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The role of eddies in determining the Southern Ocean response to the Southern Annular Mode

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The Southern Ocean shows a clear response to the Southern Annular Mode (SAM). A positive shift in the SAM is associated with cold sea surface temperature (SST) anomalies centred at 60°S and warm SST anomalies centred at 40°S, and an increase in transport of the Antarctic Circumpolar Current (ACC). The ACC transport increases due to a strengthening of the atmospheric westerlies. The SST response results from a combination of anomalous atmosphere-ocean heat fluxes and enhanced northward Ekman transport. However, eddies may act to reduce the SST response to the SAM by increasing southward heat transport, and reduce the ACC zonal transport response to the SAM by transferring momentum downwards in the water column. Consequently the Southern Ocean response to the SAM may be difficult to capture exactly with climate models that do not resolve eddies explicitly. Results are presented from the OCCAM ocean model which is run at a range of resolutions from coarse (1°) to eddy-permitting (1/12°), with wind and heat fluxes from reanalysis. Comparing coarse with fine resolutions indicates the effect of explicitly-resolved eddies on the Southern Ocean response to changes in the SAM. The regression coefficient between monthly Drake Passage transport anomalies and the SAM is smaller in the higher resolution models. Thus a change in wind stress forced by the SAM results in a smaller increase in transport when eddies are taken into account. Drake Passage transport variability is also reduced in the higher resolution models suggesting that eddies dampen the monthly variability. The observed SST response to the SAM is well represented by all resolutions of the model indicating that eddies play a minor role in determining the SST response on monthly timescales. These results illuminate the horizontal resolution required by climate modellers to accurately represent SAM-induced changes in the Southern Ocean.