EMS Annual Meeting Abstracts
Vol. 8, EMS2011-304, 2011
11th EMS / 10th ECAM

Forecasting the weather
- ensemble techniques
in probabilistic weather prediction

An analysis of changes in the extremes of temperature, precipitation, and wind speed based on regional climate projections for Germany

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Besides earthquakes and volcanic eruptions, weather catastrophes have by far the greatest societal effect of all natural disasters in terms of civil damages. Therefore, changes in the climatic extremes are definitely one of the most important aspects of climate change. However, while an increase in the frequency of hot days and warm nights over land masses can be regarded as highly probable, e.g. regional projections of heavy summer precipitation events in Central Europe vary from a slight decrease up to an increase of 30%. Generally, changes in frequencies and intensities of climatic parameters particularly affecting the general public are still very uncertain on a regional and especially local scale. Consequently, the Alliance of German Federal Agencies comprising the Federal Environment Agency (UBA), the Federal Office of Civil Protection and Disaster Assistance (BBK), the Federal Agency for Technical Relief (THW), and the National Meteorological Service (DWD) has recently commenced a research project aiming to analyze regional climate projections for Germany focussing on weather extremes and their changes.

The project is subdivided into two major parts. In the first stage the data will be examined by means of a selection of climate monitoring and climate change indices as recommended by the Expert Team on Climate Change Detection and Indices (ETCCDI) and used within the European Climate Assessment & Dataset (ECA&D) project. We will concentrate on the second part of the project, where the authors apply extreme value statistics for the determination of the modelled changes in return values/return periods primarily for the meteorological variables temperature, and precipitation. The projection data of four different regional climate projection models for Germany (CLM, REMO, WETTREG and STAR) are evaluated to form a Poisson Point Process (PPP) of peaks over threshold (POT) individually at each grid point. Avoiding all imponderableness related to parametric model selection, we estimated the intensities of the inhomogeneous PPPs nonparametrically by means of kernel smoothers. The results of this analysis show a surprisingly differentiated picture of future trends, with pronounced variation between the evolution of the target variables with respect to region and season. For example, the direction of the extreme temperatures' trend conforms perfectly to our expectations, whereas their growth factor deserves the attribute alarming (easily passing several hundred percent). The behaviour of heavy precipitation events exhibits a somewhat more diverse pattern. Applying functional cluster analysis on a Fourier basis, we identified regions with correlating trends, which span the whole spectrum of 250 percent increase to 50 percent decrease until the end of the century.

To complement the frequency analysis of threshold exceedance, the values of exceedance are subsequently evaluated within the framework of extreme value theory, namely an inhomogeneous Generalized Pareto Distribution (GPD) is fitted (season by season) to the peaks over threshold. Bearing in mind statistical and numerical robustness, we confine ourselves to a linear, but nevertheless widely excepted model. The combination of frequency analysis and the fit of the GPD finally leads to a concise and regionally differentiated evaluation of the changes in return levels of extreme weather events, which are expected to occur during the forthcoming 90 years.