An Assessment of Natural Variations in the Thermohaline Circulation and Climate Using a 1400 Year Coupled Model Calculation

Jeff Knight, Rob Allan, Chris Folland and Michael Vellinga

Hadley Centre, Met Office, London Road, Bracknell, Berkshire, United Kingdom

email: jeff.knight@metoffice.com

Results from a 1400 year calculation using the HadCM3 coupled climate model without external forcings are show the existence of a quasi-periodic mode of internal climate variability with a characteristic time scale of about 100 years. This mode is manifest in the modelled thermohaline circulation (THC), defined as the peak meridional overturning streamfunction at 30°N, which shows multi-decadal variations in strength of about 2 Sv (10%) with a coherent phase evolution for periods of up to 50 years. Additionally, global and northern hemisphere mean surface temperatures are found to vary in phase with the THC, with regressions of 0.05°C Sv^{-1} and 0.09°C Sv^{-1} respectively, suggesting that the mode is significant compared with twentieth-century climate variability. An influence on surface temperature in broad regions of the northern hemisphere is found, particularly in the North Atlantic, Pacific and Asia, as well as wind and rainfall effects, notably in Europe, north-east Brazil and the Sahel.

In the natural climate system, a lack of sub-surface marine monitoring prevents knowledge of possible past fluctuations in THC strength, constraining us to use coupled ocean-atmosphere models to make inferences about its potential behaviour. Model relationships between the THC and sea surface temperature (SST) are used to infer the strength of the natural THC and its role in the climate variability of the instrumental period. We find in particular that an increase in the THC would be consistent with a significant part of early twentieth century warming. In recent decades, SST changes similar to those observed are shown to be consistent with THC strengthening in the model. We also note the possibility that THC-climate relationships imply that the degree of future global climate warming could be temporarily enhanced or offset.