data of Airbus, which is based on the WorldDEM global dataset, created by interferometric processing of radar images by the TerraSAR-X and TanDEM-X spacecraft. The vertical accuracy of WorldDEM4Ortho is about four meters, and the pixel size is 24 meters.

For pilot calculations, hydrographs approximating the flood of 2013 are specified at the entrance boundaries along the Amur riverbed and the main tributaries. Sea levels are used at the boundaries of the Amur Liman. The maximum total discharge at the control line in Khabarovsk city is 43000 m^3/s.

The calculations are carried out using STREAM 2D CUDA software. The flow velocity, zones and depths of flooding are obtained for the entire computational domain.

The developed model is planned for the prediction and calculation of the Amur River flows in various hydrological conditions, taking into account releases from reservoirs.

IMPACT OF HPP ON THE HYDROLOGICAL REGIME OF LARGE RIVERS

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Hydroelectric power plants (HPP) on Russia's largest rivers, the Ob (Novosibirskaya) and the Yenisei (Sayano-Shushenskaya and Krasnoyarskaya), have changed their hydrological regime. The spring water flow below the HPP has decreased: below the Novosibirskaya by 6%, below the Sayano-Shushenskaya by 1.4 times and below the Krasnoyarskaya by 1.8 times. Winter water flow increased by 6 %, 2.7 and 5 times, respectively; suspended sediment load decreased by 3.5, 8.5 and more than 20 times.

As a result of HPP operation, the boundary of affluent moves along the length of the river, forming a zone of variable affluent. From 39 to 60% of the sediment load is deposited in this zone, spreading regressively up the river. In the Ob, the process of regressive accumulation of sediment continues. Downstream side of the weir is characterized by an unsteady flow regime caused by HPP release waves. On the rivers with boulder-pebble alluvium (Yenisei) the wave manifestation is more significant than on the rivers with sandy alluvium (Ob). At the Novosibirsk Reservoir in the upper part of the variable affluent zone, horizontal deformations have changed little, and the channel is still meandering. In the lower part, due to the formation of the recession curve, there was erosion and dredging of the channel already in the first decade. Later on, there was a concentration of flow in one branch, silting-up of side branches, joining of islands into large massifs. Variable affluent of the Yenisei from the Krasnoyarsk reservoir has almost no effect on channel deformations; no morphological signs of direct accumulation have been detected in the zone of variable affluent. Variable affluent stimulates shallowing of shoals, without affecting long-term reformation.

Reduced sediment flow leads to a bottom entrainment and lower water levels. Below the dam, a system of erosion and accumulation waves is formed. Below the Krasnoyarskaya HPP, a wave of erosion has led to a decrease in the area of riverside shoals and in the width of gravel banks. Below Sayano-Shushenskaya HPP the wave of transgressive erosion has led to deepening of ridges of all shoals.

RELATIONSHIP BETWEEN HYDROLOGICAL VARIABILITY AND CLIMATIC FLUCTUATIONS IN THE CHELLIF BASIN - NORTHWEST ALGERIA

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The Cheliff basin is drained by the Cheliff wadi and its tributaries over a surface area of 43 750 km². The Cheliff wadi is one of the main wadis of the Maghreb. It flows over a length of 700 km.

The main objective of this work is to determine and quantify the relationships between hydroclimatic variability and climate fluctuations at the scale of the Cheliff basin and its main sub-basins, using spectral analysis methods adapted to the study of non-stationary processes (continuous wavelet analysis, wavelet coherence analysis). Several modes of variability are identified from the analysis by station (rainfall and flow), annual, interannual and decennial cycle. Frequencies of 1 year, 2 years, 2-4 years, 4-8 years and 8-16 years were identified, over different periods at the level of each sub-basin, thus allowing a decomposition of the spatial variability of the signals highlighted by the wavelet method. Three main discontinuities are identified in 1970, 1980 and 1990 for rainfall and three discontinuities in 1970, 1986 and 2000 are identified for discharge.

A very high consistency between the variability of flow and rainfall in the Cheliff basin ranging from 72% to 85%.

The results indicate that the dominant climatic indices on the modes of variability of precipitation, at the level of the study basins, are NAO, WeMOi, and the dominant climatic indices on the modes of variability of flows are NAO and SOI for the Cheliff basin.

Keywords: Cheliff basin; hydrological variability; climate fluctuations; continuous wavelet analysis; wavelet coherence; climate indices

THE VOLGA AND THE DON WATER FLOW IN WARM CLIMATIC EPOCHS

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The features of the Volga and the Don water flow changes during the Holocene Optimum and scenario conditions of global climate warming in the current century have been revealed. Paleoclimatic reconstructions based on data of spore and pollen analysis of fossil plants and results of calculations carried out on the ensemble of global climate models of PMIP-II program, as well as scenarios of climate warming, performed on an ensemble of global climate models of CMIP3 and CMIP5 programs, have been used. Hydrological changes have been evaluated on the basis of the monthly water balance model (Georgiadi & Milyukova, 2002). Scenario air temperature in the Volga and Don basins, typical for the first third of the current century, being the closest to the temperature of the Holocene optimum, have been reconstructed on the basis of palynological data. At the same time, the simulated annual flow of the Volga and Don was lower than the modern one. This result is consistent with the estimates of the water flow obtained earlier for the Volga on the basis of zonal dependencies of annual flow, and with the results of the reconstruction of water flow based on paleomeander characteristics. At projected and the Holocene Optimum climatic conditions reconstructed within PMIP-II, it appears above modern (on the Volga) or almost does not differ from it (on the Don). In the scenario projection for the first third and the middle of the current century, the annual flow of the Volga is likely to increase as the climate warms, while the flow of the Don is likely to remain unchanged. The most noticeable differences in the Volga and Don flow in warm climate of the Holocene optimum, modern and scenario periods are manifested in changes in the intra-annual distribution of their water flow.

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TRANSFORMATION OF THE LOWER DON RUNOFF

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Lower Don is an economically developed area. Water supply is an important problem here. Climate change causes hydrological changes and ecosystem change. As a result, formed ecosystem representing less valuable in economic terms, low productivity. Global climate changes in the south part of Russia is reflected in the warming of the winter period and an increase in the amount of precipitation during the cold season.

This paper analyzes the changes in meteorological conditions in Rostov region and its influence on water regime of the Lower Don. The main flow (60 - 65%) formed by meltwater in the spring, 25-30% - through underground supply and 3-5% at the expense of atmospheric precipitation.

River is characterized by high and long spring flood. In natural conditions, it accounts for about 70% of annual runoff. Tsimlyansk reservoir smoothed seasonal distribution of runoff. Until 1952, spring floods accounted for 78% of runoff and 22% for the rest of the year. After the launch of the reservoir, the situation changed. Only 47% the flow of the river falls in the spring.

The rivers of the Don basin are now experiencing a decrease in spring runoff. At the same time, there is an increase in summer, autumn and winter runoff in comparison with the period of climatic norm.

Analysis of the annual distribution of runoff led to the allocation of two periods: before the construction of the Tsimlyansk reservoir and after the start of operation. Since 2007, there has been a constant decrease in the water content of the river, which lasted until 2016, the low-water regime.

ROLE OF SNOW COVER PROPERTIES FOR ICE FREEZING ON WATERSHEDS

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Ice blockage happens on the rivers because of their latitudinal extent, nonsimultaneous debacle and filling of the river's cross-section with ice. Determining factor of ice blockage formation is the ice thickness on the watercourse in the end of winter season. This ice thickness can be determined by the thermal regime of winter season and peculiarities of snow cover accumulation regime. Ice blockage events are typical for the rivers where the debacle happens as destruction of relatively firm ice cover by the steam force and where it takes place when the flood starts from the upper part of the basin. This is in particular possible for such large rivers, flowing from south to north, as Lena, Yenisei, Irtysh, Pechora, and North Dvina. In our case calculating scheme for ice thickness is constructed on basis of two-layer media heat conductivity problem (snow cover, ice) with phase transition on the boundary of ice and unfrozen water. Heat balance equation includes phase transition energy, inflow of heat from unfrozen water and outflow through the ice and snow cover to the atmosphere. The heat flux was calculated on basis of Fourier law as a product of heat conductivity and temperature gradient. It was supposed, that temperature changes in each media linearly. For snow cover and ice the formula of heat conductivity of two-layer media was used. It was also supposed, that snow cover consists of different layers, deposited by different snowfalls and having different structure, density and heat conductivity, depending on its density. The density and heat conductivity of each layer and the whole thickness of snow cover are determined on basis of meteorological information on air temperature, precipitation, snow thickness and snowfall's intensity at the nearest meteorological station. The regional stratigraphic column of snow cover is compiled on basis of this information and the calculation of ice growth intensity on the watercourse is performed then more precisely.

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APPLICATION OF THE LSM SWAP FOR HYDROLOGICAL SIMULATIONS AND PROJECTIONS

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The work is aimed at the solution of the topical problem of modeling the formation of the water balance components of large river basins located on different continents of the globe. The main tool used for the solution of the problem is a model complex which combines the Land Surface Model (LSM) SWAP (Soil Water – Atmosphere – Plants) with data sets on the land surface parameters and meteorological forcing data derived from in situ observations or simulated by Atmosphere – Ocean Global Climate Models (AOGCMs). The SWAP model was widely validated, in particular, when participating in a number of international projects related to modeling water and thermal regimes of various experimental sites and river basins on a local, regional, and global scale.

In this work, the model SWAP was used for simulating and projecting the dynamics of various hydrological characteristics of medium and large sized (often exceeding 10^6 km^2) river basins of the globe including 11 river basins located on different continents and 15 northern basins of the Russian Federation. The quality of the historical simulations was verified against measured daily and monthly river runoff, as well as snow characteristics (snow water equivalent and snow depth).

For projecting changes in hydrological characteristics caused by possible climate change in the 21st century, the fields of meteorological forcing data simulated by different AOGCMs for different global climatic scenarios of the SRES and RCP families were used. In so doing the results of the AOGCMs simulations were subjected to post-processing bias correction. The described technique was used for hydrological projections (including changes in the water balance components, extreme values of annual runoff, snowpack, etc.) for the aforementioned basins. Possible changes in climatic runoff were compared with the amplitude of natural variations of runoff caused by weather noise.

WATER BALANCE CHANGES IN THE WESTERN DVINA RIVER BASIN

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In this research authors focus on the runoff and water balance changes analysis in the Western Dvina River basin. The main attention is paid to the Russian and Belarussian parts of the basin. The hydrological model SWAT (Soil and Water Assessment Tool) is used as a research tool. The results of model setup, parameters sensitivity analysis, calibration and validation are the set of quantitative values of the sensitive parameters, monthly and daily river runoff and water balance components – first-step investigation is represented in [1]. Calibrated model allows to estimate spatial and temporal change of water balance components and river runoff. Spatial analysis of the distribution of water balance components revealed that high evaporation values are typical for sub-basins where lakes and wetlands prevail. Lower ground flow is typical in areas with a predominance of clay soils. According to popular climate change projections main runoff generation processes, such as snow melting and spring flood forming, are slightly shifted to earlier periods during the year. Snowmelt water yield redistribution and increased summer evapotranspiration leads to rather stable state of water yield in summer despite of general increase of precipitation in near and far future. Following the temperature changes and precipitation redistribution surface runoff and lateral runoff are expected to increase during the winter months.

[1] Terskii P., Kuleshov A., Chalov S., Terskaia A., Karthe D., Belyakova P. & Pluntke T. (2019). Assessment of Water Balance for Russian Subcatchment of Western Dvina River Using SWAT Model. Frontiers in Earth Science, 7, 241. DOI: 10.3389/feart.2019.00241

HYDROLOGICAL REGIME OF THE LOWER OB RIVER UNDER MODERN CONDITION

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The Ob is the main river of Western Siberia, one of the most dynamically developing regions of Russia. Among the various factors of the economic development of this region a special place is occupied by river flow. Changes in the flow of water, sediments, and heat determine the hydrological regime of the Ob Bay and the southern part of the Kara Sea. A detailed analysis of the hydrological observations allowed us to highlight the observed changes in the hydrological regime. The periods before 1975 and after were compared.

The water regime of the lower reaches of the Ob River is characterized by a spring-summer flood, a short full-flowing autumn period and a stable winter low-flow period. The average annual water flow to the Ob Bay is 411 km^3/year. Most of the annual sediment runoff (85%) takes place between May and August. The average duration of the positive water temperatures period is 153 days. The appearance of ice is observed on average on October 20-25. By the end of the ice-cover period, the ice thickness reaches 80-100 cm. Spring ice runs were observed in the second decade of May, and its duration is 3-5 days.

The current change in the hydrological regime of the Lower Ob River is the result of climatic and anthropogenic factors. The change in the seasonal runoff after 1975 is expressed in a significant decrease in spring-summer flood runoff and an increase in winter runoff. Change in the thermal regime is manifested in the increase in water temperature for May-July from the beginning of the 2000s. The reduction in the duration of the ice-cover period is observed and occurs primarily due to the shift in the timing of the appearance of ice and breakup.

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CORRECTION METHOD OF REANALYSIS WIND FIELD IN ESTUARINE AREAS

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Wind is an important dynamic element in estuaries, and accurate wind field data is the key to improving the accuracy of storm surge simulation in estuaries, which is of great significance to study the dynamic processes in estuarine and coastal areas and to guarantee the safety of human engineering. In this paper, we proposed a linear correction method for different wind directions based on the measured wind data and ECMWF reanalysis wind field data. The results show that the ECMWF wind speed is higher when the wind speed is small and lower when the wind speed is large, and the phenomenon of "flattening" exists. The accuracy of reanalysis wind speed and wind direction is improved after the correction proposed in this paper. Based on Delft3D, a two-dimensional hydrodynamic model of the Yangtze estuary was established, and the modified wind field was used to simulate the tide level in the Yangtze estuary during cold tide and typhoon, and the accuracy of the model, especially the simulation accuracy of storm tide level during typhoon, was significantly improved, and the error of high tide level was reduced by 16-19 cm.

DECLINING WATER RESOURCES IN WESTERN MEDITERRANEAN ASSOCIATED WITH CLIMATIC CHANGES

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In the Mediterranean, climate change and human pressures are expected to significantly impact the availability of surface water resources. In order to quantify these impacts during the last 60 years (1959-2018), we examined the hydro-climatic and land use change evolutions in six coastal river basins of the Gulf of Lions drainage basins (NW Mediterranean Sea) in southern France. In agreement with future modelling scenarios for the Mediterranean in general, the study region already depicted clear warming trends during the recent past (+1.6 °C on average), weak decreasing trends for precipitation and strong decreasing trends for water discharge (-30% to -45% depending on catchments). Our results clearly demonstrate that despite important anthropogenic water withdrawals for irrigation in some of the catchments, climate change is obviously the major driver for the detected reduction of water discharge. A simple statistical regression model based on only two climatic indices can explain 78%-88% of the variability of annual water discharge in the study catchments. It also closely reproduces the long term trends. Land use changes are dominated by the decline of agricultural activities and anthropogenic pressures on water resources rather decreased. The climatic indices we used in our statistical models can be determined by monthly temperature and precipitation data and might therefore be considered as robust estimators also for future climate change impact studies. They furthermore allow estimating the respective contributions of temperature and of precipitation in the detected changes. According to our results, temperature increase alone should therefore be responsible for an almost 25% reduction of surface water resources during the last 60 years in our study region.

RATING CURVES WITH A CLOSING WATER BALANCE IN THE BIFURCATING RHINE RIVER IN THE NETHERLANDS

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Accurate estimates of discharges in rivers are crucial for flood risk management. Rating curves are often used to obtain discharge estimates from water level measurements. In a bifurcating river, accurate estimates of the discharge distribution over distributaries is particularly important, because the discharge dominates the downstream water levels and thus the flood risk. Single-channel rating curves at two major bifurcations of the Rhine River in the Netherlands show water balance errors up to 5%, which amounts to several hundreds of cubic meters per second discharge at design conditions of around 16,000 m^3/s. Introducing an additional physical constraint that rating curves at bifurcations must have a closed water balance may reduce this error. The aim of the study was to reduce the water balance error in discharge estimates by constructing rating curves with improved water balance closure at the Rhine bifurcations. ADCP discharge measurements are available for a 31-year period for each branch at these two bifurcations. A probabilistic rating curve model was set up, whose parameters are estimated through Bayesian inference and Markov Chain Monte Carlo sampling. In this new model, water balance closure is explicitly accounted for. Therefore, interdependency is introduced in the rating curves parameters of the various branches. Water balance errors are strongly reduced to under 0.5%, while rating curve accuracy is maintained as residual errors only marginally increase. The rating curves constructed with this model have narrower credibility intervals in the high discharge domain because of the additional water balance constraint. Furthermore, these rating curves are only slightly sensitive to individual measurements in the high discharge domain, such that measurement uncertainties of the measurements in this domain have little influence on the rating curve results. These new constrained probabilistic rating curve models are applicable for hydraulic and hydrologic model calibration, flood frequency analyses and flood forecasting.

EVALUATION OF DEMS ON GIUH-NASH MODEL-BASED DIRECT SURFACE RUNOFF PREDICTION

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Digital Elevation Models (DEMs) are extensively used in hydrological modelling and deriving the geomorphological properties of catchments. Recently, hydrologists have shown interest in researching the effects of DEMs from different sources on simulated outputs. As part of these efforts, this study aims at evaluating the effects of different DEM and algorithm selection on geomorphologic instantaneous unit hydrographs (GIUH)-Nash model-based direct surface runoff (DSRO) predictions on an Eritrean catchment. Four open-source DEMs and two Quantum Geographic Information System (QGIS) algorithms (GRASS and SAGA) are applied and corresponding outputs are calibrated using five observed events. The two algorithms resulted in drainage networks of similar stream orders. The SAGA algorithm produced smaller lengths of the highest orders from the three 30 m resolution DEM-scenarios than the GRASS algorithm, leading to low values of length ratios. The objective fit functions and statistical indices indicated that the performance of the model by this approach is unsatisfactory. The vast majority of corresponding Nash-Sutcliffe efficiency (NSE) values are less than 0 that indicate the mean observed values are better predictors than predicted values. On the other hand, the results of the GRASS algorithm-based GIUH-Nash model indicated acceptable performance of the model for all the DEM-scenarios, irrespective of their sources and resolutions with NSE and special correlation coefficient (SC) greater than 0.507 and 0.843, respectively. The study concluded that DEM selection has little impact on the GIUH-Nash model based DSRO predictions and can be used indiscriminately. But, great care should still be taken while selecting stream network generating algorithms, especially for catchments whose outlets are located near the confluence of two major rivers.

In order to take a broad view of the findings of this study and promote the use of effective and appropriate runoff prediction approaches in ungauged catchments, future investigations should be undertaken in conjunction with available reference information systems. These investigations will include the GIUH-Nash model applicability and reliability in different agro-ecological zones, comparison of the selected model performance with other conventional and contemporary models and effects of DEM source and resolution and stream networks generating algorithm selection on the performance of various models in different catchments in the territory of Eritrea.

Poster Session A

"River Pollution, Ecology & Restoration"

DIFFUSE BIOGENS FLOW FROM THE CATCHMENT TO THE CHEBOKSARY RESERVOIR

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After the 1990 the water use in Russia has decreased significantly (up to 30%). Though, significant improvement in the surface water quality, especially in the basin of Volga the main Russian river, has not happened. Unsatisfactory water quality in the Volga basin seems to be a result of uncontrolled nonpoint (or diffuse) pollution from catchments as it is assumed in the national project "Enhancement of the Volga River".

Diffuse pollution means removal of dissolved and suspended pollutants from non point sources (agricultural lands, settlements without central sewage system, landfills, industrial sites) with slope and underground runoff.

High level of inorganic nitrogen and phosphorus is one of the main factors of eutrophication and algal water blooming. This study is aimed to estimate the diffuse flow of biogens by tributaries to Cheboksary Reservoir (local watershed area 135000 km^2, water surface area is 1080 km^2). The landscape-hydrological method was used to estimate the average long-term biogen diffuse flow from the reservoir catchment. The method considers catchment landscape structure (forest, agricultural lands, rural and urban areas, ravine network); anthropogenic load (mineral and organic fertilizer application, human biowaste). The effect of the nutrients retention depending on the catchment area and the volume of water flow is taken into account in calculations. The diffuse flow of biogens by surface, soil and underground runoff is calculated for the spring flood and the whole year.

Due to natural and anthropogenic factors the average long-term diffuse biogens flow of nitrogen is 20500 tons and of phosphorus is 900 tons both in mineral form. Underground and perched runoff plays significant role in nutrients removal.

The study completed according to the state assignment № 0148-2019-0007.

THE ENVIRONMENTAL RISK FOR THE ECOSYSTEM OF THE YENISEI RIVER

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The long-term monitoring of the state of the fresh-water ecosystem of the river Yenisei revealed the statistically reliable content of heavy metals (Fe, Zn, Cd, Cu, U etc.) in the water, bottom sediments, phyto- and zooplankton, and muscle mass of commercial fish consuming different types of food (benthos eaters, predators and herbivorous fish). The values of the indices of the ecological state of the Yenisei river were estimated to vary from 2.38 to 2.85 in the areas under study. A conclusion was made that the studied transects of the river Yenisei had a good ecological potential with a moderate level of ecological risks. The total index of risk for the water, taking into account the reference doses, amounts to 0.16 for the water, and to 0.47 for the flesh of commercial fish. The total index of risk for the population consuming fresh water and fish from the Yenisei river amounts to IR=0.63. The obtained value of the index is, in general, of no danger for the population health. Since the cancerogenic substances were not accurately revealed, we estimated non-cancerogenic nonthreshold risks. The non-cancerogenic nonthreshold risks for particular substances under consideration did not exceed the allowable level of 0.05 and were equal to 0.017. The estimation revealed that the ratio of developing reflectory-olfactory effects to the allowable value was equal to 0.01, and the ratio of the total noncancerogenic risk to the allowable level was 0.34. Here, the integrated indictor was 0.35, which did not exceed the regulatory level (II≤1). In general, the risks with regard to all the indicators analyzed did not exceed the allowable levels and did not require additional measures of regulating the water quality.

OXYGEN REGIME OF THE RIVERS OF EUROPEAN RUSSIA

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It is usually believed that there is a high amount dissolved oxygen in rivers, as it comes to water from the atmosphere and is generated by algae during photosynthesis. However, our studies of many rivers in the European territory of Russia (ETR) have shown that river waters are undersaturated with oxygen. The reason is a large amount of organic matter in rivers which come from the river catchment. Bacteria consume dissolved oxygen during organic matter decomposition processes.

Analysis of data collected by ROSHYDROMET during many years for rivers of Kuban, Terek, Don, Volga, Pechora, and Severnaya Dvina catchments (about 400 sites,1988-2011) has shown that the oxygen regime of rivers changes considerably from the South to the North. The average oxygen content decreases, its yearly amplitude and the winter deficit grows (expressed in saturation percentage).

The orographic factor makes a significant contribution to the spatial distribution of oxygen in rivers: less slope provides slower flow in river and lower of saturation of water with oxygen from air. Very important is the duration of the ice cover period, varying from 7 months in the North to 0 days in the South. In the ice cover period, oxygen exchange between water and air stops, usually there is no photosynthetic aeration of water; however, bacteria continue to consume oxygen.

The content of organic matter in water naturally increases from the South to the North in ETR. This is caused by increasing of specific discharge washing out organic matter from soils. It changes from 1 $l/s*km^2$ for Don to 10 $l/s*km^2$ for Severnaya Dvina. With an increase in the concentration of organic matter in water, its decomposition by bacteria increases and more oxygen is consumed.

Thus, the geographic conditions are important for the oxygen regime of the ETR rivers.

DANUBE WATER QUALITY DYNAMICS: REVIEW OF WEB OF SCIENCE ARTICLES

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The Danube is the EU's longest river and Europe's second longest, following the Volga. The Danube River Basin (DRB), totaling over 801,463 km^2 and covering 10% of Continental Europe, is the most culturally diverse worldwide, as it spans across 19 countries, is home to more than 81 million people of various ethnicities, and plays a crucial role in the continent's socioeconomic, political and cultural life. In the past half century, the wide range of industrial, urban development, agricultural and hydrotechnical activities intensified the anthropogenic pressure on the Danube and this resulted in noticeable changes in water quality. This review aims to conduct an assessment of Danube water quality dynamics over the past decades. Keywords and specific search filters were used on the Web of Science platform; out of the 124 open access articles initially available, a scientific bank of 33 relevant studies was obtained and thoroughly analysed. The main conclusions of the review are as follows: starting with the early 1970s, the Danube water regime has undergone various changes due to the construction of water reservoirs, dams and hydropower plants. From 1960 to 1990, nitrogen discharge into the Danube basin increased fivefold, whereas phosphate concentrations doubled due to growing anthropogenic inputs. Most recently, a decline in nutrient loads was noticed, which is the result of the numerous political, economic and water quality management measures that were implemented in European states. Although the Danube water quality currently has an overall upward trend, the river still shows signs of degradation downstream of major urban centers and in some of its main tributaries, due to discharges of untreated or poorly treated wastewater. Moreover, a series of studies have identified specific areas that are polluted with substances classified as European Water Framework Directive priorities and newly emerging contaminants, and this requires urgent measures.

GEOLOGICAL STATE OF THE OSETR RIVER BASIN

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This paper presents the results of geoecological assessment of anthropogenic impact on the components of the geosystems of the Osetr river in the course of work on the Osetr river of the Moscow region in the inter-war period from 2017 to 2018. To assess the quality of surface water, hydrochemical studies were conducted, which included the determination of such values as: pH, water temperature, amount of dissolved oxygen (O_2), electrical conductivity, degree of mineralization, COD, BOD_5, etc. As part of the environmental monitoring, a reconnaissance survey of the dam in the settlement of Zaraysk was conducted, during which the main environmental indicators were determined, an assessment was made on radiation, chemical, sanitary-epidemiological and physical factors of environmental risk.

The result was geoecological zoning of the middle part of the Osetr river basin on the level of contamination of the pond (WPI, SCWPI), on the proportion of anthropogenic impact and degree of anthropogenic load (the point-rating method), highlighting 5 areas of the riverbed with anthropogenic pressures and ecosystem conditions:

- according to the water pollution index (WPI), the water of the Osetr river is estimated as "moderately polluted" (WPI =1.0-2.5) from the sett. Zaraysk to the confluence of the Oka (49.2 km) and is replaced by "dirty" (WPI =4.0-6.0) to the sett. Akatyevo (2.09 km);

- the degree of water pollution (SCWPI) of the Osetr river in the selected areas is characterized as" high" due to the violation of existing standards for 5 ingredients.

Anthropogenic pressures (for example, the settlement of Zaraysk and the adjacent industrial zone) have a strong impact on the ecological state of the Osetr basin. This is the influence of the chemical, food, metallurgical industries and hydraulic engineering. The studied sections of the Osetr and Oka rivers are characterized by an average anthropogenic load with a total score of 20 to 22, which is mainly associated with the use of water resources for agricultural, household purposes, as well as the lack of organized wastewater discharge. Based on these results, forecast of the possible changes of the environment under influence of anthropogenic load and recovery programs and the protection of small and medium rivers, developed a package of measures to solve environmental problems of the Osetr river basin to prevent, minimize or eliminate harmful and undesirable environmental and social related, economic and other consequences and maintain optimum conditions of life of the population.

CHEMICAL INDICATORS OF WATER QUALITY IN PYASINO RIVER SYSTEM AFTER DIESEL FUEL SPILL AT NORILSK THERMAL POWER PLANT IN 2020

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The Pyasina is a river in Krasnoyarsk Krai, Russia. The river is 818 km long, and its basin covers 182,000 km^2. The Pyasina originates in Lake Pyasino and flows into the Pyasino Gulf of the Kara Sea. The Norilsk diesel oil spill is an ongoing industrial disaster in the Pyasina River basin. It began on 29 May 2020 when a fuel storage tank at Norilsk-Taimyr Energy's Thermal Power Plant No. 3 (owned by Nornickel) failed, flooding local rivers with up to 21,000 tonnes of diesel oil. In August 2020, the hydrochemical indicators of water bodies in this region were studied. Pollution of watercourses in the catchment of Lake Pyasino (creek nameless, R. Daldykan, R. Ambarnaya) by oil products, phenols, easily oxidizable and hard to oxidize organic matter (COD, PO and BOD5), suspended solids, inorganic salts and heavy metals with excess in MPS (including for fishery) as well as a temperature rise in waters of nameless creek nearby Thermal Power Plant were revealed. Contamination of the surface water decreases downstream in ascending order: nameless creek – Daldykan – Ambarnaya. The occurrence of petrochemical products, phenols and organic substances in the surface waters in two months after that spill is obviously due to their diffusion from the river bottom sediments, which accumulated a considerable amount of heavy fractions of diesel fuel after the accident. Increased concentrations of Ca, Cu, Zn, Mn, Co and Ni in waters of investigated tributaries of Lake Pyasino are not directly related to the accident; it results from the general technogeneous pollution of the territory and the increased geochemical background for the elements considered. Water contamination by oil products and phenols in the studied sections of Lake Pyasino (its central and northern parts) and R. Pyasina was not detected. However, concentrations of Pb exceeded MPS and Cd was present in the water, probably, due to accumulated pollutants in previous years.

SOURCES OF NUTRIENT POLLUTION IN THE CHEBOKSARY RESERVOIR

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The Cheboksary Reservoir is one of the most euthrophic artificial lakes of the Volga River system. The great difference in chemical and physical parameters of the reservoir's two main tributaries – rivers Volga and Oka – and their slow rate of lateral mixing creates high spatial variability in the lake's ecological characteristics. While most of the Volga's nutrients are assimilated in upstream reservoirs, Oka becomes the major source of nitrogen and phosphorus into the Cheboksary Reservoir due to intensive agricultural, industrial and residential development of its watershed. The Oka River also carries the nutrient pollution of the Moskva River into the Volga system.

In this study we summarize the data of our extensive field studies on the water chemistry of the Cheboksary Reservoir and its tributaries during summer of 2017-2019. We were able to point out the localization and nature of the major nutrient pollution sources in the Moskva River system, which is shown to contribute to a significant share of total nutrient input into the lake. Some of the smaller tributaries also have very high nitrogen and phosphorus content and may contribute to the eutrophication of the Cheboksary Reservoir and downstream Volga.

The results also show how the water quality of the reservoir and its tributaries varies with different volumes of water inflow. Nutrient concentrations increase in the polluted rivers during low flow periods, which may cause further damage to the Volga ecosystem.

MICROPARTICLE CONTRIBUTION TO ELEMENT TRANSPORT IN MAJOR RIVER SYSTEMS OF RUSSIA: OVERVIEW AND ANALYSIS OF VARIATION

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Distribution and dynamics of microparticles (< 10 μm) in river sediments has been rapidly gaining attention in recent years due to their important role in pollutant transport. However, despite modern advances in analytical techniques, most geochemical studies focus on airborne microparticles, while their behavior in rivers remains mostly insufficiently researched.

In the past 4 years, we have developed a novel approach to microparticle research in river sediment and collected a unique dataset on distribution and elemental composition of various size fractions of suspended sediment – including PM1 and PM10 fractions – for several major river systems in different parts of Russia. The watersheds covered by the scope of this project differ significantly in both landscape and land-use conditions and include some of the largest river systems in the world – Lena, Ob', Volga, Kolyma – as well as watersheds of great importance on national scale, such as Oka, Selenga and Terek rivers.

Our preliminary analysis shows great variation in relative contribution of PM1 and PM10 particles in riverine transport of heavy metals, including those identified as key pollutants in some of the rivers, which can be cross-referenced with mineralogical composition and origin of river sediment in each of the watersheds. While microelement concentrations in ultrafine particles were revealed to very often exceed net concentrations in sediment, their contribution to total element content depended on particle size distribution and overall chemical composition of water and sediment. In some of the rivers (e.g. Lena, Ob'), PM10 fraction contributed to more than half of total content of some elements (V, Pb, Cd, Ni, Li and many more) in suspended sediment, depending on particle size distribution and overall chemical composition of water and sediment.

MERCURY BEHAVIOR ON BOUNDARY OF NATURAL ENVIRONMENTS IN RIVERS ESTUARIES

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The purpose of the report is to study aquatic ecosystem as an arena of mercury mass transfer. The high significance of the study is due to the fact that bottom sediments are characterized as a quasi-open component of the aquatic landscape to exchange with the water column, which can lead to secondary pollution of the water column when hydrological and biogeochemical conditions change at the interface "water-bottom sediments". The research of the mercury behavior at the interface of environment is shown by the example of the water landscapes of the estuaries of two major waterways of the European territory of Russia-the Don and the Northern Dvina Rivers. A common indicator is that both rivers flow into the bay (the Taganrog and the Dvinsky Bays). However, the mouth of the Don River isn`t tidal, and the mouth of the Northern Dvina River is tidal. Those rivers are in different climatic hydrological, hydrochemical and biological conditions, they differ in the structure and level of anthropogenic pressure that they experience. Therefore, generalization, analysis and comparison of mercury distribution and behavior at the interface of environment in the estuaries of the Don and Northern Dvina Rivers are of great practical and scientific interest. The authors have the results of extensive and long-term comprehensive studies of the estuaries of those rivers to achieve the goal. According to the type of prevailing geochemical conditions and the level of anthropogenic impact at the study sites, the authors identified a number of conditions, which is characterized by pH, Eh levels and CH_4, H_2S, Hg contents.

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HYDROCHEMISTRY RESEARCH OF DOWNSTREAM OF AMUR RIVER AND AMUR LIMAN

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The Amur River has basin area equaled 1856 000 km^2 that is 10th rank within largest river of the world. The Amur River at its inflow with the Tatar Strait forms of inner part of estuary - the Amur Liman. Sakhalin Island isolates Amur Liman from the Sea of Okhotsk and the Sea of Japan, connecting it with seas by shallow and narrow straits.

In this study we use data of CTD sounding and hydrochemical analysis collected on June 14-20, 2005 and June 5-20, 2006 in downstream of Amur River and Amur Liman. Samples of surface and bottom waters were measured on following parameters: pH, total alkalinity (TA), dissolved oxygen, nutrients (P, Si, NO_2^-, NO_3^-, NH_4^+), humic substances (HS), chlorophyll *a*. Using pH and TA data, pCO_2 and dissolved inorganic carbon (DIC) were calculated.

Table 1. Fluxes of biogenic substances, humic matter, and dissolved inorganic carbon (DIC).

	Flow rate, m^3/s	P, t/day	Si, t/day	NO_2^-, t/day	NO_3^-, t/day	NH_4^+, t/day	DIC t/day	Hum, t/day
June 2005	20 805	28.41	3952	–	270	–	6022	10884
June 2006	12 854	18	1847	2.5	95	44	4409	5754

Both expeditions were carried out in June however discharges of the river were significantly different. The discharges of the river during surveys were 20,805 and 12,854 m^3/s, in 2005 and 2006, respectively. Daily fluxes of nutrients, HS and DIC supplied into Amur Liman by the River increase in accordance with the increasing of the river discharge. Despite on high chlorophyll a concentrations, the river water was a source of carbon dioxide in the atmosphere, which means that rates of mineralization of allochthonous and aoutochtonus organic matter are higher than primary production. Due to the high microbiological activity, Amur Liman is also a source of carbon dioxide in the atmosphere. This part of the estuary can be considered as a heterotrophic basin. The outer area of the Amur Liman in the Sakhalin Bay on the North and Tatar Strait in the South is major sink for atmospheric carbon dioxide, due to intensive photosynthesis. The outer area of the Amur Liman can be considered as an autotrophic basin.

CHARACTERISTICS OF MACROINVERTEBRATE ASSEMBLAGES IN ALPINE HEADWATER STREAMS

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The INTERREG project ALFFA provides a "Holistic multiscale analyses of the factors and their effects on the fish fauna in inner-Alpine Space". Therein the work package "macroinvertebrates" constitutes a link between river morphology and abiotic characteristics towards the fish population.

The Alps are a sensible ecoregion, which experiences different anthropogenic impacts and stressors. Our 81 sampling points (between 1800 and 219 m) across 22 subcatchments are located in the alpine area of Austria and Italy, namely in the region of Tyrol. All samples are from headwater tributaries of the Danube (Inn, Lech and Drava River catchment) and Adige (Puni, Saldur and Ahr catchment), which are contributing to the development of large European river systems. The Inn River (518 km) is the 3rd *largest tributary of the Danube* by discharge, and the 7th longest. Adige River (415 km) is among the biggest Italian rivers, i.e. it constitutes the 2nd longest river and has the 3rd largest catchment area.

Sampling was carried out in early spring 2018, using a multi-habitat-sampling method. Overall, we identified 407 taxa, including several new species to the region. Our data also reveals clear differences between upper and lower courses (high vs. low altitudes) as well as regional preferences. For all locations traits were analyzed (functional feeding types) and the relevant biological indices (diversity, saproby, longitudinal zonation) were calculated. Based on the macroinvertebrate assemblages we also analyze the bonity of the water courses, i.e. biomass of macro-invertebrates as food source for fish.

This study reveals the functional characteristics of benthic invertebrates along an altitudinal gradient and supports the analyses of anthropogenic stressors. Our case study highlights the importance of the biological quality element macroinvertebrates for the analyses of the ecological status of water bodies and the comparison of different catchments.

IMPACT OF RIPARIAN FOREST ON EPTS DISPERSION ACROSS EUROPEAN BIOGEOGRAPHICAL REGIONS

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Ephemeroptera, Plecoptera and Trichoptera (EPTs) are three orders of aquatic macroinvertebrates with a similar life-cycle: they live in aquatic freshwater ecosystems until they disperse by flying upstream. The aerial dispersion depends on the landscape connectivity, with landscape features influencing it, as topography in mountainous areas (Chiu et al. 2021) or permanent pools in temporal rivers (Cañedo-Argüelles et al. 2015).

Riparian vegetation can also influence the landscape connectivity for EPTs. For example, deciduous forest can facilitate the dispersion of weak flyers (Peredo Arce et al. unpublished) while coniferous forests are known to act as a dispersion barrier for aquatic macroinvertebrates (Hering et al. 1993). The impact of riparian forest on landscape connectivity can generate differences in the EPT community composition: a location supporting a community with a high share of weak dispersers has to be located in a highly connected site. Although the effects of riparian forest on aerial dispersion can differ between taxa and ecological contexts, regional differences on this relation have never been explored.

In this study the relation between riparian forest and EPT dispersion across European biogeographical regions is compared, using data from Mediterranean (Mondego, Portugal), Continental (Middle Rhine, Germany), Alpine (Inn, Austria) and Boreal (Upper Volga, Russia) catchments.

In each catchment area several locations were selected on similar streams. The EPT community composition was surveyed in each location and used to estimate its dispersion capacity using a dispersion index (Species Flying Propensity, Sarremejane et al. 2017). Riparian vegetation was quantified using land use data and aerial photography in the buffer 5 km up and downstream of each location.

We expect to find that locations with more area covered by riparian forest support EPT communities with a lower dispersion capacity and to detect differences in the relative importance of the riparian forest for this relation across European biogeographical regions.

MACROINVERTEBRATES REVEAL ENVIRONMENTAL GRADIENTS: METHODS AND METHOD DEVELOPMENT IN THE OB RIVER BASIN

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The Ob is one of the world's largest rivers, its length (with Irtysh) is 5,410 km that makes the river the seventh longest in the world. The Ob and its tributaries drain an area of approximately 2,990,000 km^2. The huge size of the Ob river catchment basin and diverse natural resources of the region give rise to numerous anthropogenic factors affecting aquatic ecosystems. Mountainous watercourses in the mercury mining zone show a decrease in total species richness and abundance of pollution-sensitive aquatic organisms (EPT-taxa) as heavy metals pollution increases. Some tributaries of the Ob middle course undergo essential anthropogenic transformations associated with the development of the mining-metallurgical industry and oil production. High biogenic loads, heating and oil pollution responsible for the increase of oligochaetes proportion in the bottom communities are typical for this area. The regulated sections of the Ob river have become the nucleus of the alien species spread in the basin. The invasion-induced growth of macroinvertebrates biomass is noted in the areas inhabited by alien species. For instance, the introduction of the riverine snail *Viviparus viviparus* in the bottom communities of the Novosibirsk reservoir has increased (100 fold and more) the average zoobenthos biomass. Increasing anthropogenic loads on water bodies calls for the development of advanced scientifically based methods for assessing their state. While in Russia monitoring is mainly based on hydrological and physico-chemical parameters, in Europe the status is assessed based on biological quality elements (BQEs). Thus, approaches from the European Water Framework Directive can support this approach and enable a cross-catchment analyses between the mountainous streams in the Austrian Alps and the headwaters of the Ob. We propose the bioindication techniques for the Ob basin with regard to type, anthropogenic impact, stress factors and response of benthic communities.

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NEMATODE FISH PARASITES IN THE DANUBE RIVER - BELGRADE SECTION

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Parasitic species of freshwater fishes represent a large group of organisms including either adults or larval stages. Macroparasites - Nematode (round worms) infect many different species of aquacultured and wild fish. Adult forms are typically found in fish digestive tract.

The present work covers the investigation of nematode parasites of fish from the Belgrade section of the Danube River. During the ichthyoparasitological study we have collected and examined 22 freshwater fish species from families Cyprinidae (14), Esocidae (1), Percidae (4), Centrarchidae (1), Gadidae (1) and Siluridae (1). A total of 802 fish specimens have been examined and 54.86% were infected. In the intestine of 12 infected fish species have been found 9 species of Nematode parasites - *Hysterothylacium bidentatum* (Linstow, 1899), *Contracaecum siniperca* (Dogiel & Achmerov, 1946), *Contracaecum* sp. juvenile (Railliet & Henry, 1912), *Cammalanus lacustris* (Zoega, 1776), *Cammalanus truncatus* (Rudolphi, 1814), *Camallanus* sp. juvenile (Railliet & Henry, 1915), *Philometra rischta* (Skrjabin, 1923), *Rhabdochona denudata* (Dujardin, 1845) and *Rhabdochona hellichi* (Šrámek, 1901). During investigation, species *Philometra rischta* has been marked off ("heat parasite"), infesting a four fish species (*Blicca bjoerkna*, *Leuciscus idus*, *Perca fluviatilis*, *Sander lucioperca*) with prevalence of infestation 1-17. Fish species with a great number of nematode parasites in intestines was *Lota lota* (four), while other were infected with one or two parasites.

Keywords: freshwater fish; intestinal parasites; Nematode; infestation; Danube River; Belgrade section; Serbia

SPATIAL MOVEMENT OF WELS CATFISH (*SILURUS GLANIS*) IN THE DANUBE

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Wels catfish (*Silurus glanis*, Linnaeus, 1758) is one of the most targeted species for recreational and commercial fishing in the Danube River, even though studies of behavior and movement patterns of Wels catfish in the Danube are rare. Wels catfish was caught downstream of Iron Gate II hydropower dam and tagged with an ultrasonic transmitter (Vemco Ltd, V16TP). Nine autonomous receivers (Vemco Ltd, VR 2W) recorded detections of spatial movement downstream of Iron Gate II dam between Serbia and Romania for almost two years, between the years 2015 and 2017. Our telemetry data found that Wels catfish exhibit relatively short movements within a maximum range (≈ 12 km), but as a territorial species most of the time it was recorded by the two receivers, close to the Iron Gate dam and location where it was caught. The longest displacement from the preferable place under Iron Gate II dam was migration to Romanian ship lock and turbines located in the right arm of the Danube River. Location under the river dam is already recognized as a place of aggregation of the fish and thus preference of predatory catfish is strongly connected with food availability. Our data revealed that dam and ship lock blocked further migration of this fish. The last signal received was during the winter 2017, which was a period with extremely low temperature and ice cover on the Danube River. Considering the fact that the ice displaced whole receiver deployment downstream the dam, we might conclude that the tagged catfish disappeared because of ice movement during the winter season. Results can be used for management ensuring habitat requirements and developing of restoration and conservation strategies.

HOLISTIC FISH-DIVERSITY ASSESSMENT IN THE VOLGA BASIN: CONVENTIONAL SURVEY, ARCHAEOZOOLOGY AND GENETICS

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The Volga is the longest river in Europe and 16th longest in the world. Studies of the fish communities in the Volga Basin date back to the Great Academic Expeditions in 1768 (Pallas, 1771; Lepekhin, 1771). Currently, about 80 fish and lamprey species are recorded in the Volga River drainage basin.

Combination of analyses of historical and present dynamics of populations of migratory fish can promote our understanding of factors affecting their recruitment and abundance. Taxonomic identification of 15,144 bone remains from 25 archaeological sites along the Middle and Lower Volga River revealed that they belonged to 38 different species of fish. These data allow retrospective comparisons and highlight the potential of archaeozoology in conservation biology. Anadromous sturgeons and salmonids were the most important species of the ancient and historical Volga River fishery. Sturgeons and salmonids are highly vulnerable to impacts of fishery and climatic changes. The sharp decline in numbers of Starry sturgeon *Acipenser stellatus*, Caspian trout *Salmo* sp. and Whitefish *Stenodus leucichthys* from the Upper and Middle Volga in the 17th and 18th centuries was likely related to a cooling period known as "Little Ice Age".

Recently environmental DNA metabarcoding was used to assess the fish fauna of the Volga River headwaters. This noninvasive approach enables to determine the number of species in an aquatic ecosystem, as well as their identity and distribution. Knowledge gaps in population genetics for certain indicator species in the Volga still needs to be filled, especially because artificial stocking of sturgeon has been carried out since the early 20th century. Genetic analysis as well as eDNA surveys have a great potential to expand knowledge of fish populations along large rivers and improve long-term biomonitoring. At present, population numbers of all anadromous sturgeons and salmonids of the Volga River are critically low. Therefore, analyses of historical data, conventional surveys as well as the inclusion of genetic approaches is essential for the development of appropriate conservation strategies.

CLIMATE CHANGE AFFECTS UNDER-ICE DYNAMICS OF PHYTOPLANKTON: CASE STUDY OF MOZHAYSK RESERVOIR

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Global climatic changes are reflected not only in the seasonal dynamics of hydrological characteristics of rivers and lakes, but also in the hydrobiological characteristics of the aquatic ecosystem. The growth and seasonal succession patterns of phytoplankton are regulated by a variety of both external and internal drivers. And climate change significantly affects the seasonal dynamics of phytoplankton in water bodies.

During our research we analyzed trends in the abundance and composition of the phytoplankton community in winter using the Mozhaysk reservoir as a case study from 2003 to 2018. We conducted a statistical evaluation of the significance in the total abundance and the current species composition of the phytoplankton community in the reservoir over the fifteen years. The rates of the main algal divisions were identified, and the frequency of occurrence and intensity of under-ice growth outbreaks were determined. Monthly dynamics of changes in phytoplankton structure during changing climatic conditions were also analyzed.

The results found were that diatom algae have been the dominant phytoplankton division in the subsurface water layer of the Mozhaysk Reservoir when covered in ice. At the same time, a significant level of cyanobacteria was found in the structure of algae in the fall, and of green and golden algae in the spring.

Observed climatic changes over the last 15 years have already led to a statistically significant increase in phytoplankton abundance in the deepest part of the reservoir, while no such changes have been found in shallower parts of the reservoir.

PHYTOPLANKTON DIVERSITY DYNAMICS OF THE DANUBIAN FLOODPLAIN LAKE IN THE CONTEXT OF GLOBAL CLIMATE CHANGE

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Floodplain area known as Kopački rit (Croatia), one of the largest conserved natural floodplains of the Danube River situated in its middle section, experienced the consequences of the global climate changes. An increase in mean annual air temperature and the extreme hydrological events, particularly extreme floods, characterised the last few decades. In order to track these changes we are focusing on the phytoplankton species diversity and dynamics found during the last half century in Lake Sakadaš, a part of the complex river-floodplain system. A complete phytoplankton diversity summarized a total of 680 taxa. Conserved hydrological fluctuations between the various floodplain habitats and the main river channel were found to be the most prominent environmental drivers that caused species sorting and supported high biodiversity. Common diversity indices used for comparison of the three phytoplankton species data matrices obtained at annual scale, reflected wider variations of biodiversity in the selected periods. The highest diversity found in the initial investigations (early 70ies) suggests the near-pristine condition, while lower diversity found thereafter shows a response to the intensity of stressors. Water pollution with organic substances from agricultural farms has been recognized as a major stressor which occurred in the past, while current impacts on biodiversity can be associated with the extreme hydrological events. Spreading of the tropical cyanobacterium *Cylindrospermopsis raciborskii* was noted from the extreme dry year of 2003 and its heavy blooms appeared periodically thereafter, depending on the hydrological condition. After the extreme flood events, (e.g. 2006, 2013), a cyclic shift between a phytoplankton dominated "turbid state" of the lake and a "clear state" with very low phytoplankton abundance and diversity appeared. Altogether, phytoplankton diversity changes that occurred during the last half century warn on the possible threats of the global climate change on the particularly endangered ecological systems, such as riverine floodplains.

ENVIRONMENTAL GUIDING PRINCIPLES FOR ALPINE RIVERS: CASE STUDY BIYA RIVER

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Anthropogenic stressors have altered the hydromorphological characteristics of many rivers worldwide, also in the European Alps. Environmental guiding principles are essential for the planning of sustainable measures in river restoration. The alpine river Biya, located in the Russian Altai mountains, is a hydromorphological reference system, which supports process understanding. Based on topographic maps and satellite data, planform hydromorphological patterns (sinuosity and channel width variability) were analyzed for selected reaches along the river. The longitudinal gradient of grain size distributions was assessed based on pebble count data from sampling sites between the river's source and its confluence with the Katun, where they join and form the Ob River. These parameters are then set in relation with changes in slope and interactions with the surrounding floodplain area. We established a catalogue of hydromorphological characteristics for the Biya, in order to support process understanding and to provide environmental guiding principles for river restoration. The type specific characteristics were compared to historical topography maps of selected segments of comparable alpine rivers. This comparison demonstrates that the dataset from the Biya River can be used as an assisting tool in the planning process of restoration measures in the European Alps.

ACTUAL ISSUES OF RIVERS BIOINDICATION: RUSSIAN EXPERIENCE AND PROSPECTIVE

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The consequences of versatile anthropogenic activities adversely affect the structure of aquatic ecosystems. These negative environmental changes can be found and formalized using bioindication methods. The vast majority of existing methods are developed to use macrozoobenthos.

Analysis of recent decades studies has shown that the set of methods used in Russia is relatively stable. According to the frequency of use, the indices can be listed as: Shannon-Weaver, saprobity of Pantle & Bukk, Woodiviss, Goodnight-Whitley, Balushkina's, EPT, BMWP, Multimetric index, ASPT. Despite the fact that the indices of saprobity, Woodiviss and Goodnight-Whitley have a number of significant drawbacks, expressed as sufficient underestimation or overestimation of the ecological situation on specific watercourses, they remain invariably popular due to simple use and the fact that they are officially included in GOST 17.1.3.07-82 "Rules for monitoring the quality of water in reservoirs and watercourses". In school studies, the Woodiviss and Mayer indices are widely used.

Among the relatively new methods, it is worth to mention the Index of Trophic Completeness (ITC), which was developed as an indicator of river and lake ecosystems functioning. ITC belongs to the group of indices based on trophic relations, taking into account the presence of trophic guilds in the benthic community. The ITC is based on the original trophic classification of macrozoobenthos and the hypothesis of the full realization of trophic links in hydrobiocenosis under the natural course of biological processes (all trophic niches are realized and occupied). If anthropogenic impact sufficiently affects the transfer of energy and organic matter in the ecosystem, then the structure of macrozoobenthos also changes, beginning from sensitive species and then entire trophic guilds of macrozoobenthos disappearance.

The index validation was checked on vast data obtained from many rivers subjected to anthropogenic impact of varying degrees. In clean rivers, downstream of 70 km^2 of the upper catchment, the trophic diversity of macrozoobenthos is maximal, regardless of the order of the watercourse and its geographical location. The trophic structure dynamic stability of macrozoobenthos was proven; no statistically significant seasonal variation of the results was found. There are certain achievements in establishing causal relationships between the type of anthropogenic impact and characteristic changes in the trophic structure of macrozoobenthos.

Research experience has shown that universal and integrated methods of bioindication (ITC, KISS, KIZ) are preferable to use, since they allow to compare rivers of different genesis and climatic zones, simplify the process of waters quality mapping in large areas. Otherwise, native indexes for specific types of rivers and regions will always require adaptation to be applied in a new region.

Poster Session B

"Sediment Transport & River Morphology"

PHYSICAL MODELLING OF SEDIMENT MANAGEMENT SCENARIOS WITH BOTTOM OUTLETS

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Sedimentation issues in hydropower reservoirs are addressed by conducting sediment management experiments on a physical model of the Pulangi IV reservoir (Mindanao, Philippines). Due to the configuration and only minor sediment management actions, this reservoir has slowly filled up and now already 2/3 of the storage volume is lost. The aim is to create new knowledge on the morphodynamics which are responsible for developing the reservoir geometry under varying conditions concerning the flow rate Q and the water level h in front of the weir. The physical model originates from a World Bank project on future sustainable sediment management, where a modification of the reservoir geometry with a longitudinal guiding dam was suggested. The horizontal scale of the physical model is 1:1000 and the vertical scale is 1:50. Clay sediments are used to fulfil the Fr* similarity. The focus of the experiments is on bottom outlet operations which are performed until a sediment equilibrium is reached in the reservoir. The simulated flow rates are mean flow rate MQ and annual flood flow HQ1. The simulated water levels range from maximum operational level to eight metres below that. Based on these variations, sluicing efficiency and the regain of storage volume will be analysed, as well as the changes in the reservoir geometry. Preliminary results consist of analysed digital elevation models and some target variables. The aim of this systematic study is to obtain data for an improved operational schedule for hydropower plants with regards to sustainable sediment management.

WATER AND SEDIMENT BUDGET OF CASIQUIARE CHANNEL LINKING ORINOCO AND AMAZON CATCHMENTS

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The Casiquiare River is a natural channel that connects two of the greatest rivers in the world, the Orinoco and the Amazon in the South American Continent. The aim of this paper is to present a review and synthesis of the hydrological and sedimentological knowledge of the Casiquiare River, including the first hydro-sedimentary balance of the Casiquiare fluvial system conducted at the bifurcation and at the mouth on September 9-12, 2000, during the expedition 'Humboldt-Amazonia 2000'. Bathymetric, flow discharge and physico-chemical measurements were made at the inlet and at the outlet of the Casiquiare Channel.

The main conclusions of this study indicate that Casiquiare is taking a significant proportion of flow (20 to 30%) from the Upper Orinoco basin to the Amazon basin. Throughout its 356 km-course, this chameleon channel undergoes significant morphological, hydrological and bio-geochemical variations between the inlet and the outlet, whose most visible witnesses are the increase in its width (3 to 4 times), flow (7 to 9 times) and its change in water color (white to black water), under the influence of tributaries coming from vast forest plains.

LENA DELTA SUSPENDED SEDIMENT BUDGET REVEALED FROM SATELLITE IMAGERY

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The delta of Lena River is one of the biggest deltas in the world. The area of river's Lena delta is the second one among Russian deltas and it is an important sedimentation barrier which declines delivery of suspended sediment into the Arctic Ocean.

This study aims at assessment of long-term and seasonal changes of sediment budget in Lena delta based on remote sensing dataset. Landsat images since 1999 were applied during ice-free period, from June to September, were analyzed. The sediment concentration (SC) at the delta topset was compared with SC data at the outlets of: the Main, Olenekskaya, Tumatskaya, Trofimovskaya and Bykovskaya channels to calculate suspended sediment budget in delta. The SC was calculated based on the archive Landsat images (more than 50 images). The model with the high accuracy of sediment concentration's detection was used for calculation of sediment suspensions. This model was based on calibration of pixels' reflection power from the satellite images according to measured turbidity data in the middle Lena River.

Literature analyses show that observations in this area of the river are not regular: measurements of the rates of discharge and runoff of sediments are taken place only in the period of ice-free period at the delta topset (Stolb Island) during summer field works. Annual sediment load transport rates along the main branches of the delta are calculated in our study with method which is based on data about rates of discharge and obtained SC datasets, which are detected along the delta arms. We also estimated the accumulation of the sediments in river's Lena delta. The fact, that sediment suspensions play critical role in the microelements-transfer, means that these estimates can help to estimate special aspects of biochemical balance of the delta.

HYDROGEOCHEMICAL FLOW DISTRIBUTION IN THE VOLGA RIVER DELTA

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The Volga River delta is the largest in Europe and eighth in the World. It presents the huge diversity of landscapes and natural processes that always attract a wide range of scientists. Therefore, appearance of new in-situ measured data on water, dissolved and suspended matter flows, their balance and spatial distribution within such a large deltaic system, is of scientific interest not only from regional but also from a global perspective.

During three different hydrological seasons in 2018-2019 (spring flood and two summer low water periods), expeditionary studies were carried out by researchers of the Lomonosov Moscow State University in the Volga delta on total route about 3.5 thousand km long. Water discharges measured at 550 locations, collected about 800 water and 150 sediment samples. It was the first modern complex hydrogeochemical expedition carried out in such scale and three relatively short periods for the whole delta. The obtained data allowed to characterize some elements of hydrogeochemical regime within 284 relatively homogeneous branches without inflow. We have determined water discharge, suspended sediment concentration, content of 70 dissolved and 61 suspended chemical elements within each branch for flood and low water periods. All information processed and stored in the special geodatabase to perform spatial analysis and mapping of this data. The scheme of discharge time series modeling developed based on obtained runoff distribution. It takes into account the water runoff distribution between branches and inter annual variability of the total inflow to the delta. Regression analysis allowed to obtain the equations to estimate sediment load and chemical flow including seasonal variability and distribution between dissolved and suspended forms according to water flow variability. Based on this approach and datasets the Volga Delta delineated by zones of erosion, transit and accumulation of substances carried by water flow.

EVOLUTION OF THE SEDIMENTARY DYNAMICS OF THE CHELIFF WADI (ALGERIA)

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Sediment loads in many rivers are changing in response to climate and/or anthropogenic changes. In many parts of the word, especially in the southern Mediterranean, the upstream supply of sediment to the sea has fallen sharply and its composition has been modified. In this context, this study examines the sedimentary archive to reconstruct the evolution of the sedimentary dynamics of the Cheliff wadi (Algeria). Studying such a topic is important to focus on the symptoms of geochemical cycling, ecosystem environments and the vulnerability of our socio-economic objectives, which are often affected by observed changes in the sediment budget. The study was conducted using a paleohydrological approach, which consists of analysing the particle size, geochemistry and date of deposition of sediments extracted from the meanders of the lower valley on alluvial terraces. This method allows to broaden the investigations beyond the period for which the measure provides information. The results indicate that the upper part consists primarily of fine sedimentary layers composed essentially of clay and silt. In addition, geochemistry shows that the latter come mainly from downstream affluents. However, dating by 137Cs tells us that these layers have been sedimented along the last six decades. As to the lower layers, they are thick and include a significant fraction of sand, a multitude of geochemical elements and were sedimented before 1960. This difference in composition reflects a change in the dynamics of the river, probably due to the many dams built across the river since 1930.

Keywords: sedimentary archive, sedimentary dynamics, Cheliff, sediment budget, paleohydrological, particle size, geochemistry, 137Cs

CONTEMPORARY SEDIMENTS OF WATER ECOSYSTEMS AS INDICATORS OF THE ANTHROPOCENE EPOCH: THEORETICAL, METHODOLOGICAL AND APPLIED ASPECTS

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Bottom sediments of water bodies are a quasi-open system with large-spread interface surface between the hydrosphere and the lithosphere. They are important accumulators of biotic and abiotic compounds including products of human activity. Due to high sorption capacity, suspended particles are able to capture pollutants and to take them out from water column during the sedimentation process. Hence, during the formation of new sediment layers, dispersed particles and pollutants are simultaneously being deposited. Extensive research carried out on large rivers (Don, Kuban, Northern Dvina, Loire), as well as in marine and freshwater systems of the Atlantic Ocean and the Arctic Ocean basins has allowed substantiating the possibility to identify the "layer of anthropogenic impact" and the Holocene – Anthropocene boundary using the information on the vertical distribution of technogenic radionuclides (Cs-137, Am-241), mercury, lead, and petroleum components in the sediment cores (Fedorov et al., 2021). The theoretical aspect of the results of the research consists in determining the parameters of the "layer of anthropogenic impact" and justifying the use of the pollutants' concentrations in the sediments beyond this layer as background values for the purposes of environmental assessment. Their applied aspect consists in substantiating the use of technogenic radionuclides (Cs-137, Am-241), mercury, lead, and petroleum components as markers of the beginning and chronology of water bodies' pollution for the purposes of their rehabilitation including clean-up operations aimed at removing contaminated sediments that can endanger aquatic life.

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SEDIMENT TRANSPORT AND BATHYMETRIC CHANGES IN THE MISSISSIPPI-ATCHAFALAYA RIVERS

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The Mississippi River (MR) and its largest distributary, the Atchafalaya River (AR), discharge a combined volume of approximately 670 km^3 (474+199 km^3) each year into the Gulf of Mexico. While the MR deltaic plain has been losing land at an average rate of 30 km^2 annually since the 1930s, the AR has been building deltaic land at a much lower rate (1-4 km^2/year) since the early 1970s. Coastal restoration projects have been proposed, many of which rely on sediment diversions from the Mississippi - Atchafalaya Rivers. Riverine sediment availability, especially sand, is a key to success of the future coastal restoration. Here we synthesize the findings from several recent studies that have investigated suspended sediment loads, bed material loads, and channel bathymetric changes from bank to bank in these two large rivers. Our assessment shows that in the past 2-3 decades, suspended sediment and bed material loads were significantly higher at the upstream location than those at the downstream locations in the last 500 kilometers of the MR. Nearly 70% of the riverine sand was trapped within the MR, and channel aggradation occurred mainly downstream of the Mississippi-Atchafalaya bifurcation and near the river mouth. In the AR, to the contrary, only about 10% of the inflow suspended sediment was trapped within the 190-km river reach. The riverbed in the first 69 kilometers downstream of the Mississippi-Atchafalaya bifurcation eroded several meters since the 1930s; however, the degradation slowed down largely in the recent decade. Channel erosion in the lower 120-km AR was marginal, especially after the Old River Control Structure was built, which regulates the MR – AR flow ratio. These findings indicate insufficient sediment availability and the need for discussion among coastal practitioners, policy makers, and researchers to identify realistic solutions that can build longer-term resilience for the Mississippi-Atchafalaya River delta.

BORE IN BRANCHES OF YANGTZE, GANGES AND AMAZON RIVERS DELTAS

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Tidal bore is a surge wave propagating upstream a funnel shaped estuary under the rival influence of resistance and confusor effects. The occurrence of tidal bore depends on tidal range, river flow and the river mouth shape. Deltas of the rivers Amazon, Yangtze and Ganges have funnel-shaped branches where tidal bores are observed. The criterion of tidal bore formation is Froude number Fr_b >1. The key problem of the paper is the role which a bore plays in sea water intrusion and in sediment transport at the estuary. The ratio river flow/tidal flow defines the type of estuarine vertical mixing and the location of formation of tidal bore front. Coefficients of turbulent diffusion below the bore front are of two orders larger than those in a river flow. Intensive turbulent diffusion results in completely vertically mixed stream at the location of front bore formation. The effect of bore wave on the upstream transfer of saline water depends on position of bore formation in the channel. Our analysis shows that at the Amazon delta branches and the Hooghly Branch bore forms upstream of the boundary of saline water intrusion, and it has no effect on propagation of saline water. In the Northern Branch of the Yangtze River tidal bore actively transports brackish water (8–10‰) upstream to the confluence with the Southern Branch. Abrupt changes of water level and pressure gradient result in intensive bottom erosion and sediment suspension in a flow at the cross section of bore inception. When the distance of bore formation is larger than convergence length, the bore wave produces its own maximum turbidity zone and specific wave shaped bottom and low-landing marshes pattern. Bore waves enhance accumulation of sediments at the upstream reaches of the estuaries causing their shoaling.

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LARGE-SCALE HYDROMORPHOLOGICAL CHARACTERISTICS OF THE GLACIAL RIVER KATUN (OB HEADWATERS)

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The Water Framework Directive stipulated the analyses of the natural state (reference condition) of fluvial systems. Different assessment and evaluation methods were developed, however as the ecological status is described by the deviation from the pristine situation, reference conditions had to be defined. During the industrialization in Europe, rivers were straightened and designed to fit human activity, thus nowadays only a few natural river systems can be used as reference conditions as well as guiding principles for river restoration projects. Our study aims to analyze the comparability of rivers from the Altai mountains with rivers in the Alps. This builds the basis to develop a recommendation on how to analyze hydromorphological characteristics of fluvial systems for subsequent processing as reference conditions as well as guiding principle in river restoration. For this purpose the width variability, sinuosity and the slope of the glacial river Katun in Siberia was analyzed using different GIS techniques and later compared to the current and historical status of the European river Inn. The longitudinal changes along the river Katun were analyzed and characterized. Additionally pebble counts were carried out along the river to assess the changing sediment composition in a glacial river along the longitudinal continuum. Combined with River Habitat Surveys it was possible to give a holistic overview of the dynamic fluvial system Katun in its upper, middle and lower reaches.

MORPHOLOGICAL CHANGE DETECTION USING TIME SERIES ANALYSIS OF SATELLITE IMAGES

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Meandering rivers are among the most dynamic earth-surface systems, which can change the morphology of floodplains. The geomorphological characteristics of rivers are key factors that affect the river's marginal areas. Karun is the most effluent and only navigable river in Iran. Karun's morphological characteristics have been changed over time due to several factors such as tectonic, hydrological, hydraulic and anthropogenic. Due to the large cities and more than five million inhabitants in Karun catchment, and the important ecological and societal-economic impacts of Karun River, investigating the morphodynamics of this river and its changes is essential to mitigate human and natural harm. This study aims to identify morphological changes that occurred in the Karun River using high resolution digital elevation model (DEM) and Landsat time series, every 15 years during 1985-2015. These satellite images analyzed and superimposed to investigate the morphological characteristics changes such as river active channel width, meander neck length, water flow length, sinuosity index, and Kornice central angle. Statistical analysis showed that the dominant pattern of the river due to the sinuosity coefficient have a meandering pattern and, most of the river pattern according to Kornice's classification falls in the category of developed meander river. The number of arteries reduced in anabranch pattern and the river is migrating to the downstream and eastern side. Thus, for effective management and planning, it is necessary to evaluate the changes in river parameters and displacements.

Keywords: Karun River, Meander parameter changes, Remote sensing, River morphology

ANALYZING MORPHODYNAMICS OF LOWER INDUS RIVER USING GIS

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Indus river is one of the largest rivers in South Asia that sustains its basin area of 1.165 million km^2 in Pakistan, India, and Afghanistan with the glacial melt from the Himalayas. The river flow fluctuates during the monsoon, as the discharge reaches its peak due to heavy rain pour. The demanding sectors of water storage, agriculture, and industry are transitional in their water consumption pattern that eventually reforms the downstream river morphology. The lower riparian areas of the river are most likely to be affected due to upstream activities. The reach of the river for this study is selected from the lower Indus basin located in the province of Sindh, Pakistan. The analysis was performed for the eastern bank of the river along which many big cities of the country are situated. The significant changes in the river course were observed using the Digital Shoreline Analysis Software (DSAS) for the past 20 years in ArcGIS. To visualize the potential reasons for river migration within levees, the digital landcover classification was performed for this riparian zone. The traces of deforestation and agriculture intensification inside the riparian area were observed and concluded as the possible reasons for the morphological change of the river's path for the particular reach. The cities considered as the economical hub for the Sindh province were found at risk of seasonal flooding due to the river's varying morphology. These cities have been flooded during the historical peak flows in the past. It is recommended to perform flood monitoring studies and to propose hazard planning strategies for the riparian districts to avoid any disaster in the future.

MODERN CHANGES IN MORPHOMETRY AND MORPHODYNAMICS OF LARGE RIVERS' DELTAS

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Based on the analysis of vast data, the worldwide distribution of bayhead and protruding deltas of large rivers was studied. Quantitative relations between the delta area and length were found for deltas of these types; some dependences of the length of the delta coastline and the number of mouths of branches on the delta length and area were also found. Empirical relations were found to exist between some morphometric characteristics of deltas and river water and sediment runoff governing delta formation. The results of the regression analysis made it possible to reveal common features of the morphometry of bayhead and protruding deltas and their essential differences, and to propose two approximate empirical geometric models of typical bayhead and protruding deltas. The obtained results can be used for rough assessment of possible changes in deltas of large rivers under anticipated variations of river water and sediment runoff and sea levels.

Since the second half of the 20th century, considerable changes appeared in the structure and regime of deltas of large rivers. These changes were due to the natural and anthropogenic decrease in river water and sediment runoff and to a stronger marine impact. River deltas have entered the number of most variable geographic objects. The changes in the bayhead deltas and protruding deltas were different. The present-day changes in protruding deltas are more diverse and significant. The seaward progradation slowed down in most deltas. The processes of inundation and erosion of the coastal parts of deltas intensified (Huanghe, Nile, Zambezi deltas). The length of delta coastline segments subject to erosion increased (Lena, Godavari, Niger deltas). The number of delta branches prograding into the sea decreased (Danube, Indus, Red deltas). In the 21st century, the changes identified in both the governing factors and the structure of deltas proper will continue and extend.

CHANNEL PROCESSES ON THE RIVERS OF THE WEST SIBERIAN

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Modern possibilities of remote sensing and GIS technology significantly expand the methods of channel processes's analysis. This approach helps to collect and visualize a large amount of statistical information about channel processes at the level of large river basins. Along with traditional methods for analyzing channel deformations, new approaches were developed and improved for estimates of the river morphodynamic. Using several methods, we got the current shores erosion on the rivers of the Ob-Irtysh basin. On the basis of the remote sensing data for different time intervals, the values of erosion rates and the length of the banks erosion were obtained. The average erosion rate of the rivers of the Ob-Irtysh basin is 1-4 m / year. Also the main parameters of river meanders were determined. It is shown that the erosion rates depend on the degree of development of the bends of the main channel and bends of braided channel. The new methodological approaches of estimate horizontal deformations give great opportunities for further investigations in the rivers. Also there are possibilities to improve forecast of dangerous channel processes.

CERTAIN ASPECTS OF THE SELENGA RIVER DELTA MODERN MORPHODYNAMICS

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Selenga river delta inundation from the mid-20th century to the present is discrete in time and confined primarily to extreme floods and rising of the Baikal Lake level. The Baikal Lake maximum level since the Irkutsk Hydroelectric Power Plant construction occurred in 1986 (455,6 m abs.), which corresponds to the most intensive alluvial deposition reconstructed from the ^{137}Cs data. The deltaic sedimentation mean rate since 1963 is estimated as 0.74-0.78 ± 0.5 cm $year^{-1}$ for the middle floodplain. For the abandoned channels occupying the distal edge of the middle floodplain (Khlystov Zaton) – at least 2.9 cm $year^{-1}$, for a low floodplain - 1.2-1.3 cm $year^{-1}$. Sedimentation rate varies depending on the water discharge and controlled by the features of the delta landscape.

Contribution of major sediment sources into formation of the different alluvial facies of the Selenga River delta obtained using the fingerprinting technique is also rather unique for the Eastern Siberia rivers: it is the channel and not the basin-originated component that dominates the deltaic floodplain sediment origination on practically all floodplain levels.

Interesting is to consider interaction between the sediment origin and particle size (here represented by weighted average diameter). Classical for most rivers is the correspondence of physical clay to basin component, and of coarser sediments to channel component. For the Selenga River delta situation it is exactly the opposite: basin-originated sediments are the largest. Deltaic floodplains are composed of finer material then the basin material in the Selenga River upper reaches.

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THE RIVER BED DEFORMATION IN THE PERMAFROST ZONE

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Active research of Arctic rivers began in the second half of the 20th century simultaneously in the USSR, Canada and Alaska due to the discovery of large mineral reserves in permafrost regions. Particular attention was paid to the influence of permafrost on the river hydrology, as an important aspect of geomorphological studies in the design of structures in the floodplains of rivers. The work is dedicated to the study of the deformation of the river bed composed of frozen and thawing soil under the water flow impact. There are two main differences in the deformation processes in the river beds located in the permafrost zone and outside: the significant impact of thermal erosion and the non-simultaneous effect of channel-forming soil melting and floods. The study is based on the results of laboratory and mathematical modeling. If the model takes into account additional factors such as heat transfer in the soil, sediment transport and the collapse of coastal slopes, it describes the studied process most fully and adequately.

Numerical experiments with an improved mathematical model of total deformations during long time intervals showed that the differences in averaged deformations calculated using the pure ablation model, i.e. excluding collapse and sediment transport, and the full model, may increase. The values of deformations calculated without taking into account sediment transport and collapse, significantly exceed ones calculated by the full model. This fact was confirmed by the experiments in the tray. The hydraulic tray experiments allowed to reproduce the effect of delayed collapse expressed in the non-simultaneous effect of melting of channel-forming soil and flooding.

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EROSION AT THE TURN SECTOR OF A RIVER IN PERMAFROST

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The features of the boundary permafrost zone, as well as the physical properties of its constituent soils, have undergone significant changes in recent decades. Currently, border permafrost is the most physically unstable system, since snow and ice, which prevail on its territory and are part of soils, are extremely unstable solids because of their direct dependence on temperature. Due to climate warming, the physical state of the coastline of rivers belonging to the zone of this border is changing; thawing and freezing at the moment has a different degree of depth and different time intervals. All this affects the stability of existing hydraulic structures and should be taken into account during the construction in the future. When designing river hydraulic structures, it is necessary to take into account both prevailing and forecasting the possible position and condition of the channel. Such a forecast allows to increase the reliability of the designed structures.

In natural conditions, making observations is not always possible due to difficult climatic conditions and requires other material costs than in the laboratory.

At a circular experimental setup for studying flow with accounting of Coriolis force due to the rotation of the centrifuge around the central axis, a study was made of the flow movement on the curve, where the behavior of frozen and unfrozen soil at the turn of the channel was studied. Also the influence of snow cover on erosion of the coastal slope, as well as the influence of the direction of movement flow in a circle (influence of Coriolis force) was modeled.

This study was supported by the government programs No. 0147-2019-0001 (registration number AAAA-A18-118022090056-0). The experiments with frozen soils in laboratory trays were curried with the support of the Russian Foundation for Basic Research, project no. 18-05-00178.

TRANSITIONAL BEDFORM AND VELOCITY INSTABILITIES AT THE SOLIMÕES-NEGRO CONFLUENCE

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River confluences impose convective instabilities on the morphodynamic, hydrodynamic and sedimentary processes that develop on the main, tributary, and post confluence channels. These instabilities are controlled by the confluence momentum ratio and the junction geometric characteristics, namely, degree of discordance and confluence angle as well as eventually by differences in water density. The Solimões-Negro confluence (Brazil) constitutes one of the largest World's fluvial structures, and therefore has attracted the attention of the international scientific community. This contribution is based on observations from bedform survey and flow velocity Acoustic Doppler Current Profiler (ADCP) measurements at the confluence in question. It presents a wavelet analysis of the confluence bedform instabilities, which allows for identifying the bedform hierarchies that are modified by the local turbulent flow structures. Likewise, the analysis underlines the potential of wavelet transforms to provide an objective frame to locate and delimitate the margins of confluence morphologic broad regions (i.e., zone avalanche faces, zone pronounce scour, and zone of post confluence bars), which are subsequently related to the confluence hydrodynamic zones (i.e., stagnation zone, region of deflection, zone of maximum velocity and zone of flow recovery).

Poster Session B

"Integrated River Basin Management"

UNDERSTANDING PERUVIAN AMAZON RIVERS TO DEVELOP BMP FOR INFRASTRUCTURE: AMAZON WATERWAY

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The Amazon Waterway is an infrastructure project with a vast area of influence in Peru, as it involves 2,760 km of the four largest Amazonian rivers. The Peruvian Government proposes this project as the solution to ensure and guarantee navigation all year and to promote a more competitive fluvial and commercial transport, profitable and efficient along these rivers. This is the first time a national waterway occurs in Peru and there is no prior experiences and studies. Thus, navigability studies, norms, and standard recommendations are taken from previous experiences carried out in other parts of the world. These are not necessarily the most appropriate references, and with no adequate methodologies, baseline and impact assessments will be incomplete and deficient.

CITA-UTEC is working actively to determine the geomorphological baseline of rivers in the Amazon lowlands and to develop Best Management Practices (BMPs) methodologies that include remote sensing analysis and multitemporal analysis of physical parameters and dynamic process of rivers. These methodologies seek to develop useful tools to carry out more efficient studies and formulation of projects based on a comprehensive understanding of rivers dynamics. CITA-UTEC will also develop mathematical models to predict morphodynamics of Amazonian rivers and describe potential scenarios of impacts after infrastructure projects.

CITA-UTEC considers the Amazon Waterway a good opportunity to encourage the development of scientific analysis to understand impacts of infrastructure projects in rivers, and the development of BMP is timely considering the magnitude and no previous experiences of this type of projects in Peru.

DYNAMICS OF LAND USE AND PRODUCTIVITY INDICATORS OF THE LENA RIVER BASIN

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The research is devoted to the impact assessment of biotic, abiotic and anthropogenic factors on the production processes dynamics in the Lena River basin landscapes (2001-2019).

Materials and methods: Land types are determined basing on HDF rasters for the period of 2001-2019 according to the Modis equipment open data. The productivity indicators calculation in carbon units is based on Modis GPP/NPP data. The analysis of land-use characteristics and productivity indicators has been carried out in the basin as a whole, by its natural zones. The assessment of the land use structure and phytoproductivity indicators of the Lena River basin on the basis of remote data revealed that all its natural zones are subject to change. However, in general the basin is not significantly changing due to its large area.

In tundra and the Arctic desert, the climatic parameters are changing more substantially in comparison to the other zones, and here the land use structure is more stable. In the zone of the Arctic desert, the temperature increase and precipitation decrease causes the decrease in the percentage of the wetlands which are displaced mainly by the grassy vegetation, but these changes do not affect large areas. The phytoproductivity growth tends to increase (for example, in tundra from 2001 to 2019, productivity in July increased from 20g/m^2 C to 27g/m^2 C), against the background of considerable fluctuations within the period.

Deforestation, fires, and reforestation activities in the forest tundra and taiga have caused the changes in the forest land structure. The larch forest areas of high coverage are reduced but the sparse woodlands territories increase. The changes in the weather conditions are less pronounced here. Remote sensing data capture the trends of change, however, the northern landscapes of the Arctic deserts and tundra require detailed research.

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ASSESSMENT OF FLOODING RISK IN MEDICAL FACILITIES IN TOKYO LOWLANDS

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Tokyo is the capital of Japan, and is located on the large delta formed among the Tone, Ara and Tama rivers. The Tone, Ara and Tama rivers are large rivers and have been ranked as first class rivers in Japan defined by MILT (Ministry of Land, Infrastructure, Transport and Tourism). In the Edo era, this area developed as a political and cultural center. Starting in the Meiji era, it became highly industrialized, which led to widespread land subsidence due to groundwater use. As a result, the ground level has become lower than the mean sea and river level in the region, leading to the risk of flooding. Since the Tokyo region contains a large amount of infrastructure and medical facilities, serious flooding can be potentially catastrophic. In the present study, we surveyed hospitals at risk of flooding and investigated the floors on which medical equipment was installed. First, we tried to obtain the information through a questionnaire from hospitals. A comparison of the ground level of hospitals with the estimated inundation depth based on the inundation hazard map produced by the Tokyo Metropolitan Government showed that many hospitals may be subject to serious flooding. Critically, resources such as CT, MRI, and X-ray equipment are often on the ground floor because of their weight and the flow of medical consulting procedures. Since it is impossible to make the entire building water resistant, if a doctor's office or a central facility is installed on the ground floor, it should be ensured that these rooms will not be flooded. It is also important to ensure a continuous supply of fresh water and electricity during a flood.

STUDY ON EMERGENCY DRAWDOWN CAPABILITY OF DAMS IN KOREA

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Frequent and extreme hydrologic events, greater than the traditional statistical design criteria, are expected due to an abnormal climate change. It is well known that security of dam safety could be getting worse as hydrologic uncertainties are getting raised. Therefore, provision of emergency facilities is necessary to lower the failure possibility of hydraulic structures. In case of dams, the risk of failure could be raised due to a catastrophic high flood or structural problems such as seepage or leakage through dam body. One of the popular measures lowering the uncertainties could be an increase of reservoir's emergency drawdown capability. In other words, emergency drawdown facility is a key factor to minimize the catastrophic dam failure regardless of the causes. However, there is no generally accepted design standard for sizing the emergency drawdown capability in Korea. Especially, no definition and the quantity of drawdown rate are specified yet.

The purposes of this study are the examination of existing emergency drawdown facilities' capability and the provision of general standard which can be applied for preliminary design of emergency drawdown facilities and safety downstream.

In this study, literature review was carried out and adopted seven standards to examine the applicability. The structural stability of a specific fill dam from the seepage, which seems under the worst condition in South Korea, was carried out with assumed scenarios; various reservoir water depth(h) drawdown rates, various reservoir storage volume(V) drawdown rates with consideration of the relationship between h and V. Furthermore, parameters were examined which could be the most appropriate in defining the drawdown rate.

This study suggested a methodology which can provide the quantity of emergency drawdown rate for preliminary design step. The adopted methodologies were applied to 34 dams in Korea and compared with the existing capabilities.

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