International Max Planck Research School on
EARTH SYSTEM MODELLING

Low frequency variability of the Meridional Overturning Circulation

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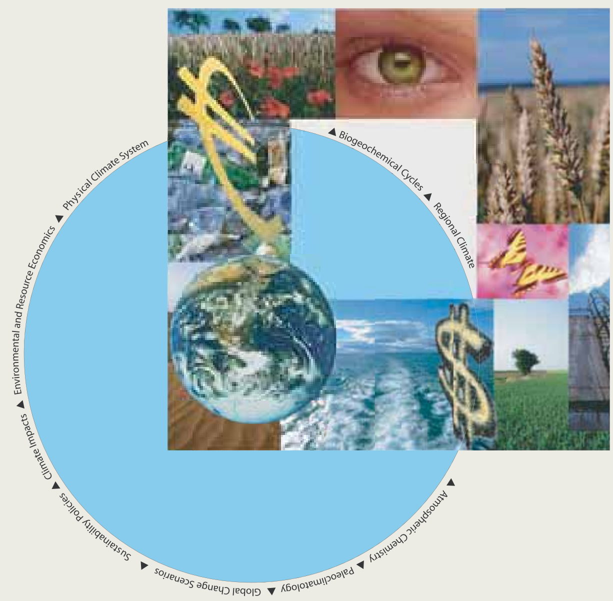

Abstract

The purpose of this thesis is to investigate the variability of the Meridional Overturning Circulation (MOC) using state-of-the-art GCMs, with a special interest on interdecadal to multidecadal time scales. We start from the general spectral behavior of the simulated MOC variability which is followed by detailed discussions on the low frequency variability of the MOC.

Though most of the current studies focus on specific periodicities of the MOC, no consensus has been reached on its general spectral behavior. Results from two coupled climate models are analyzed. A general consistency in the MOC spectrum exists between two coupled models, which, however, differ from the type often assumed with the MOC in previous studies. A comparison between two simulations of the same model with different resolution reveals substantial deviation on the MOC low frequency variability. These results suggest that caution is required concerning the MOC behavior at low frequencies which certainly should be considered to test model performance.

Analyses of a suite of sensitivity experiments suggest the coexistence of the inter- and multi-decadal variability (IDV and MDV), which are associated with an ocean self-sustained mode and an air-sea coupled mode respectively. This provides a new interpretation to the wide-spread time scales associated with the low frequency variability of the MOC.

The IDV is investigated using the ocean-only model driven by climatological surface fluxes. The important role of ocean dynamics in the North Atlantic subpolar gyre is highlighted. The IDV of the MOC is characterized as a geostrophic process, thus tightly associated with the horizontal density gradients. Our results provide a strong support to those derived from less complex models in previous studies.

The air-sea coupling is shown of great importance for the MDV of the MOC. While the MDV bears similarity to the mechanism associated with the IDV, our results show that presence of the air-sea coupling is critical to the existence of a significant MDV mode. This air-sea coupling involves a fast response of the ocean gyre to the anomalous wind stress, which enhances the density anomalies in the deep convection sites in the Labrador Sea and hence the associated MOC anomalies. The MOC-related variability in the North Atlantic also affects the North Pacific via atmosphere teleconnection through which the MOC variation at low frequencies impacts the North Pacific and potentially interacts with ENSO.