Ocean Heat Balance in the ACCESS Ocean Model: Regional variability of dominant mechanisms of heat uptake over the historical period.

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The Australian Community Climate and Earth System Simulator (ACCESS) is being prepared for a forthcoming submission to the Climate Model Intercomparison Project - phase 6 (CMIP6). In addition to the entry-level CMIP6 submission requirements (DECK and historical simulations), we plan for participation in a number of the 21 additional CMIP6 Model Intercomparison Projects (MIPS). Of particular relevance to ocean climate study is participation in the Ocean Model Intercomparison Project (OMIP) and the Flux Anomaly Forced Model Intercomparison Project (FAFMIP). In preparation for the ACCESS submissions, a detailed analysis of the ocean heat budget, and the dominant mechanisms of heat transport is being undertaken with the ACCESS Ocean Model (ACCESS-OM). Ocean heat uptake along with its vertical and lateral redistribution are one of the main factors contributing to the large intermodel spread in the magnitude and regional patterns of sea level rise projections for the 21st century. Here, we perform a heat budget analysis to quantify the physical processes involved in ocean heat uptake and redistribution in contemporary simulations utilising ACCESS-OM. The model is forced with atmospheric reanalyses from the Coordinated Ocean-Sea ice Reference Experiments (CORE-II, 1948-2007) and the Japanese Reanalysis (JRA-55, 1958-2015). Our results show that the global vertical heat balance proposed by Munk (1966) between downward flux by diffusion and upward flux by the mean advection is only held at the tropics and has a small global impact. In the top 500 m, warming from vertical diffusion is balanced by cooling from mixed-layer physics. Below 500 m, regardless of depth level, warming due to mean advection and vertical diffusion counteracts cooling due to isoneutral diffusion and mesoscale eddies. Overall, the global balance is largely dominated by ocean processes in high latitude areas of the North Atlantic and Southern Ocean but with regional differences. The heat balance in the North Atlantic is mostly explained by an advective balance between the mean circulation (warming) and mesoscale eddies (cooling), within the 400-2000 m depth interval. In the Southern Ocean (south of 30˚S), mean advection plays a major role below the mixed layer down to 4000 m, and is mainly counterbalanced by isoneutral diffusion above 900 m and mesoscale eddies below 900 m. We note, however, that within the Southern Ocean, the balancing terms vary depending on latitude band (30˚-45˚S and poleward of 50˚S). The Subantarctic zone holds a similar balance as found in the Southern Ocean despite a stronger advective downward flux above 2000 m, which drives a warming tendency at intermediate depths with significant contribution to the model drift. South of 50˚S, the vertical diffusion of heat changes its sign due to convective processes and cools the ocean interior, resulting in a consistent deep ocean cooling drift which subsequently penetrates into other ocean basins. The subtropics also play a role in the model drift, where a warming trend occurs above 500 m due to intense positive convergence of heat driven by vertical diffusion.

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