# Atmospheric Drivers of Extreme Flood Events (ADEFE)


## Abstract

The Research Unit "Space-Time Dynamics of Extreme Floods (SPATE)", was established in December 2016 by the German Research Foundation (*Deutsche Forschungsgemeinschaft*, *DFG*, FOR2416), to enable researchers to better understand the atmospheric, catchment and river system processes and their interactions leading to extreme flood events (http://www.spate-floods.com).

Extreme flood events are affected by atmospheric conditions, landscape and river conditions. The meteorological situation is a key driver of river discharges. Meteorological processes evolve in a complex way in time and space. Therefore, extreme flood events need to be analysed from a multi-scale point of view, having in mind the event scale processes (magnitude, previous weather conditions, etc.), the spatial scales (landscape, topography, etc.) and the temporal scale (period of occurrence, duration, etc.). In addition, there are uncertainties related to the predictions at all scales that need to be accounted for. To cover all the requirements of the analyses of drivers to extreme floods, SPATE is made of eight subprojects with experts on different fields such as meteorology, hydrology and statistics, coming from different universities and research centres in Germany together with the Vienna University of Technology.

The proposed project is part of SPATE and focuses on the atmospheric processes driving to extreme floods. It is therefore crucial to have a consistent atmospheric state with high spatial resolution over a long period of time, that allows us to obtain correct conclusions about the atmospheric drivers of extreme floods. The European Centre for Medium-Range Weather Forecast has recently released the 20th century reanalyses, the so-called ERA-20C (http://www.ecmwf.int/en/ research/climate-reanalysis/era-20c), that provides a four-dimensional self- consistent atmospheric state based on 4D-Var data assimilation from the year 1900 onwards. This reanalysis is provided on a grid, whose space distance between grid points is of approximately 125 km. However, for a hydro-meteorological analysis as the one needed to understand extreme floods, ERA-20C's atmospheric fields are too coarse-gridded and therefore do not include the important regional precipitation amplification factors. Since the interest focuses on a finer grid, an atmosphere-land-surface regional model, the COSMO-CLM (http://www.clm-community.eu), will be used to downscale the ERA-20C reanalysis to a resolution of around 12 km. This new product will cover the lack of high resolution reanalysis covering the last century over Europe, since the regional reanalysis products available are only for a few decades at best (see, for example, the European project "Uncertainties in Ensembles of Regional Reanalysis; UERRA, http://www.uerra.eu)".
ERA-20C is a product obtained by reanalysing the weather during the years from 1900 to 2010, using a coupled atmosphere/land-surface/Ocean-waves model. In the process, surface observations, in particular, surface and mean sea level pressures, and surface marine winds are assimilated. This means, that only surface observations are assimilated and the upper information is not taken into account. This may limit the quality of the product. However, other products including upper air data, like the ERA-PreSAT, reduce the covered period to just a few decades: 1939-1967.

The proposed centennial simulation will involve three models coupled with each other, representing the three main components: atmosphere-land surface, ocean and rivers. The COSMO-CLM, that is an atmosphere-land-surface regional model, will be coupled to the ocean NEMO model (“Nucleus for European Modelling of the Ocean”), mutually interchanging information. NEMO is intended to be a tool to study the ocean and its interactions with the others components of the earth climate system over a wide range of space and time scales (https://www.nemo-ocean.eu). The river contribution will be added through the TRIP model ("Total Runoff Integrating Pathways"), that will receive information from the COSMO-CLM model and will pass information to the NEMO system. The TRIP model helps to isolate the river basins, inter-basin translation of water through river channels, as well as collect and route runoff to the river mouth(s) for all the major rivers (http://hydro.iis.u-tokyo.ac.jp/%7Etaikan/TRIPDATA/TRIPDATA.html).
Regarding the domain, the so-called EURO-CORDEX and MED-CORDEX domains, used already in on-going projects, will be cover by the slightly bigger domain defined for this project.
To conclude, we are also interested in investigating regional and local meteorological factors of extreme flood events. Precipitation leading to extreme flood events is a mixture of frontal, orographic and convective precipitation. In the downscaled atmospheric state, the orography (e.g. mountains and valleys) is still represented in a coarse grid-space (12 km). In addition, convective precipitation is parameterized with a convection parametrization scheme that is known to be misleading. Therefore, to analyse orographic precipitation, we need to go for a smaller grid-space and so, run convection permitting simulations. Hence, in order to study the role of regional and local amplification mechanisms like soil moisture-precipitation, we will perform convection permitting simulations (CPS), using COSMO-CLM with grid-spacing <2 km of flood events in the meso- and macro-scale hydrological catchments investigated by SPATE. The surface/soil in the CPS will be initialized by the downscaled atmospheric state obtained earlier in this project. These simulations will provide very high-resolution precipitation fields, which can be used to analyse the regional and local meteorological factors leading to extreme flood events.