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Annual and seasonal climatology of total cloudiness in the Arctic from satellite and surface observations and reanalyses

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The Arctic is a very sensitive region to the global climate change. An increase of air temperature is accompanied with changes in other climate variables, particularly, with a decrease of the Arctic sea ice extent and cloud cover changes. In the Arctic region, clouds slightly enhance surface cooling only for a few weeks in the midsummer and have a warming effect in the rest of the year. The sensitivity of cloud radiative forcing is about 1 watt per square meter per 1% of cloud cover in the Arctic. Thus, relatively a small percentage of changes in cloud cover or cloud properties could result in an anomalous climate forcing of several watts per square meter. Considering an importance of clouds in the Arctic, it is crucial to know exactly when and where clouds exist. However, the detection of clouds in the Arctic is intrinsically difficult.

We present here an intercomparison of the up-to-date climatologies of total cloudiness in the Arctic from satellite (APP-x, CERES, ISCCP, MODIS, PATMOS-x) and surface observations (EECRA) and 8 reanalyses (ERA-40, ERA-Interim, JRA-25, MERRA, NCEP/NCAR, NCEP/DOE, NCEP-CFSR, NOAA-CIRES 20CR).

The Arctic annual mean TCF is 0.70 ± 0.03 according to different observations. It is greater over the ocean (0.74 ± 0.04) than over land (0.67 ± 0.03). Different observations are in a better agreement in summer than in winter and over the ocean than over land for the Arctic mean TCF as well as for the spatial distribution of TCF. The interannual variability is higher in winter than in summer according to all observation-derived data, which may be associated with uncertainties in observations that greater in winter than in summer. Total cloud fraction in the Arctic has the prominent annual cycle according to all observations excluding PATMOS-x and ISCCP. The time of TCF maximum corresponds with the time of the sea-ice extent minimum (early summer – late autumn) and vice versa (late spring). In general, reanalyses do not capture this feature of TCF annual cycle. According to the most of reanalyses, the maximum of TCF is shifted to October-November. NCEP/NCAR, NCEP/DOE and JRA-25 reanalyses show less TCF than observations during the whole year. Other reanalyses are in a close agreement with observations during summer, while in wintertime they show noticeably higher values of TCF than observations.

Spatial distribution of the annual mean TCF collocates with the spatial distribution of the annual mean surface skin temperature. The annual mean TCF minimum occurs over the northeastern part of Greenland and coincides with the minimum of the skin surface temperature. Whilst, the annual mean TCF maximum is noted over the warmest part of the Arctic (The Norwegian and Barents Sea). Reanalyses capture the position of the TCF minimum correctly, but some of them erroneously shows the highest values of TCF over the central part of the Arctic Ocean but not over the Norwegian and Barents Sea as observations do. In addition, reanalyses show higher spatial correlation of TCF with observations in summer than in winter and over the ocean than over land. The spatial distributions of TCF from different satellite observations are in a closer agreement over the ocean in winter and over land in summer. The presumable reason for this peculiarity is the mosaic structure of the underneath surface which depends on season in an opposite manner for land and for the ocean. This feature is not revealed when satellite data compared with surface observations which does not depend on surface characteristics.

For the whole year, the greatest disagreement among observations was revealed in regions with the ice/snow surface. Furthermore, we found that agreement in winter is poor in regions with the presence of strong low-tropospheric temperature inversions. This can indicate the difference in the cloud-detection algorithms as the main causes of the discrepancies among observations. Nonetheless, other causes of data discrepancies are also should taken into account (diurnal cycle, differences in averaging period, differences between observations and reanalyses in defining cloudiness).

At present, it is hard to distinguish the best observational dataset for the Arctic cloudiness. Further analyses should be carried out for the specific regions with the greatest disagreement among cloudiness datasets, particularly Greenland, the Canadian Arctic Archipelago and the northern part of East Siberia.