Extreme wave events attribution using ERA5 datasets for storm-surge studies in the northern Adriatic sea

Federico Porcu¹, Leonardo Aragão¹, Margherita Aguzzi², Andrea Valentini², Sisay Debele³, Prashant Kumar³, Michael Loupis⁴, Myriam Montesarchio⁵, Paola Mercogliano⁵, and Silvana Di Sabatino¹

¹Department of Physics and Astronomy, University of Bologna, Italy (federico.porcu@unibo.it)
²Hydro-Meteo-Climate Service of ARPAE Emilia-Romagna, Bologna, Italy
³Department of Civil and Environmental Engineering, University of Surrey, Guildford, United Kingdom
⁴Innovative Technologies Center S.A., Athens, Greece
⁵CIRA, Capua, Italy

Extreme hydro-meteorological events are often defined by the statistical analysis of some parameter that measures the strength of the event over a long enough time series. The parameter could refer to the intensity of the event in terms of energy or to the impact of the event on the environment. This attribution becomes even more relevant when used as reference for future climate projections, suggesting a possible increase in the number of extreme events considering the attribution applied to the past database.

In the literature concerning storm-surge, the use of significant wave height (Hs) percentiles to define thresholds of an extreme event is a common practice when dealing with sufficiently long datasets. Usually, this value ranges from 90th up to 99.5th trying to highlight about 3-6 Hs peaks per year. But, in fact, thresholds should provide a benchmark for how much a region can withstand an extreme event. The Italian coast of the northern Adriatic is recently increasing its sensitivity to such episodes, that threaten one of the most active touristic hub of Italy, the highly valuable Po Delta UNESCO Biosphere Reserve and city of Venice fragile structure. Recently in late 2019, a strong event hit Venice with high tides flooding the city's main monument, St. Mark's Basilica, for the 6th time in 1200 years, with levels very similar to the worst event in history in 1966.

Attempting to better understand the distribution of these extreme events throughout last decades and how reanalysis products can be useful for storm-surge studies, this paper presents a climatological comparison of significant wave height data extracted from ECMWF ERA5 against the entire historical series available to the Nausicaa wave buoy. This station, owned and managed by ARPAE, is located about 8 km offshore the Municipality of Cesenatico, where the seabed is about 10m, and since 2007 has been used to monitor and prevent sea level related events. In the last 12 years, at least 10 extreme events have been reported based on hourly measured data in Nausicaa and the damage observed along the coast, allowing the local authorities to define Hs thresholds as 1.5 m to significant events and 3.0 m for extreme events. However, analysing the measured data in this period, at least 26 events that exceeded the 3 m threshold were observed, representing the
percentile 99.81th of the historical series, whereas only 10 storm-surge events resulted in damage to cities or environmental protection areas. When analysing Hs extracted from ERA5 at the nearest grid point to Nausicaa (~ 30 km) for the same 26 events, all events were correctly identified by reanalysis and represented with an averaged correlation of 0.96. For Hs series extracted from ERA5, values above 3 m reached the 99.83rd percentile for the same period from 2007 to 2018, and 99.84th when expanded to the last 30 years (since 1989), showing that, although quite restricted, the 99.8th percentile seems to be a good value for identifying extreme events of storm-surge in the northern Adriatic Sea.