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Monitoring lakes and cryogenic processes in Siberia with Sentinel-1 and 2 data

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Lakes and ponds are ubiquitous features of the arctic tundra landscape. They are often associated with thermokarst phenomena (thaw lakes). Their changes over time are expected to reflect changes in permafrost. Satellite data are commonly used to analyze spatial and temporal patters of tundra lakes. High spatial as well as temporal resolution is required. Both SAR as well as optical data can be utilized. Features of interest are not only size and shape but also bathymetric and associated properties. The latter specifically includes ground fast lake ice along shallow shelfs and can be derived from SAR. Of further interest are degradation features along the lake rims. They require sufficient spatial resolution in order to map them.

The Yamal peninsula is mostly underlain by continuous permafrost. The distribution of lakes is largely related to the patterns of marine terraces. A comprehensive dataset of land surface features from long term in situ and high resolution satellite data is available for central Yamal. We have utilized Sentinel-1 as well as Sentinel-2 data for mapping of these lakes and their surroundings.

A lake map has been derived from Sentinel-2 within the framework of the ESA DUE GlobPermafrost project as part of the landcover prototype development. Major challenges have been frequent cloud cover, seasonal lake change, sediments in lakes of floodplains and with erosional features as well as reflectance properties of high arctic lakes within wetland areas. Two years of data (summer 2016 and 2017) have been required for complete coverage of the area of interest. Post processing has been required for treatment of artefacts due to cloud masking effects. Results are also compared to acquisitions from the Spot5Take campaign from 2015 as well as a trend product from Landsat (30m) spanning 1998-1999 and 2000-2015. It can be demonstrated that the spatial resolution of Sentinel-2 and SPOT (10m) is sufficient to identify erosional features along the lake margins, but quantification of changes from year to year require more detail. Trends in greenness can be observed in Landsat after 2000, what indicates initiation during this time period.

C-band SAR data as available from Sentinel-1 provide year to year changes in ground fast ice conditions and reveal differences in lake bathymetry among the terraces. There are however a range of phenomena on larger lakes which impact the ground-fast ice detection. These features can be identified in both, Sentinel- 1 and Sentinel-2 data.

Our results exemplify some challenges of landcover mapping in permafrost regions, but also detail the information gain from using Sentinel-1 and Sentinel-2 data.