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LAKE MONITORING IN SIBERIA WITH SENTINEL-1 AND 2 DATA
Lakes in the Arctic

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.

Spatial resolution is crucial.

Landsat trends, Nitze et al. 2017
www.globpermafrost.info
Tassled cap trend 1999-2015

Gain of information from Sentinel-2?

Landsat trends, Nitze et al. 2017
Information from SAR

Features of interest are not only size and shape but also bathymetry and associated properties. The latter specifically includes **ground fast lake ice** along shallow shelves and can be derived from SAR.

Changes over time reflect climate change

ASAR WS, Bartsch et al. 2017
Example ASAR WS analyses for more than 3 Mio lakes, late winter stage (April) incidence angle dependent threshold method

Gain of information from Sentinel-1?

ASAR WS 2008, Bartsch et al. 2017
The Yamal peninsula is mostly underlain by continuous permafrost. The distribution of lakes is largely related to the patterns of marine terraces.
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 (required as input for permafrost modelling). Major challenges are 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.

Short season - Only two months per year
A post processing scheme has been developed for treatment of artifacts due to cloud masking effects based on time series analyses.

-> Loss of information on inundation.
Sentinel-1

changed to IW (24 days revisit frequency)
Sentinel-1 for ground-fast lake ice

Higher spatial resolution of Sentinel-1 compared to ASAR WS. Features within the ice become visible.

Demands other approaches than thresholding
- Iterative Region Growing using Semantics (IRGS) applied in e.g. Surdu et al. (2014) to Radarsat
- object oriented?
Improvements can be made under the assumption that ground fast ice can only occur along the rims of the lakes (based on extensive bathymetric surveys of Russian Academy of Science).

Assumption 1 km diameter area in lake centre floating: 7/11% of Yamal lakes wrongly classified with simple threshold methods. With flood fill 0/4% (2016/2017).

Pointner (2017), Pointner et al. in review

Example workflow

(a) Masked SAR image with background pixels in black,
(b) Image after threshold classification,
(c) Image after classification and flood-fill from the background region,
(d) Final classification result
„Disturbance“ effects

April

Pointner (2017)

Month used for permafrost applications

2016

2017

σ₀ [dB]

0

-20

0 2.5 5 7.5 10 km

Pointner (2017)
Previous findings

Russian scientists interpret the phenomena as gas bubbles and suggest use of space observations for exploration.

Bogolavjensky et al. 2016
Circular features in lake ice

- Large circular patterns in lake ice known from lake Baikal as well as Hovsgol (Kouraev et al., Limnology and Oceanography 2016).
- They develop during the second part of the winter, similarly to our observed patterns, but are much bigger, 2 - 8 km in diameter.
- In situ measurements showed that ice is thinner at these sites. Water temperature measurements suggested the development of eddies within the water, which affect the ice above and cause the circular shapes.
- Smaller temperature anomalies under ice have been reported by Forrest et al. (Limnology and Oceanography 2013) and Kirillin et al. (Geophysical Research Letters 2015).
- **Eddy formation** could therefore also a potential explanation for the observed features.
Summary

There are many challenges for lake mapping in permafrost regions (short season, clouds, EW versus IW), but also detail the information gain from using Sentinel-1 and Sentinel-2 data.

Sentinel-1 can be applied to continue ground fast ice records of ASAR WS and additional features can be identified.