Geophysical Research Abstracts
Vol. 14, EGU2012-7526, 2012
EGU General Assembly 2012

Ocean heat uptake processes in the Southern Ocean in HiGEM1.2, a climate model with an eddy-permitting ocean

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A large fraction of the global ocean heat uptake in 21st century simulations with the CMIP3 models occurs in the Southern Ocean. The question addressed here is which processes exactly are relevant for transport and storage of the heat. Previous work suggests that a substantial part of the warming is due to wind forcing in the form of Ekman pumping. However, these results are based on models that do not resolve oceanic mesoscale eddies. It is known that the improved representation of mesoscale eddies substantially changes the response of the Southern Ocean circulation to strengthening winds, which are in turn a consequence of increased atmospheric greenhouse gas concentrations. In particular, the volume transport of the Antarctic Circumpolar Current tends to not increase, indicating an increased eddy-induced overturning with southward transport in the surface layer. HiGEM1.2, a fully coupled AOGCM with a 1/3 degree resolution, eddy-permitting ocean, shares this feature. This facilitates an analysis of the implications of the increased eddy-induced overturning for ocean heat uptake, using detailed diagnostics of the tracer transport equation. In this way, the roles of surface fluxes, mixed layer processes, advection, convection and further processes can be quantified.

In addition, the analysis of ocean heat uptake in the CMIP3 models reveals that in different regions heat accumulates on different depths. Specifically, there is substantial deep heat uptake in the mid- to high-latitude Southern Ocean in the ensemble mean. HiGEM1.2 displays deep ocean heat uptake in parts of this region too, which permits a detailed analysis using the methods indicated above. Given the dependence of the thermal expansivity of sea water on pressure and temperature, the impact of deep ocean heat uptake on sea level change is explored as well.