SPATE

# Space-Time Dynamics of Extreme Floods

Newsletter

## Edition 1


Coordinator: Prof. Dr. Andreas Schumann

Ruhr-University Bochum
Institute of Hydrology, Water Resources Management and Environmental Engineering
D – 44801 Bochum

Phone: +49 (0)234 / 3224693

Fax: +49 (0)234 / 3214153

E-Mail: andreas.schumann@rub.de


www.spate-floods.com

**Welcome to the SPATE-newsletter**

According to the regulations of our funding agency DFG, we have to summarise our research activities in a finale report and a symposium at the end of the first funding period. As this will be in the year 2020, we inform in this newsletter about our ongoing activities with the following intentions:

- To represent the activities and current results of our research group to interested people in and outside of our hydrological and meteorological communities,
- To strengthen the contacts of our research group to other researchers, which are interested in the same topics or methodologies,
- To document interim results, based on the series of regular meetings of our cluster groups or symposia.

As this is the first newsletter, we summarise here our project by a short description of the contents of subprojects, but give also an overview about the main results of the Kick-Off meeting. As part of all our newsletters, a list of publications is added to give interested readers the option to have a closer look on publications from members of our research group with related subjects. Finally yet importantly, we have the series of SPATE- discussion papers, where publications of research group members are provided if the regulations of publishers offer such an opportunity. Such publications are listed at the end of every newsletter.

With regard to the scientific aspects of our joint research project, I emphasize here two points only:

- Beside the socio-economic relevance of floods, such events are very interesting research subjects because of the intriguing non-linear interactions and feedbacks involved, interesting issues of generalisation and the need for investigating them in an interdisciplinary way. Extreme floods are not very well understood to date but new, high resolution data and new concepts for quantifying interactions promise a major breakthrough of a body of research carried out in a coordinated way.
- Interdisciplinary and coordinated research activities are indispensable to understand the atmospheric, catchment and river system processes and their interactions leading to extreme river floods in a coherent way. Our research unit was formed to maximise the potential of the cooperation between the research partners which consists of three layers of integration: research themes focusing on the science questions, subprojects revolving around specific research tasks, and a joint study object of extreme floods in Germany and Austria. These three layers determine the cohesion of our activities.

In the following, the subprojects present themselves and give an overview about our research topics and capacities. The next issues of the newsletter will be structured by research themes to specify our hypotheses, methodologies and (if possible) results.

I hope that I could raise your interest in this newsletter and you will become a follower our project in the next years.

With kind regards,

Andreas Schumann

(Project Speaker)

**Members of the SPATE-project**

Prof. Dr. Andreas Schumann, Dr. Svenja Fischer, Rana Bengül
Subproject 1 (Ruhr-University Bochum)

Prof. Dr. Bodo Ahrens, Dr. Cristina Primo Ramos, Amelie Krug
Subproject 2 (Goethe-University Frankfurt)

Prof. Dr. Bruno Merz, Dr. Heidi Kreibich, Dr. Sergiy Vorogushyn, Dr. Björn Guse, Luzie Wietzke
Subproject 3 (GFZ Potsdam)

Prof. Dr. Ralf Merz, Larisa Tarasova
Subproject 4 (UFZ Halle/Saale)

Prof. Dr. András Bárdossy, Dr. Jochen Seidel, Faizan Anwar
Subproject 5 (University of Stuttgart)

Prof. Dr. Günter Blöschl, Dr. Magdalena Rogger, Dr. Alberto Viglione, Dr. Andrea Kiss, David Lun
Subproject 6 (Technical University of Vienna)

Prof. Dr. Uwe Haberlandt, Stefan Plötner, Ross Pidoto
Subproject 7 (Leibniz University Hannover)

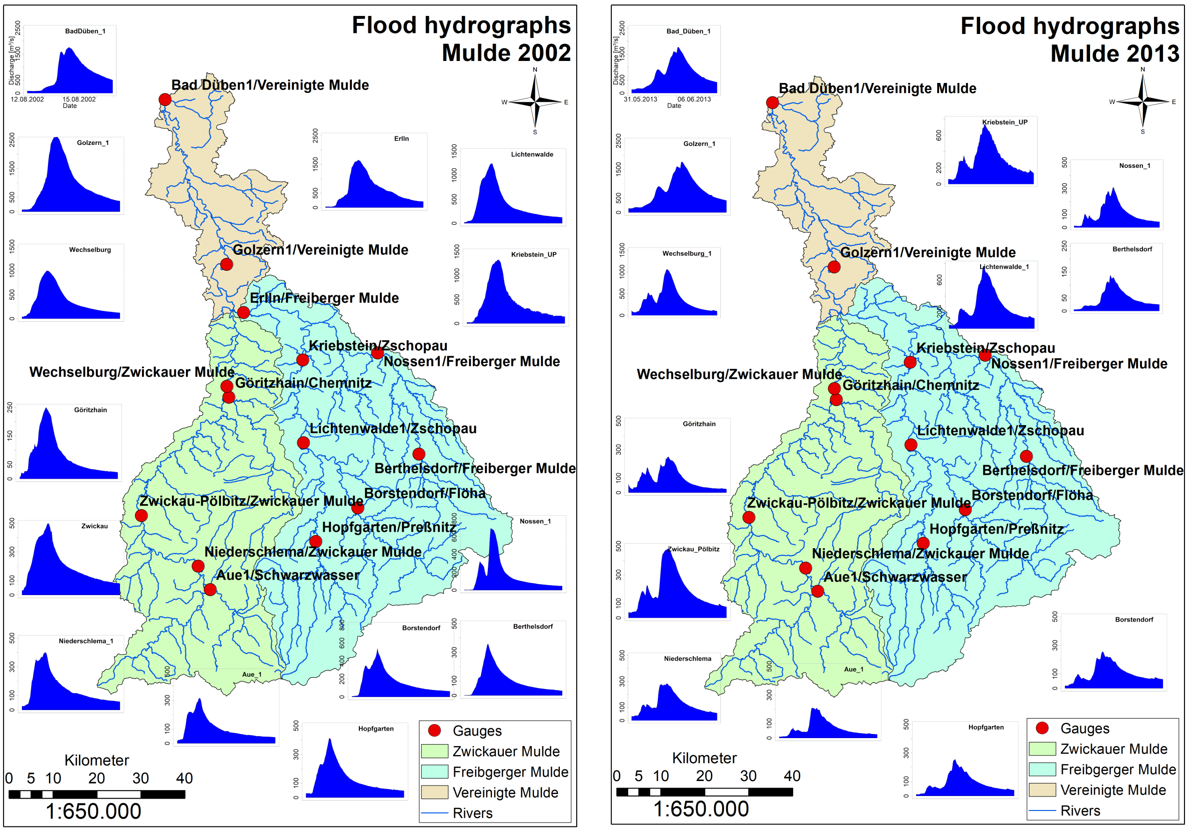
*Members of the research unit SPATE at the Kick-off Meeting in 2017 in Potsdam*

## Presentation of Subprojects

### SP1: Hydrology of extraordinary floods – event analysis
### Ruhr-University Bochum

The subproject 1 examines how extreme floods are generated, which factors affect their peaks, volumes and shapes and how these factors interact with each other. In this context a detailed analysis of extreme flood events in different regions is conducted, where the largest floods in selected river basins of Germany and Austria will be analysed in regards to flood generating processes and the interaction between these processes. Particular consideration will be given to precipitation, soil moisture and the interaction with runoff generation and the routing of the flood waves.

First, the available hydrological and meteorological data of the Mulde and Inn basins are processed and extreme flood events are selected according to a statistical classification method. Flood timescales are then used to characterise the similarities and differences between flood types. To detect the climatic conditions for these flood types, the antecedent moisture of the catchments of selected gauges is determined. The analysis is divided into three sectors: antecedent precipitation, discharge previous to the flood event and the spatial distribution of the flood triggering rainfalls.




*Flood hydrographs of the 2002 (left) and 2013 (right) flood along the Mulde River and its tributaries at selected gauges.*

For this purpose a GIS based modelling approach will be developed. Such modelling approach is needed to estimate the flood characteristics that cannot be deduced directly from observed data. Large-scale precipitation fields will be analysed using machine learning algorithms to classify the heterogeneity of hydrological loads and to obtain a spatial differentiation of the response time in the catchment. Further factors that are responsible for the extremisation of the flood such as soil moisture, intersection of flood waves and extreme precipitation intensity or volume are estimated. On this basis a derivation of extreme flood scenarios will be done for observed smaller floods. The aim of this study is to create a generalised understanding of extreme floods and the specific process controls that depend on the catchment characteristics and hydro-meteorological conditions.

## SP2: Atmospheric drivers of extreme floods
## Goethe-University Frankfurt

Extreme precipitation is the main atmospheric driver of extreme floods. Processes leading to heavy precipitation are controlled by preceding and ongoing weather. They are amplified by local factors such as frontal activity, convective and orographic processes. Furthermore, climate variability controls the weather at synoptic scales by modifying the frequencies of weather types or typical cyclone paths. Therefore, the prerequisites of extreme floods are not only influenced on a local scale but also on a large scale. Hence, the study of atmospheric factors driving to extreme flood events implies the analyses of multi-processes and multiple-scales. Our research will focus on these aspects.

The aim of this subproject is to provide a multi-scale and multiprocess point of view, based on robust statistics, to better understand which atmospheric factors lead to extreme flood events, what are possible future flood extremes and what is their predictability. In particular, we will focus on three aspects of the extreme floods events: leading large-scale atmospheric conditions, involved small scales processes and temporal variability.

1) **Large-scale atmospheric conditions** leading to extreme floods events: typical circulation weather types and water source regions involved in extreme flood events have to be identified. Of special interest are multiplicative events like a Vb cyclone in an already wet season, clusters of cyclone events, or heavy rain over melting snow events.

2) **Small-scale processes:** which processes enhance precipitation and its regional and local impact and hence, which processes change the air mass and fronts on their path to the flood events. It is important to identify the local effects of orography and land surface characteristics (i.e. soil moisture, roughness) on precipitation processes. With convection permitting hindcasts, the relative importance of frontal, orographic and convective precipitation shall be investigated.

3) **Temporal variability:** how and why the large- and local-scale atmospheric factors have changed in the past. For this aim, we want to identify the role of the low-frequency atmospheric variability, like the wintertime northern annular mode (NAM) and the North Atlantic Oscillation (NAO), and their influence on the weather types which lead to extreme floods. Ultimately, the goal is to simulate future extreme flood-producing precipitation events under climate change scenarios and to quantify their predictability.

## SP3: From small to extreme floods
## GFZ Potsdam

The overarching goal of SP3 is to achieve a better understanding of causes for the occurrence of extreme floods in comparison to small and medium floods. A comprehensive analysis on the main factors and whose interactions controlling the probability of extreme floods is conducted.

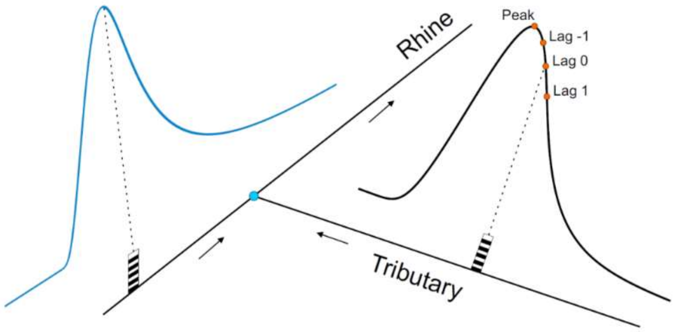
The research work at GFZ Potsdam is structured into three working packages:

WP1 is focused on tail behavior of extreme value distributions of precipitation and discharge. Several studies show that heavy-tail behavior plays an important role in extreme value distributions of hydro-meteorological variables. The upper tail behavior of distributions is found to be controlled by a complex interplay of climate and catchment characteristics. To consider the spatio-temporal variability of flood-driving processes, further research combining multi-variate data analysis and process understanding is important to achieve a better understanding of heavy tails in distributions of hydro-meteorological variables.

The aim is to identify major factors and processes for the occurrence of heavy tails in flood and heavy precipitation distributions. Therefore, a comprehensive analysis of signatures of catchment and climate characteristics and of tail behavior is taken out by means of multivariate data analysis for a large data set of German and Austrian catchments.

In WP2, the superposition of flood waves at the confluence of rivers is investigated as a potential driver for the occurrence of extreme floods which can influence the tail behavior of flood distributions. River network processes like channel-floodplain interactions and superposition of waves can have substantial impact on flood characteristics including the volume, peak and shape of the hydrograph as well as the extent of inundation. Important factors controlling superposition are spatial and temporal rainfall patterns, flood generation processes, topographic source areas and timing and peak heights of tributary hydrographs. Large catchments with braided river network and large storage capacity are expected to have higher potential to be affected by flood wave superposition in comparison to smaller catchments.

The aim is to deepen the knowledge of important factors and interactions controlling flood wave transformation. Superposition patterns will be detected in large river systems and atmospheric conditions and catchment state will be analyzed to identify dominant factors. Further, the scaling of flood wave superposition with flood magnitude will be analyzed in order to find differences between the impact of superposition on extreme and small or medium floods. Therefore, specific conditions in the past are identified in which a superposition of flood waves of main river and tributary lead to an increase in the flood volume and peak and superposition patterns are contrasted with flood generation processes in order to find main controls.




*Scheme of flood wave superposition in river Rhine (from Vorogushyn und Merz, 2013)*

In **WP3**, the knowledge derived from WP1 and WP2 is combined to study non-linearity behavior of extreme floods in comparison to small and medium floods. Several studies point out the complex interplay between atmospheric processes and catchment conditions in the case of extreme flood events. Important causes of non-linear behavior in extreme flood generation are threshold processes that can lead to a switch in the hydrological system.

The aim is to analyze source and degree of non-linearity behavior along the complete flood generation cascade to detect differences in the generation processes of extreme floods compared to small and medium floods. Again, heavy-tail behavior is analyzed but with a focus on process understanding. Therefore, catchment conditions (e.g. soil moisture conditions) and atmospheric situations (e.g. precipitation volume and weather conditions) are jointly considered.

## SP4: Flood typology – controls in a changing world<br>UFZ Halle/Saale

The sub-project 4 will focus on developing process-based flood typology, which will account for the atmospheric, catchment and river system processes of floods, as all three are important in characterising the essential flood properties. Depending on the generating processes flood event types varies in their resulting characteristics such as the shape of the flood hydrograph, their spatial coverage, time of occurrence within the year, dependence on antecedent soil moisture. Hence a classification enables to break down the plethora of different flood events in typical representatives by a clear description of similarities and differences in flood producing processes and resulting event characteristics. The classification allows us to compare only those events, which stems from similar processes and will give deeper insight in the spatio-temporal changes of differing flood producing factors.

The objective of the first phase of the project is to develop a hierarchical typology of flood events in Germany and Austria. The classification will be built on indicators of flood processes and resulting event characteristics such as the intensity, duration and spatial coverage of flood producing precipitation event, weather patterns, antecedent soil moisture states and snow. Using the classification we will analyse how flood types changed regionally over the study period and how flood types change from small to more extreme floods.

To enable classification of single flood events, first rainfall-runoff events will be separated from continuous time series. After separating single flood events, indicators describing important event characteristics, such as peak flow, event duration, flood time scale will be calculated for the single flood events and their spatio-temporal variability will be analysed in respect to climate and landscape characteristics. The analysis will give first insight in the spatio-temporal patterns of flood event characteristics (independent of flood generating processes).

In the next step potential flood types and indicators, describing event characteristics, will be developed. First, potential flood types will be hypothesized based on existing flood typologies and process studies of single flood events. Second, a set of indicators ("flood event signatures") will be derived, which represent the catchment functioning and are used to associate single events in flood types. Hence, these indicators have to grasp the different factors of the dominating flood generating processes, such as climatic forcing, catchment response and routing effects. The indicators can be event specific and contain information on intensity, duration and spatial coverage of flood producing precipitation events, soil moisture states and snow cover, the spatial coverage of the flood events, the reaction time of flood runoff and the shape of the flood hydrograph. Indicators can also represent more static catchment characteristics such as information on topography, land use or amount of impermeable soils. For each flood event, a set of indicators will be derived, which will be the base for further classification.

The derived indicators will be used to associate single events to flood types. Floods are the interplay of meteorological forcing, catchment response and routing effects. Different combinations of typical precipitation processes, runoff generation and routing effects may result in flood runoff. To capture the large number of different process combination in an effective way, a stepwise classification is envisaged. In a first step, the meteorological condition is analysed to distinguish, e.g. between synoptic and convective rainfall events, based on the meteorological indicators, such as rainfall duration and volume or the spatio-temporal pattern of the rainfall fields. In a second step, the processes leading to runoff are analysed.

The three levels of flood generating mechanisms (meteorological forcing, catchment response and routing effects) will then be combined to form classes of flood types, such as flood type „convective rainfall + infiltration excess runoff + no routing effects". It is assumed that by such a hierarchical classification, the different process combinations can be better represented, than in existing classification schemes where meteorological forcing, catchment response and routing effects are treated in a lumped way. However, if typical combinations of the three levels occur, such combination may be summarised in one type.

**SP5: Investigating simultaneous occurrences of extreme floods and precipitation events University of Stuttgart**

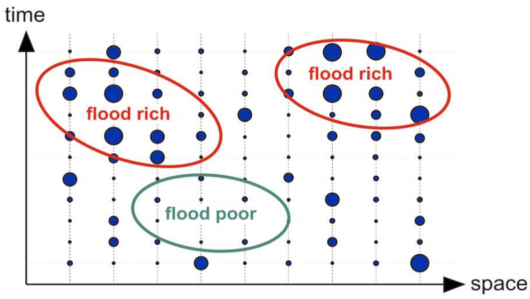
Traditionally, extremes are investigated using univariate extreme value statistics. This approach may be appropriate for discharges at selected sites, but not for precipitation where volumes correspond to space-time extent of the rainfall field. Further simultaneous occurrence of floods in different catchments may cause extreme floods downstream. Therefore, the investigation of the spatial extent of floods is also of great importance. The purpose of this project is to investigate spatial extent of extremes, using spatial copulas and entropy. The dependence structure of high intensity precipitation is investigated on different temporal and spatial scales. As the spatial distribution of precipitation depends strongly on the weather situation, the investigation includes a classification of the atmospheric circulation patterns (CPs). These classifications are based on gridded sea level pressure data, and uses fuzzy rules for their definition. In order to obtain meaningful classes a semi-supervised learning procedure is used. For a given calibration period a simulated annealing based optimization of the fuzzy rules is performed so that the obtained CPs can explain both dry and wet conditions well. Validation periods are used to check the temporal transferability of these patterns. Spatial statistical investigations are conditioned on these CPs. The methodology is applied on a set of different catchments in Austria and in Germany.

**SP6: Decadal changes of flood probabilities**
**Technical University Vienna**

Recently there have been a number of major floods in Europe and it seems as if they had increased in number and magnitude. In many catchments the recent floods are much larger than the second largest event on record. A very important question hence is whether the probabilities of the occurrence of such extreme floods have increased in recent years and what the drivers could be.

In SP6 this issue is addressed by analysing flood changes in Germany and Austria in a consistent way. The research in SP6 is focusing on: (1) the detection of flood changes from long data series of German and Austrian floods, (2) the extension of the analyses back in time by historical information and (3) a new approach for attributing flood changes to their drivers by including regional information. The project is therefore structured into 3 work packages (WPs).

The detection of flood changes, as opposed to the traditional trend analysis, focuses on the decadal variability of floods. This means that rather than identifying trends from long data records, flood rich and flood poor periods are identified in space and time.




*Schematic diagram of flood rich flood poor periods in space and time*

Furthermore, instead of the traditional evaluation of flood peaks alone, the flood generating processes are also taken into account. While the flood magnitude is very important from a practical perspective, it contains little information on what has caused the flood. In order to identify flood changes in more detail and to facilitate the attribution of flood changes to their drivers, flood indicators are additionally used in the analysis.

Since flood records from the observational periods are usually not much longer than 200 years, historical flood data sets are used in WP2 to extend the data analyses of WP1 to the 18th century and earlier for one macroscale catchment (the Danube) and one mesoscale catchment (the Mulde) in the study region Germany/Austria. Historical information is usually less detailed and mainly relies on documentary evidence such as narrative sources and legal-administrative institutional documentation but it is able to shed light on the extreme floods of the past 500-700 years. In order to obtain a synoptic view of flood occurrence over a region, the historical information on flood magnitude is interpolated in time and space using the thin-plate-spline technique with parameters chosen to preserve the spatio-temporal correlations of the phenomenon.

In WP3 the flood data in the regions where changes in flood occurrence are identified in WP1 and WP2 are confronted with precipitation data, air temperature data, land use change data and data on river works with the aim of identifying the drivers responsible for the changes. For this purpose long term precipitation and air temperature data are used and time series relating to land use changes and river works. A new framework for attributing flood changes to their drivers is used based on a regional fingerprint analysis, a combination of two techniques: fingerprinting analysis and regional frequency analysis.

**SP7: Predictability of extreme floods**
**Leibniz University Hannover**

The predictability of extreme floods and the quantification of related uncertainties for unobserved locations in the coming decades will be the focus of investigation for sub-project 7. Through the prediction of floods, estimates of flood quantiles and return periods at unobserved locations and/or future time periods can be better understood. The predictability subsequently describes the quantification and attribution of uncertainty. A central component of this sub-project will be the improved prediction for unobserved locations and/or future time periods in terms of accuracy and robustness. The focus lies on the distinction of flood geneses, in other words, the flood causing processes. The attribution and reduction of uncertainties is of special consideration.

Work package 1 will focus on data-based predictability of extreme floods. The quantification of uncertainties will be exclusively based upon the hydrological input data. In order to account for the varying flood drivers, a subdivision of the data ensemble will be performed by flood type.

A local univariate flood frequency analysis will be performed. Here, stationarity will be assumed in relation to observed flood peaks. Long-term runoff time series will be coupled with varying flood driving factors, such as precipitation, temperature and catchment characteristics, to help distinguish between differing flood geneses. Estimated flood quantiles for specific return periods for the entire sample will then be compared to sub-samples classified by flood drivers.

In the next step the above mentioned procedure is adapted to the univariate, regional flood frequency analysis. To achieve this, homogeneous regions within the study area must first be determined. These regions will be based upon catchment characteristics. In a last sub-step, the estimated flood quantile uncertainties will be compared with the associated driving factors. This process will confirm dominate driving factors and enable a better process understanding.

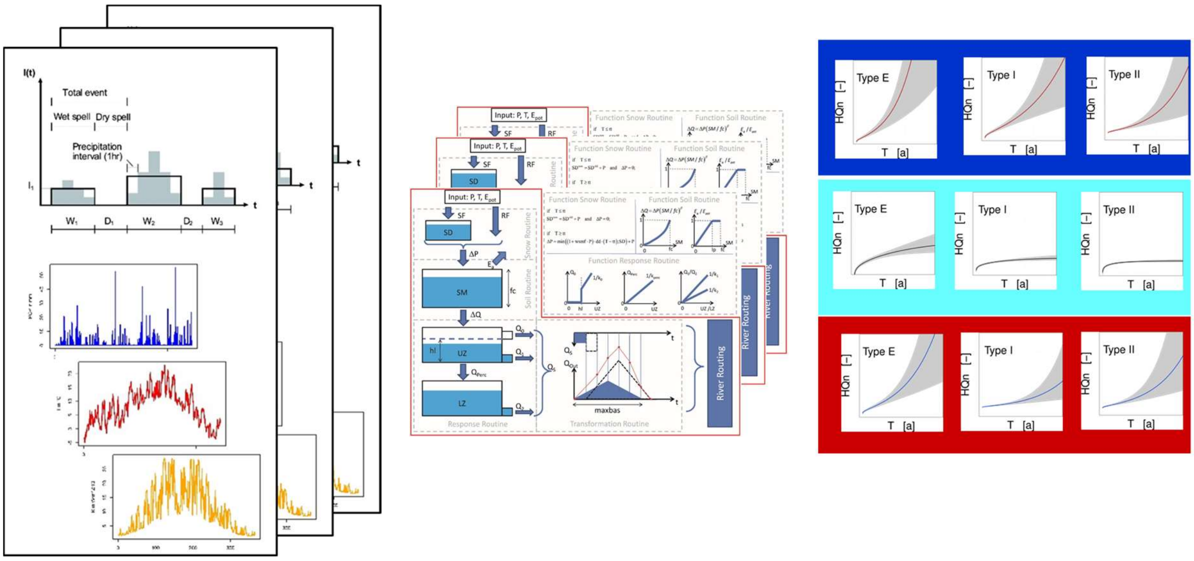
The aim of the work package 2 is to develop a stochastic weather generator capable of simulating both space and time consistent weather variables (eg. precipitation, radiation, temperature) across a variety of spatial scales, from the lower mesoscale (10 km²) up to the macroscale (104 km²). The temporal scale will be hourly, in order to adequately simulate flood generation processes at lower scales. In addition, the weather generator will be conditioned upon climate variables, allowing the model to be applied across a range of possible future climate scenarios.

Other climate variables, such as temperature and radiation, will be simulated conditioned on the space-time event time series of the wet and dry state from the rainfall model. Alternatively, it may indeed prove more efficient to implement a reverse approach, whereby the rainfall model is conditioned on one or more of the other climate variables (temperature, radiation etc.). Cross correlations between the climate variables themselves and additionally precipitation will be preserved.

The first step of the third work package will be the validation of the weather generator considering its suitability to varying climate data. Individual meso-scale catchments will then be selected, modelled and evaluated, using the generated climate data as input. A simultaneous assessment of all catchments will then be undertaken, in order to asses scaling effects within the weather generator.

The second step will involve the generation of a reference simulation. For this, very long time series (10,000 years) of rainfall and other climate variables will be needed, as generated from the weather generator, for varying time and spatial scales. The resulting flood quantiles and return periods will serve as a reference for the concluding uncertainty analysis.

As a last step, a Monte-Carlo simulation will then be performed to quantify the uncertainty.




a) b) c)

*Model-based predictability of floods: a) reference and Monte-Carlo simulations utilising the weather generator; b) Reference and Monte-Carlo simulations utilising the hydrological model; c) Predictability of floods utilising scenario modelling of varying parameter sets of the weather generator and the model parameterisation of the hydrological model.*

**September 2017:**
**Kick-Off Meeting SPATE in Potsdam**

The joint work within the research group started with a Kick-Off Meeting. This took place at the German Research Center for Geosciences (GFZ) in Potsdam from 25.09.-27.09.2017. The aim of this meeting was the presentation of initial research and the working schedule for the subprojects. Based on this, cooperation was manifested and synergies formed that were and will be used to promote the work within the working groups. A first result is the common data basis of the research group, which was and still is implemented in the project-cloud. There, every subproject provides their specific local and global data sets for the other subprojects. With this, discharge or precipitation data from one catchment (e.g. the Neckar catchment) can be compared with data from another catchment (e.g. the Mulde catchment in Saxony) in terms of for example model outputs which can be used for a methodological extension. Moreover, also precipitation and discharge data for whole Germany are available within the research group and in the near future even re-analyse data for precipitation.

This diversity of data proved popular for the members of the project at the Kick-Off Meeting and shall be used in all subprojects. Additionally, the cooperation between the subprojects has been revealed and show promising possibilities. For example, the work of subproject 1 in Bochum where statistical methods for the classification of extreme flood events were developed can be combined with methods for the classification of flood types of subproject 4 in Halle to define the event types that significantly cause extreme floods. This cooperation is further extended by subproject 2 in Frankfurt, which models and types re-analyse data for precipitation and meteorological patterns, to model the generating mechanisms of floods. These aspects will be supplemented by additional research concerning spatial dependence and temporal variability of extreme floods or their genesis by simulation of precipitation fields and many more.

Important for all cooperation and research within the group is a common approach for the basic data consideration. Hence, it was stated, how extreme events shall be classified and which models shall be used to determine e.g. the soil moisture. This consistency is an essential advantage of the research group, since all research results are made comparable and combinable. In the following project meetings this will be strained further, e.g. for the flood typology at the next meeting in Halle, February 2018.

Besides research at the Kick-Off Meeting much attention was paid to the togetherness within the research group. Hence, there has been an evening meeting especially for the early career scientist to get to know each other as well as a collective dinner for all participants of the meeting. Additionally, a training for gender equality was performed, where Dr. Hüttges (GFZ) gave a talk on „Sensibilisierung zur Vermeidung von Ungleichbehandlung“ with interesting insights on the partially unconscious unequal treatment role assignment especially in professional life.

**Early Career Scientists' Workshop**

During the Kick-Off Meeting of the SPATE-Project a workshop with the topic of "how to structure your PhD and work with joy" for all PhD-Students in the project was held by Dipl.-Päd. Svenja Neupert (Kompetenzia International).

Subjects like how to structure your PhD, time management and work process were discussed during the workshop. The topic "how to structure your PhD" included the creation of a 3-year timetable, which got divided into categories like: research, teaching, publications and networking. Additionally the conflict between actual PhD research and other responsibilities of the workload were discussed. The next step was a one pager regarding the "w-questions" (why, who, what, etc.). This was done to create a rough overview of the necessary steps for the PhD theses and where and with whom to do them. After the rough plan was made, time management tips were given for a better understanding of the small scale timetable and how to stay inside the created timetable. The first part of this session was about work-life-balance. Each PhD student clarified for him- or herself, his/her current state and target situation. What is wanted in their private live and in their career? After that, it was talked about prioritising work processes and how long an average person can work productively. One of the steps to a productive work session, according to Svenja Neupert, is prioritising. Therefore, an average weekly timetable within the productive timeline was created and each task was divided into "important", "important but can be done at a later time" and "administration" work.

The last step was the organisation of the work process for a more efficient work flow. For this the DISC Model was used which divides the work process into four phases: the dominant processes like goals and essentials, initiative work processes which includes new ideas and creativity thinking, steady processes like routines and plans which structure the work and the conscientious of each students work, where they work with details, find mistakes and check their resources.

All in all the workshop made the PhD-students visualise the different steps that they will be facing during their time on their theses to prepare them for possible problems ahead and to master the difficult task of structuring their work from the begin on to create a more efficient work process during their now hopefully enjoyable time in the project.

## Publications

### 1) Publications in journals

### Accepted:

**Vorogushyn, S. (SP3)**, Bates, P., de Bruijn, K., Castellarin, A., **Kreibich, H. (SP3)**, Priest, S., Schröter, K., Bagli, S., Blöschl, G., Domeneghetti, A., Gouldby, B., Klijn, F., Lammersen, R., Neal, J., Ridder, N., Terink, W., Viavattene, C., Viglione, A., Zanardo, S. and **Merz, B. (SP3)**: Evolutionary leap in large-scale flood risk assessment needed. *Wiley Interdisciplinary Reviews (WIREs) Water, accepted.*

### Published since last newsletter:

Conticello, F., Cioffi, F., **Merz, B. (SP3)** and Lall, U. (2017): An event synchronization method to link heavy rainfall events and large-scale atmospheric circulation features. *Int. J. Climatol*. doi:10.1002/joc.5255.

Doycheva, K., Horn, G., Koch, C., **Schumann, A. (SP1)** and König, M. (2017): Assessment and weighting of meteorological ensemble forecast members based on supervised machine learning with application to run-off simulations and flood warning. *Advanced Engineering Informatics* 33, 427-439.

**Fischer, S. (SP1), Schumann, A. (SP1)** and Schnurr, A. (2017): Ordinal Pattern Dependence between Hydrological Time Series. *Journal of Hydrology* 548, 536-551.

**Kreibich, H. (SP3)**, Di Baldassarre, G., **Vorogushyn, S. (SP3**), Aerts, J. C. J. H., Apel, H., Aronica, G. T., Arnbjerg-Nielsen, K., Bouwer, L. M., Bubeck, P., Caloiero, T., Do, T. C., Cortès, M., Gain, A. K., Giampá, V., Kuhlicke, C., Kundzewicz, Z. W., Llasat, M. C., Mård, J., Matczak, P., Mazzoleni, M., Molinari, D., Nguyen, D., Petrucci, O., Schröter, K., Slager, K., Thieken, A. H., Ward, P. J. and **Merz, B. (SP3)** (2017): Adaptation to flood risk - results of international paired flood event studies. *Earth's Future*, 5, 10, 953-965.

**Kreibich, H. (SP3)**, Müller, M., Schröter, K. and Thieken, A. H. (2017): New insights into flood warning reception and emergency response by affected parties. *Natural Hazards and Earth System Sciences (NHESS)* 17, 2075-2092.

Lilienthal, J., Fried, R. and **Schumann, A. (SP1)** (2017): Homogeneity testing for skewed and cross-correlated data in regional flood frequency analysis. *Journal of Hydrology* 556, 557-571.

**Schumann, A. (SP1)** (2017): Flood safety versus remaining risks - options and limitations of probabilistic concepts in flood management. *Water Resources Management* 31 (10), 3131–3145.

**Schumann, A. (SP1)** and **Fischer, S. (SP1)** (2017): Berücksichtigung von Starkregenereignissen in der saisonalen Hochwasserstatistik mit Hilfe statistischer Mischungsmodelle. *Hydrologie und Wasserwirtschaft* 61(1), 36-49.

**Schumann, A. (SP1)** and **Fischer, S. (SP1)** (2017): Flood risk and flood processes in a changing environment. *European Water* 57, 19-25.

Triet, N. V. K., Dung, N. V., Fujii, H., Kummu, M., **Merz, B. (SP3)** and Apel, H. (2017): Has dyke development in the Vietnamese Mekong Delta shifted flood hazard downstream?, *Hydrology and Earth System Sciences*, 21(8), 3991-4010.

## 2) Software

S. Fischer (SP1), "Disagg: Disaggregation of daily discharges", R package version 0.1, www.github.cum/svenjafischer/Disagg

## Talks

### 1) Invited talks:

Kreibich, H. (SP3) (2017): Validation of flood loss estimation models. VALIDATION IN FLOOD RISK MODELLING: COMBINING SCIENTIFIC, POLICY AND MARKET PERSPECTIVES, Politecnico di Milano, Milano, Italy, 20-21 November 2017

Merz, B. (SP3) (2017): Climate and Flood Risk, presented at 8th Water Research Horizon Conference 2017, 19/20 September 2017, Hamburg

### 2) Other talks on conferences:

Ahrens, B. (SP2): Klimasystemmodellierung: Wetter-, Klimavorhersage, Klimaprojektion und Entscheidungshorizonte, Expertise und Entscheidungen

über Umwelt, Gesundheit und Sicherheit im 20. und 21. Jahrhundert, Freiburg Institute for Advanced Studies, 6 October 2017, Freiburg.

Fischer, S. (SP1): Consideration of flood geneses in flood statistics by a mixture POT-model, StaHy 2017, 21-22 September 2017, Warsaw, Poland.

Kreibich, H. (SP3) (2017): Learning from floods to mitigate flood risk. Seventh International Conference on Flood Management (ICFM7), 5 -7 September 2017, Leeds, UK.

Kreibich, H. (SP3) (2017): Improving the flood risk management of commercial properties– Can surveyors help? Seventh International Conference on Flood Management (ICFM7), 5 - 7 September 2017, Leeds, UK.

Metin, A. D., Apel, H., Guse, B. (SP3), Nguyen, V. D., Kreibich, H. (SP3), Schröter, K., Vorogushyn, S. (SP3), Merz, B. (SP3) (2017): How do changes in different drivers along the risk chain affect flood risk?, Seventh International Conference on Flood Management, ICFM7, 5 – 7 September 2017, Leeds, UK

Merz, B. (SP3) (2017): Complexity and Cognitive Biases in Flood Risk Assessment and Management, Potsdam Summer School 2017, 4 – 13 September 2017, IASS Potsdam.

Merz, R. (SP4): Understanding and Prediction of Floods, Sino-German workshop on Water Resources Regulation, 28 October 2017, Nanjing, China.

Schumann, A. (SP1): Flood risk and flood processes in a changing environment, EWRA 2017, 5-9 July, Athens, Greece.

Schumann, A. (SP1): Limits to apply new scientific tools for flood design in practice, IAHS Scientific Assembly 2017, 10-14 July 2017, Port Elizabeth, South-Africa.

Tarasova, L. (SP4): Spatio-temporal patterns of event characteristics, Sino-German workshop on Water Resources Regulation, 28 October 2017, Nanjing, China.

### 3) Talks for faculty seminars:

Fischer, S. (SP1): Robuste Schätzverfahren in der Hochwasserstatistik, Fakultätsseminar, 17.10.2017, Fakultät für Mathematik, Universität Siegen.

Haberlandt, U. (SP7). Stochastic precipitation models for flood analyses. Vortrag im PhD Seminar, Lehrstuhl für Hydrologie und Flussgebietsmanagement, TU München, 23.11.2017.

Merz, R. (SP4): Understanding and Prediction of Floods, Faculty Seminar, 27.10.2017, College of Sustainable Environmental Engineering, Tongji University, Shanghai, China.

Merz, R. (SP4): Understanding and Prediction of Floods, Institute Seminar, 2.11.2017, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Science, Beijing, China.

Tarasova, L. (SP4): Spatio-temporal patterns of event characteristics, Institute Seminar, 2.11.2017, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Science, Beijing, China.

Tarasova, L. (SP4): Understanding and Predicting Hydrological Processes at catchment scale, Institute Seminar, 5-7.11.2017, Northwest Institute of Eco-Environment and Resources, Chinese Academy of Science, Lanzhou, China.

### 4) Poster

Tarasova, L. (SP4), Poncelet, C., Zink, M., Merz, R. (SP4): Exploring rainfall-runoff events: temporal dynamics, spatial pattern and drivers of space-time variability in Germany, 20.08.2017, Aberdeen Catchment Science Summer School, Aberdeen, UK.

### PhD-Thesis in the project

Fischer, S. (SP1): Robust estimation methods with application to flood statistics, Fakultät Statistik, TU Dortmund, 04.08.2017.

### Discussion Papers

01/2017 Schumann, Andreas (SP1): Flood safety versus remaining risks - options and limitations of probabilistic concepts in flood management

All Discussion Papers are available at:

www.spate-floods.com