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Drone-based sea ice albedo measurements and photogrammetry during the Arctic freeze-up in the MOSAiC expedition

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Aerial albedo measurements and detailed surface topography of sea ice are needed to characterize the distribution of the various surface types (melt ponds of different depth and size, ice of different thicknesses, leads, ridges) and to determine how they contribute to the areal-averaged albedo on different horizontal scales. These measurements represent the bridge between the albedo measured from surface-based platforms, which typically have metre-to-tens-of-meters footprint, and satellite observations or large-grid model outputs.

Two drones were operated in synergy to measure the albedo and map the surface topography of the sea ice during the leg 5 of the MOSAiC expedition (August-September 2020), when concurrent albedo and surface roughness measurements were collected using surface-based instruments. The drone SPECTRA was equipped with paired Kipp and Zonen CM4 pyranometers measuring broadband albedo and paired Ocean Optics STS VIS (350 – 800 nm) and NIR (650-1100 nm) micro-radiometers measuring visible and near-infrared spectral albedo, and the drone Mavic 2 Pro was equipped with camera to perform photography mapping of the area measured by the SPECTRA drone.

Here we illustrate the collected data, which show a drastic change in sea ice albedo during the observing period, from the initial melting state to the freezing and snow accumulation state, and demonstrate how this change is related to the evolution of the different surface features, melt ponds and leads above all. From the data analysis we can conclude that the 30m albedo is not significantly affected by the individual surface features and, therefore, it is potentially representative of the sea ice albedo in satellite footprint and model grid areas.

The Digital Elevation Models (DEMs) of the sea ice surface obtained from UAV photogrammetry are combined with the DEMs based on Structure From Motion technique that apply photos manually taken close to the surface. This will enable us to derive the surface roughness from sub-millimeter to meter scales, which is critical to interpret the observed albedo and to develop correction methods to eliminate the artefacts caused by shadows.

The UAV-based albedo and surface roughness are highly complementary also to analogous helicopter-based observations, and will be relevant for the interpretation of all the physical and

biochemical processes observed at and near the sea ice surface during the transition from melting to freezing and growing.