Southern Ocean characteristics control Meridional Overturning: sensitivity studies using a zonally averaged ocean model

Master-Thesis in Physical Oceanography

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Abstract

The Meridional Overturning Circulation (MOC) is of essential importance for global climate. Sensitivity studies using a zonally averaged ocean model are conducted and validate a dynamically consistent closure by Brüggemann et al. (2011, in press), which solves the inconsistency, that the meridional gradient of zonally averaged pressure is not directly related to the meridional flow. The validation is based on comparison with scaling laws for the overturning strength, which have been confirmed by zonally averaged and zonally resolved models in the past.

A fairly realistic flow field with a dominant cell associated with North Atlantic Deep Water (NADW) and a smaller bottom cell associated with Antarctic Bottom Water (AABW) is realised after stepwise implementation of the Southern Ocean and zonal wind stress. The characterisitcs of the overturning are determined by the equator-to-pole density gradient, the vertical diffusivity, Southern Ocean wind stress and the meridional extent of the Southern Ocean. The cross-equatorial heat transport is essentially depending on wind stress over the Southern Ocean. The Residual Mean theory (Viebahn and Eden (2010) and Ito and Marshall (2008)) for Southern Ocean circulation is reviewed and proves to be generally consistent with the model results. Differences between the northern and southern equator-to-pole buoyancy gradient are a crucial switch to let one overturning cell become dominant throughout the domain. The AABW cell vanishes completely for a southern gradient, which is 1 K smaller than its northern counterpart. Results from a zonally resolved model show decent similarities with results from the zonally averaged model, as the observed shortcomings are similar to the ones already stated by the authors of the model. The simple convection parameterisation in the code is suspected of being a possible source for deviations.