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On the relation of meridional density gradients and Southern Ocean wind stress with respect to the global meridional overturning circulation: A model study

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Experiments in the coupled climate model CLIM*BER*-3α, which contains an oceanic general circulation model, show deep upwelling in the Southern Ocean to be proportional to the surface wind stress in the latitudinal band of Drake Passage. At the same time, large scale meridional overturning circulation in each basin is determined by the respective meridional density gradient. The distribution of the Southern Ocean upwelling onto the oceanic basins is thus controlled by buoyancy distribution; the inflow into each basin being proportional to the respective meridional density gradient. The constant of proportionality is the same for all basins. For strongly reduced wind stress in the Southern Ocean, the circulation enters a regime where Atlantic overturning is maintained through Pacific upwelling, in order to satisfy the transports set by the density gradients. We therefore propose that both Southern Ocean upwelling and meridional density gradients set up a system of conditions that determine the global meridional overturning circulation. A number of experiments were designed in order to investigate this hypothesis. These are simulations with varying winds in the Southern Ocean from 0.2 to 1.5 times presently observed fields combined with varying surface freshwater fluxes to the North Atlantic and North Pacific.