Monitoring bedfast ice in Siberian Arctic lakes using TerraSAR-X backscatter and interferometric coherence time series

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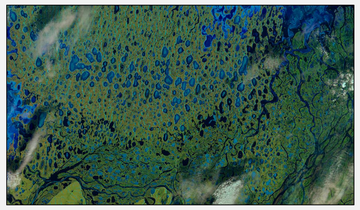
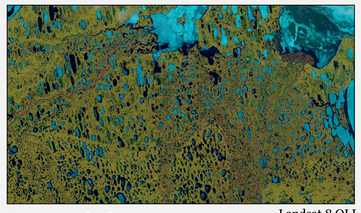
Introduction

Large part of the land area is covered by lakes in permafrost regions in the Arctic:



Lena River Delta, Siberia
June 2016



Barrow, Alaska
June 2016

Landsat 8 OLI
USGS EROS Center

Ice regimes:

<u>floating ice</u>
lakes do not freeze to the bottom
→
- microbial activity in sediments
- heat flux through the ice to the atmosphere
- thawing of permafrost beneath the lake
- habitat for fauna
- available freshwater

<u>grounded (bedfast) ice</u>
lakes completely freeze to the bottom
→
- reduced microbial activity in sediments
- reduced heat flux through the ice to the atmosphere
- no thawing of permafrost beneath the lake
- no habitat for fauna
- no freshwater

It is important to distinguish these ice regimes

Data and methods

TerraSAR-X (TSX) data:
- 2012-2015
- X-band (3.1 cm wavelength)
- temporal resolution: 11 days
- spatial resolution: 10 x 10 m

95 backscatter intensity images (amplitude)

83 11-day coherence images (include phase information)

14 in situ ice thickness measurements in April 2015:
7 locations with floating ice (Fl-1..Fl-7)
7 locations with grounded ice (Gr-1...Gr-7)

Canadian Lake Ice Model (CLIMo)

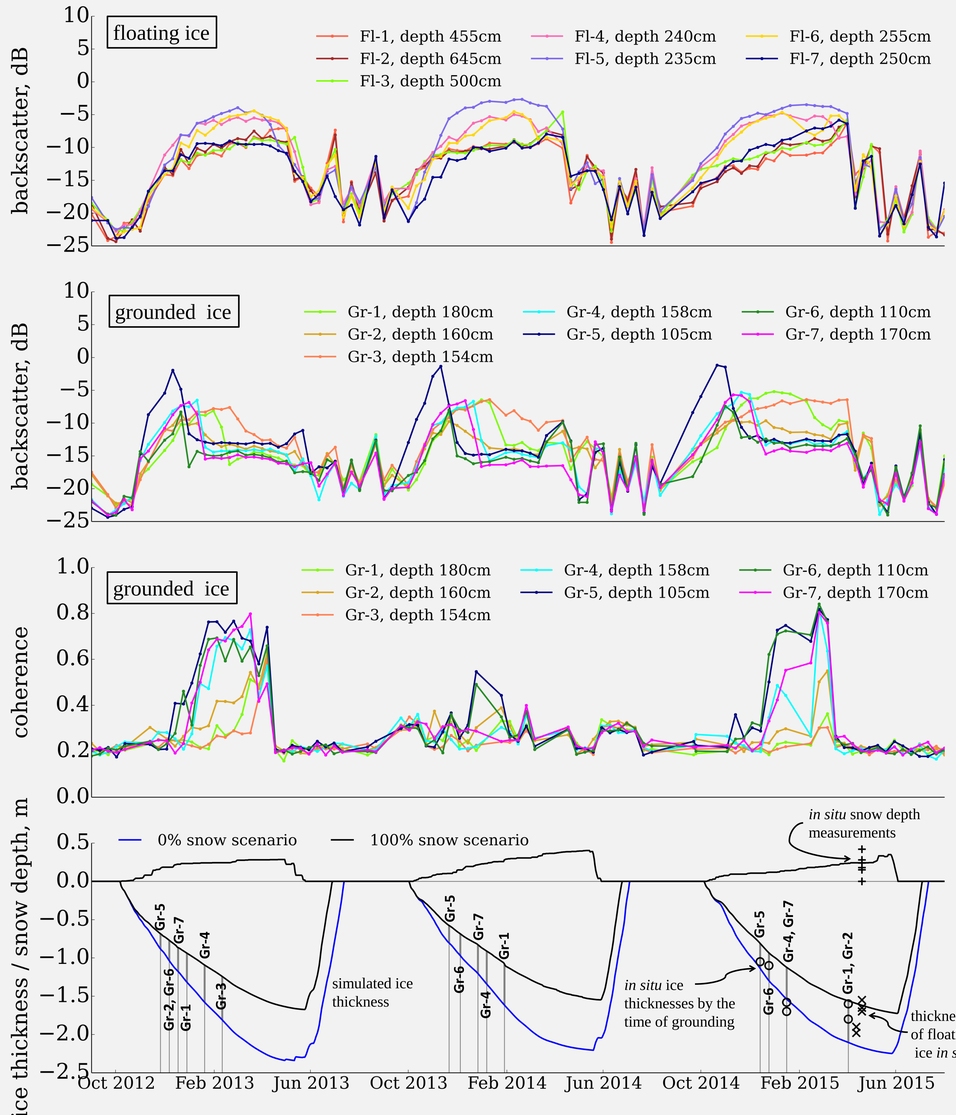
<u>Floating ice:</u>
backscatter intensity is high from rough interface between ice and water

<u>Grounded ice:</u>
backscatter intensity is low due to absorption of a signal into frozen sediments

<u>Floating ice:</u>
coherence is low due to continuous changes at ice-water interface due to ice growth

<u>Grounded ice:</u>
coherence is high due to ceased ice growth

Results



- TSX backscatter intensity remained stable for the floating ice and decreased abruptly with ice grounding during the winter
- 11-day interferometric coherence increased with ice grounding
- timing of ice grounding was inferred on the order of 11 days
- in some cases, the timing of ice grounding could not be inferred unambiguously, and this is likely, due to a mixed signal from both grounded and floating ice within a ROI
- the thickness of grounded ice was obtained using the model CLIMo and the timing of ice grounding
- comparison with in situ measurements showed a good agreement

Conclusions and outlook

- TSX backscatter is very suitable for distinguishing between floating and grounded lake ice
- TSX allows for the extraction of the timing of ice grounding at a higher temporal resolution (11 days) then it was possible with previous SAR missions. Sentinel-1 twins have potential for better temporal resolution with their 6 days revisit cycle
- interferometric coherence with a minimal time span provides complementary information on ice grounding and spring melt onset
- SAR data used in combination with lake ice models, such as CLIMo, can be used for the retrieval of grounded ice thickness and, consequently, bathymetry of shallow lakes

The study was published in the **Remote Sensing** journal in November, 2016:

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scan to get the publication

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