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Sensitivity of the ocean overturning circulation to wind and mixing: theoretical scalings and global ocean models

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The meridional overturning circulation (MOC) is a planetary-scale oceanic flow which is of direct importance to the climate system: it transports heat meridionally and regulates the exchange of CO_2 with the atmosphere. The MOC is forced by wind and heat and freshwater fluxes at the surface and turbulent mixing in the ocean interior. A number of conceptual theories for the sensitivity of the MOC to changes in forcing have recently been developed and tested with idealized numerical models. However, the skill of the simple conceptual theories to describe the MOC simulated with higher complexity global models remains largely unknown. In this study, we present a systematic comparison of theoretical and modelled sensitivity of the MOC and associated deep ocean stratification to vertical mixing and southern hemisphere westerlies. The results show that theories that simplify the ocean into a single-basin, zonally-symmetric box are generally in a good agreement with a realistic, global ocean circulation model. Some disagreement occurs in the abyssal ocean, where complex bottom topography is not taken into account by simple theories. Distinct regimes, where the MOC has a different sensitivity to wind or mixing, as predicted by simple theories, are also clearly shown by the global ocean model. The sensitivity of the Indo-Pacific, Atlantic, and global basins is analysed separately to validate the conceptual understanding of the upper and lower overturning cells in the theory.