Geophysical Research Abstracts
Vol. 19, EGU2017-902, 2017
EGU General Assembly 2017

Understanding spatial variability in extreme estuarine water levels to inform better coastal management practise.

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Coastal zones worldwide are subject to short term, local variations in sea-level, particularly communities and industries developed on estuaries. Astronomical high tides, meteorological storm surges and increased river flow present a combined flood hazard. This can elevate water level at the coast above predicted levels, generating extreme water levels. These contributions can also interact to alter the phase and amplitude of tides and surges, and thus cause significant mismatches between the predicted and observed water level. The combined effect of tide, surge, river flow and their interactions are the key to understanding and assessing flood risk in estuarine environments for design purposes.

Delft3D-FLOW, a hydrodynamic model which solves the unsteady shallow-water equation, is used to access spatial variability in extreme water levels for a range of historical events of different severity within the Severn Estuary, southwest England. Long-term tide gauge records from Ilfracombe and Mumbles and river level data from Sandhurst are analysed to generate a series of extreme water level events, representing the 90th, 95th and 99th percentile conditions, to force the model boundaries. To separate out the time-varying contributions of tidal, fluvial, meteorological processes and their interactions the model is run with different physical forcing. A low pass filter is applied to “de-tide” the residual water elevation, to separate out the time-varying meteorological residual and the tide-surge interactions within the surge. The filtered surge is recombined with the predicted tide so the peak occurs at different times relative to high water. The resulting time series are used to force the model boundary to identify how the interactive processes influence the timing of extreme water level across the estuarine domain. This methodology is first validated using the most extreme event on record to ensure that modelled extreme water levels can be predicted with confidence.

Changes in maximum water level are observed in areas where nuclear assets are located (Hinkley, Oldbury & Berkeley) and further upstream, e.g., close to the tidal limit of the Severn Estuary at Epney. Change in crest shape (area and duration above the MSHW) are analysed to understand changes to flood hazard around the peak of the tide. The work concludes that changes in maximum water level can be attributed to the change in time of the peak of the surge relative to high water, the surge shape (classified by skew and kurtosis) and severity of the event. The results can be used to understand the spatial variability in extreme water levels relative to a tide gauge location, which can then be applied to other management needs in hypertidal estuaries worldwide.