Project: 983
Title: Decadal variability of flood triggering extreme precipitation events
Report for period 01.01.2021-31.07.2021

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The main goal of the project is the quantification of flood risk for several Central European river networks. Data source is the LAERTES-EU data set (Ehmele et al., 2020). Daily precipitation sums were comprehensively bias-corrected to avoid overestimated discharges in the subsequent hydrological simulations, where the Rhine catchment served as a pilot area for validation and calibration.
In 2021, the newest version of LAERTES-EU was used for further investigations on climatological time scales. The focus is on longer-term internal climate variabilities and trends of meteorological extremes and related teleconnections to large scale atmospheric patterns. Furthermore, the causal, spatial, and temporal relations of meteorological extremes, so called compound events, are of special interest. In addition, preparations have been done to extend the extreme event catalogue by wind storms and also future projection, which will be relevant for further analysis.
Beside this climate perspective, the characteristics of a specific extreme weather period in the Western Mediterranean in 2018 was investigated. Therefore, high-resolution and convection permitting event simulations have been performed with the COSMO model in NWP mode (numerical weather prediction). The focus lies on the representation of these events across scales from climate simulations (20 years) over seasonal simulations (2 months) to the mentioned event simulations of 2-4 days. The investigations are still ongoing.
Based on the granted DKRZ resources, a few publications are in preparation or already published. The application of LAERTES-EU for hydrological simulations and risk analysis with focus on the pilot area of the Rhine catchment is discussed in Ehmele et al. (2021) which is currently in review. In preparation is a study on compound events (Ehmele et al., planned for late 2021) and on teleconnections (Feldmann et al., planned for late 2021). The submission of the results of our investigation on the Mediterranean extreme events is planned for early autumn 2021.

Example of application:
Figure 1 shows the annual cycle of monthly precipitation totals averaged over the Rhine catchment for two data blocks of LAERTES-EU before and after bias correction in comparison to two observational data sets. The uncorrected data shows a distinct positive bias for both data block 2 and 4. While the annual cycle is more or less captured in data block 2, the shape is different for data block 4. After the bias correction the bias is significantly reduced and also data block 4 now captures the annual cycle better and with good agreement to both observational data sets.

Figure 2 shows exemplarily a possible investigation of compound events. The results are based on relative extremeness indices, representing the deviation in terms of standard deviation compared to a climatology for each grid point and each calendar day. Values below -1.5 are indicated as extreme low (e.g., severe drought in case of precipitation), values above +1.5 are extreme high (e.g., heat waves in case of temperature). The figure shows the number of days per year where the both the temperature and precipitation-based index show extremeness for a single grid point in Central Europe. It turns out, that there are periods with more events (e.g., late 1970s) and periods with less activity (e.g., early 1990s).

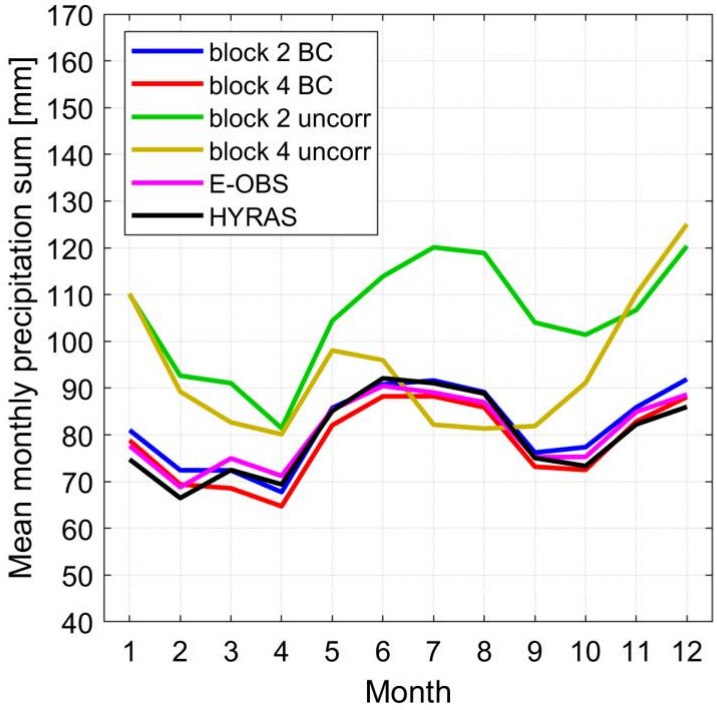

Figure 1: *Annual cycle of the spatially averaged mean monthly precipitation sum [in mm] based on LAERTES-EU data block 2 and 4 for uncorrected model data (uncorr), bias-corrected data (BC), and the observational data sets E-OBS, and HYRAS (from Ehmele et al.,2021).*

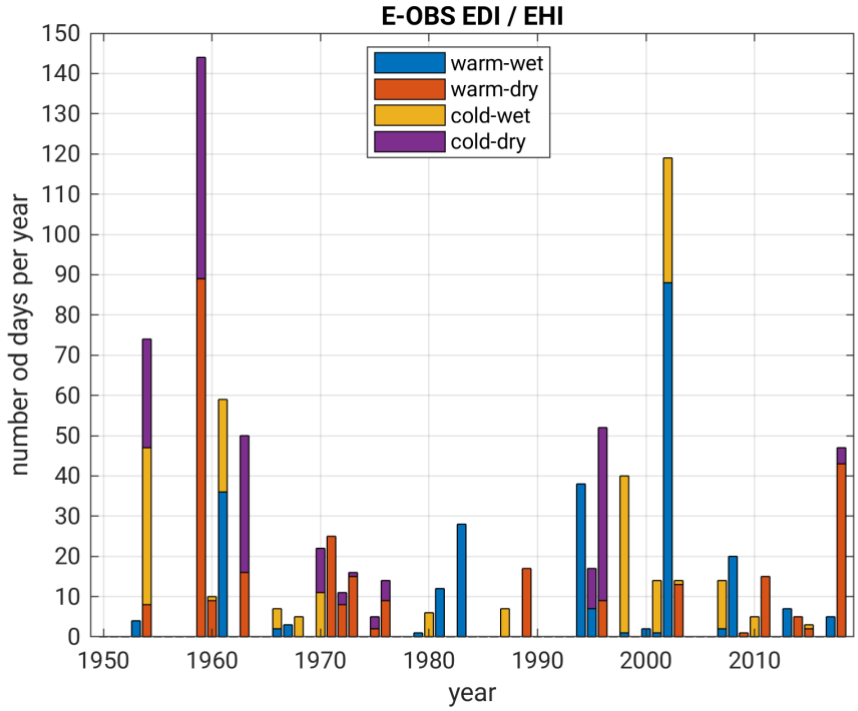

Figure 2: *Occurrence in days per year of compound temperature and precipitation extremes based on relative extremeness indices for the period 1950-2018 for a single grid point in Central Europe using the E-OBS observational data set. The color coding represents the four possible combinations of temperature and precipitation extremes (publication in preparation).*

Publications made possible through DKRZ-resources in project bb0983:

(1) Ehmele, F., Kautz, L.-A., Feldmann, H., and Pinto, J. G. (2020): Long-term variance of heavy precipitation across central Europe using a large ensemble of regional climate model simulations, *Earth Syst. Dynam.*, 11, 469–490, doi: 10.5194/esd-11-469-2020

(2) Kautz L.-A., Ehmele F., Ludwig P., Lentink H.S., Kadlec M., Buldmann B., Feldmann H., Kelemen F.D., Pinto J.G. (2019): Towards the Development of a Pan-European Stochastic Precipitation Dataset. *Hydrol. and Earth Syst. Scienc. Discuss.*, doi: 10.5194/hess-2019-77.

(3) Ehmele, F., Kautz, L.-A., Feldmann, H., He, Y., Kadlec, M., Kelemen, F. D., Lentink, H. S., Ludwig, P., Manful, D., and Pinto, J. G. (2021) Adaptation and Application of the large LAERTES-EU RCM Ensemble for Modeling Hydrological Extremes: A pilot study for the Rhine basin, Nat. Hazards Earth Syst. Sci. Discuss. https://doi.org/10.5194/nhess-2021-150, *in review.*

(4) Feldmann H., and others (2021): Teleconnections/Decadal variability of precipitation. *In preparation*

(5) Ehmele F., and others (2021): Long-term variability and trend of compound meteorological extremes in Central Europe using the large RCM ensemble LAERTES-EU. *In preparation.*

(6) Kodayar S., Ehmele F., Caldas-Alvarez A., and others (2021): The 2018 High Precipitation Event period in the Western Mediterranean – representation across scales. *In preparation.*