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# Development of WaMM (Water Mass Model): A new box model for climate studies

**S. B. Grigg**, and N. J. Holbrook

Dept. of Physical Geography, Macquarie University, Sydney, Australia

We present a new ocean box model to be used for long timescale climate studies. The model uses water mass layers for its deep boxes and the water mass outcrops for the surface boxes. As such, is named the Water Mass Model (WaMM). The use of water masses (or layered boxes) allows greater vertical resolution in the model without substantially increasing the number of boxes. It also allows us to include density driven flows at the surface and in the deep where a “traditional” box model with only two layers (surface and deep) would only allow density driven flows in one layer with the other being necessarily determined by continuity. We undertake an investigation into various options for the pathways of the continuity flows, testing both the traditional vertical continuity pathways, and alternative horizontal continuity pathways. This is motivated by the desire to avoid large diapycnal flows, particularly through the base of the Thermocline, that are necessary with the vertical continuity flow option. We find the model that includes horizontal continuity flows instead of vertical continuity is no longer able to produce a completely collapsed, “no flow” equilibrium solution, even with very low vertical mixing. The reasons for this are discussed. Finally we use the WaMM configuration to construct an asymmetric model of the Atlantic where two key topographical asymmetries are included. The first is the lack of meridional boundaries across the mid-latitudes of the Southern Hemisphere. We simulate this by disallowing geostrophic flow across 40oS and investigate the impact on the asymmetrical solution. The second topographic asymmetry is the inclusion of the Greenland-Iceland-Scotland (GIS) sill which forces dense water created in the Arctic Ocean up into the mid-depths of the ocean, where it entrains lighter water and enters the Atlantic as deep water rather than as bottom water. We analyse the impact of each of these asymmetries on the overall circulation pattern.