EGU22-2316
https://doi.org/10.5194/egusphere-egu22-2316
EGU General Assembly 2022

Identifying the drivers of Subantarctic mode water thickness across the south Pacific.

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Subantarctic mode water (SAMW) is a subsurface water mass which is formed through surface heat loss. This leads to thick winter mixed layers which are then subducted resulting in a low stratification subsurface watermass. SAMW formation regions are important for the storage and transport of heat and carbon. Recently, it was found that SAMW layers are getting thicker each year over much of the Southern Ocean. In the South Pacific mode water formation region, a central and eastern pool of mode water has been found to have winter thicknesses that vary strongly interannually and out of phase across the basin. This is associated with peaks in sea level pressure variability at a quasi-stationary anomaly situated between the two pools.

To investigate how this external forcing, as well as the propagation of upstream anomalies, affects these mode water pools, a set of adjoint sensitivity experiments are conducted. The traditional approach to adjoint sensitivity experiments in the ECCOv4 state estimate uses a vertical mask that is fixed at all times. Instead, the adjoint is developed so that a density following mask is employed, which more closely reflects how water masses preferentially spread along density surfaces.

The ECCOv4 state estimate, with this new feature, is used to conduct a set of adjoint sensitivity experiments that directly quantify the role of local versus remote forcing in setting the variability in regional mode water properties raised in recent studies. Two separate adjoint sensitivity experiments are completed with horizontal masks in the two pools of mode water in the south east Pacific mode water formation region. The objective function used here is the yearly averaged heat content over the pool and the density surfaces. The analysis compares the effect of local versus remote forcing, identifying the separate effects of the wind stress, heat flux, and freshwater flux. The sensitivities of the SAMW are then identified in terms of the different forcing components associated with the atmospheric modes, ENSO and SAM.