

Space-Time Dynamics of Extreme Floods

S^PA^TE

Edition 8

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Newsletter

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Extreme Floods: a re-occurring challenge

Dear colleagues and followers of the SPATE research unit,

In July this year, the topic of our research group, extreme flooding, unfortunately became one of the headlines of the year in Central Europe. The images of the devastating effects of the mid-July floods in Germany, the Netherlands and Belgium will stay with us for a long time. Many people lost their lives or their belongings and even now only a fraction of the damage has been repaired. Once again, this event showed us how important it is to better understand extreme floods. In this case, extraordinary conditions led to the enormous rainfall masses that ultimately turned small rivers into raging torrents. The question of how this event could occur and how likely it is to recur is also being investigated in our research group. The expert opinion of many of our sub-project leaders was much sought after in the media. As sad as this event is, we are nevertheless glad that more attention is being paid to the topic of extreme flooding. Research is far from complete in this area and there is still much for all of us to do.

In this issue we again provide the latest findings of our research group and report on our activities. We are particularly pleased that, despite the Corona pandemic, we were able to get our early careers ready for academic careers via online networking meetings and workshops. And our meetings in the research group were also characterised by intensive exchange, despite the online format. As conferences and meetings in presence are slowly starting up again, we hope to be able to start up presence meetings again soon. Until then, we hope, as always, that you will find interesting news in this newsletter. In this edition, we also start with our new series that highlights the cooperation between our subprojects. This first edition deals with the detection of flood-rich and flood-poor periods, a cooperation between sub-project 1 and 6.

On behalf of the whole SPATE-project, with kind regards,

Svenja Fischer and Andreas Schumann

Members of the SPATE-project

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

Prof. Dr. Bodo Ahrens, Mostafa Hamouda
Subproject 2 (Goethe-University Frankfurt)

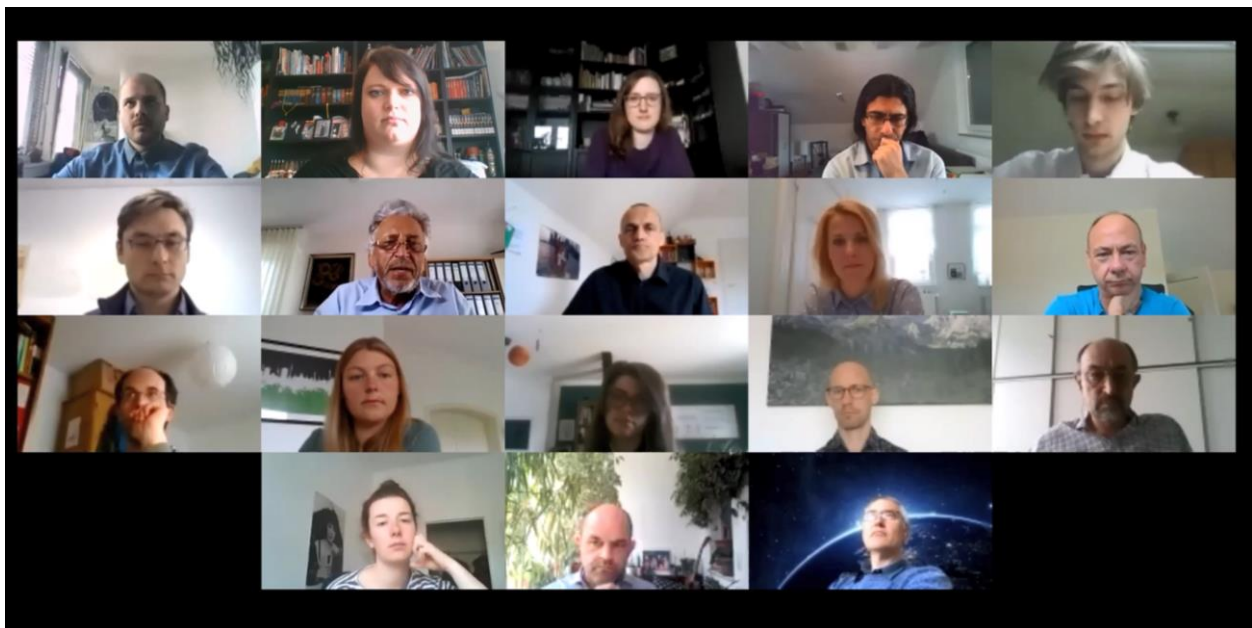
Dr. Sergiy Vorogushyn, Prof. Dr. Bruno Merz, Dr. Björn Guse, Elena Macdonald, Luzie Wietzke
Subproject 3 (GFZ Potsdam)

Prof. Dr. Ralf Merz, Dr. 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. Miriam Bertola, David Lun
Subproject 6 (Technical University of Vienna)

Prof. Dr. Uwe Haberlandt, Dr. Anne Bartens, Ross Pidoto, Luisa Thiele
Subproject 7 (Leibniz University Hannover)



Members of the research unit SPATE at the first online SPATE-Meeting

Trends or cycles: Flood-rich and flood-poor periods

Recent studies suggest that flood-rich and flood-poor periods are present in many flood peak discharge series around the globe. Understanding the occurrence of these periods and their driving mechanisms is important for estimating future flood probabilities reliably. In a joint work of sub-projects 1 and 6, the methodology of Scan-statistics is introduced for identifying flood-rich and flood-poor periods (i.e. anomalies) in flood discharge records. Exceedances of quantiles with 2-year, 5-year and 10-year return periods are used to identify periods with unusually many (or few) threshold exceedances with respect to the reference condition of independent and identically distributed random variables.

The method was first applied to 2201 annual flood peak series in Europe between 1960 and 2010. Results indicated evidence for the existence of flood-rich and flood-poor periods, as about 2 to 3 times more anomalies were detected than what would be expected by chance. The frequency of the anomalies tended to decrease with an increasing threshold return period which is consistent with previous studies. In the Northwest of Europe, the frequency of stations with flood-rich periods tended to increase over time and the frequency of stations with flood-poor periods tended to decrease. In the East and South of Europe, the opposite was the case. There appeared to exist a turning point around 1970 when the frequencies of anomalies start to change most clearly. This turning point occurred at the same time as a turning point of the North Atlantic Oscillation index.

In a second approach, the proposed methodology was extended to peak-over-threshold (flood) series and combined with a flood typology in order to attribute the periods to their flood-generating mechanisms. The method was applied to 164 observed flood series in Southern Germany from 1930 to 2018. The results revealed significant flood-rich periods of heavy-rainfall floods, especially in the Danube river basin in the most recent decades. These are consistent with trend analyses from the literature. Additionally, significant flood-poor periods of snowmelt-floods in the immediate past were detected, especially for low-elevation catchments in the alpine foreland and the uplands. The occurrence of flood-rich and flood-poor periods was interpreted in terms of increases in the frequency of heavy rainfall in the alpine foreland and decreases of both soil moisture and snow cover in the midlands.

This cooperation addresses one of the 23 Unsolved Problems (Blöschl et al., 2019) identified in hydrological sciences and is therefore at the forefront of hydrological research. More details can be found in the publication of Lun et al. (2020).

References

- Blöschl, G., Bierkens, M.F.P., Chambel, A., Cudennec, C. et al. (2019): Twenty-three unsolved problems in hydrology (UPH) – a community perspective, *Hydrological Sciences Journal*, 64:10, 1141-1158, DOI: 10.1080/02626667.2019.1620507
- Lun, D., Fischer, S., Viglione, A., and Blöschl, G.: Detecting Flood-Rich and Flood-Poor Periods in Annual Peak Discharges Across Europe. *Water Resources Research*, <https://doi.org/10.1029/2019WR026575>.

Offered professorships, honours, awards

Svenja Fischer (SP1) and Philipp Bühler (formerly SP1) have been awarded with the Tison Award 2021 of IAHS for their paper: Svenja Fischer, Andreas Schumann & Philipp Bühler (2019) Timescale-based flood typing to estimate temporal changes in flood frequencies, *Hydrological Sciences Journal*, 64:15, 1867-1892, DOI: 10.1080/02626667.2019.1679376

Larisa Tarasova (SP6) has received UFZ Doctoral Award 2021.

Publications

1) Publications in journals

Published since last newsletter:

Astagneau, P.C., Thirel, G., Delaigue, O., Guillaume, J.H.A., Parajka, J., Brauer, C.C., Viglione, A. (Mercator-fellow), Buytaert, W., and Beven, K.J. (2021): Hydrology modelling R packages: a unified analysis of models and practicalities from a user perspective, *Hydrology and Earth System Sciences*, 25(7), 3937-3973, doi:10.5194/hess-25-3937-2021.

Barendrecht, M.H., S. McCarthy and A. Viglione (Mercator-fellow) (2021): A comparative analysis of the relationship between flood experience and private flood mitigation behaviour in the regions of England, *Journal of Flood Risk Management*, 14(2), e12700, doi:10.1111/jfr3.12700.

Fischer, S., and Schumann, A. (both SP1): Multivariate Flood Frequency Analysis in Large River Basins Considering Tributary Impacts and Flood Types. *Water Resources Research* 57 (8), <https://doi.org/10.1029/2020WR029029>, 2021.

Fischer, S., and Schumann, A. (both SP1): Regionalisation of flood frequencies based on flood type-specific mixture distributions. *Journal of Hydrology X*, 13, <https://doi.org/10.1016/j.hydroa.2021.100107>, 2021.

Kuhlicke, C., Albert, C., Bachmann, D., Birkmann, J., Borchardt, D., Fekete, A., Greiving, S., Hansjürgens, B., Jüpner, R., Krabisch, S., Krellenberg, K., Merz, B. (SP3), Müller, R., Rink, D., Rinke, K., Schüttrumpf, H., Schwarze, R., Teutsch, G., Thieken, A., Ueberham, M., & Voss, M. (2021): Fünf Prinzipien für klimasichere Kommunen und Städte. *Korrespondenz Wasserwirtschaft: KW*, 14(9), 537-539.

Lun, D. (SP6), Viglione, A. (Mercator-fellow), Bertola, M. (SP6), Komma, J., Parajka, J., Valent, P., and Blöschl, G. (SP6) (2021): Characteristics and process controls of statistical flood moments in Europe – a data-based analysis, *Hydrol. Earth Syst. Sci.*, 25, 5535–5560, <https://doi.org/10.5194/hess-25-5535-2021>.

Merz, B. (SP3), Blöschl, G. (SP6), Vorogushyn, S. (SP3), Dottori, F., Aerts, J. C. J. H., Bates, P., Bertola, M. (SP6), Kemter, M., Kreibich, H., Lall, U., Macdonald, E. (SP3) (2021): Causes, impacts and patterns of disastrous river floods. - *Nature Reviews Earth & Environment*, 2, 592-609. <https://doi.org/10.1038/s43017-021-00195-3>

Merz, B. (SP3), Kreibich, H., Thieken, A., Vorogushyn, S. (SP3) (2021): Überraschende Hochwasserereignisse: Lehren für Risikoanalysen. *Notfallvorsorge: die Zeitschrift für Bevölkerungsschutz und Katastrophenhilfe*, 52, 3, 19-23.

Nguyen, D., Merz, B. (SP3), Hundecha, Y., Haberlandt, U. (SP7), Vorogushyn, S. (SP3) (2021): Comprehensive evaluation of an improved large-scale multi-site weather generator for Germany. *International Journal of Climatology*, 41, 10, 4933-4956.

Sairam, N., Brill, F., Sieg, T., Farrag, M., Kellermann, P., Nguyen, D., Lüdtke, S., Merz, B. (SP3), Schröter, K., Vorogushyn, S. (SP3), Kreibich, H. (2021): Process-based flood risk assessment for Germany. *Earth's Future*, 9, 10, e2021EF002259.

Ullrich, S. (SP3), Hegnauer, M., Nguyen, D., Merz, B. (SP3), Kwadijk, J., Vorogushyn, S. (SP3) (2021): Comparative evaluation of two types of stochastic weather generators for synthetic precipitation in the Rhine basin. *Journal of Hydrology*, 601, 126544.

Accepted:

Basso, S. (SP4), Botter, G., Merz, R. (SP4), Miniussi, A. (2021) PHEV! The PHysically-based Extreme Value distribution of river flows, *ERL*, <https://doi.org/10.1088/1748-9326/ac3d59>

Pre-prints:

Fischer, S. (SP1): Comparison of annual maximum series and flood-type-differentiated mixture models of partial duration series. *ArXiv*. <http://arxiv.org/abs/2111.13393>

2) Popular sciences publications:

Barion, D., Buchholz, O., Einfalt, T., Fischer, S., Johann, G., Leutnant, D., Meyer, B., Mudersbach, C., Piroth, K. Ross, U., Scheibel, M., und Schumann, A. (2021): HKC-Werkstattbericht 2021: Umgang mit hydrologischen Belastungsgrößen in Zeiten des Klimawandels - Hochwasser und Starkregen. Hochwasserkompetenzzentrum e.V.

Interview with S. Vorogushyn (SP3): Woran das Hochwasser-Warnsystem scheiterte, *Wirtschaftswoche* 23.7.2021 by T. Gürtler und T. Natzel.

Interview with S. Vorogushyn (SP3): Klima schützen und an Extreme anpassen. *Bauernverband*, dbk 9/21.

3) Appearances in radio, television or magazines

Interview with G. Blöschl (SP6): Wenn der Starkregen kommt: Klimakrise trifft auf Wetterphänomen. *MDR*. <https://www.mdr.de/wissen/hochwasser-starkregen-wetter-klima-extremwetter-100.html>

Interview with G. Blöschl (SP6): Hochwasser-Katastrophe und Klimawandel – wie hängen sie zusammen? *Schweriner Volkszeitung*. <https://www.svz.de/deutschland-welt/panorama/Hochwasser-und-Duerren-Extremwetter-als-Folgen-des-Klimawandels-id32935387.html>

Interview with B. Merz (SP3): Warum stieg das Wasser so schnell? *Deutschlandfunk Kultur*, 15.07.2021, Julius Stucke. https://www.deutschlandfunkkultur.de/starkregen-in-westdeutschland-warum-stieg-das-wasser-so.1008.de.html?dram:article_id=500358

Interview with B. Merz (SP3): Wie sich Städte gegen Extremwetter wapnen, *Tagesschau*, 16.07.2021, Stefan Keilmann. <https://www.tagesschau.de/inland/gesell-schaft/hydrologe-hochwasserschutz-101.html>

Interview with B. Merz (SP3): Wie kam es zur Flutkatastrophe? *Hydrologe Bruno Merz im Gespräch*, *Deutsche Welle*, 16.07.2021, DW Nachrichten. <https://www.dw.com/de/wie-kam-es-zur-flutkatastrophe-hydrologe-bruno-merz-im-gespr%C3%A4ch/av-58294838>

Interview with R. Merz (SP4): Wie Deutschland bis 2050 aussehen könnte. *ZDF* <https://www.zdf.de/nachrichten/panorama/klimawandel-auswirkungen-wohnen-gesundheit-landwirtschaft-100.html>

Interview with R. Merz (SP4): Wie der Klimawandel Deutschland verändern wird. *Spiegel*. <https://www.spiegel.de/wissenschaft/natur/hitze-hochwasser-und-landwirtschaft-wie-der-klimawandel-deutschland-veraendern-wird-a-2767ff8f-4df4-4054-aa26-3c00bba6e899>

Talks

1) Invited talks:

Ahrens, B. (SP2): Convective Intensification of Flood Risk: Examples in Central Europe. Talk at Sino-German Sustainable Development Forum, Zhejiang University (virtual), 24.09.2021

Ahrens, B. (SP2): An overview of global and regional climate change. Talk at Webinar "Climate change impacts, mitigation and adaptation: Climate actions for green growth and economy" (virtual), NEGAAS, Nepal, 4.10.2021

Fischer, S. (SP1): Extreme value statistics – Why once-in-a-century floods can happen twice in ten years. Commerzbank Frankfurt (virtual), 16.07.2021.

Merz, B. (SP3): Wie wird ein Hochwasser zur Katastrophe? Tag der Hydrologie in Potsdam, 30.08. - 01.09.21.

2) Other talks at conferences

Barendrecht, M.H., Viglione, A. (Mercator-fellow), Kreibich, H. and Blöschl, G. (SP6): A Budyko-like framework for exploring the controls of long-term flood risk in coupled human-flood systems, 1st Sociohydrology Conference, Delft, 6-8 September 2021.

Bertola, M. (SP6), Viglione, A. (Mercator-fellow), and Blöschl, G. (SP6): Analisi dei cambiamenti nel regime delle piene in Europa ed individuazione delle potenziali cause, XXXVII Convegno Nazionale di Idraulica e Costruzioni Idrauliche - IDRA2020, online 14-16 June 2021.

Bertola, M. (SP6), Viglione, A. (Mercator-fellow), Parajka, J., and Blöschl, G. (SP6): Modelling snow water equivalent storage and snowmelt across Europe with a simple degree-day model, XXIX Conference of the Danubian Countries, online, 6–8 Sept 2021, <https://www.chmi.cz/files/portal/docs/reditel/SIS/nakladatelstvi/assets/danube.pdf>.

Bertola, M. (SP6), Viglione, A. (Mercator-fellow), Vorogushyn, S. (SP3), Lun, D. (SP6), Merz, B. (SP3), and Blöschl, G. (SP6): Regional attribution analysis of changes in flood quantiles across Europe during the past five decades, STAHY 2021, online, 16–17 Sept 2021.

Borzi, I., Viglione, A. (Mercator-fellow), Bonaccorso, B., and Sivapalan, M.: La Modellazione Socio-Idrologica a Supporto di una Gestione Sostenibile delle Risorse Idriche XXXVII Convegno Nazionale di Idraulica e Costruzioni Idrauliche - IDRA2020, online 14-16 June 2021.

Ganora, D., Apostolo, A., Brignolo, I., Monforte, I., Viglione, A. (Mercator fellow), and Claps, P.: Piene di Progetto nei Bacini Alpini: Analisi di Trend in Italia e Austria, XXXVII Convegno Nazionale di Idraulica e Costruzioni Idrauliche - IDRA2020, online 14-16 June 2021.

Haberlandt, U. (SP7), Thiele, L. (SP7), Fischer, S. (SP1) and Schumann, A. (SP1): Spatio-temporal conditional simulation of rainfall for maximisation of floods, ICSH-STAHY 2021, online, 16 – 17 September, 2021.

Macdonald, E. (SP3), Merz, B. (SP3), Guse, B. (SP3), Wietzke, L. (SP3), Kemter, M., and Vorogushyn, S. (SP3): Drivers of heavy-tail behaviour of flood peak distributions in Germany and Austria. ICSH-STAHY Workshop 2021, online, 16.09. - 17.09.2021

Merz, B. (SP3), Basso, S. (SP4), Guse, B. (SP3), Merz, R. (SP4), Vorogushyn, S. (SP3): Causes of heavy tails in flood peak distributions, 4th European Conference on Flood Risk Management, June 2021, Budapest/Hungary.

Pesce, M., Hardenberg, J., and Viglione, A. (Meractor fellow): Spatio-Temporal Correlation of Extreme Climate Indices and River Floods in Northwestern Italy, XXXVII Convegno Nazionale di Idraulica e Costruzioni Idrauliche - IDRA2020, online 14-16 June 2021.

Tarasova, L. (SP4), Lun, D. (SP6), Blöschl, G. (SP6), Basso, S. (SP4), Miniussi, A., Bertola, M. (SP6), Kumar, R., Rakovec, O., Samaniego, L., Thober, S., Merz, R. (SP4), Do Changing Flood Generation Processes Promote the Occurrence of Flood Anomalies in Europe? AGU Fall Meeting, New Orleans, 2021

Tarasova, L. (SP4), Lun, D. (SP6), Blöschl, G. (SP6), Basso, S. (SP4), Miniussi, A., Bertola, M. (SP5), Kumar, R., Rakovec, O., Samaniego, L., Thober, S., Merz, R. (SP4) Impact of changing flood generation processes on the regional occurrence of flood anomalies in Europe, STAHY Conference, virtual, 2021

Viglione, A. (Mercator-fellow), Aronica, G., Borga, M., Castellarin, A., Chirico, G.B., Claps, P., Montanari, A., Persiano, S., and Volpi, E.: Trend Osservati nelle Serie dei Massimi Annuali di Portata di Piena dell'Ultimo Cinquantennio: una Prospettiva Italiana, XXXVII Convegno Nazionale di Idraulica e Costruzioni Idrauliche - IDRA2020, online 14-16 June 2021.

Viglione, A. (Mercator-Fellow), Pesce, M., Tarasova, L. (SP4), Basso, S. (SP4), Merz, R. (SP4) Regional Calibration for a Distributed Catchment Model: an Application in North-Western Italy. AGU Fall Meeting, New Orleans, 2021

Viglione, A. (Meractor-fellow), Mukherjee, J., Annis, A., Archfield, S., Castro, C., Hirabayashi, Y., Höllermann, B., Lafaye de Micheaux, F., Llasat, M.C., Mazzoleni, M., Merz, B. (SP3), Nakamura, S., Nardi, F., Rusca, M., and Yan, H.: Human-Flood Systems: a multidisciplinary perspective, 1st Sociohydrology Conference, Delft, 6-8 September 2021.

Vorogushyn, S (SP3), Apel, H., Kemter, M.: Hydraulische Analyse von Hochwassergefährdung im Ahrtal unter Berücksichtigung historischer Ereignisse. Tag der Hydrologie in Potsdam, 30.08. - 01.09.21.

3) Talks at faculty seminars:

Bertola, M. (SP6): Regional attribution analysis of changes in flood quantiles across Europe during the past five decades, Workshop on "Novel hydrological concepts for the engineering practice", Bologna (Italy), September 29, 2021

Fischer, S. (SP1): Hochwasserstatistik: (zu) nah am Wasser gebaut? Antrittsvorlesung Ruhr-Universität Bochum, 17.11.2021.

Merz, R. (SP4), Tarasova, L. (SP4), Basso, S. (SP4): The flood cooking book: ingredients and regional flavors of floods across Germany, Workshop on "Novel hydrological concepts for the engineering practice", Bologna, September 29, 2021

Viglione, A. (Mercator-fellow): Flood Frequency Hydrology: Information vs. Uncertainty, Workshop on "Novel hydrological concepts for the engineering practice", Bologna, 29 September 2021.

4) Poster

Tarasova, L. (SP4), Basso, S. (SP4), Miniussi, A., Blöschl, G. (SP6), Lun, D. (SP6), Bertola, M. (SP6), Kumar, R., Rakovec, O., Samaniego, L., Thober, S., Merz, R. (SP4): Changing flood generation processes across European catchments, NatRiskChange Conference, Potsdam, 2021

Fischer, S: (SP1), Pahlow, M., and Singh, S.: Spatio-Temporal Distribution of Flood Event Types in New Zealand. NZHS 60th Conference, 30 November – 3 December 2021, Wellington, NZ.

Guse, B. (SP3), Wietzke, L. (SP3), Merz, B. (SP3), Vorogushyn, S. (SP3) (2021): Einfluss von Nebenflüssen auf die Wiederkehrintervall von Hochwässern, Tag der Hydrologie 2021 in Potsdam, 30.08. - 01.09.21.

Macdonald, E. (SP3), Merz, B. (SP3), Guse, B. (SP3), Wietzke, L. (SP3), Kemter, M., and Vorogushyn, S. (SP3): Der Einfluss von Ereignis- und Einzugsgebietscharakteristika auf das Heavy-Tail-Verhalten von Hochwasser-Verteilungsfunktionen. Tag der Hydrologie 2021 in Potsdam, 30.08. - 01.09.21

Macdonald, E. (SP3), Merz, B. (SP3), Guse, B. (SP3), Wietzke, L. (SP3), Kemter, M., and Vorogushyn, S. (SP3): Controls of heavy-tail behaviour of floods in Germany and Austria. Second International Conference on Natural Hazards and Risks in a Changing World (NatRiskChange) 2021, 05.10. - 06.10.21

Speckhann, G. A., Dung, N. V., Guse, B. (SP3), Kreibich, H., Merz, B. (SP3) (2021): Changes in flood risk due to the presence of dams in the German part of the Rhine catchment., Second International Conference on Natural Hazards and Risks in a Changing World 2021 (NatRiskChange) 2021, 05.10. - 06.10.21.

Wietzke, L. (SP3), Vorogushyn, S. (SP3), Guse, B. (SP3), Merz, B. (SP3) (2021): Heavy Tails in Extremniederschlägen: Welche Rolle spielen Saisonalität und Niederschlagsregime?, Tag der Hydrologie in Potsdam, 30.08. - 01.09.21.

Theses

S. Fischer (SP1): Consideration of deterministic hydrology to improve flood statistics for extreme floods. Habilitation thesis for the field "Stochastic Hydrology", Faculty of Civil and Environmental Engineering, Ruhr-University Bochum, July 2021.

Björn Guse (SP3): Achieving hydrological consistency in space and time in ecohydrological models. Habilitation thesis at the Christian-Albrechts-Universität zu Kiel in the Faculty of Mathematics and Natural Sciences (18.05.2021)

S. Aala, "Effects of space-time dynamics of precipitation on runoff event characteristics in the Bode River Basin (Saxony-Anhalt)", TH Köln, M.Sc. Thesis (Supervisors: Tarasova, L. (SP4), Ribbe, L.)

Workshops, Conferences

Organisation of the „Tag der Hydrologie 2021“ in Potsdam with the topic „Hydrologie: Verbindung der Umweltsphären und – disziplinen: Axel Bronstert, Björn Guse (SP3), Theresa Blume

Visits

Svenja Fischer (SP1) visited subproject 6 at the Technical University Vienna at October 11-15 to work on the joint research on flood-type-specific flood-rich and flood-poor periods for Peak-over-Threshold data and dependence measures for short-range dependent data.