Project: 983
Title: Decadal variability of flood triggering extreme precipitation events
Project leader: Joaquim G. Pinto
Report for period 01.01.2018-31.12.2018

To quantify the flood risk for large European river catchments (namely Danube, Elbe, Oder, Rhine, and Vistula), a centennial dataset of the daily 2 m mean temperature and the daily precipitation sum was generated in 2018 to be used as input for a hydrological rainfall-runoff model developed by the University of East Anglia. With this aim, we run the regional climate model COSMO-CLM (CCLM) with two different global reanalysis data sets (ERA-Interim, Dee et al., 2011; ERA-20C, Hersbach et al., 2013) as initial and boundary conditions. The simulations were finished in early 2018. The two downscaling simulations provide 37 (ERA-Interim) + 111 (ERA-20C) years of regional data for Europe at a horizontal resolution of 0.22°. Due to the bias of model data towards observations, a bias correction as well as a dry day correction had to be applied. In 2018, we additionally tested several bias correction methods, including linear, non-linear as well as distribution-driven approaches (Fang et al., 2015). The daily E-OBS gridded data set (0.25° horizontal resolution, Haylock et al., 2008) was used as reference data for the bias correction. At the moment, we are working at two papers that present findings from this project. In the first paper (Quandt et al., 2018), we introduce the applied methods (dynamical downscaling plus bias correction). Bias correction methods are evaluated in a climatological perspective as well as for specific heavy precipitation events. We found that empirical quantile mapping is one of the most suitable methods to correct daily precipitation sums. The second paper (Ehmele et al., 2018) addresses long-term variability and trends of heavy precipitation in centennials dataset. We found a significant increasing trend of heavy precipitation for northern parts of Central Europe, while there is a decreasing trend in the Mediterranean region. In addition, high-resolution (7 km and 2.8 km) simulations of specific flooding events were performed in 2018. This was done to investigate the benefit of a higher resolution in the representation of daily precipitation sums.

Example of application: Representation of the Danube Flooding event in 2002

In August 2002, record-breaking precipitation amounts were observed, which lead to severe flooding in the Elbe catchment and parts of the Danube catchment (Ulbrich et al., 2003a). Two high precipitation events in the first half of August were the main contributors to these severe flooding events, which caused 100 fatalities and an estimated economic loss over 14 billion Euros (Ulbrich et al., 2003a). The synoptic situation was influenced by a surface cyclone that moved from the Mediterranean basin into Central Europe, known as Vb cyclones track (Ulbrich et al., 2003b).
Regarding the second precipitation peak, the daily precipitation sum on 11 August 2002 is illustrated in Figure 1. In E-OBS, an extended area of high precipitation with peak values over 70 mm is visible within the Danube catchment. In the 25 km run (driven with ERA-Interim), the precipitation sum is underestimated. It is increased in the 7 km and 2.8 km runs being closer to observations, but with an overestimation of precipitation along the coast of Croatia. In conclusion, the higher resolution leads to improvements in the representation of heavy precipitation on 11 August 2002.

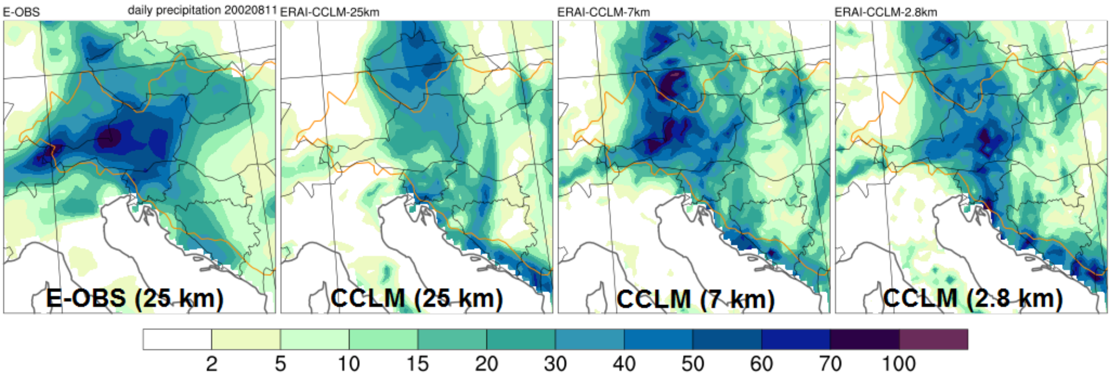

Figure 1: *Daily precipitation sum (shading in mm) on 11 August 2002 for E-OBS (25 km) and downscaled ERA-Interim data on three resolutions, namely 25 km, 7 km, and 2.8 km (from left to right). Gray lines represent country boundaries, orange lines mark the western part of the Danube catchment.*

References:

Compo G., et al. (2011): The twentieth-century-reanalysis-project, Q. J. Roy. Meteorol. Soc., 137, 1–28.

Dee DP, et al. (2011) The ERA-Interim reanalysis: configuration and performance of the data assimilation system. *Q. J. R. Meteorol. Soc*., **137**, 553–597, doi: 10.1002/qj.828.

Ehmele F, Quandt LA, Feldmann H, Buldmann B, Pinto JG (2018): Long-Term Variability and Trends of Heavy Precipitation in Central Europe – Part I: Validation of Century-long Reanalysis Data Sets. *In preparation*.

Fang G, Yang J, Chen Y, Zammit C (2015): Comparing bias correction methods in downscaling meteorological variables for a hydrological impact study in an arid area in China, *Hydrology and Erath System Sciences*, **19**, 2547-2559, doi: 10.5194/hess-19-2547-2015

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.

Hersbach H, Peubey C, Simmons A, Poli P, Dee D and Berrisford P (2013) ERA-20CM: a twentieth century atmospheric model ensemble. *ECMWF Technical Report ERA Report Series* **16**, 44

Quandt LA, Ehmele F, Ludwig P, Lentink HS, Kelemen FD, Kadlec M, Pinto JG (2018): Towards the Development of a Pan-European Stochastic Precipitation Dataset. *In preparation*.

Ulbrich U, Brüchner T, Fink AH, Leckebusch GC, Krüger A, Pinto JG (2003a): The central European floods of August 2002: Part 1 – Rainfall periods and flood development, *Weather*, **58**, 371-377, doi: 10.1256/wea.61.03A

Ulbrich U, Brüchner T, Fink AH, Leckebusch GC, Krüger A, Pinto JG (2003b): The central European floods of August 2002: Part 2 – Synoptic causes and considerations with respect to climate change, *Weather*, **58**, 434-442, doi: 10.1256/wea.61.03B