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On predicting future economic losses from tropical cyclones: Comparing damage functions for the Eastern USA

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Recent years have seen an intense scientific debate of what to expect from future tropical cyclone activity under climate change [1,2]. Besides the projection of cyclones' genesis points and trajectories it is the cyclone's impact on future societies that needs to be quantified.

In our present work, where we focus on the Eastern USA, we start out with a comprehensive comparison of a variety of presently available and novel functional relationships that are used to link cyclones' physical properties with their damage caused on the ground. These so-called *damage functions* make use of high quality data sets consisting of gridded population data, exposed capital at risk, and information on the cyclone's extension and its translational and locally resolved maximum wind speed.

Based on a cross-validation ansatz we train a multitude of damage functions on a large variety of data sets in order to evaluate their performance on an equally sized test sample. Although different damage analyses have been conducted in the literature [3,4,5,6], the efforts have so far primarily been focused on determining fit parameters for individual data sets. As our analysis consists of a wide range of damage functions implemented on identical data sets, we can rigorously evaluate which (type of) damage function (for which set of parameters) does best in reproducing damages and should therefore be used for future loss analysis with highest certainty.

We find that the benefits of using locally resolved data input tend to be outweighed by the large uncertainties that accompany the data. More coarse and generalized data input therefore captures the diversity of cyclonic features better. Furthermore, our analysis shows that a non-linear relation between wind speed and damage outperforms the linear as well as the exponential relationship discussed in the literature.

In a second step, the damage function with the highest predictive quality is implemented to predict potential future cyclone losses for the Eastern USA until the year 2100. The projection is based on downscaling five different GCM model runs for the RCP8.5 scenario, as conducted by Emanuel et al. [7], and accounts for population and GDP changes relying on the newly developed Shared Socioenonomic Pathways (SSPs) [8]. We hereby contribute valuable input to the scientific community as well as the societies at risk.

The possibility of extending this work to different regions in order to access the future impact of tropical cyclones on a global scale will also be discussed.

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