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Creating a global database with return periods of extreme sea levels caused by tropical and extratropical cyclones

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Storm surges are driven by low air pressure and strong winds in tropical (TC) and extratropical cyclones (ETC). Coastal flooding is often caused by this type of extreme weather with large socio-economic impacts in densely populated and low-lying coastal areas. Recent examples of coastal disasters include typhoon Hagibis that made landfall in Japan, Hurricane Dorian which devastated the northwestern Bahamas, and extratropical cyclone Xaver that affected northern Europe. Each of these storms generated dangerous storm surges, reaching 6m in some parts of the Bahamas during Hurricane Dorian with approximately 100 fatalities as a result. Economic losses are estimated at 10 billion U.S. Dollars for both typhoon Hagibis and hurricane Dorian.

To inform flood risk management and develop effective adaptation strategies it is important to have accurate information on return periods of extreme sea levels. To date, there exists no global database with return periods of extreme sea levels that fully includes TCs. Global databases of extreme sea levels are typically based on historical climate simulations covering multiple decades. While this is sufficient for ETCs, TCs will be underestimated in such databases. This because TCs have generally low probabilities and affect only a small stretch of coastline, compared to ETCs. A climate reanalysis covering multiple decades includes too few TCs to perform an extreme value analysis. To resolve this, previous studies at local scale have used synthetic TC tracks generated by a statistical model to estimate the probabilities of extreme sea levels.

The aim of this research is to develop a global database of extreme sea levels that include both ETCs and TCs. For ETCs, we force the hydrodynamic Global Tide and Surge Model (GTSM) with ERA5 10-meter wind speed and air pressure data to calculate the return periods of extreme sea levels based on the period 1979-2017. Since ERA5 includes all storms, we filter out extreme sea levels caused by TCs. Preliminary results show that GTSM forced with ERA5 atmospheric data performs well for ETCs. For TCs, we force GTSM with synthetic TC tracks that correspond to 10.000 year of TC statistics. The synthetic tracks of TCs are obtained from the STORM model (Bloemendaal et al., in review) based on the International Best Track Archive for Climate Stewardship (IBTrACS) TC database. With STORM it is possible to statistically extend the ~38-year observed dataset to a 10.000-year synthetic dataset. The synthetic dataset preserves the climatological statistics as found in the original dataset. Finally, we will merge the TC and ETC related return periods to create a global extreme sea level database.