Analysis of overflow and wave overtopping of the Scardovari lagoon levees

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ABSTRACT

This paper studies the Scardovari lagoon (Po Delta, Italy) in relation to the coastal flooding of the low-lying rear area, that is protected by earth levees. The paper aims at identifying the critical stretches, also in view of climate changes. Three different scenarios are investigated considering both the future sea-level rise and the rate of subsidence that affects the area. Field measurements, numerical models and analytical tools are used to define the overflow and wave overtopping. It is found that the critical stretches that require mitigation measures are mainly located in the North-eastern sector.

KEY WORDS: coastal flooding; numerical model; ADCIRC; STWAVE; coastal levee; Po Delta.

INTRODUCTION

Deltas are dynamic and fragile systems, subject to rapid alterations due to natural processes and anthropogenic pressures. Sea storms, natural and human-induced subsidence and other threats that affect such areas will probably be exacerbated due to the expected sea-level rise (Nicholls et al. 2010). These environments, therefore, require careful monitoring in order to safeguard their environmental and economic value. Accurate management of these territories assumes a compelling role concerning: (i) the protection from coastal flooding (hydraulic defense of the hinterland); (ii) the preservation of the existing production activity (for instance fishing and aquaculture); (iii) the safeguarding of the environment (habitats).

The Po Delta is the biggest Italian wetland, covering an area of about 400 km² (Simeoni & Corbau, 2009). The coast is characterized by low sandy and vulnerable barrier islands that separate lagoons from the sea. The lagoons are wide shallow water bodies bordered with coastal levees that protect the inland that has elevations almost completely below sea level. The breeding of mussels and clams here represents the main production activity.

During the recent extreme meteorological events (October 2018 and November 2019) occurred in the Venetian coast, the entire Po Delta area was affected by erosion of the coastal sandbanks. In the lagoons behind, the effect of storm surges in combination with waves has led to erosion, localized instability of the first defense line (coastal levees), and the filling of some of the lagoon channels with consequences on the delicate ecosystems.

The objective of this study is to identify the critical stretches of the coastal levees located in the perimeter of the Scardovari lagoon, in the Southern Po Delta, in relation to the risk of flooding in view of climate change, considering short, medium and long term scenarios. These scenarios account for subsidence rate and sea-level rise predictions.

The failure mechanisms that can occur along these levees (Özer et al. 2020) are correlated to geotechnical phenomena, for instance internal/external erosion or instability, and to hydraulic phenomena, i.e. overflow and overtopping. Since this study focuses on flooding hazard, only the latter mechanisms are investigated.

For this purpose, a set of field measurements and numerical simulations of wind setup and waves are carried out. The ADCIRC (ADvanced CIRCulation, Luettich and Westerink, 2004) and the STWAVE (STeady-state spectral WAVE, Smith, 2001) models are used to evaluate respectively the wind set-up and the waves along the lagoon perimeter. The two models represent the state-of-the-art modelling tools for coastal flooding assessment (Spaulding et al., 2016). The overflow and wave overtopping are predicted thanks to the Eurotop (2018) formulae and used to highlight the most vulnerable stretches along the coastal levees.

This study is a preliminary analysis that will be confirmed by ongoing research, in the framework of a project supported by a regional administration (Agenzia Interregionale per il fiume Po). The final expected result is a set of design guidelines, that include the upgrading of the existing typical levee cross-sections to favour resilience and adaptability.

In addition to this introduction, this paper includes three main sections and a concluding paragraph. First, the methods are described. Then the case study (Scardovari lagoon) is detailed, and the results of the numerical simulations are presented. In the last section, the overtopping