Synthetic Aperture Radar (SAR) detects large gas seep in lake

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Photo: Oct. 2009
from Walter Anthony et al. 2012, Nature Geoscience
North Blair Lake

SAR Dec. 7, 2007
L-band Palsar (HH)

Planet Nov. 23, 2021

May 5, 2005
High backscatter feature showed in every available L-band single-pol (HH) image from 1992-2011 (historical JERS-1 not shown here).
We found a large (80 x 100 m) seep field at GPS location of high SAR backscatter.

Measured flux outside of seep area and over seep with LGR, a dynamic floating chamber.

Gas samples collected by underwater bubble trap within seep.

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Ebullition was $661 \pm 174 \text{ mg CH}_4 \text{ m}^{-2} \text{ d}^{-1}$ which was ~45 times higher than background diffusive CH$_4$.

Bubbles were 6.6% CH$_4$; low concentration indicating possible groundwater association.

$^{14}$C$_{CH_4}$ age was 18,470 ± 50 years BP.

Stable isotope $\delta^{13}$C$_{CH_4}$ of -44.5 ± 0. ‰ suggests a potential thermogenic origin.

Bubble diameter was < 1 cm, smaller than 1-2 cm bubbles we see in ecologic seeps.

Bathymetry measurements by fieldworkers revealed a pock mark 8 m deep directly below the seep.

Lake depth outside of the seep ranged from ~1-4 m.
Limited amount of quad-pol data shows

1) Roughness

2) Volumetric scattering
L-band Quad-pol polarimetric decomposition, November 27, 2009

Yamaguchi 3 Roughness

Backscatter (dB)
- > -6
- -6 to -7
- -7 to -8
- -8 to -9
- -9 to -10
- -10 to -11
- -11 to -12
- -12 to -13
- -13 to -14
- -14 to -15
- -15 to -16
- -16 to -17
- -17 to -18
- -18 to -19
- -19 to -20
- -20 to -24
- -24 to -28
- -28 to -32
- -32 to -36
- < -36

Roughness can indicate ecologic methane

Yamaguchi 3 Volumetric Scattering

Volumetric scattering does not indicate ecologic methane

Ecologic seeps

Geologic seeps can be one large seep or many smaller seeps. They can be open or ice-covered.
Sentinel-1

C-band SAR
Backscatter (dB)

- > -6
- -6 to -7
- -7 to -8
- -8 to -9
- -9 to -10
- -10 to -11
- -11 to -12
- -12 to -13
- -13 to -14
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- -15 to -16
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- -19 to -20
- -20 to -24
- -24 to -28
- -28 to -32
- -32 to -36
- < -36

Dual-pol with an eye toward NISAR:
- C-band can affirm presence of seep
- Volumetric scattering can be seen with VH
- Dual-pol NISAR (L-band, launch 2024) will also give more information by providing a cross-pol
Conclusions

• L-band SAR shows large methane geologic seeps as high backscatter features in every L-band image from 1992-2011

• C-band can confirm presence of a seep, although obscured in spring

• Scattering mechanism -- combination of roughness and volumetric scattering

• Upcoming NISAR mission will provide current L-band SAR imagery in dual-polarization

• SAR has the potential to be a remote sensing tool that can detect large methane seeps in lakes across a landscape: colleague Natalie Tyler is working on that.
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