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Southern Ocean ventilation and bottom water formation driven by Weddell Sea polynyas

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A distinct feature of the last glacial period, are the abrupt temperature fluctuations in Greenland associated with Dansgaard-Oeschger events and a similar but opposite response in Antarctica. The prevailing hypothesis behind this inter-hemispheric coupling, points to changes in deep water formation as the main driver, thus highlighting the pivotal role of the high latitude oceans in global climate.
Bottom water formation through open-ocean deep convection in an Antarctic polynya, a large open water area inside the winter sea ice cover, provide a potential mechanism to trigger such changes in ocean circulation.
In this study, an ocean-sea ice only version of the Norwegian Earth System Model (NorESM) is explored and shows strong open-ocean deep convection associated with large polynyas in the Weddell Sea. This provides us with an opportunity to test (1) how internal ocean dynamics can trigger abrupt changes in sea-ice cover and (2) how these polynyas affect the overturning circulation through changes in bottom water formation.
During the 1,000 year long free-running simulation two polynyas are observed.
We show, that the polynya is caused by subsurface warming leading to a gradual weakening of the surface stratification which destabilizes the whole water column and eventually triggers deep convective overturning. This mixes up relatively warm deep water causing extensive melt of sea ice in the Weddell Sea, while cold and fresh surface water sinks to the bottom. Consequently, the polynya leads to extensive bottom water formation and increase in the northward flow of Antarctic Bottom Water, while the southward flow of North Atlantic Deep Water is reduced.
Finally, our results suggest that a decrease in the temperature of warm deep water in the Weddell Sea leads to cessation of open-ocean deep convection. This raises the question if open-ocean deep convection associated with polynyas in the Southern Ocean could be a realistic feature in a cold, glacial climate.