Engineering Risk Analysis Group
Prof. Dr. Daniel Straub

Master's Thesis - Environmental Engineering

Analysis of spatial correlation patterns of European storm events and their effect on infrastructure network reliability

Michael Neumayer, October 2016

Background

Many parts of everyday life depend on a sufficient supply with various resources. Therefore, the robustness of infrastructure systems is one of the most important factors for smooth functioning of society. Thus, it is necessary to determine the reliability of infrastructure systems and to be aware of the possible consequences of a system failure. Many power outages with severe consequences are related to spatial distributed natural hazards such as earthquakes or storm events. Hence, it is important to analyze the reliability of power grids subject to these natural hazards. The purpose of this thesis is to analyze whether there is a correlation between the spatial wind speed distribution patterns of European storm events, represented by the range of the underlying semivariogram model, and its effects on the reliability of a benchmark power grid.

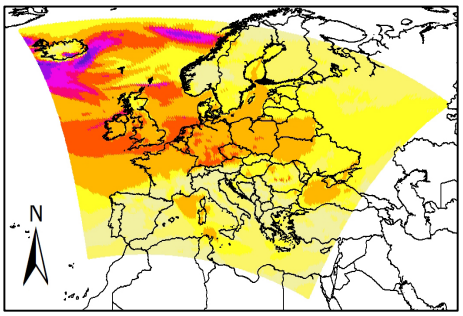

Figure 1: Illustrative European storm event

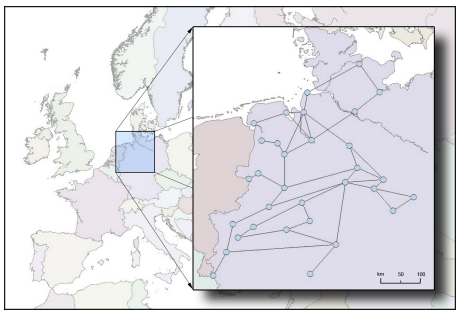

Figure 2: Utilized benchmark power grid

Methodology

The quantification of the spatial correlation patterns of European storm events is realized by means of semivariogram analysis. Here, the focus is on the range of the resulting semivariogram models. 52 European storm events are investigated throughout the analyses. The power grid model is based on the Nordic 32-bus benchmark system and it is located in the north-west of Germany. The grid is modeled as a complex graph and its failure probability associated with each of the 52 European storm events is determined by Monte Carlo Simulation. Here, the system failure event is defined as the case when the graph representing the power grid is not connected anymore due to failed transmission lines as a consequence of wind load

Results

It is found that the results of the semivariogram analyses of the investigated storm events are affected by high uncertainties. Furthermore, it is shown that there is a very weak correlation, if any, between the determined ranges of the underlying semivariogram models of the storm events and the modelled system failure probabilities of the power grid associated with each storm event. One of the main reasons for the weak correlation could be, that the ranges are determined based on the whole footprints of the storm events, while the power grid is only subject to a relatively small area of the considered storm events.

Supervised by M.Sc. Anke Scherb, Prof. Dr. Daniel Straub