Geophysical Research Abstracts
Vol. 16, EGU2014-11299, 2014
EGU General Assembly 2014

Evaluation of coastal vulnerability: comparison of two different methodologies adopted by the Emilia-Romagna Region (Italy)

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In the last years a large number of catastrophic events have occurred along worldwide coastlines (e.g.: 2012 Superstorm Sandy, US East Coast). European countries have to face similar calamities such as those caused by the recent Xaver cyclone (December 2013).

The Emilia-Romagna coastline, Italy, along the North Adriatic Sea, is affected by storms that cause extensive damages. The coast has low elevations, is highly urbanised and there is a massive presence of defence structures. The area is micro-tidal (neap/spring tide ranges = 0.4/0.8 m), low energetic (65% Hs<=1 m) but subjected to significant surge levels (1 year return period = 0.85 m). Therefore an evaluation of the vulnerability of the coastal area is an urgent matter.

The Regional Geological Survey has completed an analysis of three scenarios of damage produced by the concurrent happening of a marine storm and high surge levels (1-in-1, 10, 100 year return period) and high spring tidal levels (+0.45 m MSL). Wave heights were used to calculate run-up values along the whole coastline (on 187 equally spaced profiles extracted from LIDAR datasets). The result is a list of ten typology of different levels of damage obtained through the comparison between the computed water levels, for each scenario and along each profile, and the topography/human occupation of the coast. The assessment reveals that 60% of the coastline is vulnerable to the 1-in-1 year return period scenario, thus even modal meteorological conditions can generate significant losses. A comparison was made between the produced typologies and the actual damage caused by a recent storm and the correspondence is almost identical, underlining that the method is reliable.

Because the above-mentioned methodology is only punctual, the Geological Survey has started a different evaluation of the areal extension of inundations. The methodology considers the concurrent happening of the same return period storms but in terms of wave set-up only (not including run-up) plus surge levels (extracted from the literature) plus high spring tide level. To find the extension of inundated areas and the intrusion distance of marine water inland, the Cost-Distance tool of ArcGIS was used. The tool is able to evaluate the contribution of each “cell”, in which the coast has been divided (from LIDAR data), to avoid or favour the water movement inland, considering its location with respect to the shoreline, its elevation above MSL and the elevation/location of nearby cells. It does not account for water infiltration and terrain roughness, therefore, to avoid getting unrealistic results, an attenuation artifice was introduced: the maximum water level surface, calculated for each return period, is projected inland following a sloping plane. The intrusion distance is determined by the intersection of the oblique water surface and the ground. This artifice, together with the Cost-Distance tool, produces consistent results if compared to observed inundations with similar return periods.

A further implementation of coastal vulnerability assessment will be performed through numerical modelling and Bayesian approaches (RISC-KIT EU Project, www.risckit.eu, GA 603458).