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Arctic polynyas: Retrieval of wintertime sea-ice production using satellite-derived thin-ice thickness distributions

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Knowledge of wintertime sea-ice production in polynyas is an important aspect of atmosphere – sea-ice – ocean interactions in high latitudes, and a precise quantification can be for instance utilized to verify frequently used climate and ocean models. This study features a high-resolution (2km) MODIS thermal infrared satellite data set with spatial and temporal characteristics of 17 coastal polynya regions over the entire Arctic basin for 2002/2003 to 2017/2018, as well as a similar data set based on lower resolution (6.25km) AMSR-E passive microwave satellite data for a nine-year overlapping comparison period (up to 2010/2011).

The MODIS data set is relying on a 1D energy balance model, where quasi-daily thin-ice thickness composites (up to 20cm) are directly derived from ice-surface temperature swath-data and ERA-Interim atmospheric reanalysis data. Dedicated cloud screening and spatial/temporal interpolation techniques are therein applied to effectively account for sensor-specific drawbacks. In case of the AMSR-E data set, thin-ice thicknesses are derived using an empirical approach that utilizes a characteristic polarization ratio (PR) – ice thickness relationship. In both data sets, the daily pan-Arctic mapping of thin-ice thicknesses allows for a long-term derivation of important polynya properties such as polynya area (POLA) and potential thermodynamic ice production (IP).

It shows that the average POLA (average accumulated IP) for all Arctic polynyas combined is 1.99 x 10^5 km^2 (1.34 x 10^3 km^3) when derived from MODIS data and 2.23 x 10^5 km^2 (1.29 x 10^3 km^3) in case of AMSR-E data. Although the two data sets are independently derived, they show quite similar spatial and temporal variations of POLA and IP, which suggests a high reliability of both data sets. Hence, despite all methodical differences, both data sets are to a large degree coherent in terms of capturing the general spatial and temporal characteristics of Arctic polynyas for the overlapping 9-yr period. Emerging positive trends in POLA and IP over the long 16-yr period of the MODIS data set are mainly visible in the Eastern Arctic and are potentially related to large-scale atmospheric modes and/or changing characteristics of the Transpolar drift system.