Geophysical Research Abstracts, Vol. 9, 09419, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-09419

Simulation of the Atlantic Multidecadal Oscillation and its climate impacts compared to model responses to natural and anthropogenic forcings

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We present a comparison of a 1400 year control simulation of the HadCM3 model with instrumental temperature data sets that shows the model produces a quasi-periodic mode with a pattern, amplitude and characteristic time scale similar to that of the observed Atlantic Multidecadal Oscillation (AMO). The simulation implies the AMO is a genuine long-lived cyclical climate phenomenon related to large-scale oceanic heat transport variations associated with changes in the strength of the oceanic meridional overturning circulation (MOC). The existence of such a mode in the model implies the AMO may provide some predictability of climate for several decades. We find a mechanism involving delayed negative feedback on the overturning through the northward transport of anomalous tropical freshwater resulting from sea-surface temperature-induced displacement of the mean Intertropical Convergence Zone (ITCZ). The simulated shift in the Atlantic-sector ITCZ is shown to influence north-east Brazil and Sahel rainfall in a very similar manner to that observed in the 20th century, and is likely to be important in determining the AMO's impact on the Pacific Ocean. The results also support observed links between the AMO and other regional climate phenomena, such as Atlantic hurricane formation and European climate, which hitherto have been based on only short observational records.

The consistency between the observed AMO and North Atlantic SST variability in coupled twentieth century simulations with natural and anthropogenic forcings submitted for the IPCC Fourth Assessment report is also examined. It is shown that this is difficult to assess with individual model ensembles as the ensemble size is generally too small to constrain the ensemble mean. On the other hand, combining the results of the ensembles from different models it is possible to create a super-ensemble of suf-

ficient size to allow a good estimate of the super-ensemble mean. This can be viewed as a ’best-estimate’ of the climate response to natural and anthropogenic forcings. We show a clear statistical separation of the observed SST from the estimated forced response, suggesting that the AMO is inconsistent with historical forcings. In this case, either (i) past climate forcings are incorrectly specified in the models, (ii) the models respond incorrectly to forcings, or (iii) the AMO is an internal climate mode. This last possibility is consistent with the results of the long control simulation.