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Storm surge and river interaction in etuaries

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In coastal areas, particularly in regions developed on estuaries, extreme river flow can combine with storm surges to present a combined hazard. This combined risk is likely to be more prominent in estuaries where fluvial fresh water input comes from catchments in hilly regions where the dependence of extreme river discharge and sea level elevation can be most statistically significant (Svensson and Jones, 2004). The risk associated with these combined coastal hazards could increase due to climate change if there were an increase in the frequency of extreme weather events. The global (IPCC, 2007) and local (Woodworth et al., 2009) rise in mean sea-level will increase the magnitude of extreme sea levels and surges will act on a higher coastal sea level and therefore increase the risk to coastal property and infrastructure. This may be associated with an increase in precipitation during extreme storm events which will have a large impact on river flooding. Therefore, the need for accurate operational forecasting of storm events will increase with the focus shifting to changes in the extreme 'tail end' of the distribution of storm events. Ideally an operational model that integrates storm surge, wave and fluvial forecasting with inundation and simulates their combined influence would be most effective for planning with respect to flood plain development, evacuation and flood defence. Current operational storm surge models are typically based on two-dimensional depth-averaged shallow water equations (Flather, 2000). Inundation models often use an approximation of the original shallow water equations which neglect the inertial terms (Prestininzi et al., 2011). These 2D flood plain inundation models are often coupled with a 1D model of the main channel of a river or estuary which permits the exchange of mass but assumes a limited exchange of momentum (Bates et al., 2005). A finite volume model (FVCOM) is used to investigate the combined influence of storm surge and river flow on flood plain inundation based on idealised estuary test cases. The combined influence of storm surge and river discharge typical of extremes in estuary systems in Britain (up to 2 m and 1500 m3s-1) was found to induce interactions that lead to increases in the non-tidal residual elevation of up to 0.4 m. However, the extent of the inundation was found to be mainly controlled by the surge elevation. Exceeding the threshold of the up-estuary channel capacity was found to cause a non-linear increase in the area of the inundation for any given peak river discharge, after which the rate of increase in inundation area as the surge height increases declines and is determined by the slope of the flood plain. This threshold is determined by the surge elevation with exception to the highest peak river discharges. It was also found that the extent of the interactions and inundation are highly dependent on the geometry of the estuary and the timing of the surge with respect to peak river discharge. This work forms the basis for a real estuary situation to be tested to assess the implications for combined surge and high river flow scenarios.