Tyndall Centre
for Climate Change Research

Towards a vulnerability assessment for the UK coastline

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Tyndall Centre for Climate Change Research Technical Report 10

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This is the final report from Tyndall research project IT1.15 (Towards a vulnerability assessment for the UK coastline). The following researchers worked on this project:

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Towards a vulnerability assessment for the UK coastline.
Final Report (Part -1) for Project IT1.15

Non-technical summary.

Coastal communities are more vulnerable to climate change than inland communities because, in addition to changes in meteorological parameters, they are also affected by changes in oceanic parameters, especially increases in sea level and wave heights. Both direct effects (for example changes in coastal erosion, storm surges and water temperature) and indirect effects (like reductions in fishing stocks and in the number of days suitable for fishing) will have physical and socio-economic impacts on coastal communities. This project examined the major physical impacts that projected climatic and oceanic change will have on the coastline of UK.

Sea levels, measured by coastal tide gauges and satellites and inferred from numerical models, were used to estimate the relative contributions to coastal sea level change arising from global climate change and from changes in regional climatic parameters as expressed by changes in the North Atlantic Oscillation (NAO). In addition, satellite measurements of wave height were used to assess the effects of climate change (global and regional) on the wave climate. Historic wave height and sea level changes were combined with climate model scenarios under enhanced greenhouse forcing to provide, in combination with vertical land movements, estimates of future sea level trends and wave height conditions around the coasts of the British Isles. Present and future regional impacts of climate change on coastal communities were assessed by exploring the effects that increased sea level and wave heights have on two types of coastal community: one in Scotland, located on a coast not vulnerable to sea level rise but vulnerable to increasing storminess and wave height increases; the other two communities in southeastern England, both vulnerable to sea level rise, coastal erosion and increasing wave heights.

Key Research Objectives

● To assess the effect that global and regional climate change has on sea level rise, significant wave height, and also their extremes, and to identify the physical mechanisms by which these effects are realised.

● To generate scenarios of regional sea level and significant wave height changes, based on scenarios of future global sea level rise and NAO behaviour.

● To identify the impacts that climate change induced modifications in sea level rise and wave height have on coastal communities and assess their future effects. This third objective is achieved by concentrating on three examples of coastal society, one in western Scotland and two in southern England.

Work undertaken

● Sea levels estimated from tide gauges and satellite altimetry have been analysed and modelled by the use of a two dimensional tide+surge model. Their relationship with the NAO Index has been established. The contribution of NAO-induced wind and atmospheric pressure variations on

sea level has also been resolved. In addition, the variability over time of the relationship between sea level and the NAO has been resolved and the variation of extremes of sea level over time has also been analysed.

● Significant wave heights from satellite altimetry and from wave buoys have been analysed. Wave models for the three areas of interest have been produced. The effect of NAO on occurrence of rough seas has also been examined.

● An ensemble of climate model simulations was examined to determine sea-level-related climate change and associated uncertainties (as expressed by intra-model differences). Specifically, the relationship of UK sea level change with global projections and the possible future behaviour of the NAO were diagnosed. These relationships were then combined to generate local scenarios for the three areas of interest.

● Geomorphological changes in Christchurch Bay have been estimated and related to available in situ climate data.

● Temporal variability of socioeconomic data in west Scotland has been examined in relation to climate forcing.

● The socio-economic impacts of sea level and wave height change in Christchurch Bay have been assessed.

Results

The scientific objectives were achieved with one exception (see next section). The analysis work on sea level and waves (variability and extremes), the wave modeling, the geomorphological changes and socioeconomic work have produced original and important results which have been, or will be, reported in high-quality international journals (see final section). The synthesis work has produced a methodology both for deriving local or regional scenarios and for quantifying the relationship of socio-economic impacts to climate forcing factors. These are also to be reported in the scientific literature. Major points that have been clarified:

● Sea level and wave heights along the Northern European coast are in most places significantly correlated with regional climate variations, especially with the winter NAO index. For UK sea level, however, the relationship is weaker and thus, if the NAO centers of action remain stable under conditions of global warming, the impact of this regional climate oscillation on coastal processes is likely to be small.

● Although extreme sea levels do not show marked increases over the last two centuries, increases *have* been documented over the last four decades. These more recent increases result from the influence of the NAO on mean sea level. Similarly, recent changes in extreme wave heights are also NAO-related. Outside the region of increased westerlies related to the NAO, no increase in storminess is found.

● A methodology for the construction of local scenarios of sea level and wave heights involving local data, wave modelling and output from climate models, has been developed and applied to three coastal locations in the UK.

● The exploratory studies undertaken indicate that in general a signature of the NAO signal is not detectable in most of the socio-economic parameters examined, nor in the geomorphological

parameters examined. This indicates that other factors are more dominant than the NAO in influencing local processes of social, economic and geomorphological change in the coastal zone.

Relevance to Tyndall Centre research strategy and overall objectives

The research objectives relate directly to Tyndall Centre's Research Theme 4 as they combine climate predictions and past effects in order to estimate the contribution of regional climate variability to changes in important parameters of the coastal environment and their impact on coastal societies. Specifically it contributes to the Regional Coastal Simulator project by providing a flexible wave model for the region of East Anglia and a methodology for combining regional and global projections of sea level rise and wave changes. (Unfortunately the geomorphological study for North Norfolk has not taken place due to unforeseen difficulties.) The project also developed close interaction with stakeholders in Scotland and the south of England.

Potential for further work

Both the wave and the sea level work needs to be continued. Moreover, to assess the impact of climate change on shorelines it is necessary to better understand the dynamics of short-term geomorphological change. For the Tyndall Centre, the major interest would be to attempt to integrate further the climate and sea level forcing with social impacts and possible adaptation responses. This is being attempted in the Regional Coasal Simulator. Studies such as completed in this project will be continued/extended as part of research programmes of member laboratories.

Key Publications

Jevrejeva S., J. Moore, P.Woodworth and A. Grinsted, Influence of large scale atmospheric circulation on the European sea level: results from wavelet transform, Tellus (submitted), 2003.

[contact: plw@pol.ac.uk]

Osborn T.J. The winter North Atlantic Oscillation: the roles of internal variability and greenhouse gas forcing. Climate Dynamics (submitted), 2003.

[contact: t.osborn@uea.ac.uk]

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Tyndall Centre
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The inter-disciplinary Tyndall Centre for Climate Change Research undertakes integrated research into the long-term consequences of climate change for society and into the development of sustainable responses that governments, business-leaders and decision-makers can evaluate and implement. Achieving these objectives brings together UK climate scientists, social scientists, engineers and economists in a unique collaborative research effort.

Research at the Tyndall Centre is organised into four research themes that collectively contribute to all aspects of the climate change issue: Integrating Frameworks; Decarbonising Modern Societies; Adapting to Climate Change; and Sustaining the Coastal Zone. All thematic fields address a clear problem posed to society by climate change, and will generate results to guide the strategic development of climate change mitigation and adaptation policies at local, national and global scales.

The Tyndall Centre is named after the 19th century UK scientist John Tyndall, who was the first to prove the Earth's natural greenhouse effect and suggested that slight changes in atmospheric composition could bring about climate variations. In addition, he was committed to improving the quality of science education and knowledge.

The Tyndall Centre is a partnership of the following institutions:

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