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On the response of Southern Hemisphere subpolar gyres to climate change in coupled climate models

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We investigate the responses of the Southern Hemisphere subpolar gyres to projected climate changes over the 21st century by CMIP3 and CMIP5 models. Under increased greenhouse gas forcing, the Southern Hemisphere westerly winds consistently become intensified, resulting in increased cyclonic wind forcing in the subpolar region in these models. Under such wind forcing changes, it is a robust feature that there are consistent increases in the westward flow close to the coast of Antarctica, with strong implications to the mass balance of the Antarctic ice shelves and ice sheets. However, there are large discrepancies in the responses of the gyre axes and overall gyre strengths. Some models show equatorward expansions of the southern gyre limbs, resulting in consistent and large gyre strength increases, while some other models show poleward contractions of the gyres, and generally small and less consistent gyre strength changes. These uncertainties are primarily a result of the uncertain simulations of eddy-driven circulations in the Antarctic Circumpolar Current. The associated buoyancy forcing changes play a secondary role in driving these oceanic responses.

This study reveals that there are large uncertainties in the projections of the subpolar circulation in the current generation of coupled climate models, though CMIP5 models have considerably smaller inter-model spreads in the present-day and projected gyre strengths. To predict the subpolar circulation changes, future improved modelling studies need to particularly reduce the uncertainties in the projections of the westerly jet and to reduce the uncertainties in the eddy-driven circulation responses to wind forcing changes.