Background

Atmospheric climate model biases have been shown to be sensitive to large-scale sea surface temperature (SST) biases (1,2). Despite improvements on the large-scale, smaller regions of SST biases remain. When these are located in regions of deep atmosphere-ocean interactions, there is potential for a propagation of biases.

In general, the local response mechanism to dissipate anomalous diabatic heating in the mid-latitudes may be via any of the following mechanisms:

1. meridional heat advection by a mean wind anomaly (1,2)
2. meridional heat advection by the transient eddies (3)
3. ascent (2) and the associated adiabatic cooling if over the western boundary currents.

In this study, the role of winter Gulf Stream biases from a high resolution fully coupled global climate model (HadGEM3-GC2) are examined with a focus on the tropospheric response in the atmospheric model component, by performing three sensitivity experiments.

Data

- ECMWF Interim Reanalysis (ERA-Interim) (2)
- UK Met Office Unified Model, Global Coupled model version 2.0 (GC2) (7)
- The ¼° coupled ocean used in GC2-Coupled (GC2-C) has a spatially small, but large in magnitude temperature (SST) biases.

Experimental design

The ¼° coupled ocean used in GC2-Coupled (GC2-C) has a spatially small, but large in magnitude temperature (SST) biases. Despite improvements on the large-scale, smaller regions of SST biases remain. When these are located in regions of deep atmosphere-ocean interactions, there is potential for a propagation of biases.

The anomalous heating imposed over the Gulf Stream is balanced not by meridional heat transport (not shown), either mean or eddy, but by enhanced ascent (as shown in Fig. 3). This deep ascent is up to twice as strong over the SST biases, and is mostly made up of ascent which is over the fronts of the transient ascent. The SST biases remain. When these are located in regions of deep atmosphere-ocean interactions, there is potential for a propagation of biases.

The winter (DJF) season: from 1981–2008 is used for ERA-Interim and GA6; 27 years of the GC2 simulation are also used, with perpetual present-day forcing.

The significance of differences has been assessed by using a Monte-Carlo method with 10,000 trials, two tailed.

Results

The surface flux response is consistent with the biases and imposed biases (Fig. 2). Enhanced upwarping surface heat fluxes occur over the warm biased SSTs.

The transient ascent, and wave response pathways may have implications for the ability of the model to respond correctly to variability or changes in the Gulf Stream.