Project: **1064**

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

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Report period: **2019-01-01 to 2019-12-31**

The main goal of the Atmospheric Drivers of Extreme Flood Events (ADEFE) project is to provide information about which the atmospheric processes driving to extreme floods in Germany are. This is also our contribution to the Research Unit SPATE ("Space-Time Dynamics of Extreme Floods") established in December 2016 by the German Research Foundation (*Deutsche Forschungsgemeinschaft, DFG*). To achieve this aim, we first need to have a consistent 4-dimensional atmospheric state (4DAS) with a spatial resolution able to include regional precipitation amplification factors and for a long time period that allows the analysis of extremes. This goal was achieved this year.

To obtain the 4DAS, the so-called reanalysis ERA20C from the European Centre for Medium-Range Weather Forecast was downscaled to an horizontal grid-spacing of 0.11°x0.11° (~12km) using a coupled regional climate system model (RCSM) consisting of an atmospheric and land part given by the regional model COSMO-CLM, coupled to three marginal Seas (the Mediterranean Sea, North and Baltic Seas) given by two versions of the NEMO ocean model (NEMO-MED12 and NEMO-NORDIC) and to the rivers given by the TRIP model. Thus, four models were coupled every 3 hours via the coupler OASIS-3_MCT. The coupled RCSM run for the period 1901-2010 over a domain centred in Europe and covering the so-called EURO-CORDEX and MED-CORDEX domains.

This is an unprecedentedly long high-resolution dataset, covering more than a whole century. The first task was to evaluate the stability of the system. We considered three variables (surface temperature, 2m temperature and total precipitation), to show that the system runs stable over the whole century, with no drift nor evolving bias. This evaluation led to one manuscript (Primo et al. 2019).

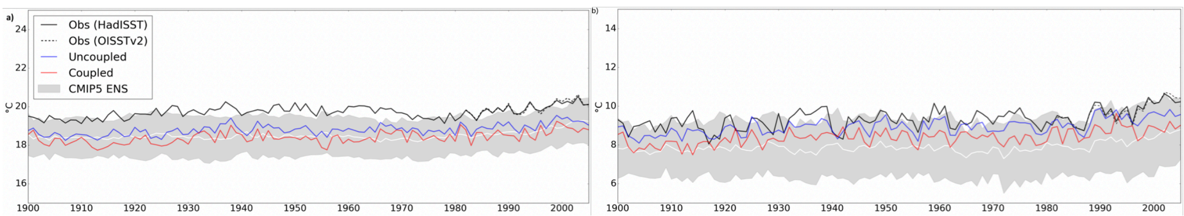


Figure 1. Sea surface temperature annual means over the marginal seas of the coupled simulation (CCLM-NEMO) with resolution 0.22x0.22 between 1900 and 2005, compared to observations (HadISST and OISSTv2), to the atmosphere-only CCLM simulation (with SSTs prescribed by the driving MPI-ESM nudged to observations), and an ensemble mean (white line) and spread (shaded area) from CMIP5 simulations. a) Mediterranean Sea and b) Baltic and North Sea.

In addition, we could also quantify the added value of coupling the marginal seas compared to an atmosphere-only COSMO-CLM simulation, what led to another manuscript (Kelemen et al. 2019). In particular, there is added value in precipitation in winter:

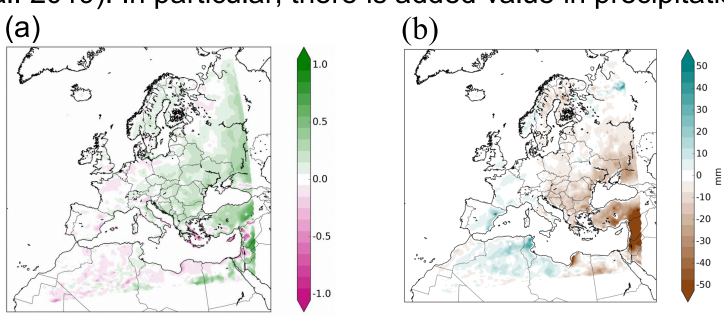


Figure 2. (a) MSESS of the mean winter precipitation sums when comparing the coupled system to the uncoupled with respect to CRU for the period 1901-2009. (b) The difference of mean soil moisture content during winter between the coupled and the uncoupled simulation.

A comparison of two centennial coupled simulations (spatial resolution 0.22°x0.22° driven by the global MPI-ESM and spatial resolution 0.11°x0.11° driven by ERA20C coupled also to the TRIP model) shows the benefits of the improvements of this new simulation (better spatial horizontal resolution, better driving data, close water cycle in the Mediterranean). This can be appreciated, for example, in the calculation of climate change indices, like the CWD. This index accounts for the maximum length of wet spell (maximum number of consecutive days with precipitation above 1mm per year).

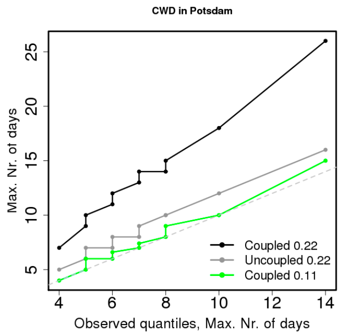
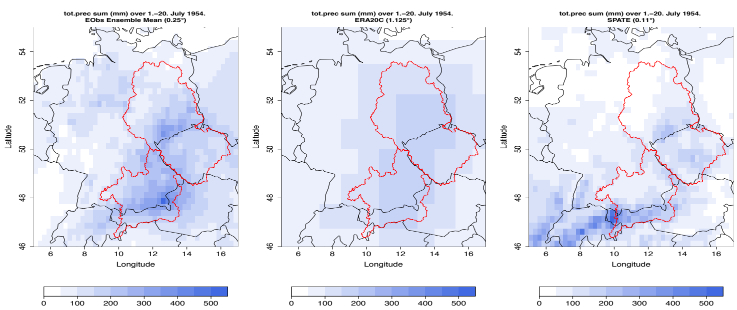


Figure 3. q-q plot of the CWD in Potsdam for three different centennial simulations:

CCLM, 0.22°x0.22°
CCLM+NEMO, 0.22°x0.22°
CCLM+NEMO+TRIP,0.11°x0.11°

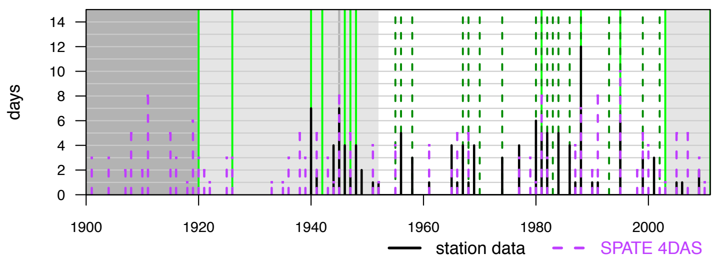
The simulated 4DAS also allows other interesting studies like:

(a) cyclone tracking and further events downscaling with a convection-permitting model within a consistent dataset. Fig. 4 shows the precipitation subsequently leading to an extreme flood event in July 1954 E-Obs data, ERA20C reanalysis and 4DAS. Red lines represent parts of the Danube and Elbe catchments.



(b) Study of rain-on-snow events. Krug et al. (2019) defined an atmospheric proxy based on station measurements to estimate rain-on-snow flood events during the 20th century. Green lines represent observed trans-basin winter floods; The time-periods which were excluded from the hydrological flood classification are grey-shaded.

Nr. of detected 120 days with highest rank of our atmospheric proxy



References

Krug, A., **C. Primo**, S. Fischer, A. Schumann, B. Ahrens (2019) On the temporal variability of widespread rain-on-snow floods. Subm. to MetZ.

Kelemen, F.D., **C. Primo**, H. Feldmann, B. Ahrens (2019). Added value of atmosphere-ocean coupling in a century-long regional climate simulation. Atmosphere. 10(9), 537. https://doi.org/10.3390/atmos10090537

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