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Coastal flood analysis and visualisation for a small town

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ABSTRACT

Extreme sea levels and floods are a widespread threat to coastal communities, and sea-level rise is increasing the probability of such events. This paper describes how inundation modelling was used to engage local stakeholders about climate change and adaptation, for a town (Yarmouth) on the UK south coast. This included a participatory visualisation exercise using three extreme sea level scenarios, informed by a recent flood event. Further analysis, informed by the repeated floods during the 2013/14 storm surge season, placed these scenarios in a broader perspective across a range of events. Results indicate that coastal flooding may become a significant issue during this century due to sea-level rise, unless there is adaptation. These methods engaged the interest of the community, and this paper presents practical considerations for future studies. A similar approach could be applied widely at the community level and form an important component of coastal flood management, including planning responses to sea-level rise.

1. Introduction

The low elevation coastal zone below 10 m is home to 600 million people and is vulnerable to the effects of extreme sea level events and climate change (e.g. McGranahan et al., 2007; Lichter et al., 2010). There have been considerable improvements to risk management since the 31 January-1 February 1953 North Sea storm floods (which killed >2100 people in northern Europe – Baxter, 2005; Gerritsen, 2005; Jonkman and Kelman, 2005) and the 1962 Elbe floods (which killed 300 people in Hamburg, Germany – Bütow, 1963). However there are still deadly coastal flood events from storm surges, recent examples include Hurricane Katrina (US Gulf coast, August 2005), Cyclone Nargis (Myanmar, May 2008), Storm Xynthia (French Atlantic coast, February 2010), Hurricane Sandy (US east coast, October 2012), and Typhoon Haiyan (Philippines, November 2013). On 5–6 December 2013, the UK and neighbouring north-west European countries experienced a surge event similar to that of 1953, although defences and flood warnings reduced the impact (Wadey et al., 2015). Despite safety measures, the UK and coastal regions worldwide face sea level rise (SLR) alongside coastal population and economic growth, which are increasing exposure and risk to flooding (Evans, 2004; Haigh et al., 2010a,b; Haigh et al., 2011; Hallegatte et al., 2013; Stevens et al., 2014). Without adaptation 0.2–4.6% of the global population may be flooded annually in 2100 with scenarios of 0.25–1.23 m global mean SLR (Hinkel et al., 2014). Adaptation can greatly reduce these impacts, although timely, well-informed decisions are essential.

The aim of this paper is to provide a flood modelling case study for a coastal town (Yarmouth, Isle of Wight, south coast UK). This stems from a project carried out by local government to engage and educate the community to adapt to the impacts of climate change (HCC, 2014). There are few published case studies at this local scale

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which, in combination, describe and evaluate coastal flood modelling, visualisation and community participation. Yarmouth is within the Solent, a region with a large (and growing) coastal population that is exposed to coastal flooding (Stevens et al., 2015). Some areas do not have flood defence systems hence are susceptible to the impacts of SLR (Wadey et al., 2012). In this context, there has for some time been recognition that public participation, consultation, and provision of information should play a larger role in flood risk management and adaptation decisions (*c.f.* O'Riordan and Ward, 1997; Fordham, 1999; Jude et al., 2006). Landscape visualisation of model simulations can quickly convey strong messages, condense complex information, engage people in issues of environmental change, and motivate personal action (Nicholson-Cole, 2005; Sheppard, 2005, 2012). Combining high resolution data, numerical flood models and visualisation tools provide opportunities for society to respond to virtual, as well as real, flood events. Model exercises have been shown to be a powerful tool in changing perceptions of flood risk without waiting for an event to occur (Evans et al., 2014).

The three main objectives of this paper are:

1. Describe a participatory visualisation exercise for coastal flooding. This is an account of the production of detailed visualisations of coastal flood events, using a small number of community-selected scenarios (present day extreme sea levels and with SLR);
2. Place the results of (1) in context with coastal flood events across a wider range of simulations and background data, especially to reflect experiences during the stormy winter of 2013/2014 which caused repeated surges and coastal floods. It is explained how (1) and (2) can be complementary and reinforcing.
3. Develop generic lessons for the application of these types of methods elsewhere.

The structure of this paper is as follows: the project and case study area are described (Section 2) followed by an overview of the data and methods (Section 3). Section 4 describes the outcomes of the first two objectives; followed by discussion and conclusions which meet objective 3 (Section 5).

2. Background

Yarmouth is a small port and market town within the Solent (a body of water between the mainland England and the Isle of Wight) (Fig. 1). Sea level and flood history analysis has indicated that the region has experienced regular coastal flooding over the 20th and early 21st century, often resulting in property damage, but with no known loss of life (Ruocco et al., 2011). Anecdotal evidence suggests that more severe events occurred in the 19th and early 20th centuries (Lamb, 1991; West, 2010), and a total of 25,000 properties are theoretically exposed to a 1 in 200 year sea level event (Wadey et al., 2012). The Solent is renowned for its complex tides (Pugh, 1987), as the M_4 and M_6 constituents are relatively large compared to the amplitude of the semidiurnal lunar (M_2) tidal constituent. The tidal range at Yarmouth is approximately 2 m, whilst meteorologically-induced changes to sea level (primarily storm surges) in the region rarely exceed 1 m, and there is only a 0.41 m difference between the 1 in 10 and 1 in 1000 year extreme sea level event at Yarmouth (McMillan et al., 2011). The largest surges in the Solent are formed from low pressure systems that move from the Atlantic eastward over southern England (Haigh et al., 2004), although large North Sea surge events are also transmitted into the English Channel through the Dover Strait (Law,

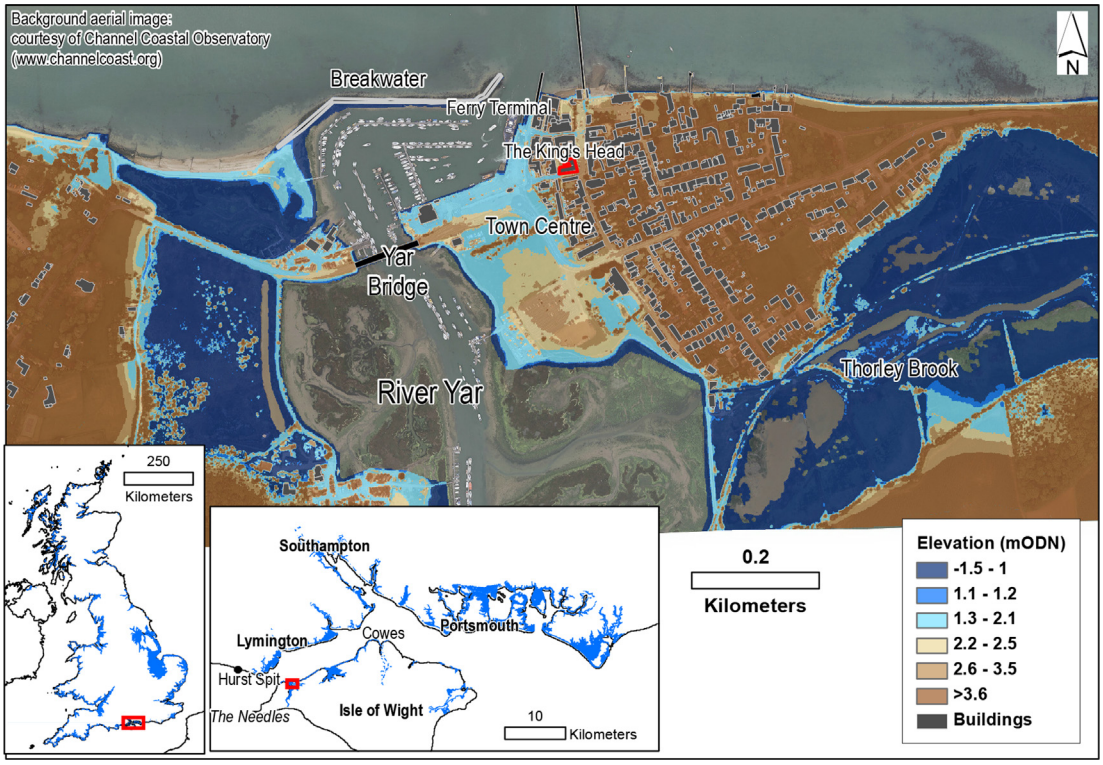

Fig. 1. Location map of Yarmouth showing topographic heights, defences and buildings. The UK (lower left), and the Solent flood plains (lower central) are also shown (UK coastal floodplain is estimated from land heights <5mODN using SRTM DEM from NASA/NGA/DLR/ASI; Solent floodplain is an outline of land below a 1 in 200 year sea level from Wadey et al., 2012). The datum mODN is mean sea level at Newlyn, Cornwall between 1915 and 1921.