Geophysical Research Abstracts
Vol. 14, EGU2012-13060, 2012
EGU General Assembly 2012

Joint probabilities of extreme precipitation and wind gusts in Germany

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Extreme meteorological events such as storms, heavy rain, floods, droughts and heat waves can have devastating consequences for human health, infrastructure and ecosystems. Concomitantly occurring extreme events might interact synergistically to produce a particularly hazardous impact. The joint occurrence of droughts and heat waves, for example, can have a very different impact on human health and ecosystems both in quantity and quality, than just one of the two extreme events.

The co-occurrence of certain types of extreme events is plausible from physical and dynamical considerations, for example heavy precipitation and high wind speeds in the pathway of strong extratropical cyclones. The winter storm *Kyrill* not only caused wind gust speeds well in excess of 30 m/s across Europe, but also brought 24 h precipitation sums greater than the mean January accumulations in some regions. However, the existence of such compound risks is currently not accounted for by insurance companies, who assume independence of extreme weather events to calculate their premiums.

While there are established statistical methods to model the extremes of univariate meteorological variables, the modelling of multidimensional extremes calls for an approach that is tailored to the specific problem at hand. A first step involves defining extreme bivariate wind/precipitation events. Because precipitation and wind gusts caused by the same cyclone or convective cell do not occur at exactly the same location and at the same time, it is necessary to find a sound definition of "extreme compound event" for this case. We present a data driven method to choose appropriate time and space intervals that define "concomitance" for wind and precipitation extremes. Based on station data of wind speed and gridded precipitation data, we arrive at time and space intervals that compare well with the typical time and space scales of extratropical cyclones, i.e. a maximum time lag of 1 day and a maximum distance of about 300 km between associated wind and rain events.

After modelling extreme precipitation and wind separately, we explore the practicability of characterising their joint distribution using a bivariate threshold excess model. In particular, we present different dependence measures and report about the computational feasibility and available computer codes.