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A simple scaling for the ACC strength in climate models

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The Antarctic Circumpolar Current (ACC) is the strongest current in the global oceans. Yet its theoretical understanding is still incomplete, which is due to the complex interaction of forcing fields (wind, buoyancy) and processes within the ocean (eddy-induced transports, bottom form stress) on various spatial scales. The current class of global coupled climate models, as used for the IPCC AR4, are being far from ideal tools to model the ACC. The reason is that the eddy-induced transports are not resolved by this class of models. Instead, the vast majority of these models use the Gent & McWilliams parameterization of eddy-induced transports. Here we develop a scaling that explains the strong variation of the ACC strength across the IPCC AR4 climate models. The scaling is derived analytically starting from earlier work by Marshall & Radko (2003). It highlights the dependence of the ACC strength on the wind stress, the meridional density gradient and, before all, the eddy-induced diffusivity coefficient used in the Gent & McWilliams parameterization. Using the analytical derivation of the scaling it is shown how the scaling depends on assumptions about the surface boundary conditions and about the specific implementation of the Gent & McWilliams parameterization. The scaling correlates very well with the data from the IPCC AR4 climate models. The results show the strong role of the Gent & McWilliams parameterization in determining the simulated ACC strength. This calls for an intensified development of global climate models that resolve the eddy-induced transports.