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Freshwater Input and CaCO3 Saturation State in the Davis Strait

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Freshwater dynamics in the polar oceans have important implications for the global climate. Modelling studies indicate a sensitive response of the Atlantic meridional overturning circulation (MOC) to changes in the surface buoyancy fluxes. Freshwater inputs to the deep convection sites in the Labrador Sea and the Nordic Seas potentially influence deep convection regimes, and therefore MOC. Freshwater in the polar oceans originates from sea-ice meltwater, precipitation, river input and meltwater from glacial ice sheets. These different freshwater sources may variably influence the saturation state of seawater with respect to calcium carbonate (Ω), since different freshwater components have a variety of carbon contents and buffer capacities. Observed changes in sea ice coverage in the Arctic Ocean, high latitude hydrological cycles, and melting of the Greenland ice sheet will therefore potentially alter not only the buoyancy flux of the deep convection regions but also the CaCO3 saturation state.

The Davis Strait connects the Labrador Sea with the Arctic through Baffin Bay and provides a good platform to observe the propagation of changes in the Arctic to the Labrador Sea, while the Greenland side of the Strait is also an active fishery site. The Arctic outflow is fresher than the receiving Atlantic water and is therefore a source of freshwater to the Labrador Sea. In an ongoing time-series study of the Davis Strait we conducted simultaneous measurements of multiple tracers to quantify freshwater composition (oxygen isotope composition (δ18O), salinity and nutrient ratios), and dissolved inorganic carbon and total alkalinity in order to calculate Ω. The fractions of local sea ice meltwater, meteoric water (fluvial, glaciofluvial and precipitation) and the contribution from the Arctic outflow were quantified. The freshwater contribution from the Arctic outflow was identified using a modified nutrient ratio method and further de-convoluted into sea ice meltwater, meteoric water and the Pacific water at the formation site. The Arctic outflow dominates the water mass of the western Davis Strait (>60%). The sea ice meltwater fraction is small (<2%) and limited to the surface layer of the central and western part of the section. The meteoric water fraction is higher at Greenland side of Davis Strait and highest on Greenland Shelf (>6%), which is considered to originate from glacial meltwater from Greenland. The freshwater inventory in the surface 200m in the western Davis Strait was equivalent to around 13-14 m with 2-3 m of brine rejection and with 15-16 m freshwater contribution from Arctic outflow. At the Greenland side of Davis Strait the freshwater inventory was around 4-5m and virtually all of this freshwater was of meteoric origin (meltwater from Greenland ice sheet). Within the surface 50 m, salinity and Ω were not correlated, although the Arctic freshwater component was negatively correlated with Ω. The meteoric water fraction on the Greenland Shelf and Slope also did not show a clear relationship with Ω. The contribution of Sea ice meltwater was small and did not materially influence Ω in this study. Processes such as photosynthesis at the surface layer and de-nitrification at the bottom layer seem to offset the influence of Greenland ice sheet meltwater.