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WISDOM GPR performance assessment in a cold artificial environment

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The WISDOM (Water Ice Subsurface Deposit Observation on Mars) GPR is one of the instruments that have been selected as part of the Pasteur payload of ESA's 2018 ExoMars Rover mission. WISDOM has been designed to obtain information about the nature of the subsurface along the rover path with the objective to explore the first $\sim$ 3 m of the soil with a vertical resolution of a few centimetres. The sub-surface properties that can be addressed with WISDOM are variations in composition, texture, stratification (e.g., number, thickness and orientation of layers), the presence of unconformities and other structural characteristics (such as fractures and the deformation of strata). It is then essential to quantify the performances of WISDOM in controlled conditions, and several full polarimetric measurements have been carried out with the prototype in a cold artificial environment. The main objectives are the detection of different interface between homogeneous materials with WISDOM. The characterization of the material (porosity, % of water, dielectric properties, thickness and depth, temperature ...) is well-controlled. The cold room facility of IDES at Orsay (France) has been used, the ambient temperature ranged from -7˚C to -10˚C. A tank laying on the metallic floor (height: 0.5m, width: 0.80 m, length: 1.20m) in macrolon can contain liquid or frozen water or layers (dielectric contrasts) of home-maid permafrost (frozen saturated sand) with and without embedded objects or fractures. The temperature inside the medium (ice or permafrost) is controlled, the radar antennas are put on a sheet of polystyrene over the tank. Frequent measurements were performed (every 2cm) along a track from one side to the other side of the tank. The experimental conditions were:

(1)dry cold sand (Fontainebleau sand) : porosity 35% density 2,67 (2) saturated wet sand : 35% of water (3) permafrost (frozen saturated sand) : 35% of ice content

1 layer: 3 consecutive experiments : 10cm dry sand (1) 10cm saturated sand (2) 10cm permafrost(3)

2 layers :previous 10cm permafrost in the bottom +3 consecutive experiments : 10cm dry sand (1) 10cm saturated sand (2) 10cm permafrost(3) . Basalt rocks and air fractures are or are not embedded in the layers

Values of the permittivity of dry sand and permafrost were retrieve by two different ways.

1.Retrieval of the sand and permafrost permittivity from delay measurements knowing the layer thickness d

$$\varepsilon_r = ct/2d = n^2$$

2. Retrieval of the sand and permafrost permittivity from amplitude measurements knowing a calibration reference (reflection over a metallic plate), R is the Fresnel coefficient between the air and the medium.

$$A_{int}/A_{air} = R = \frac{n-1}{n+1}, \varepsilon_r = \frac{1+R}{1-R} = n^2$$

Results :

- Internal layering is observed. The transition between dry sand and permafrost can be detected.
- The permittivity can be retrieved from delay or amplitude measurements as well

from delay measurements : dry sand ε_r = 2.71 permafrost ε_r = 3.72

from amplitude measurements : dry sand ε_r = 2.73 permafrost ε_r = 3.35

- Embedded objects are detected,
- Fracture and its orientation is detected.