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Storm surge distribution along the Mediterranean coast: Characteristics and evolution

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Abstract

This study describes the evolution sea level extremes along the Mediterranean coasts that results from a 4-member model ensemble of model simulations covering the period 1951-2050 under the A1B emission scenario. The results are obtained by forcing a hydro-dynamical shallow water model (HYPSE) with 6-hourly meteorological fields produced by state-of-the-art global and regional climate models that have been used in the CIRCE fp6 project. The climate change signal is computed as the difference between severe storm surge statistics in the 1971-2000 and 2021-2050 periods. All sea level time series are filtered in order to cancel sea level rise and steric effects and consider only the contribution due to marine storminess. Results show that large sea level extremes occur only in the North Adriatic and in the Gulf of Gabes and this situation does not change in future climate scenarios. Further extreme values are not expected to significantly change during the next decades because of changes in storminess. However, changes in mean sea level and land subsidence (which are not considered in this study) might change significantly the frequency of coastal floods in spite of the low sensitivity of storminess to climate change.

Keywords: storm surge, climate change, Mediterranean coast, marine storminess, sea level

1. Introduction

Floods produced by storm surges are an important issues for many Mediterranean coastal areas as documented by case studies (e.g. Nichols and Hoozemans, 1996) on cities (Venice and Alexandria), deltas (Nile, Po, Rhone and Ebro), and islands (Cyprus, Crete). The severity of future floods depends on sea level rise, vertical land motion and

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marine storminess. This study describes the effect of this last factor in the present and future climate conditions, attempting to consider this issue at basin scale. This analysis integrates previous studies, which have recently addressed specific stretches of the Mediterranean coastline (e.g. Ullmann et al., 2007 and 2008; Sánchez-Arcilla et al., 2008; Mosso et al., 2009, Snoussi et al., 2008 among others) with a sequence of studies focusing on the Adriatic Sea (Lionello, 2005; Lionello et al., 2003; 2012a; 2012b).

This study uses an ensemble of recent climate simulations for forcing a barotropic tide surge model and studying the present distribution and the future evolution of storm surge extremes. Barotropic circulation models are a consolidated tool for investigating the effect of wind and atmospheric pressure variations on sea level at various time scales (e.g. Gomis et al., 2008), who investigated the role of pressure and wind on Sea level low frequency variability. In summary, we use a set of climate scenarios, which describe the evolution of mean sea level pressure (MSLP) and surface wind fields, for computing the corresponding evolution of sea level extremes.

Our analysis considers both maxima and minima (that is positive and negative surges). Positive surges are produced by pressure minima and wind blowing towards the shore in shallow waters. Negative surges are produced by pressure maxima and offshore winds (we consider both positive and negative extremes). Astronomical tide is not included, but it can be separately computed and added to storm surge levels for obtaining the actual sea level fluctuations. However, it has been shown that the effect of climate change on astronomical tide is small in the Adriatic basin (Lionello et al., 2005) and consequently negligible in the rest of the basin where its level is small. This study contributes new information to the existing literature on this subject (e.g. Marcos et al. 2011), because it is based on a new set of climate simulations, which include a high resolution interactive Mediterranean sea as a climate mode component a representation of the air-sea interaction that is more accurate than in previous studies.

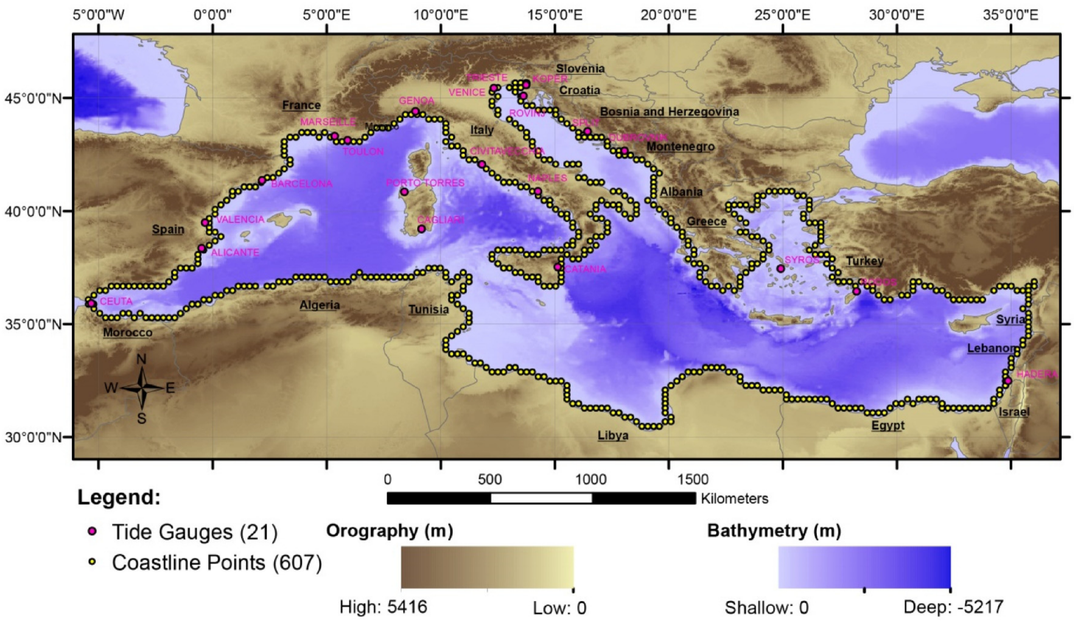

Fig. 1. Bathymetry of the Mediterranean sea. Yellow dots denote the coastal grid points used in the following figure2 for climate change analysis.

2. Data and methods

This study analyses future changes of storm surge extremes under the A1B climate scenario, which gives an intermediate level of warming among the 6 IPCC scenario groups described in Nakićenović et al. (2000). The four climate scenario datasets have been produced in the CIRCE project (Gualdi et al., 2012) and contain a sequence of 6-hourly meteorological fields covering the period 1951- 2050: