Polarimetric characterisation of two layered frozen lakes

HELMHOLTZ ALLIANCE
PLANETARY EVOLUTION AND LIFE

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Introduction

In terms of radar remote sensing, one of the challenges of future planetary SAR missions will be the estimation of surface, subsurface and upper layer geometric and dielectric characteristics that translate to the localization of subsurface ice and water bodies and could be an indicator for a habitable planet.

As an example of two-layer structures on earth are frozen lakes. Similar two layer structures ice/water most likely appear on other planets as well. The upper layer consists of ice and the lower one is water. The ice water interface provides high reflectivity for the electromagnetic wave because of the strong dielectric contrast between the two media. Therefore it is a good candidate for evaluating SAR Polarimetric capabilities in subsurface probing. For this L-Band full Polarimetric ALOS PALSAR data are used in this research.

Ice lake theory

- The unfrozen lake surface or a thin layer of ice Fig1(b) has lower back scattered power than the frozen surface with a thick ice layer.
- The ice presence introduce a higher back scattering as it produce a dihedral reflection between ice inhomogeneity inclusions and ice water interface Fig1(a).
- When the lake is frozen to the bed (grounded ice) then the back scattering is lower than for floated ice because of the water ice interface absence Fig1(c).

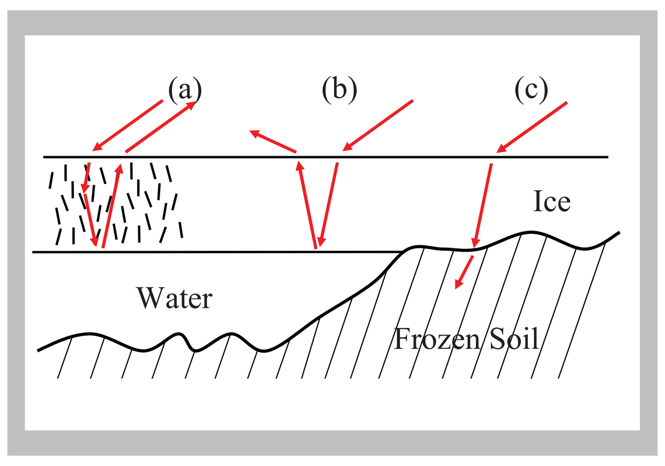


Fig. 1: The dominated scattering mechanism in a frozen lake . a) Thick ice layer with volume inhomogeneity (floated ice), b) Thin Ice layer or unfrozen lake, c) frozen to bed lake (grounded ice).

Polarimetric theory

- With two transmitting/recieveing antennas, that are perpendicularly orientated, two orthogonal polarimetric waves can be obtained.
- Target that varies with space and time can be described by statistical matrices, e.g. Coherency matrix.
- For the interpretation of high order scattering mechanisms, two main parameters obtained from Coherency matrix decomposition are considered here: Entropy (H) and Alpha (α).

0<H<1 where:

H=0 → Totally Polarised Scatterer

H=1 → Totally Unpolarised Scatterer

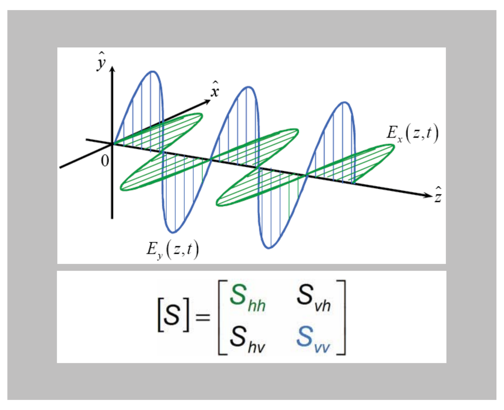
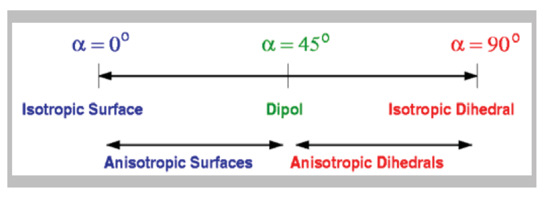


Fig. 1: The most common example of two orthogonal polarization are horizontal and vertical polarizations.



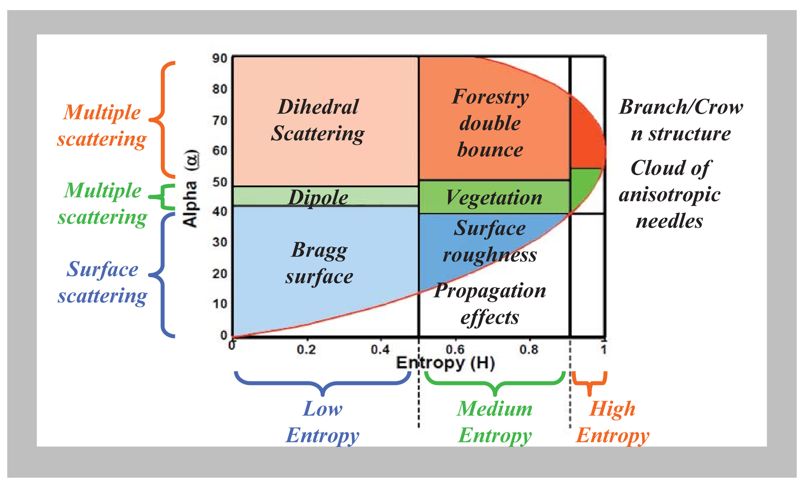


Fig. 3: Segmentation of the H and α space.

Conclusions

1. Observing Lake Ice with Polarimetric SAR instrument has been done.
2. SAR polarimetry can distinguish between grounded ice, and floated ice.
3. Previous method requires power changes observation between summer and winter, while polarimetry do not require temporal changes.
4. The presence of large scale inhomogeneity (methane bubbles) produce volume scattering in the polarimetric signature which can be identified.

Results

Data Sites:

ALOS PALSAR quadpol includeing from different parts of the world different times of the year have been considered and aquired of lake ice.

In general the freezing of the sites start on October, the maximum ice thickness is obtained during May, melting starts on July.

1. Churchill (Canada) (N58.72°, E-93.78°)
2. Baker lake (Canada) (N64.32°,E-95.97°)
3. Lena Delta (Russia) (N73.3°,E125.33°)

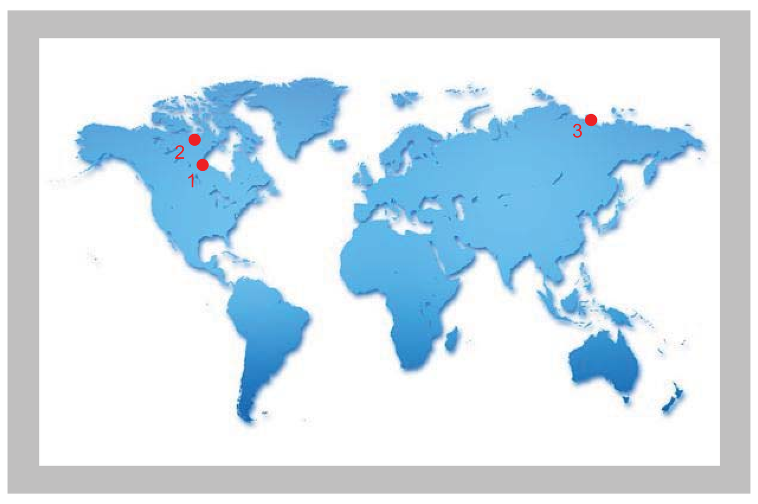
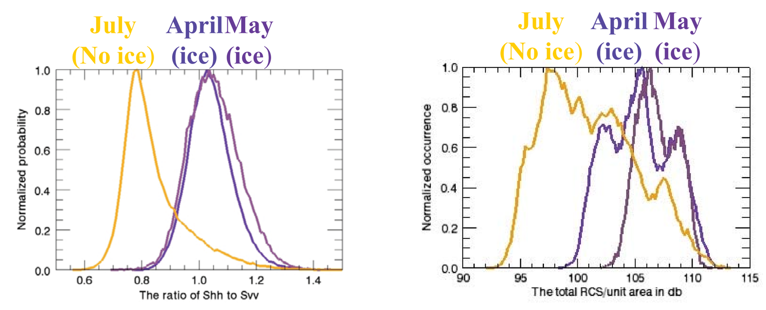
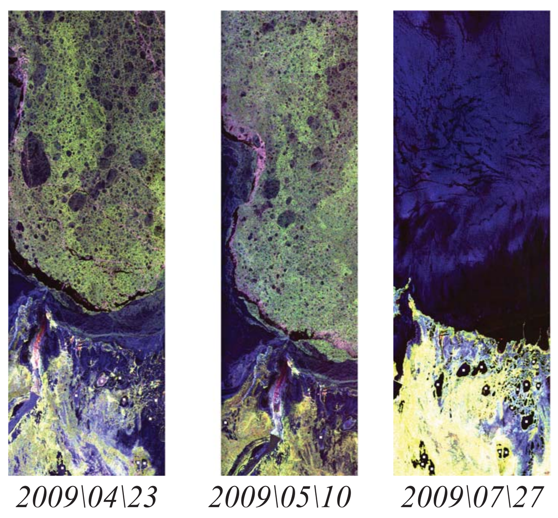


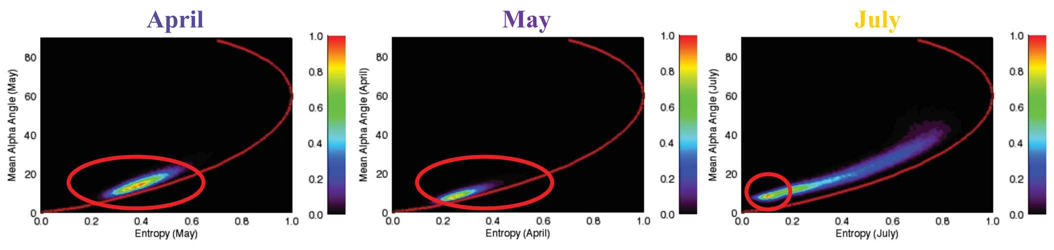
Fig. 4: Considered Sites for ALOS data

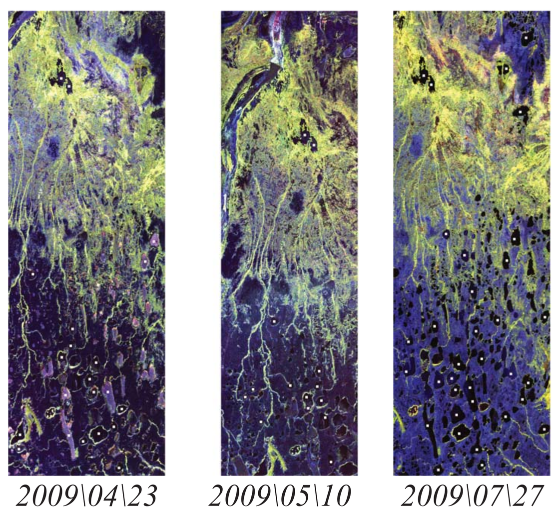
1. Churchill





- The backscattered power is lower when the ice is not present.
- The Bragg surface model predict an $S_{hh}/S_{vv}<1$ which is consistent with the case of July observation.
- The presence of ice increases the S_{hh}/S_{vv} to usually larger than 1.

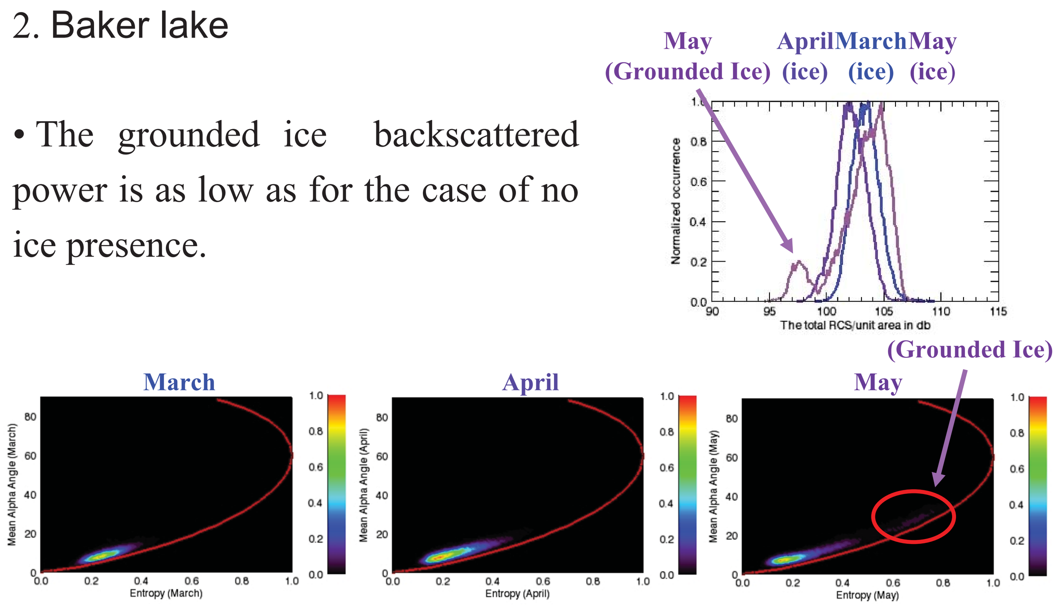


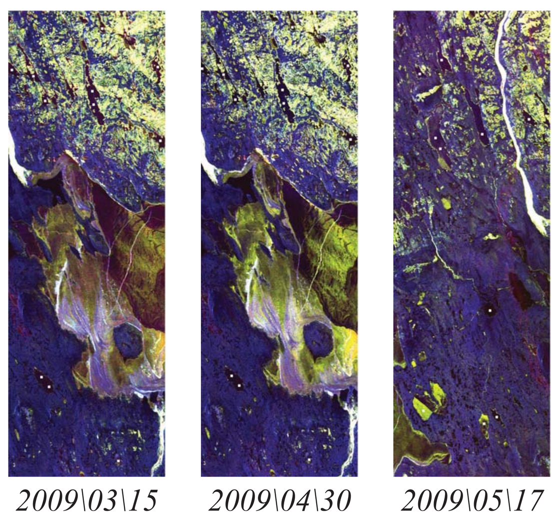


- For April and May, the double bounce reflection between the ice inhomogeneity and ice water interface increases H and α.
- In July the back scattering is dominated by a surface contribution. The high spread of H and α values is due to the lower SNR during summer and also the presence of melting process

2. Baker lake

- The grounded ice backscattered power is as low as for the case of no ice presence.

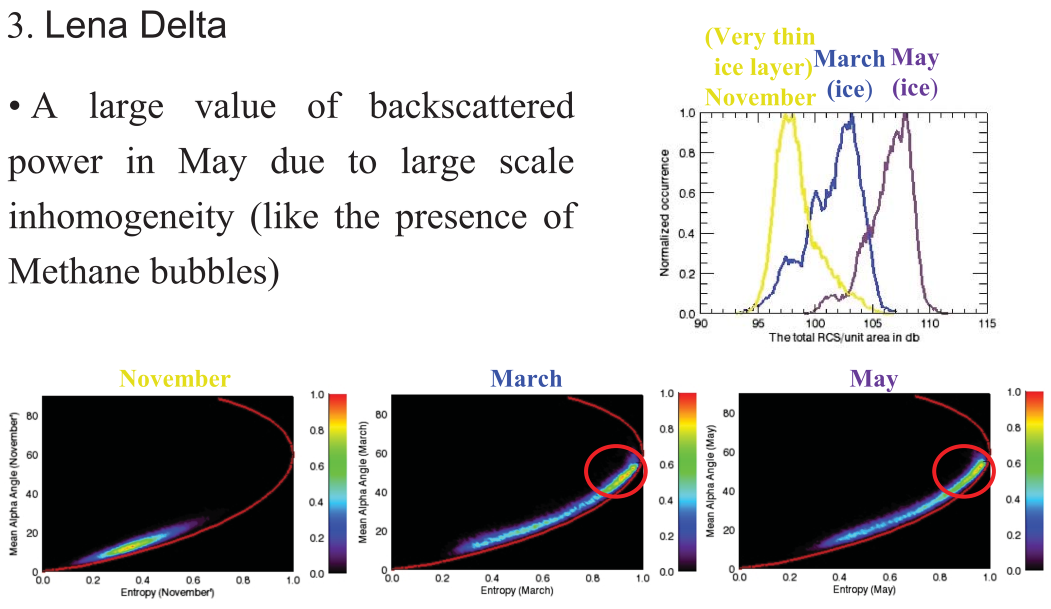


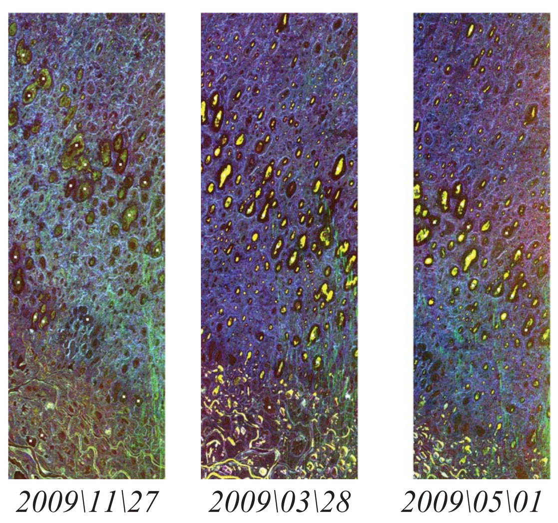


- During May, some lakes in this site are frozen to the bed, the backscattering is not dominated anymore by the double bounce mechanism, so higher H is obtained.

3. Lena Delta

- A large value of backscattered power in May due to large scale inhomogeneity (like the presence of Methane bubbles)





- Some of the lakes contain random shape Methane bubbles. Their presence contributes with a large volume scattering which dominate over other scattering models.

References

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