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Role of mesoscale eddies in cross-frontal transport of carbon and nutrients in the Southern Ocean

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The Southern Ocean plays a key role in oceanic carbon storage and global nutrient distributions. Here, carbon and nutrients are transferred into the ocean interior by the formation and subduction of mode and intermediate water masses. Much of the subducted carbon and nutrients in these water masses derive from waters upwelled at the Antarctic Divergence that must cross the numerous fronts of the Antarctic Circumpolar Current (ACC) to reach the sites of water mass formation. These energetic frontal jets are natural barriers to tracer exchange but allow some crossings via specific mechanisms. While northward Ekman transport has been elucidated as the major mechanism for cross-frontal transport of tracers at intra-annual scale, little is known about the role of mesoscale eddies in mediating tracer exchange across fronts.

This study aims to address the role of mesoscale eddies in cross-frontal transport of carbon and nutrients in the Southern Ocean while (i) quantifying the net transport of tracers across the various fronts of the ACC, (ii) describing the hot spots of tracer exchange, (iii) investigating the time-scales of this exchange and its response to climate change. To this purpose, we use a 1/10° configuration of the GFDL climate model (CM2.6) coupled to a simplified version of the biogeochemistry model BLING where dissolved inorganic carbon (DIC), phosphate and oxygen are simulated. The model is started from observations with DIC corrected to preindustrial conditions, and run for a 120 year spin-up from which two 80 year simulations are performed: a preindustrial control with constant radiative forcing and a sensitivity with a 1%/year increase in atmospheric CO_2 concentration. We focus our analyses on the last 20 years of both simulations sampled at monthly frequency. Online tendency terms are used to compute the total transport of DIC, phosphate and oxygen across the main fronts of the ACC, and to single out the mesoscale eddy component of the transport. The contribution of mesoscale eddies to the total cross-frontal transport is presented for each biogeochemical tracer along with its spatial and temporal variabilities. The response of the various components of the transport to climate change is also investigated.