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Subantarctic mode water formation rate estimates from a data assimilating model

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We assess the accuracy of the recently obtained air-sea buoyancy fluxes and resulting Subantarctic Mode Water (SAMW) formation rates for years 2005 and 2006 from an eddy-resolving data assimilating ocean model (the Southern Ocean State Estimate, SOSE). The main novelty of SOSE is that it provides a complete and consistent data set including atmospheric forcing fields and three-dimensional oceanographic fields. Even for the studies that require only the sea surface oceanic data, SOSE has the advantage over the air-sea heat flux estimates from the numerical weather prediction models that it provides the sea surface temperature and salinity which are dynamically consistent with the atmospheric forcing.

SAMW formation rates are estimated using SOSE as input in Walin analysis. This requires knowledge of air-sea buoyancy flux and interior diapycnal buoyancy flux together with the ocean density fields. SAMW formation rates in a given density range are result of a near-cancellation of buoyancy fluxes associated with freshwater and air-sea heat flux in that density range, thus making accurate formation rate estimates even more difficult to obtain in the data sparse Southern Ocean.

The quality of the SOSE air-sea heat and freshwater flux estimates has been assessed by verifying that the SOSE differences from NCEP-NCAR Reanalysis 1 (NCEP1) forcing fields (which SOSE used as an initial guess) largely correct the NCEP1 biases reported by the Working Group on Air-Sea Fluxes, and are also largely in agreement with those of the recent Large and Yeager (2009) flux estimates.

The SOSE formation rate estimates correctly reproduce SAMW density range as determined by hydrography (sigma-theta=27.1 for Pacific SAMW and sigma-theta=26.8 for the Indian SAMW. The SOSE formation rate estimates for years 2005 (2006) are 5.3 Sv (6.0 Sv) of Pacific SAMW and 4.6 Sv (3.5 Sv) of the Indian SAMW. Pacific SAMW formation rate estimates closely match the corresponding estimates obtained from CFC-12 inventories by Hartin et al. (2008).

The accuracy of both the SOSE air-sea buoyancy flux estimates as well as the SAMW/AAIW formation rate estimates supports the use of the data assimilating models as a method to overcome the sparness of the observations in the Southern Ocean.