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A synoptic climatology of sea surges in the Atlantic coast of SW Europe

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Outputs currently available from AGCM agree to predict a significant global sea-level rise for the present century. Such sea level rise will lead a gradual retreat of the coast line, but the largest impacts will be linked to episodically events of strong atmospheric forcing represented by deep atmospheric disturbances, especially if they combine with extreme astronomical high tides. Moreover, at local and regional scale, the interaction between the prevailing flows during such events and the actual orientation of the coast line will accelerate or mitigate such impacts. The objective of this contribution is to assess the local and regional atmospheric conditions conductive to sea surges along the Atlantic coast of southwestern Europe (from Brittany to the Gibraltar Strait). To explore the atmospheric mechanisms responsible for the sign and magnitude of sea surges, we combined a regional Eulerian approach (a synoptic typing), a larger-scale Lagrangian method, based on the analysis of storm-tracks over the Atlantic, and synop reports from the closest meteorological stations to the tide gauges. Furthermore, the role played by the North Atlantic Oscillation and other major modes of atmospheric circulation is explored. The tide gauge data set consists of 10 stations disseminated along the French, Spanish and Portuguese coasts. Hourly data between 1992 and 2005 were provided by Puertos del Estado and Instituto Español de Oceanografía, for the Spanish stations, and by the Coastal Sea Level Monitoring System SONEL for the French ones. Data from the Portuguese station of Cascais was retrieved from the University of Hawai Sea level Center web site (http://uhslc.soest.hawaii.edu/). Surface meteorological variables (sea level pressure and wind speed and direction) were retrieved from ISWHO (Integrated Surface Hourly

Observations) CD Rom collection. Sea level pressure, surface 10m U and V wind components gridded data were obtained from ECMWF ERA40 Reanalysis. Storm tracks and cyclone statistics were extracted from the CDC Map Room Climate Products Storm Track Data (http://www.cdc.noaa.gov/map/clim/st_data.html). Our results show that positive surges, more frequent in fall and early winter, are linked to extratropical disturbances tracking from Central Atlantic to Europe, accompanied by strong westerly, southwesterly and northwesterly winds. Conversely, stable circulations, due to the displacement of the Azores High to the area or the blocking of continental cells over the British Isles or Western Europe, driving Northeasterly and Easterly winds, are the genesis of the negative surges. As a whole, winds are less relevant as meteorological forcing than air pressure in the magnitude of the surges, although they modulate the regional differences between areas well exposed to the predominant westerly and southwesterly winds, like the French coast, where the variability of surge heights is larger due to the wider shelf, and the more sheltered areas, like the Gulf of Biscay, where the piling up effect of the northwesterly winds is balanced by the pressure rise behind cold fronts and a narrower shelf. A principal component analysis upon daily maximum meteorological residuals highlighted the homogeneous behavior of the tide gauges, which allow us to perform a regionalization and provided with a regional quantitative index to identify the largest storm surges (top 95%) at regional basis. The climatology of several characteristics of the extratopical cyclones responsible for those extreme events (track, location during the events, deepening/filling rate, speed) was also performed. The signal of the North Atlantic Oscillation is stronger at the southern tide gauges, while in the northernmost observatories the coherence with the NAO index is better at decadal than at interannual basis. The comparison between winters with comparable NAO index but different storm tacks and locations of the high pressure cells highlight some clues about the problem.