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Winter mixed layer in the southern Indian Ocean in a high-resolution atmosphere-ocean coupled model

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Abstract

One of most frequently asked questions in climate modelling is whether it is necessary to resolve mesoscale eddies in the ocean in order to accurately predict future climate. Winter mixed layer (WML) depths help control subduction rates and are therefore important for setting ocean uptake of heat and anthropogenic CO_2. Here, we compare the WML depth and subduction in the southern Indian Ocean in an ocean-atmosphere coupled model where the horizontal resolution in the ocean is at 1° and $1/3^\circ$. In the model with eddy-permitting ocean the WML field in the southern Indian Ocean compares well with the observations. In contrast, in the coarse-resolution ocean model the WML is too shallow and has the wrong spatial structure. The reasons for the better simulation of WML in the eddy-permitting ocean model are:

1. The Agulhas Current continues further south after leaving the coast. Consequently, the sea surface temperature south of the Subtropical Front (STF) in the Indian Ocean is higher and so even though the atmosphere is also warmer there is a greater air-sea temperature difference and a greater heat loss.
2. The accumulated heat loss between the STF and Subantarctic Front is crucial for setting the WML depth. With a greater heat loss upstream, stratification between the two fronts is destroyed and so the mixed layer becomes deeper downstream.

Consequently, the subduction rate in the model with eddy-permitting ocean is closer to the observational estimates.