IMPACTS OF CLIMATE CHANGE ON SEA TEMPERATURE

Robert Marsh and Elizabeth Kent
National Oceanography Centre, Southampton

Executive Summary

Sea surface temperatures (SST) have been rising in both the mid-latitude North Atlantic and UK coastal waters in recent decades. The broad Atlantic pattern of warming can be seen in Fig. 1, depicting SST anomalies in 2005/06, relative to the 1985 – 2003 average, based on satellite data. For this period, particularly strong anomalies (~2°C) are visible in the north-west Atlantic. In addition to *surface* warming, there is evidence from ‘Argo’ profiling floats of a simultaneous warming within the upper 1500m of the Atlantic, focussed within the 50-60N latitude. There is no clear consensus on the mechanism for this, which must either be due to surface heat gain or anomalous influx of warmer waters. Considering UK coastal waters only, using preliminary fields from the NOC SST *in-situ* dataset, widespread surface warming is evident around much of the coast throughout the 1970 – 2004 period (Fig. 2). The largest rates of warming are located within the English Channel and North Sea regions, where changes have approached 2°C in magnitude. The weakest warming is seen to the north-west of the UK. The pattern of these changes is broadly similar to that shown by marine air temperature, for the same period.

Level of Confidence

High

Key sources of Information

See Supporting Evidence

Supporting Evidence

Measurements of SST are obtained from many different sources. While ocean-based instruments provide the ultimate “ground truth”, satellite-based sensors observe SST in almost real time. The NOAA/NASA Pathfinder SST product (see http://podaac.jpl.nasa.gov/sst/) provides high-resolution datasets from 1985 to 2004 and we can supplement these with data from the Advanced Microwave Scanning Radiometer (AMSR-E), a passive microwave instrument providing SST observations through non-raining cloud (see http://www.remss.com/amsr). To comment on the large-scale Atlantic changes, we also use output from a simulation of the Ocean Circulation and Climate Advanced Model (OCCAM, see Marsh *et al.,* 2005). In addition to satellite and model datasets, blended and ship-based SST products are also available. The NOC dataset, used to comment on UK coastal changes, is derived from Voluntary Observing Ship reports in the International Comprehensive Ocean-Atmosphere Data Set (ICOADS, Worley *et al.,* 2005), on a global 1° x 1° grid at daily time intervals up to the end of 2004 (Kent and Berry, 2005). Combined satellite and non-satellite based data are also collated and updated monthly, in the form of HadISST (see http://www.hadobs.org/). This dataset is widely used in climate studies. Monthly SST anomalies in the OCCAM, AMSR-E and NOC data reported here are in general significantly correlated with HadISST (Marsh *et al.,* 2006).

Compared to other oceans, the Atlantic sector appears to be warming the most dramatically, accounting for 53% of World Ocean warming from 1955-98. Most warming has occurred in the upper 700m in the North Atlantic (Levitus *et al.*, 2005), but this has not been completely linear (for example, up to the early 1970s, some negative heat content anomalies were visible). Nonetheless, the recent heat content anomaly has tended to be positive, and particularly rapid warming since the 1980s is evident, focused over the tropics and mid-latitudes (Marsh *et al.*, 2006). The introduction, in the late 1990s, of ‘Argo’ floats (see http://www.argo.ucsd.edu/) has enabled more accurate estimates of ocean heat content, revealing strong warming of the upper 1500 m in the northern North Atlantic (Ivchenko *et al.*, 2006). Attribution of ongoing warming to anthropogenic influence has been established through analysis of climate model experiments (e.g. Pierce *et al.,* 2006), although the precise mechanisms for regional warming are not yet clear. In the Atlantic sector there is evidence that the meridional overturning circulation (MOC) has slowed in the subtropics since the early 1990s (Bryden *et al.*, 2005). This raises the paradox of warming despite reduced oceanic heat transport and has fuelled an enthusiastic debate (e.g. Hirschi *et al.,* 2006; Latif *et al*., 2006; Wunsch and Heimbach, 2006). Long-term changes are also compounded by variations associated with other processes, one particular example being the North Atlantic Oscillation (NAO), which has been shown to impact the structure of heat transport (Brauch and Gerdes, 2005).

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Figures

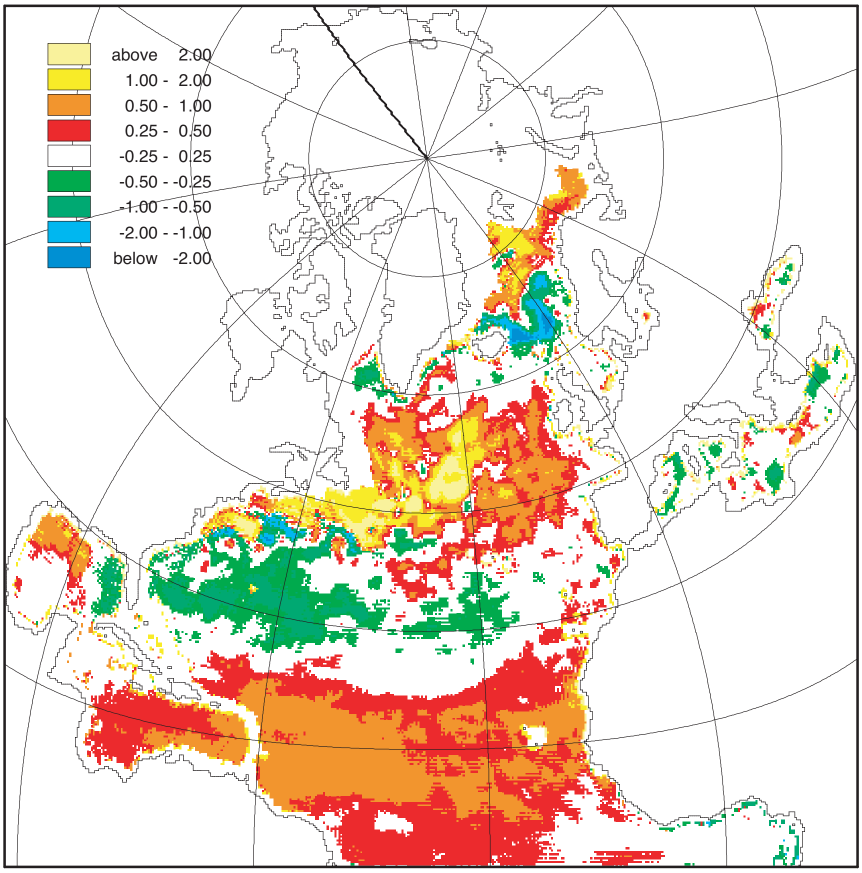

Figure 1. July 2005 – June 2006 averaged SST anomalies in the North Atlantic/Arctic.

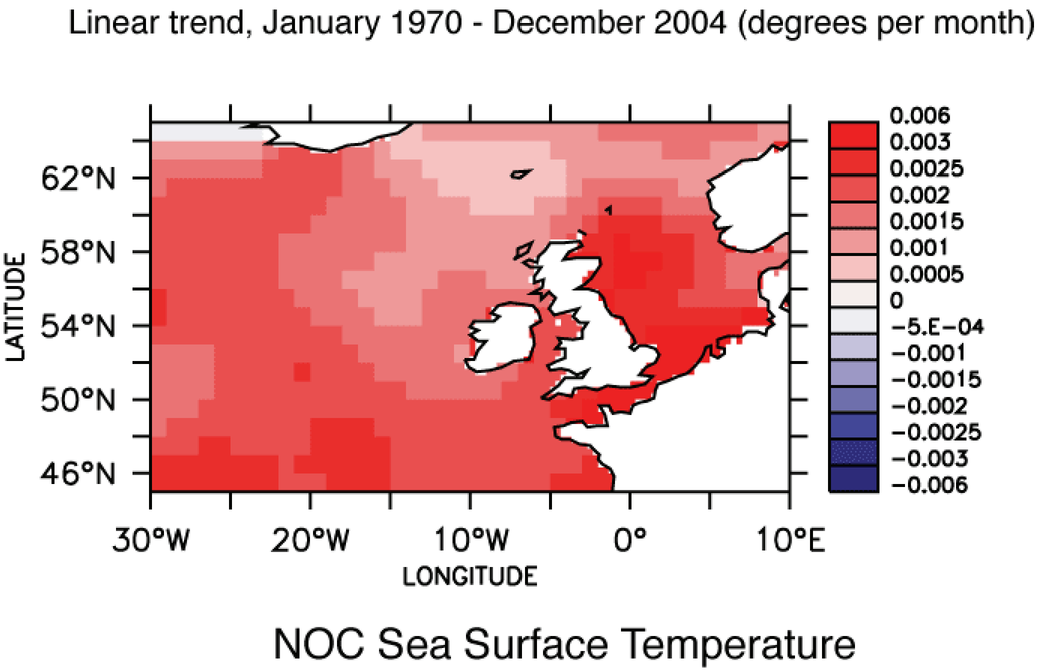

Figure 2. 1970 – 2004 linear trends of observed SST within the UK coastal region.

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