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Snowfall and snow accumulation processes during MOSAiC

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Due to logistical challenges, snowfall in the high Arctic has rarely been measured, which is particularly valid for longer time-spans and the polar night. When estimating snowfall with precipitation gauges, a snowfall reference and detailed knowledge of how the precipitated snow accumulated or eroded is required.

To overcome snowfall uncertainties and to improve accumulated and eroded snow estimates, we used data from precipitation gauges, snow particle counters (SPCs) and a K_a-Band ARM Zenith Radar (KAZR) installed on and around research vessel (RV) Polarstern during the snow accumulation season of MOSAiC (October 2019 - May 2020). In addition to this, direct snow water equivalent (SWE) measurements were conducted and SWE estimates were retrieved from SnowMicroPen (SMP) measurements distributed all over the floe. The evolution of accumulated snow mass was finally computed by applying a simple fitted z-SWE function to snow depths that were measured approximately weekly along a fixed transect path with a Magnaprobe. The transects paths were along two distinct ice types: predominantly level remnant ice that at the start of the winter had large refrozen melt ponds, and predominantly deformed thick second year ice (SYI).

We could show that at least 34 mm of snow has accumulated and approximately 9 kg m^{-2} of snow mass was eroded between 31 October 2019 and 26 April 2020. In the beginning of the winter, the total estimated SWE on level remnant ice was only 42 % of SWE on deformed SYI. By end of April 2020 the values almost equalized as the snow mass on remnant ice reached almost 90 % of the

snow mass over deformed SYI.

Based on the SWE evolution of the snowpack, we validated precipitation sensors and the reanalysis ERA5 for their capability to estimate snowfall. Eroded snow mass, among other processes, led to a discrepancy of precipitation- sensor estimated snowfall and computed SWE of the snow cover from 20 February 2020 on. However, for the time period before the first net erosion could be observed we found best agreements of cumulated snowfall and SWE for the Vaisala Present Weather Detector (PWD22) installed on the vessel (RMSE = 2 mm) and for snowfall retrievals from the KAZR (RMSE = 4 mm). Other sensors largely overestimated snowfall (corrected OTT Pluvio^2: 14 mm; Vaisala PWD22 on the ice: 26 mm, OTT Parsivel^2 on RV Polarstern: 51 mm). ERA5 overestimates snowfall too, with 13 mm and an increasing positive bias from March 2020 on. With horizontal snow mass fluxes derived from SPCs we could show that the Vaisala PWD22 on RV Polarstern was effectively protected against blowing snow. This, however, greatly affected snowfall measurements of instruments collocated on the ice. Further, we investigated a high-wind event in February 2020 resulting in high blowing snow mass fluxes and an average eroded snow mass of 5.5 kg m^{-2}. The lifted blowing snow particles from the surface led to strong overestimation of snowfall from instruments installed on the ice which cannot be corrected with conventional correction methods.