Universität Potsdam


Theresia Petrow | Axel Bronstert | Annegret Thieken | Kristin Vogel (Eds.)

International Conference on „Natural Hazards and Risks in a Changing World“

4–5 October 2018
University of Potsdam

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Book of abstracts of the International Conference on Natural Hazards and Risks in a Changing World

Edition 2018

Editors: Theresia Petrow, Axel Bronstert, Annegret Thieken and Kristin Vogel

Cover images:

Impacts of a flash flood in the town of Braunsbach. Germany, Photo: Ana Lucía Vela (2016)

Flooded road in the city of Meißen, Germany, Photo: Theresia Petrow (2013)

Damaged road in Kumamoto (Japan), Photo: Haneda Yasutaka (2016)

This work has been supported by the Deutschen Forschungsgemeinschaft (DFG) through the Research Training Group “Natural Hazards and Risks in a Changing World” (NatRiskChange; GRK 2043/1)

Universität Potsdam 2018

Published online at the
Institutional Repository of the University of Potsdam:
URN urn:nbn:de:kobv:517-opus4- 416613
http://nbn-resolving.de/urn:nbn:de:kobv:517-opus4- 416613

International Conference on "Natural Hazards and Risks in a Changing World"

4-5 October 2018

University of Potsdam

Scientific Committee

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- **Prof. Dr. Fabrice Cotton,** Helmholtz Centre Potsdam, German Research Centre for Geosciences - GFZ, Potsdam, Germany
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Preface

Natural hazards such as floods, earthquakes, landslides, and multi-hazard events heavily affect human societies and call for better management strategies. Due to the severity of such events, it is of utmost importance to understand whether and how they change in response to evolving hydro-climatological, geo-physical and socio-economic conditions. These conditions jointly determine the magnitude, frequency, and impact of disasters, and are changing in response to climate change and human behavior. Therefore methods are needed for hazard and risk quantification accounting for the transient nature of hazards and risks in response to changing natural and anthropogenic altered systems. The purpose of this conference is to bring together researchers from natural sciences (e.g. hydrology, meteorology, geomorphology, hydraulic engineering, environmental science, seismology, geography), risk research, nonlinear systems dynamics, and applied mathematics to discuss new insights and developments about data science, changing systems, multi-hazard events and the linkage between hazard and vulnerabilities under unstable environmental conditions. Knowledge transfer, communication and networking will be key issues of the conference. The conference is organized by means of invited talks given by outstanding experts, oral presentations, poster sessions and discussions.

We are very pleased to welcome you to Potsdam. We hope you will enjoy your participation at the *International Conference on Natural Hazards and Risks in a Changing World* and have an exciting and beneficial experience. Finally, we would like to thank all speakers, participants, supporters, and sponsors for their contributions that for sure will make this event a very remarkable and fruitful meeting. We acknowledge the valuable support of the Deutsche Forschungsgemeinschaft DFG (Research Training Group “Natural Hazards and Risks in a Changing World” (NatRiskChange; GRK 2043/1), as the conference would not have been possible without their help. Without your cooperation, this conference would neither be possible nor successful.

Axel Bronstert, Annegret Thieken and Theresia Petrow

Potsdam, 4 October 2018

Thursday, 4th October 2018

8:00 – 9:00 Registration
9:00 – 9:15 Welcome and opening by Axel Bronstert (Chair of the RTG NatRiskChange), Lecture Hall H02
9:15 – 9:30 Welcome and opening by Oliver Günther (President of UP)
9:30 – 10:15 **Keynote Speech "Changing systems" by Prof. Dr. Hans Joachim Schellnhuber** (Potsdam Institute for Climate Impact Research (PIK) Potsdam), Moderation: A. Bronstert
10:15 – 10:45 Coffee break
10:45 – 12:45 Parallel sessions

	Session 1: „Floods and Droughts" (Convener: H. Kreibich) Lecture Hall H02	**Session 2: „Geophysical Hazards" (Convener: F. Cotton) Lecture Hall H01**
10:45-11:05	Increasing severity of floods associated with changing climate in the coastal megacities of India (S.N. Krishnapillai)	A Physics-Based PSHA Conceptual Workflow for Low-Strain Areas (M.J. Ziebarth)
11:05-11:25	Flood risk (d)evolution: disentangling key drivers of flood risk change with a retro-model experiment (M. Mosimann)	Learning more to predict landslides in different scales (Regional to local) (U. Ozturk)
11:25-11:45	From Fire to Frosts to Floods, and from Droughts to Diseases to Discomfort: Prognoses into the Future of Climate Drivers in an Already Climate Stressed South Africa (R. Schulze (invited))	Sinkhole characterization with supplementing geophysical methods – the joint project SIMULTAN (Ch. Krawczyk)
11:45-12:05	The influence of transient flood risk factor on the expectation of loss (K. Piroth)	A regionalized strain-rate based seismicity model for subduction zones (J.A.B. Viveros)
12:05-12:25	Development of Droughts in Brazil in the last years (E.S.P.R. Martins (invited))	Coupling Empirical and Simulation-based Ground Motion Model (H. Razafindrakoto)
12:25-12:45	Flash-Floods: more often, more severe, more damaging? An analysis of hydro-geo-environmental conditions and anthropogenic impacts (A. Bronstert)	Variabilities and Uncertainties in Seismic Ground-Motion Prediction: Implications on Seismic Hazard Assessment (S.R. Kotha)

12:45 – 14:00 Lunch - Discussion and Poster Session

14:00 – 14:45 **Keynote Speech "Linking hazard and vulnerability" by Prof. Dr. Jeroen Aerts** (VU Amsterdam, Institute for Environmental Studies), Moderation: A. Thieken; Lecture Hall H02

14:45 – 16:00 Poster Session (incl. coffee break)

16:00 – 18:00 Parallel sessions „Linking Hazard and Vulnerability" and „Modelling and Data"

	Session 3: „Linking Hazard and Vulnerability" (Convener: A. Walz) Lecture Hall H02	**Session 4: „Modelling and Data" (Convener: G. Zöller) Lecture Hall H01**
16:00-16:20	Adaptability as a strategy to manage natural hazards in an uncertain future (D. Straub)	EMRA: A Decision support system for monitoring, warning and risk assessment of weather extremes for agriculture (Th. Ulbrich)
16:20-16:40	Efficiency of flood protection measures (W. Kron)	Sub-hourly extreme rainfall scenarios (following Clausius-Clapeyron) (G. Bürger)
16:40-17:00	Translating flood disasters into the future – a storyline approach to build flood resilience (J. Sillmann)	Damage estimation for hydro-meteorological hazards at seamless spatial scales (T. Sieg)
17:00-17:20	Human influence and response to socio-natural hazards (G. Baldassarre)	Basic European Assets Map, a Copernicus Service addressing cross border activities (A. Assmann)
17:20-17:40	What approaches and data are needed to better understand trends in drought and flood impacts? (H. Kreibich)	Forecasting Weather Related Fire Brigade Operations by linking meteorological forecasts with vulnerability indicators 54 (M. Göber)
17:40-18:00	The 1968 floods in South-East of the United Kingdom: A 50 Year Retrospective (H. Rodda)	Improving hazard communication using online map services and interactive visualization approaches: experiences from cooperation with administration partners in Saxony (Germany), Argentina and Colombia (A. Bergner)

18:00 End of Plenary

19:00 Conference Dinner

Friday, 5th October 2018

09:00 – 09:45 **Invited Talk "Data Science" by Prof. Dr. Matthias Holschneider** (University of Potsdam, Institute of Mathematics), Moderation: F. Scherbaum; Lecture Hall H02

09:45 – 10:00 **DKKV Award „prepardness 2030"**, Moderation: F. Scherbaum

10:00 – 10:30 Coffee break

10:30 – 12:30 Parallel sessions „Exposure and Risk Management" and „Data Science and Information Systems"

	Session 5: „Exposure and Risk Management" incl. awardee (Convener: A. Thieken) Lecture Hall H02	**Session 6: „Data Science and Information Systems" (Convener: K. Vogel) Lecture Hall H01**
10:30-10:50	DKKV awardee	Developing Machine Learning Approaches for the Seismological data in Northern Chile (J. Bedford)
10:50-11:10	Climate impact simulations indicate that historical warming has at least tripled global population annually exposed to extreme events (S. Lange)	Why omnipresent input data flaws may hamper a dynamic perspective in data-driven landslide susceptibility modelling (S. Steger)
11:10-11:30	ESPREssO – Enhancing synergies for disaster prevention in the European Union (L. Schüller)	Probabilistic multi-variate framework for reliable pluvial flood loss estimation (V. Rözer)
11:30-11:50	Demographic Change and Natural Hazard Risk Management - a disregarded link? On overview of policy perspectives from Austria (L. Löschner)	Unchanged frequency of Himalayan glacial lake outburst floods since the late 1980s (G. Veh)
11:50-12:10	Systemic Risks – Concepts and Suggestions for Risk Governance (P-J. Schweizer)	Country-scale survey of anthropogenic hazard using Sentinel-1 big data (M.H. Haghighi)
12:10-12:30	Assessing sea level rise risks in changing coastal environments: a national assessment supporting disasters management and climate change adaptation (S. Torresan)	Change-point detection for seismicity parameter (B. Fiedler)

12:30 – 13:30 Lunch

13:30 – 14:30 Poster Session (incl. coffee)

14:30 – 15:15 **Keynote Speech "Cascade and Multi-Hazard" by Prof. Dr. Jakob Rhyner** (United Nations University, Institute for Environment and Human Security), Moderation: O. Korup; Lecture Hall H02

15:15 – 16:15 Session „Cascade and Multi-Hazard"

	Session 7: „Cascade and Multi-Hazard" (Convener: Prof. Dr. Oliver Korup) **Lecture Hall H02**
15:15-15:35	From single-hazard to multi-hazard risk assessment including the analysis of dynamic exposure and vulnerability aimed at the model-ling of cascading effects (Ch. Geiß)
15:35-15:55	Perspective and limitations of Multi-Risk Assessment (M. Pittore)
15:55-16:15	Towards an event-based quantitative model for interacting hazard events (A. Tilloy)

16:15 – 17:00 Discussion and goodbye (Prof. Annegret Thieken and Prof. Axel Bronstert)

Talks

Keynote Speeches

Where on Earth Are We Heading?

H. J. Schellnhuber (1)

(1) Potsdam Institute for Climate Impact Research (PIK), Potsdam, Germany

The year 2017, third-warmest on record in spite of the absence of El Niño, has been an "annus horribilis": downpours and floods, heat waves and wildfires, and, most prominently, unprecedented storms (Irma, Harvey and Maria) pushed communities around the globe near or even across the edge of collapse. Our industrial civilization has transformed the planet already, shifting the climate system far out of its natural regime of very slow, insolation-driven oscillations. The impact of climate change on societies can no longer be ignored, with entire regions in the Global South possibly turning uninhabitable and the risk for armed conflicts or forced migration rising.

Yet there is an even bigger risk looming: As discussed in a recent article (Steffen et al. 2018), it is not guaranteed that the climate system can be safely "parked" in the 1.5-2 °C corridor as prescribed by the Paris Agreement. With atmospheric CO_2-concentrations exceeding 450 ppm and many positive feedback mechanisms at work in the Earth System, the sliding of the planet into a "hothouse state" cannot be excluded. This would send the global environment back some 15 million years, into the Miocene. As a consequence, greenhouse gas emissions need to be reduced worldwide at least in line with the Paris Agreement, but most preferably faster.

Linking Hazard and Vulnerability: the case of flood risk management

J.C.J.H. Aerts (1)

(1) VU University Amsterdam

Timely and accurate information on the dynamics of vulnerability of natural hazards, such as floods, is essential for designing and implementing effective climate change adaptation and disaster risk-reduction policies. For this, it is essential to understand the behavior of individuals, businesses, and government entities before, during, and after a disaster, since this can dramatically affect the impact and recovery time. Since existing risk assessment methods rarely include this critical 'dynamic vulnerability' factor, significant progress has been made in the socio-hydrological community[1] to address human activities (development of flood protection, reservoir operations, land management practices) in hydrological models.
This presentation gives an historic overview of traditional methods to integrate vulnerability, for example, using a 'top- down' scenario approach, where either climate change, socio economic trends and adaptation are treated as external forcing to a physically based hydrological model. Furthermore, it is demonstrated that vulnerability research has made significant steps in identifying the relevant vulnerability indicators[2], but has not yet provided the necessary tools to dynamically integrate vulnerability in risk assessment or hydrological models.
However, recent research shows novel methods to integrate human behavior with hydrological models. This presentation shows the recent innovations for flood risk assessment, and provides novel insight into how flood risk management policies can be developed and prioritized[2]. It is shown that using e.g. Agent Based Models, these behavioral adaptation dynamics may lead to a more realistic characterization of the risks and improved assessment of the effectiveness of risk management strategies and investments.

1. Di Baldassarre, G., Viglione, A., Carr, G., Kuil, L., Salinas, L., & Bloschl, G. Socio-hydrology: conceptualising human-flood interactions. Hydrol. Earth Syst. Sci., 17, 3295–3303 (2013).
2. Cutter, S.L., C. Emrich, D. Morath, and C.M. Dunning, 2013. Integrating social vulnerability into federal flood risk management planning, J. Flood Risk Management, 6(4):332-344.
3. Aerts, J.C.J.H., Botzen, W.J., Clarke, K., Cutter, S.L., Michel-Kerjan, E., Surminski, S., Mysiak, J., Merz, B., Hall, J., Kunreuther, H. (2018) Including Human Behavior in Flood risk assessment. Nature CC. 8, 193-199

Data analysis from the Bayesian point of view

M. Holschneider (1)

(1) University of Potsdam, Germany

The investigation of techniques of how to bring together models and data is a recent field of scientific interest. It is largely the increasing amount of available data and its heterogeneous nature which has boosted in the last years the new emerging field of data science. At the heart of many concepts of how to bring together statistical descriptive models and data is the so called Bayesian approach of statistical modelling. Although the underlying basic mathematical structure is almost as old as the calculus of probabilities, it is only recently that thanks to the increasing computing capabilities, the Bayesian computations become feasible for large data sets. In this talk we will give a primer on this technique of statistical data interpretation and we will pinpoint in particular to some surprising difficulties in the interpretation of the results of a Bayesian computation. In particular the influence of seemingly natural but inappropriate choices for the prior may lead to sever difficulties in the understanding. Several examples from natural sciences will be presented ranging from earthquake data to geomagnetic data analysis.

Cascade and Multi-Hazard

J. Rhyner (1)

(1) United Nations University

Traditionally natural hazard risk management has concentrated on single, non-cascading hazard processes, which is a successful approach under many circumstances. A good process understanding as well as a good database are crucial for a successful risk management, be it in the preparation, early warning, intervention or reconstruction phase. – However, complex hazard events, with multiple sub-processes, in parallel ("multi") and/or sequential ("cascade") mode, possibly interacting with each other, evade this simplified picture. Complex hazard events can connect very different domains, ranging from the physical hazard processes, technical infrastructures, to social-ecological and economical dynamics, each with its own mechanisms and temporal and spatial scales. From a scientific point of view, this requires a strongly interdisciplinary approach, particularly in understanding the interfaces between the different domains. From a risk management perspective, complexity often leads to an idiosyncratic nature of the hazard events, hampering a comprehensive understanding, a systematic data collection, as well as the transferability of practical experience. – This keynote speech will not attempt to provide a comprehensive theory of complex hazard events, but will use a series of examples (past hazards event as well as hypothetical ones), and available literature, to scrape out some characteristics as well as possible approaches to handle them in practice.

Session 1: Changing Systems: Hydro-Climatological Hazards

Development of Droughts in Brazil in the last years

E. Sávio P. R. Martins (1)

(1) Research Institute of Meteorology and Water Resources

The recent hydrological crisis in Brazil has affected not only the Northeast Region of Brazil, commonly subject to recurrent droughts, but also the large metropolitan areas of São Paulo, Belo Horizonte, and Rio de Janeiro. For the Northeast Region, the present water crisis is the result of a multiyear drought, which has thus far lasted from 2012 to 2018 – at least, in most part of the region. The magnitude of the crises caused by the droughts of this period in the northeast region, however, has meant that the question of water resources management associated with water security has entered the national political agenda, creating an opportunity to better structure and prepare the country to confront future droughts and dry periods. This study describes the multi-year drought experienced by the Northeast between 2012 and 2018, contextualizing the extreme variability experienced by the region. At the same time, the article examines the climate forcings that influenced drought in the region and how well the climate forecast system in place was able to capture that.

Additionally, in order to better understand past and future characteristics of droughts in the region other analyzes were performed/presented to identify/show:

1. the factors that influence vulnerability: static (physiography), semi-static (e.g. population density, water uses) and variable factors (e.g. rainfall, streamflow, storage in reservoirs);
2. the relationship between average drought frequency and the potential evapotranspiration / precipitation ratio for semi-arid and subhumid areas in the region;
3. the relationship between average drought frequency and the ratio of mean annual deficit to mean annual precipitation for semi-arid and subhumid areas in the region;
4. the effect of a network of reservoirs on the spatial distribution of stored surface water volumes over time. This particular analysis is carried out using as case of study the Banabuiu River Basin, located in the central part of Ceará State (van Öel *et al*., 2018);
5. the possible changes in the hydrometeorological hazard in terms of: (a) the accumulated precipitation; (b) the difference between precipitation and evaporation ($P-E$); and (c) its potential impact on two São Francisco River Basin reservoirs inflows (Q). These results were part of an assessment and attribution analysis of the 2016 Northeast Region drought event (Martins *et al.*, 2018).

Most, if not all, of the analyzes before mentioned seems to be a necessary step before engaging in elaboration of drought mitigation plans, since they may provide important information regarding, for example, how drought characteristics varies across climate regions and how different factors affect vulnerability to droughts.

From Fire to Frosts to Floods, and from Droughts to Diseases to Discomfort: Prognoses into the Future of Climate Drivers in an Already Climate Stressed South Africa

R. Schulze (1)

(1) University of KwaZulu-Natal Pietermaritzburg 3201 South Africa

Even under present conditions, South Africa is already a climate stressed country with a highly variable rainfall, some excessive climate driven extremes and experiencing a wide range of primary and higher order weather and climate impacts ranging from severe floods and droughts, natural fires, human and animal discomfort as well as climate related diseases. Many of these impacts are likely to be exacerbated by climate change. A recently completed comprehensive study over South Africa has assessed projected impacts of climate change for the phenomena named above, and for many more, with impacts mapped on a fine spatial resolution. The presentation outlines methodologies applied, isolates some key areas of concern, highlights those regions within the country that are more at risk than others by being more sensitive to climatic perturbations and presents ideas to decision makers on mitigation and adaptation pathways.

Increasing severity of floods associated with changing climate in the coastal megacities of India

S. Nair Krishnapillai (1)

(1) Centre for Earth Research and Environment Management Kochi 682036 India

Millions of poor people with low adaptive capacity living in slums and coastal zones of the cities make India highly vulnerable to the impacts of climate change. Extremes in climate together with anthropogenic activities cause severe floods in the coastal megacities Mumbai, Kolkata and Chennai, resulting in casualties and large-scale damage to infrastructure. Uncontrolled growth in urban population due to migration from rural areas and illegal migration from neighbouring countries makes flood management complicated. Indiscriminate encroachment into waterways, inadequate capacity of drains and improper maintenance of the drainage infrastructure creates severe floods in every rainy season. These cities also face threat from the sea level rise, increased wave action and increasing frequency and severity of cyclones. Flooding due to waves and storm surges contaminate the coastal water resources. Rising sea level may further deteriorate it. Destruction of wetlands, paddy fields and canals in and around the cities aggravate the flood conditions. Release of solid wastes into sewage channels results in flash floods, leading to serious environmental and health issues. Coastal flooding creates socio-economic issues such as mass migration to the interior leading to competition and conflict over resources and large investment required for adaptation and impact mitigation. This paper analyses the impact of floods in the coastal megacities of India and critically reviews the current policies and adaptation strategies. Analysis shows an increasing trend in rainfall seasonality and intensity, and proneness to floods. Current measures for the flood impact mitigation and climate change adaptation in Indian cities are poor. National Disaster Management Authority is yet to release guidelines for urban flood management. Climate policy doesn't consider urban water issues seriously. Implementation of regulations such as the coastal zone regulation act often fails because of various administrative, social, political and economic reasons. India needs to develop an appropriate strategy and policy for climate change adaptation and impact mitigation, with special focus on the coastal cities. Suggestions for an appropriate urban policy and flood impact mitigation strategy have been provided, considering the present scenario and possible changes predicted by models.

Flood risk (d)evolution: disentangling key drivers of flood risk change with a retro-model experiment

M. Mosimann (1), P. Hofer, V. Röthlisberger, J. A. Ramirez, M. Keiler, R. Weingartner, A. Paul Zischg

(1) Geographisches Institut, Universität Bern, Bern 3012 Switzerland

Flood risks are dynamically changing over time. Over decades and centuries, the main drivers for flood risk change are influenced either by perturbations or slow alterations in the natural environment or, more importantly, by socio-economic development and human interventions. However, changes in the natural and human environment are intertwined. Thus, the analysis of the main drivers for flood risk changes requires a disentangling of the individual risk components. Here, we present a method for isolating the individual effects of selected drivers of change and selected flood risk management options based on a model experiment. In contrast to purely synthetic model experiments, we built our analyses upon a retro-model consisting of several spatio-temporal stages of river morphology and settlement structure. The main advantage of this approach is that the overall long-term dynamics are known and do not have to be assumed. We used this model setup to analyse the temporal evolution of the flood risk, for an ex-post evaluation of the key drivers of change, and for analysing possible alternative pathways for flood risk evolution under different governance settings. We showed that in the study region the construction of lateral levees and the consecutive river incision are the main drivers for decreasing flood risks over the last century. A rebound effect in flood risk can be observed following an increase in settlements since the 1960s. This effect is not as relevant as the river engineering measures, but it will become increasingly relevant in the future with continued socio-economic growth. The presented approach could provide a methodological framework for studying pathways for future flood risk evolvement and for the formulation of narratives for adapting governmental flood risk strategies to the spatio-temporal dynamics in the built environment. The model experiment is visualized in a web-based interactive application (www.risikodynamik.ch). The app allows analyzing different combinations of the main flood risk drivers.

The influence of transient flood risk factor on the expectation of loss

K. Piroth (1), K. Rother

(1) CDM Smith Alsbach 64665 Deutschland

The working Group HW4-5 of the German Association of Water, Waste Water and Waste has been established in 2017 to report on the state of the art knowledge how transient (changing) relevant processes in flood risk management are influencing the expectation of loss. The relevant processes (parameters) are: the 1) the expected change of the probability of occurrence of floods (Hydrology) for example due to climate changes or land use in the catchment areas 2) Changes in the flood profile of the river which influences the water level for a specific discharge (Hydraulic) 3) Development of the total values at risk in the potential flooding area of the river (total value) and 4) the vulnerability defined as the potential to overcome a flooding with a minimum of losses due to well selected construction materials. All these 4 parameters are changing with time and all 4 are connected in a multiplicative functional chain with the expectation of value. Flood Protection measure are preventing areas from flooding up to a specific discharge in the river and these measures initiates in many cases a atmosphere of safety which leads to less Flood prevention in the "protected areas" which finally leads to significantly higher values at risk in these areas and the aspect of vulnerability is also more and more neglected. Finally this could lead to a higher expected value of losses. The work is still ongoing so in the presentation the basic model concept (idea) and preliminary results (as available) are presented.

Flash-Floods: more often, more severe, more damaging? An analysis of hydro-geo-environmental conditions and anthropogenic impacts

A.Bronstert (1), A. Agarwal (1), B. Boessenkool (1), I. Crisologo (1), M. Fischer (2), M. Heistermann (1), L. Köhn-Reich (1), T. Moran (2), U. Ozturk (1), C. Reinhardt-Imjela (2), D. Wendi (1)

(1) University of Potsdam, Germany,
(2) FU Berlin

In recent years, urban and rural flash floods in Europe and abroad have gained considerable attention, because of their sudden occurrence, severe material damages and even danger to life of inhabitants. This contribution addresses questions about possibly changing occurrence frequencies of such events, meteorological, hydrological and hydraulic mechanisms which may have lead to an altered flash flood occurrence and associated damages.

We take the flash-flood in Braunsbach as an example. In this area of Northeastern part of the state of Baden-Wuerttemberg, Germany, a particularly concise flash flood event occurred at the end of May 2016. This extreme cascade of natural events, i.e. extreme rainfall intensity, causing extreme surface runoff and channel discharge, furthermore great debris flow, lead to immense damage in this particular village. 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 presentation analyses also the role of various human activities, such as altered probability of storm rainfall events, land use effects as a consequence of agricultural practices, and impacts of hydraulic constructions, such as torrent control and urban river constructions.

Session2: Geophysical Hazards

Sinkhole characterization with supplementing geophysical methods – the joint project SIMULTAN

C. Krawczyk (1) and SIMULTAN Research Group

(1) Helmholtz Centre Potsdam, German Research Centre for Geosciences - GFZ, Potsdam, Germany

Scientific key questions in sinkhole research encompass the geophysical characterization of subsidence areas, the control of void evolution and sinkhole formation at depth, or if microearthquakes are precursors for larger rock fall or collapse events. Close to surface, sinkholes manifest in a variety of ways, depending on both process stage and rate. While collapse structures occur rapidly and within a few minutes, continuous subsidence is observed in many sinkhole areas, that progresses slowly and for many years with only a few mm/year. Therefore, the joint project SIMULTAN (Sinkhole Instability: integrated MULTi-scale monitoring and ANalysis) develops and applies an early recognition system of sinkhole instability, unrest and collapse in Germany, especially for urban areas. The research approach combines structural, geodetic, geophysical, petrophysical, and hydrogeological mapping methods, accompanied by sensor development, multi-scale monitoring, modelling, and an information platform. Two focus areas are investigated in Germany, for which sinkhole unrest has been identified. The surveyed areas are representative of evaporitic sinkhole formation, and are highly relevant since located in densely populated areas. Shear-wave reflection seismics enables high-resolution structural imaging of critical zones, while additional vertical seismic profiling (VSP) provides hints on subrosive zones by velocity analyses. Spatial detection thresholds for microseismic events were calculated using a combination of synthetic event signals and noise recorded in the field. Improvements of the detection and localization capability due to additional borehole stations and surface mini-arrays were investigated. The potential to detect mass dislocations in the upper subsurface is proven by repeated gravimetry and levelling campaigns, that are supplemented by micro-gravimetry. How combined direct-push and SIP-monitoring will characterize sufficiently the soil-water-interaction in the upper 40 m is still in the testing phase, but stable inversion schemes are yielded. All these petrophysical parameters gained are fed into modelling and simulation studies that describe dissolution initiation and explain realistic collapse scenarios in the light of overburden strength. The geophysical surveys, monitoring campaigns, and modelled scenarios provided so far by the integrated project SIMULTAN show both the feasibility and limits of approaches chosen. The reduction of seismic velocities and irregularities in wave-propagation behavior in the presence of subrosion are an important attribute that should be further evaluated with respect to its sensitivity and the technical implementation of it into a prediction tool. After a 2-years period of surveying only, we recommend that time-lapse and monitoring surveys shall be maintained during the next years to explore attribute sensitivity. InSAR monitoring should complement the geodetic monitoring setups, to better rate the sinkhole process and its stage in an area. The combination of the above results with scenario modelling finally yields background and basic information for decision makers, and the cooperation with geological surveys will advance the development of sinkhole instability recognition systems.Visit the SIMULTAN Research Group for more detailed and steadily updated information under http://simultan.gfz-potsdam.de .

A regionalized strain-rate based seismicity model for subduction zones

J. Antonio Bayona Viveros (1), S. von Specht (1), A. Strader (1), F. Cotton (1), S. Hainzl (1), D. Schorlemmer (1)

(1) Helmholtz Centre Potsdam, German Research Centre for Geosciences - GFZ, Potsdam, Germany

The occurrence of the 2004 Sumatra (M = 9.1), the 2011 Tohoku (M = 9.0) or the 2017 Mexico (M = 7.1) earthquakes have shown that seismicity models may locally fail since existing earthquake catalogs are still too short to sample the largest possible events along faults and plate boundaries. Currently, geodetic strain rates, earthquake catalog-data and plate-motion models provide global homogeneous coverage and constitute the basis towards the development of better constrained high-resolution seismicity forecasts. The SHIFT_GSRM seismicity model, for instance, computes long-term seismic moment rates using rates of crustal interseismic deformation. Although SHIFT_GSRM properly estimates earthquake rates in active continental regions, it underestimates number of earthquakes in subduction zones by a factor of approximately 3.We present a generalized SHIFT_GSRM moment-rate equation, which explicitly accounts for the effect of fault dipping and uses regional seismicity parameters (e.g. seismogenic thickness and seismic coupling coefficient) as input data.With this method, we overpredict rates of seismic moment release and improve SHIFT_GSRM computations at 34 subduction zones. This permits us to discuss about those trench segments where the elastic rebound has not been yet compensated by the occurrence of large events and, most importantly, about how these results could be used as scientific evidence for earthquake warning in these regions.

A Physics-Based PSHA Conceptual Workflow for Low-Strain Areas

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In probabilistic seismic hazard assessment (PSHA), the contemporary framework for quantifying the impact of seismicity, occurrence rates of future earthquakes are estimated from earthquake catalogues under the assumption of stationarity. WhilePSHA is well-established for regions of high seismicity, it has been questioned in recent years if this approach also provides a reliable framework for low-strain regions where the earthquake catalogues may contain insufficient information to constrain long-term activity rates. Stable continental regions (SCRs) are a prominent example of such regions, since low strain and, consequently, low energy loading rates lead to low seismicity rates. Additionally, a discussion has sparked recently whether SCRs are in fact stationary systems, or if their seismicity consists solely of unique relaxations of a pre-stressed lithosphere or temporal changes in crustal strength. In this work, we propose a physics-based modification of the established PSHA source workflow that relaxes the underlying assumptions only minimally. This novel approach to PSHA integrates conservation of energy using geomechanical models to estimate the energy density and its accumulation rate. In combination with existing records and material properties this density is used to determine the spatial variation in the parameters of a Gutenberg-Richter type magnitude-frequency relation. Through the introduction of the physical properties, the approach is feasible for all regions whose catalogues contain data above the magnitude of completeness and for which sufficient information for geomechanical models is available. As a result, it may enhance the achievable accuracy of the classical PSHA in SCRs, where seismicity at high magnitudes is scarce, and may benefit, through constraints in stress accumulation, from the increase in 3Dsurface deformation time series from geodetic observations. Furthermore, this new framework gives the opportunity to include specific physical or geological knowledge of the region to be implemented to further enhance the precision. We present the basic conceptual workflow of our physics-based PSHA and a feasibility test.

Variabilities and Uncertainties in Seismic Ground-Motion Prediction: Implications on Seismic Hazard Assessment

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Among the key challenges of Engineering Seismology is to empirically model the earthquake phenomenon in order to predict accurate and precise seismic ground-motions in a geographical region. The unsolvable natural variability associated with ground-motion prediction strongly influences the Probabilistic Seismic Hazard and Risk Assessment, which in turn sets the design standard of engineered structures. Fortunately, with the exponential growth of recorded seismological data and the advent of machine learning techniques, quantification and calibration of latent physical processes that govern the observed ground-motion variability is now viable. Last three years, exploiting the potential of multiple large ground-motion datasets (NGA-West2, RESORCE and KiK-Net) with mixed-effects analysis and unsupervised machine learning techniques, we developed new Ground-Motion Prediction Equations (GMPEs) with source-, path- and site-specific effects systematically constrained and prediction variances dramatically reduced. We implemented these new non-ergodic GMPEs in hazard computations and demonstrated their significant impact on assessed hazard levels in Europe and Middle-Eastern regions (Kotha et al., 2016, Bindi et al., 2017, Kotha et al., 2017, Kotha et al., 2018). The large datasets of today, for the first time, allow empirical modeling of complex earthquake phenomena - which were theorized decades ago by Seismologist, but being unquantifiable, were often discounted from natural risk assessment of built environment.

Coupling Empirical and Simulation-based Ground Motion Model

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This study aims to couple empirical and simulated ground motions to better constrain the near-source ground motion prediction. Simulations are performed using a stochastic full waveform method, and considering a set of potential future earthquakes from a realization of seismicity for a given period of time. Variability in the rupture process (slip distribution, relative position of the hypocenter) is also incorporated to capture the resulting ground motion variability due to near-source phenomena like directivity effects. Intensity measures from the simulation and empirical ground motion models are extracted to analyze the ground motion variability and to get an insights on the choice of the transition distance for the coupling. This study is particularly important for areas with sparse ground motion data and could potentially improve the seismic hazard assessment.

Learning more to predict landslides in different scales (Regional to local)

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An efficient landslide risk assessment is linked to realizing the triggering mechanisms (i.e. Rainfall, Earthquake). For example, quantifying regional-scale trajectories of extreme rainfall will aid predicting landslide prone regions or the earthquake directivity assists identifying boundary conditions of a landscape for concomitant landslide hazards. We explored the weights of different parameters that bias the landslide distribution through investigating rainfall and earthquake triggered landslides in different scales. We used event-synchronization derived network analysis to compare spatial features of extreme rainfall over Japan using satellite-derived rainfall data (TRMM-3B42V7). Then we traced the network flux over long distances (>10^2 km) employing radial statistics, which allows us to observe the general pattern of extreme rainfall tracks. Although increase in the rainfall intensity and duration positively correlates with landslide occurrence, common trajectories of typhoons and frontal storms are insufficient to explain the spatial distribution of landslides in regional scale (>10^2 km). We witnessed in Braunsbach (a case study location in Germany) that landslides are triggered by rainfall derived flash floods by e.g. hillslope toe removal. Thus, we found that the morphometric features of slope and curvature play a more dominant role in micro scale (<10 km^2). Slope and curvature are also important in case of the distribution of the earthquake triggered landslides. We discovered that the earthquake influence is amplified due to topographic site effects, e.g., surface slopes, height, and/or width of hills in another case study in Kumamoto (Japan). Nevertheless, morphometric features fail in explaining the distribution of landslides the preferred orientation of the landslides, which is normal to the rupture plane, is dominated mainly by the directivity effect of the earthquake.

Session 3: Linking Hazard and Vulnerability

Adaptability as a strategy to manage natural hazards in an uncertain future

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Future natural hazard risks are subject to significant uncertainty, because of evolving socio-economic and climatic processes that are at best partially understood. When planning long-term measures for dealing with these hazards, in particular civil infrastructure with lifetimes in the order of 50-100 years, these uncertainties must be addressed. Consider the planning or upgrading of a sewer system in an urban setting, where a trade-off must be found between the lifetime cost of the system and the risk of flooding, with uncertainty on the future land-use, population equivalents and climate. One strategy to deal with such uncertainties is to implement measures that are adaptable (flexible), which can be adjusted to changing demands and conditions in the future with limited effort. However, flexibility often comes at a cost, and it is thus relevant to quantify the benefit of the system flexibility in view of the future uncertainties. In this talk, we first discuss the nature of flexible and adaptable measures and then suggest a quantitative definition of flexibility. We then present a framework for quantifying the effect of flexibility on the lifetime cost and risk of measures, based on sequential decision analysis under uncertainty. We use a generic model in an attempt to make general recommendations on the use of flexible solutions for risk protection. Additionally, we demonstrate the approach through a case study on the optimization of a protection system against fluvial floods in Bavaria.

Efficiency of flood protection measures

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The statement “Flood losses are increasing” is found in many publications dealing with floods and their consequences. While there is no question that absolute loss figures from extreme events tend to reach higher values today than in the past, the statement must be rendered more precisely. In fact we cannot see, globally and in many regions, a clear signal of a rising trend in many time series of losses. While the number of loss events is typically increasing, loss amounts are displaying a different pattern: the frequency of significant losses is falling, but if a loss occurs, it tends to be extremely high. One explanation for this observation is the development in flood control and flood protection in many countries. Increasing population density, higher wealth and higher vulnerability, but also environmental changes in the catchments and of the drainage systems which influence the genesis of floods, let alone climatic changes, make losses more severe. On the other hand, flood risk management measures such as retention areas and dykes should reduce losses during discharges with a return period of less than roughly 100 years, the typical design value. This is a qualitative statement. There are only few studies that have proved it by comparing the actual performance of flood control systems. Some examples of flood control measures are presented. Performance or efficiency is calculated by comparing the costs of investment and maintenance against the losses prevented after a measure was put in place. Detailed figures are available for two major systems: The city of Hamburg/Germany established a protection system against storm surges after a catastrophic event in 1962. Up to now, about 2.6bn euros has been invested (expressed in values of 2018). However, the estimated pay-off of the measures already exceeds 15bn euros. The Mississippi River and Tributary (MR&T) project, established in 1928 after the Mississippi deluge of 1927, has consumed more than US$ 15bn in investments so far (original values). The damage prevented by those measures is estimated by the Mississippi River Commission at US$ 823bn – 54 times as much. The construction of the Sylvenstein reservoir in Bavaria/Germany has shown similar success, as do many other projects around the world. But studies explicitly comparing costs and reduced losses are still very sparse. More investigations are badly needed. They can effectively raise awareness of decision makers and the general public.

Translating flood disasters into the future – a storyline approach to build flood resilience

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At the end of October 2014, an enormous atmospheric river reached the West Coast of Norway, producing extreme amounts of precipitation and consequently, devastating floods in several valleys. With the vulnerability of the local communities as main motivation, this study started by discussing with different stakeholders (municipalities, hydropower companies, meteorological service, television channels and state authorities) what information they wished to have in hand to be better prepared for a future, and potentially more intense, precipitation events caused by atmospheric rivers. Taking a “tales of future weather” approach, we aim at gaining a more realistic picture of how a specific future extreme weather event at the West Coast of Norway might look like, rather than providing an estimation of the probability of future extreme precipitation in that region. With the same modelling chain used routinely for weather prediction by the Norwegian Meteorological Institute, we perform a high-resolution ensemble with the regional numerical weather prediction model AROME MetCOop (spatial resolution of 2.5 km) for the October 2014 event. For the operational weather forecasts, the AROME MetCOop model is driven by the ECMWF forecasts, but here, we drive the model with simulations of an analogue of the October 2014 event in the EC-EARTH global Earth System model (spatial resolution of 25 km) under present and future climate conditions. Finally, to better illustrate how a future flood might look like, we use a version of the HBV hydrology model to compute the river discharge in the river catchment of interest using the present and future simulations downscaled with AROME MetCOop. The results will be distributed by standard (weather prediction) communication channels of the Norwegian Meteorological Institute and thus, will be easily accessible by end-users for analyzing the impact of the events in the future and support decision-making on hazard prevention and control.

Human influence and response to socio-natural hazards

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Climate change, globalization, urbanization, social isolation, and increased interconnectedness between natural, social, and technological systems challenge our ability to plan appropriate risk reduction measures. Economic losses caused by natural hazards – such as earthquakes, floods, and storms and volcanic eruptions – are increasing in many regions of the world, despite scientific progress and community efforts to enhance disaster risk reduction (DRR). Here a new integrative framework recognizing the complexity as well as the spatial and temporal evolution of both socio-technical vulnerabilities and natural hazards is proposed. The research framework acknowledges a careful treatment of individual cases as tightly coupled socio-natural systems and it emphasizes the role of reciprocal feedback mechanisms between physical and social processes. Applications to hydrological hazards (floods and droughts) are shown to demonstrate the potentials and limitations of the proposed framework.

What approaches and data are needed to better understand trends in drought and flood impacts?

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Impacts due to droughts and floods are high. The observed increasing trend of flood impacts is mainly determined by exposure increase, while an effect of change in hazard due to anthropogenic climate change has hardly been observed to date. However, the climate signal might be masked by a counteracting decrease in vulnerability due to effective risk management and other formal measures like land use planning. A decrease in drought impacts cannot be detected, even though a decrease of vulnerability to drought might be expected, due to technical development and implemented risk reduction strategies. On the other hand, vulnerability to droughts may have increased because societies have become more dependent on water, grow more risky crops, etc. Many factors and processes influence vulnerability to droughts and floods, and detailed knowledge about temporal trends in vulnerability and impacts are largely lacking. With this presentation, we aim to raise awareness and encourage a more in-depth exchange between drought and flood experts about attribution of impact changes based on historic assessments, with a view to project future changes in risk. We will present an overview of expected main drivers of impact changes and discuss how these could be monitored. We argue that the main obstacles to scientific advancement in this area is a lack of common concepts and approaches as well as of detailed, consistent time series of hazard, exposure, vulnerability and impact data. We present an overview of available impact information, discuss their advantages and disadvantages, and propose which types of data are needed for making progress in attributing temporal changes of impacts. With this presentation we hope to trigger further discussion and activities of drought and flood experts to jointly advance our knowledge about past and future trends in vulnerability and impacts.

The 1968 floods in South-East of the United Kingdom: A 50 Year Retrospective

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The flooding which affected the south-eastern part of the UK exactly 50 years ago in September 1968 was an extreme event which has no parallel over the period since meteorological and hydrological monitoring has been in place up to the present day. Rainfall totals reached 130mm in 24 hours and over 200mm in 48 hours – nearly 40% of the annual average rainfall. The event gave rise to the highest flows on record on 33 rivers which still have not been exceeded. It was also a catastrophic event in terms of the amount of disruption, damage and economic losses, with estimates of around 15,000 properties being flooded. This current study discusses the characteristics of the 1968 flood, the rainfall, river flows and the areas affected, and the impact if the same event were to occur today. The analysis makes use of flood extent maps for the event using observed flood levels from 64 river gauging stations. The maps have been generated using a cell-based modelling routine in ArcGIS based on a mapped river network and a 50m resolution digital terrain model. A combination of the flood extents with current land-use maps provides information on the number and types of properties affected and enables an estimate of the economic losses if the event were to occur today. The study also considers the implications of climate change with a warmer atmosphere giving rise to event greater rainfall magnitudes and how the changing social environment will also lead to a greater flood risk.

Session 4: Modelling and Data

Sub-hourly extreme rainfall scenarios (following Clausius-Clapeyron)

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Sub-hourly rainfall scenarios are derived from a global climate simulation using a two-step procedure, and statistics describing present and future extreme rainfall are estimated. In the first step, daily global climate fields are spatially downscaled to local temperature (T) and precipitation (P) scenarios in the second, the daily local series are disaggregated to a temporal resolution of 10 minutes using a multiplicative random cascade model. That model is used in two versions, a classical version (MC) and one with a novel implementation of Clausius-Clapeyron (CC) sensitivity of sub-hourly extreme rainfall on T (MC+). Using simulated and downscaled T and P for present climate, the resulting T sensitivity verifies well with observations. In consequence, the full range of extreme rainfall is better represented by MC+, which should also apply to future values due to the validity of the CC law. Unlike MC, MC+ reproduces most of the long-term trends in extreme sub-hourly P. Because both simulated present and future short-term heavy rainfall is more variable for MC+, the corresponding signal-to-noise problem needs extra care. First estimates indicate, however, that on average, future 3y return levels increase by 7% for MC and by 20% for MC+.

Damage estimation for hydro-meteorological hazards at seamless spatial scales

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Financial loss of approximately 110 billion US-Dollar was caused by hydro-meteorological hazards globally in 2016 yet, reliable hazard damage modeling that is consistent at all spatial scales and represents the uncertainties associated with the estimations is missing. Many hazard damage models are derived at the object level. The application, however, often takes place at a lower spatial resolution leading to inconsistencies. In addition, spatial exposure data such as land use data sets are often inhomogeneous in itself. Most state of the art methods are not able to represent uncertainties associated with the different components of the risk namely the hazard, the exposure and the vulnerability of the exposed objects. Therefore, this study aims to introduce a concept which considers uncertainties associated with hydro-meteorological hazard damage estimations at seamless spatial scales. The consideration of individual objects affected by hydro-meteorological hazards enables the estimation of the damage at arbitrary spatial scales. The number of affected objects can e.g. be obtained by data sources such as openbuidingmap.org, which provides a refined version of open street map. Additional information about the objects needed for the damage modeling, such as building type or hazard intensity, is sampled from distributions representing the regional and/or event characteristics. Various data sources to derive these distributions can be used, e.g. surveys, official statistics, data sets available in similar regions, expert knowledge and hazard maps. Several realizations regarding the characteristics are sampled for each individual object resulting in corresponding damage estimations for each realization. Hence uncertainties associated with the exposed objects or the hazard characteristics at these objects are also represented by distributions of possible occurring damage. The concept is applied and validated for flood damage estimation of companies in Saxony, Germany for the flood event in the year 2013. The results show that the damage estimates are more accurate compared to damage estimates of damage models using land use data. Further, the damage estimation works reliably at all spatial scales.

EMRA: A Decision support system for monitoring, warning and risk assessment of weather extremes for agriculture

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Monitoring weather extremes and their impacts is crucial to adapt cultivation methods for agriculturists to support decision making and to refine soil policies especially in the context of climate change. A precondition for an effective monitoring is the availability of indices representing the spatiotemporal dynamic of influencing factors like precipitation, temperature or soil coverage as well as data on impacts of weather extremes. Against this background we cooperate with meteorologists, agricultural scientists and practitioners to develop the „Extreme weather Monitoring and Risk Assessment“ tool EMRA. This decision support tool will be interactive and includes both a website and a mobile application. EMRA aggregates phenological information and geo data to identify historic, acute and long-term weather risks specified to crops and geographic regions. Hence it will derive practice-oriented and personalized advice to agriculturalists and agricultural consultants, including damage reduction potential of counter measures and a warning system for acute threats. EMRA also incorporates the knowledge of farmers about their vulnerability to extreme weather events and climate change. This is prepared by a nationwide survey among farmers on weather induced crop damage. EMRA employs two case studies: “apples in northern Germany” and “winter wheat in Uckermark”. In the case study in the county Uckermark situated in north-eastern Germany, we show process chains for the derivation of dynamic weather and soil erosion indices. The algorithms couple phenological information, satellite images as well as daily data sets of precipitation and temperature (Gerstmann et al. 2016, Möller et al. 2017, Möller et al. 2018). The resulting database allows both (1) the localization of hot spot parcels, which show a potentially high risk of soil erosion as well as (2) the identification of extreme weather conditions like drought during sensitive growing periods of winter wheat. The modeling results are essential background information for the practice-oriented decision support. Modeling results are continuously both validated and trained by contrasting them to feedback from associated model farms and EMRA users.EMRA is funded by the German Federal Ministry of Food and Agriculture (BMEL). In the long run we aspire to permanently run EMRA and expand it on further crops and regions in Germany.

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Forecasting Weather Related Fire Brigade Operations by linking meteorological forecasts with vulnerability indicators

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It has been stated in the Sendai Framework for Disaster Risk Reduction 2015-2030 by the United Nations, that the implementation of effective disaster risk reduction measures should be based on an under-standing of disaster risks, including all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment. On local and national levels, this requires to systematically evaluate, record, share and publicly account for disaster losses to gain understanding of the impacts in the context of event-specific hazard, exposure and vulnerability information. Severe convective events, accompanied by strong wind gusts, high intensity precipitation and hail often cause large impacts on society. Particularly in large metropolitan areas these events can pose enormous challenges to civil protection agencies such as fire brigades. In order to maintain an effective management of fire brigade operations in advance as well as during such events it would certainly be of great value to be able to predict possible impacts on high spatial resolution, such as urban district scale or higher. However predictability of local impacts is strongly limited due to a lack of predictive skill for severe weather conditions on such small scales, particularly for lead times of hours and more. Secondly, impacts strongly depend on non-meteorological factors such as the local exposure to specific hazards as well as the vulnerability of exposed assets. In this study we developed a high-resolved impact model for operations of the Berlin fire brigade for convective thunderstorm events, mainly focusing on impacts related to heavy precipitation and hail. Based on weather related operation records of the Berlin fire brigade this study investigates in how far data from state of the art nowcasting systems could potentially be used to predict local weather impacts on very short lead times. For this, an analysis of the relation between local thunderstorm conditions and the occurrence of local fire brigade operations in Berlin has been conducted. Convective cell footprints, comprising spatial information on the maximum observed radar reflectivity have been constructed from KONRAD analyses data. Local radar reflectivity as a predictor for the cell intensity is linked to the occurrence of fire brigade operations. A strong dependence of operation occurrences, particularly for those operations tagged with the keyword water damage, at locations affected by a thunderstorm cell is found. Within a 1x1 km area and in a time interval of 6 hours after a thunderstorm event, the likelihood of a water damage to occur after a convective event has been detected is found to be roughly 4%, compared to 0.5% if the area has not been affected. Employing exposure indicators as derived from open street map data, the likelihood for operation occurrences can be stratified finding a strong dependence on building density. For areas with lowest building densities, i.e. an area coverage of buildings ranging between 0% and 2%, the likelihood for an operation occurrence within a 1x1km is only 0.4%. Similarly, probabilities increase to more than 11% for areas with high building densities (area coverage of buildings above 20%). Two severe convective events are analyzed in greater detail, demonstrating the applicability of the model and pointing out how such approach could be used as the basis for the design of future warning systems based on impact- and risk- forecasts.

Basic European Assets Map, a Copernicus Service addressing cross border activities

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The BEAM (Basic European Assets Map) methodology and data set has been developed to estimate, evaluate and compare real and potential damages caused by natural disasters all across Europe, focussing both on European and national studies. This results in a significant advantage in cross border projects. Furthermore, the service concept is designed in a way that it can easily be refined to more detailed land use and statistical data.BEAM displays assets in monetary values per area unit (€/m²). The complete asset information is composed of different layers, as within a damage assessment calculation each type of asset needs to be calculated applying a different damage function. The information provided is completed by an additional layer showing the population density.BEAM is designed to perform cross border studies and to compare potential damages throughout Europe using a reliable and uniform data base. An additional advantage is the fact that the underlying methodology is scalable and can be adapted to more detailed land use and statistical data if required. Furthermore, as BEAM is coupled to the CORINE and Urban atlas data sets as well as to European statistics, it can be used for multi temporal analysis. As the concept strictly separates assets from damages, it can easily be applied to all types of risk and is thus an ideal basis for multi-risk-analysis. To perform this, already a lot of damage functions for different types of natural hazards have been collected, adopted and applied in different projects. In the FP 7 project IncREO the BEAM-methodology set has been updated by integration of additional input data sets and also has some additional output layers to offer, still the compatibility with the first release was a major concern within the development. The data set has been used in the flood risk atlases of Danube and Elbe, last activation within the Copernicus scheme has been in 2017 for Finland, further activations are expected for 2018.

Improving hazard communication using online map services and interactive visualization approaches: experiences from cooperation with administration partners in Saxony (Germany), Argentina and Colombia

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The way we investigate natural hazards and risk mitigation may be improved by efforts to better visualize available data and to improve risk communication. Here, we present 3 real-world examples, where we applied user-focused visualization techniques and online-map services to improve the communication between scientists and non-academic stakeholders. All approaches were developed in close cooperation with governmental authorities responsible for hazard mitigation. We focused on the improvement of modern visualization approaches, which go beyond classic GIS mapping services. Also, we integrated individual expectations of the end-users in order to improve the transfer of scientific knowledge and the usage of our expertise. We present the following three examples: (1) applied 3D visualization of geodata in a flooding context of Southern Saxony by jointly developing a presentation and study environment using a 3D-immersive visualization setting, where stakeholders and scientists jointly got confronted with the local settings. The approach supported the discussion with local authorities demonstrating the real-world effects of relief gradients, soil saturation or locally concentrated stream power (2) We applied a table-top mapping device (digital maps on a 55-inch table-top touch screen) to facilitate the presentation of studied surface processes in a landslide-prone area in Colombia. The table-top mapping device allowed a more direct interaction between the scientific presenter and the non-academic audience trough fast and simultaneous (gesture and haptic) manipulation of the presented data (3) We developed new online-based map services which allow the integration of WMS, RSS- and CAP-feed data in a user-centered online platform. We jointly established our approach with the Argentine Science and Technology Network for Comprehensive Risk Management (MinCyT) and the Institute of Scientific and Technical Research for the Defense (CITEDEF) in order to increase the online available information about natural hazards and risks. This approach enhances communication, because it provides access to already existing data obtained in several (scientific) projects to local decision makers which had no access before. Based on feedback from the presented projects and presentations at other venues, such like the NASA - FOSS 4 GIs exercise, we understand our efforts as a highly valuable contribution to improve the communication between scientists and stakeholders and the easier accessibility of scientific knowledge to a non-academic community in a natural hazard and risk context.

Session 5: Exposure and Risk Management

Climate impact simulations indicate that historical warming has at least tripled global population annually exposed to extreme events

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Weather induced extreme events such as crop failure, river floods, tropical cyclones, heatwaves and droughts represent an immediate threat to communities. In spite of their different characteristics they have a joint potential to cause (long-term) economic losses, displacement, persistence of poverty, or social destabilisation. However, the detection of a climate signal in these social dynamics is difficult due to limited availability of observational records and the complex interplay of bio-physical and direct human drivers. However, according to newly released synchronized climate impact simulations, climate change from pre-industrial conditions to today's 1°C of global warming alone has at least tripled the number of people exposed to extreme events. Assuming fixed year 2005 socio-economic conditions the population exposed to spatially confined events (river floods, tropical cyclones, wildfires, and crop failures) shows a purely climate change-driven increase of 67 mio

people at 1.5°C, and 95 mio people at 2°C global warming compared to pre-industrial climate conditions. The population exposed to spatially extensive events (droughts and heatwaves) increases by 455 mio people at 1.5°C and 781 mio people at 2°C. The repository of harmonized multi-impact model data is intended to evolve in parallel to the climate modelling exercise CMIP and provide the basis for new event-based approaches to estimate the societal impacts of climate change.

Assessing sea level rise risks in changing coastal environments: a national assessment supporting disasters management and climate change adaptation

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Gradually increasing sea levels and extreme events related to changing climate conditions are causing serious threats to coastal areas, affecting both natural and human systems. Moreover, there is growing evidence that socio-economic dynamics (e.g. unplanned urbanization, land use and demographic changes) would increase coastal flood risk in the next decades. Understanding how natural and human-induced drivers concur to determine exposure, vulnerability and risks in coastal areas is of paramount importance for mainstreaming effective climate adaptation and risk reduction policies into coastal zone management. In the frame of the SAVEMEDCOASTS project (www.savemedcoasts.eu), a Climate change Coastal Risk Index (CCRI) was developed to provide guidance and operative criteria for exposure, vulnerability and risk assessment in Mediterranean coastal areas. The overall aim of the index is to identify, map and prioritize natural and human targets at higher risk from climate-related hazards (sea level rise inundation and storm surge flooding) in vulnerable (flood-prone) coastal areas, providing a knowledge base for national-scale adaptation planning and disaster risk management. The index combines (i) hazard-prone areas potentially inundated by sea level rise and extreme water levels in future RCP4.5 and RCP8.5 scenarios (ii) exposure, including a classification of ecosystem services supplied by coastal areas (provisioning, regulation and maintenance, cultural) and indicators of economic, social and manufactured capitals (iii) vulnerability, represented by indicators of geomorphic susceptibility to flooding and adaptive capacity. The CCRI was applied to the Italian peninsula producing a range of spatial risk and vulnerability indicators and statistics including, the estimate of population, infrastructures, urbanized and agricultural areas at risk for different administrative units. The main steps of the methodology and the applicability of results for decision-makers and risk practitioners are here presented and discussed.

Demographic Change and Natural Hazard Risk Management – a Disregarded Link? An Overview of Policy Perspectives from Austria

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The evolving paradigm of natural hazard risk management increasingly builds on the notion that both constituents of flood risk – hazard and vulnerability – are non-stationary and that risk is a dynamic entity (cf. Merz et al. 2010). Land use change in catchments and climate-induced changes in the hydrological cycle influence the intensity and/or frequency of hydro-meteorological hazards, in particular of river floods (cf. Hall et al. 2014). Settlement development and the accumulation of assets in hazard areas, on the other hand, are key driver of the observed increase in damage potential (cf. Di Baldassare et al. 2013), while societal factors significantly determine the vulnerability to natural hazards, i.e. the individual or collective ability to anticipate, cope and recover from the impact of a hazard (cf. Kuhlicke et al. 2011). Despite a broadened perspective and a stronger consideration of the spatio-temporal dynamics of natural risks, both scholarly and policy attention focuses on urban areas that exhibit socio-economic growth. Structurally weak (rural) regions facing population decline and demographic ageing are largely unaccounted for, although demographic trends across Europe indicate that many regions, i.a. the Baltic States, the eastern German Länder, peripheral Alpine regions and large parts of South-Eastern Europe, face sustained population loss or stagnation due to ageing and out-migration (EU 2016). As many of these areas are prone to natural hazards and are repeatedly affected by damaging events, this contribution explores the linkages between demographic change and natural hazard risk management. The contribution builds on the risk management cycle to conceptually dissect how demographic change impacts the individual and societal capacities to protect against hazards, to mitigate and prevent future risks, as well as to prepare for and to cope with damaging events. Based on an online survey among Austrian federal and state policy makers in water management, spatial planning and civil protection (N=75) and a systematic review of the corresponding sectoral policy documents, the study investigates to which extent demographic change is a relevant factor in Austria's flood risk management and is reflected in regionally-attuned flood risk management strategies. Specifically, the study explores policy perspectives concerning the influence of demographic change on (i) the readiness for long-term investments in hazard protection infrastructure, (ii) hazard exposure and settlement development strategies and (iii) social vulnerability to flooding and the capacities to cope with and recover from extreme events. Preliminary findings indicate that – despite an on-going shift toward an anticipatory, forward-looking approach in Austrian flood risk management – socio-demographic change is not explicitly regarded as a relevant factor in disaster risk reduction strategies. Although policy makers are overwhelmingly aware of the societal challenges related to demographic change they i.a. do not consider it a (politically) feasible option to curb public expenditure in flood protection for "shrinking" areas. On the other, they i.a.

acknowledge the need to tailor the communication of hazard and risk information for older residents and to better consider their particular needs when developing emergency rescue plans.

ESPREssO – Enhancing synergies for disaster prevention in the European Union

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ESPREssO aims at contributing to a new strategic vision to approach disaster risk reduction and climate change adaptation, thereby opening new frontiers for research and policy making. In particular, ESPREssO has three objectives: Challenge 1: to propose ways to create more coherent national and European approaches on disaster risk reduction, climate change adaptation and resilience strengthening Challenge 2: to enhance risk management capabilities by bridging the gap between science and legal/policy issues at local and national levels in six European countries Challenge 3: to address the issue of efficient management of transboundary crises. In fact the Sendai Framework for Disaster Risk Reduction 2015-2030 indicates this issue as one of the main unsolved problems at the global level. To overcome these three challenges, a strong interaction with relevant stakeholders from different European countries and from the fields of policy making, research and operational civil protection is required and has been carried out by creating an extensive stakeholder forum within ESPREssO. To elicit the needs and knowledge from the stakeholders, three scenario exercises – one for each of the challenges mentioned above – were used to trigger discussions among the stakeholders expressing their different opinions and perspectives. The scenario exercises were not implemented as an operational training, but rather as a board game representing an abstract and simplified version of reality. The use of the scenario exercises has been found to be a valuable tool for knowledge elicitation as it has created a 'safe' environment in which stakeholders can discuss and share experiences, also with stakeholders they do not usually meet. These findings will feed into the ESPREssO Guidelines on risk management capability, as called for in the forthcoming Civil Protection legislation and a Vision Paper on future research strategies in order to better define the research priorities following the Sendai Framework for Disaster Risk Reduction 2015-2030.

Partners: AMRA (IT), GFZ (DE), BRGM (FR), DKKV (DE), ETHZ (CH), HUD (UK), UCPH (DK)

Note: Results and findings have been achieved by the consortium of the ESPREssO project.

Systemic Risks – Concepts and Suggestions for Risk Governance

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Modern pluralistic societies face many challenges. Human life, societal welfare and the environment are especially challenged by large, systemic risks such as climate change, epidemics, financial breakdown and social inequality. Systemic risks can be outlined by four major properties. First, systemic risks are characterised by scientific complexity and epistemological uncertainty. Science cannot identify the probabilities or the extent of damage in any accurate fashion. Instead, science utilizes models of scenario building, amongst other, to sketch out the stochastic nature of systemic risks. Second, systemic risks are transboundary and global in nature. They transgress nation states and call for international cooperation. Third, although systemic risks originate in one subsystem of society or the environment, ripple effects have far-reaching consequences. Fourth, future technological and societal developments are non-linear. Science struggles to identify tipping points of technological and social trends. Nevertheless, political decision makers call for scientific advice to govern our emergent future. Therefore, systemic risks pose great challenges to governance because they are highly interconnected and complex, stochastic and non-linear in their cause-effect relationships. Furthermore, they are often underestimated in public policy arenas and public perception. Consequentially, systemic risks demand cooperative management efforts of experts, corporate sector, civil society and regulators. Effective risk management must strike a balance between efficiency and resilience, and the solutions devised must be fair to all people affected. Effective, inclusive governance strategies are necessary to pursue the goals of resilience and sustainable development. Another complicating factor is the fact that we have to deal with the challenges of complexity, uncertainty and ambiguity when governing systemic risks. These challenges are inherent to risk itself and limit our understanding - analysis and assessment - of risk. Furthermore, complexity, uncertainty and ambiguity influence approaches towards risk management and consequentially risk management options. While data is plentiful, there is still a lack of structures and processes that allow meaningful integration into decision-making and policy processes. The meta-theoretical concept of inclusive governance therefore serves as a guiding framework to tackle the challenges of systemic risks, because it aims to merge all relevant types of knowledge – both within and outside science – in order to jointly find solutions amongst stakeholders that help initiate, support and scientifically accompany the transformation to sustainable development. The concepts of complexity, uncertainty and ambiguity and the way in which they pose challenges to governance are key to the comprehensive understanding of systemic risks. These concepts can only be fully grasped using a transdisciplinary approach towards risk analysis and governance. In this regard, the concept of inclusive governance seems the most promising to meet the challenges of sustainable risk governance in the Anthropocene. Risk communication and the engagement of stakeholders and civil society lie at the heart of this concept. The inclusion of stakeholders a civil society promises two major advantages compared to traditional top-down approaches of regulation. First, the inclusion of various forms of knowledge, i.e. factual, local and procedural knowledge, as well as knowledge for orientation, promise in due governance processes a better quality of decision-making. The interests and concerns of stakeholders and civil society need to be known in order to find adequate trade-offs be-

tween policy options. Second, socially acceptable decision-making rests on striking a balance between the various interests and concerns in pluralistic modern societies. Inclusive governance aspires to meet this challenge by incorporating and balancing these various claims in the decision-making process. As a result of the complex nature of systemic risks, which threatens all social subsystems due to their ubiquitous and transboundary nature, decision-making needs to live up to these challenges by giving all relevant interests and concerns in society due consideration. The contribution draws on evidence from the project "Systemic Risks" conducted at the Institute for Advanced Sustainability Studies Potsdam, Germany. The project investigates the complex interface of science, politics and the economy. Furthermore, the project is targeted at contributing towards better governance of systemic risks.

Session 6: Data Science and Information Systems

Developing Machine Learning Approaches for the Seismological data in Northern Chile

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The past decade of continuous seismological and geodetic monitoring of the North Chile Subduction Zone with the Integrated Plate Boundary Observatory Chile (IPOC) has yielded so far approximately 10TB of seismological and geodetic data. In this presentation, we will show the progress of our Machine Learning focussed research into the earthquake activity in this region. This work is a collaboration between the Berlin-Potsdam Geo.X geoscientists and the Saarland University computer scientists in Saarbruecken. We will show the main results of the feature engineering, the feature processing flow, and the most promising avenues of machine learning that have emerged from these preliminary analyses.

Change-point detection for seismicity parameter

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The detection of the associated changes of the earthquake activity is of great interest, because it might help to identify natural aseismic deformation patterns (such as slow slip events) and the occurrence of induced seismicity related to human activities. We develop a Bayesian approach to detect change-points automatically in seismicity data. Using the Bayes factor we select a suitable model, estimate possible change-points, and we additionally use a likelihood ratio test to calculate the significance of the change of the intensity. The approach is extended to spatio-temporal data in order to detect the area in which the changes occur. Another issue is the change of the Richter b-value, which quantifies the ratio of large to small earthquakes and acts as a proxy for the stress state. We focus on the automatic detection of statistically significant temporal changes of the b-value in seismicity data. Therefore we use again Bayes factors for model selection and estimate multiple change-points of the frequency-magnitude distribution in time. For both cases the methods are first applied to synthetic data showing its capability to detect real change-points. Finally, we apply this approach to examples of observational data sets.

Why omnipresent input data flaws may hamper a dynamic perspective in data-driven landslide susceptibility modelling

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Static landslide susceptibility models at regional or supra-regional scale are usually assessed on the basis of statistical and machine learning classification algorithms. The data-driven elaboration of zones where landslides can be expected in the future is often considered vital to guide civil protection measures and spatial planning activities. Landslide susceptibility models also serve as a basis for analyses that go beyond the pure identification of landslide-prone zones, such as the assessment of landslide hazard or landslide risk. Ongoing technological advances and the growing prevalence of user-friendly software offers constantly increasing possibilities to create statistical models on the basis of available environmental information. However, observable and projected environmental changes give rise to the question whether the adopted static perspective, which goes hand in hand with the neglection of changing environmental conditions, is still appropriate to identify areas that may fail in the future. Indeed, from a geomorphic perspective, a dynamic point of view is required and should replace the currently adopted steady-state assumption. During the last decade, an increasing number of scientists and institutions highlighted the demand to account for changing environmental conditions in natural hazard modelling. Up to now, only few researchers attempted an explicit inclusion of changing environmental factors to identify landslide-prone terrain using data-driven methods. This contribution (i) highlights major drawbacks in the “static” data-driven assessment of susceptible areas and (ii) discusses why the generation of a dynamic statistical landslide susceptibility model may be a challenging task, particularly for large areas and in the common presence of uncertain spatio-temporal information. The introduction summarizes the conceptual background behind data-driven landslide susceptibility modelling by outlining advantages, disadvantages and the actual impossibility to neglect dynamic factors completely. The presented case studies exemplarily highlight the effects of omnipresent error-prone input data on the explanatory power of subsequent modelling results. For instance, it is shown how biased landslide information can distort the reliability of automated variable selections, calculated performance estimates as well as the geomorphic plausibility of the final maps. Based on the current practice in the field of statistical landslide susceptibility modelling and the identified drawbacks, it is concluded that the application of more complex and flexible algorithms or a consideration of changing environmental variables can even intensify model uncertainties. The omnipresence of flawed spatio-temporal information related to landsliding and its environmental controls renders a dynamic data-driven analysis of susceptible terrain highly uncertain and anything but trivial.

Country-scale survey of anthropogenic hazard using Sentinel-1 big data

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Land subsidence associated with the overdraft of groundwater is an anthropogenic hazard that affects human societies in many arid and semi-arid parts of the world. It not only degrades the capacity of groundwater reservoirs but also poses a significant threat to residential areas and infrastructures. Detecting the regions affected by land subsidence is a prerequisite to risk management and strategy development. However, the fact that land subsidence is a localized phenomenon, but expands over vast areas makes it difficult to develop an effective strategy to identify and observe them using ground-based measurements. In the past three decades, InSAR (Interferometric Synthetic Aperture Radar) has become a proven tool for displacement analysis associated with many kinds of natural and anthropogenic hazards. It has been used widely to detect and monitor land subsidence at a local to regional scales in many studies. In the last four years, increasing amount of data provided by Copernicus Sentinel-1 mission has further revolutionized availability of SAR data with regular acquisition everywhere, offering a new opportunity to study land subsidence at a country scale. However, dealing with big data provided by Sentinel-1 requires new approaches to be developed for InSAR time-series analysis. In this study, we use all data acquired by Sentinel-1 over Iran to study land subsidence due to groundwater overexploitation across the country. We suggest a scalable data mining technique that can process big data and retrieve information about the land subsidence across the country. Through a big data analysis framework, the raw data are transformed into information at a given operational scale. Spatially dense information improves alerting and decision support capabilities. On the other hand, the dense temporal information provides insight into the behavior of the surface to groundwater level changes.

Unchanged frequency of Himalayan glacial lake outburst floods since the late 1980s

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Increased runoff from shrinking glaciers in the Hindu Kush-Karakoram-Himalaya (HKKH) region has formed more than 8,000 meltwater lakes, some of them growing rapidly in past decades. Larger and more numerous lakes could raise the frequency of potentially destructive glacial lake outburst floods (GLOFs), and possibly increase the risk to local communities, livestock, and infrastructure downstream. While this hypothesis appears as one plausible result of atmospheric warming, none of the few available databases support this position. We speculate that reports on historic GLOFs preferentially involved larger or destructive cases. In trying to account for this possible reporting bias, we aim at compiling the first consistent GLOF inventory for the HKKH to examine the spatial pattern and changes in GLOF frequency in the past three decades. We developed a machine-learning approach to predict land cover on 8,210 Landsat images and to detect areas where shrinking water bodies left traces of fresh sediments or flood tracks downstream. Using this strategy we were able to nearly triple the count of 15 previously known GLOFs by adding 23 previously unrecognised cases since 1988. Our observations accentuate the previously reported clustering of GLOFs in the southern Himalayan arc and low GLOF abundance in the northern Hindu Kush-Karakoram ranges. Documented and newly detected outburst floods often lie only few kilometres apart, involved comparable volumes, though newly detected GLOFs had shorter impact lengths we also found that population density hardly matters as a potential reporting bias. The mean frequency of ~1.3 GLOFs per year had no credible posterior trend (in a Bayesian sense) despite increases of meltwater areas in most of the HKKH during the Landsat era. Since the number of GLOFs per unit meltwater has nominally declined over the past three decades, we caution against projecting an increasing GLOF frequency to the future. We emphasize the importance of GLOF triggers whose magnitude and frequency are still largely unknown and difficult to quantify with Landsat images. We prompt a better characterisation of the topographic setting of glacial lakes to improve current understanding and predicting future GLOFs.

Probabilistic multi-variate framework for reliable pluvial flood loss estimation

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Pluvial flood events of different magnitudes such as in Copenhagen 2011, Beijing 2012 or Houston, TX 2017 have caused overall economic losses in the range of tens of billion Euros over the last decade. Unlike riverine flooding, pluvial floods are directly caused by rainstorms with high rainfall rates well above the design levels of urban drainage systems. A projected increase in frequency and intensity of heavy rainfall events in many areas around the globe and an ongoing urbanization may further increase pluvial flood losses in the future. For risk assessment and an efficient adaptation to pluvial floods, a quantification of the risk is needed. Currently, empirical or synthetic relationships between the water depth and the absolute or relative building loss are widely used to estimate the economic risks of flooding. However, the uncertainties associated with these approaches are particularly high for loss estimates with high spatial resolutions (i.e. on the property level), required due to the small scale variations of pluvial flooding. To quantify these uncertainties and improve the reliability of high resolution loss estimates, we present a probabilistic multi-variate loss estimation model for pluvial floods based on empirical data. The model was developed in a two-step process using a machine learning approach and a comprehensive database comprising 783 records of direct building loss to private households. In a first step, an ensemble of linear and non-linear machine learning algorithms were used to identify the most important loss influencing factors among a set of 57 candidate variables. In a second step, the most important loss influencing variables were used to develop a probabilistic multi-variate pluvial flood loss model using Bayesian beta regression. To account for cases, where high individual coping capacities and low water levels did not lead to any direct building damage, a zero-inflation component was added to the beta regression model. Probabilistic loss estimates are made through Bayesian inference using Markov Chain Monte Carlo (MCMC) sampling. In comparison with deterministic and ensemble model approaches using the same database, it can be shown that the probabilistic multi-variate loss estimation framework is able to considerably improve the accuracy and reliability of loss estimates on the level of individual buildings.

Session 7: Cascade and Multi-Hazard

From single-hazard to multi-hazard risk assessment including the analysis of dynamic exposure and vulnerability aimed at the modelling of cascading effects

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With the growing density of population and ongoing urbanization processes, vulnerability of human societies to natural hazards has increased around the globe. To counteract this trend, an efficient risk management is necessary, for which reliable information is essential. Most existing hazard and risk information systems address only single components of a complex risk assessment chain, as for instance focusing on specific hazards or simple loss measures. Complex interactions, such as cascading effects, are typically not considered, as well as many of the underlying sources of uncertainty. This can lead to inadequate risk management strategies, thus hindering efficient prevention and mitigation measures and ultimately undermining the resilience of societies. The German research project RIESGOS (Multi-risk analysis and information system components for the Andes region) will address these issues and elaborate novel scientific approaches related to the assessment of multi-hazards compound risk, including dynamic multi-hazard exposure and vulnerability analysis, aimed at the modelling of cascading and interaction effects for the Andean region in Chile, Ecuador and Peru. Modular interactive web services will be developed and implemented in a flexible and scalable multi-risk information system demonstrator. This shall allow end-users from civil protection and disaster management authorities to simulate and analyse complex multi-risk scenarios with the ultimate goal of risk reduction and enhanced disaster management. The project team is considering scenarios for floods, landslides, volcanic eruptions, earthquakes,

tsunamis and their mutual dependencies from the perspective of ‘what would happen if…?’. This scenario-based approach can be integrated into a probabilistic risk assessment framework to ensure the cost-effectiveness of recommended strategies. The process is supported by the development and application of new approaches on risk communication. Guidelines for the integration of multi-risk information into land use planning and emergency response plans are also going to be developed and tested for their applicability. The RIESGOS project is cooperating with South American research partners and will be guided by the needs of the potential users and the practical applicability. The research and development project RIESGOS (Grant No. 03G0876) is funded by the German Federal Ministry of Education and Research (BMBF) as part of the funding programme 'CLIENT II – International Partnerships for Sustainable Innovations'.

Perspective and limitations of Multi-Risk Assessment

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Damaging phenomena related to a variety of geo-hazards constantly threaten people, the built environment and its vulnerable infrastructure on a global scale. These phenomena may unfold across different spatial and temporal scales with a frequency and intensity which depend on the type of underlying geologic process. Since the spatial extent and amount of the related adverse consequences may also vary substantially, the increasing urbanisation and the subsequent socio-economic development continuously raise the bar for the Civil Protection authorities and the decision makers striving to control and reduce the associated risk. A consistent analysis of such consequences may provide a useful guidance to implement efficient Disaster Risk Reduction (DRR) actions but, especially in case of strong events, quantifying this impact should also include the concurrent consideration of different types of hazards (e.g. earthquakes, tsunami, landslides) and their possible interaction, also in terms of vulnerability and loss. The perspective of integrated multi-risk assessment is certainly desirable, also in the framework of the 2015-2030 Sendai agreement, and may greatly improve our current understanding of the dynamics of Natural Risks. The associated challenges are however significant, and call upon a strong and collaborative interdisciplinary effort that may help bridging gaps among different disciplines, possibly leading to new scientific paradigms.

Towards an event-based quantitative model for interacting hazard events

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Every year individual hazards and hazard interactions in the UK have the potential to cause damage to infrastructure, including socio-economic losses. On 28th July 2014, flash flood, lightning, hail and heavy rain occurred together, leading to travel disruption and housing damages. There is a real interest across academia and industry about quantifying natural hazard interactions in particular, safety is an overriding priority for EDF Energy and it is important that their infrastructure is adequately protected against natural hazards. Here we use the grey- and peer-review literature to critically identify, compare and contrast current research available for the quantification of hazard interactions inside a considered event. Interaction relationships between hazards can be modelled using different approaches, including (i) mechanistic, (ii) empirical, and (iii) probabilistic. When addressing more than two hazards, we are looking to move beyond standard models for interacting hazards and instead focus on multi-hazard events. There are two ways of dealing with multi-hazard events. One following a site specific approach, i.e. all hazards are analysed separately at a given location which does not account for potential interactions. The other approach is an event-based approach which allows us to analyse more than one hazard at a time with several different hazards occurring together. The latter approach is explored in more detail in the work presented here. We define multi-hazard events as natural events during which there is a strong probability of observing more than one individual hazard. The aim is to display such an event as a probabilistic network of interrelated variables. Within this framework, we want to explore a novel way to model multi-hazard events including several variables. As a case study, we shall present the interaction structure between hazards within a thunderstorm. We focus on thunderstorms hitting the south east of the UK (like the event observed on 28th July 2014).

Posters

Predicting Future Soil Erosion and Runoff by Using WEPP Model in Lattakia-Syria

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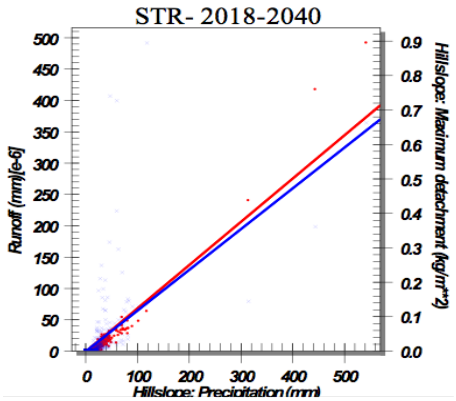
In the last decades of the 20th century, Syrian agriculture sector begins to suffer from many problems such as drought, land degradation (soil erosion, wind erosion, desertification, salinization) and climate change. Soil erosion in Syria is one of the most threatened phenomena which affect more than 85% of agriculture lands, therefore the aim of this study was to predict the future soil erosion and runoff as a tool of sustainable soil resource management and environmental Early warning system. To achieve the study goals 77 soil samples were collected and analyzed from Lattakia governorate (Syria), as a basic soil information for WEPP model. Simultaneously, other input data such as climate data, land use data and slope had been collected also. finally, all input files (soil data, climate data, land use data, slope) had been prepared to run the WEPP model from 2018 to 2040.

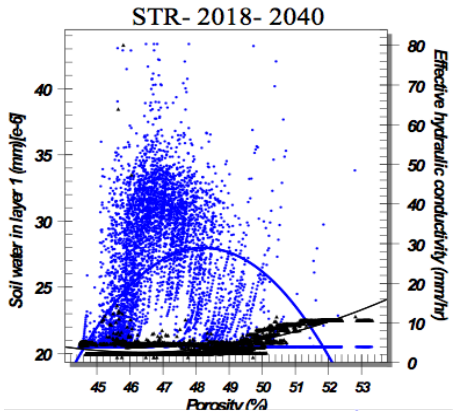
By using a first-order, two-state Markov chain based on conditional transition probabilities of a wet day following a wet day ($P_{w/w}$) and a wet day following a dry day ($P_{w/d}$), the results showed 1584 rainstorms and 15056.7 mm of rainfall through the whole period. While the statistical analyses of expected rainfall changes from 2018 to 2040 demonstrate a slight linear increase of +0.66 mm for each year, with highest predict amount of rainfall (1157.7 mm) in 2022 and 2037, as a consequence, 40% of rainfall will lead to runoff and the highest amount will be in 2022 and 2037. Meanwhile, predicted soil water erosion ranges from slight erosion (1.8 t/ha/y) to moderate (8.55 t/ha/y), the analyzed data illustrate that the soil erosion correlates with Runoff (mm) ($\boldsymbol{q}$); Effective Hydraulic Conductivity (ms^{-1}) ($\boldsymbol{K^e}$); Porosity (%) ($\boldsymbol{\varphi}$) and water content of the surface layer (%) ($\boldsymbol{\Theta}$).

As a conclusion, WEPP model could bee I good tool for predicting future soil erosion and helping in soil conservation scenarios, but it is very important to compare the future simulated amount with measurements amount to validate the efficiency of WEPP model in terms of predicting of soil erosion in Mediterranean conditions and Syrian soil.

Keywords: Soil Erosion, WEPP, Rainfall, Syria.



Simulated relationship between run-off detachment and rainfall in STR



Simulated relationship between effective hydraulic conductivity, porosity and moisture of the surface layer. in STR

The application of an index of connectivity as a proxy for flooding risk assessment in a Mediterranean alluvial plain

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The Mediterranean landscape, which is arguably the most human-impacted terrain on Earth, is characterized by high (often extreme) temporal variability in precipitation, and hence discharge. In addition, severe flash floods are an inherent Mediterranean characteristic and because of the occurrence of extreme events in ungauged catchments, there is generally no measured discharge information or formal records of the magnitude of the events. Consequently, flash floods and, especially, geomorphic processes affecting alluvial fans remain poorly understood due that the fluvial network is poorly incised and diffuse. Mediterranean countries are also so-called as very sensitive to global change, considering that as the combination of climate change (e.g. increase of extreme storm events) and the direct human influence (e.g. changes on land uses). Both human-impacts and sensitivity to global change are particularly serious in most of the Mediterranean islands, as it is the case of Mallorca. It illustrates the transformation of the economy, society, and environment of Mediterranean tourist resorts and how, over the past few decades, changes in land uses have transformed the hydrological systems. Such transformations, in combination with climate change are generating an increase of floods in places where they were historically managed by a systematic use of traditional soil and water conservation practices that laminated and diverted the flash floods. As a synthetic approach between ecology, hydrology and geomorphology, connectivity is defined as the transfer of matter between two different landscape compartments hydrologic connectivity is the water-mediated transport of matter, energy and organisms within or between elements of the hydrologic cycle. Knowledge of the spatial distribution and the temporal evolution of connectivity in the actual landscape is crucial because it can be used as a tool to estimate the probability that a given part of the landscape transfer its contribution elsewhere in the catchment. Consequently, the index of connectivity allows us to know which areas of the catchment act as flow-paths hence directing the fluxes (what would equal to “river channels”) and which other are predominately zones of accumulation, i.e. areas prone to be flooded therefore the index of connectivity could theoretically allow us to assess about the areas which are likely to be flooded (flooding risk) during a high-magnitude rainfall event in a certain catchment. Within this framework, we analyze the affectation that several consecutive extraordinary rainfall events (December 2016- January 2017), had on an alluvial plain widely modified by humans during millennia in the island of

Mallorca, the Campos basin (380 km2). We therefore aim to evaluate the likelihood of using the index of connectivity –IC– as a proxy for flooding risks. Secondary goals are:

- the analysis and determination of the best pixel-size resolution for using the IC as a tool for flooding risks forecast,
- the evaluation of the effects of the historical and present man-made alterations of the drainage network on the water fluxes distribution and
- the analysis of the magnitude-frequency of such extraordinary events and its hydrological response, i.e. flooding, on the study area.

Impact of mitigation policy on drought vulnerability and risk reduction

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The linkages between drought monitoring and early warning, mitigation, planning and policy-making is complex since the challenges relate to increased climatic variability, water scarcity, water resources management, crop failure, food security and desertification, posing serious threats, especially to drought-prone regions. The first and most common approach by both developing and developed nations is post-impact interventions i.e. a reactive approach. These are relief measures, emergency assistance programmes which provide money or other assistance (e.g. livestock feed, water, food) to the affected population. The alternative policy approach is a proactive approach that involves and emphasises on mitigation measures to minimize the impact of drought. In this article, the impact of proactive approach towards drought mitigation in the case study area of India's Gujarat state was studied to understand the strategies and adaptive measures that have helped the people in coping with drought, and reduced risks by shifting from crisis management to a sustainable living. The earlier reactive measures were mainly relief initiatives including distribution of monetary benefits post-drought, which was insufficient to control the damage already caused to the agro-economic society. The impacts from a single drought led to drying up of fields, low productivity of crops, damage to groundwater quality and poor soil conditions. During and post-drought social impacts included mass migration, human trafficking, and suicides due to unrepayable loans. The situation often forces the women folk to enter into prostitution in order to support their families. With gradual shift in the approach from reactive to proactive, preventive measures were incorporated and adapted as the villagers became aware of the drawbacks of crisis management approach that proved ineffective to solve the long-term and recurring impacts of drought. The pre-drought strategies are diverse aiming minimization of drought impacts not only on water resources and agriculture but also on ecology, economy and society. Important drought-preparedness measures includes early prediction and forecasting of weak monsoon and heat wave events, increasing water-holding capacity of soil, irrigation through sprinklers, changing crop types, crop schedules, and cropping patterns, water conservation by digging of small community ponds and check dams, shifting to animal husbandry and practicing other alternative livelihood options other than farming. These strategies enabled households to better cushion the adverse effects of impending droughts. Government interventions by providing better drought forecasting, construction of canals, water purification and desalinisation plants have successfully reduced water scarcity, and have improved the drinking water and irrigation water supply to remote areas with scanty rainfall. The social support schemes and self-help groups have helped in educating the women to earn through non-farm alternative livelihood options like handicrafts and diamond polishing. Besides, provision of hundred days' on-field job has reduced mass-migration of people. This clearly indicates how a shift in the strategy and policy towards drought management with regional and area-specific preventive measures can reduce drought impacts, vulnerability and risk, and thereby can transform a drought-prone region into a drought-resilient region under the ongoing climate change scenario.

Acknowledgement to Dr. Chandrashekhar Bhuiyan for his suggestions on this paper.

Assessment of Sentinel-1 C-band SAR data for mapping potentially affected areas following natural hazards

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The emergence of the Sentinel-1A and 1B satellites now offers freely available and widely accessible synthetic aperture radar (SAR) data for global application. The near-global coverage and rapid repeat time (1-2 weeks) gives Sentinel-1 data the potential to be a widely used and powerful tool for monitoring the Earth's surface. The interferometric coherence, or correlation, between two SAR images has proved useful to map potentially damaged regions following a natural disaster. However, much work in this vein has been based on L-band radar (e.g., ALOS). While L-band SAR has the advantage of being less sensitive to changes such as land cover perturbation, it is often prohibitively expensive to acquire and not widely accessible, and therefore not well-suited to rapid deployment following a disaster. While more widely available, the C-band SAR provided by Sentinel-1 is more sensitive to changes in land cover, such as agriculture, that can cause low or noisy coherence. Applying C-band SAR data to post-disaster mapping without taking this into account can result in an inability to differentiate signal from noise when interpreting InSAR coherence. \tOur research objective is to determine if readily-available C-band SAR can be deployed \tfor rapid response following a natural disaster by exploiting a timeseries of coherence \timages for three regions of interest: (1) Tropical Freetown, Sierreleone following fatal \tmudslides on 14 August 2017 (2) Temperate Berlin-Brandenburg following Orcan \tXavier on 5 October 2017 (3) Kermanshah Province, Iran following the 7.3 Mw \tearthquake on 12 November 2017.To overcome the inherent limitations of C-band InSAR, we construct a timeseries of coherence maps using a minimum of one year of data. Based on this timeseries, we determine the 'typical' behaviour of coherence within each pixel of the gridded coherence raster, accounting for factors such as seasonality and the inherent noise from vegetation. The pixel-by-pixel coherence distributions are compared to the coherence values following a natural disaster to determine: (1) where spatially statistically significant coherence loss has occurred (2) to what degree the post-event coherence value deviates from the median (e.g., 1st, 5th percentile).

Decadal trends in the timing of the snowmelt season in High Mountain Asia

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High Mountain Asia (HMA), which encompasses the Himalaya, Karakoram, Pamir, Tien Shan, and the Tibetan Plateau, is the primary 'water tower' for much of Asia, serving more than a billion downstream users. Many catchments receive the majority of their yearly water budget in the form of snow – the vast majority of which is not monitored by sparse weather networks in the region. Changes in the spatial and temporal distribution of snowmelt will impact both seasonal water provision, such as for hydropower and agriculture, and potentially change the incidence and distribution of snowmelt-related flooding. We leverage passive microwave data, flown on five sensors (SSMI, AMSR, SSMIS, AMSR2, and GPM, 1987-2016), to examine trends in the timing and spatial distribution of snowmelt. We developed a novel snowmelt-tracking algorithm, validated against both manual control data and extensive climatic datasets, which effectively identifies the onset and end of the snowmelt season on a pixel-by-pixel basis. To increase the robustness of our snowmelt trend analysis over the 29-year time series, we group our data into self-similar clusters via hierarchical clustering. From our analysis we make the following four key observations. (1) The end of the snowmelt season is trending almost universally earlier in HMA, indicating that snow is generally melting earlier and faster in HMA. (2) The length of the snowmelt season is shrinking in the majority of HMA, although there are some isolated cold regions which have seen longer snowmelt periods over the past decades. (3) Trends in snowmelt timing are not monolithic there have been several periods of trend reversal during our 29-year time series. This indicates that inter-annual variability in snowfall amounts is a large control on the timing of the snowmelt season. (4) Some regions with stable or growing glaciers, such as the Kunlun Shan, see later snowmelt onset and longer snowmelt periods, indicating that changes in the timing of snowmelt could account for some of the heterogeneity in glacier mass change in HMA. This study provides a basis for analyzing changes in the timing of snowmelt in a large, remote, and poorly-monitored region of the globe, and highlights that climate trends should be considered for effective water planning in HMA.

Unravelling the spatial diversity of Indian rainfall teleconnections using event synchronization-based multiscale nonlinear method

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An advanced understanding of synchronous occurrences of heavy rainfall teleconnection and their spatial diversity in space and time is vital, for instance, for predictions of extreme rainfall events and timing of monsoon onsets but also for agriculture and insurance sector. In this study, the spatial synchronization structure is analyzed at multi-time scales as a teleconnection network constructed from precipitation event series and prominent climate indices such as the El Niño/Southern Oscillation (Nino 3.4), Indian Ocean Dipole (IOD), North Atlantic Oscillation (NAO), Pacific Decadal Oscillation (PDO), Atlantic Multidecadal Oscillation (AMO). We propose a general framework to disentangle the dependency structure between extreme events and climate indices at different temporal scales by introducing the concept of multiscale event synchronization derived from non-linear synchronization measure. We apply our method to Indian precipitation and prominent climate indices at different temporal scales. Our results reveal that there is a significant synchronization of these climate indices at different temporal scales, with diversity in the spatial dependency pattern of the Indian precipitation. Additionally, we compare the results obtained from this study with the state-of-the-art wavelet coherence to show that our method is different from others and highly effective.

Linking hazard and vulnerability: Structural health monitoring of hydropower dams and surrounding slopes in the Kyrgyz Republic

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Plans to construct hydroelectric dams in the Kyrgyz Republic and the need to assess the state of existing structures, especially with respect to earthquakes and landslides, requires structural and slope monitoring systems that provide fast and robust information to decision makers in the event of emergencies. Here we aim at developing, installing and testing a robust, cost-effective and flexible monitoring system for the Kurpsai Hydropower Station (HPS) in Kyrgyzstan including a multi-parameter risk assessment due to earthquakes and landslides. The concept of structural health monitoring on the Kurpsai dam distinguishes two time scales: the long-term monitoring of static deformations over days, months and years and the short-term monitoring of structural response to earthquake shocks and extreme operational regimes. The long-term monitoring includes a combination of three different techniques, i.e. (1) absolute static displacements measured by special GPS sensors placed on each block on the dam crest, (2) opening of the slits between concrete blocks by the fibre optical strain sensors, (3) deformation measured by means of the Interferometric Synthetic Aperture Radar (InSAR). The short-term changes of the dam and the surrounding hillsides are monitored by means of multi-parameter sensors placed on selected characteristic points of the structure and surrounding based on a fully decentralised approach. Such approach allows for the fragility curves to be directly integrated into the on-site calculations, allowing some degree of decision-making without the necessity of a remote centre. Moreover, the continuous recording of seismic noise, i.e., the persistent vibration of the ground due to a multitude of natural and anthropogenic causes, allows for the continuous assessment of the mechanical characteristics of a dam (and hence, fragility curves) and/or landslide body and any changes therein. For example, considering landslides, the cross-correlation of seismic noise traces can allow the precise location of changes at the base of the sliding layer.

Past and future drought in Northwestern Algeria: Case of Beni dam catchement

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In last decades, the impact of climate changing started to appear in the Mediterranean basin and semiarid regions. The severity and frequency of drought events in North-Western Algeria have affected water resources availability and agriculture. This study aim to evaluate the temporal evolution of drought events characteristics such as drought duration, frequency and severity in the Beni Bahdel dam situated in the Tafna catchment North-western Algeria. For this purpose, the drought characteristics have been identified from the Standardized precipitation index (SPI) computed for the period from 1941 to 2100 using precipitation data from observation and eight regional climate simulations of CORDEX-Africa. The ability of the model simulations was firstly assessed to reproduce the observed drought characteristics. Then, future changes of drought characteristics over the twenty-first century were projected under two Representative Concentration Pathway scenarios (RCP4.5 and RCP8.5). Results has shown an amplification of drought events frequencies and durations in the future especially under RCP8.5 scenario.

System Dynamics Modelling for mountain water management and climate change adaptation

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Keywords: climate change adaptation, mountain regions, water management, water scarcity, system dynamics modelling

Mountain environments are facing important impacts due to climate change and human activities. Shifts of temperature and precipitation are affecting the amount of available water in mountain environments, especially decreasing snow and glaciers resources. Tourist activities, hydropower and agricultural production in the Alps usually rely on unsustainable use of water. Moreover, there is a need to understand the future impacts of climate change on water resources to design and implement risk management and adaptation strategies. System dynamics modelling (SDM) combines biophysical and socio-economic variables allowing an explicit representation of their complex interactions and dependencies. A conceptual framework has been developed, encompassing climatic and anthropogenic changes in water availability as well as socio-economic water use from the strategic sectors of mountain regions (e.g. discharge reduction due to long-term glaciers melting affecting hydropower production). This framework will be translated into a quantitative SDM model and applied to the Noce river within the Province of Trento (Italy), where concerns about water scarcity is rapidly increasing due to recent events of low winter snow precipitation and intensive spring-summer consumptions. The model will integrate Euro-Cordex climate scenarios to simulate future conditions of water availability, as well as water consumption data from hydropower, agricultural and domestic use, providing information on the current and future water demand. Results will shed light on mountain system's resilience to water scarcity and future multiple impacts across sectors. Finally, SDM fosters the understanding of the dynamics involved in the mountain water management, describing the emergent behaviour coming from variables interactions. By doing so, it would be possible to prioritize strategies that enhance system's resilience for improved water efficiency, water storage, capture methods and emergency measures across different sectors for climate change adaptation.

An Applied Comparison of Quantitative Decision-Support Methods for the Efficient and Robust Protection of the German Baltic Sea Coast against Flooding

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Cost-benefit analysis (CBA) can be applied to identify efficient flood protection decisions within scenarios, whereas quantitative methods for robust decision-making (RDM) can provide insights in the robust performance of these decisions. However, a comprehensive comparison of applications of methods for RDM with CBA to coastal flood protection decisions is absent. To address this limitation, this paper applies CBA and a range of loss- and regret-based methods for RDM to the German Baltic Sea coast. To this end, data gaps on flood risk and protection are filled first that hinder the application of these methods to the region. The results of the CBA suggest that some areas at the German Baltic Sea coast are currently under-protected from a social welfare perspective. Despite highly uncertain, initial investment might be in the order of [] mln Euro under low sea-level rise (SLR) and socio-economic scenarios and [] mln euro under high SLR and socio-economic scenarios. The solutions of loss-based and regret-based worst-case analyses, and those of average-regret and low-regret analyses, range from [] to [] between the least and the most conservative approach applied. The use of multiple SLR input ranges and info-gap analysis demonstrate that RDM is further complicated by the lack of a well-defined SLR upper bound. The paper concludes that CBA and the applied methods for RDM are complementary: combining these methods can help decision-makers to narrow down the number of 'good' solutions, i.e. solutions that are both potentially efficient and sufficiently robust, as well as to show efficiency-robustness trade-offs beyond a selected set of plausible futures.

Changes in risk perception over time: Longitudinal evidence in the North-eastern Italian Alps

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Hydrological hazards are causing more and more damage in many regions of the world because of climatic and socio-economic changes. Risk is often defined as a combination of the probability of an event to happen and its potential negative consequences. When it comes to disaster risk reduction at the local level, effective actions can be taken to reduce the potential losses, such as building a more resilient community. One way of promoting community resilience is to increase people's awareness of their surroundings and potential threats. To contribute to the improvement of risk communication activities, this study aims at understanding how risk perception changes over time, particularly in the absence of extreme events. Two case studies are analysed: Romagnano and Vermiglio-Rio Cortina. The two villages are located in the North-eastern Italian Alps, in the province of Trento. These areas were affected by heavy rainfall events that caused debris flows in 2000 (both in Romagnano and Vermiglio-Rio Cortina) and 2002 (in Vermiglio-Rio Cortina only). A few years after these event, in 2005, surveys were conducted in both areas by Scolobig et al. (2012) to assess the non-trivial relationship between risk awareness and preparedness. The authors found that, even when individuals are aware of the hazard risk, they are not necessarily prepared to face it. To unravel the potential changes in risk perception over time, we conducted a longitudinal study in 2018, which builds on the questionnaire that was administered in 2005. Given the absence of extreme events for almost twenty years, we test the hypothesis that risk awareness has significantly reduced. To this end, we repeated part of the original surveys in both areas and compared the results to the outcomes of the 2005 surveys. In addition, qualitative data collected through interviews and informal meetings with local authorities complement the surveys and provide key information on changes in the political contexts, risk communication strategies, and demography at the community level. The results of this longitudinal study are relevant, as they help reveal the factors leading (or not) to changes in risk perception. This can guide the study of socio-hydrological systems, inform risk assessment methods, and contribute to the development of better policies for disaster risk reduction.

Can the Indian summer monsoon be predicted in early May from coupled atmosphere-ocean models, and is there any improvement from recent modeling?

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Every year, millions of people are awaiting the current forecast of Indian Summer Monsoon Rainfall (ISMR, = accumulated all-India Jun-Sep rainfall), which effects planning and decision processes for different kinds of economic sectors with impacts on food security and water management. Ongoing development in seasonal forecasting by coupled atmosphere-ocean models have raised hopes in improving seasonal ISMR predictions. A lot of studies have investigated single seasonal forecast products, but a systematic comparison and analysis for IMSR, using all available models presently available (early 2018), is still missing. Our aim is to provide a coherent analysis of the following four systems: CSFv2 from NCEP and ENSEMBLES, SEAS4, and SEAS5 from ECMWF. Using forecasts issued in early May, correlation analysis for the predicted ISMR proves to be highly dependent on the chosen years. Comparisons of two different observational data sets revealed that also small discrepancies can highly influence correlation skill, especially for CFSv2. Overall, CFSv2 and ENSEMBLES produced the best correlation skills, whereas the newest ECMWF prediction system SEAS5 shows no skill improvement over SEAS4, which points to the challenge for future model development.

Flash floods compared to river floods – psychological impacts and implications on precautionary behaviour

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River floods belong to the most costly natural hazards in Germany which occur periodically. In May and June 2016, intense rainfall triggered severe flash floods and debris flows which hit several municipalities in Southern Germany and caused monetary losses of EUR 2.6 billion. Flash floods and debris flows are still unfamiliar events in Germany outside alpine regions. However, they describe a serious hazard which - besides monetary losses - induces mental health problems (psychological stress) and thus demands damage mitigation. In respect of riverine floods, individuals play an important role in integrated flood risk management by implementing private precaution measures. Yet, this strategy seems applicable to prevent losses also during flash floods. Since previous studies pointed out that psychological attributes of affected individuals lead to protective or non-protective responses, psychological characteristics can be potentially helpful to predict the implementation of private precaution measures. Therefore, this study follows two major aims. First, differences between flash floods and riverine floods concerning their psychological impacts on flood affected individuals are analysed. Having surveyed flood affected households after the severe river flood in 2013 (which affected the Elbe, Danube, Weser and Rhine) and after the German-wide heavy rainfall in June 2016, psychological indicators such as avoidance, fatalism, threat appraisal, burden and coping appraisal could be derived and compared among both flood types. Second, personal character traits and attitudes towards private precaution are tested regarding their predictive power for an individual protective response. Preliminary outcomes indicate that negative impacts of riverine floods and strong flash floods on affected people are comparable with respect to psychological attributes such as burden, perceived threat, avoidance and fatalism. Additionally, first results indicate that fatalistic attitudes and avoidance are, for both flood types, positively correlated to lower coping behaviour. These findings need to be better accounted for in risk communication strategies.

Characterizing Long-Term Background Seismicity Rates: Testing the Integration of Strain Rate Data in Global and European Seismicity Models

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Locations and magnitudes of recent large earthquakes have sometimes contradicted seismicity rates expected by earthquake source models that form the basis of Probabilistic Seismic Hazard Analysis (PSHA). The discrepancies are a consequence of underestimating either the seismicity rate or expected maximum magnitude, both of which are primarily derived from historical and instrumental earthquake-catalog data. Furthermore, conflicting seismicity rates inferred from GPS velocity and seismicity data have been observed, suggesting that earthquake-catalog data may not completely account for seismic moment release.\tThe Global Earthquake Activity Rate (GEAR1) seismicity model is currently undergoing prospective evaluation within the Collaboratory for the Study of Earthquake Predictability (CSEP). Testing results during the 1/10/2015-7/9/2017 evaluation period indicate that global background M = 5.767 seismicity rates are best constrained by a combination of strain rate and earthquake-catalog data. At the 0.05 significance level, both the Kagan-Jackson smoothed seismicity and the SHIFT_GSRM seismicity forecasts can be rejected in favor of GEAR1. However, both strain rate-based models (SHIFT_GSRM and SHIFT_GSRM2F) fail to forecast the spatial earthquake distribution during the evaluation period, indicating that further research is warranted on the performance of the GEAR1 and SHIFT_GSRM models in localized regions. \tWithin the Italy CSEP testing and SHARE hazard model regions, we test the impact of integrating strain rate data in background seismicity models used for seismic hazard analysis. We investigate how the stability of the GEAR1 model optimization is affected by the availability of geodetic and earthquake-catalog data. Furthermore, we test the impact of earthquake-catalog data availability and integration of smaller earthquakes on forecast performance stability.

The combined influence of wind speed and wind direction on the flooding of the German North Sea Coast

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The German North Sea Coast consists of low lying lands. Therefore, it is prone to flooding due to storm surges. As well, the outflow of rivers into the North Sea can be reduced or even rendered impossible due to high water levels at the coast. Both, storm surges and the interrupted outflow of coastal rivers into the North Sea are caused by high wind speeds in connection to specific wind directions. In the Network of Experts of the German BMVI (Ministry for Transport and Digital Infrastructure) the causes and consequences of coastal inundation and the resulting impact on the transport are investigated. High water levels due to storm surges and to reduced river overflow can cause flooding of harbors, routes, or train rails, which might also lead to disturbances of the infrastructure. Additionally, the transport of goods and the public transport are disturbed.The critical values of the wind speed e.g. for a storm surge, are depending on the wind direction. Therefore, if the influence of possible future changes of wind fields on storm surges and the draining of the rivers should be investigated, a combined examination of wind speed and direction is necessary. This can be either done by investigating the so called effective direction in which the impact of the wind on the water level is most effective. This direction is evaluated using an empirical formula for skew surge. The effective wind speed is then calculated as the magnitude of the wind vector that is projected onto the effective wind direction. Alternatively, the surge at a specific location at the coast is approximated by a regression model using the wind speed and direction. Finally, joint probabilities for wind speed and direction are calculated and the possible changes of the probabilities are examined. The results for the three methods are compared and the implications on the possible future probability of flooding are examined.

Archetypes of Climate Vulnerability: a Mixedmethod Approach Applied in the Peruvian Andes

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Farm household systems (FHSs) in the Andes handle climate-related hazards such as frost and droughts with risk-coping and risk-management strategies based on the adaptive capital available to them. Nevertheless, a higher frequency of climatic stressors observed during the last few decades is challenging their capacity to adapt at a pace fast enough to keep up with the changes in external conditions. This increases the demand on the scientific community from policy and decisionmakers to investigate climate impacts and propose viable adaptation pathways at the local and regional scales. Better understanding heterogeneity in climate vulnerability is an important step towards addressing this demand. We present here a mixed-method approach to assessing archetypes or patterns of climate vulnerability that combines qualitative tools from participatory rural assessment approaches and quantitative techniques including cluster analysis. We illustrate this by looking at a case study of the Central Andes of Peru. The operationalization of the methods revealed differential factors for climate vulnerability, allowing us to categorize FHS archetypes according to the differences in those underlying factors. The archetypes differed mainly according to farm area, agro-ecological zones, irrigation, off-farm employment and climate-related damages. The results suggest that the approach is useful for explaining vulnerability as a function of recurrent internal and external determinants of vulnerability and developing related adaptive strategies.

Estimating potential damage caused by pluvial floods

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In recent years, pluvial floods have caused tremendous damage in German cities. For example, the city of Münster (population: 310 000) was hit by an extreme rainfall event on 28 July 2014, which caused losses in the residential sector of more than EUR 70 million. Due to a lack of accurate, comparable and consistent hazard maps, damage data and loss models for pluvial flooding, only little is known about the damage potentially caused by this flood type. Based on a number of case studies and a regionalisation approach, this study aims to quantify the impacts of pluvial flooding on urban areas in North Rhine-Westphalia. At first, a loss model is derived from a unique dataset containing losses caused by recent pluvial floods, as well as a wide range of factors potentially influencing damage at the household level. Second, this model is calibrated to the Münster-event of 2014 and then applied to other urban areas in North Rhine-Westphalia using hazard maps on pluvial flooding. Further, regionalisation is achieved by means of unit damage values, i.e. damage per capita, damage per m² urban area and damage in relation to the total residential building assets. By combining these with current land cover data and a future land use scenario, the total damage potential and its future development is finally estimated for all of North Rhine-Westphalia. Besides this large-scale estimation, the unit values can be used by city planners and developers as a starting point for prevention planning.

Improving real time flood forecasting in catchments with rapid using bayesian approach

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Flood early warning systems are widely used operational tools, however, the reliability of their predictions (timing and magnitude of floods to exceed a warning threshold) still depends heavily on several, often unrealistic, assumptions made at the system design stage. The assumptions frequently include: 1) a chosen hydrological model is perfect (that includes both hydrological model structure and parameters), 2) observations of model input and output are error-free, and 3) a data assimilation algorithm used to update model states and adjust forecasted flows is adequate. This work presents an operational system for river basin real time flood forecasting and early warning named (in Spanish SALIF). The employed data assimilation algorithms use Bayesian inference for real time data assimilation and forecasting - specifically, Ensemble Kalman Filter and Regularized Particle Filter and data and model structure uncertainty are explicitly included. The proposed system is applied to the catchments prone to economic loss due to flooding in the Cantabria region of Northern Spain. Results show that when both the observational data and hydrological model are adequate flood predictions are reliable, and Regularized Particles Filter is preferable.

An Indicator-based Approach to Link Vulnerability and Hazard in Risk Assessment for Cultural Heritage Sites

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Cultural heritage properties as an integral part of the built environment play a significant role in economic development and in strengthening social capital and cultural diversity. However, historic sites are extremely exposed to the adverse effects of natural hazards and climate change threats, with consequences ranging from gradual decay and deterioration to outright catastrophic losses. The incorporation of 'Cultural Heritage' in disaster resilience has been emphasised in the recent UN's Sendai Framework for Disaster Risk Reduction 2015-2030 and respective reporting and monitoring methodologies. Recognizing the above challenge, the STORM (Safeguarding Cultural Heritage through Technical and Organisational Resources Management) project aims to develop an innovative methodology and associated supporting tools for managing risks related to natural hazards and climate change threats. The proposed methodology is applied to five pilot sites in Europe: the Baths of Diocletian in Italy, the historical centre of Rethymno in Greece, the Mellor Heritage project in the UK, the Roman Ruins of Tróia in Portugal, and the Ancient City of Ephesus in Turkey. Within the context of the STORM project, this study aims to present a systematic and integrated methodology of risk assessment while considering the specific characteristics of historic places. To fulfil the aim, the development of a Cultural Heritage Risk Index (CHRI) is proposed through the application of an indicator-based approach to analyse the components of risk as follows: •\tHazard: hazards leading to sudden-onset disasters (e.g. earthquakes, storms, and flooding) and those leading to slow-onset disasters (e.g. wetting-drying cycles, wind-driven rain, and heat waves) are incorporated in the assessment procedure. Where appropriate, also future changes in hazards as a result of a changing climate are taken into account•\tExposure: movable and immovable heritage assets and their associated intangible attributes are considered as elements at risk. Thus, exposure assessment focuses on the analysis of the significance of heritage elements within the pilot sites and •\tVulnerability: a Cultural Heritage Vulnerability Index (CHVI) is developed to evaluate the susceptibility of each pilot site to potential impacts according to their structural and material characteristics. Furthermore, the index takes into account the adaptive and coping capacities of the management systems. The above-mentioned components are aggregated to generate risk maps applying GIS modelling and spatial analysis tools. The risk maps provide the assessment team and stakeholders with a common understanding of the vulnerability and risk in the pilot sites, according to the corresponding hazards that the heritage elements are exposed to. The proposed assessment procedure will further facilitate decision-making and risk management in a multi-hazard context to determine site-specific risk treatment strategies.(This research is based on the EU-project 'Safeguarding Cultural Heritage through Technical and

Organisational Resources Management' (STORM), funded by the European Union's Horizon 2020 research and innovation programme under grant agreement n°700191.)

More room for water

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Since ancient times, and more intensively from the mid-19th century, inundated areas and wetlands have been lost as the space belonging to water has been reduced. The surfaces 'taken' from rivers were intended primarily for agriculture and urban development. The middle of the 19th century saw the emergence of such regulation works on the Rhine River and, in the first half of the 20th century, in the United States (de Bruin, 2005 and Cassidy, 1962). Similar developments occurred worldwide. At the end of the 20th century, many rivers flowed in highly confined channels. This resulted in the changes reducing water resources of appropriate quality, affecting natural habitats, causing major flood damage, decreasing groundwater stock, and deteriorating water quality. The water regime integrates all events across space and is manifested in a close connection between surface water and groundwater regimes. Reduction of groundwater storage is directly linked with low flows of surface waters and, vice versa, river training works reduce groundwater storage.\tTwenty years ago the maintenance of embankments of regulated natural watercourses was brought to a halt, and the new practice was seen as eco-friendly maintenance of watercourses. Many river banks were overgrown with bushes and the space for water was only further reduced. In some places, the vegetation in the narrow channels completely obscured the surface of the water Today, developments in urban water management should allow the increase of the room for water and, moreover, give back to the river at least some of the space that it once possessed. Furthermore, we have to make room for water infrastructure with storage and waste water treatment facilities. Water attracts the attention of city authorities when problems occur, rather than during the planning of urban development. As it is, suitable land is urbanised and already occupied due to the various needs of the city, while solutions are complex and expensive. The release and creation of space for water needs is subject to strong personal and other public interests even though these areas can also be used for other urban purposes, their primary role of supporting the water regime must be ensured. In any event, releasing more room for water pays out economically in the long-term, for which, nevertheless, long-term strategic decisions for landscape planning and real-estate policy are required. Natural based solution often could not be implemented without additional room for water. More room for water means: more room for river, more room for creaks, more room for torren, more room for wadi, more room for ground water recharge, more room for water storage, more room for wetlands, more water resources, more security for people and ecosystem at all. In the paper we will present some good and bed practice for flood risk reduction purpose.

Learning Bayesian Networks for Natural Hazard Assessments

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The study of natural hazards and risks is characterized by a variety of uncertainties, that e.g. stem from an incomplete process understanding, inaccurate or incomplete data or intrinsic randomness. Consequently, for reliable natural hazard assessments it is crucial not only to capture and quantify involved uncertainties, but also to express and communicate uncertainties in an intuitive way. In order to meet these requirements the probabilistic framework of Bayesian networks provides a suitable framework for diverse natural hazard and vulnerability studies. Treating each model component as random variable, Bayesian networks aim at capturing the joint distribution of all considered variables. Thus, a major advantage of Bayesian networks is their ability to consider dependencies not only pairwise, but to capture the joint effects and interactions of all driving forces. For instance, a Bayesian network for damaging processes might not only show the impact of precautionary measures, but reveal the mutual effects of precaution and the quality of warning for a variety of different hazard scenarios. The graphical representation of Bayesian networks helps to study the change of probabilities for changing circumstances and may thus simplify the communication between scientists and public authorities. The presented work deals with the challenges that arise, when Bayesian networks are learned from real-world data in the natural hazard domain (e.g. flood damage data) and targets at an improved prediction performance of Bayesian networks.

Periglacial hazard assessment based on a rock glacier inventory – a case study for South Tyrol, Italy

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Rock glaciers are a periglacial landform that got relatively little attention in scientific research despite their capacity to store and release substantial amounts of water and sediment. This makes them an important water supplier for many dry mountainous areas of the world but also a source of rapid sediment movements like debris flows or rock fall. Thanks to international research projects, the data availability on permafrost-features improved significantly during the last decade. Many regions in the European Alps and outside nowadays dispose of rock glacier inventories that may be useful to assess the potential hazards that degrading rock glaciers pose. In the present work, a rock glacier inventory as well as high-resolution topographical data, natural hazard event databases and aerial imagery are applied to assess the hazard potential of rock glaciers for the entire region of South Tyrol, Northern Italy. Firstly, existing databases of gravitational and hydraulic hazards are screened on past events that may had their origin at rock glacier fronts. Then, the hazard potential of each rock glacier is evaluated based on its topographical properties (terrain steepness, rock glacier front angle, connectivity to downslope torrent channels). Detailed site investigations on potentially hazardous rock glaciers are conducted according to a previously defined protocol in order to establish a database containing information on the relevant mass wasting process (debris slide, debris flow, rock fall,..) and material parameters like the grain size distribution. GIS-based process path and run-out simulations of gravitational mass movements originating at rock glacier fronts are then calibrated and run to delineate potentially affected areas below the rock glacier. The results of this study are then used as the starting point for further investigations related to mass movements related to rock glaciers. These can be an in-depth investigation of one local study site, or an assessment of risks that may affect alpine recreational infrastructure (e.g. hiking paths or shelters). Especially for South Tyrol, this study has a potential practical relevance since the assessment of permafrost-related hazards is implemented in the regional law of hazard mapping.

Direct and indirect Vulnerability analysis framework for decentralized Power Systems

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The sustainability development goals by the UN reinforce the need for a transformation of the classical centralized power system into a decentralized power grid with more and more renewables as clean local energy resources. Furthermore, the ongoing increase of automation and power consumption illustrates the growing importance of power systems accompanied by a simultaneously increase of vulnerability: Besides ICT-related vulnerabilities, e. g. cyber-attacks, many components of a decentralized energy system are located not on the utility's premise and are therefore prone to physical damage. Impacts of natural hazards like hurricanes or earthquakes on a power system, considered itself as a critical infrastructure, may cause power shortages that affect other critical infrastructures. Such cascading phenomena within a complex infrastructure landscape, as existing in urban systems, may result in severe interruptions of critical services. A good understanding of the various indirect impacts of severe natural events enables more focused pre-disaster mitigation measures in terms of hardening components, building redundancies, or developing smart measures. For this purpose, an agent-based infrastructure model and a demand model w.r.t. critical services, adapted to urban systems, constitute the main pillars of a simulation framework that allows to analyze the severity of indirect impacts. A predefined first impact component failure scenario within a power system belonging to an urban environment is the starting point of simulated cascades causing functional degradation of critical infrastructures. Thus, critical infrastructure vulnerability in terms of functional impairment or loss of services as a consequence of first impact damages can be estimated by such models. Therefore, the infrastructure simulation framework includes a generic disruption framework that allows to specify any type of first impact-failure scenario that is of interest, e.g. non-functional network nodes or transmission lines, destroyed PV-modules or power storages etc. A deep exposure and vulnerability analysis w.r.t. traditional and decentralized components of a power system, e.g. substations, power storages, transmission and distribution poles etc. can be used to derive plausible direct impact or component failure scenarios that are considered to be plausible and relevant. These disruption scenarios can be used and appropriately translated into a story compatible with the language of the aforementioned generic disruption framework of the infrastructure model. As a consequence, coupling the findings of a first impact loss analysis for power systems with an infrastructure simulation allows direct and indirect vulnerability analyses. This type of integrated vulnerability analysis framework can be used for developing resilience building strategies in terms of mitigation or preparedness plans on the power system and the infrastructural level in general but also on the organizational level.

Coping with climate change risks by tailor-made insurance solutions – A public-private success story

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Globally, there is increased concern of the potential impacts of extreme climate events on loss and damage of people, assets and property. We developed a scientific approach, which intends to operationalize a system, called Oasis Loss Modelling Framework (LMF), which combines climate services with loss and damage information to provide a standardized, transparent and comparable risk assessment for the private insurance sector. This risk assessment connects the insurance sector with science-based loss determination tools. Demonstrators are developed for climatic and hydrological risks in the Danube basin and crop failure risks in Eastern Africa, as is presented here, but also for climate change risks on forest fire, public health in the Berlin-Potsdam area and tropical cyclones in East Asia. The flood risk demonstrator has developed a multi-hazard, multi-risk catastrophe model including a stochastic weather generator, a hydrological and hydrodynamic model as well as an exposure database for the entire Danube basin. Results are able to inform (re)insurance companies, municipalities and other stakeholders about current and future, climate change driven flood risks. Early results have shown remarkable increases in flood risks in the current and future climate periods in comparison to the reference period (1970-1999). The results are provided to cooperating insurance companies as well as public sector partners of the cities of Budapest, Hungary and Novi Sad, Serbia. The agricultural demonstrator has disentangled the sources of risk for crop yield failures. Based on these results an insurance index is developed which covers the actual crop yields much better than the often used precipitation indices. Due to the high accuracy and disentangling of weather and non-weather related influences on crop yield, the suggested insurance index has the potential to reduce moral hazard and create a high insurance acceptance among smallholder farmers. To transfer the scientific solution to the private sector, the Oasis LMF system has opened an eMarket (oasishub.co) place as matchmaking facility for catastrophe and climate data, tools and services, which challenges more traditional, proprietary risk providers.

Exploring human response to floods using satellite data

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Flooding is one of the most damaging natural hazards, and its negative impacts have increased dramatically in many regions of the world over recent decades. To understand temporal and spatial changes of flood risk, we need to unravel the way in which humans adapt and respond to flood events. In this study, we address one of the least quantified aspects of adaptation to flood risk namely, how the occurrence of major floods relates to changes in settlement dynamics close to the river, i.e., do people resettle further away from flood-prone areas to prevent or reduce future losses? We further address how these relationships are influenced by different levels of structural flood protection. Addressing these questions have previously not been possible due to limitations in traditional census data. However, through analysis of nighttime lights from satellite data we are able to explore, for the first time, long-term changes in human proximity to rivers to the occurrence of catastrophic flood events. This is done in 16 countries across the globe as well as in four contrasting hotspot areas spanning four continents. We found that societies with low protection levels tend to resettle further away from the river after damaging flood events. Conversely, societies with high protection levels show no significant changes in human proximity to the river. Instead, they tend to reinforce flood protection and quickly resettle in flood-prone areas after an event, continuing to heavily rely on structural measures. Our work reveals interesting aspects of human adaptation to flood risk, and offers key insights for comparing different risk reduction strategies. In addition, this study provides a framework that can be used to further investigate human response to floods, which is relevant as urbanization of floodplains continues and put more people and economic assets at risk.

Unraveling the contribution of storm-surges, sea-level, and urban growth in the future flood-damage response of urban settlements

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In Europe alone, several thousands of very diverse urban settlements are threatened by coastal flooding. For the future, direct damages from coastal flooding are expected to be on the rise due to the effects of climate change and an increasing exposure in asset value. These effects will not be constant across urban settlements but differentiated. In order to attribute increasing levels of damage, we systematically investigate the nexus between altered storm-surge climate, sea-level rise, and urban growth for a large sample of urban settlements along the European coasts. We employ an automated clustering procedure to identify exposed urban settlements and estimate direct monetary damages from land-cover and digital elevation data. The top-down modelling approach relates the different forecasts for sea-level rise and storm surge change (RCP scenarios 4.5 and 8.5) with increasing levels of urban expansion. We report on the dependencies of influencing factors along cluster size and geographical location. The large number of investigated clusters enables a statistical characterization of the typical damage response subject to climate and urban growth. Thus it becomes possible to differentiate clusters with a typical response to damages (in which similar adaptive actions could be transferred) from those exhibiting particular characteristics. The added level of detail on influencing factors of coastal damage can be used to inform future coastal adaptation policies. In particular the attribution of potential flood damage to urban growth constitutes important information for stakeholders. The results reveal both the adverse consequences of ongoing urban growth and, importantly, the adaptation potential of guided settlement. The potential of the latter has often been side-tracked in the academic literature, where the focus rests on coastal protection. Given the ability of cities to dynamically steer urban development in contrast to the global inertia of slowing down sea-level change, this work provides the first insights for a better consideration of planned urban growth as adaptive response.

Merging competitive runoff modeling approaches for assessing freshwater inflow into the Small Aral Sea

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The Aral Sea and its basin are among the highly recognizable examples of significant environmental changes which took place in Central Asia during the last decades. Induced by river runoff exploitation across large irrigation systems the Aral Sea level has significantly decreased and run irreversible ecosystem and water balance shifts. Nowadays the Small Aral Sea has no straightforward hydrological connection with dying southern sea basins and tends to stay a separate part under current social and political situation in the region. It is essential to devote scientific attention to this region as a real live example of the human-induced impact on water balance and its response. The main volume of the freshwater inflow into the Small Aral Sea is formed on the Syr-Darya river basin which is among the most significant and highly-vulnerable river basins in Central Asia. There are thirteen large reservoirs and much local water management related installations on the Syr-Darya river and its tributaries which utilize full freshwater potential for irrigational, industrial, recreational, and social needs. This complex structure of water management system coupled with the total absence of data describes its functioning is a challenge for any approach directed to the accurate assessment of the Small Aral Sea freshwater budget formation and evolution across the basin. Taking into account these apparent challenges we have built a hydrological modeling system based on coupling physically-based runoff formation model with an ensemble of data-driven statistical models. The physically-based model was calibrated for assessing daily runoff for twenty-four mountainous river basins then parameters regionalization procedure was used for deriving gridded runoff dataset for the delineated Syr-Darya river runoff formation zone. Data-driven models (Random Forest, Gradient Boosting) were trained successively for the last gauge on the Syr-Darya river based on all available monthly observations using leave-one-out cross-validation technique for avoiding overfitting. The provided gridded dataset for monthly runoff assessment for basins in the formation zone is in good accordance with the observational data. Results also show a satisfactory efficiency of data-driven model ensembles to reproduce monthly freshwater inflow into the Small Aral Sea: coefficient of determination between observed and ensemble mean values reaches 0.8. Sensitivity analysis of data-driven models' inputs reveals the dominant importance of runoff realization derived from the formation zone gridded runoff dataset which is based on a physical realism of the used hydrological model. Our work shows the possibility to develop a valuable water assessment tool both for territories with complex water management system and strong water-related data scarcity.

Quantification of the impact of climate change on flow peaks and hydrograph volumes for hydrological dam design and safety

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A recent study has shown that annual maximum daily rainfall will increase in the future because of climate change in several regions of Spain, according to climate projections provided by EURO-CORDEX. This study aims at understanding how the expected changes in precipitation extremes will affect the flood behaviour in the future. In Spain, floods are usually generated by rainfall. However, for a given rainfall event, the flood magnitude also depend on the initial moisture content in the catchment, which in turn also depends on precipitation and temperature in the days before its occurrence. Therefore, the expected changes in precipitation extremes cannot be transformed directly into changes in runoff. Hydrological modelling is required to characterise the rainfall-runoff process adequately in a changing climate to estimate flood changes. For hydrological dam safety, the risk of dam overtopping is given by the maximum water elevation reached during the routing process. The complexity of the routing process in a reservoir requires a representation of the full hydrograph. Consequently, not only the flood peak is the variable of interest, but also the flood hydrograph volume. This paper aims at finding how expected precipitation changes in the future will affect the magnitude of both flood peaks and hydrograph volumes. Four catchments located in central western Spain have been selected as case studies. The HBV hydrological model has been calibrated, using the observed precipitation, temperature and streamflow data available at a daily scale. Daily rainfall and temperature projections for RCP 4.5 and 8.5 provided by EURO-CORDEX have been used, after correcting the bias. Finally, change rates or deltas have been calculated for a set of variables that describe a flood hydrograph: quantiles of flood peak and cumulative volumes in one, three, five and seven days. Finally, streamflow series supplied by the calibrated HBV models under climate change scenarios have been used as inflow at the reservoirs located at the outlet of the four catchments considered, in order to quantify the impact of climate change on hydrological dam safety. As the four dams have controlled spillways, the Volumetric Evaluation Method has been used to account for how gates are operated. The results have shown that the correct calibration of some parameters of the HBV model is essential to obtain coherent results, mainly those related to surface runoff generation. In addition, soil moisture content at the beginning of flood events influences on flood magnitudes. Consequently, expected changes in precipitation extremes are usually smoothed by the reduction of soil moisture content due to expected increases in temperatures and decreases in mean annual precipitation. In addition, differing results are obtained depending on the climate model considered. Consequently, uncertainty due to differing climate model outputs is accounted for in the delta changes obtained for flood peak and volume hydrograph quantiles for a set of return periods.

Hydrological changes in Lake Malawi catchment

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Lake Malawi is a very important water resource in Malawi in many aspects including hydropower generation. It is the third largest lake in Africa and its surface area and basin are 28,800<U+3016>km<U+3017>^2 and 97,700<U+3016>km<U+3017>^2 respectively. The lake has only one outlet, i.e. to the Shire River, and serves as the reservoir for hydropower generation within this river. 98% of Malawi electricity production is done here and there are plans to increase hydropower plants in the river. In this regard, the recent changes of the hydrological and hydrometeorological variables such as precipitation, evaporation, lake level, and outflow runoff are investigated within this study by applying Mann-Kendall, Sen`s Slope, and Pettit-tests. That way trend significance, trend magnitudes and potential period of turning points could be identified. The results show that both lake level and lake outflow had a significant decrease during the period 1970 to 2013, and a prominent turning point was the year 1990. The lake level was decreasing with an average rate of 0.027m per year which is 0.27m in 10 years. For the same period, rainfall also decreased significantly in the basin by 5% in 10 years. The rainfall decrease mainly took place from 1980s to early 1990s and matched with the onset of lake level decrease and lake outflow. Evaporation showed also a slight significant increasing trend particularly after 1986. The results indicate that changes in the hydrological system of Lake Malawi are mainly driven by changes in the hydroclimatological system rather than by immediate anthropogenic forces. The findings are essential for water management in the basin, particularly hydropower expansion strategies in the Shire River.

Changes in Rhine flood seasonality due to climate change

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Continued climatic changes alter hydrological processes all over the world. Also affected are river systems, which play an important socio-economic and ecological role for neighbouring societies. Possible changes in river flow and underlying drivers need to be investigated thoroughly in order to develop mitigation and prevention strategies. The Rhine river drainage basin encloses large areas of Central and Western Europe and numerous large cities are located along the river. In general, the total flow regime of the Rhine river comprises two components: 1) the alpine nival regime and 2) the middle mountain region pluvial regime. The nival regime is characterized by runoff caused by temperature-driven snowmelt with maximum runoff in early summer, the pluvial regime by large scale rainfall events over the upper and middle Rhine region occurring mainly during winter and springtime. Regarding flood events, the seasonality of runoff peaks from the two regimes are separated in time. However, a first analysis of discharge time series indicate changes in both, magnitude and seasonality of the two flow regimes. Snowmelt in the alpine area is occurring earlier in the year and high flow situation in the pluvial regime are more frequent. To further investigate whether changes in flood seasonality and magnitude result in the formation of a new Rhine flow regime and a merging and superposition of nival and pluvial flood types, we analyse discharge time series recorded along the Rhine river and all its major tributaries. Furthermore we aim to apply the mesoscale Hydrologic Model (mHM) for the Rhine river catchment under both historic and future climatic conditions to gain better insight into the complex river system and to asses characteristics of a possible future overlap of pluvial and nival floods.

BINGO PROJECT: Impacts of Climate Change on Lower Tagus Aquifers

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Aquifers also suffer impacts from climate change, which rises new challenges to integrated and sustainable water management, in its quality, quantity and ecosystem support components. Climate change studies usually have time horizons of 50 to 100 years, which hinders the decision-making concerning water management policies once these are usually based on short-period projections. BINGO project tries to overcome this handicap by analysing the impacts of climate change in the short-to-medium time horizon. FEFLOW is used to analyse the impacts on 3 aquifers of the Lower Tagus Watershed due to recharge changes determined for an ensemble of climate realisations for 2016-2025. Results show that piezometric changes associated with such climate realisations are small, although locally they can be important. The model is now being developed to simulate saltwater intrusion due to sea level rise in the Tagus estuary and coastal area. The results of the model will support risk analysis and the choice of adaptation measures.

Comparing significant differences among data from affected households by different flood types

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Germany has been frequently hit by large-scale floods. Since 2002, there have been at least eight with flood-related annual losses of more than EUR 100 million the 20002-event with EUR 11.6 billion being the maximum. Despite existent methods for flood loss estimation, there is disagreement over the reported losses and several attempts of flood loss modelling found in literature, from uni- to multivariate solutions, are still inaccurate, showing that the loss process is not thoroughly understood and therefore loss estimation remains a required but unsolved task. Surveys of residents affected by the main flooding events in Germany have covered varied aspects of the damages, such as the warning, and socio-economic conditions of the household - a broad dataset rarely found elsewhere. Previous efforts and exploratory data analysis showed that these potential predictors for the estimation of loss are non-Gaussian distributed and, although Bayesian Networks do not confirm causality, complex connections among the predictors are noticeable. Despite the broadness of information, the characteristics of the dataset (non-Gaussian, heterogeneous variance, multicollinearity) hinder more direct loss modelling and require in-depth data analysis and comprehensive approaches to better understand the inner relationships among the different aspects of the flood loss process. One potential predictor of flood loss is the flood type, which mainly led to the inundation of a particular building, i.e. levee breach, riverine flooding, surface runoff, or rising groundwater. Since it is feasible to collect information on the flood type in future events and it is a variable found in other databases worldwide, it is of interest to assess its potential as a predictor of flood losses to test or improve the transferability of loss models. In this work, we explore the independence of 29 selected potential predictors (addressing hazard, warning process, flood experience and precaution, building, and socio-economic information on the household) to the flood type nominal variable, and analyse whether there is a significant difference among its levels that justify the inclusion of the variable as predictor. Regarding independence, due to the non-Gaussian distribution, the Kruskal-Wallis test was run for each variable per flood type class, with significance level confirmed by post hoc tests. The analysis reveals that information on the household and its socio-economic condition are mainly independent to flood type, whilst variables addressing the hazard, the warning process, and the losses (either absolute monetary loss or the relative loss, i.e. ratio between the loss and the building value) show significantly different levels across the different flood types, implying that their effects may be dependent (or confounded) and deserves further studies. Straightforward variable selections such as linear regression backward elimination and forward selection showed that flood type is a relevant predictor. Moreover, a “no pooling” multilevel modelling was accomplished taking nominal variables, such as flood type, as an initial sample split and at each level, a decision tree was developed with the basic predictor water depth. In both variable selection and multilevel modelling, flood type is pointed as the best candidate after water depth itself, and further studies to refine these models should be carried out, including other predictor candidates.

Transferability of probabilistic flood loss models – a case study with Empirical and Synthetic flood loss data from Germany and UK

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A number of flood loss estimation models have been developed for Germany using empirical datasets collected via telephone surveys after the flood events in 2002, 2005, 2006, 2011 and 2013. The FLEMOps models (Flood Loss Estimation Model for private sector) are a family of models with varying complexity, all using hazard, exposure and vulnerability variables to predict economic losses. They include rule-based models, multi-variable data mining models (Regression Trees, Bagging Decision Trees) and Bayesian probabilistic models. The models with more parameters improve the ability to describe the underlying damaging processes. Flood loss estimation models are temporally and spatially localized. However, in practice the models developed in one region are transferred to another, without testing their suitability for the region and purpose. Several validation studies show that empirical and synthetic depth-damage curve estimates are associated with high uncertainties when applied to regions outside the area or country for which the models were developed. The aim of this work is to test the suitability of a probabilistic multi-variable model (BN-FLEMOps) for spatial transfer between two countries by answering the following research questions: 1.\tHow well does a probabilistic model (BN-FLEMOps) perform in a cross-country transferability setting? 2.\tAre there approaches (e.g. like updating with information from locally developed synthetic functions) which improve the model performance in a transferability test?

Enhancing the consistency of spaceborne and ground-based radar comparisons by using quality filters

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Ground weather radars (GR) and radar-based rainfall estimates are helpful in providing real-time high resolution precipitation information needed for early warning systems, especially in tropical climates where monsoon and typhoons are in abundance, such as in the Philippines. Traditionally, GRs are calibrated by comparing rainfall estimates to rain gauge networks. However, the sparse network of rain gauges in the Philippines makes monitoring and calibration a challenge. In this study, we examine the potential of using spaceborne radar (SR) observations on-board the TRMM and GPM satellites as basis for comparison to determine the calibration bias of the Subic radar in the Philippines. The method proposed by Schwaller and Morris (2011) that applies a 3D volume-matching algorithm is further extended by a framework that takes into account the data quality of each ground radar bin is implemented on five years (2012-2016) of observations. The GR calibration bias is computed as a quality-weighted average of reflectivity differences between the matching GR-SR volumes. The beam blockage fraction is used as an exemplary basis for the data quality index. The results show that using the extended framework allows the consistency between SR and GR observations to be improved, and thus the precision of the bias estimates.

The diminishing stabilizer: the impact of natural gas hydrates on the geo-mechanical properties of marine sediments

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Natural gas hydrates are ice-like crystalline solids consisting of hydrogen bonded network of water molecules and gas molecules, mainly methane. They form at elevated pressure and cold temperature conditions in presence of sufficient amounts of gas and water. Among others, these conditions are fulfilled at continental margins and permafrost regions where natural gas hydrates occur. Within these hydrate-bearing sediments, gas hydrates may occur as cementing solid at the contact area of sediment grains or as pore filling and load bearing hydrate. The morphology of the formed gas hydrate depends on the formation conditions and affects the properties of the host sediment: gas hydrates may support the grain skeleton, take over effective stress, and considerably increase sediment stiffness even at low concentrations. Conversely, the dissociation of natural gas hydrates, especially in marine sediments at the continental margins, likely results in the reduction of the mechanical strength of the host sediment, may also induce overpressure due to gas release and may decrease the slope stability. Since continental shelf and slope regions are used by humans for several activities, which largely rely on the mechanical stability of the marine sediment, the knowledge concerning the key factors and processes determining the stability of the weakly consolidated marine slope sediments is crucial. A key factor is the response of natural gas hydrates to potential ocean warming as a result of climate warming or human activities such as the production of methane from hydrate-bearing sediments. Both lead to a decrease of hydrate saturation and, therefore, to a change of the geo-mechanical properties of the host sediment. In the framework of the SUGAR project we developed a ring shear cell and investigated the residual and peak shear strength of hydrate-bearing sediments. Based on literature data and our preliminary results we discuss the dependency of the mechanical properties of hydrate-bearing sediments on the hydrate saturation and the potential consequences.

An evaluation and monetary assessment of the impact of flooding on subjective well-being across genders in vietnam

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The tangible impacts from flooding have been well studied, though the intangible impacts flooding have as a whole less well-studied. Moreover, we know that in general the impacts of flooding are gender specific in that men and women are affected differently. These differing impacts create a gender based flood resilience gap between men and women. This paper investigates how the flood risk domain affects welfare across genders using a sample of 1010 respondents in coastal and urban areas of central Vietnam. We study this using a mediation style analysis of the flood risk domain on subjective well-being. We find that for both male and female respondents experiencing a flood inflicts a large initial drop in welfare. Male respondents tended to recover their welfare losses by nearly 80% within 5 years while female respondents were associated with a recovery of 70%. A monetization of the impacts floods have on well-being shows that US$10000 and US$11000 in compensation would be needed to compensate SWB losses of female and males, respectively. Overall, we find that the gender flood resilience gap is identifiable in the long-run subjective well-being impacts as female respondents were more heavily impacted.

Quantification of recurring flood dynamics

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The recurrence of flood discharge peak and maximum depth are some of the hydrological signatures and are popular choice for flood risk assessment due to their close relationship with socio-economic impact of flood and often used for damage modeling. But what if our question is whether the flood process dynamics is rare or unseasonal (influenced by unusual or more driving mechanism, e.g. ice jam, dam break, clogged drain, etc.) and especially if hydrological boundary condition is no longer the same as before. Although other indices derived from hydrological signature (e.g. volume, slopes, base flow index, etc.) are useful descriptor of a process dynamics, most of them are still either just a part of hydrograph, or derived as an aggregate (e.g. slopes and volume) and therefore unable to provide bigger picture of the flood dynamics and suffer from statistical uncertainty. Furthermore, with singular descriptor from the mentioned, different flood dynamics (i.e. resulted from different processes/ boundary conditions) could be mistaken as the same and might lead to misinterpretation (e.g. snow melt and rainfall triggered runoff may easily share similar flood peak and volume). In this study we propose a more elaborate hydrological signature index to quantify recurring similarity (and dissimilarity) between flood or event dynamics as implied by their phase space trajectories. These phase space trajectories are reconstructed from their corresponding hydrographs (i.e., event time series) using Taken's time delay embedding method. This reconstructed phase space allows multi-dimensional relationship between observation points (e.g., at different time of the event) to be analyzed. Such analysis could imply the relationships of several magnitude-time points in their sequence that are relevant to the complex cascading processes in flood. An example is when there is a small to moderate rainfall enough to partially or fully saturate ground or soil layer, the subsequent rainfall/ inflow event may not need to reach usual flood trigger threshold to cause inundation and the compactness of water content in the soil would also cause the flood recession to last longer. This study intends to introduce the approach of quantifying and comparing rainfall-runoff event process dynamics implied by their aforementioned multi-dimensional phase space through Cross Recurrence Plot (CRP) and their quantification (RQA) specifically for river discharge time series. Such endeavor would then allow hydrologist to evaluate if there has been temporal changes in flood dynamics (e.g. dissimilar phase space between different time periods) at different watersheds.

Impacts of atmospheric blocking on extreme air pollution over Europe: Implications under climate change

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A critical implication of climate change is to alter the frequency and intensity of climate extreme events (e.g. heat waves, cold spells). Evidence suggests that when extreme weather and air pollution episodes occur in coincidence, their health effects are nonlinearly amplified beyond the sum of their individual effects. For instance, heat waves and pollution episodes can share a common meteorological driver, which can worsen their impacts on human health and ecosystems. Atmospheric blocking is a considered as one of the most impactful weather regimes over Europe that has been related to weather extreme events (e.g. heatwaves, cold spells) and usually leads to stagnation of weather patterns favouring accumulation of pollutants. Thus, changes in the frequency and duration of atmospheric blocking episodes might have an influence weather extremes and consequently impact future air quality. Due to the strong relationship between pollution episodes and climate, assessing the risks of extreme events that occur in coincidence still remains a challenge. The growing increase of big geoscience data motivates the development of new problem formulation and learning algorithms applicable to large datasets in order to understand the impacts of natural hazards. Specifically, the links between patterns of air pollution and climatic factors can be learned from historical data and captured by a statistical model. Based on statistical modelling, this study aims to assess the impacts of atmospheric blocking activity on extreme air pollution and the implications under climate change over Europe. We propose an extreme value theory approach to examine the effect of persistent weather patterns (i.e. atmospheric blocking) on ozone pollution episodes. Furthermore, we examine whether there exists a statistically connectedness between extreme events in space and time. For that, we use daily values of surface ozone concentrations from monitoring sites provided by the European Environment Agency's AirBase network and meteorological variables from ERA-Interim reanalysis to assess weather patterns.

Dynamic Risk Mapping in Fluvial Flood application using a two-dimensional Hydrodynamic Model Incorporating the Model Parameter Uncertainties

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Flood inundation models are central components in flood risk analysis as they transform the discharge from hydrological models into distributed predictions of flood hazards in terms of water depth, inundation extent and flow velocity. Flood forecasting models have the potential to extend the lead time provided to issuing flood warnings and can produce additional information to improve decision making. However, the model uncertainties are not associated while publishing the inundation maps and in assessing the potential risks. The main objective of the paper is to access the real-time potential spatial-temporal risk incorporating the model parameter uncertainty of the 2D hydrodynamic model. HEC-RAS is used as the 2D hydrodynamic model and the uncertainty of the model roughness is estimated by using 1000 uniform model parameter sets. The uncertainties quantiles of the water depth are associated with specific land use features. The presented paper focuses on buildings and bridges in the study area as the main land use features. The study area is in the city of Kulmbach in Upper Main river catchment in Germany. Furthermore, a framework of an evacuation strategy is presented using the real-time flood inundation forecast and information of spatial-temporal potential risks are accessed using a damage function and made available to the end users via webgis application in real-time. The end users are disaster relief organisations such as the Federal Agency for Technical Relief (THW), the German Red Cross and the Bavarian Water Authorities. The framework facilitates the end users helps anticipate the impact of flood disaster and to make decision under uncertainty.

Probabilistic multi-variable flood loss modeling with BN-FLEMOps in the German Danube Basin

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The frequent occurrence of large river floods and the resulting economic loss emphasize the need for risk oriented flood management approaches. Flood loss estimation on the meso-scale is an integral component for the implementation of the EU Floods Directive and an indispensable tool for the insurance and re-insurance industry to calculate premiums and define solvency requirements. Despite this important role, flood loss models often rely on simple water-depth to damage relations and usually neglect other flood intensity metrics and other relevant factors describing the resistance characteristic. Further, flood loss predictions are associated with large uncertainty. We approach this problem by proposing the multi-variable probabilistic loss model BN-FLEMOps (Bayesian Network – Flood Loss Estimation Model private sector) that allows for the consideration of multiple predictor variables and the quantification of uncertainties in model outputs. BN-FLEMOps estimates relative loss to residential buildings in dependence on flood experience of the population, precautionary measures, building area, return period, duration and water depth. The model is based on empirical data and has been validated in a number of case studies throughout Europe. The focus of this contribution is on the application of the model within a continuous long-term simulation, over a period of 10.000 years, of the German part of the Danube for current climate conditions. This simulation builds on the outputs of the Future Danube Model. A model chain consisting of a stochastic weather generator, a hydrological model and a hydrodynamic model. Within this set-up, large-scale risk assessment is investigated under consideration of uncertainties regarding the flood hazard, described via a stochastic event set and uncertainty of flood loss estimates, which is represented by the conditional probability distribution of relative flood loss within the Bayesian Network.

Risk analysis of dzud (severe winter disasters) in Mongolia

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Mass livestock mortality, known as dzud, causes significant socioeconomic problems in Mongolia. Existing studies argue that the frequency and intensity of dzud are rising due to the combined effects of climate change and variability, and socioeconomic dynamics. However, few studies investigate risk analysis for dzud and the recurrence of dzud using a long climatic record. Given that climate is a significant driver of the occurrence of dzud and there is a signal of cyclic climate regimes at the interannual to centurial scales, the risk analysis of dzud from the perspective of climate regimes is critical. This study aims to fill the gaps in technical knowledge about the recurrence probability of dzud by estimating the return levels of relevant climatic variables. Our study uses a long-term proxy of droughts, the tree-ring reconstructed Palmer Drought Severity Index (PDSI) between 1700-present. Our study also simulates winter minimum temperature in Mongolia from the instrumental data in Siberia, including data from the early 19th century. Based on these data, we estimate the distributions of summer drought conditions and winter minimum temperature and their return levels in Mongolia for risk analysis. Based on the Generalized Extreme Value (GEV), the return levels of drought conditions are changing over time and its variabilities are increasing for all the regions. Furthermore, this study finds that the median of 100-year return levels of the winter minimum temperature in Mongolia is -26.08 Celsius degrees for the Southwest, -27.99 Celsius degrees for the Northwest, and -25.31 Celsius degrees for the East. These return period estimates will fill in the gaps between studies on the meteorological characteristics and socioeconomic impacts on livestock populations, and the design of the livestock index insurance.

The influence of the Pacific Decadal Oscillation PDO on the summer rain and the incidence of Tropical Systems in Baja California Sur, Mexico, under the effect of Climate Change.

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The influence of the Pacific Decadal Oscillation PDO on the summer rain and the incidence of Tropical Systems in Baja California Sur, Mexico, under the effect of Climate Change. Jobst Wurl and Brenda Bello JiménezChanges in the climate system over time are influenced by variations in the internal dynamics, which are the result of the interaction processes between the various components of the climate system (atmosphere, hydrosphere, cryosphere, etc.), or due to the presence of external forcings of natural origin (for example, variations in solar activity or volcanic activity) or of human origin (such as increased greenhouse gas emissions, changes in the use of soil, etc.).If external forcings do not occur, the climate changes may be influenced by the processes of the internal dynamics of the system, which are associated with ocean-atmosphere interaction processes. Previous studies indicated that climatic variability can be associated to the phenomenon often to El Niño-Southern Oscillation (ENSO) or variations in periods of decades such as those associated with the Pacific Decadal Oscillation (PDO) and the Multi-Decadal Oscillation of the Atlantic (AMO).The analysis of the daily rainfall data showed that there has been a significant increase in the frequency of extreme rainfall in the last 10 years, since, in this last decade, the number of events has quadrupled compared to those registered in the decade of The 30's.The temperature analysis revealed that the anomaly of maximum temperature has remained positive from 1992 to 2014. The analysis of the synoptic patterns of sea surface temperature showed that it has increased and the climate change scenarios indicate that for the following decades it will continue to increase so that in the coming years, there will be more energy (heat) and surface available for the development and strengthening of a tropical system. The analysis of climate change indices allowed to identify a decrease in the number of days without precipitation, so it is concluded that there occurs currently more rainfall in fewer days due to the presence of extreme hydrometeorological events. An increase in the frequency and intensity of extreme rainfall events were observed, and a slight increase in annual accumulated rainfall. In Baja California Sur, the correlation analysis between the historical data of the Pacific Decadal Oscillation (PDO) with the observed records of monthly accumulated precipitation indicates that the PDO has a regional influence. Taking into account all the trajectories of the systems, formed in the eastern Pacific since 1949 to 2014, for the period from July to October, during the negative phase of the PDO, they impacted in 3 out of 10 cases, while in its positive phase the relation is 2 out of 10. Although the probability of impact resulted greater in the negative phase of the PDO, it is during its positive phase when more intense tropical systems occur and this is intensified in case of El Niño.

Differential SAR Interferometry for earthquake source modeling: 29 March 2017 Kamchatka earthquake case study

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An appropriate knowledge about the fault geometry and slip distribution is important for a better assessment of seismic hazard in tectonically active areas. In this regard, the space borne technique of Differential SAR Interferometry (DInSAR) has contributed a lot in the past two decades by mapping co-seismic surface deformations, and derive the seismic source model from it. Kamchatka Peninsula, located on the far eastern edge of Russia, hosts some of the most alive volcanoes and is one of the most seismologically active regions in the world. It is situated at a triple junction area where the Pacific, Bering and Okhotsk plates come together. On 29 March 2017 a Mw 6.6 earthquake occured north of the arcs junction, in South-Ozernogo bay. The aforementioned tectonic mechanism of this region is still not well understood and several different theories have been proposed by the research community. This seismic event may give valuable contribution to the interpretation of the complex tectonic setting of this region. For this analysis two different SAR datasets were used to perform the interferometric analysis and detect the coseismic surface displacement: ALOS-II descending interferometric pair, covering 6th March 2017 (before the event) and 1st May 2017 (after the main event and the four aftershoks), and Sentinel-1 descending interferometric pair, covering 17th March 2017 (before the event) and 29th March 2017 (after the main event).Coseismic uplift was detected from both datasets, amounting to a maximum of 23 mm near the shoreline. Nonlinear inversion using elastic half-space modeling suggests a north-west-dipping oblique thrust faulting with right-lateral rupture. The epicenter was located almost 2 km east from the cost at depth of around 12 km. The fault geometry is consistent with that determined from the seismological analysis. However, some disagreements are present regarding the epicenter location and depth.

Data mining and model development for predicting flood-induced structural damage

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In early 2017, the coast of Peru has been hit by a rare and unpredicted Fenómeno El Niño Costero (FENC), resulting in floods of historical scale. This disaster directly affected over 1.5 million people, among them at least 162 dead, destroyed more than 100.000 houses, and caused severe damage to infrastructure and economy (Venkateswaran et al. 2017). This event once more demonstrated the vulnerability of the region to flooding, despite broad awareness of the issue. The RIESGOS project – coordinated by the German Aerospace Center (DLR) – aims at developing modern multi-risk analysis and information system components for the Andes region. This interdisciplinary approach will comprise information on floods, earthquakes, tsunamis, landslides, and volcanic hazards. As one component within the project, a flood loss model specifically designed for the Andes region will be developed. In the first phase, data mining techniques are utilized for the analysis of structural damages from different datasets. This is a complex task, since flood characteristics differ between regions and events (including pluvial floods, long-lasting inundations, and flash floods with high sediment load, termed 'huaycos'). The aim is to identify and quantify the most relevant drivers of structural damage under different conditions. Candidate variables include hazard information (e.g. water depth, flow velocity, duration of flooding), but also building characteristics (e.g. material or building area). Detailed exposure information is expected to improve the model, since the quality of buildings in the Andes region ranges from very low to very high standards – although it is still unclear to which extent buildings of different quality are affected by flooding, since high quality buildings are often constructed in areas of low hazard probability. This is opposed to the situation in central Europe, where most buildings are of similar quality (i.e. most buildings are similarly susceptible towards flooding) or regions of low water depth (e.g. Mekong Delta), where content damage is more important. Classification algorithms are trained and evaluated to predict categorical classes of structural damage. The best model will eventually be implemented as a web-service to interact with other components of the RIESGOS scenario-based demonstrator. * Venkateswaran K., MacClune K., and Enriquez, M.F. (2017): Learning from El Niño Costero 2017: Opportunities for Building Resilience in Peru. ISET International and the Zurich Flood Resilience Alliance. http://floodresilience.net/resources/collection/perc

Has dyke development in the Vietnamese Mekong Delta shifted flood hazard downstream?

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In the Vietnamese part of the Mekong Delta (VMD) the areas with three rice crops per year have been expanded rapidly during the last 15 years. Paddy-rice cultivation during the flood season has been made possible by implementing high-dyke flood defenses and flood control structures. However, there are widespread claims that the high-dyke system has increased water levels in downstream areas. Our study aims at resolving this issue by attributing observed changes in flood characteristics to high-dyke construction and other possible causes. Maximum water levels and duration above the flood alarm level are analyzed for gradual trends and step changes at different discharge gauges. Strong and robust increasing trends of peak water levels and duration downstream of the high-dyke areas are found with a step change in 2000/2001, i.e. immediately after the disastrous flood which initiated the high-dyke development. These changes are in contrast to the negative trends detected at stations upstream of the high-dyke areas. This spatially different behavior of changes in flood characteristics seems to support the public claims. To separate the impact of the high-dyke development from the impact of the other drivers, i.e. changes in the flood hydrograph entering the Mekong Delta, and changes in the tidal dynamics, hydraulic model simulations of the two recent large flood events in 2000 and 2011 are performed. The hydraulic model is run for a set of scenarios whereas the different drivers are interchanged. The simulations reveal that for the central VMD an increase of 9–13 cm in flood peak and 15 days in duration can be attributed to high-dyke development. However, for this area the tidal dynamics have an even larger effect in the range of 19–32 cm. However, the relative contributions of the three drivers of change vary in space across the delta. In summary, our study confirms the claims that the high-dyke development has raised the flood hazard downstream. However, it is not the only and not the most important driver of the observed changes. It has to be noted that changes in tidal levels caused by sea level rise in combination with the widely observed land subsidence and the temporal coincidence of high water levels and spring tides have even larger impacts. It is recommended to develop flood risk management strategies using the high-dyke areas as retention zones to mitigate the flood hazard downstream.

Climate change induced modifications of Nordic flood regimes

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Observed and projected changes in the climate system are supposed to intensify the hydrological cycle which will, in turn, have direct implications for hydrological extremes such as flooding. The impacts of climate change on hydrological extremes are, however, expected to vary across different regions due to the prevailing hydrometeorological regimes and the nature of climate change in specific regions. For mountainous and Nordic regions, where the role of snowmelt vs. rainfall is highly relevant for the seasonal flood regimes, the impacts of climate change on runoff and flooding are expected to be more diverse and severe than in other regions. Taking various catchments from Norway as an example, this study applies observation-based trend analyses and scenario-based modelling as complementary approaches to investigate the impacts of recent and projected changes in the hydrometeorological triggers on Nordic flood regimes. Furthermore, an event-based approach is proposed to attribute dominant flood generating processes (i.e. rainfall and snowmelt) to observed and projected peak flow events so that changes for both groups of flood events could be analyzed separately. The main results of this study can be summarized as follows:

- Floods tend to become more frequent but necessarily higher.
- Rainfall (snowmelt) has gained an increasing (decreasing) importance for observed flood regimes, and the projections indicate that this development will be even more prominent in the future.
- Possible systematic shifts in flood seasonality highly correspond to changes in the relative role of flood generating processes.
- Distinguishing between flood generating processes allows for identifying (in)consistencies with changes in the hydrometeorological drivers and generally aids for a better understanding of flood regime changes in Nordic catchments.

Large-scale derived flood frequency analysis for Germany based on weather generator and hydrological modelling

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The study presents an approach to derive flood frequencies at the national scale of Germany based on combination of a multi-site multi-variate weather generator and a hydrological model. . The weather generator conditioned on observed data was used to generate long time series of synthetic daily meteorological fields (precipitation, temperature, humidity, solar radiation) retaining their spatial correlation structure. The performance of the weather generator was evaluated with focus on the representation of extremes and spatial dependence structure. Daily synthetic meteorological fields were used to drive a hydrological model of all major river basins in Germany to produce long discharge time series used as a basis for frequency analysis. The derived flood frequency curves at gauge locations are compared to (1) flood frequency derived based on observed discharge series and (2) to flood frequency based on discharge simulations driven by observed climate data. The analysis elucidates the advantages of the derived flood frequency analysis, but also shows the uncertainties related to the weather generator and the hydrological model.

Remote sensing time series analysis for identifying spatiotemporal landslide activity in multihazard environments

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Landslides are a worldwide natural hazard causing thousands of fatalities and severe monetary losses every year. They often occur as cascading effects in case of natural disasters such as earthquakes or hydrometeorological extreme events (e.g. typhoons). Recent prominent examples are the Kaikoura earthquake in New Zealand (Nov 2016), the Gorkha earthquake in Nepal (Apr/May 2015), and the Typhoon Morakot in Taiwan (Aug 2009). Each of these events caused more than 10.000 landslides that contributed substantially to the overall disaster's impact. The ever increasing availability of optical satellite remote sensing data presents a great potential for systematic and efficient mapping of such widespread landslide occurrence in order to better understand and predict landslide processes and thus to contribute to the reduction of future landslide consequences. We developed an automatic approach for large area multi-temporal landslide mapping using optical satellite remote sensing time series data. The approach enables the identification of individual landslide objects and the time period of their occurrence which is determined by the temporal resolution of the available imagery. The approach allows for rapid response mapping in case of major disasters, representing crucial information for the coordination of emergency response actions in the direct aftermath of a disaster. To evaluate the disasters' influence on the intensity of landslide activity landslide rates before and after the disasters' occurrence need to be compared. For this purpose the developed landslide mapping approach can be applied to longer-term time series acquired by diverse optical multispectral sensors in order to systematically identify occurrence patterns of landslides over longer period of time. Thus, the background activity of landslides before the disaster can be analyzed against the direct landslide impact caused by the disaster and the longer-term post disaster landslide occurrence to analyze potential transient effects. The developed approach has been applied for spatiotemporal landslide mapping in in large regions of several thousand square kilometers related to catastrophic triggering events, such as the Nepal and the New Zealand earthquakes as well the Mocoa flood in Colombia. Moreover, its potential has also been shown for reconstructing long-term landslide occurrence in Southern Kyrgyzstan spanning several decades. Newly available satellite remote sensing systems, such as Sentinel-2 and the planet constellation will further increase its potential for detailed spatiotemporal landslide mapping and monitoring.

A globally consistent tropical cyclone impact model

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Many Climate Services, like the assessment of sovereign or sectoral risks, require globally consistent and comparable estimates of climate and weather impacts. For many hazard types, however, lacking and inhomogeneous data have been limiting most empirical studies and modelling approaches to local and regional cases. This is also the case for tropical cyclones, one of the world's most damaging natural hazards. To address this gap, a global tropical cyclone impact model is developed and calibrated. In the open-source and -access probabilistic impact model CLIMADA, risk is calculated as a function of hazard intensity, exposure and vulnerability. One of the main drivers of uncertainty in tropical cyclone impact models the vulnerability, i.e. the shape and scaling of damage functions linking hazard intensity (e.g. wind speed) with damage degrees. Using an optimization algorithm, scale and shape of damage functions are calibrated regionally against historical yearly damages from the Emergency Events Database (EM-DAT).For the calibration, exposure is estimated based on the gridded product of night light intensity and population density, so called Lit Population (Zhao et al., 2017). Lit Population is then normalized for each country and scaled with estimates of GDP and GDP-to-wealth-ratios to obtain a global map of exposed values. As a hazard, maximum wind speed intensity based on historical storm tracks from the International Best Track Archive for Climate Stewardship (IBTrACS) (Knapp et al., 2010) is modelled on a global 10km-grid.The calibration regions are chosen according to the ocean basins with tropical cyclone activity: North West Pacific, North Atlantic, North Indian, South Indian and South Pacific Ocean (including Oceania). Calibrating each region separately allows to implicitly account for inter-regional differences including likely inconsistencies between different data sources of the IBTrACS. At the same time the geographical extend of the regions allows to include sufficient data points per region to ensure robust calibration. Here, we present the methodology in greater detail, including results, consistency and sensitivity checks, and the application of the calibrated impact model questions related to global change. Moreover, we discuss limitations and the potential to apply a similar calibration process to other natural hazards.

Attributing reductions in flood losses to improvements in risk management

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Extreme event attribution studies are used to investigate the causal factors contributing to the characteristics (probability and magnitude) of specific events. In recent years, the framework of 'event attribution in the context of climate change' has been developed, attempting to understand the role of human-induced climate change on extreme events characteristics. We propose to transfer this framework to the context of flood risk management to understand the loss reducing effect of risk management strategies, such as dike heightening or improvements in private precaution. Following the framework developed by the climate change community, we define a factual world, i.e. a world as it existed during a specific flood event, and compare to it a counterfactual world, i.e. a hypothetical world that might have occurred given a certain situation with changed risk management. Since there are several confounding factors and since our models are uncertain, only probabilistic statements can be derived. We apply this concept to the June 2013 flood in the Mulde catchment, Germany, and quantify the probability of obtaining a flood loss equal or larger than the loss observed in 2013 for the factual and several counterfactual worlds. The comparison of these probabilities quantifies the role of different risk reduction measures in reducing loss.

InSAR Time Series Analysis for Deriving the Landslide Kinematics in Nepal from ALOS-I Data

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The landslides and flood occurring in Nepal are among the major natural hazards in this region. The Northern parts of Nepal are located on Himalaya mountains and are affected by the heavy rainfall. Therefore assessing the kinematics of landslides in those areas has become an important topic. The study area in this research consists of 3 landslides in Annapurna range of the Himalays close to the Nepal-China border. The aim of the study is to use the ALOS-I satellite data for deriving the kinematics of landslides. In order to achieve this goal, we used the InSAR (Interferometric Synthetic-Aperture Radar) technique utilizing data from ALOS-I satellite between the years 2007-2011. We performed the PSI (Persistent Scatterers Interferometry) time-series analysis for deriving the kinematics of landslides based on the temporal evolution of surface deformations in the study area. This approach reduces the limitations of the typical SAR Interferometry such as temporal de-correlation by considering more than two acquired data sets into analysis process, which improves the accuracy of the results to few millimeters. Meanwhile there are some constraints that hinder the accuracy of results from PSI analysis such as the area's slope and existing topography, the incidence angle of the satellite to the ground, which need to be filtered from the final results. Eventually, the final results present the average velocity of the landslides in Nepal after filtering the mentioned constraints which are discussed in this poster.

Index Terms: Slow moving landslides, ALOS-I satellite, InSAR, Time-series analysis, Deformation, PSI, Landslide velocity

InSAR Time Series Analysis of Postseismic Deformation based on L-band Wide-Swath SAR Data

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A major Mw .7.8 earthquake occurred on April 16. 2016 in Ecuador. It happened near the north shoreline and caused a lot of damages to this area, more than 600 people died and more than 15000 people injured. In this study we analyze coseismic and postseismic surfacedeformation related to this event using Synthetic Aperture Radar (SAR) data. We utilize L-band wide-Swath data from ALOS-2 satellite, which is one of the new generation of satellite synthetic aperture radar missions launched by Japan Aerospace Exploration Agency (JAXA). It obtains wide-swath SAR data that covers large area thanks to its ScanSAR mode. With l-band (~24 cm wavelength) and well-controlled orbit, it obtains data with a short baseline and produces data with good coherence compared to previous. In this research we apply ScanSAR interferometry. However, due to the lower frequency of SAR data and their large coverage, the differential ionospheric path delay that happens during the aqquisition of the data at different times leads to error in the generated interferograms. We implement split-spectrum method to estimate the ionospheric phase and remove it from the generated interferograms before time-series analysis. The preliminary results are presented and discussed in this presentation.

Index Terms: Advanced Land Observation Satellite-2 (ALOS-2), scanning synthetic aperture radar (ScanSAR), earthquake, postseismic deformation, Ionosphere.

Modelling PNW Seismicity with HIST-ETAS: Towards Improved Aftershock Forecasting

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The Pacific Northwest (PNW) of North America has substantial earthquake risk, which must be mitigated using spatially-varying and accurate forecast models. A number of tectonic systems contribute to PNW seismic risk. The Cascadia Subduction Zone lies under the Pacific Ocean and generates rare but massive events furthermore, the crustal faults under land produce much more frequent, though usually lower-magnitude, seismicity. These faults lie under population centers (e.g., the Seattle and Tacoma Faults) and are believed to comprise several distinct tectonic regimes (e.g, the subducting slab produces earthquakes with different spatiotemporal dynamics than shallow crustal faults). Managing earthquake risk in the PNW requires earthquake occurrence models that not only have optimal fit to earthquake catalogs but also characterize the spatial nonstationarity in the dynamics of earthquake occurrence. Such models are being used in other regions (e.g., California) to produce probabilistic forecasts, particularly for occurrence of aftershocks following a large-magnitude event. However, all forecasts come with uncertainty, arising from multiple sources, which must be rigorously quantified to properly assess seismic risk. To improve aftershock forecasting in the PNW, we model its earthquake occurrence using the hierarchical space-time Epidemic Type Aftershock Sequence (HIST-ETAS) method. We also contribute a thorough quantification of uncertainty of the results of this model. ETAS is a space-time point process model where the total earthquake rate is governed by a set of parameters directly related to earthquake risk, such as background seismicity and aftershock productivity. The HIST-ETAS version allows for the estimates of these parameters to vary over the spatial domain, important for the tectonically diverse PNW. We combine three earthquake catalogs for the PNW from 1970-2001, including a dataset of error estimates for reported magnitudes and locations for all earthquakes in the final catalog. Unlike other earthquake occurrence models, we seek to propagate the measurement errors through the model to obtain more realistic uncertainties. HIST-ETAS models are fit to the PNW catalog, resulting in spatially-varying estimates of important aftershock parameters, as well as overall seismicity rates. We discuss what effect including earthquake depths in these models may have on the results. Standard errors that incorporate the known measurement errors are derived for these parameter estimates. We use a simulation-based approach that isolates the effect of measurement errors and model stochasticity on model estimates. Bayesian uncertainty quantification is also considered. Efficient processing and analysis of thousands of simulated catalogs and models requires modern computational tools. Preliminary results are available for several HIST-ETAS models for a subregion centered around the Puget Sound in western Washington. The variation across space in estimated seismicity rates and ETAS parameters is visually apparent and will be more rigorously tested. The effect of measurement error on model outcomes is more nuanced and also changes with space and time. Implications for operational aftershock forecasting are discussed.

Modelling Rapid Changes in Ice-rich Permafrost Landscapes

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Ice-rich permafrost is estimated to underlie 20% of the terrestrial Arctic. These landscapes are particularly vulnerable to thawing processes referred to as thermokarst, which manifest in the emergence of characteristic landforms and rapidly changing landscapes. Prominent examples for theses processes are ground subsidence, thaw slumps, thermo-erosional valleys or the degradation of ice-wedge polygonal tundra. Altogether thermokarst poses risks to infrastructure and ecosystems in the Arctic, particularly in conjunction with a warming climate. To assess theses risks efficient prediction tools are demanded which are able to simulate the landscape changes due to thawing of ice-rich permafrost. We present a novel modeling approach based on the one-dimensional permafrost model CryoGrid3 that is capable of simulating physical dynamics of thermokarst landforms. For this, the landscape is partitioned into a set of distinct tiles which represent functionally different landscape units. Adjacent tiles are able to exchange water, snow and heat laterally. Thus our approach allows to represent non-linear and scale-dependent processes within the framework of a one-dimensional land surface model. We demonstrate the capability of our approach with showcasing the degradation of an ice-wedge polygonal tundra landscape. This landscape change involves a transition from an intact to an degraded permafrost landscape which can be considered as a regime shift between different stationary states. We further quantify the implications of this transition for cycling of water and energy in the landscape. We discuss the applicability of our model approach to other ice-rich permafrost landforms and its potential to a pan-Arctic risk assessment for infrastructure a ecosystems.

Characterizing the precipitating systems in Ceará – Brazil

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The Ceará state is located in northeastern Brazil with a semi-arid climate regime. The rainy season is concentrated from February to May and it is characterized by rainfall accumulation of 600 mm and frequently experiences extreme events such as drought and floods. According to previous studies, this region is influenced by the intertropical convergence zone, incursion of cold fronts, upper level cyclonic vortices, squall lines oceanic mesoscale convective system also by sea and land breezes. Despite these differences, most of the rainy systems in land arise from warm clouds and are driven by local circulation and convection. To better understand the contribution of each of those systems, we will employ FUNCEME's Doppler S band weather radar, located in Quixeramobim (geographic center of the Ceará state), during the rainy season of 2015, 2016 and 2017. For this analysis, we will depict the probability distributions related to duration, horizontal and vertical extent and elaborate a spatial contribution maps using open source tools as OpenCV and Wradlib. Furthermore for the severe events related to floods, we will also investigate these raining systems in terms of frequency of occurrence and their life cycle.

Evaluating an private flood protection education programme

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Flooding has become an increasingly relevant topic in Germany, which major flood events along the Elbe and Danube rivers in 2002 and 2013 have highlighted. Private protection measures can help reduce the potential damage to private households from flooding. Hence, a range of private protection measures are being promoted via different risk communication methods. Education programmes on private flood protection however have not been systematically evaluated so far. Therefore, we designed and evaluated an educational workshop that covers different aspects of flood protection for private households. In the German federal states of Saxony-Anhalt, Saxony, Berlin and Hamburg, six workshops were conducted, four of which took place in flood-prone areas. In total n=115 people participated. Based on the Protection Motivation Theory (PMT) a questionnaire was created, which the participants filled out before and after the workshop. The scales means before and after the intervention were compared using ANOVA. Significant increases in self-efficacy η^2=.382), subjective knowledge (η^2=.296) and intention to show certain protection actions (η^2=.193) were observed. Participants who reported lower levels of previous knowledge, those that had not experienced a flood before and those of younger age profited more: They showed a higher increase in self-efficacy and knowledge than people with higher previous knowledge, flood experience and higher age. The flood education workshops proved to be a helpful tool in sensitising residents of flood-prone areas on the topic of private flood protection and empowering them to show flood protective behaviour themselves. The fact that especially flood inexperienced people reported a higher level of self-efficacy and knowledge is promising for flood risk management. The transferability of the study's results into the contexts of other hazards shall be addressed in future research.

Seismic Attenuation Characteristics in Kyushu

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We have analysed seismic waveforms from Kyushu (SW Japan) to infer the frequency-dependent attenuation characteristics of seismic waves. A standard spectral inversion is applied to the K-/KiK-Net strong-motion data set to obtain initial estimates of attenuation t*. In a second step the t* estimates are used to infer the structure of the quality factor (Q). The Q tomography is performed with RAMLA, a non-negative least squares routine. While RAMLA was designed for ray paths only, we incorporated smoothing kernels based on scattering and absorption sensitivity kernels. The primary purpose of these kernels is to facilitate a geometrical constraint on the Q model with a physical basis. The application of sensitivity kernels also limits the choice of smoothing parameters, a common problem in velocity/attenuation tomography studies. Since most parts of Kyushu are characterized by crustal seismicity only, the tomography maps mostly crustal Q and the inversion problem is reduced to two dimensions. The obtained Q model is used in a detailed analysis of seismic waveforms from the 2016 M 7.1 Kumamoto earthquake and its aftershocks in central Kyushu. The earthquake sequence is investigated for spatiotemporal changes in seismic attenuation due to changes in Q related with the earthquakes. Eventual variations are compared to seismic velocity changes. Detailed information of the attenuation is a necessary prerequisite to infer source parameters (seismic moment and corner frequency) and study their potential time-dependencies in the mainshock-aftershock sequence.

Flood Modeling of Kağıthane River Basin in Istanbul, Turkey

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Increase in population and industry, change in land use and climate cause flood in especially residential areas. The role of land use types on watershed hydrology and storm water management should be investigated to avoid present and future problems like flood to reduce adverse impacts of urbanization and thus water scarcity. Floods are natural disasters which results in water level rise in the stream bed or high surface runoff. Especially in highly urbanized areas, flood causes great loss of life and property. One of the major causes of floods is meteorological phenomena (heavy precipitation, snowfall). In addition, human factor, rapid population growth, infrastructural problems are also among major reasons of flooding. Thus, the flow regimes of the river beds in the urbanized areas should be investigated. In Turkey, quantity and damages of flood change from year to year depending on the geographical location of the region, urbanization, and meteorological conditions. Within the scope of this study, the flood hazard map for Kağıthane River Basin located in Istanbul, Turkey is generated and assessed for prediciton of future events and flood management. For this purpose, Watershed Modeling System (WMS), Hydrologic Engineering Center-Hydrologic Modelling System (HEC-HMS) and Hydrologic Engineering Center-River Analysis System (HEC-RAS) are employed. Kağıthane River has 131 km2 of watershed area and is the most important one of the two rivers flowing into the Golden Horn. The main channel passes through Kemerburgaz and the total length of the river is 37 km. Although downstream of the channel is restored, upstream of the channel is natural which involves flood risk for residential areas in this region. For hydrological modeling, satellite and elevation maps of the basin are obtained by using WMS computer program. Then, the prepared data set is incorporated into the HEC-HMS to establish the hydrological model. The surface runoff obtained from HEC-HMS is used as input in HEC-RAS program for the hydraulic modeling. Finally, flood hazard map of the main river and the basin is obtained. The obtained flood hazard map is evaluated and regions affected by the flood within the watershed are determined. Accordingly, solutions for the areas that may be affected by the flood are suggested.

Key Words: Kağıthane Stream, Natural Disaster, Flood, WMS, HEC-HMS, HEC-RAS

Use of synthetic pulse models for assessing near-fault earthquake behavior of base-isolated buildings considering lead core heating

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Seismic isolation not only reduces the energy input to the structures during an earthquake by increasing the fundamental period of the structure but also increases the amount of dissipated energy by providing additional damping. However, these long-period structural systems may be vulnerable to large-amplitude long-period velocity pulses that may appear in near-fault ground motions. To top it off, past research showed that the effect of lead core heating in lead rubber bearings (LRBs), which causes strength degradation and thus leads to increased isolator displacements, is more pronounced in near-fault earthquakes which contain velocity pulses of aforementioned characteristics. Consequently, seismic responses of buildings equipped with base-isolation systems which employ LRBs under pulse-like near-fault ground motions have been an important topic of discussion. On the other hand, the number of recorded near-fault earthquakes to date may be inadequate for use in investigations in this area, particularly for those of comprehensive parametric nature. This difficulty may be overcome by utilizing synthetic pulse models which simulate the effects of near-fault historical ground motions. Among the most popular synthetic pulse models, Agrawal and He model is very convenient for use in parametric studies with the ability to generate a different number of cycles by adjusting a parameter, which is the damping factor for the decaying sinusoid. The capability of sample synthetic ground motion pulses modeled with Agrawal and He model for adequately representing their counterpart actual near-fault ground motion records in terms of the response of base-isolated buildings and base-isolated liquid storage tanks were previously examined but lead core heating effect was not taken into account in these studies. In this study, it is aimed to investigate whether it is appropriate to use Agrawal and He synthetic pulse model in assessing the seismic response of base-isolated buildings under near-fault ground motion records when lead core heating in LRBs is of concern. In order to examine this issue, a benchmark base-isolated reinforced concrete building is modeled in OpenSees Program considering lead core heating properties of LRBs and nonlinear time history analyses are carried out under two representative near-fault historical earthquake records and their synthetic counterpart Agrawal and He pulse models. Time histories, as well as peak and root-mean-square values of the floor accelerations and base displacement responses obtained from time history analyses, are reported comparatively. Although some discrepancies were observed, Agrawal and He synthetic pulse model proved to be successful in capturing the overall seismic behaviour and thus it is concluded that it can efficiently be used in assessing the near-fault earthquake behaviour of base-isolated buildings considering lead core heating.