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Storm-induced risk assessment: Evaluation of two tools at the regional and hotspot scale

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ABSTRACT

Coastal zones are under increasing risk as coastal hazards increase due to climate change and the consequences of these also increase due to on-going economic development. To effectively deal with this increased risk requires the development of validated tools to identify coastal areas of higher risk and to evaluate the effectiveness of disaster risk reduction (DRR) measures. This paper analyses the performance in the application of two tools which have been developed in the RISC-KIT project: the regional Coastal Risk Assessment Framework (CRAF) and a hotspot early warning system coupled with a decision support system (EWS/DSS). The paper discusses the main achievements of the tools as well as improvements needed to support their further use by the coastal community. The CRAF, a tool to identify and rank hotspots of coastal risk at the regional scale, provides useful results for coastal managers and stakeholders. A change over time of the hotspots location and ranking can be analysed as a function of changes on coastal occupation or climate change. This tool is highly dependent on the quality of available information and a major constraint to its application is the relatively poor availability and accessibility of high-quality data, particularly in respect to social-economic indicators, and to lesser extent the physical environment. The EWS/DSS can be used as a warning system to predict potential impacts or to test the effectiveness of risk reduction measures at a given hotspot. This tool provides high resolution results, but needs validation against impact data, which are still scarce. The EWS/DSS tool can be improved by enhancing the vulnerability relationships and detailing the receptors in each area (increasing the detail, but also model simulations). The developed EWS/DSS can be adapted and extended to include a greater range of conditions (including climate change), receptors, hazards and impacts, enhancing disaster preparedness for effective risk reduction for further events or morphological conditions. Despite these concerns, the tools assessed in this paper proved to be valuable instruments for coastal management and risk reduction that can be adopted in a wide range of coastal areas.

1. Introduction

Storms impacting coastal areas are responsible for severe hazards (e.g., overwash, inundation, erosion) that can lead to the destruction of goods and loss of life in occupied areas. Recent examples of the above include the severe coastal erosion caused by Storm Hercules on the coasts of France and England (Castelle et al., 2015; Masselink et al., 2016a,b) and the associated destruction of assets; the inundation and loss of life in association with Storm Xynthia in France (e.g., Garnier and Surville, 2011; Bertin et al., 2012; Vinet et al., 2012); the vast destruction due to Superstorm Sandy in the Caribbean and USA (Bennington and Farmer, 2015; Clay et al., 2016), to Hurricane Katrina in the USA (Link, 2010; Kantha, 2013), and to Typhoon Haiyan in the Philippines. Those events highlight how coastal hazards pose a significant risk worldwide and can impact large cities or regions. Potential damages and risks are expected to increase in the near future not only in association with climate change

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and sea level rise, but also due to the increasing human occupation and economic development in coastal areas (IPCC, 2014; Neumann et al., 2015). The development of methods for detailed assessment of the risk in coastal regions and the evaluation of the effectiveness of disaster risk reduction (DRR) measures is, therefore, required. The development of such tools is important to prevent, or mitigate disasters; promote early warnings to stakeholders; and decide the best management options with the limited resources available to coastal managers. This topic has been of particular concern at the European level and funding has been awarded to projects devoted to mitigating risks at coastal areas, such as the RISC-KIT project (Resilience Increasing Strategies for Coasts – Toolkit; www.RISCKIT.eu).

The main goal of the RISC-KIT project was to provide such tools to the coastal community (scientists, technicians, managers), at different levels (for details see Van Dongeren et al., 2017). These tools include a Storm Impact Database (Ciavola and Harley, 2017) which stores information on storm event impacts; a web-based management guide which documents the available DRR measures (Stelljes et al., 2017); and a multi-criteria assessment to help choosing the best management solutions using a participatory approach (Barquet and Cumiskey, 2017). Among the developed tools two are devoted to identify the areas of highest storm-induced risk and to evaluate the effectiveness of DRR measures:

A) The CRAF (Coastal Risk Assessment Framework; see Viavattene et al., 2017b) with two goals: i) hotspot identification at the regional scale (order of ~100 km); and ii) risk evaluation and ranking within selected hotspots. In this paper hotspots (HS) are defined as locations where risk due to extreme hydro-meteo events (e.g., storms) is highest along the coast and high-resolution modelling is recommended to further assess the coastal risk.
B) An early warning system coupled with a decision support system (EWS/DSS) with two main uses: i) as an Early Warning System just prior to a storm event; and ii) as an assessment tool to evaluate potential hazards and the effectiveness of DRR measures well before an event.

The main goal of this paper is to critically review the performance and experience in application of these two tools; to provide insights on how they should be applied; and to discuss their potential, limitations and need for further improvements, based on their application in ten case studies covering the European regional seas. After a summary of the case studies and of the risk assessment tools, the paper presents an evaluation of the tools and ends with a summary of the main application potential and restrictions to their use. For specific details on the application of the tools in each case study, we refer the reader to the set of case study papers in this special issue (see Van Dongeren et al., 2017).

2. Case studies

The RISC-KIT case studies (Fig. 1) include sites on every European regional sea, with diverse characteristics in terms of geomorphic setting, land use, forcing and hazard type, as well as distinct socio-economic, cultural and environmental aspects. The sites considered are located on: the Atlantic Ocean (La Faute-sur-Mer – France and Ria Formosa – Portugal); the Mediterranean Sea (Tordera Delta – Spain, Bocca di Magra and Porto Garibaldi-Bellochio – Italy); the Black Sea (Varna – Bulgaria); the Baltic Sea (Kristianstad – Sweden and Kiel Fjord – Germany); and the North Sea (North Norfolk – United Kingdom and Zeebrugge – Belgium).

The diversity of the sites can be summarized as follows:

a) *Hydro-meteo forcing*, as relatively low wave energy in small or enclosed seas (Mediterranean, Adriatic, Baltic and Black Sea) when compared to more exposed coasts (Atlantic and North Sea), different tidal ranges (from macro-to microtidal), influence/absence of fluvial/estuarine interaction, and high (e.g., Adriatic and North Sea coasts) to

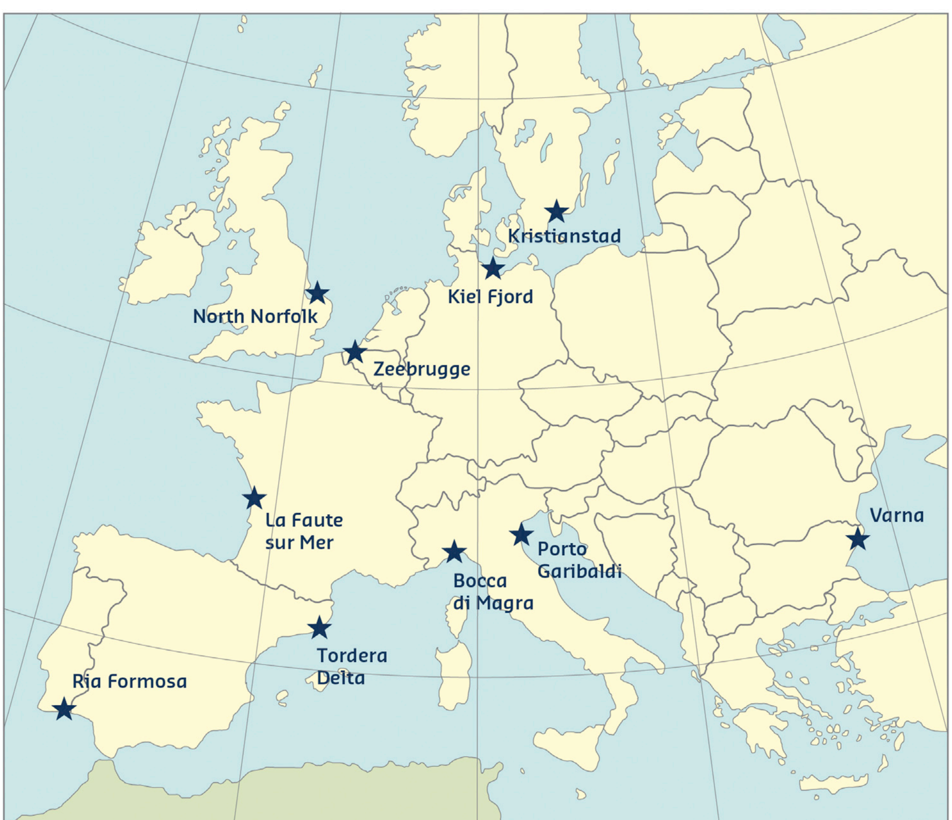

Fig. 1. RISC-KIT case study sites location (from Van Dongeren et al., 2017).