Engineering Risk Analysis Group
Prof. Dr Daniel Straub

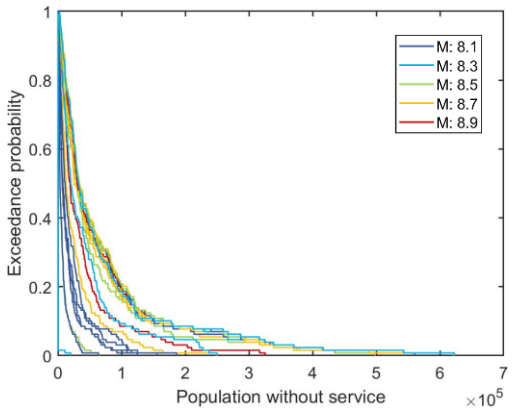
MSc thesis

Seismic and Tsunami Hazard Analysis and cascading Effects to the Power Network in Lima and Callao, Peru

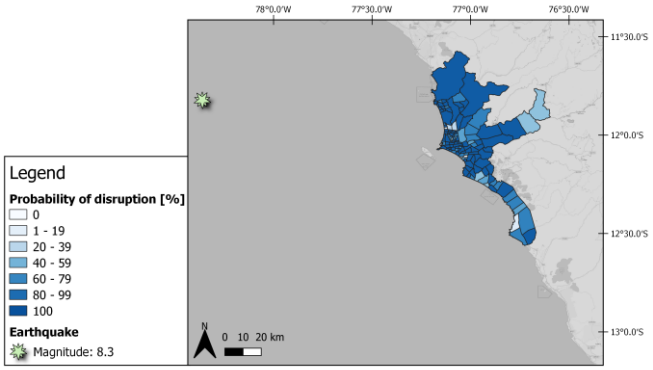
Cathrin Merscher, November 2020

Background

In 2017, Hurricane Maria caused a power outage in Puerto Rico that lasted for over ten months. Natural hazards can affect basic supply systems of a society. This study looks at a specific pair of natural hazards - high-magnitude earthquake followed by a tsunami wave and their effects on an electricity network. The consequences of damages caused by the two individual hazards along with damage propagation are calculated using network-based simulations. It is crucial to consider the damage profile of earthquakes and tsunamis separately as well as combined and use different fragility functions to evaluate the vulnerability of the components of the power network in Lima and Callao.



Exceedance probability functions for earthquake scenarios with different magnitude



Representation of consumer areas with respective probability of disruption due to an earthquake with magnitude 8.3

Methodology

The simulation method is evaluated for scenarios based on historical data, and subsequently for stochastic events. The necessary components of the method include the generation of seismic and tsunami hazard maps for different scenarios and the development of a network based on the power grid. Fragility functions are assigned to the components of the network. The simulation considers the direct effects of the two hazards and the cascading effect in the network itself. System vulnerability is measured by means of effects on areas of the population without service.

Conclusion

The results show a stronger loss of electricity for the areas with increasing magnitude considering both natural hazards. Some scenarios cause damage to the network only due to the tsunami. Regarding specific components of the power network two substations are more vulnerable to tsunami waves. With an occurrence probability of 0,27% for the stochastic scenarios the simulation suggests an overall risk for the population of Lima of 0,213%. That implies that every year 20,000 inhabitants are without electricity.

Supervised by M.Sc. Hugo Rosero

Prof. Dr. Daniel Straub