MCCIP Marine Climate Change Impacts Partnership

Topic

Coastal flooding (science)

Author

Jason Lowe

Organisation represented

Hadley Centre for Climate Prediction and Research (Reading Unit), Meteorology Building, University of Reading, Earley Gate, Reading RG6 6BB

Executive summary

Storm surges are short-lived increases in local water level, above that of the tide. They are driven by low atmospheric pressure and winds, typically in shallow seas. If they occur at or near a high tide large surges are liable to cause flooding. Previous extreme surge events, such as that during the Winter of 1953, have led to a considerable loss of life and damage to property around the coastline of the southern North Sea.

An increasing trend in extreme water levels has been observed and is most likely to be a consequence of the rise in average sea level. Future extreme flood events may become more common as a result of increases in local relative time average sea level or altered atmospheric storminess, which could change the storm surge characteristics. The predictions presented in the **UKCIP02** analysis show the increase in the height of a flood event with a 50-year return period might be more than 1m during the 21st century at some locations. Most locations were predicted to experience a smaller increase. Comparison of the UKCIP02 results with other studies suggests that the pattern of increases in storm surge height is currently very uncertain and our confidence in being able to accurately predict the changes in extreme water level events is low. Research is underway to improve this situation by using ensembles of model simulations to better quantify the range of uncertainty. These new results will be made available as part of **UKCIP08**. The UKCIP08 results, along with the IPCC 4th assessment report results, will form part of the evidence base that Defra will consider in the future to update it's advice on climate change impacts on the coast. The UKCIP08 new results aim to provide probabilistic information for business planning and longer-term development at the coast.

Full review

Coastal flood risk

Coastal flood risk is a function of the probability of coastal flooding and the consequential damage, and hence depends on both the exposure of assets to flooding, and the standard of defences that exist. Presently, coastal flood risk is estimated to be about 50% of the national flood risk in England and Wales, with average annual damages of £0.5 billion. In the Foresight analysis, scenarios of potential changes in coastal flood risk due to changes in climate, society and the economy over the 21st century were analysed using a national-scale quantified flood risk analysis methodology (Hall et al., 2006; Thorne et al., 2007). Assuming that there is no adaptation to increasing coastal flood risk, the expected average annual damage in England and Wales due to coastal flooding is predicted to increase by two to 25 times to £1.0 and £13.5 billion. The great uncertainty reflects the range in the scenarios of climate and socio-economic change. Importantly, the proportion of national flood risk that is attributable to coastal flooding is projected to increase in all cases to between 60 and 70% of the total flood risk. Adaptation options including construction of coastal dikes or retreat from coastal floodplains were also analysed. These adaptations are shown to be able to reduce coastal flood risk to between £0.2 and £0.8 billion. The capital cost of the associated coastal engineering works is estimated to be between £12 and £40 billion. Non-structural measures to reduce risk can make a major contribution to reducing the cost and environmental impact of engineering measures and this strengthens the importance of linking planning with shoreline management.

Extreme sea level

Storm surges are short-lived increases in local water level, relative to the tide, typically occurring in shallow seas. Positive surges are of most concern, representing an increase in water level and an increased likelihood of flooding. They are driven by low atmospheric pressure and strong winds, and water levels can be enhanced locally by the coastal topography, which sometimes leads to a funnelling effect (Wells, 1997).

The damage resulting from storm surges is greatest when they occur at or near a high tide. Previous extreme surge events, such as that during the night of 31st January/1st February 1953, have led to a considerable loss of life and damage to property around the coastline of the Southern North Sea. In the United Kingdom the 1953 surge event killed an estimated 307 people in the counties of Lincolnshire, Norfolk, Suffolk and Essex. In Holland the death toll reached 1835.

There is evidence from tide gauges around the United Kingdom coastline of the long-term rise in mean sea level. However, extreme sea levels appear to change in a similar way and there is no clear evidence of a long-term trend in the storm surge height (Araujo *et al*., 2002). Our ability to detect such a trend is made difficult by the limited number of very long period tide gauge records with a high enough sampling frequency, and the existence of sizeable long period natural variability, as seen in a long Liverpool record analysed by Woodworth & Blackman, 2002.

During the 21st century the characteristics of extreme flood events are expected to change due to: the increase in time average sea level, the expected changes in atmospheric storminess (which alters the storm surge component) and local vertical land movements. The first two components are likely to be driven by future human induced changes in the climate but in the UK the final term is mostly due to the long term natural response of the system to the shrinkage of land ice since the end of the last ice age. A number of recent studies (von Storch & Reichardt, 1997; Flather *et al*, 2001; Lowe *et al*., 2001; Debernard *et al*., 2002; Lowe & Gregory, 2005; Woth, 2005; Woth *et al*., 2006) have attempted to estimate the change in the storm surge component using computer models of the atmosphere and either models of the shelf seas or a statistical **downscaling** technique to estimate the surges. Lowe & Gregory (2005) showed that there is a significant spread in the predictions of 21st century storm surge results and a research priority is to quantify the range of this uncertainty.

When the projected future changes in storm surges are combined with those in time average sea level and vertical land movements an estimate of the change in the height of extreme sea level events can be obtained. Figure 1 shows the predicted 21st century changes in storm surge height under an **SRES** A2 emissions scenario. This component of the change in extreme water levels is driven by changes in atmospheric storminess. The change in extreme water level, as presented in United Kingdom Climate Impacts Programme 2002 report (UKCIP, 2002), combines this component of change with the effects of an increase in mean sea level and vertical land movement information to give a total change in extreme water levels (Figure 2). An alternative way to express these results is as the change in the frequency of a given size of event seen from the land. At Immingham, on the east coast of the UK, an event with a return period of around 150 years in the present day climate is estimated to occur on average more frequently than once per decade by the end of the 21st century under an SRES A2 emissions scenario.

The confidence in the predictions of changes in sea level extremes at any particular location is currently low. A major program of work is being undertaken by the Met Office Hadley Centre and the Proudman Oceanographic Laboratory to produce a new set of extreme water level projections for the 21st century and will be delivered as part of **UKCIP08**. These newer results represent a first attempt to systematically quantify the uncertainty in extreme future sea levels in order to produce results more suitable for use in risk assessments. Additionally, the simulated changes in atmospheric wind used in a subset of the surge simulations will be used by POL to make an initial consistent estimate of future sea surface wave characteristics.

Figures

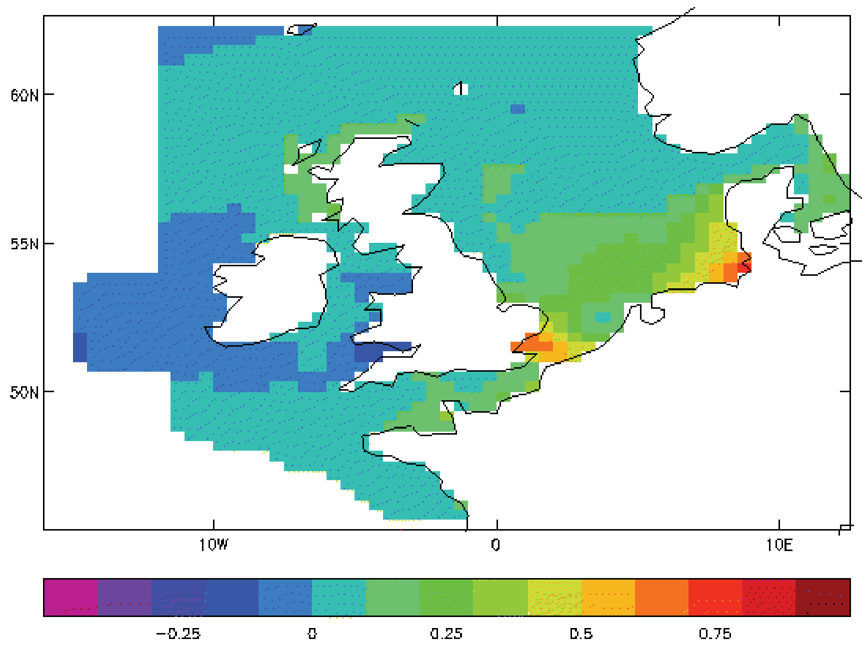

Figure 1. Simulated change in the height (m) of a storm surge with a 50-year return period during the 21st century under SRES A2 scenario. The results were produced with the Hadley Centre climate models and POL storm surge model.

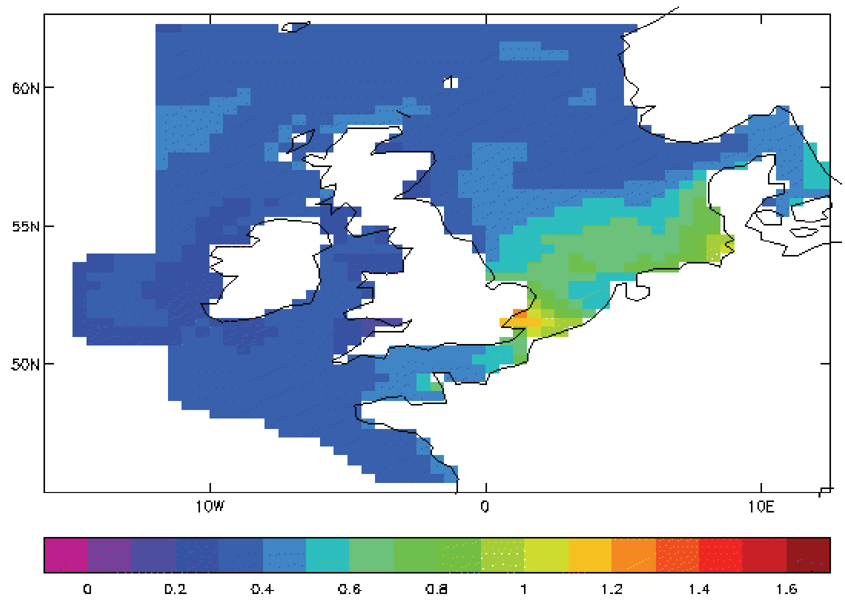

Figure 2. Simulated change in the height (m) of extreme water levels (measured relative to the present day tide) with a 50-year return period during the 21st century under SRES A2 scenario. The results include changes in storm surges, a rise in time average sea level and vertical land movements.

Confidence assessments

'What is already happening' – Low

'What could happen in the future' - Low

Knowledge gaps

See executive summary

Commercial impacts

Coastal flood risk is a function of the probability of coastal flooding and the consequential damage, and hence depends on both the exposure of assets to flooding, and the standard of defences that exist. Presently, coastal flood risk is estimated to be about 50% of the national flood risk in England and Wales, with average annual damages of £0.5 billion. In the Foresight analysis, scenarios of potential changes in coastal flood risk due to changes in climate, society and the economy over the 21st century were analysed using a national-scale quantified flood risk analysis methodology (Hall et al., 2006; Thorne et al., 2007). Assuming that there is no adaptation to increasing coastal flood risk, the expected average annual damage in England and Wales due to coastal flooding is predicted to increase by two to 25 times to £1.0 and £13.5 billion. The great uncertainty reflects the range in the scenarios of climate and socio-economic change. Importantly, the proportion of national flood risk that is attributable to coastal flooding is projected to increase in all cases to between 60 and 70% of the total flood risk. Adaptation options including construction of coastal dikes or retreat from coastal floodplains were also analysed. These adaptations are shown to be able to reduce coastal flood risk to between £0.2 and £0.8 billion. The capital cost of the associated coastal engineering works is estimated to be between £12 and £40 billion. Non-structural measures to reduce risk can make a major contribution to reducing the cost and environmental impact of engineering measures and this strengthens the importance of linking planning with shoreline management.

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