**Project: 983**
**Title: Decadal variability of flood triggering extreme precipitation events**
**Report for period 01.01.2020-31.12.2020**

**Project leader: Joaquim G. Pinto**
**Additional Users: Florian Ehmele, Hilke S. Lentink, Patrick Ludwig, Lisa-Ann Kautz, Hendrik Feldmann**
**Institute of Meteorology and Climate Research, Karlsruhe Institute of Technology**

The main purpose of this project is still the quantification of flood risk along major river networks in Central Europe. Therefore, we use a novel dataset based on regional climate model simulations called LAERTES-EU (Ehmele et al.,2020) which consist of over 12,000 simulated years. The daily mean 2-meter temperature and daily precipitation amount have been extracted and adjusted to be applicable for hydrological modelling. For both variables a bias correction has been performed using quantile mapping. In case of precipitation, a dry-day correction was also necessary to reduce model artefacts (Feldmann et al. 2008). As reference and for validation, we used the E-OBS (version 17, Haylock et al, 2008) and the HYRAS data sets (Rauth et al., 2013).
In 2020, further analysis and validation of the applied bias correction were done. We found some issues related to sparse observational data in some areas leading to too low precipitation amounts. Due to this, we adjusted the dry-day and bias correction methods for the complete LAERTES-EU ensemble. While all tests have been limited to the Central European area with land-grid points only, the LAERTES-EU ensemble is now dry-day and bias corrected for the complete EURO-CORDEX region. Ocean grid points remain uncorrected in this new version. Furthermore, the newest version of LAERTES-EU uses the current E-OBS version v21.0e (e = ensemble version; Cornes et al.,2018).
Additionally, some case studies with the COSMO-CLM model for high precipitation events in the Western Mediterranean area have been simulated going down to a convection permitting resolution of 2.8km. Focus is on possible mechanisms behind a clustering of such events and also on the model performance as some of these events could not be reconstructed with standard simulation setups. The investigations on that are still ongoing and will continue in 2021.
Currently there are a few papers in preparation or already published, dealing with results of this project. The first one (Ehmele et al.,2020) introduces the LERTES-EU ensemble an analyses long-term trends of precipitation in Central Europe. The second one (Kautz et al., 2020) will focus on the adaptions of LAERTES-EU for hydrological application, namely the bias correction and the added value of using such a large ensemble. The submission is planned for late 2020. Furthermore, a study on mechanisms and teleconnection behind decadal oscillations of extreme precipitation is in preparation (Feldmann et al.,2021; submission in early 2021).
Looking beyond the horizon of precipitation, the LAERTES-EU ensemble is currently extended by other near-surface variables (e.g. wind speed) to analyse so called compound extreme events (Ehmele et al.,2021; submission planned for early 2021).

Example of application:
Figure 1 (Ehmele et al., 2020) shows the trend matrix for the LAERTES-EU ensemble for the Prudence region Mid-Europe for the yearly 99$^{th}$ percentile of precipitation on wet days. The time series are split in sub-series of minimum 10-year length up to a maximum of 110 years. For each sub-series the linear trend was calculated. On a decadal time scale (diagonal line) a distinct oscillation is found with periods of increasing and decreasing precipitation (Fig. 1b). Overall, trends in LAERTES-EU are robust with high number of members showing the same trend (Fig. 1a) but only a smaller part are statistically significant (Fig. 1c). For longer time periods (bottom right corner) a slightly positive trend is visible.

Regarding hydrological applications, Figure 2 (Kautz et al., 2020) shows estimated return periods of discharge for the Rhine river exemplary at Emmerich station near the German-Dutch border. It is clearly visible that the applied bias correction has an added value to such applications as the distribution is very close to the observed one afterwards. The uncorrected LAERTES-EU data cause too high discharges in the hydrological model which will lead to various issues in catastrophe modeling and risk assessments. It is also shown that gridded observational data sets like E-OBS or HYRAS have problems to cover the observations as well which originates from the limited time frame of couple of decades, which is not sufficient to estimate high return periods. For this purpose, the thousands of years within LAERTES-EU lead to a significant improvements in the estimation of return periods.

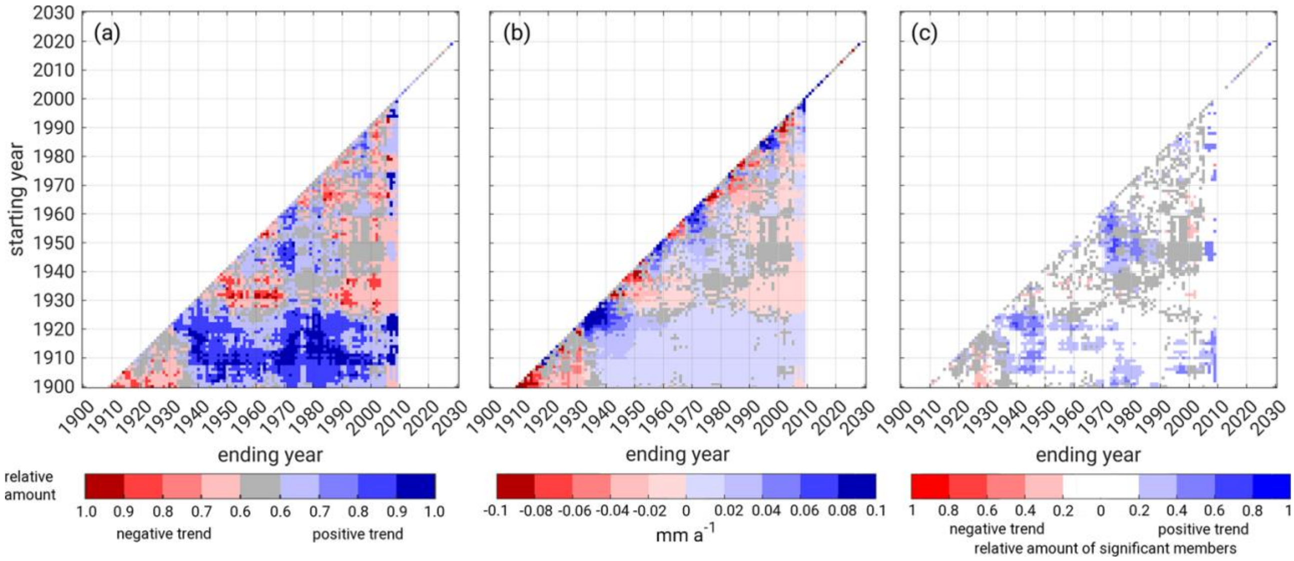


***Figure 1:*** *Trend analysis of the 99 % percentile (wet days only) of daily spatial mean precipitation for Prudence Region Mid-Europe with (a) the relative amount of members of LAERTES-EU with a positive (blue) or negative (red) trend; (b) the trend in milimenter per year averaged over the members from (a), and (c) relative amount of members from (a) with a significant trend; cases with no distinct number (less than 60 %) of members with same trend sign are marked in gray in (a)-(c). (Ehmele et al., 2020)*

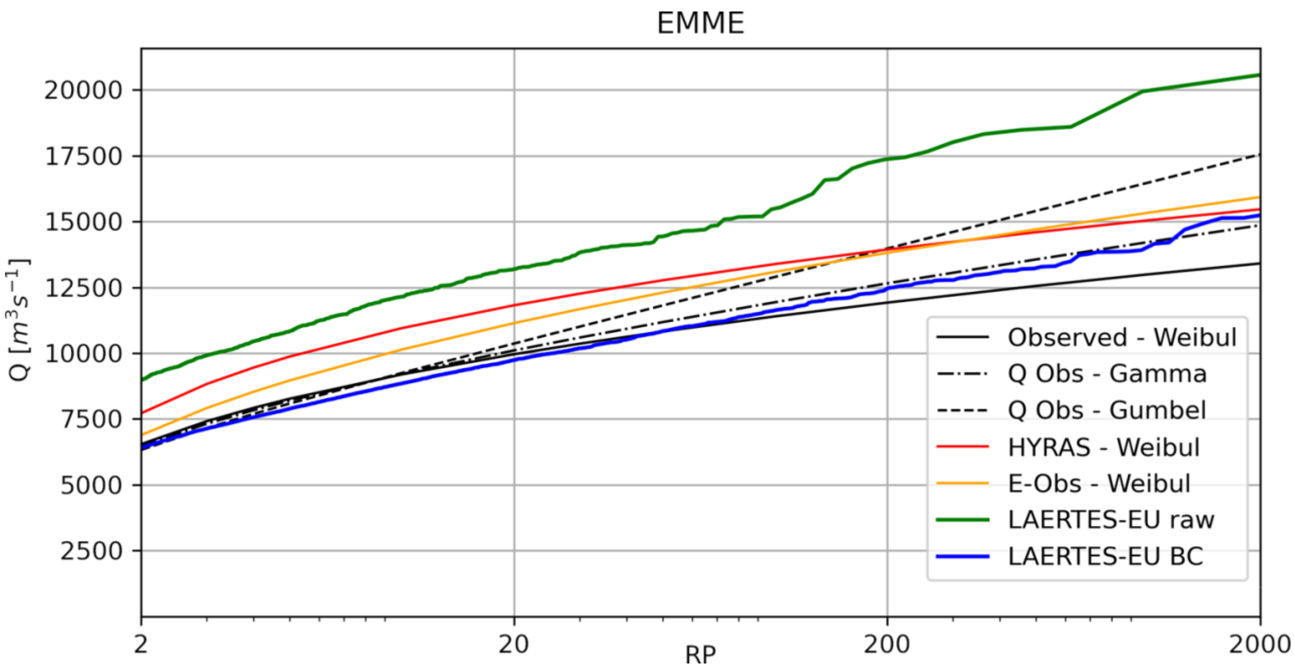


***Figure 2:*** *Return values of observed and simulated discharges at Emmerich (EMME, Rhine river) gauging station. Given are the Weibull (black solid), Gumbel (black dashed), and Gamma distributions (black dot-dashed) for observed discharges as well as the Weibull distributions for the simulation forced with observed precipitation from E-OBS (orange) and HYRAS (red). The results from uncorrected LAERTES-EU driven simulations are given in green and those driven by corrected LAERTES-EU data are shown in blue.*

**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) Kautz L.-A., Ehmele F., Kadlec M. He Y., Lentink H.S., Buldmann B., Feldmann H., Manful D., Puncochar P., Kelemen F.D., Ludwig P., and Pinto J.G. (2020): Adaption of the LAERTES-EU data set for the use in hydrological applications and catastrophe modeling. *In preparation*

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

**References**

Feldmann H., Frueh B., Schaedler G., Panitz HJ, Keuler K., Jacob D, & Lorenz P (2008): Evaluation of the precipitation for South-western Germany from high resolution simulations with regional climate models. *Meteorologische Zeitschrift*, 17, 455-465. doi: 10.1127/0941-2948/2008/0295

Haylock MR, Hofstra N, Klein Tank AMG, Klok EJ, Jones PD, New M (2008) A European daily high-resolution gridded dataset of surface temperature and precipitation. *J. Geophys. Res - Atmospheres*, 113, D20119, doi: 10.1029/2008JD010201.

Rauthe, M., Steiner, H., Riediger, U., Mazurkiewicz, A., and Gratzki, A. (2013): A Central European precipitation climatology–Part I: Generation and validation of a high-resolution gridded daily data set (HYRAS), *Meteorol. Z.,* 22, 235–256, doi: 10.1127/0941-2948/2013/0436