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Multi-decadal changes in southern hemisphere subduction rates in a 1/12° ocean model hindcast

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Mode and Intermediate Waters formed in the mid-latitudes of the Southern Ocean represent a major agent for the ventilation of the southern hemisphere lower thermocline, playing a key role in the uptake and intermittent storage of anthropogenic CO_2. Long-term hydrographic records as well as modelling studies have provided indications that characteristics of these water masses have been changing over the last decades. Changes in heat, freshwater and momentum fluxes may all contribute to the water mass variability. In this study, we investigate the temporal and spatial variability of Subantarctic Mode Water (SAMW) and Antarctic Intermediate Water (AAIW) formation and its linkages to changing atmospheric conditions with a global ocean – sea-ice model for the time period 1979-2007. The model employs a horizontal resolution of 1/12° for the Southern Ocean and is forced with the CORE-II interannually-varying atmospheric forcing data set. The hindcast simulation is complemented by a second experiment with a repeated 'normal-year' atmospheric forcing in order to separate atmospherically-related changes from stochastic variability and spurious model trends. We find that subduction rates in the density range of SAMW and AAIW are dominated by the lateral induction term and as such are tightly linked to the maximum mixed layer depth (MLD) at the end of winter. The model simulation shows multi-decadal trends in subduction rates, however the trends are not uniform across the density range of SAMW/ AAIW and differ between the Pacific and Indian Ocean sectors.

Largest changes in AAIW formation are found in the southeast Pacific, whereas changes in SAMW formation are most pronounced in the Indian Ocean. In the Pacific, the decrease of subduction rates in the AAIW range is contrasted by a positive trend in the SAMW range.

The changes in subduction rates are linked to salinity and thus density trends of the winter mixed layer that can be traced to multi-decadal trends in heat and freshwater fluxes at the surface.