Helmholtz-Zentrum
Geesthacht
Zentrum für Material- und Küstenforschung

Extreme summer precipitation in Central Europe over the past millennium: role of external forcing in ensemble of simulations with Earth System models

Eduardo Zorita (eduardo.zorita@hzg.de), Institute of Coastal Research,
Helmholtz-Zentrum Geesthacht, Germany

1. In Central Europe, summer floodings caused by extreme rain are one of the most destructive weather events in terms of lives and property losses. In this study we analyse climate simulations to investigate to what extent the external climate forcing over the past millennium may have modulated the frequency of such flooding events in that period. The models used are the Earth System models MPI-ESM-P (Max-Planck-Institute for Meteorology Earth system Model, paleo version) and CESM (Community Earth System Model, Last Millennium Ensemble). For each of these models, an ensemble of simulations covering the past millennium, with 3 and 13 simulations respectively, is available. Both models have been profusely used for paleoclimate studies.

2. A prime example of Central European floods occurred in August 2002. The amount of daily precipitation total reached approximately 80 mm/day in some locations. Heavy rain was also reported in the previous days, causing a saturation of the soil and ultimately leading to extensive flooding. The precipitation is driven by a synoptic weather pattern, categorized as Vb, which can be briefly described as a low pressure weather system originating in the Gulf of Genua, directing north towards Central Europe, and delivering high amounts of water vapour evaporated from the warm Mediterranean Sea. Similar events are regularly described not only in the recent weather records, but also its impact can be clearly described in historical accounts.

3. A preliminary question is weather global climate models, in view of their coarse spatial resolution of about 150 km, may be at all able to realistically represent these type of extreme precipitation, which driven by a relatively small-scale weather pattern. To address this question, we identify the day in one of the MPI-ESM-P simulations and in one of the CESM simulations with the strongest daily precipitation simulated over the past millennium in one model grid-cell co-located with the observed extreme on August 12th 2002. We compare the sea-level -pressure patterns **simulated** on that day and on the previous three days with the sea-level-pressure patterns **observed** on August 12th 2002 and on the previous 3 days. The visual comparison in Figure 1 indicates that both models reproduce relatively well the sequence of weather patterns leading to extreme precipitation , although they are some slight differences with respect to observations.

4. The source of moisture for the strong precipitation is known to lie in the evaporation from the Mediterranean Sea. We also test here whether this is also the case in the simulations. Figure 2 shows the anomalous (relative to the long-term monthly mean) latent heat derived from the NCEP reanalysis and from the MPI-ESM-P and CESM simulations. The figure indeed suggests that extreme precipitation can also be linked to evaporation from the Mediterranean Sea in both simulations.

5. Finally, we explore whether the frequency of extreme precipitation, defined as the number excellences over a certain thresholds, in **gliding 30-year periods** is connected to the total external climate forcing (solar variations, volcanic activity, greenhouse gases). We do not explore here the possible impacts of individual volcanic eruptions. In both ensembles (MPI-ESM-P and CESM), the individual simulations show temporal variations in the frequency of extreme precipitation that are not-synchronized. Also, this frequency is not statistically connected to the average large-scale temperature in the simulations, either averaged over the Northern hemisphere or over the North-Atlantic-European-Mediterranean sector. We conclude that decadal variations in the frequency of extreme precipitation over the past millennium cannot, therefore, be attributed to the external forcing. Also, the simulations do not show a systematic increase or decrease over the last 150 years.

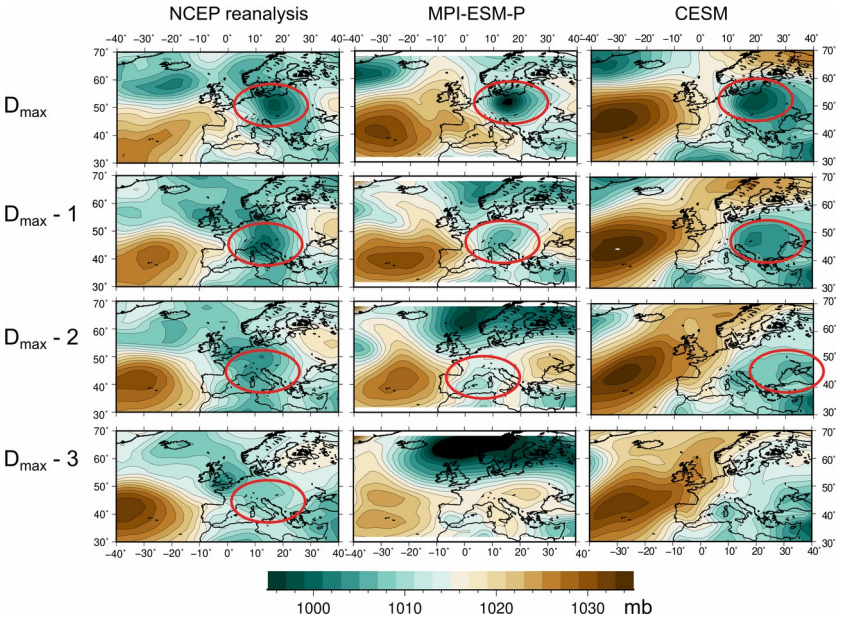

Figure 1: Sea-level-pressure patterns on days of extreme Central European precipitation, (Dmax) and on the three previous days. For NCEP reanalysis Dmax=August 12th 2002; for MPI-ESM-P Dmax= August 13th 1123; for CESM Dmax=30th July 1323.
Red circles highlight the low-pressure cells leading to extreme precipitation.

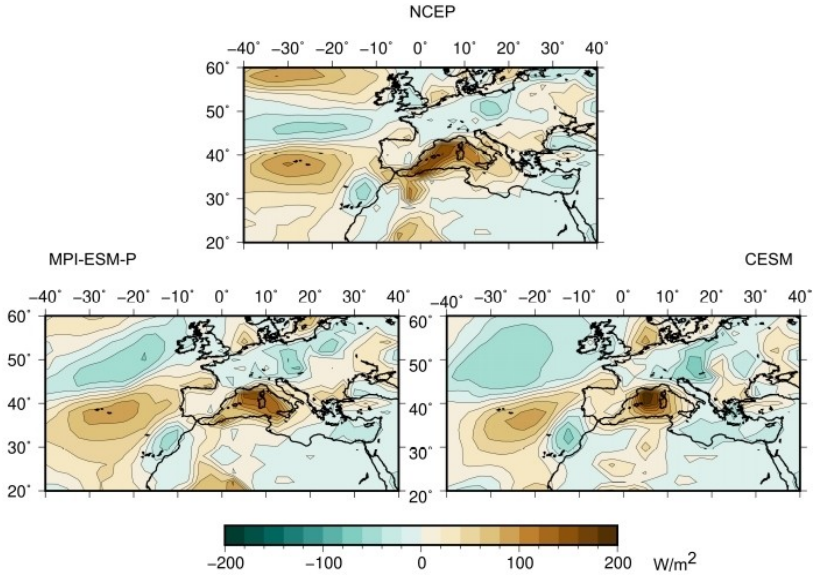

Figure 2: Latent-heat anomalies (with respect to their long-term monthly mean) on the days of maximum precipitation Dmax (see caption figure 1) derived from the NCEP reanalysis and the two simulations with Earth System Models.