IMPACTS OF CLIMATE CHANGE ON SEA LEVEL

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Executive Summary

Tide gauge measurements suggest that global average sea level has risen during the 20th century by between 1 and 2mm/yr. Recent satellite altimeter measurements, which have better spatial coverage than the tide gauges but span a much shorter time period, indicate that between 1993 and 2003 the rate of rise was around 3mm/yr. At present it is unclear whether this apparent increase in rate is due to natural variability of the climate or is part of a long-term acceleration in the rate of rise.

During the 21st century we predict, with a high confidence, that the global average sea level will rise. However, we have only a low to moderate confidence in the magnitude of the rise. The third assessment of the IPCC presented a range of projected sea-level rise between 1990 and 2100 of 9-88cm, with the largest contribution coming from thermal expansion. This range aims to account for uncertainty in the emissions scenario and in the modelling techniques.

We do not expect the pattern of time average sea-level rise to be spatially uniform. We have a low to moderate confidence in the prediction that some locations will experience future increases of around 50% more than the global average, but the confidence in where this will occur is very low. We can not yet rule out the regional enhancement occurring in the North Atlantic, where it might affect UK waters. When considering flooding the vertical movement of the land must also be included, giving a relative sea level change. The vertical land movement varies considerably with location.

Level of Confidence

High confidence that the global average sea level will rise.

Low to moderate confidence in the magnitude of the rise.

Low to moderate confidence in the prediction that some locations will experience future increases of around 50% more than the global average, but the confidence in where this will occur is very low.

Key Sources of Information

See supporting evidence

Supporting Evidence

Sea-level rise can cause a range of impacts, most obviously inundation. However, whilst the average rise in sea-level over long timescales may directly flood some low lying areas the extremes of sea level are often more damaging. A range of coastal impacts are considered in the Intergovernmental Panel on Climate Change's third assessment report from working group 2 (IPCC TAR WG2, 2001).

Tide gauge measurements suggest that the global average sea level has risen during the 20th century by between 1 and 2 mm/yr (IPCC TAR WG1, 2001). Recent satellite altimeter results, which have better spatial coverage but were obtained over a much shorter period, show a rise of around 3mm/yr between 1993 and 2003 (Cazenave and Nerem, 2004). It is not yet clear whether this increase over the 20th century average rate is part of a long-term acceleration or is due to natural variability of the climate system. Reconstructions of 20th century sea level using a combination of tide gauges and altimeter results (e.g. Holgate and Woodworth, 2004; Church and White, 2006) show periods earlier in the century that also have a rate of rise that is greater than the century scale average, although the latter authors did also note a long term acceleration.

Attempts to simulate observed sea-level rise using climate model simulations driven by both man-made and natural forcing (Gregroy *et al.,* 2006) suggest that while we are able to credibly simulate the individual contributions from the major known sources, the simulated 20th century total sea-level rise is less than observed. The reason for this discrepancy remains an active area of research.

Estimates of 21st century sea-level rise can be produced using computer models of varying complexity. The Intergovernmental Panel on Climate Change's third assessment report from working group 1 (IPCC TAR WG1, 2001) presented a range of estimated future sea-level rise between 1990 and 2100 of 9-88cm (Figure 1), with the largest contribution coming from thermal expansion. This range aims to account for uncertainty in the emissions scenario and in the model techniques.

We do not expect the pattern of time average sea-level change to be spatially uniform. Figure 2 shows a simulation from one climate model, HadCM3. We have a low to moderate confidence in the prediction that some locations will experience future increases of around 50% more than the global average, but our confidence in where the above average increases will occur is very low (Gregory *et al.,* 2001). We cannot yet rule out significant regional enhancement occurring in the North Atlantic, where it might affect UK waters.

A further issue of importance is whether the contributions from the Greenland and Antarctic ice sheets could in fact be larger than expected. If atmospheric greenhouse gas concentrations continue to rise beyond the end of the 21st century then it is likely that the sea-level rise contribution from these sources will increase, although our ability to model the changes currently have many limitations. Several authors (e.g. Rignot, 2006; Rignot and Kanagaratnam, 2006; Luckman et al., 2006) have noted the recent acceleration of outlet glaciers in both major ice sheets, which could be a first sign of an accelerated decline in the ice volume and a faster rate of rise in sea level. However, most of these studies cover fairly short periods of time and it is unclear whether we are seeing a long-term acceleration or shorter-term variability. Developing improved models of ice processes is another active research area.

Finally, from the perspective of flooding, the vertical movement of the land must also be considered. Shennan and Horton (2002) present estimates of the land movement around the United Kingdom coastline. It should be noted that some locations experience a fall whereas others show a rise, with large variations around the coastline. When added to the local time mean sea-level change the land movement terms could either increase or decrease the relative sea-level rise by up to 20 cm during the 21st century.

Please acknowledge this document as: Lowe, J. (2006). Impacts of Climate Change on Sea Level in Marine Climate Change Impacts Annual Report Card 2006 (Eds. Buckley, P.J, Dye, S.R. and Baxter, J.M), Online Summary Reports, MCCIP, Lowestoft, www.mccip.org.uk

Figures

Figure 1: Predicted changes in global average sea level. This range aims to account for uncertainty in the emissions scenario and in the model techniques. Taken from the IPCC's third assessment (www.grida.no/climate/ipcc_tar/wg1/index.htm).

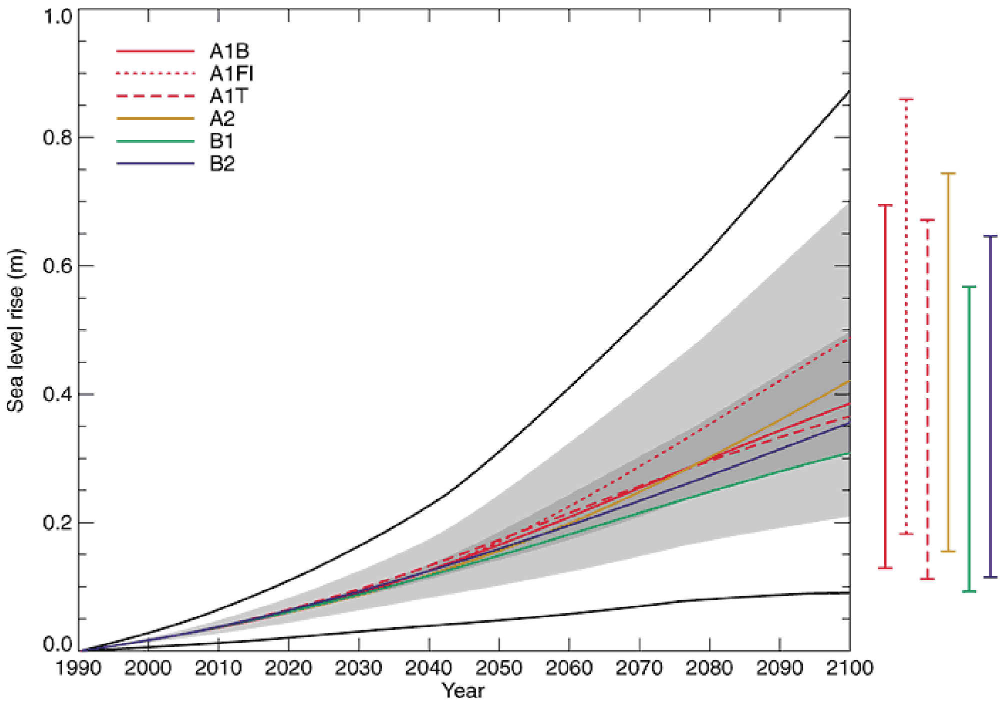
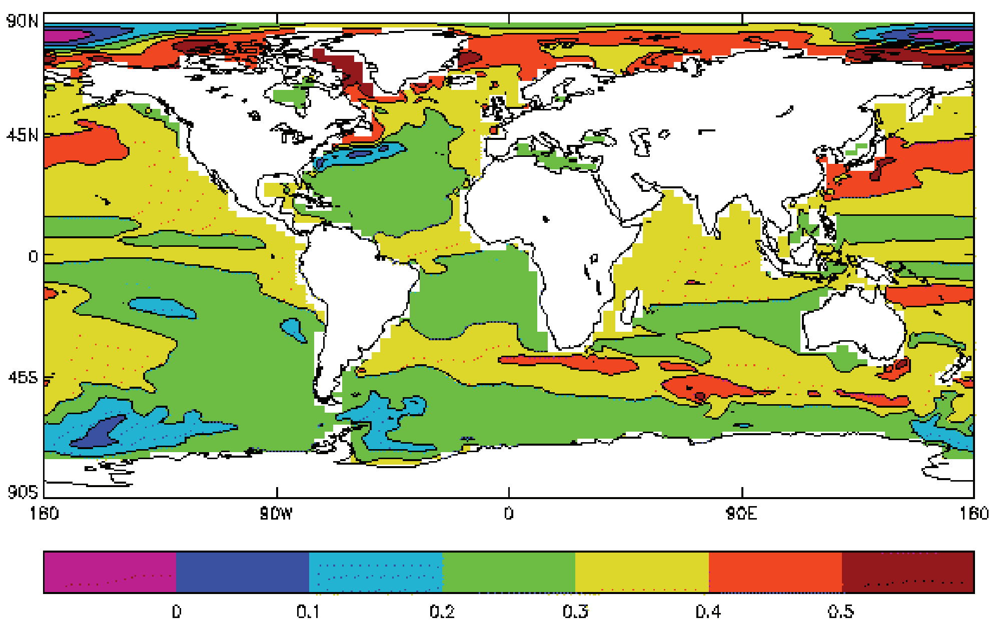


Figure 2: Predicted changes (m) in the spatial pattern of sea level rise from the HadCM3 climate model. The changes are between present day and the end of the 21st century for an SRES A2 scenario.



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