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High resolution helicopter-borne surface temperatures for satellite validation

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We conducted thermal infrared imaging during 35 helicopter survey flights during the Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC) from October 2019 to April 2020, during which the icebreaker *Polarstern* drifted with the sea ice in the Central Arctic. Surface temperature maps at a high resolution of 1 m are derived for a local, 5 km, and regional, 30 km, scale by merging more than 150,000 thermal infrared images. We analyze the temporal and spatial variability of the surface temperatures throughout the whole winter. While in winter the snow-covered sea ice appears very cold, thin ice and open water are significantly warmer and dominate the heat exchange between the ocean, ice, and atmosphere. Thus, in winter small cracks and leads act as windows for increased heat exchange from the warmer ocean to the colder atmosphere. These features are becoming increasingly present in a warming Arctic when the ice is thinning, moves faster, and breaks up more easily. With thermal infrared observations, we can characterize surface types based on the surface temperature of snow, sea ice, and ocean water surfaces. In our study, we developed a lead classification scheme based on an adaptive surface temperature threshold method. This allows us to identify single leads, determine the lead area fraction and lead properties like width and orientation. Results show that the lead width distribution follows a power law in agreement with previous studies; i.e. there are many narrow leads and a decreasing number of wider leads. This supports our assumption that there are many features on a small scale which can not be fully resolved by thermal infrared satellites with a spatial resolution of 1 km or lower. We use a surface temperatures dataset from the Moderate Resolution Imaging Spectroradiometer (MODIS) and investigate the sub-footprint scale variability and validate the satellite surface temperature based on our high resolution data. From this, we want to learn how well the small scale surface heterogeneity is represented in the satellite signal. For example, a continuous area of thin ice yields the same average surface temperature within the satellite footprint as a situation of dominantly thick ice with a few open water leads. However, the localization of ocean-ice-atmosphere exchange processes and amount of heat and gas fluxes would be very different for the two situations. The high resolution helicopter borne surface temperature data can support regional process studies to better analyze the influence of sea ice surface heterogeneity on polar climate processes.