Novel machine-learning based cloud mask and its application for Antarctic polynya monitoring using MODIS thermal-infrared imagery

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The frequent presence of cloud cover in polar regions limits the use of the Moderate-Resolution Imaging Spectroradiometer (MODIS) and similar instruments for the investigation and monitoring of sea-ice polynyas compared to passive-microwave-based sensors. The very low thermal contrast between present clouds and the sea-ice surface in combination with the lack of available visible and near-infrared channels during polar nighttime results in deficiencies in the MODIS cloud mask and dependent MODIS data products. This leads to frequent misclassifications of i) present clouds as sea ice/open water (false-negative) and ii) open-water/thin-ice areas as clouds (false-positive), which results in an underestimation of actual polynya area and subsequent derived information.

Here, we present a novel machine-learning based approach using a deep neural network that is able to reliably discriminate between clouds, sea-ice, and open-water/thin-ice areas in a given swath solely from thermal-infrared MODIS channels and derived additional information. Compared to the reference MODIS sea-ice product for the year 2017, our data results in an overall increase of 20% in annual swath-based coverage for the Brunt Ice Shelf polynya, attributed to an improved cloud-cover discrimination and the reduction of false-positive classifications. At the same time, the mean annual polynya area decreases by 44% through the reduction of false-negative classifications of warm clouds as thin ice. Additionally, higher spatial coverage results in an overall better sub-daily representation of thin-ice conditions that cannot be reconstructed with current state-of-the-art cloud-cover compensation methods.