Geophysical Research Abstracts
Vol. 12, EGU2010-2908, 2010
EGU General Assembly 2010
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Impact of atmospheric feedbacks on the stability of the thermohaline circulation in the Atlantic ocean

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How do atmospheric feedbacks affect the stability of thermohaline circulation in the Atlantic ocean?

This question has been asked several times in literature during the last decade, but no final answer is widely accepted. Idealised and simpler general circulation models apparently contradict the results of state of the art computations. While the former ones hint at the existence of a stable collapsed state and multiple equilibria, the latter do not show such behaviour. Understanding the relative importance of the salt advection feedback in the ocean and of the response of the atmosphere to a thermohaline circulation depression is a crucial point in this work. A combined approach is developed to start answering these questions, focusing on the physical mechanisms that may change the stability properties of density driven circulation.

An atmosphere/ocean/sea–ice coupled general circulation model (Speedo/CLIO) is used in two different setups. First, the statistical steady state of the model is recorded. In a second experiment, a collapse of thermohaline circulation is induced with a freshwater pulse in the north Atlantic. Thermohaline circulation does not recover even after the release of the pulse, and a second steady state with no thermohaline circulation is attained. Using these two runs, the anomalies can be computed as linear regressions on the local value of sea surface temperature and on northern hemisphere average sea surface temperature separately.

With this approach, both natural variability of atmospheric forcing due to local temperature anomalies and large scale changes due to the collapse of thermohaline circulation can be represented. Changes in freshwater and heat fluxes are the most significant. The northern–southern Atlantic temperature dipole and the southward shift of intertropical convergence zone, believed to be the main atmospheric signals in response to a collapse of thermohaline circulation, are evident in the second experiment and well recorded by linear regressions. The linearly perturbed climatology is used successfully as boundary condition for the ocean–only component of Speedo/CLIO. The model shows only minor drift ($\approx 0.3°C$ in 1000 years) and variability is consistent with that of the coupled model.