Geophysical Research Abstracts
Vol. 20, EGU2018-10195-1, 2018
EGU General Assembly 2018

Using Sentinel 2 and the ArcticDEM to create a new glacier inventory for Franz-Josef-Land, Russian Arctic

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The glaciers and ice caps on Franz-Josef Land in the northern Russian Arctic are difficult to map automatically as they are normally surrounded by sea ice for the entire year. With the now largely ice-free Arctic Ocean, automated mapping of glacier extents from optical satellite data is for the first time possible in this region, i.e. without including sea ice in the classification. On 16.9.2016 Sentinel 2 acquired an image of entire Franz-Josef-Land that was almost free of sea ice, clouds and seasonal snow outside of glaciers. Indeed, several ice caps at lower elevations were also completely free of snow and firn, showing dark layers revealing ice flow dynamics. The likely very negative mass balances in 2016 resulted in near optimal conditions for precise mapping of glacier extents.

We have used this rare opportunity to create a new glacier inventory for the entire region. Whereas the dataset that is currently available in the RGI had been derived by manual delineation from combining ten years of Landsat data (2000-2010), our new inventory was basically acquired in one day (with the exception of two tiles acquired on 12.7. and 3.9.2016), i.e. providing a real snapshot of glacier extent that is much more suitable for change assessment. Additionally, we used the now available 5 m ArcticDEM to derive drainage divides and topographic parameters for all glaciers instead of the multi-temporal ASTER GDEMv2 that was used for the RGI version. The ArcticDEM together with the dark layers visible in the optical images allowed us to considerably improve the location of drainage divides and to calculate up-to-date and temporarily consistent topographic information for each glacier unit.

Glacier classification with the simple band ratio method (red/SWIR) included sensor noise over the ice-free ocean as glacier ice. So we used an additional blue band threshold to automatically exclude the comparably dark ocean. Drainage divides were adjusted manually using a flow direction grid and kept roughly consistent with the previous inventory. We also created a second inventory without topographic divides as dividing ice caps into separate flow units might not be useful for some applications, This inventory has 208 entities >0.1 km2 covering an area of 11792 km2. Compared to the Russian glacier inventory from the mid 1950s (13739 km2), the area loss over 63 years is 14% (or -0.23% per year). Assuming the RGI refers to about 2005, mean annual area changes for the first and second periods are -0.15% and -0.65%, indicating a recent strong acceleration of area loss. Compared to the RGI outlines, the observed retreat of individual ice cap units has a high spatial variability, but seems to be largest for marine terminating sections.