

The potential of using Sentinel-1 and ALOS PALSAR-2 data for characterizing West Siberian lake ice backscatter anomalies

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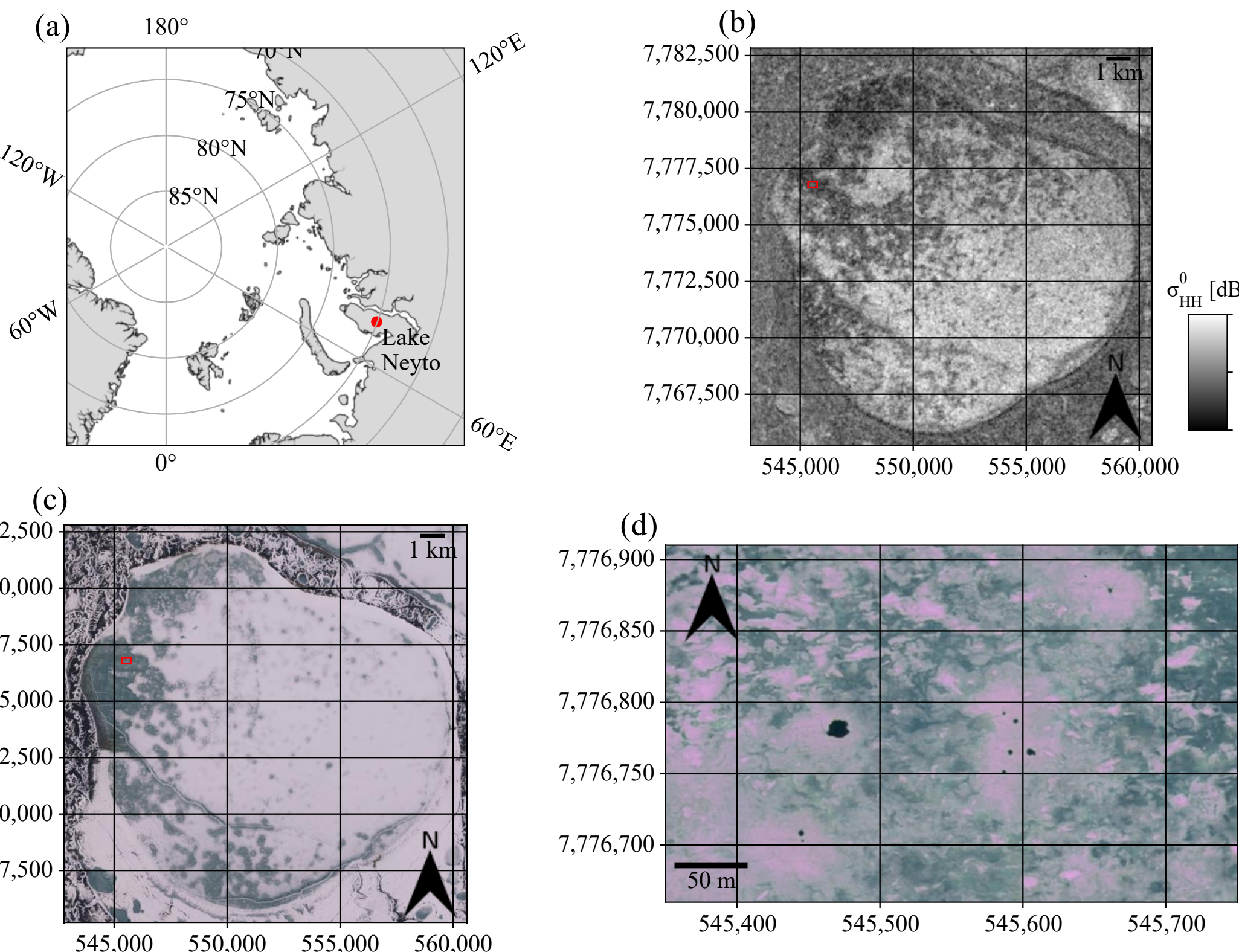
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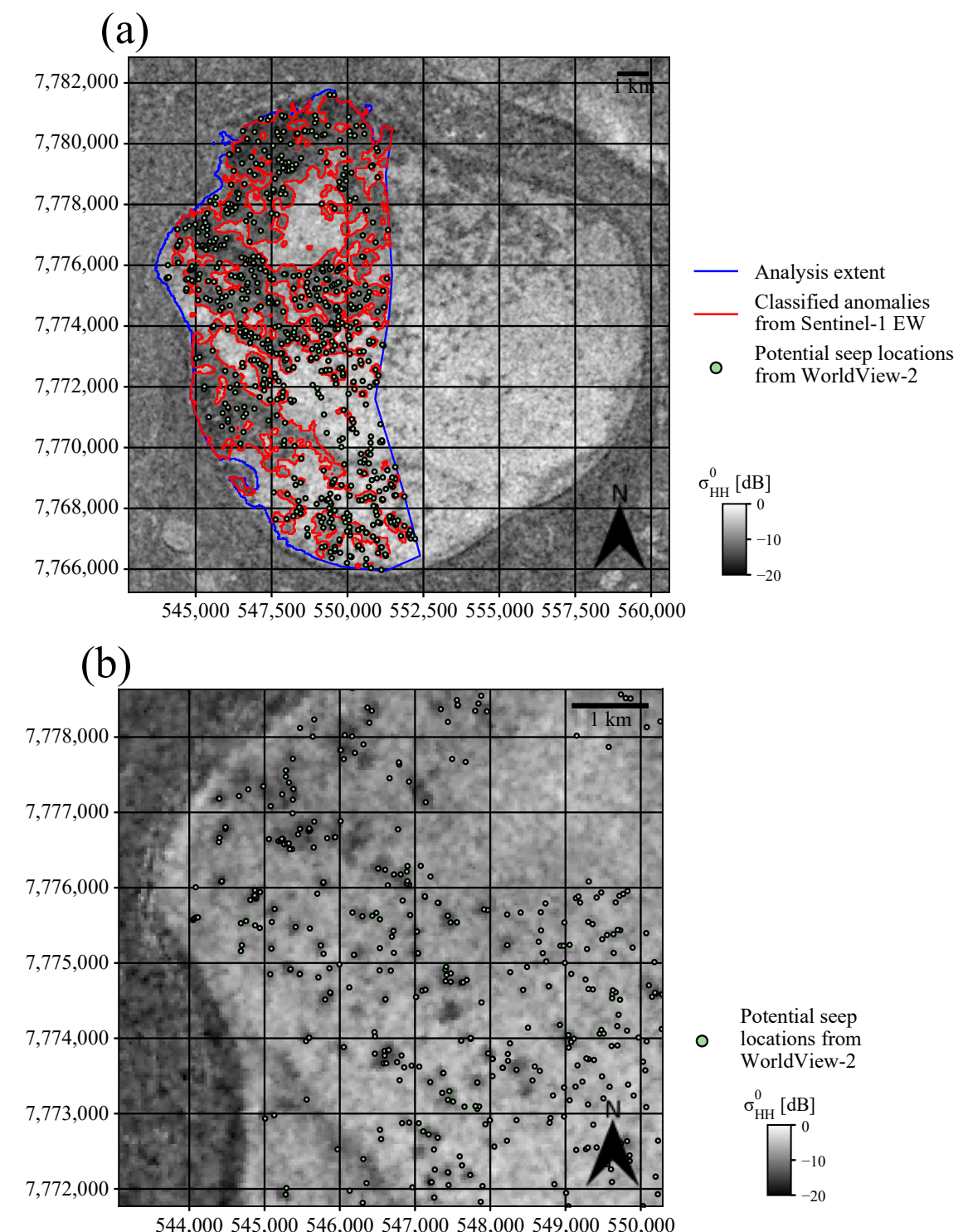
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Motivation – West Siberian Lake Ice Backscatter Anomalies and Potential Relation to Methane Emissions

Lake Neyto and Potential Relation to Methane Emissions

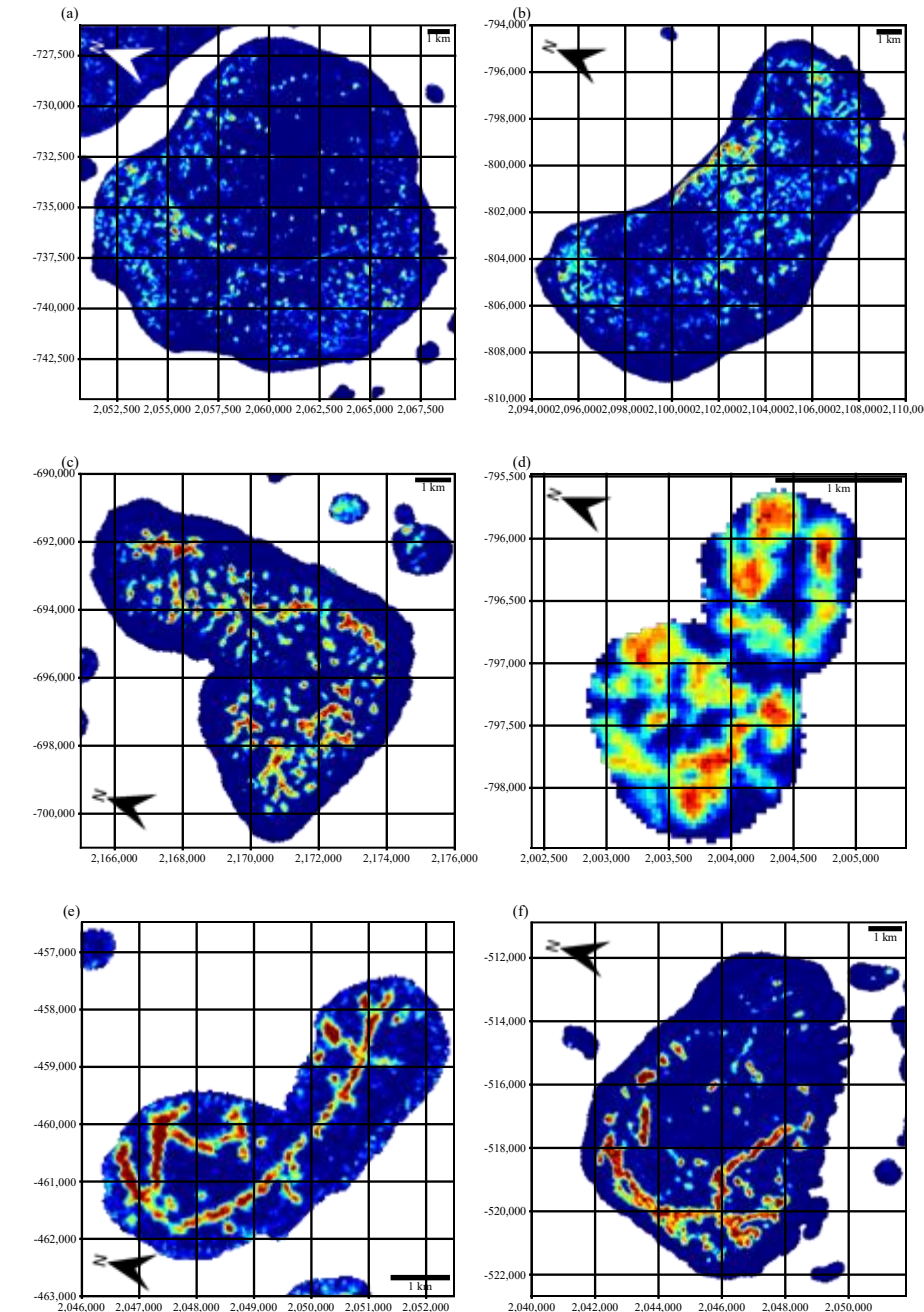


Backscatter anomalies (dark tones in otherwise bright lake region) in spring Sentinel-1 SAR imagery of lake ice (b) resemble patterns in Sentinel-2 optical imagery (c). Holes in lake ice potentially related to strong methane emissions were identified in a WorldView-2 VHR imagery (d). Location of Lake Neyto is shown in (a). Acquisition dates: (b) 16 May 2016 (c) 21 May 2016, (d) 22 May 2016. Source: Pointner et al. (2021).

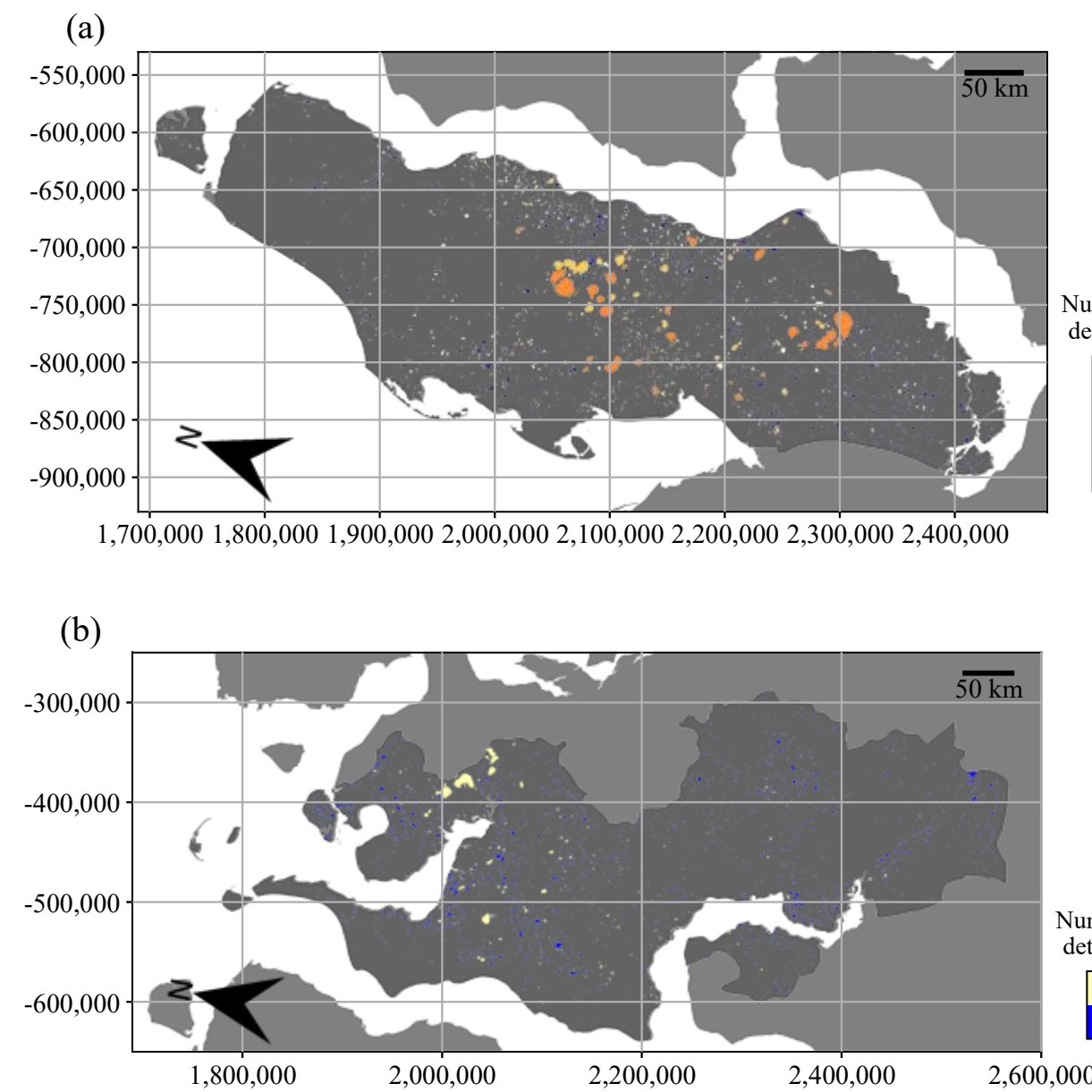


Mapped holes from the WorldView-2 scene from 22 May 2016 and comparison to Sentinel-1 backscatter anomalies on different dates. (a) 16 May 2016, (b) 7 April 2016. Hypothesis is that flooding through holes (potentially related to methane emissions) leads to slushing and wetting of the snow during late winter and spring. Source: Pointner et al. (2021).

Similar Anomalies on Western Siberian Lakes



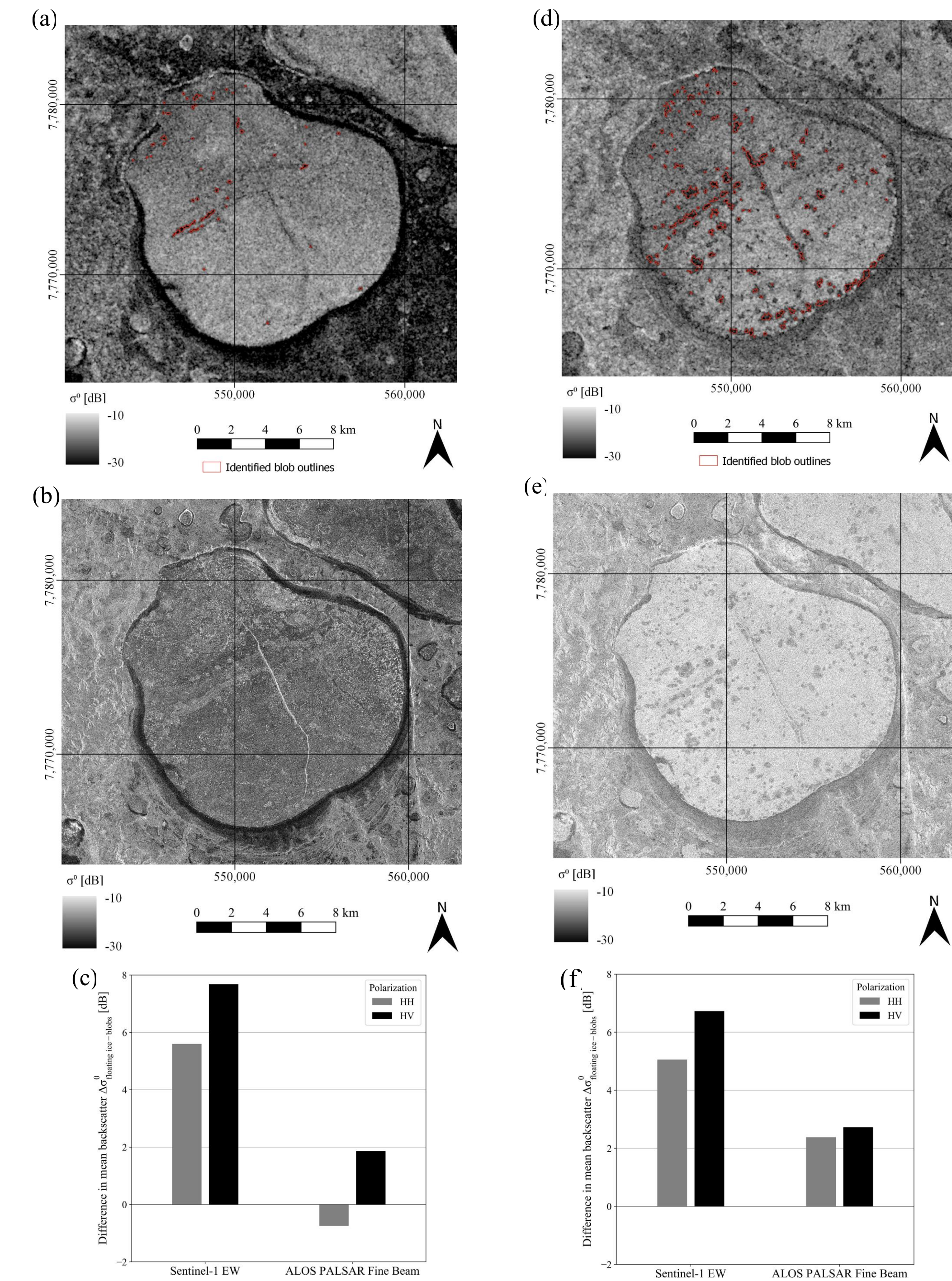
Similar anomalies on other West Siberian lakes based on backscatter difference from temporal Theil-Sen regression on Sentinel-1 imagery on Google Earth Engine in different years (Source: Pointner and Bartsch, 2021). If or how many of them might be potentially related to methane emissions cannot be deduced due to lack of reference data.



Potential candidate lakes for similar phenomena as on Lake Neyto on Yamal (a) and Tazovskiy (b) Peninsulas. Shown are number of years in which potential anomalies have been detected from backscatter difference images generated on Google Earth Engine. Source: Pointner and Bartsch (2021).

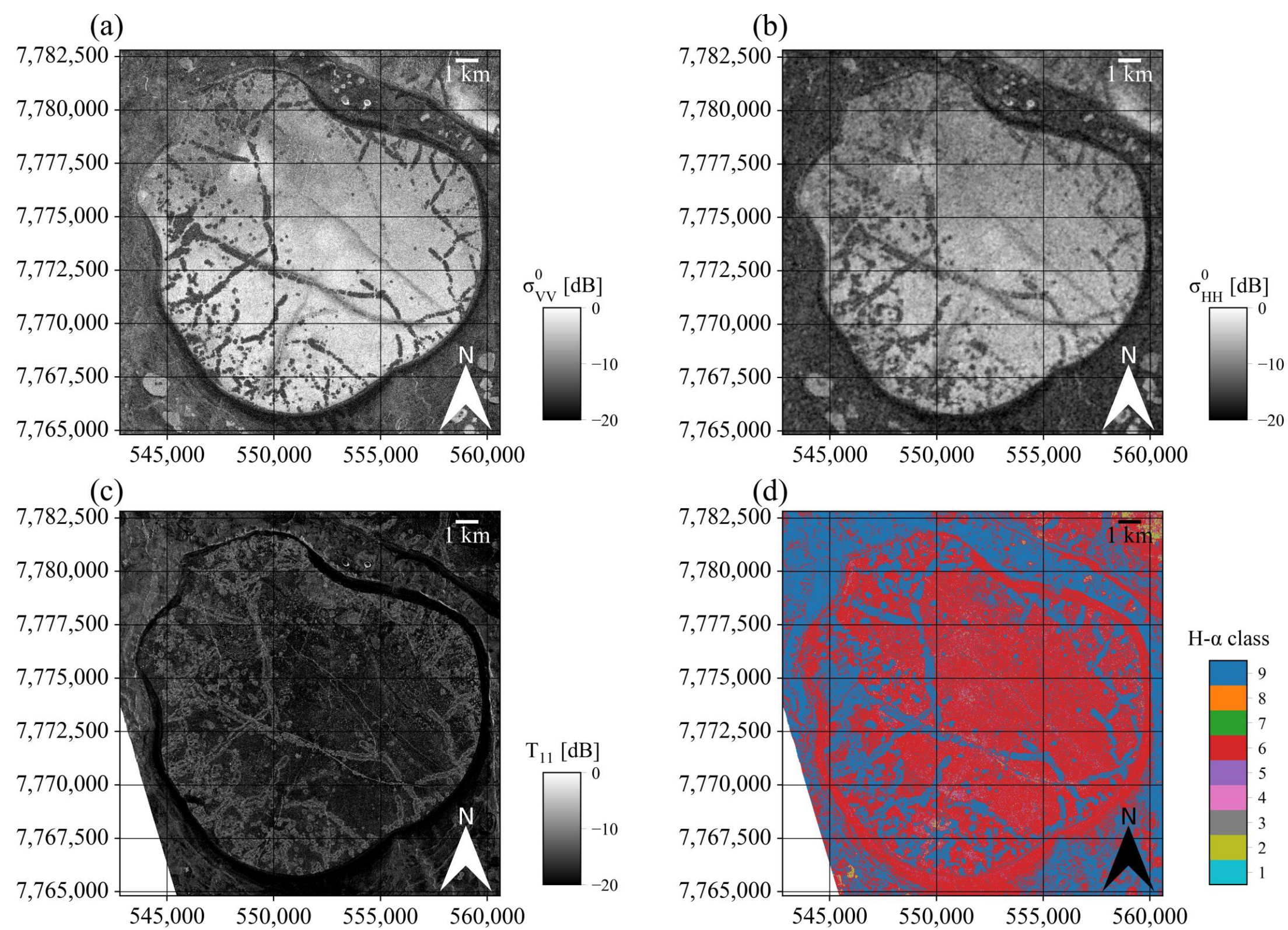
ALOS PALSAR-2 and Sentinel-1 for Characterization of Anomalies (Lake Neyto)

Differences in Backscatter Signatures



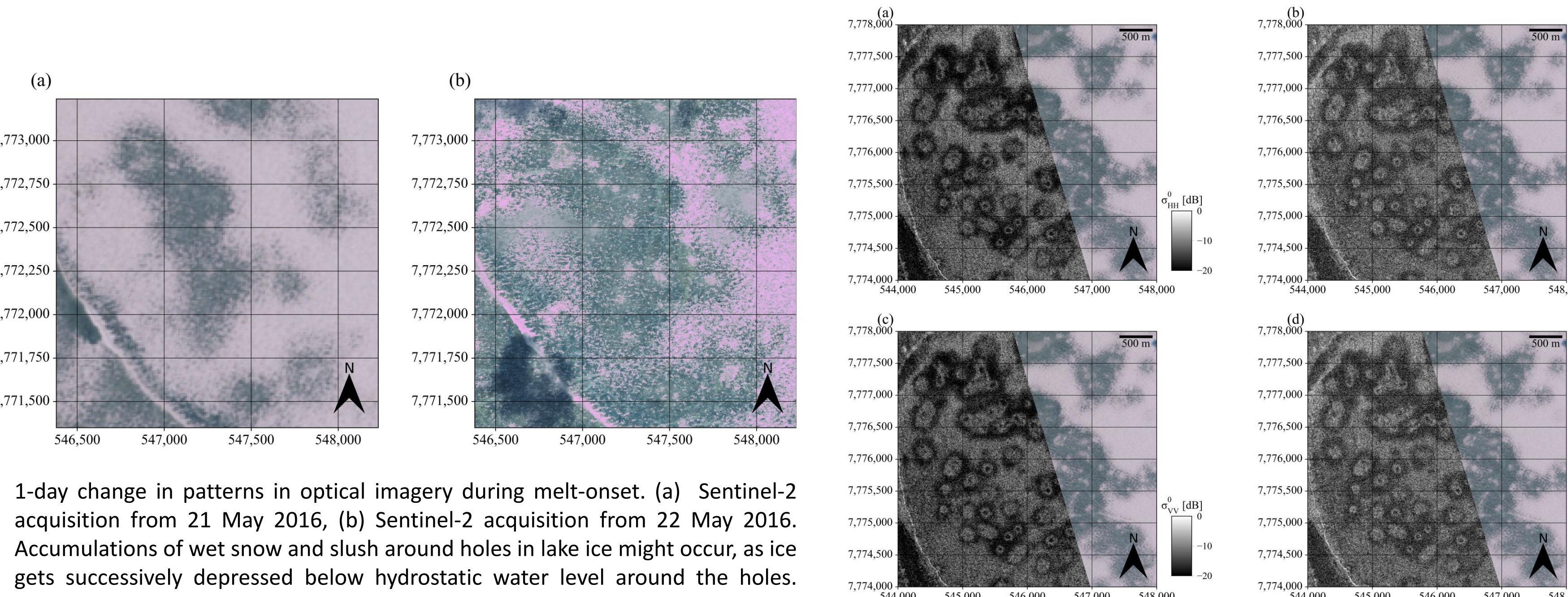
While lake ice backscatter anomalies always manifest in dark tones in C-band Sentinel-1 SAR imagery ((a) and (d)), anomalies can be characterized by slightly brighter tones (or darker tones in comparison to the surrounding pixels in L-band ALOS PALSAR-2 imagery ((b) and (e)) and backscatter level can also vary between polarization channels. (a) Sentinel-1 HV-polarized scene from 25 April 2018, (b) ALOS PALSAR-2 HH-polarized scene from 24 April 2018, (c) Sentinel-1 HV-polarized scene from 31 May 2018, (d) ALOS PALSAR-2 HH-polarized scene from 31 May 2018. (e) and (f) show differences between anomalies and regular floating lake ice per sensor and polarization channel for the scenes above the chart concerned. Red outlines in (a) and (d) indicate sample locations for the anomaly class.

Sentinel-1 Sensor Modes and ALOS PALSAR-2 Polarimetry



Comparison between Sentinel-1 Interferometric Wide Swath (IW) mode (a), Sentinel-1 Extra Wide Swath (EW) Mode (b), ALOS PALSAR-2 surface scattering component (T_{11}) (c) and unsupervised polarimetric classification based on entropy (H)-alpha plane. As on the left panel, anomalies are always characterized by low backscatter in C-band Sentinel-1 acquisitions. Higher surface scattering from anomaly outlines than from regular floating lake ice is observed in T_{11} , which might potentially relate to scattering from slush and/or wet snow. Regular floating lake ice is largely classified as random surface scatterer and anomalies as 'Bragg surface'. In-situ data are needed to further understand causes for different backscatter intensities and scattering mechanisms. Acquisition dates: (a) 10 April 2015, (b) 23 April 2015, (c) 18 April 2015, (d) 18 April 2015 (same scene as in c). Source: Pointner et al. (2021).

Patterns in Melt-Onset Imagery



1-day change in patterns in optical imagery during melt-onset. (a) Sentinel-2 acquisition from 21 May 2016, (b) Sentinel-2 acquisition from 22 May 2016. Accumulations of wet snow and slush around holes in lake ice might occur, as ice gets successively depressed below hydrostatic water level around the holes. When comparing the two acquisitions, further accumulating might be responsible for expansion of snow.

ALOS PALSAR-2 scene acquired on 30 April 2016, on top of same Sentinel-2 scene as left. Strong similarities are apparent although 3 weeks difference in acquisition times. (a) HH, (b) HV, (c) VV, (d) VH. Here, backscatter signature is similar in all polarization bands. Signature might be related to scattering from slush and wet snow or might be related to wetness of the snow in general. In-situ data are needed for detailed assessment.

Summary and Outlook

- C-band backscatter anomalies in Sentinel-1 imagery potentially related to methane emissions have been described in detail for Lake Neyto, but may occur on many lakes in Western Siberia
- In C-band (Sentinel-1) anomalies are always characterized by lower backscatter than surrounding regular floating lake ice pixels, but backscatter signatures vary between acquisitions and polarizations for L-band (ALOS PALSAR-2), which may be related to snow structure or wetness
- Polarimetric analyzes may help to infer scattering mechanisms, but it is not clear why anomalies are classified as 'Bragg surface' in the above example
- Imagery acquired around melt-onset may give further insight on potential accumulations of slush and snow
- ALOS PALSAR-2 provides additional value to characterize anomalies, but in-situ data are needed to understand mechanisms in detail

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References:

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