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Circumpolar polynya characteristics in the Arctic between 2002/2003 and 2014/2015 as derived from MODIS thermal infrared imagery and ERA-Interim reanalysis

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In this pan-Arctic study, high-resolution MODIS thermal infrared satellite data are used to infer spatial and temporal characteristics of 16 prominent coastal polynya regions and leads over the entire Arctic basin. Thin-ice thickness distributions ($\leq$ 20cm) are calculated from MODIS ice-surface temperatures swath-data (MOD/MYD29), combined with ECMWF ERA-Interim atmospheric reanalysis data in an energy balance model for the last 13 winter-seasons (2002/2003 to 2014/2015; November to March). From all available swath-data, (quasi-) daily thin-ice thickness composites are computed in order to derive valuable quantities such as polynya area and total thermodynamic ice production. Two different cloud-cover correction schemes are applied to account for cloud and data gaps in the MODIS composites. During the investigated period, the average total wintertime accumulated ice production in all 16 polynya regions is estimated with about 1481 $\pm$ 262 km^3, plus an additional 65 $\pm$ 59 km^3 if leads in the central Arctic Ocean are taken into consideration. The largest contributions originate from the Kara Sea region and the North Water polynya (both $\sim$19%) as well as scattered smaller polynyas in the Canadian Arctic Archipelago (all combined $\sim$15%), while other well-known sites of polynya formation (Laptev Sea, Chukchi Sea) show smaller contributions with around 2-7%. Compared to another recently published pan-Arctic polynya study using coarser resolution passive microwave remote sensing data, our estimates are considerably larger due to distinct differences regarding the observed winter-period and applied polynya masks/reference areas. In addition, the use of high-resolution MODIS data increases the capability to resolve small scale (> 2km) thin-ice features such as leads, which therefore contribute to our ice production estimates. Despite the short record of 13 winter-seasons, positive trends in ice production can be detected for some regions of the eastern Arctic (most significant in the Laptev Sea region with an increase of 6.8 km^3/yr) and the North Water polynya, while other polynyas in the western Arctic show more pronounced interannual variability with slightly negative trends. We assume that distinct atmospheric and oceanic patterns are responsible for these regionally different developments. Although there is still a strong need for reliable thin-ice thickness validation data and despite potential ambiguities from still inherent cloud effects in the MODIS data, we think that our study contains the most accurate estimations of circumpolar polynya dynamics and ice production to date. Regarding future atmosphere- and ocean-modelling efforts in the Arctic, this high-resolution data set is certainly highly valuable.