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Investigation of Mechanical and Thermal Wind Sensitivity on the Mesoscale Eddies in the Southern Ocean

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In this study, a high-resolution eddy resolving regional ocean + sea ice coupled model (MITgcm) is used to study the effects of increasing westerlies along the Southern Ocean. Previous studies only focused on increasing wind stress, thus not taking into account of atmosphere-to-ocean heat and freshwater fluxes. Here, we conduct two concurrent simulations; i) 1.5 times increased wind stress (i.e. increased only mechanical forcing) ii) 1.2247 times increased wind speed (i.e. both mechanical and thermal flux forcing). Model domain covers whole Southern Hemisphere with lateral open boundary conditions from ECCOv2 ocean reanalysis and surface boundary conditions from ECMWF ERA-5 atmospheric reanalysis. In both sensitivity scenarios, due to the increase in the wind stress, the Ekman transport towards Equator towards north is increased. This caused increased upwelling of warmer North Atlantic Deep Water (NADW) near the Antarctic ice sheet. Both scenarios show reduced sea ice formation with up to 2 million km^2 in the austral summer and up to 4 million km^2 during the austral winter. Sea ice extent is reduced more in the mechanical forcing simulation than the mechanical+thermal forcing one. This is a clear result that increased wind anomalies should be studied with increased wind rather than increased stress. The reduction in the sea ice coverage that is attributed to the warmer water mass can also be observed through the Sea Surface Temperature (SST) values. The first case shows up to 1 – 1.5 °C very close to the Antarctica, whereas the second case shows a much limited SST change around 0.5 °C.

Both sensitivity scenarios show an increase of the transport along Drake Passage. However, the mechanical+thermal case shows larger increase in the Drake transport compared to the mechanical case. This indicates that a change in the Antarctic Circumpolar Circulation also modifies the meridional density gradient along with the upwelling characteristics. Finally, overturning transport in the density space shows that Subtropical Cell and ACC upper Cell strengthen in the mechanical+thermal case, while there are no significant changes in the thermal case. In both simulations, Subpolar Cell increases and Lower Cell decreases. We conclude that studying increased westerlies with two different approaches show significant changes in the surface and deep circulation. Previous studies which taken into only mechanical forcing part are missing thermal component of the wind effects.