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The response of the Antarctic Circumpolar Current to recent climate change in non-eddying and eddy-permitting ocean simulations

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The response of the Antarctic Circumpolar Current (ACC) to recent climate change is investigated using ocean model simulations at different horizontal resolutions. The simulations are performed with the NEMO-LIM2 ocean-sea ice model at a non-eddying resolution of ~0.5^{o} (ORCA05) and at an eddy-permitting resolution of ~0.25^{o} (ORCA025). The models are integrated using both climatological (i.e. repeated annual cycle) and interannual forcing for the period 1948-2007. In the 100-year climatological simulations, the ACC is found to spuriously drift of a few Sv per decade because of insufficient formation of high-latitude dense waters. This bias is typical of ocean models at this resolution; yet it hinders the study of ACC changes in response to decadal climate trends. To improve the simulated across-ACC density gradient, a weak restoring of deep temperature and salinity is applied to dense waters located south of the ACC. We show that the spurious ACC drift in the climatological simulation is significantly reduced, whilst its interannual variability in the hindcast simulations is not affected. In response to increased Southern Hemisphere Westerlies in the past decades, both the ORCA05 and ORCA025 simulations exhibit changes in ocean circulation and a latitudinal redistribution of heat and freshwater. In the non-eddying ORCA05 simulation, the ACC transport increases almost linearly with the westerly wind increase, and its path shifts southward in conjunction with poleward intensifying winds. This evolution is typical of non-eddying ocean models, in which the ACC response to increased westerly winds is governed by enhanced northward Ekman transport and upwelling of dense waters. The results obtained with the non-eddying ORCA05 simulation are contrasted with those obtained with the eddy-permitting ORCA025 simulation, and the resolution-dependence of the ACC response to wind changes is highlighted.