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Mesoscale Ocean Eddies and Climate Change over the Southern Ocean

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We considered observed and simulated Southern Ocean's sea-level pressure (SLP; NCEP–NCAR reanalysis) and sea-surface temperature (SST; GISS data set) secular trends in 1950–2000. The main feature of the observed SLP evolution is a largely monotonic decrease south of 50º S, accompanied by a slight opposite trend to the north of this latitude. The multi-model ensemble mean of SLP based on the World Climate Research Programme's (WCRP's) Coupled Model Intercomparison Project phase 3 (CMIP3) multi-model dataset also shows the trend of the same sign, albeit with a much smaller amplitude. On the other hand, both observations and model simulations are characterized by very similar positive SST trends in the Southern Ocean. One possible hypothesis that may reconcile these two features is that SST secular changes are dominated by processes that do not involve forced oceanic response to atmospheric wind modifications, which is however quite unlikely. Another possibility is that the similarity of observed SST response to the simulated one, despite very different wind forcing, is due to a much stronger resistance of oceanic circulation and, hence, observed SSTs to this forcing compared to that suggested by CMIP3 model simulations. Using eddy-resolving and coarse-grained models of the Southern Ocean circulation, we argue that this enhanced resistance has to do with nonlinear dynamics of oceanic eddies, which are grossly under-resolved in the current generation of climate general circulation models.