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A Lagrangian model analysis of Arctic water mass transformations and exports.

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We investigate the origin of the water masses exported from the Arctic Ocean to the North Atlantic along both sides of Greenland through Davis Strait and Fram Strait, using an original numerical method. A quantitative Lagrangian analysis is applied to the monthly climatological 3D output of a simulation using the global ocean/sea-ice high resolution DRAKKAR model (12 km grid spacing in the Arctic Ocean), in order to establish a mean quantitative circulation scheme. The sensitivity of the picture to a change of the Arctic Oscillation state is also investigated. We quantify the relative contributions of the different branches of circulation for the export to the North Atlantic, as well as the related timescales and water mass transformations.

In the model, the outflow through Davis Strait consists in equal part of Pacific and Atlantic Water, whilst the export through Fram Strait consists fully of Atlantic Water. The possible lack of Pacific Water on the eastern side of Greenland is discussed in detail. Pacific Water is transferred quickly (O(10 years)) to the North Atlantic, through the upper layer of the Beaufort Gyre, where gradual warming and salinification occur. Atlantic Water exiting in the surface layer along both sides of Greenland remains about 10 years in the Arctic Basin, and undergoes cooling and significant freshening. Atlantic Water exiting through the intermediate and deep layers in Fram Strait follows different possible pathways in the Arctic, with trajectories being subject to topography constraints. The travel time depends strongly on the followed pathway (from 1 year to 1000 years) and the transformations (mainly an intense cooling) are less important than in the surface layer. The role of the Barents Sea in the modification of the Atlantic inflow is specially emphasized. We find that the Barents Sea branch (Atlantic Water that enters through the Barents Sea) is almost fully transformed there in less than a year, due to exchanges with the very cold atmosphere.