Project: **1064** Project title: **Atmospheric Drivers of Extreme Flood Events (ADEFE)** Principal investigator: **Cristina Primo Ramos** Report period: **2018-01-01 to 2018-12-31**

Atmospheric Drivers of Extreme Flood Events (ADEFE) is a project whose aim is to simulate a consistent 4D-var state of the atmosphere over Europe for a long period (more than one hundred years) with a spatial resolution able to include regional precipitation amplification factors. This state will be used to provide information about which atmospheric processes drive to extreme floods in Germany, what is 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*).

ADEFE consists of two phases. The first one is a test phase in which four numerical models are coupled and tested to simulate the interactions among three different components of an earth climate system: 1) the atmosphere and land, represented by the regional numerical model COSMO-CLM, 2) the ocean, represented by two ocean models, one focused on the Mediterranean Sea named NEMO-Med and other focused on the Baltic and Nordic Seas named NEMO-Baltic, 3) the rivers, represented by the Total Runoff Integrating Pathways model TRIP. Once these 4-coupled models run stable, the second phase consists in running 110 years of simulations over Europe with a spatial resolution 0.11° during the period 1901-2010.

During the first year of the project, the first phase was successfully completed and the four coupled models run already in mistral. This phase consisted in implementating the required software to couple four models via oasis-3_MTC, running a test using the "*lucia*" tool to estimate an optimal number of processors per model, and finally obtaining a first verification of the output produced. Fig 1 shows a comparison of the computing time of the information exchanged by the four models with the coupler oasis. COSMO-CLM is the most high-demanding model, due to the 0.11° spatial resolution. Therefore, the number of processors used by NEMO were decreased to locate the majority of the processors used to run COSMO-CLM. TRIP model only requires one processor, so the waiting time cannot be improved. The choice of the final number of processors was also done to minimize interconnection among nodes.

Three of these models, COSMO-CLM, NEMO-Med and NEMO-Baltic, have been already used in mistral by our group to run a centennial simulation, however, the contribution of the TRIP model is a novelty, and so this model had to be previously tested. Fig 2 represents a comparison between the climatological cycle of the river run-off of the Mediterranean Sea given by the 4-coupled model simulation and the observed climatological run-off values of the Mediterranean Sea. It should be noted, that our simulation differs from the observed climatological values in the contribution of the Black Sea, that is added to the Runoff over the Mediterranean Sea.



Figure 1. Calculation and waiting time of the oasis components of the 4-coupled system.



Figure 2. Comparison of the simulated run-off over the Mediterranean Sea and the observed climatological run-off.

The climatological cycle of the run-off is well represented for the period used (first 40 years of the simulation). A correct simulation of the rivers sums up value to our simulation, since rivers are the last element needed to close the water-cycle, what is crucial to understand the atmospheric process that drives extreme floods.

Currently, the second phase is in progress and forty years have been already simulated. In addition to the inclusion of the TRIP model, this simulation has also two main new aspects in comparison to the previous centennial simulation run by our group. The new 0.11° resolution (in comparison with the 0.22° from the previous one) aims to represent in a better way precipitation events that happen in a local scale, and that are decisive in the occurrence of extreme flood events. On the other hand, an improved reanalysis was used to drive our regional model, the so-called ERA20C, provided by the European Center for Medium-Range Weather Forecast. This reanalysis assimilates observations of surface pressure and surface marine winds and seems to improve the reanalysis 20CR provided by NCEP used in previous simulations.

In particular, we are interested in extreme flood cases. In collaboration with the hydrologists of the SPATE unit, we are provided with a list of extreme flood events in Germany. Fig 3 shows an example in 1940, in which an extreme flood happened in Germany, especially in the Elbe catchment. On the left hand, a map of the total precipitation sum over Germany in January 1940 with 0.22° resolution is represented. The right map shows the results obtained with the new simulation having a resolution of 0.11°. This figure shows how the new simulation reduces the overestimation of the total precipitation that happened in the Alps, as well as it simulates high total precipitation sums in places like Dresden, that were very affected.



Figure 3. Total precipitation of January 1940 simulated by a 3-coupled system with resolution 0.22° (left) and the new 4-coupled system with resolution 0.11°.

These promising results suggest that our simulation might contribute to improve our understanding of the atmospheric drivers of extreme floods in Germany and we are looking forward to having the complete simulation finished in the second year of the project.