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Effects of lead width variation, re-freezing and mixing events on lead water structure in the central Arctic

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We undertook a lead survey during the international drift campaign MOSAiC, Leg 5 (from 22 August to 17 September 2020) to understand the effects of lead width variation, re-freezing, and mixing events on lead water vertical structure. At the beginning of the survey period, the freshwater layer was occupied for the top 1 m depth and there were strong vertical gradients in temperature, salinity, and dissolved oxygen (DO) within 1 m depth: from 0.0°C to –1.6°C for temperature, from 0.0 to 31.4 psu for salinity, and 10.5 to 13.5 mg L^{-1} for DO. A strong DO minimum layer corresponded with a salinity of 25 psu, and usually occurred at the freshwater–seawater interface at approx. 1 m depth, most likely as a result of an accumulation of organic matter and ongoing degradation/respiration processes at this interface. However, during the survey period, these strong gradients weakened and reduced the freshwater layer thickness (FLT). In the first half of the sampling period (until 4 September), FLT changed due to variations in lead width: as lead width increased, FLT decreased due to a stretching of the freshwater layer. In the second half of the sampling period, FLT was controlled by the surface ice formation (re-freezing) and mixing processes along the lower boundary of the freshwater layer. Surface ice formation removed freshwater and the formation of surface ice (about 0.2 m thick) explains 20% of the reduction of FLT. The remaining 80% of the reduction of FLT was due to the mixing process within the water column that was initiated by cooling and re-freezing. This mixing process diluted the salinity from 31.6 to 29.3 psu in the water below freshwater layer towards the end of the survey period. Our results indicate that lead water structure can change rapidly and dynamically and that this has significant effects on the biogeochemical exchange between lead systems and the atmosphere.