INTERNATIONAL SYMPOSIUM ON:

THE EFFECTS OF GLOBAL CHANGE ON FLOODS, FLUVIAL GEOMORPHOLOGY AND RELATED HAZARDS IN MOUNTAINOUS RIVERS

6-8 March 2017

Potsdam, Germany



BOOK OF ABSTRACTS

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- **Prof. Dr. Axel Bronstert,** Chair of Hydrology and Climatology**,** Institute of Earth and Environmental Science, University of Potsdam, Potsdam, Germany
- **Prof. Dr. Annegret Thieken,** Institute of Earth and Environmental Science University of Potsdam, Potsdam, Germany
- **Dr. Theresia Petrow,** Institute of Earth and Environmental Science University of Potsdam, Potsdam, Germany
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- **Prof. Dr. Peter Rutschmann,** Chair of Hydraulic and Water Resources Engineering, Department of Civil, Geo and Environmental Engineering, Technical University of Munich, Munich, Germany
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- **Prof. Dr. Marco Borga,** Departments of Land and Agroforest Environments, University of Padova, Padova, Italy
- **Prof. Dr. Gerd Bürger,** Institute of Earth and Environmental Science, University of Potsdam, Potsdam, Germany

Book of abstracts of the International Symposium on the Effects of Global Change on Floods, Fluvial Geomorphology and Related Hazards in Mountainous Rivers

Edition 2017

Editors: José Andrés López-Tarazón, Axel Bronstert, Annegret Thieken and Theresia Petrow

With contributions of all conference participants

Cover images: impacts of a flash flood in the town of Braunsbach. Photos: Ana Lucía Vela (June 2016)

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Preface

Both Alpine and Mediterranean areas are considered sensitive to so-called global change, considered as the combination of climate and land use changes. All panels on climate evolution predict future scenarios of increasing frequency and magnitude of floods which are likely to lead to huge geomorphic adjustments of river channels so major metamorphosis of fluvial systems is expected as a result of global change. Such pressures are likely to give rise to major ecological and economic changes and challenges that governments need to address as a matter of priority. Changes in river flow regimes associated with global change are therefore ushering in a new era, where there is a critical need to evaluate hydro-geomorphological hazards from headwaters to lowland areas (flooding can be not just a problem related to being under the water). A key question is how our understanding of these hazards associated with global change can be improved; improvement has to come from integrated research which includes the climatological and physical conditions that could influence the hydrology and sediment generation and hence the conveyance of water and sediments (including the river's capacity, i.e. amount of sediment, and competence, i.e. channel deformation) and the vulnerabilities and economic repercussions of changing hydrological hazards (including the evaluation of the hydro-geomorphological risks too).

Within this framework, the purpose of this international symposium is to bring together researchers from several disciplines as hydrology, fluvial geomorphology, hydraulic engineering, environmental science, geography, economy (and any other related discipline) to discuss the effects of global change over the river system in relation with floods. The symposium is organized by means of invited talks given by prominent experts, oral lectures, poster sessions and discussion sessions for each individual topic; it will try to improve our understanding of how rivers are likely to evolve as a result of global change and hence address the associated hazards of that fluvial environmental change concerning flooding.

Four main topics are going to be addressed:

- Modelling global change (i.e. climate and land-use) at relevant spatial (regional, local) and temporal (from the long-term to the single-event) scales.

- Measuring and modelling river floods from the hydrological, sediment transport (both suspended and bedload) and channel morphology points of view at different spatial (from the catchment to the reach) and temporal (from the long-term to the single-event) scales.

- Evaluation and assessment of current and future river flooding hazards and risks in a global change perspective.

- Catchment management to face river floods in a changing world.

We are very pleased to welcome you to Potsdam. We hope you will enjoy your participation at the *International Symposium on the Effects of Global Change on Floods, Fluvial Geomorphology and Related Hazards in Mountainous Rivers* and have an exciting and profitable experience. Finally, we would like to thank all speakers, participants, supporters, and sponsors for their contributions that for sure will make of this event a very remarkable and fruitful meeting. We acknowledge the valuable support of the European Commission (Marie Curie Intra-European Fellowship, Project ‘‘Floodhazards’’, PIEF-GA-2013-622468, Seventh EU Framework Programme) and the Deutschen Forschungsgemeinschaft (Research Training Group “Natural Hazards and Risks in a Changing World” (NatRiskChange; GRK 2043/1) as the symposium would not have been possible without their help. Without your cooperation, this symposium would not be either possible or successful.

José Andrés López-Tarazón, Axel Bronstert, Annegret Thieken and Theresia Petrow

Potsdam-Golm, 6 March 2017

FINAL PROGRAMME

Monday, 6th March 2017

8:00 – 8:30 Registration

8:30 – 9:00 Welcome and opening

Prof. Dr. Axel Bronstert[1] and Dr. José Andrés López-Tarazón[1,2,3]
[1]Chair of Hydrology and Climatology, Institute of Earth and Environmental Science, University of Potsdam, Potsdam, Germany
[2]School of Natural Sciences and Psychology, Liverpool John Moores University, Liverpool, UK
[3]Fluvial Dynamics Research Group, Department of Environment and Soil Sciences, University of Lleida, Lleida, Spain

Session 1: Modelling global change at relevant spatial and temporal scales

Chairperson: Prof. Dr. Axel Bronstert

9:00 – 9:45 Downscaling future climate scenarios for impact assessment

Dr. Donal Mullan
School of Natural and Built Environment, Queen's University Belfast, Northern Ireland, UK

9:45 – 10:00 Fluvial geomorphology in abandoned mountain landscapes: Pisuerga headwaters, Spain

A. Pisabarro
Department of Geography. University of Valladolid, Spain

10:00 – 10:15 Flood and sediment hazard estimation based on land use changes in a tropical watershed in Indonesia

S.Y. Siswanto[1,2] and F. Francés[1]
[1]Research Institute of Water and Environmental Engineering (IIAMA), Universitat Politècnica de València, Spain
[2]Universitas Padjadjaran, Sumedang, Indonesia

10:15 – 10:30 Rain, snow and floods - possible Rhine flow regime changes

B. Boessenkool, A. Bronstert and G. Bürger
Institute of Earth and Environmental Science, University of Potsdam, Germany

10:30 – 11:15 Coffee Break

Session 2: Measuring and modelling river floods from the hydrological, sediment transport and channel morphology points of view at different spatial and temporal scales

Chairperson: Dr. José Andrés López-Tarazón

11:15 – 12:00 Floods are no pure water events – measuring and modelling floods with sediments

Prof. Dr. Rutschmann
Chair of Hydraulic and Water Resources Engineering, Department of Civil, Geo and Environmental Engineering, Technical University of Munich, Munich, Germany

12:00 – 12:15 Hydro-geomorphological features of the Braunsbach flood 2016

U. Ozturk[1,2], D. Wendi[1,2,3], A. Riemer[1], A. Agarwal[1,2,3], I. Crisologo[1], J.A. López-Tarazón[1,4,5] and O. Korup[1]
[1]Institute of Earth and Environmental Sciences, University of Potsdam
[2]Potsdam Institute for Climate Impact Research – PIK
[3]Helmholtz Centre Potsdam, German Research Centre for Geosciences - GFZ;
[4]School of Natural Sciences and Psychology, Liverpool John Moores University, Liverpool, UK;
[5]Fluvial Dynamics Research Group, Department of Environment and Soil Sciences, University of Lleida, Lleida, Spain

12:15 – 12:30 Geomorphic response to extreme flood events: the September 2015 event in the Nure and Trebbia river catchments (northern Italy)

V. Scorpio[1], M. Righini[2], S. Crema[3], D. Zoccatelli[4], G. Ciccarese[5], M. Borga[4], M. Cavalli[3], F. Comiti[1], A. Corsini[5], L. Marchi[3], N. Surian[2], F. Filippi[6] and G. Truffelli[7]
[1]Faculty of Science and Technology, Free University of Bozen-Bolzano, Bolzano, Italy
[2]Department of Geo-science, University of Padova, Padova, Italy
[3]CNR IRPI, Padova, Italy
[4]Department of land and Agroforest Environments, University of Padova, Padova, Italy
[5]Department of Chemical and Geological Sciences, University of Modena and Reggio Emilia, Modena, Italy
[6]Agenzia Interregionale per il Fiume Po, Parma, Italy
[7]Emilia Romagna Region, Parma, Italy

12:30 – 12:45 Morphological changes and large wood transport in two steep torrents during a severe flash flood in South-Western Germany

A. Lucía, M. Schwientek, J. Eberle and C. Zarfl
Center for Applied Geosciences, Faculty of Science, Universität Tübingen, Tübingen, Germany

13:00 – 14:00 Lunch

Discussion and Poster Sessions

14:00 – 15:30 Group Discussions

15:30 – 17:00 Poster session / Coffee Break

17:00 End of Plenary

19:30 Joint Dinner

Tuesday, 7th March 2017

Session 3: Evaluation and assessment of current and future river flooding hazards and risks in a global change perspective

Chairperson: Prof. Dr. Annegret Thieken

9:00 – 9:45 **Challenges of dealing with flood hazard and risk under global change conditions**

Dr. Michael Bründl

Head Research Group Avalanche Dynamics and Risk Management, Research Unit Snow Avalanches and Prevention, WSL Institute for Snow and Avalanche Research SLF, Davos Dorf, Switzerland

9:45 – 10:00 **Extreme flows in small alpine catchments under current and future climate conditions: impact of temporal rainfall disaggregation**

K. Breinl[1], G. Di Baldassarre[1] and H. Müller[2]

[1]Uppsala University, Department of Earth Sciences, Uppsala, Sweden

[2]Leibniz Universität Hannover, Institute of Water Resources Management, Hydrology and Agricultural Hydraulic Engineering, Hanover, Germany

10:00 – 10:15 **Surprise – a neglected element in flood hazard and risk assessment**

B. Merz[1,2], S. Vorogushyn[1], U. Lall[3,4], A. Viglione[5] and G. Blöschl[5]

[1]GFZ German Research Center for Geosciences, Section 5.4 - Hydrology, Potsdam, Germany

[2]Institute of Earth and Environmental Science, University of Potsdam, Potsdam, Germany

[3]Columbia Water Center, Columbia University, New York, USA

[4]Department of Earth and Environmental Engineering, Columbia University, New York, USA

[5]Institute of Hydraulic Engineering and Water Resources Management, Vienna University of Technology, Vienna, Austria

10:15 – 10:30 **Urbanization and changing flood risk: a multi-level analysis**

B. Dewals, M. Bruwier, A. Mustafa, P. Archambeau, S. Erpicum, J. Teller and M. Pirotton

Hydraulics in Environmental and Civil Engineering (HECE) & Local Environment Management and Analysis (LEMA), University of Liege (ULg), Liege, Belgium

10:30 – 10:45 **Alpine catchment sensitivities to extreme rainstorm-driven torrential hazards in Styria, Austria**

S. Lutzmann[1,2], K. Schröer[1,3], C. Hohmann[1,3], G. Kirchengast[1,3] and O. Sass[1,2]

[1]FWF DK Climate Change, University of Graz, Graz, Austria

[2]Department of Geography and Regional Science, University of Graz, Graz, Austria

[3]Wegener Center for Climate and Global Change, University of Graz, Graz, Austria

10:45 – 11:15 Coffee Break

Session 4: Catchment management to face river floods in a changing world

Chairperson: Dr. Donal Mullan

11:15 – 12:00 **Hydrologic and geomorphic response to extreme storms in river systems: observations needs for improved risk and basin management**

Prof. Dr. Marco Borga[1], F. Comiti[2], N. Surian[3] and L. Marchi[4]

[1]Department of Land and Agroforest Environments, University of Padova, Padova, Italy

[2]Faculty of Science and Technology, Free University of Bozen-Bolzano, Bolzano, Italy

[3]Department of Geosciences, University of Padova, Padova, Italy

[4]CNR IRPI, Padova, Italy

12:00 – 12:15 The impact of the human-induced deforestation since late middle ages on recent flood magnitudes in the ore mountains

C. Reinhardt-Imjela, R. Imjela, J. Bölscher and A. Schulte
Freie Universität Berlin, Department of Earth Sciences, Applied Geography, Environmental Hydrology and Resource Management, Berlin, Germany

12:15 – 12:30 Geological setting controls on a flood dynamics in lowland natural and embanked rivers (Poland)

G. Wierzbicki[1], P. Ostrowski[1], T. Falkowski[1] and M. Mazgajski[2]
[1]Warsaw University of Life Science - SGGW, Faculty of Civil and Environmental Engineering, Warsaw, Poland
[2]Division of the Measurement and Observation Service in Warsaw, Institute of Meteorology and Water Management – National Research Institute IMGW-PIB, Warsaw, Poland

12:30 – 12:45 Hydromorphological effects of an open stone ramp on flood events in the Saalach river

M. Reisenbüchler, M. D. Bui, D. Skublics and P. Rutschmann
Chair of Hydraulic and Water Resources Engineering, Department of Civil, Geo and Environmental Engineering, Technical University of Munich, Munich, Germany

12:45 – 13:00 River flood risk reduction in mountainous basins in Poland

Z. W. Kundzewicz
Institute for Agricultural and Forest Management, Polish Academy of Sciences, Poznan, Poland

13:00 – 14:00 Lunch

Discussion and Poster Sessions

14:00 – 15:30 Group Discussions

15:30 – 17:00 Poster session / Coffee Break

17:00 End of Plenary

Wednesday, 8th March 2017

Chairperson: Dr. Theresia Petrow

Session 5: Extra session on Flash Floods

9:00 – 9:45 A forensic hazard analysis of an extreme flash flood, 29th May 2016, in SW Germany

Prof. Dr. Axel Bronstert[1] A. Agarwal[1,2], B. Boessenkool[1], M. Fischer[3], M. Heistermann[1], L. Köhn-Reich[1], T. Moran[3], D. Wendi[1,4]
[1]Institute of Earth and Environmental Science, University of Potsdam, Potsdam, Germany
[2]Research Domain transdisziplinäre Konzepte und Methoden, Potsdam-Institut für Klimafolgenforschung
[3]Institut für Meteorologie, Freie Universität Berlin
[4]GFZ German Research Center for Geosciences, Section 5.4 – Hydrology, Potsdam, Germany

9:45 – 10:30 What can we know about future short-term heavy rainfall?

Prof. Dr. Gerd Bürger[1,2]
[1]Institute of Earth and Environmental Science, University of Potsdam, Potsdam, Germany
[2]Institute of Meteorology, Free University of Berlin, Berlin, Germany

10:30 – 11:15 Coffee Break

11:15 – 12:30 Discussion Plenary: put together previous discussions, outcomes drafting

12:30 – 13:00 Synthesis of symposium

13:00 End of symposium

Posters

Session 1: Modelling global change at relevant spatial and temporal scales

1.- Reanalysis on daily discharge in snow dominant region considering uncertainty in snow measurement
S. Kim[1], Y. Tachikawa[1] and E. Nakakita[2]
[1]Graduate School of Engineering, Kyoto University
[2]Disaster Prevention Research Institute, Kyoto University

2.- Understanding future projected changes and trend in extreme hydro-climatic events in selected Norwegian and Polish catchments
H.K. Meresa, R.J. Romanowicz and J.J. Napiórkowski
Institute of Geophysics, Polish Academy of Sciences, Warsaw, Poland

3.- Global hydrological cycle and river discharge trends
B. Nurtaev
Institute of Helioclimatology, Germany

4.- Detection of flood trends in the North-Western Pakistan from 1961 to 2013
M.N. Anjum[1,2], Y. Ding[1,2], D. Shangguan[2] and M.W. Ijaz[3]
[1]Division of Hydrology Water-Land Resources in Cold and Arid Regions, Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences, P.R. China
[2]State Key Laboratory of Cryospheric Science, Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences, P.R. China
[3]United States-Pakistan Centre for Advance Studies in Water, Mehran University of Engineering and Technology, Pakistan

5.- Framework for a semi-automatic calibration of a hydrological model on the mesoscale for the analysis of climate change impacts on hydrological extreme events
F. Willkofer, R.R. Wood, F.J. Schmid, F. von Trentini and R. Ludwig
Department of Geography, Ludwig-Maximilians-Universität, Munich, Germany

Session 2: Measuring and modelling river floods from the hydrological, sediment transport and channel morphology points of view at different spatial and temporal scales

1.- Assessing hydrological modelling in a Mediterranean temporary river at event scale
J. Fortesa[1], J. García Hernández[2], A. Calsamiglia[1], J. Fluixá[2], J. García-Comendador[1], N. Lerma[3] and J. Estrany[1]
[1]Department of Geography, University of the Balearic Islands, Palma, Spain
[2]Centre de Recherche sur l'Environnement Alpin, CREALP, Sion, Switzerland
[3]Instituto de Ingeniería del Agua y Medio Ambiente, Universitat Politècnica de València

2.- Application of 2D modelling of gravel-bed river flow dynamics, during high discharge, for reference condition assessment (a case study from upper Wisłoka, Beskid Niski mts, S Poland)
D. Giriat[1], K. Kulesza[2], A. Strużyński[3] and M. Wyrębek[4]
[1]Department of Geomorphology, Institute of Physical Geography, University of Warsaw, Warszaw, Poland.
[2]Institute of Meteorology and Water Management - National Research Institute, Board of Water-Management Systems, Kraków, Poland
[3]University of Agriculture in Kraków, Department of Hydraulic Engineering and Geotechnics, Kraków, Poland.

3.- Analysis of turbulent flow characteristics around the bar in a braided river model
M.A. Khan and N. Sharma
Department of Water Resources Development and Management, IIT Roorkee, India.

4.- Geomorphic disasters for Alawsag valley in Jalawla city\Iraq
H. M. Majed
College of education for humanities sciences, Geography Dep., University of Dyala, Iraq

5.- Tree rings as a source of data on flood occurrence and water levels in small ungauged catchments (Sudeten mts., Poland and Czech republic)
I. Malik, M. Wistuba and D. Absalon
University of Silesia in Katowice, Faculty of Earth Sciences, Sosnowiec, Poland

6.- Assessment of the morphological evolution of a river reach by means of numerical simulation, the river Ésera in Perarrúa (Spain)
B. Nácher-Rodríguez[1], F.J. Vallés-Morán[1], A. Balaguer-Beser[2], G. Lobera[3], J.A. López-Tarazón[3,4,5], D. Vericat[3,6] and R.J. Batalla[3,6,7]
[1]Research Institute of Water and Environmental Engineering. Universitat Politècnica de València, Valencia, Spain
[2]Department of Applied Mathematics. Universitat Politècnica de València, València, Spain
[3]Fluvial Dynamics Research Group –RIUS, University of Lleida, Lleida, Catalonia, Spain
[4]Institute of Earth and Environmental Science, University of Potsdam, Potsdam, Germany
[5]School of Natural Sciences and Psychology, Liverpool John Moores University, Liverpool, UK
[6]Forest Sciences Centre of Catalonia, Solsona, Catalonia, Spain
[7]Catalan Institute for Water Research, Girona, Catalonia, Spain

7.- Debris floods and mass movements of diverse magnitude and frequency in an inhabited high-mountain environment (Sichuan, China) – A tree-ring based hazard assessment
M. Wistuba[1], I. Malik[1], Y. Tie[2], P. Owczarek[3], B. Woskowicz-Ślęzak[1] and K. Łuszczyńska[1]
[1]University of Silesia in Katowice, Faculty of Earth Sciences, Sosnowiec, Poland
[2]China Geological Survey, Chengdu Center, Chengdu, China
[3]University of Wrocław, Institute of Geography and Regional Development, Wrocław, Poland

Session 3: Evaluation and assessment of current and future river flooding hazards and risks in a global change perspective

1.- Integrated analysis of rainfall-runoff and flood inundation by the RRI model in the Chikusa river basin
K. Yamamoto[1], T. Sayama[2], K. Takara[2], A. Konja[3] and Y. Nakamura[3]
[1]Department of Civil and Earth Resources Engineering, Kyoto University, Kyoto, Japan
[2]Disaster Prevention Research Institute, Kyoto University, Uji, Japan
[3]Mitsui Consultants Co., Ltd.

2.- Simulation of flash floods in small catchments using a robust shallow water model
F. Tügel[1], I. Özgen[1], A. Hadidi[2], U. Tröger[2] and R. Hinkelmann[1]
[1]Chair of Water Resources Management and Modeling of Hydrosystems, Technische Universität Berlin, Berlin, Germany
[2]Technische Universität Berlin, Zentralinstitut El Gouna, El Gouna, Egypt

3.- Construction and uncertainty of synthetic design hydrographs for mountainous catchments
M.I. Brunner[1,2], A. C. Favre[2], J. Seibert[1] and A. Sikorska[1]
[1]Department of Geography, University of Zurich, Zurich, Switzerland
[2]Université Grenoble-Alpes, Grenoble INP, LTHE, Grenoble, France

4.- A retrospective damage analysis for the flash flood in Braunsbach on May 29th, 2016

K. Vogel[1], J. Laudan[1], T. Sieg[1,2], V. Rözer[2] and A.H. Thieken[1]
[1]Institute of Earth and Environmental Science, University of Potsdam, Potsdam, Germany
[2]GFZ German Research Centre for Geosciences, Department of Hydrology, Potsdam, Germany

Session 4: Catchment management to face river floods in a changing world

1.- Contemporary gravel-bed channel modification – the effect of flood frequency change and catchment afforestation (a case study from the Upper Wisłoka, Beskid Niski mts., S Poland)

D. Giriat[1], E. Gorczyca[2] and M. Sobucki[2]
[1]Department of Geomorphology, Faculty of Geography and Regional Studies, University of Warsaw, Warsaw, Poland
[2]Department of Geomorphology, Institute of Geography and Spatial Management, Jagiellonian University, Kraków, Poland

2.- Analysis of decentralised flood retention capabilities in the catchment of the Natzschung river (central Ore mountains) using the rainfall-runoff model NASIM

J. Bölscher[1]
[1]Freie Universität Berlin, Institute of Geographical Sciences, Berlin, Germany

3.- Geomorphological based methodology and regulation proposal for risk classification in torrential areas

S. Riba[1,2,3], J. Altimir[2,3] and V. Medina de Iglesias[1]
[1]Escola Tècnica Superior d'Enginyers de Camins, Canals i Ports de Barcelona, Universitat Politècnica de Catalunya, Barcelona, Spain
[2]Euroconsult, Andorra la Vella, Andorra
[3]Nivorisk, Ordino, Andorra

4.- The FLUMEN soil erosion modelling framework to assess mountain catchments

M. Märker[1], S. Chalov, M. Habl, J. Jarsö, I. Rellini, C. Conoscenti, T. Popusoi, N. Christi, Y. Andreychuk, V. Hochschild, R. Zakerinejad, A. Tsyplekov, O. Yermolaev, and FLUMEN consortium
[1]Earth and Environmental Department, University of Pavia, Pavia, Italy

5.- Causal factors genesis of floods in the souss river watershed and mapping flood hazard using GIS

B. Bouaakkaz and Z. El Morjani
Taroudant Poly-Disciplinary Faculty, Ibn Zohr University of Agadir, Agadir, Morocco

6.- Prioritizing mountainous watersheds in Indian Himalayas based on gross soil erosion and geomorphologic parameters

A. Kumar and K. Kumar
Department of Soil and Water Conservation Engineering, College of Technology G. B. Pant, University of Agriculture and Technology, Uttarakhand, India

7.- Geomorphological evolution of a river reach after a high intense gravel-mining operation

J.A. López-Tarazón[1,2,3], G. Lobera[3], D. Vericat[3,4] and R.J. Batalla[3,5]
[1]Institute of Earth and Environmental Science, University of Potsdam, Germany.
[2]School of Natural Sciences and Psychology, Liverpool John Moores University, Liverpool, UK.
[3]Fluvial Dynamics Research Group, University of Lleida, Lleida, Catalonia, Spain.
[4]Forest Sciences Centre of Catalonia, Solsona, Catalonia, Spain
[5]Catalan Institute for Water Research, Girona, Catalonia, Spain

ORAL PRESENTATIONS

DOWNSCALING FUTURE CLIMATE SCENARIOS FOR IMPACT ASSESSMENT

Dr. Donal Mullan

School of Natural and Built Environment, Queen's University Belfast, Northern Ireland, UK

Despite the ever-increasing spatial resolution of global climate models (GCMs), their output remains too coarse to be applied directly to impact models for a range of sectors. For example, hydrological applications typically require information at the catchment-scale, while some applications such as soil erosion and crop growth – where point-scale processes dominate – require information at a site-specific scale. Downscaling techniques are used to bridge this gap between what GCMs provide and what impact modellers require. A range of downscaling options exist – from dynamical approaches involving the nesting of a regional climate model within a host GCM to more computationally inexpensive statistical downscaling (SD) techniques involving the development of statistical relationships between climate at the GCM scale and the local climate. This keynote will focus on the utility of these SD techniques in the context of climate impacts modelling, by (1) reviewing the advantages and limitations of various SD options; and (2) providing some case studies of SD applied to various impact sectors. It is intended that the keynote will help illustrate the benefits and drawbacks of applying various SD techniques to a range of impact sectors.

FLUVIAL GEOMORPHOLOGY IN ABANDONED MOUNTAIN LANDSCAPES: PISUERGA HEADWATERS, SPAIN

A. Pisabarro

Department of Geography. University of Valladolid, Spain

The Atlantic mountains of Spain joined to the nearby interior lands, are suffering a strongly landscape change due to an intensive emigration to the big cities since middle of XX century. This landscape change is based on the transformation of cultivate fields and grasslands to unclear forest and shrubs which is getting a decrease in the runoff and a change in the morphodynamical behaviour of the creeks in headwaters. This key impact, however, should be pondered with the role of climate change in a mountain with fast variable atmospheric situations between years with intense and variable snowfalls and rainfalls without negative tendency and with the fact of an increase in temperatures. With this background, the research aims to know exactly the impact of the landscape transformation over the fluvial system.

The global methodology consists in monitoring a catchment of 233 km^2 with approximately 2 habitants/km^2 in a geo-historical perspective of the concept of “global change” where is possible to advertising the diachronic evolution in land use and land covers while old manuscripts, photointerpretation and remote sensing. The climatic parameters have been studied through meteorological stations and historical data, and the hydrological response along the times is read through well-known techniques in sedimentology on the banks, landscape interpretation and discharge data. Recently the hydrological response and the sediment yield has been interpreted with rhythmites in the bottom of a reservoir downstream. Besides, has been studied the different behaviour between the valleys in the Pisuerga headwaters with the mentioned perspective geo-historical.

The results show that the river morphology of the rivers is being affected by the decrease in runoff; e.g. narrowing of channels, banks stabilization, growth of riverbank vegetation or reduction in sinuosity. Also, the volume and grain-size of sediment transported is descending in the last two decades with less extreme floods than ever meanwhile organic matter inside the flow is rising.

FLOOD AND SEDIMENT HAZARD ESTIMATION BASED ON LAND USE CHANGES IN A TROPICAL WATERSHED IN INDONESIA

S. Y. Siswanto[1,2], F. Francés[1]

[1] Research Institute of Water and Environmental Engineering (IIAMA), Universitat Politècnica de València, Spain
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The high precipitation amounts over tropical watersheds drive the hydrological process and create high rate of overland flow as a driving factor for floods, erosion in the uplands and sedimentation in the lower areas, including the siltation of reservoirs. The Citarum Hulu watershed is located in West Java, Indonesia and drains into the Saguling reservoir. The region is very vital and reservoir is a strategic infrastructure in the region for urban and industrial water supply and hydroelectricity production. However, flood hazard often happens followed by severe erosion and sedimentation. The catchment has suffered significant land use changes since the mid of the last century and our hypothesis stated that the change of land use creates a high influence in water, flood and sediment cycles.

In order to shed more light on the problem, a distributed hydrological-sediment model, called TETIS, has been implemented at a daily time step of hydro meteorological data series from 1985 to 2014. The needed parameter maps were estimated using a GIS, taking into account the three different historical and three scenarios of land use maps. The calibration of the hydrological sub-model was done using the parameter maps corresponding to the 2009 land use for the period 2008-2010 (with one year for warming up the model), resulting in a final Nash-Sutcliffe efficiency index NSE=0.81. For the validation, we used two different periods (2012-2014 and 1994-1996, corresponding to the 2014 and 1994 land use maps respectively), giving NSE= 0.52 and NSE= 0.45 respectively. Three historical land uses (corresponding to years 1994, 2009 and 2014) and three scenarios (conservation, Indonesian government plan and natural vegetation) have been implemented into a model. The return period of flood quintiles were calculated by the Maximum-Likelihood-method with the AFINS-Tool. Annual historical bathymetries in the reservoir were used to calibrate and validate the sediment sub-model involving Miller's density evolution and trap efficiency of Brune's equation. The error volume for the sediment sub-model validation was recorded only 2.5%.

The implemented model of land use change shows that those are influencing the water cycle, flood quantile and sedimentation. Due to the reduction of forest area, the actual evapotranspiration has been reduced 11.0% from the 1994 to the 2014 scenario, increasing mainly the overland flow (17.5%). It increases the water yield from 853.8 mm/year to 963.6 mm/year. Gumbel quantile estimation showed the best result for predicting the return period of flood quantile in the study area with decreasing of 5.3-7.4 % for return periods of 5 to 100 years for the land use change 1994 to 2009. Meanwhile the changes in land use 1994 to 2014 showed a decreasing of 5.7 to 7.90% for the same return period. Flood quantile estimation of three land use scenarios showed the decreasing of maximum flood occurrence of about 2.24 to 30.71% compared to 2014 land use. The sediment yield increment was recorded from 3,354,321 ton/year for the 1994 scenario to 4,410,699 ton/year for the 2014 land use scenario (14.5 and 19 ton/Ha/year respectively). This increment will decrease the expected life of the reservoir from 243 to 185 years.

RAIN, SNOW AND FLOODS - POSSIBLE RHINE FLOW REGIME CHANGES

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The seasonality of large floods in the Rhine is changing. In the alpine nival regime, snow melt floods occur earlier in the year and in the pluvial middle-Rhine regime, rain flood magnitudes rise. Each flood type is currently separated in time, but they may overlap in the future due to climate change. Such a concurrence could create a new type of hydrologic extremes with disastrous consequences. The aim of the research project is to quantify the probability for a future overlap of pluvial and nival floods. We are setting up the multiscale Hydrological Model (mHM) for the Rhine catchment and plan to run it with stochastically downscaled temperature and rainfall extremes from climate model weather projections. So far, we have visualized past changes in flood seasonality along gauges at the Rhine and large tributaries. The results indicate that it is indeed relevant to examine flow regime changes in more detail.

FLOODS ARE NO PURE WATER EVENTS – MEASURING AND MODELLING FLOODS WITH SEDIMENTS

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Most of the more dimensional numerical flood computations do not consider sediment transport even though changes of the river bed, local erosion and deposition play a crucial role on flow capacities of river cross sections. Reasons for not considering these effects are manifold: Lack of appropriate tools, lack of knowhow, long computation times, difficulties with boundary conditions etc.

My presentation highlights the possibilities and necessities of numerical tools using classical concepts with empirical sediment transport equations. A model system, which combines flow calculation with graded sediment transport and bed level change, has been applied for flood management at the Danube, Inn or Saalach and also for fish habitat improvement at the Rhine River between Lake of Constance and Basel. For large areas and long-term modelling it is necessary to improve computational capacities using High-Performance-Computing techniques like planned for the “Wasser-Zukunft-Bayern” project combining hydrologic and hydraulic models for the entire region of Bavaria and in a very high spatial and temporal resolution.

However, one has to state that empirical relations used in such approaches are a week point. Most of these relations were derived years ago in flumes using cross-sectionally averaged flow quantities. Alternatively, instead of such relations sediment transport could be modelled using artificial neuronal networks (ANN) in various forms. Results are presented using various ANN approaches, they are compared and conclusions are drawn. However, ANNs are not only capable of mimicking sediment transport but they are also capable of replacing continuum approaches for flow computations with considerable speed up times. In addition, computations are very much dependent on suitable boundary conditions and these can very well be computed using ANN.

Finally yet importantly measuring techniques for physical model studies are presented which allow to measure bed levels during physical model operation with very high spatial resolution and with high measuring frequency.

HYDRO-GEOMORPHOLOGICAL FEATURES OF THE BRAUNSBACH FLOOD 2016

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Following an unusual heavy precipitation on 29th May 2016 with a total precipitation of 105 mm fallen in just one day, intense rainfall events in southern Germany led to severe flash floods and debris flows in several municipalities in the German federal state of Baden Württemberg. Especially south-western German town of Braunsbach witnessed flood outburst with massive amounts of rubbles and muddy sediments. This flash flood, as the combination of surging water with 42,000 m^3 of sediment, sourced by 48 landslides, remarkable river bank erosion and river bed incision, was responsible of smashing numerous buildings, cars and town facilities, leaving residents with damage and losses. As a response to the significance of the event, members of the research training group NatRiskChange formed a task force team in order to portray the overall picture of the disaster. The present analysis emphasizes on the hydro-geomorphology, in which comparisons of the event and study catchment is made in contrast to similar past events and regional catchments. They include the estimation of removed sediments/materials, meteorological overview and the assessment hydro-geological characteristics.

GEOMORPHIC RESPONSE TO EXTREME FLOOD EVENTS: THE SEPTEMBER 2015 EVENT IN THE NURE AND TREBBIA RIVER CATCHMENTS (NORTHERN ITALY)

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The occurrence of large floods often leads to sudden channel changes, which in inhabited areas determine damages and casualties. Nonetheless, few worldwide studies are relating the magnitude of channel modifications to the potential controlling factors. This study analyses the geomorphic response of the Nure and Trebbia rivers (northern Apennines; catchment areas 467 and 1085 km^2, respectively) and 21 tributaries to a high-magnitude flood, which took place on 14th September, 2015. Spatial distribution of rainfall showed that the highest amounts and intensities (up to approximately 330 mm in 9 hours and 100 mm in 1 hour) were located in the upper sectors of the catchments. The peak discharge of the Nure River, evaluated at the village of Farini (middle-higher sector), was approximately 1800 m^3/s (unit peak discharge of 8.82 m^3 s^{-1} km^{-2}), which corresponds to a return period exceeding 300 years. As a consequence, a large number of shallow landslides coupled with the channels occurred.

The approach to flood analysis encompassed: (i) hydrological and hydraulic analysis of the flood event; (ii) analysis of sediment delivery to the channel network by means of landslides mapping; (iii) assessment of morphological modifications of the channels, including both channel width (through multi-temporal orthophotos) and bed elevation (by comparing post-event LiDAR and pre-event cross-sectional surveys).

In the main river channels, the most important effects were channel widening and bed aggradation. Channel widening occurred to the detriment of islands and floodplains. The assessment, in the Nure River, of the ratio between post-flood and pre-flood channel width resulted in a range from 1.13 to 5.2. Reaches with limited or null channel width modifications were characterized by higher lateral confinement by resistant bedrock. Mean bed elevation variation was 0.9 m on average, with a maximum value of 1.8 m. Areal and elevation changes showed a good correlation, as reaches affected by higher sedimentation were also those featuring intense widening. Most of the tributaries were affected by notable widening, with channel width ratio ranging from 1.4 to 6.1. Preliminary results on the relation between the width ratio and the unit stream power show that the minimum stream power required to cause widening turns out to be about 1000 Wm^{-2}. Widening was more intense in the channels that were narrower prior to the event. Also, the increase in channel width is positively correlated with average slope and with the diameter of the larger boulders transported during the flood. Overall, the magnitude of channel changes display a reduction moving from the lower order channels to the main channels, and within these latter, moving downstream.

This study shows that an integrated approach encompassing different methods and types of evidence provides fundamental information for understanding of geomorphic effects induced by intense flood events and exploring relationships between morphological changes and controlling factors. In term of hazard, outcomes of this study can be used to support planning along river corridors, especially considering future climatic scenarios and the relevant increase in frequency and magnitude of floods.

MORPHOLOGICAL CHANGES AND LARGE WOOD TRANSPORT IN TWO STEEP TORRENTS DURING A SEVERE FLASH FLOOD IN SOUTH-WESTERN GERMANY

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According to current climate models that predict a change in global precipitation patterns temperate areas will experience intensified rainfalls increasing the probability of extreme rain events. These may result in flash floods that are locally exceptional and difficult to monitor effectively with classical monitoring techniques. Therefore, post event surveys are key for understanding of the underlying processes and driving factors.

This work presents a post event survey study, addressing the geomorphic response, sediment and large wood budget of two torrents, Grimmbach and Orlacher Bach, in south-western Germany, state of Baden-Württemberg, that were affected by a flash flood on May 29, 2016. The rivers are located in the region of the South German Scarplands, and are two adjacent tributaries of the Kocher river. The Kocher river is incised 200 m deep in a Triassic limestone plateau, and the two studied tributaries form steep valleys that erode into the right slope of the Kocher valley. During the event a large amount of wood (1200-3000 m^3) was deposited at the outlet of the Grimmbach catchment which clogged and damaged a bridge of a cycling path, while Orlacher Bach flows directly through the small town of Braunsbach which was devastated during the event. The severity of the event in these two small catchments (30.0 km^2 and 5.95 km^2, respectively) is remarkable in drainage areas with a relatively low average slope (10.7 and 12.0%, respectively).

In order to gain a better understanding of the driving forces during this flood event an integrated approach was applied, including (i) an estimate of peak discharges, (ii) an analysis of changes in channel width by comparing available aerial photographs before the flood with our aerial surveys with an Unmanned Aerial Vehicle right after the flood and validation with field observations, (iii) a detailed mapping of landslides and analysis of their connectivity with the channel network, (iv) an analysis of the amounts of large wood recruited and deposited in the channel and finally, (v) an attempt to analyse the sediment budget from the landslides, incision and accumulation along the fluvial network.

Preliminary results show high unit peak discharges ranging from 13.6 to 22.6 $m^3 s^{-1} km^{-2}$ in the Grimmbach while Bronstert et al. (submitted) estimated 20 $m^3 s^{-1} km^{-2}$ in the Orlacher Bach. The studied channels have dramatically changed their geometry, with considerable incision and landslides in the Orlacher Bach catchment and widening up to 15 m, from 2 to 4 m in its initial width. In the Grimmbach catchment landslides are more frequent in the upper reaches, while widening, up to 70 m (4-10 m pre-event channel width), is remarkable in the lower reaches. This generated a vast amount of large wood recruitment which is deposited not only at the catchment outlet but along the entire channel.

The results of this study show that the crucial roles of sediment availability as well as large wood dynamics during extreme events have to be taken into account for a management of similar catchments in the region, especially to prevent interactions with infrastructures.

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CHALLENGES OF DEALING WITH FLOOD HAZARD AND RISK UNDER GLOBAL CHANGE CONDITIONS

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In the last years, several flood events have caused considerable damage and fatalities both in Europe and worldwide. The intensity and the rapid onset of extreme runoff of even small streams during recent events have surprised experts and authorities alike as well as the affected population. In the special report SREX of the IPCC and state-of-the-art literature it is argued that frequency and intensity of extreme hydrological events is likely to increase rather than decrease due to rising air temperature and changing precipitation patterns with strong regional variations.

In Switzerland, a set of climate scenarios was developed in the CH2011 project in order to have a common basis for assessment of climate change impacts. The CH2014 project subsequently analysed the impact of these climate scenarios on cryosphere, hydrology, biodiversity, forests, agriculture, energy and health. In other studies, the CH2011-scenarios were taken as input for example to quantitatively evaluate the consequences of increased flood risk on economic sectors. The results of these analyses form the basis for the climate change adaptation strategy, which has been developed in Switzerland during recent years.

However, it is still a scientific challenge to judge the effects of temperature and precipitation changes on natural hazard processes. The formation of flood processes in mountain catchments depends on a variety of factors such as terrain characteristics, the availability of loose material, the degree of weathering, the degradation of permafrost, the amount of melt water or the seasonal distribution of precipitation as rain or snow. In a recent study, the sensitivity of natural hazard processes to the CH2011-scenarios was evaluated. The results show for example that the frequency of small, medium and large flood events may be expected to increase in most parts of Switzerland except in certain areas of the Jura region, where a decrease is likelier.

Dealing with these expected changes poses a challenge for the affected societies. The integrated risk management approach considering prevention, intervention and recovery sets a path to sustainably deal with global change processes. The occurrence of damage events in the last decades has induced several improvements in flood risk management, which can be interpreted as a learning process of the authorities and affected societies. Some of these improvements will be presented and discussed in the light of climate and socio-economic changes which can be expected in future. The presentation concludes with some issues that should be tackled in order to increase the resilience of societies to floods and other hazard processes in the future.

EXTREME FLOWS IN SMALL ALPINE CATCHMENTS UNDER CURRENT AND FUTURE CLIMATE CONDITIONS: IMPACT OF TEMPORAL RAINFALL DISAGGREGATION

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The assessment of low-frequent extreme flows is often achieved by coupling a weather generator with hydrological modelling. Weather generators at daily resolution are established tools for extrapolation of observations and come along with advantages compared to the direct generation at sub-daily time series. However, hydrological modelling in small and medium catchments requires weather time series of sub-daily resolution, for example hourly resolution. One strategy to overcome this problem is a combination of a daily weather generator and temporal disaggregation techniques. A method for the disaggregation of daily rainfall is the multiplicative random cascade model. The idea behind this model is that rainfall from a coarse time step is disaggregated into *b* finer time steps, where *b* is the branching number determining the number of finer time steps. The rainfall volume is conserved exactly during the disaggregation process. Starting from daily resolution with *b* = 2, hourly time series cannot be achieved. For this reason Lisniak et al. (2013) changed the first disaggregation step to a branching number of 3, meaning the first split provided 3 x 8 hours. The possibility for the split in this disaggregation step includes seven possibilities with three weighing factors. These seven possibilities were changed into a low parameter version by Müller and Haberlandt (2015) called “uniform splitting” to avoid over-parameterization, where the number of wet boxes was kept but the position was randomly assigned. The rainfall was then distributed uniformly according to the number of wet boxes. In addition, the parameters for multiplicative random cascade models often differ significantly for higher and lower rainfall volumes, which is why the parameters are typically derived below and above a threshold at each disaggregation level, which was the mean of the rainfall volume in Müller and Haberlandt (2015). In this research, the impact of the first

disaggregation step into 3 x 8 hours with increased (Lisniak et al., 2013) and reduced parameters (Müller and Haberlandt, 2015) as well as different volume thresholds on the characteristics of generated extreme flows (peak, timing, hydrograph) is examined using the conceptual HBV model to simulate the hydrologic behavior of Alpine catchments in Tyrol and South Tyrol with areas between 60km² and 150km². In addition to the observed period, the daily weather generator is parameterized with output from EURO-CORDEX RCMs to examine the rainfall disaggregation on projected extreme flows, likewise considering the different versions of the multiplicative random cascade model.

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SURPRISE – A NEGLECTED ELEMENT IN FLOOD HAZARD AND RISK ASSESSMENT

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Unexpected incidents, failures and disasters are abundant in the history of flooding events. We argue that surprise is a neglected element in flood hazard and risk assessment. Two sources of surprise are identified: (1) the complexity of flood risk systems, represented by non-linearities, interdependencies and non-stationarities, and (2) cognitive biases in human perception and decision making. Flood risk assessments are particularly prone to cognitive biases due to the rarity and uniqueness of extremes, thus impeding validation. We reflect on possible approaches to better understanding and reducing the potential for surprise and its adverse consequences. It is concluded that flood risk assessment should account for the potential for surprise and devastating consequences.

ALPINE CATCHMENT SENSITIVITIES TO EXTREME RAINSTORM-DRIVEN TORRENTIAL HAZARDS IN STYRIA, AUSTRIA

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Torrential processes in steep alpine headwater catchments pose one of the most frequent risks in the densely populated alpine region. They tend to be triggered during heavy and highly localized rainstorm events. In view of rapid global change, concerns exist on how intensified water cycles might affect sediment flows in mountain channels. However, the geomorphic response of torrent systems to external drivers is strongly mediated by the systems' internal configuration and conditions.

This study aims at investigating critical spatial controls of torrent catchment sensitivities on a regional scale for the Eastern Alps in Styria, Austria. In an interdisciplinary, holistic approach – crucial for understanding water-sediment flow dynamics – we analyze the function of climatic, hydrologic and geomorphic system components.

A Styria wide database of torrential events dating back to the 1950's is investigated. Based on statistical methods and GIS modelling, we assess the ability of multiple meteo – hydro – geomorphic variables to explain the observed spatial variability of torrent hazard magnitude and frequency distributions for catchment units as designated by the Austrian Torrent and Avalanche Control Service. Catchment – internal, bottom up conditions like relief, channel network (e.g. stream power, drainage density, hydrologic reaction time), sediment availability (e.g. glacial valley fillings), soil characteristics and vegetation cover are quantified. Lithologic and climatic top-down constraints across catchments affect torrent stability on a larger scale. Long-term regional rainfall characteristics are deduced from daily precipitation station data of the Austrian Meteorological Service.

Grouping catchments into distinct sensitivity classes results in a torrent disposition map for Styria. Applying climate scenarios, changing spatiotemporal distributions of catchments sensitive towards heavier and more frequent precipitation can be determined giving valuable advice for planning and managing mountain protection zones.

URBANIZATION AND CHANGING FLOOD RISK: A MULTI-LEVEL ANALYSIS

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Landuse change, particularly urbanization, influences flood risk through multiple pathways, including climate (e.g., modified evapotranspiration), runoff in the catchment (reduced infiltration), inundation flows (obstruction by buildings) and flood exposure (higher value of elements-at-risk in the floodplains). Most studies so far considered only a subpart of these processes; but they failed to give a more holistic view of the impacts of urbanization on future flood risk. In the research presented here, we investigate the influence of urbanization at multiple levels: i) agent-based landuse modelling is coupled to hydrological modelling at the catchment level to capture the influence of urbanization on runoff production and routing; ii) following a stochastic approach, hydraulic modelling at the level of urban districts enables the evaluation of increases in flood levels due to flow obstruction by buildings for a high numbers of computer-generated urban patterns; iii) for multiple urban expansion scenarios, damage modelling at the floodplain level is used to derive the resulting changes in flood risk.

In the presentation at the workshop, we propose to focus on item 2, which gives valuable insights into the influence of small-scale spatial patterns on future flood risk. The main goal of this specific research line is to clarify how flow properties are influenced by the characteristics of urban patterns such as road width, orientation or curvature. These geometric factors may influence the discharge partition between the roads as well as the flow depths and velocities, both within the considered urban area as well as upstream and downstream. We considered nine factors controlling the urban pattern: average road length, road base orientation, road curvature, major and secondary road widths, open space ratio, parcel mean area, building setbacks, and built-up coverage. A set of 2,000 alternate urban patterns was generated randomly using an urban procedural model. This model provides the shape of roads, parcels and buildings with their geometry and relative location to the ground, over a square area of 1 km².

Steady 2-D hydraulic computations were performed for these 2,000 different urban patterns with identical hydraulic boundary conditions. The computation time was reduced by using a sub-grid model technique. This model uses relatively coarse computational cells; but preserves information from the detailed topographic data through the use of anisotropic porosity parameters. This enabled increasing the grid spacing by one order of magnitude while preserving a similar level of accuracy as with a fine mesh. This sub-grid modelling technique was validated against an existing detailed and verified hydraulic model. Based on the computed flow fields for the 2,000 urban patterns, a regression analysis was performed to outline the most influential urban characteristics. The outcomes of this study pave the way for better informed guidelines regarding spatial planning in flood-prone areas.

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HYDROLOGIC AND GEOMORPHIC RESPONSE TO EXTREME STORMS IN RIVER SYSTEMS: OBSERVATIONS NEEDS FOR IMPROVED RISK AND BASIN MANAGEMENT

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The changing frequency and severity of extreme flood events are becoming increasingly apparent over multi-decadal timescales at the global scale, even though confidence in climate risk scenarios is clouded by the confounding effects of hydrological and landscape system dynamics and time-varying factors such as land use changes. Improved flood risk management builds upon disentangling climate change impacts from other controlling factors, thereby contributing to the debate over the need for societal adaptation to extreme events. In this work we focus on the coupled hydrologic and geomorphic controls of flood risk at the catchment scale. Sediment (and large wood) transport events, of both high and low magnitude, have the potential to reshape channel and floodplain topography, thus introducing an additional source of uncertainty in the quantification of flood hazard. However, determining the extent to which such events are actually able to modify channel geometry is rather complex. Indeed, not all the large floods cause major reshaping of the river corridor, whereas relatively low-magnitude, high-frequency floods may result in major morphological changes.

Post-flood surveys designed to integrate interlinked observations of hydrologic response together with sediment and large wood transport provide key data for better understand and predict extreme floods and their morphological responses. In turn, the knowledge of runoff response and morphological effects of the floods may inform improved flood risk management strategies and interventions at basin scale, especially in poorly gauged basins. However, integrated observations of hydrologic and geomorphic responses, and identification of controlling factors, is difficult, even because large geomorphic impacts inject large uncertainties in the post-flood estimation of peak discharges.

Here we revisit lessons learnt from a number of integrated post-flood surveys carried out in Italy in the last five years in gravel-bed rivers draining areas up to approximately 1000 km^2. This provides an opportunity to discuss methods for the integration of observations from post-flood surveys into flood risk management and basin management practice.

THE IMPACT OF THE HUMAN-INDUCED DEFORESTATION SINCE LATE MIDDLE AGES ON RECENT FLOOD MAGNITUDES IN THE ORE MOUNTAINS

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Vegetation is one of the main controlling factors in the system of flood runoff formation in headwater areas. Especially the absence or presence of forests has a substantial influence on the development of surface runoff and peak discharge as well as on the water balance on the catchment scale. In Germany there is a long history of wood consumption, deforestation and forest recovery. Thus the Ore Mountains in Southeastern Germany were covered by natural mixed forests until the 11^{th} century. Deforestation began in the 12^{th} century with the growing mining activities. Mining reached a period of prosperity in the 15^{th} and 16^{th} century accompanied by a substantial shortage of wood caused by the heavy consumption for construction purposes and charcoal production. In the 18^{th} and 19^{th} century large areas were reforested with spruce monocultures. In modern times, i.e. from the 1950s until the political turn in Eastern Germany at the end of the 1980s, these spruces monocultures especially along the main ridge of the mountain chain suffered from severe SO_2 pollution related to mining and industrial activities in the Eger area (Czech Republic) and Eastern Germany. In some regions in the Central and Eastern Ore Mountains such as the forest area Deutscheinsiedel more than 95% of the spruce stands were completely destroyed or damaged.

The knowledge on the hydrological function of forests in the water cycle and the forest history in Germany lead to the question, how the historical deforestation has influenced flood generation and the magnitude of flood peaks in the Ore Mountains. The study is based on a rainfall-runoff modelling of the Upper Floeha River in the Ore Mountains (Free State of Saxony, Southeastern Germany) with the mainly physically-based modelling system WaSiM-ETH. With the calibrated model an extreme flood event was simulated under recent land use conditions using statistical storm rainfall intensities with a return period of 100 years and a duration of 12 hours. Then the event under recent condition is compared with model outputs for scenarios reflecting historical conditions such as the full forest cover in the middle ages and the conditions before the onset of 20^{th} century forest decline.

The simulations reveal a significant impact of large-scale deforestation and forest decline on the magnitude of flood events. Depending on the percentage of forest and the forest type an up to 45% lower peak discharge was observed in the historical scenarios. These results show clearly, that forests are an important element of flood risk management and forest conservancy and land use management are essential to avoid any loss in the water retention in headwater areas.

GEOLOGICAL SETTING CONTROLS ON A FLOOD DYNAMICS IN LOWLAND NATURAL AND EMBANKED RIVERS (POLAND)

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Since 1950 the great acceleration in the economic growth and world population is being observed. This sharp worldwide increase of human activity caused a planetary response of the Earth that is called a global change. European rivers were trained and its floodplains were domesticated a long time before the beginning of global change dated back to the end of World War II. Poland, exactly central and eastern part of the state, is an exceptional case in the problem of human pressure on rivers. Due to history of the country in 19th century (borderland of Russian Empire) and 20th century (soviet economic policy resulting in great investment plans and lack of funds for its implementation) large lowland rivers in Poland have not been regulated and still can be treated as natural comparing to the other big rivers in Western or Eastern Europe that became well-managed inland waterways. However, climate and land use change in Poland is similar to the rest of the continent, therefore the study of the effects of global change on floods and fluvial geomorphology in "wild" rivers can prove very useful for understanding the effects of global change in Europe.

The aim of our study is: (1) read the flood dynamics written in the archive of floodplain morphology by processes of erosion and accumulation of overbank flow during palaeoflood events; (2) explore the geological setting of the river valley focusing on the morphology of suballuvial surface and especially its local elevations under the river channel; (3) analyse the dynamics of the last flood events in the river; (4) determine how geological setting controls on a flood dynamics.

The study area covers 2 reaches of the middle Vistula river valley (150 km upstream from Warsaw and 100 km downstream from Warsaw) and 1 reach of the Big river valley close to the border with Belarus. Both rivers have not regulated channels: meandering and connected to the whole floodplain in the Bug river, braided and embanked from the floodplain in the Vistula river. The methods we have used are: (a) remote sensing including VHR images and LIDAR data for (1) floodplain geomorphology; (b) drilling for (2) geological setting; (c) basic analysis of hydrological data from ADCP measurements and river gauge telemetry as well as geomorphological mapping for the recent flood dynamics, (d) GIS analysis in a large scale for (4) determining the role of geological setting.

The results of our regional study indicate that geological setting controls on the recent flood dynamics. While focusing on the climate change and human impact on rivers we usually forget about the relevance of geological factor. Today that factor still plays so important role as it did in the past before global change.

HYDROMORPHOLOGICAL EFFECTS OF AN OPEN STONE RAMP ON FLOOD EVENTS IN THE SAALACH RIVER

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Man-made structures in the Saalach River produced feedback on the hydromorphological characteristics of the river regime. In some river reaches, the Saalach has lost most of its former typical characteristics of a mountain river with high variation in discharge and sediment transport. Among the negative effects, an extreme flow discharge in combination with the river bed variation can be one of the possible causes of flood disasters along the river. As an example, the heavy and long lasting rainfall in June 2013 led to an enormous flood with a peak discharge of 1100 m^3/s, which was close to a 100-year flood. Currently, the city of Freilassing is not protected against such a flood-event sufficiently.

With the aim of protecting against erosion and keeping the river bed on a defined stable level, in 2005/06 an open stone ramp has been constructed at river kilometre (rkm) 4.6 upstream of the hydropower plant Rott. In order to analyse the stone ramp for hydromorphological consistency and evaluate its influence during flood events, a numerical model for this river stretch has been developed at the Chair of Hydraulic and Water Resources Engineering, TUM. The model concept is based on the computer program TELEMAC-SISYPHE, and extended with our own developments for graded sediment transport in rivers. This task is quite important for a correct representation of river bed armouring and layering. Using the new concept, the transient composition of different bed layers and the exchange processes between them due to fractional sediment transport can be described more sufficiently. The new model provided adequate and stable numerical hydromorphological results.

In this paper, we present fundamentals of the modelling work including the model development, calibration, validation and implementation. Several scenarios have been created to identify critical areas and evaluate countermeasures. Remarks on reducing the water levels in the floodplain and improving the flood protection for Freilassing are also proposed.

RIVER FLOOD RISK REDUCTION IN MOUNTAINOUS BASINS IN POLAND

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Poland is largely a lowland country, albeit with international mountain ranges in the south – the Carpathians (including the High Polish Tatra Mountains with peaks up to 2499 m) and the Sudeten. Precipitation in the mountains is higher than anywhere else in the country, also due to the orographic effect. In the mountainous areas of Poland many river floods have been born. Floods are typically caused by summer precipitation, mostly in June, July and August, but occasionally also in May and September. Short-lasting convective rain of high intensity can lead to a flash flood, while a long-lasting rain of moderate intensity can lead to large-scale flooding. At times, precipitation of a few hundred milimeters falls within a few days and some circulation patterns, e.g. the Vb track, have predisposition to produce high 2-3 day rainfall totals ad flood hazard. Then, huge masses of water may propagate downstreams and cause embankment failures and inundation of extensive areas. Intense precipitation is on the rise in the warming climate and this statement can be ilustrated by observations and even more so – by projections.

Changes in flood risk in mountainous basins in Poland will be discussed. They have been caused by changes in the climatic system, but also by changes in the terrestrial and socio-economic systems. Important land-use changes are related to urbanization and change in forest cover (mostly – increase in forest cover) and development of flood plain areas.

Flood risk reduction is conceived at various scales – from national through regional, to river basin and household level. Flood management strategies embrace preventon, defense, mitigation, preparation and recovery. In Poland, structural defenses have always been dominating. However, most flood damage has resulted from dike failures. Indeed, some hydrotechnical works have magnified rather than reduced the flood hazard. Nevertheless, flood control is clearly necessary to protect developed and urbanized areas.

Some flood runoff regulation effect has resulted from reforestation (afforestation) of basins and increasing water storage, by way of enhancing basin storage (catching water where it falls), channel storage, dams and reservoirs, dry reservoirs, and polders. Construction of flood embankments and channel regulation (straightening, shortening, and narrowing of river beds, as well as conversion of a multi-thread bed to a single-thread bed) results in flood runoff acceleration. Flood embankments and channel regulation decrease sediment supply. Also increase in forest cover and in-channel gravel mining cause sediment starvation of the river. The joint effect observed in mountainous basins in Poland is the river bed incision and erosion, creating risk to roads and bridges. A review of flood risk reduction activities in the mountainous basins in Poland is offered.

A FORENSIC HAZARD ANALYSIS OF AN EXTREME FLASH FLOOD, 29TH MAY 2016, IN SW GERMANY

Prof. Dr. A. Bronstert[1], A. Agarwal[1,2], B. Boessenkool[1], M. Fischer[3], M. Heistermann[1], L. Köhn-Reich[1], T. Moran[3], D. Wendi[1,4]

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The flash-flood in Braunsbach in the north-eastern part of Baden-Wuerttemberg was a particularly concise event of the floods in southern Germany at the end of May / early June 2016. The extreme runoff event with great debris transport caused immense damage in the village. In this presentation, the event is retrospectively analyzed with regard to meteorology, hydrology, geomorphology and damage to obtain a quantitative assessment of the processes and their development. For this purpose, rain station data and radar data from the German Weather Service were analyzed, maximum discharge volumes during the event were estimated, hydrographs of nearby gauging stations were evaluated, volumes of land-slides and deposited debris were estimates and damage to houses were assessed. The results show that it was a very rare rainfall event with extreme intensities, which in combination with catchment properties led to extreme runoff, causing geomorphological hazards, too. Due to the complex and interacting processes, no single flood cause can be identified, since only the interplay of those lead to such an event. The role of different human activities on the origin and/or intensification of such an extreme event is also discussed.

WHAT CAN WE KNOW ABOUT FUTURE SHORT-TERM HEAVY RAINFALL?

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A recent attentional shift away from climate models "back to" basic physics has opened some new avenues towards the problem of present and future short-term heavy rainfall. Because climate models are still incapable of providing reliable sub-daily/hourly processes (physics) and long enough samples (statistics), such assessments are better framed within the basic physical law of Clausius-Clapeyron: The water holding capacity increases exponentially with temperature. What follows from that, what has been done so far, and what can still be expected is discussed in this talk.

POSTER PRESENTATIONS

REANALYSIS ON DAILY DISCHARGE IN SNOW DOMINANT REGION CONSIDERING UNCERTAINTY IN SNOW MEASUREMENT

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This study to improve the accuracy of discharge simulation at the head water of the Tone River Basin (Yagisawa Dam Basin; 167 km^2 and Naramata Dam Basin; 67 km^2), Japan, where the river discharge is governed by the snowmelt and thus much uncertainty was originated in our previous study (Kim *et al*, 2011). To decrease the uncertainty in our hydrological modeling and simulation, snowmelt amounts are estimated rigorously using an improved degree-day method. The degree-day method, which is the simplest method to estimate snowmelt, is adopted with an improved degree-day factor estimation method. The degree-day factor for the target area is estimated using the observed temperature and the observed river discharge of the snowmelt season. Using long-term observed data, the unique relationship between the degree-day factor and temperature are extracted, and the estimated degree-day factor as a function of temperature is applied for the winter season discharge simulation. Rainfall-runoff simulation for the rest of season is done by the kinematic wave model based on the stage–discharge relationship, considering surface–subsurface flow generation. Finally, long-term (1979-2008) simulation output for the dam inflow is reconstructed and compared with the observed one.

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FRAMEWORK FOR A SEMI-AUTOMATIC CALIBRATION OF A HYDROLOGICAL MODEL ON THE MESOSCALE FOR THE ANALYSIS OF CLIMATE CHANGE IMPACTS ON HYDROLOGICAL EXTREME EVENTS

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The ClimEx project (Climate change and hydrological extreme events – risks and perspectives for water management in Bavaria and Québec) focuses on the effects of climate change on hydro-meteorological extreme events and their implications for water management in Bavaria and Québec. It builds on the conjoint analysis of a large ensemble of the CRCM5, driven by 50 members of the CanESM2, and the latest information provided through the CORDEX-initiative, to better asses the influence of natural climate variability and climatic change in the dynamics of extreme events. Furthermore, these 50 members of a single RCM will enhance extreme value statistics (extreme return periods) by exploiting the available 2.800 model years for the reference period from 1950 to 2005.

In order to assess the impact of climate change on the intensity and frequency of hydrological extremes – in our case extreme high flows – the process based, fully distributed and deterministic hydrological model WaSiM is set up for the so called hydrological Bavaria in high spatial (500 m) and temporal (3h) resolution. The hydrological Bavaria (100.000 km²) comprises the Danube and Main river catchments, as well as their major tributaries subdivided into 98 sub-catchments. The calibration towards a good representation of water balance and especially peak flows is a crucial part for the analysis on future development of floods in particular. Hence, WaSiM is calibrated in three steps changing the parameters of the groundwater model, snow model, and the model of the unsaturated zone within their respective physical boundaries. With groundwater affecting the base flow segment of the runoff spectrum, it is calibrated by means of a good low flow representation. The snow model is calibrated towards measurements of snow height and matching the beginning of the melting period. While groundwater and snow are calibrated manually, the parameters of the unsaturated zone are calibrated using the dynamically dimensioned search (DDS) algorithm. In order to receive an overall good model fit for water balance and peak flows the objective function to minimize combines several criteria: the Nash and Sutcliff efficiency (linear and logarithmic - NSE), the Kling-Gupta efficiency (KGE) and the root mean square error to standard deviation ratio (RSR).

UNDERSTANDING FUTURE PROJECTED CHANGES AND TREND IN EXTREME HYDRO-CLIMATIC EVENTS IN SELECTED NORWEGIAN AND POLISH CATCHMENTS

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The aim of the study is to investigate trends in high and low hydro-climatic indices using novel and conventional tools, for future climate projections in the 21st century. Selected quasi natural Norwegian and Polish catchments are used as a case study. The climate change projections are obtained from regional climate models or/and global circulation models forced with RCP4.5 and RCP8.5 emission scenarios. The study catchments have diverse hydro-climatic conditions. The flood regime of all the catchments is driven either by rainfall and/or snow-melt. Streamflow projections are provided by the simulation of the GR4J rainfall-runoff conceptual model, coupled with climate model projections for the catchments. The trends are analyzed using a conventional Modified Mann Kendall statistical approach, a time frequency approach based on wavelet discrete transform (DWT) and the Dynamic Harmonic Regression (DHR) method. We address the problems of auto-correlation, seasonality and inter-annual variability of the derived indices. A Modified Mann Kendall (MMK) method is applied to cope with the autocorrelation of the time series. The DHR method is based on the unobserved component approach. Together with estimates of the components, the uncertainty of the estimates is also calculated. The results of the DHR analysis (trend) are compared with the calculated MMK and DWT trends. Among other indices we study the Maximum Annual Flows and Minimum Annual Flows. The results indicate that changes in trends of the projected indices are the most conservative when DHR methods are applied than conventional trend techniques. The wavelet-based approach is the most subjective and gives the least conservative trend estimates. Trends depend on the catchment flow regime. In rainfall-driven flood regime an increase in the amount of precipitation is followed by increased flows, with strong seasonal changes. In catchments with snow-driven flood regime the decrease in annual floods is observed at the end of the 21st century.

Acknowledgements

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GLOBAL HYDROLOGICAL CYCLE AND RIVER DISCHARGE TRENDS

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The global water cycle is the continuous movement of water on the Earth. Heating of the ocean water by the sun is the key process that keeps the hydrologic cycle in motion. The evaporation of water into the atmosphere requires an enormous amount of energy, which ultimately comes from the sun. The ocean is the heart of the hydrological cycle, holding about 97% of the Earth's water. The large heat capacity of the ocean delays the effect of warming trend in lower atmosphere. Incoming energy enters in Earth's atmosphere 99.97% of the energy that enters our climate system comes from the Sun, 0.025% - geothermal energy, 0.007% - the current world energy consumption equivalent to the incident solar energy. The sun bathes the Earth's equator with enormous amount of solar energy (about 3000 watts/m^2). This energy evaporates ocean water and causes atmospheric convection and is transported polewards by winds.

We compared Total Solar Irradiance with Global Sea Level data over the period of 1700-2008 and have found following relationship: GMSL = 255.1TSI – 34846; r = 0.8, where GMSL-Global Mean Sea Level, TSI-Total Solar Irradiance, r-correlation coefficient. The Rhine River, with runoff formation in the Alps Mountains, show also close link to solar activity. Relationship of the Rhine River (Koeln station) from sunspots over the period 1855-2008: Q Rhine = 0.195W + 56.18; r = 0.83, where- Q Rhine –Rhine River discharge, km^3, W-sunspot number, r- correlation coefficient. Negative relationship was detected between solar activity and the Karun River (Iran) discharge over the period 1913-1986: Q Karun = -0.073W+ 28.77; r = 0.84. Negative relationship was also detected between solar activity and the Yangtze River (China) discharge over the period 1878-1996: Q Yangtze= = -1.328x + 795.64; r = 0.88.

Global Land and Ocean Temperature Anomalies also close depends on solar activity (period of observation 1880-2008): T= 0.007W – 0.470; r = 0.79. In accordance with NASA forecasting the next two solar cycles will be below average in intensity (for the current cycle Sunspot Cycle 24 average number of sunspots have been forecasted as W=35) and for next solar cycle 25 more low. This actually will lead to a decrease of the temperature on 1-1.5 degree in both averaged solar cycles. This temperature decrease will lead to accumulation of water in glaciers and to decrease of the ocean global level.

DETECTION OF FLOOD TRENDS IN THE NORTH-WESTERN PAKISTAN FROM 1961 TO 2013

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Variations in regional hydrological cycle and subsequent shift in river flow regimes are more pronounced consequences of climate change. In recent decades floods have become more frequent and severe in the north-western rivers of Pakistan. Therefore, present study attempts to investigate the prevailing trends in floods from 1961 to 2013 in the Swat and Panjkora river basins, north-western Pakistan. The modified Mann Kendal (MMK) trend test was used over five flood indicators i.e., annual maximum daily discharge (AMD), annual winter maximum daily discharge (AWMD), annual summer maximum daily discharge (ASMD), annual peak over threshold magnitude of largest independent flood event (POT1M), annual peak over threshold magnitudes of largest three independent flood events (POT3M) in order to detect the trends at 5 % significant level. Our analysis identified significant trends in floods in the Kalam sub-basin, which is situated in the northern high altitude region of the Swat Basin. In that sub-basin, the annual and summer floods were decreasing significantly, while winter floods were increasing significantly. A general increasing trend (not field-significant) over all flood indicators on annual as well as seasonal scales was found in rest of the Swat and Panjkora River basins. Furthermore, changes in winter season were larger as compared with summer season. Overall, the flood trends analysis along with its quantification indicates that the Panjkora River basin and southern parts of the Swat River basin bear high flood risks. Thus, watershed managers and policy makers should focus on these areas while devising flood mitigation plans.

ASSESSMENT OF THE MORPHOLOGICAL EVOLUTION OF A RIVER REACH BY MEANS OF NUMERICAL SIMULATION, THE RIVER ÉSERA IN PERARRÚA (SPAIN)

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Nowadays, hydraulic two dimensional numerical models, that are able to evaluate bed evolution, are a powerful tool to simulate sediment transport in alluvial river beds. Once calibrated, this kind of models can be applied to analyse the morphological changes that a river may experience, due to either anthropic action (river restoration projects, river protection works that lead to a new equilibrium state, etc.) or global change effects.

This study aims to evaluate the potential of these models to represent the morphological evolution in a specific case study. That is a reach of the Ésera River, where it flows through the Perrarúa village (Aragon, Spain). In this reach, major morphological changes have occurred, induced and enlarged by a massive extraction of sediments from the river bed, where originally a gravel bar existed. The evolution of the reach, including the incipient formation of a new bar, is studied by means of hydraulic simulation with mobile bed conditions. The software used in this study is the numerical model Iber, which simulates open flows by solving the well-known Shallow Water Equations, coupled to the Exner equation and several sediment transport formulas (for both bedload and suspended sediment transport) to evaluate bed evolution. Therefore, it can be applied to simulate sediment transport processes in rivers and estuaries.

Simulations are performed with the data gathered during the time frame of the Consolider Ingenio 2010 CSD2009-00065 SCARCE Project, funded by the Spanish Ministry of Economy and Competitiveness. During three years, an extensive field work was carried out, to obtain the following data at different time stages: topography and bathymetry, grain-size distribution of the sediment in the studied area, vegetation or land cover, river discharge with corresponding calibration points (water surface elevation), and suspended sediment and bedload transport. All of this information is essential to calibrate and validate the results of the numerical model. First step in this study consists on the analysis of the hydrological discharge series, along the considered time span, in order to detect single flood events that may have cause a significant river sediment mobilization. Hydraulic simulation of these events, altogether with the existing sediment sizes and the critical conditions for the incipient motion of those sizes, can be used to determine which discharges (or hydraulic conditions) do indeed mobilize sediment particles. By doing so, the hydrological series can be filtered, and so only the events exceeding a certain threshold have to be simulated, running the model in a sequential way. Afterwards, the results obtained after long-term simulation periods will be compared with the observed field data, assessing the capabilities of the model to represent the formation of the new bar, where it was originally located.

ASSESSING HYDROLOGICAL MODELLING IN A MEDITERRANEAN TEMPORARY RIVER AT EVENT SCALE

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Hydrology in Mediterranean catchments is characterized by short-lived regimes intrinsically caused by a high inter- and intra-annual precipitation variability and specifically by carbonate lithologies. Rainfall intensity is a key factor for the spasmodic hydrological response in an energetic environment characterized and shaped by severe flash floods. Moreover, antecedent soil moisture conditions play a key role in the runoff because of the irregularity of flow with intense dry periods. In recent decades, changes in land uses have transformed hydrological systems and increased the pressure on the coastal areas of the Mediterranean basin through urban effluents and intensive agricultural activity on flat areas. In its turn, marginal steeper lands on mountainous areas have affected by land abandonment of soil and water conservation structures leading to afforestation. Consequently, the hydrological catchment response was modified and generated a geomorphological change in channels and floodplains. In this context, modelling is required to simulate the hydrologic response under different runoff scenarios within the global change dynamic, especially considering that these processes encompass dangerous natural hazards.

In this study, the observed and predicted discharge during three hydrological years was analysed at event temporal scale using 21 events (with $Q > 0.2$ m^3 s^{-1}) in a small Mediterranean temporary headwater catchment (i.e., 4 km^2). The measured discharge is compared with the predicted one for assessing the capability of the applied semi-distributed hydrological software *RS Minerve* using the *SOCONT* model. General results for model efficiency indicators, ranging 0 to 1 (being 1 the best value), were Nash 0.58 (discharge observations explained by the simulation), Nash-ln 0.49 (low discharge observations explained by the simulation) and Kling-Gupta Efficiency 0.77 (correlation, bias and variability indicator). Relative volume bias indicator was $2 \cdot 10^{-5}$ (relative error between the simulated and the observed volumes). This comparison was carried out using the mean discharge, maximum discharge, runoff coefficient and volume discharge. Mean discharge and mean runoff for simulated events were 14% and 18% respectively higher than measured events; whilst for the major measured events (i.e., peak discharge > 0.7 $m^3 s^{-1}$) were 25% and 12% higher respectively. In a more detailed analysis for the major events, the mean difference between simulated and measured peak discharges were 45%; although for the highest peak discharge (i.e., 1.5 $m^3 s^{-1}$) this difference was only 18%. Considering temporariness of fluvial Mediterranean regimes, poorer simulation in those major events occurred after dry periods being the differences for the peak discharges of 99% (i.e., 0.7 $m^3 s^{-1}$ *vs* 0.001 $m^3 s^{-1}$). Likewise, the hydrological model applied during three years was poorer for low discharges (i.e., Nash-ln value), because differences with measured discharge illustrated a lack of adjustment in the simulation caused by events under dry antecedent conditions (i.e., after summer period).

A longer temporal data series is then necessary to improve the model, including a wider range of flash flood events to obtain a better calibration of these hydrologic processes highly related with hazards. Then, hydrological modelling will be useful as a tool for forecasting flash floods.

APPLICATION OF 2D MODELLING OF GRAVEL-BED RIVER FLOW DYNAMICS, DURING HIGH DISCHARGE, FOR REFERENCE CONDITION ASSESSMENT (A CASE STUDY FROM UPPER WISŁOKA, BESKID NISKI MTS, S POLAND)

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In an effort to restore gravel-bed rivers to a more natural state, the determining of a contemporary hydromorphological reference condition is essential to understanding the “why and how” of fluvial processes. The CCHE2D model has been used to simulate water flow velocity and shear stress over the surface of the diagonal, side gravel bar, so as to interpret contemporary channel changes and to outline hydrodynamic reference condition. The Upper Wisłoka is a semi-natural gravel-bed river located in Polish Flysch Carpathians (Beskid Niski Mountains). The study reach, of about 1 km in length, is located in the upper course of the river, near the Swiatkowa Mała village, and has a mean slope of 0.0053. The GPS RTK data (obtained in 2015) and ranging (LiDAR) data were used to produce the high resolution DTM, which allow detailed studies at the reach scale. Extensive field geomorphological and sedimentological surveys have been also carried out for surface material and reach morphology characteristic. Simulation was performed for the given flow conditions, ranging from 3 to 149 m^3/s, according to the data provided by the Institute of Meteorology and Water Management - National Research Institute for the gauge station Krempna-Kotan. Simulations were performed at intervals of 0.2 sec. The model was run under the hypothesis of a substantial equilibrium between sediment input and transport capacity. In this way, the model results were considered as a reference condition. The results of the modeling are consistent with field observations. During the low-flow (3-30 m^3/s) water flows only in the main channel. During higher water stages, water flows over the bar surface but firstly through the bar chute. The largest obtained flow velocity value was 3.29 m/s and the shear stresses comes up to 107.2 N/m^2. In the main channel, during the discharge of

79 m^3/s, the sediment transport is fixed (the shear stress value below 70 N/m^2). Modelling results were verified by comparing with bar and channel reach morphological changes, as observed since 1967. Applied 2D model described well the location of bar accretion areas and erosion sites. The proximal part of the bar undergoes most intensive changes. Obtained results indicate the potential model application to other reaches of the Upper Wisłoka River, in order to assess their stability and medium-term evolution.

GEOMORPHIC DISASTERS FOR ALAWSAG VALLEY IN JALAWLA CITY\IRAQ

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The study area consisting of weak geological structure, varieties in rainfall amount with each year, scarceness of vegetation on slopes, disparity of discharge of the valley ,the nature surface of the area its undulating ,intensive urban extension on both banks of the valley, the valley channel shape is gorge susceptible for many Geomorphic disasters like floods, soil fall, soil creep ,landslide, which represented an menace of population who lives within the buffer zone of the valley ,this study suggesting an remote monitoring and control system(RMCS) for the floods by the satellites.

TREE RINGS AS A SOURCE OF DATA ON FLOOD OCCURRENCE AND WATER LEVELS IN SMALL UNGAUGED CATCHMENTS (SUDETEN MTS., POLAND AND CZECH REPUBLIC)

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In vast, monitored catchments of large rivers development of floods can be analysed and forecasted based on data from numerous gauging stations. However, flood hazard also occurs an poses threat to people and settlements in small ungauged catchments, in upper parts of larger basins. In such catchments, besides lack of monitoring data, historical records are often scarce. Thus the only source of data are palaeogeographic reconstructions and among them dendrochronology seems to be the most promising approach. Studies based on wood anatomy of roots can provide data on flood occurrence with annual or even seasonal accuracy.

During floods, due to lateral bank erosion, roots of trees are often exposed from under soil cover and/or injured by transported debris. Change of growth conditions after exposure (in particular: increased daily and annual temperature ranges) results in the change of wood anatomy: roots of coniferous trees start produce smaller cells (decrease of lumen in earlywood to 50%). Sudden appearance of late wood in tree rings following the exposure can also be observed. Root injury can be dated based on scars, callus tissue, resin ducts and concentrations.

The goal of our study was to date flood occurrence in 3 small, ungauged mountain catchments based on tree roots exposed in stream banks during flood events. In catchments of Łomnica, Łomniczka (Karkonosze Mts., Western Sudetes, Poland) and Sokoli (Hruby Jesenik Mts, Eastern Sudetes, Czech Republic) we sampled roots of Norway spruces (*Picea abies* Karst.) exposed in stream banks, at diverse elevations above normal water level. Root samples were sanded to expose wood structure. Their cross sections were analysed in reflected lights, under a stereomicroscope in search for anatomy features diagnostic for root exposure and/or wounding. If necessary thin sections were also prepared to be analysed under optical transmission microscope. In all samples we dated flood events by counting annual rings developed after root exposure and wounding. Besides having dated major flood events which covered large areas, including valleys of main rivers (e.g. 1997, 1998) we were able to detect events of local character and smaller magnitude (e.g. 1970, 1978, 1986, 1991). For each stream and each single flood event we analysed elevation of roots exposed and/or injured in relation to normal water level and local topography (in particular: channel and valley cross-section at a sampling site). Through combining results of dendrochronological study with hydrological and meteorological data from the nearest gauging stations we estimated water levels of streams under study during past flood events.

DEBRIS FLOODS AND MASS MOVEMENTS OF DIVERSE MAGNITUDE AND FREQUENCY IN AN INHABITED HIGH-MOUNTAIN ENVIRONMENT (SICHUAN, CHINA) – A TREE-RING BASED HAZARD ASSESSMENT

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Floods and mass movements can pose serious threat to peoples' lives and property in densely inhabited mountain regions. Assessment and management of geomorphic risk is a problem which can only be resolved through identifying background and mechanisms of the processes. Knowledge on their magnitude and frequency is fundamental for developing strategies of hazard mitigation. Despite that, catchment monitoring is available for very few sites and historical records are fragmentary or absent. In such cases dendrochronology can be one of the most precise methods for dating past events. Our study aims to provide a tree-ring based discussion on hazards caused by debris floods, debris flows and rockfalls in an inhabited and touristically exploited high-mountain area. The goal is to estimate frequencies, magnitudes and triggering factors for phenomena of diverse origin and scale endangering settlements in the Moxi basin (Hengduan Mts, China).

We collected samples for dendrochronological dating of hazardous processes in three study sites. On terraces and slope of the Xiaohezi gully (site I) we determined the age of 30 spruce trees indicating date of the last debris flow moulding relief. On the Daozhao debris cone (site II) for 43 alders we dated events of stem wounding by debris flows. Stem injury was also dated in 15 alders sampled on the Nimatuo rockfall track (site III).

Recurrence intervals were calculated for geomorphic hazards observed in the Moxi basin. During the last 55 years large debris flows and debris floods originating in large, high-elevated and glaciated catchments occurred every 18 years (site I). During the last 20 years small debris flows fed from mid-sized and medium elevated catchments occurred every 7 years (site II). Rockfalls, with very small and steep source areas occurred every 2.85 years (site III). In general, the level of geomorphic activity in the Moxi basin is high. The phenomena under study are characterized by clearly different frequencies. Small-magnitude hazards occur exponentially more frequently than large ones. Although among dated events we identified some precipitation-dependent, most of them were co-triggered by rainfall and earthquakes. Based on the results from three study sites, representing hazards typical for the study area, the general level of hazard for whole Moxi basin was estimated as 45 large debris floods/flows, 280 smaller debris flows and thousands of single rockfall evens reaching the main valley of the Moxi basin per century, endangering almost all inhabited parts of the study area.

ANALYSIS OF TURBULENT FLOW CHARACTERISTICS AROUND THE BAR IN A BRAIDED RIVER MODEL

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Braiding of the river is characterized by the division of channel around the alluvial island. Braided river is currently important topic of study, several scientists doing research on the complexity of braided river and flow characteristics around the bar. A turbulent flow characteristic around the braided bar is much more complex as compared to the straight and meandering rivers. Some research has been done to understand the turbulence characteristics of flow in braided river, however, these works are not sufficient to fully understand the turbulence characteristics of flow around the braid bar. The results of measurements of three-dimensional velocities carried out in a laboratory model of braided river are presented in this paper. Quadrant analysis was performed which demonstrated the importance of ejection and sweep phases in sediment detachment and transport. Special attention has been given to sweep and ejection bursting events due to their relation with the sediment entrainment and transport. This paper describes the results of an experimental study on the turbulence characteristics of flow near the bar in a braided river model. In this study, the model of the braided river is constructed in the River Engineering Lab IIT Roorkee. The elliptical bar of size 30 cm by 45 cm and height 14.5 cm is constructed in the mid portion of the channel.

Instantaneous velocities were measured with the use of a three-component Acoustic Doppler velocimeter (ADV) at 12 locations around the bar. The maximum value of turbulent kinetic energy, Reynolds shear stress and the turbulence intensity were found to occur near the bed level. These turbulent parameters have greater values for scouring points, this shows that these parameters are related with the scouring near the braided bar. The transition probability of 16 possible bursting movements are computed, the results shows that the $p_{2\rightarrow2}$, $p_{4\rightarrow4}$movements are closely related with the erosion/deposition magnitude around the bar in a braided river model.

INTEGRATED ANALYSIS OF RAINFALL-RUNOFF AND FLOOD INUNDATION BY THE RRI MODEL IN THE CHIKUSA RIVER BASIN

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The floods and inundation events occur more frequently in small and intermediate rivers due to localized and severe rainfall. The Sayo river, the upper Chikusa River Basin, was flooded by Typhoon No 9 in August, 2009. During the flood event, a large area was inundated especially in the Sayo city due to overtopped water, rainfall-runoff from mountainous areas and tributaries as well as local precipitation. Twenty persons were killed and missed by the flash flood during evacuations.

To mitigate those damages, it is important to predict flood and inundation disaster. The distributed rainfall-runoff models have been commonly used to predict floods in real-time. However, most of the models simulate only rainfall-runoff processes and do not simulate inundation phenomena. On the other hand, most of inundation models simulate flooding by setting upstream river discharges or water-level boundary conditions, which are generally difficult to estimate in real time. Furthermore, identifying the simulation domain itself can be challenging task if floods occur multiple locations and start interacting with each other. Therefore, it is more realistic to apply an inundation model by integrating rainfall-runoff processes at river basin scale.

The Rainfall-Runoff-Inundation model was developed and has been mostly applied to large scale floods in Asian countries1). Although previous studies show that the RRI is adequate to simulate the large scale flooding using satellite topography data and empirical equations of river cross sections, the model is sensitive to input data, especially cross section data or dam for better representation of inundation areas1). For this reason, the model performance should be validated using local information. In this research, the RRI model is calibrated and validated by simulating some flood events in the entire Chikusa River Basin using gauge-adjusted radar rainfall, DEM by laser profiler and cross section data covering most of the rivers at the basin.

Flood discharge and inundation distribution are evaluated qualitatively and quantitatively. Estimated flood discharge and water level are in good agreement with the observation at eleven gauging stations. The maximum inundation extent shows similar pattern to inundation marks at the scale of the entire river basin. Focusing on floodplains around the Sayo city, the simulated inundation level is also good agreement with observations. At Sayo town hall, the relative error is 0.1. The inundation movement is also estimated by the RRI. The simulation indicates that the inundation started from 21:00 on 9th August and expanded gradually through the night in the Sayo town area. According to a survey on flooded area at the night on 9th August, the simulation results imply that the model agrees with real time inundation simulation. In conclusion, the RRI can be used for simulating flood events at an entire river basin in Japan by calibrating with local information and validating with observed values and a survey on the flood trace.

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SIMULATION OF FLASH FLOODS IN SMALL CATCHMENTS USING A ROBUST SHALLOW WATER MODEL

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Flash floods as a result of heavy rainfalls often cause severe damages to settlements and the environment. In the Eastern Desert of Egypt, rainfalls are rare but sometimes very heavy and can lead to flash floods in the wadi systems affecting settlements and infrastructures. Recent events happened in March 2014 and in October 2016: heavy rainstorms resulted in flash floods in different regions of Egypt and caused losses of many human lifes, many injured, lots of house and car damages as well as the closing of main roads. Areas with weak infrastructure were particularly affected. In future, the occurrence and intensity of extreme rainfalls might increase due to climate change and measures to reduce the risk of flooding have to be realized. The simulation of flash floods is an important tool to analyze flow processes during and after heavy rainfall events and to investigate possible mitigation measures. Generally, rainfall-runoff simulation in catchments is carried out with hydrological models. In recent years, shallow water-based models have been further developed and applied. Due to high-resolution surveying data they enable a more detailed consideration of topography, flooding areas and local flow processes and can even resolve urban structures. They can be used for rainfall-runoff modelling in small catchments or in combination with hydrological models to simulate the last part of the flow from a valley to a city.

The Hydroinformatics Modelling System (HMS) is a Java-based framework which is developed at the Chair of Water Resources Management and Modeling of Hydrosystems, Technische Universität Berlin. The two–dimensional depth–averaged shallow water equations are discretized with a robust cell–centered finite volume method and solved with an explicit MUSCL scheme. HMS can be used for different applications, as for example rainfall-runoff and flood modelling. Precipitation and infiltration are considered as source/sink terms in the mass balance equation. A shallow water model of the region of El Gouna was set up in HMS to investigate flash floods in the catchment of a local wadi (Wadi Bili). The numerical model represents an area of 10 km x 6 km with a resolution of 30 m x 30 m. During the flash flood event on 9 March 2014, data of rainfall and runoff were measured and are published in the doctoral thesis of Hadidi (2016). This data was used to simulate the flash flood event with HMS. The results show the propagation of the flash flood from the wadi outlet to the City of El Gouna. The model will be applied to investigate different scenarios of structural measures to protect the city of El Gouna against flash floods, e.g. dams, canals, basins and local measures for buildings.

CONSTRUCTION AND UNCERTAINTY OF SYNTHETIC DESIGN HYDROGRAPHS FOR MOUNTAINOUS CATCHMENTS

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When evaluating the damage potential in flood prone areas, it is not sufficient to focus on a univariate analysis of peak discharges, but it is at least equally important to estimate the flood volume or even better the entire flood hydrograph. A joint consideration of peak discharges and flood volumes for flood hazard assessment is therefore crucial when assessing flood risks for current or future conditions. However, such an assessment it not commonly included in climate impact studies.

We present an approach to develop synthetic design hydrographs for mountainous catchments based on observed, sampled runoff data, taking into account the dependence between peak discharges and flood volumes, and representing the form of the hydrograph. The form of the hydrograph is modelled using a probability density function and the dependence between the design variables peak discharge and flood volume is modelled using a copula. Our approach does not only allow the construction of catchment specific design hydrographs but also the construction of flood type specific hydrographs such as flash-floods, short-rain floods, long-rain floods, and rain-on-snow floods. The inclusion of process-based knowledge by the use of flood types enables us to get an idea of the variability of potential floods due to the variability of different flood types. Such a flood type specific analysis is beneficial when assessing climate change impacts because expected changes in processes, such as an increase in the proportion of flash-floods due to increasing precipitation intensities, are directly incorporated into the analysis and considered in flood risk management.

Design flood estimates are inherently uncertain and it is crucial to assess the uncertainty coming from the different uncertainty sources to get an idea of their reliability. The influence of different uncertainty sources, such as flood sampling, the choice of the marginal distributions of peak discharges and flood volumes, or the choice of the dependence structure on the resulting design flood estimates is explicitly evaluated. Knowledge of the uncertainty of design flood estimates is the basis for a discrimination between uncertainties introduced by the hydrograph construction process and uncertainties related to climate change. It allows the distinction between internal variability of flood hydrographs and the signal of climate change.

A RETROSPECTIVE DAMAGE ANALYSIS FOR THE FLASH FLOOD IN BRAUNSBACH ON MAY 29TH, 2016

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At the end of May and early June 2016 Central Europe was hit by severe storm events with exceptional high rainfall intensities. As a consequence, especially the south of Germany suffered high losses, mainly caused by severe surface water flooding and flash floods, partly accompanied by mud and debris flow. On the evening of May 29th, 2016, a flood outburst with massive amounts of rubble and muddy sediments hit the town of Braunsbach (Baden-Württemberg). The total damage caused in the municipality, with a population of 2500, is estimated to EUR 104 million.

Due to recent severe riverine flooding in Germany, particularly in August 2002 and June 2013, the flood risk management system in Germany has been considerably improved. However, when implementing the European Floods Directive in Germany, surface water flooding and flash floods were not considered as risks of national importance and thus neglected. The destructive events of May and June 2016 have shown that research on and management of surface water flooding and flash floods need to catch up.

The DFG Graduate School “Natural hazards and risks in a changing world” (NatRiskChange) at the University of Potsdam investigated the flash flood in Braunsbach as a showcase for the events triggered in spring 2016. In addition to investigations on meteorology, hydrology and geomorphology, the affected buildings were inspected with regard to the caused damage. Ten days after the flood event, a team of five researchers collected data describing the type, condition, use and surrounding of the buildings as well as the estimated peak water level at the considered building and the severity of the visible structural damage. The data analysis shows that the building damage does not exclusively depend on the water depth, which is often considered as the only damage driving factor in riverine flood loss modeling, but it is also to a strong extent affected by the exposition of the building to the flow direction. The results emphasize the differences between the damaging processes of flash floods compared to river floods. Not only the high flow velocities, but also a high sediment and debris load increase the damage caused to buildings. A reliable damage assessment for flash floods in hilly regions, thus requires the consideration of their specific behavior. Therefore, additional data of different flash flood events is needed to further improve the understanding of damaging processes as well as to identify damage driving/reducing factors in different urban environments.

CONTEMPORARY GRAVEL-BED CHANNEL MODIFICATION – THE EFFECT OF FLOOD FREQUENCY CHANGE AND CATCHMENT AFFORESTATION (A CASE STUDY FROM THE UPPER WISŁOKA, BESKID NISKI MTS., S POLAND)

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Rivers in montane regions are highly exposed to changing environmental conditions and human activity. Currently, there is an emphasis on restoration of gravel-bed rivers in the montane regions. Deciding on what and where to restore requires an understanding of relationships between fluvial processes along with establishment of hydromorphological reference conditions.

This paper uses evidence from the upper Wisłoka River (Beskid Niski Mountains) in Polish East Carpathians, to demonstrate relative channel change over a 50-year period in a semi-natural river. Channel planform change was studied in three chosen reaches of the upper Wisłoka River – Świątkowa, Krempna and Myscowa, and identified using four air photographs dating from 1967 to 1997, four orthophotographs (2003 to 2012), two DTMs (2012, 2013) and field measurements (2010 – 2015). Precipitation and water stage data were analysed for the same time scale.

Each of the approximately 1.5-2 km long study reaches underwent significant channel form modification, especially in channel sinuosity and width; the main channel has shifted within river migration zone. Changes are also marked in granulometric composition of channel deposits. The probable cause of the observed channel planform tranformation is the combination of intense afforestation (an increase of forest cover of about 40%) started in 1947th as a result of the region depopulation, an increase of flood frequency (from 0,7 to 2,2) and episodic inputs of sediment generated by bank erosion, landslides, river regulation and gravel-bed mining. Large floods in the last 50 years have produced an evidence of channel change, however since 2005 the intensity of processes increased. Locally, a significant channel bar accretion and accumulation of hyper-concentrated deposits within the active zone has been noticed following floods in May and June 2005, March 2007, June 2009, July 2010 and 2011 and in May 2015.

This emphasizes the need to base the reference state for river restoration on contemporary hydromorphological conditions. In our opinion, especially important is to provide conditions for free channel process development. Furthermore, not an active restoration project itself, but a proper and thorough recognition of environmental conditions is the key issue in montane rivers restoration problems.

ANALYSIS OF DECENTRALISED FLOOD RETENTION CAPABILITIES IN THE CATCHMENT OF THE NATZSCHUNG RIVER (CENTRAL ORE MOUNTAINS) USING THE RAINFALL-RUNOFF MODEL NASIM

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The concept of decentralised flood protection (or water retention) is based on localising and using the natural capability of a catchment to retard run off as early as possible, and at several places at the same time, by means of a combination of different small-scale technical and non-technical measures (Assmann, 1999; DWA, 2006; DWA, 2013a; Schulte et al., 2007). Intense rainfall and heavy floods in August 2002, which caused extraordinarily high levels of inundation and damage, affected the Ore Mountains, a low range mountain region in eastern Germany. Against this background, the objective of this investigation has been developed to analyse the capability of headwater areas to mitigate floods for downstream locations at different spatial scales. Based on this idea, the hydrological effect of selected small, well-placed retention facilities was analysed for the Natzschung catchment.

The above-mentioned concept is well established in German literature and recent studies have been reviewed, but it is also well known in the international context (Liaw et al., 2006; Mendel & Liebscher, 2010; Poulard et al., 2010; Scholz & Yang, 2010). Over recent years, several approaches and investigations have analysed the performance of these measures in terms of retention or detention ponds and other techniques (Reinhardt et al., 2011; Rieger, 2012). The discussion of pros and cons is still in progress, but the lack of data clearly remains an issue, especially concerning the capability and the effect of retention facilities at different spatial scales and for varying flood return periods (McMinn et al., 2010; Mendel & Liebscher, 2010). The analysis of the Natzschung catchment offered the potential for uncontrolled retention facilities at 19 locations, in the upper and middle basin. They include already existing small retention and detention ponds, and areas with valley-crossing street embankments with an ambiguous purpose. These facilities were implemented in a distributed hydrological model (NASIM) to simulate local and regional flood retarding effects with regard to a 100-year flood recurrence interval. The total storage capacity is over 500.000 m³ at a mean storage level of 3.6 m, and encompasses an area of more than 50 km². At all retention facilities, the discharge at the outlets is curbed and reduced by between 6 % and 75 %, with a mean of 40 %. More than 390.000 m³ of the retention capacity is used (72 %). This scenario induced a decrease in peak discharge from a level of 63.4 m³/s to a value of 45.2 m³/s (-28.7 %) at the gauging station Rothenthal (total area of 75 km²). At the catchment outlet 5 km downstream, the peak discharge remains lowered, at a level of 53.7 m³/s (-25.4 %). At both locations, the peak arrived forty-five minutes later.

For all analysed locations in the catchment, a distinct effect concerning the peak reduction and the temporal shift of the peak could be observed. At the gauging station the HQ_{100} could be attenuated to a discharge comparable to a return period under a 50 year flood event ($<HQ_{50}$). This is not only important for the main objective of flood protection, as a reduction in discharge also means a decrease in stream power, erosion and the sediment transport capacity of fluvial systems (Borga et al., 2011). After the August flood in 2002, several streams along the Ore Mountains were affected by sediment deposition dominated by boulders and cobbles. The sediments reduced the hydraulic cross section of the rivers and caused severe damage along the banks (IKSE, 2004; LFULG, 2009; LTV, 2004; RMD, 2005). The results have also shown that the total storage capacity is sufficient, but a redesign or a flexible control system of the outlets and the storage level of the basins could lower the costs and also improve the performance for larger flood events. However, the detection, survey and implementation of these kinds of retention facilities are labour and cost-intensive and need to be improved. This flood retention concept considers regional and local flood protection targets and the specific hydrological conditions and capabilities of a catchment. The implementation of these kind of measures in stream headwaters could be a feasible way to establish an effective and additional flood protection for the local and downstream settlements of the Ore Mountains, and for other low range mountain systems.

GEOMORPHOLOGICAL BASED METHODOLOGY AND REGULATION PROPOSAL FOR RISK CLASSIFICATION IN TORRENTIAL AREAS

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Over the last 20 years, Europe has been affected by intense flooding events (over 100) having as a result more than 700 deaths and multi-million euro losses. We could highlight the Danube and Elba rivers overflow in summer 2002 and more regional torrential events such as the 1998 tragedy in Biescas (Camping Las Nieves, Spain) or the Garonne river overflow in 2013. As a consequence, both governments and public opinion have increased their awareness regarding the danger and risks associated to natural hazards, more specifically to torrential and fluvial hydraulics. This increased awareness added to the technical progress occurred during the last years has led to the development of new directives, local laws and natural hazards prevention plans that have strongly impacted urbanism and its socio-economical sphere.

However, despite the set of directives and regulations approved during the last years (in Andorra, Switzerland, Spain or France), there has been a focus on fluvial flooding areas at a general country level. Mountain areas exposed to torrential events have not been considered with the consequent lack of associated cartography and regulations. It should be underlined that, usually, torrential events have occurrence probabilities and induce losses different from the big fluvial floods. Therefore, some mountain areas have no regional methodology to develop a proper cartography and risk classification. Usually, the detection, zonation and evaluation of areas prone to develop torrential or debris flow events is hard to forecast without clear geomorphological evidence identified through field work, historical records, ortophotos or multi-annual aerial photography. The following field data also plays a primary role: precipitation records, depth and flow data, stream centerline sedimentograms, mountain river sediment analysis, hydraulic section analysis at outflow points, deposition analysis in dejection cones, etc.

The goal of this article is to obtain a set of criteria through a methodology based on a geological and geomorphological analysis of the different parts that constitute the geometry of a mountain river. These should enable the creation of a local qualitative zonation related to the potential risk of exposed areas. Historical data on torrential events and local place names will also be taken into account. The outcome of a regional scale zonation will provide a decision making tool to filter hazards that will be analyzed according to its relevance. It will also detail how to approach them at a later stage (field work or numerical models, among others). We will suggest a set of regulations to define which detailed studies need to be undertaken in any mountain river to assess its level of risk.

THE FLUMEN SOIL EROSION MODELLING FRAMEWORK TO ASSESS MOUNTAIN CATCHMENTS

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Parametric erosion approaches (such as Universal Soil equation) were developed for the assessment of agricultural areas. However, the application of models to different environments is often inappropriate. Nonetheless, it is often the only way to get a first idea about the relative distribution of erosion intensities since the input data are relatively easy to derive. Our study is aimed at assessing mountain catchments characterized by erosion pattern induced by various geomorphological driving factors such as: i) volcanic (Kamchatka peninsula), ii) alpine glaciered (Northern Sweden), iii) Mediterranean high-gradient (Italy, Liguria, Sicily), iv) continental piedmont (Northern Mongolia and Italy, Tuscany Intra-Appeninic) as well as v) semiarid and tectonically induced Iran piedmont areas. We combined modeling, field data and remote sensing techniques for the particular mountain river basins in order to make a methodological review and provide a comparative study of erosion phenomena in various environments. Universal soil loss equations' parametric (semi-distributed) approach (RUSLE) and its modifications like MUSLE were applied for annual, monthly and daily erosion rates. Equations to estimate universal soil equation parameters and sediment delivery ratio (SDR) were modified in order to assess spatial "cascade" variability. We used also more sophisticated approaches like combined gully/ debris flow models that were integrated into an USPED approach (Mitasova, 1995) to calculate catchment erosion and to predict sediment delivery processes using net erosion and accumulation algorithms. Additionally spatially distributed, pixel based WATEM/SEDEM (Van Oost et al., 2000 and Van Rompaey et al., 2001) which consider transport capacity of the overland flow was also applied for the selected catchments. The results indicate advantages and limitations of the various approaches. However, the FLUMEN framework delivered a standardized concept based on common methodologies to characterize the relevant driving

forces. Moreover, additional sediment sources not covered by traditional approaches were included to provide a detailed spatio-temporal characterization of the erosion and sediment transport processes in various environments.

CAUSAL FACTORS GENESIS OF FLOODS IN THE SOUSS RIVER WATERSHED AND MAPPING FLOOD HAZARD USING GIS

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In the last two decades, a number of significant natural disasters in Morocco and in the rest of the world resulted in many lives lost, livelihoods destroyed, and disability among the affected populations. In Morocco, floods, one of the most devastating natural hazards, caused more than 1,165 deaths, more than 232,896 affected population, and more than US$ 295 million in damage from 1995 to 2005 (CRED, 2015). Douben (Douben, 2006) defined a flood as a temporary condition of surface water (river, lake, sea) in which the water level and/or discharge exceeds a certain value thereby escaping from its normal confines. The Souss River (25% plain and 75% mountain) is not immune to this natural disaster. Indeed, its area is characterized by a very rugged terrain, steep slopes, high relief, variable climates, and a relatively degraded vegetation cover, which are favorable factors to the genesis of floods (Chakir et al, 2015).

Although small floods are beneficial to the functioning of river Souss, short-term extreme floods could jeopardize agricultural lands, existing infrastructure (housing, roads, tracks, etc.), and sometimes people’s lives in addition to the isolation of some villages. Many floods occurred between 1960 and 2015 at Taroudant, Sidi Moussa El Hamri, Agadir-Ida Ou Tanane, Tizi N’test and Aı¨t Melloul they should serve as a reminder that floods are a serious risk to those living and working in the area. Trends to climate change and land use do background increases the risk of flood. The United Nations International Strategy for Disaster Reduction (UNISDR), defines risk as being “the probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural or human induced hazards and vulnerable conditions.” Therefore, risk as presented in the below formula as follows:
RISK= (Hazard x Vulnerability)/Capacity

This study describes a simple and cost-effective methodology and process to accurately delineate the flood hazard areas in the Souss River basin from the available database using a geographic information system (GIS), remote sensing and multicreter analysis with 30 arc-second spatial resolution.

Indeed, the implementation of this method goes through the application of the following steps: 1. Identification of the causal factors; 2. Creation and classification of the past flood frequency distribution map; 3. Estimation of the weighted score for each causal factor by crossing them with the reclassified flood frequency layer; 4. Standardization of the weighted scores; 5. Classification of the resulting map to obtain the spatial distribution of the intensity level of flood hazard. Finally, the flood hazard index distribution map was reclassified into five intensity levels (very low, low, medium, high, and very high) using the Reclassify function and a natural breaks method (also referred to as the optimal breaks method and Jenks method).

Besides, the improvement of the risk management is considered among the actions determined for a better environmental protection, human health and for a sustainable development, by structural measurements (dams, afforestation of the basin, and mechanical treatment of the catchment area….). The Agency of the hydraulic basin of Souss Massa and Draa (ABHSMD), the local authorities and the civil society seen the gravity of the flood risk, are called to intervene to limit the damage and limit vulnerability towards the population. They have to become aware of the scale of the danger and have to make sensitive the population to avoid as far as possible the losses of the properties (goods) and casualties.

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PRIORITIZING MOUNTAINOUS WATERSHEDS IN INDIAN HIMALAYAS BASED ON GROSS SOIL EROSION AND GEOMORPHOLOGIC PARAMETERS

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The lands in mountainous regions are often subjected to soil erosion and degradation due to unabated actions of rain and wind which ultimately results in changes in river morphology, reservoir sedimentation and reduction in river storage capacity, floods etc. Such situations are more prevalent in the developing countries like India due to various types of socio-economic constraints. Watershed prioritization is a process of ranking different watersheds according to the order in which they will be treated through appropriate soil and water conservation measures.

This study was undertaken to prioritize watersheds based on gross soil erosion using Universal Soil Loss Equation (USLE) and geomorphologic parameters of the Chaukhutia sub-catchment of the Ramganga River catchment in the Indian central Himalayan region. Chaukhutia sub-catchment was initially digitized from the topo-sheet and later updated using satellite imagery of the study area, which was divided into 16 watersheds. Geomorphologic analysis of these watersheds was carried out with the help of ArcGIS software. Remote sensing and GIS techniques were very effective in satellite imagery analysis, estimation of gross soil erosion and geomorphologic parameters, and creation of thematic maps for the study area.

The R-factor of USLE was determined using rainfall data (1975-2004) at three raingauge stations. Thiessen polygons for these raingauge stations were drawn with the help of Quantum GIS 1.8.0-Lisboa software. Other factors of USLE and the gross soil erosion were determined using ArcGIS software. The geomorphologic parameters considered for watershed prioritization were bifurcation ratio, drainage density, stream frequency, texture ratio, mean length of overland flow, form factor, circulatory ratio, compactness coefficient and elongation ratio. Gross soil erosion was integrated with geomorphologic parameters to prioritize the watersheds for determining critical areas affected by soil erosion. All the parameters of gross soil erosion and geomorphology were ranked according to their potential to create erosion hazards. The compound rank (Cr) was determined for each watershed on the basis of the average value of ranks of individual parameters considered for prioritization. Prioritization of watersheds based the compound rank of gross soil erosion and geomorphologic parameter combined was found to be a better criterion. The watershed having the lowest value of compound rank (Cr) was given the highest priority of 1, the next higher value of Cr for a watershed was given priority 2 and so on. The results revealed that the watershed located at the farthest upstream of the basin got the highest priority, while the one near the outlet of the basin got the lowest priority. Out of total 16 watersheds, 5, 3, 5, 2 and 1 number of watersheds were categorized with very high, high, medium, low and very low priority, respectively.

GEOMORPHOLOGICAL EVOLUTION OF A RIVER REACH AFTER A HIGH INTENSE GRAVEL-MINING OPERATION

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Physical processes in rivers are the result of the interaction between flow regime and hydraulics, morphology, sedimentology and sediment transport. The frequency and magnitude of physical disturbance (i.e., bed stability) control habitat integrity and, consequently, ecological diversity of a particular fluvial system. Most rivers experience human-induced perturbations that alter such hydrosedimentary equilibrium, thus affecting the habitat of aquatic species. A dynamic balance may take long time to be newly attained. Within this context, gravel mining is well known to affect channel characteristics mostly at the local scale, but its effect may also propagate downstream and upstream. Sedimentary forms are modified during extraction and habitat features are reduced or even eliminated. Effects tend to be most acute in contrasted climatic environments, such as the Mediterranean areas, in which climatic and hydrological variability maximises effects of impacts and precludes short regeneration periods. Present research focuses on the 3-yr evolution of a river reach, which experienced an intense gravel extraction. The selected area is located in the River Ésera (Ebro basin), where interactions between morphodynamics and habitat recovery are examined. Emphasis was put on the evaluation of sedimentary, morphological and hydraulic variables to later compare pre (t0) and post extraction situations (t_1, t_2,…, t_n). Methodology included: i) grain size distribution characterization, ii) description of channel morphology by means of close-range aerial photographs and iii) determination of flow parameters.

Consequences of the gravel extraction, by comparing the aerial photos of the pre and post extraction situations, resulted in the elimination of the central bar, which was stable and partially vegetated, together with 2 smaller bars located upstream.

However, it can be observed a tendency to recover the initial geomorphology. Comparisons of the DEMs (i.e., DoD) provided a reduction in height of up to 2 m, while accumulations of ca. 1.5 m were observed at some places. DoD allowed to calculate in ca. 5000 m^3 the total volume of sediment extracted, although a large part of these lost sediments have been already redeposited. Several changes can be seen in the results obtained by the hydraulic simulation; due to the elimination and recovery of the central gravel bar the submerged bed-surface and the width of the reach, for a first increase (and later loss) and a clear reduction (and later increase) of velocity and depth.

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Mountainous areas are considered sensitive to so-called global change, considered as the combination of climate and land use changes. All panels on climate evolution predict future scenarios of increasing frequency and magnitude of floods which are likely to lead to huge geomorphic adjustments of river channels so major metamorphosis of fluvial systems is expected as a result of global change. Such pressures are likely to give rise to major ecological and economic changes and challenges that governments need to address as a matter of priority. A key question is how our understanding of these hazards associated with global change can be improved; improvement has to come from integrated research which includes the climatological and physical conditions that could influence the hydrology and sediment generation and hence the conveyance of water and sediments and the vulnerabilities and economic repercussions of changing hydrological hazards.

Within this framework, the purpose of the symposium was to bring together researchers from several disciplines as hydrology, fluvial geomorphology, hydraulic engineering, environmental science, geography, economy (and any other related discipline) to discuss the effects of global change over the river system in relation with floods. The symposium tried to improve our understanding of how rivers are likely to evolve as a result of global change and hence address the associated hazards of that fluvial environmental change concerning flooding.