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Southern Ocean adjustment, eddy saturation and intrinsic variability

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We examine the robustness of Southern Ocean 'eddy saturation', a conceptual model used to explain why (eastward) volume transport remains steady under increasing (eastward) wind stress over long timescales. Mesoscale eddies play a central role, so it is important to resolve them explicitly and also to examine the dynamics over interannual to decadal timescales - a challenge for current climate models. In addition, nonlinear sensitive dependence may become more important as eddies are resolved, so alternative modelling approaches are required to understand eddy saturation. Using two varieties of ensemble experiments with an eddy-resolving, quasi-geostrophic channel model (Q-GCM) we examine the sensitivity of the transport to both the magnitude of the applied wind stress trend and to intrinsic nonlinear dynamics. Regimes exist for which the eddy saturation description is slightly too simple, although it broadly holds. Consideration of the intrinsic variability is shown to be important, otherwise wrong conclusions about the typical transport sensitivity could be assumed. We find that dynamics associated with seafloor topography play a significant role in the Southern Ocean adjustment under increased wind forcing and that the simple scalar metrics of eddy saturation obscure an interesting dynamical response.