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Impact of coastal polynyas on dense shelf water formation in the Weddell Sea

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Dense shelf water is an essential ingredient to the formation of Antarctic Bottom Water (AABW). It is formed on the continental shelves surrounding Antarctica, when freezing rates are sufficiently high to push ocean salinity to values of 34.65 and higher. Coastal polynyas, where the ice is driven away from the coastline, maintain the highest freezing rates in Antarctic winter. Since the Weddell Sea is considered the most productive source region of AABW, we investigate the dense water formation on the continental shelves of the southwestern Weddell Sea, with a focus on the role of coastal polynyas, using the Finite Element Sea ice-Ocean Model (FESOM), a primitive-equation, hydrostatic ocean model coupled with a dynamic-thermodynamic sea ice model. The horizontal resolution of the global, unstructured mesh is up to 3 km at the southwestern Weddell Sea coastline; in vertical direction the mesh features 37 depth levels (resolution increases toward the surface). The model was initialized on 01/01/1980 with data from the Polar Hydrographic Climatology and forced with NCEP/NCAR Reanalysis data. The 20-year period 1990-2009 is used for analysis. Our results indicate that in an average year, the polynya freezing rates of 9 cm d^{-1} (corresponding to a salt input of 2.5 kg $m^{-2}d^{-1}$) cause a seasonal variation in salinity of 0.3 psu under the Ronne polynya and result in the production of $5{\cdot}10^4$ km^3 dense shelf water, which leaves the continental shelf (outlined by the 700 m isobath in this study) at a long-term mean volume flux of 5.2 Sv. Some of this water contributes to the formation of Weddell Sea Deep/Bottom Water, but a large fraction is diluted by mixing with ambient water and leaves the Weddell Sea at intermediate levels.