Engineering Risk Analysis Group
Prof. Dr Daniel Straub

Master's Thesis - Environmental Engineering

Identification and Analysis of Serial Clustering of North Atlantic Winter Storms

Annemarie Büttner, February 2016

Background

European winter storms are the natural hazard which causes more (insured) losses in Germany than all other natural hazards combined. Especially extreme storm seasons pose a major socio-economic risk and lead to high accumulated losses, like in 1999 where Martin, Lothar and Anatol descended over Central Europe in a short period of time. The characteristic of North Atlantic winter storms to arise in groups and cause extreme storm seasons is called serial clustering. Clustering is quantified by the dispersion coefficient representing the variance-to- mean ratio of the seasonal storm counts. Dispersion coefficient values bigger than 0.1 imply statistically significant clustering behaviour of storms.

Methodology

Historical storms were extracted from 140 years of global 6-hourly wind speed data of the 20th Century Reanalysis. Additionally, decadal prediction models from the Canadian Climate Centre with 510 years and two models from the Max-Planck-Institute for Meteorology (MPI), namely MXMR (570 years) and MXEL (2860 years), were used to track storms. As continuative approach, single ensembles of future projections from 2006 to 2100 were regarded for the climate scenarios RCP 4.5 and RCP 8.5. The tracking was based on an impact-related storm definition that uses the local 98th wind speed percentile threshold to extract storms. Intense storms were filtered from all storms by their StormSeverity Index values and destructive storms by their damage potential.

Results

Serial clustering of winter storms over the North Atlantic and Europe could be proven and quantified in all models. The dispersion coefficient for all storms and the entire study area in the reanalysis is quantified with 0.54 (0.47 for destructive storms). The Canadian model indicates slightly higher and the MPI models slightly lower clustering.. Clustering is not equally distributed over Europe. The clustering hotspots in all models are the UK, Northern France, Southern Scandinavia, the Benelux states and Northern Germany. The pronounced clustering patterns are located at the flanks of the North Atlantic storm track. A general decrease of the dispersion coefficient value could be detected with increasing storm intensity and thus intense and destructive storms cluster less than all storms. In the long-term future projections, no significant changes in the clustering behaviour could be detected.

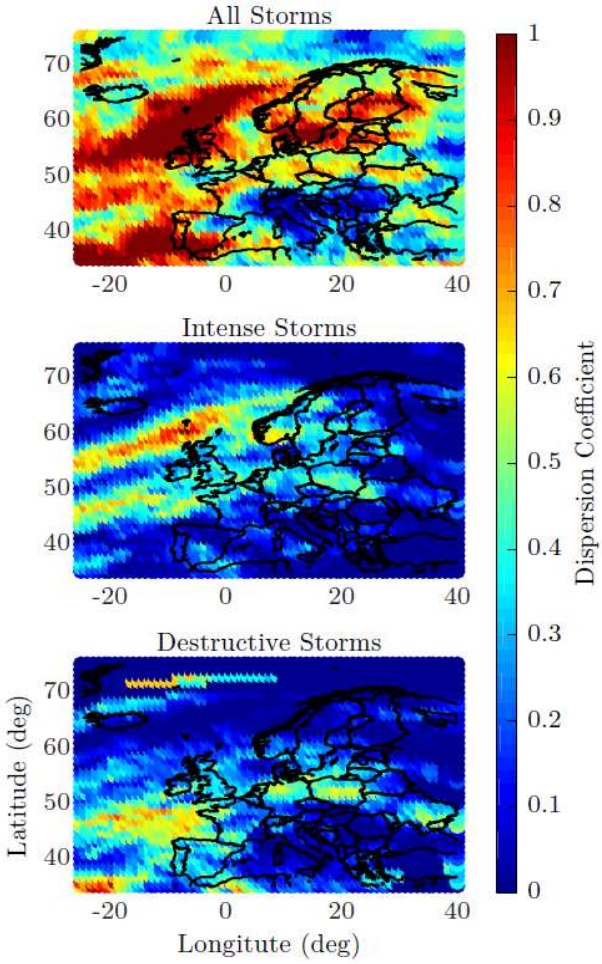

Figure: Clustering of 20th Century Reanalysis

In cooperation with Swiss Re
Supervised by M.Sc. Anke Scherb, Prof. Dr. Daniel Straub (TUM), Dr. Dominik Renggli (Swiss Re)