Project: **1064**

Project title: **Atmospheric Drivers of Extreme Flood Events (ADEFE)**

Principal investigator: **Amelie Krug, IAU (Goethe-University Frankfurt)**

Report period: **2020-01-01 to 2020-12-31**

Despite progress in flood research during the recent decades, there is still a large knowledge gap on the causative processes of extreme river floods and their spatial and temporal evolution. The objective of the research unit "Space-Time Dynamics of Extreme Floods" (SPATE) funded by the Deutsche Forschungsgemeinschaft (FOR 2416, http://spate-floods.com/) is to investigate these processes. Last year the SPATE project was extended for three more years until summer 2023. The main goal of the *Atmospheric Drivers of Extreme Flood Events (ADEFE)* project is to support the SPATE project with information about the atmospheric state and atmospheric drivers of flood events.

During the last year, we finished with the dynamically downscaling of the ERA-20C reanalysis from 1901 to 2010 ("4DAS"). The downscaling was performed over Europe with a high-resolution and interactively coupled atmosphere-ocean model setup (COSMO-CLM+NEMO-MED+NEMO-NORDIC+TRIP). Our main task during 2020 was analysing these data and preparing it for various hydro-meteorological analyses. That included, for example, following studies.

Processes intensifying the precipitation impact of Vb-cyclones[1,2]

Several extreme summer floods in Central Europe during the past century were associated with so-called Vb-cyclones. We investigated processes intensifying the precipitation impact of Vb-cyclones in Central Europe with Lagrangian[3,4] moisture source diagnostics. Overall, an enhanced and, interestingly, dynamically driven moisture uptake over the Mediterranean Sea was characteristic for heavy precipitation Vb-events, even though the dominating moisture uptake regions were the European continent and the North Sea.

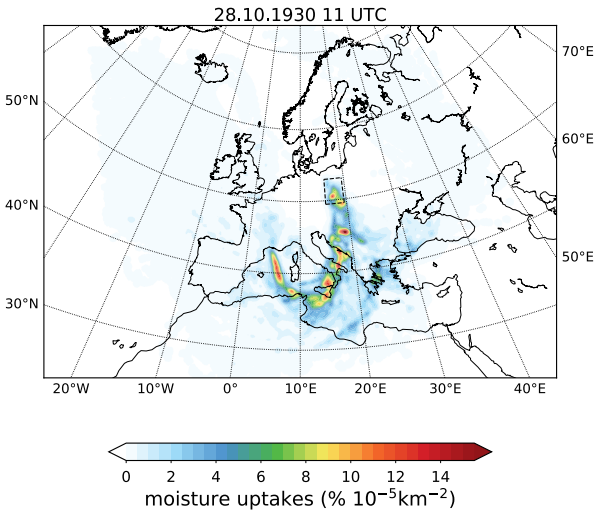


Fig. 1: Moisture uptake for precipitation in the Odra catchment (black rectangle) on 28.10.1930 10UTC-11UTC. Data basis: dynamically downscaled ERA-20C reanalysis "4DAS".

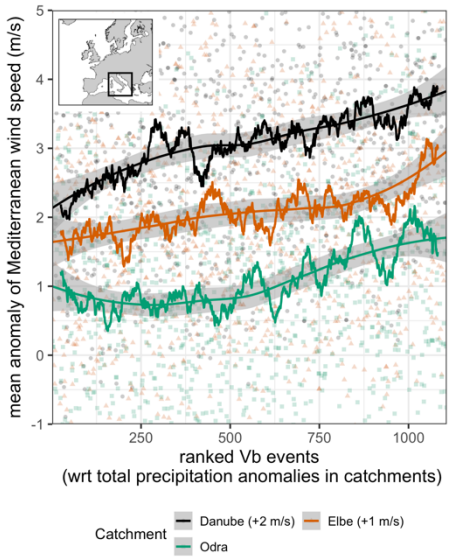
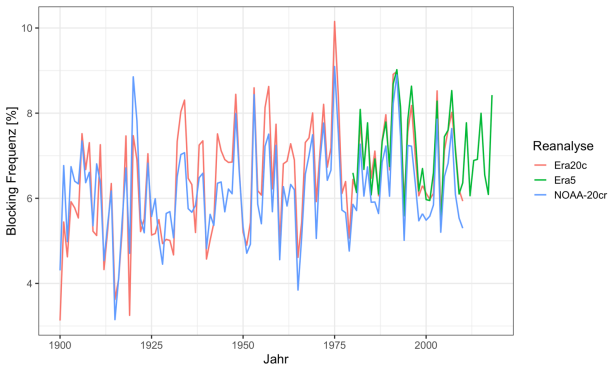


Fig 2: Mean daily anomalies of wind speed in the Mediterranean Sea for low precipitation impact (x=0) to the highest precipitation impact Vb-cyclones (x=1107). Data basis: "4DAS" from 1901 to 2010.

Impact of atmospheric blocks on extreme floods in Central Europe



Atmospheric blocking highs can cause precipitation anomalies in Central Europe[5] and may be linked with temporal clustered Vb-events[6] like in July 1954[1]. We calculated several atmospheric blocking indices from 1901 to 2010. This will serve as a data basis for analysing the hydro-climatic drivers of extreme floods and associated changes in flood type occurrence.

Fig 2: Frequency of atmospheric blocks over the North Atlantic and Europe (1900 - 2010).

Sensitivity experiments for selected Rhine flood events

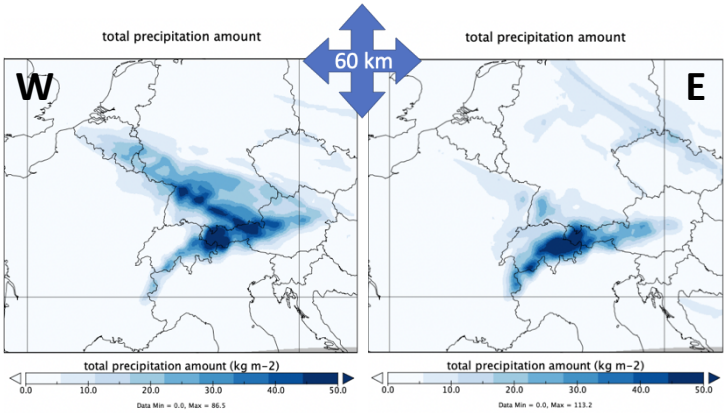


Fig 3: Total precipitation sum on 17.02.1958 for a shift of the atmospheric boundary conditions to the west (W) and east (E).

For selected Rhine floods, we shifted the atmospheric boundary conditions by 5 grid points (about 60km) to generate different event scenarios under preservation of orographic effects. Our 4DAS serves thereby as a reference. With doing so, worst-case scenarios and the impact of tributary river flow superposition can be analysed.

Moreover, our dynamically downscaled reanalysis served as a data basis for

Kemter, M., Merz, B., Marwan, N., Vorogushyn, S., & Blöschl, G. (2020). Joint trends in flood magnitudes and spatial extents across Europe. *Geophysical Research Letters*, 47. https://doi.org/10.1029/2020GL087464, and

Krug, A., Primo, C., Fischer, S., Schumann, A. & Ahrens, B. (2020). On the temporal variability of widespread rain-on-snow floods. *Meteorologische Zeitschrift* **29**, 147–163. https://doi.org/10.1127/metz/2020/0989

Our original plan was to extend the 4DAS by dynamically downscaling of a CMIP6 climate projection. However, our schedule delayed and we are pre-processing the boundary conditions for COSMO-CLM and the regional implementations for NEMO for an EC-Earth ssp5-8.5 member right now.

References

1. Krug, A., Aemisegger, F., Sprenger, M., Primo, C., and Ahrens, B. (2020): Moisture sources of extreme Vb-floods in Central Europe, *EGU General Assembly 2020, Online*, 4–8 May 2020, EGU2020-2315, https://doi.org/10.5194/egusphere-egu2020-2315
2. Krug, A., Aemisegger, F., Sprenger, M., Primo, C., and Ahrens, B. (2020): What intensifies Vb-cyclone precipitation in Central Europe? *In prep.*
3. Sprenger, M., H. Wernli (2015): The LAGRANTO Lagrangian analysis tool – version 2.0. – Geoscientific Model Development 8, 2569–2586, DOI: 10.5194/gmd-8-2569-2015.
4. Sodemann, H., C. Schwierz, H. Wernli, 2008: Interannual variability of Greenland winter precipitation sources: Lagrangian moisture diagnostic and North Atlantic Oscillation influence. – Journal of Geophysical Research 113, D03107, DOI: 10.1029/2007JD008503.
5. Lenggenhager, S., Martius, O. (2019): Atmospheric blocks modulate the odds of heavy precipitation events in Europe. *Clim Dyn* **53,** 4155–4171.
6. Hofstätter, M., & Blöschl, G. (2019): Vb cyclones synchronized with the Arctic-/North Atlantic Oscillation. *Journal of Geophysical Research: Atmospheres*, **124**, 3259– 3278.