**Polarimetric characterisation of two layered frozen lakes**

**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 geometrical 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 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 presence of ice introduces a higher back scattering as it produces 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 (fluctuated ice). b) Thin ice layer or unfrozen lake. (ice to bed lake (grounded ice)).](image)

**Polarimetric theory**

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

![Fig. 2: Segmentation of the H and α space](image)

**Conclusions**

1. Observing Lake Ice with Polarimetric SAR instrument has been done.
2. SAR polarmetry 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 including from different parts of the world different times of the year have been considered and acquired of lake ice.

In general the freezing of the sites start on October, the maximum ice thickness is obtained during May, and 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°, E125.3°)

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