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Changes in extreme storm surge events in Southern Europe

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Coastal areas are particularly vulnerable to climate variability and changes in sea level. Extreme sea level events have immediate impacts on the coast. A key component of the sea level is the storm surge (sea level variation due to wind and atmospheric pressure gradients). Thus, in this work we have used a storm surge hindcast and a time-dependent extreme model to estimate changes in magnitude and frequency of extreme storm surge events. A common approach to explore changes in extreme values is the percentile time series analysis. Here, we have applied a time-dependent Pareto-Poisson model to obtain the level associated with a specific return period as well as long term trends.

A set of 61-year (1948-2009) high-resolution storm surge hindcast named GOS (Global Ocean Surges) has been performed in Southern Europe using the Regional Ocean Modelling System (ROMS) of Rutgers University. The model domain encloses Southern Europe, including the Mediterranean Sea and the Spanish Atlantic coast, with a horizontal resolution of 1/8º ($\sim$ 13 Km). ROMS model was driven hourly with a high-resolution atmospheric dataset of 30 Km. The atmospheric dataset, named SeaWind reanalysis, is the result of a dynamical downscaling: a regional re-forecast coupling the WRF-ARW model to NCEP reanalysis. Surge elevations calculated by ROMS model were validated with measures from tide gauges and also with altimetry data. The accuracy of the simulation was quantified by means of key statistical parameters, such as correlation factor, bias and root mean square error. A good agreement between modelled and measured data was found, showing the capability of the model to simulate accurately sea level and extreme storm surge events.

GOS database was used to estimate long-term trends in the storm surge events. The extreme values have been defined by the Peak Over Threshold technique. The threshold for each grid cell has been set at the 99.5 percentile of the complete record considering three days independence between storms. After applying this method, a description of the extreme values in terms of occurrence rate per year of events and persistence over the threshold is provided. We have found completely different patterns in the duration of the extreme events (around 20 hours in the Atlantic area whilst 10 hours is the mean in the Mediterranean Sea). Long-term trends in storm surge are analyzed by including lineal trends on scale parameter of Pareto and Poisson parameter just in the case they are statistically significant. Model parameters were estimated by maximum likelihood. Changes on fifty-year return level have been estimated. Results show spatial patterns on trends in the Mediterranean Sea. Positive and negative trends are found in terms of magnitude but only negative trends are observed from the frequency analysis.

Keywords: Storm surge, extreme events, hindcast, Pareto, Poisson, extreme value model, non-stationary