Geophysical Research Abstracts
Vol. 12, EGU2010-14872, 2010
EGU General Assembly 2010

Energetic analysis of simulated time-dependent changes in the Atlantic meridional overturning circulation in response to increasing atmospheric CO2 concentration

Jonathan Gregory (1,2) and Remi Tailleux (3)

(1) NCAS-climate, Department of Meteorology, University of Reading, UK, (2) Met Office Hadley Centre, Exeter, UK, (3) Department of Meteorology, University of Reading, UK [r.g.j.tailleux@reading.ac.uk]

Atmosphere-ocean general circulation models (AOGCMs) predict a weakening of the Atlantic meridional overturning circulation (AMOC) during the 21st century in response to anthropogenic forcing of climate, but there is a large model uncertainty in the magnitude of the predicted change. The weakening of the AMOC is generally understood to be the result of increased buoyancy input to the north Atlantic in a warmer climate, leading to reduced convection and deep water formation. Consistent with this idea, model analyses have shown empirical relationships between the AMOC and various measures of the meridional density gradient, but this link is not direct because the large-scale ocean circulation is essentially geostrophic, making currents and pressure gradients orthogonal. If kinetic energy (KE) is considered instead of momentum, the dominant geostrophic balance is eliminated. Diagnosis of the KE balance of the HadCM3 AOGCM and its low-resolution version FAMOUS shows that in the global mean of the steady-state control climate KE is supplied to the ocean by the wind and dissipated by viscous forces, and the circulation does work against the pressure-gradient force, mainly in the Southern Ocean. In the Atlantic Ocean, however, the pressure-gradient force does work on the circulation, thus generating KE, especially in the high-latitude regions of deep water formation. Moreover a decline in this term under increasing CO2 is the most marked change in the KE balance of the Atlantic. During CO2-forced climate change, there is a very good temporal correlation between the AMOC strength and the rate of KE generation by the pressure-gradient force in 50-70deg N of the Atlantic Ocean in HadCM3, FAMOUS and seven other AOGCMs of the Coupled Model Intercomparison Project Phase 3. Both the change in KE generation during climate change, and the sensitivity of the AMOC to KE input, are model-dependent, and both contribute to the model spread in projections of AMOC weakening. The former relates to surface buoyancy forcing and advective feedbacks, the latter to ocean dynamics.