SHARAD DATA MAPPING FOR SURFACE ICE DETECTION. Luigi Castaldo[1], Daniel Mège[1], Roberto Orosei[2], Giovanni Alberti[3] , Joanna Gurgurewicz[1,4], [1]Institute of Geological Sciences PAS, Wrocław, Poland, [2]Istituto di Radioastronomia, Istituto Nazionale di Astrofisica, Bologna, Italy, [3]CO.RI.S.T.A., Napoli, Italy, [4]Space Research Centre PAS, Warsaw, Poland

Introduction: SHARAD is a synthetic aperture, orbital sounding radar, carried by NASA's Mars Reconnaissance Orbiter [1]. The echo from the surface itself is useful to study the first layer of the Mars surface. A proper mathematical model, in condition of favorable radar viewing geometry, interface scattering, surface and volume scattering, and material properties, may allow to realize a surface permittivity map. The study of the reflectivity of the surface echo is a means to obtain information on the composition and geometry of the ground. SHARAD data gathering and processing should be transparent to the user, the first requirement, for the majority of users of SHARAD data, is that the data collection and processing techniques used to produce the images should be irrelevant, and scientific properties should be the main interest. A mathematical method of calibration has been developed, adopting a models of surface scattering in place of “ground truth”, to estimate the variation of geophysical parameter as geometry variations, slopes and material composition and possibility of ice presence, across the Martian surface.

Scattering model: Scattering from natural surfaces plays a fundamental role in wave propagation and remote sensing. Mathematical models of the natural surfaces on Mars or other ones too are not available because of surface complexity. Instead, the fractal geometry approach has been used, and proved useful because of the surface under investigation are originated by natural phenomenon and doesn’t have artificial artefact [2, 3]. The reason is that forces that model natural surfaces (gravity and microgravity, tensions, frictions, vibrations, erosion, thermal and freezing gradients, chemical reaction, etc.; as well as periodic and aperiodic happenings: seasons and vegetation changes, sun, wind, rain, snow, slides, subsidence, etc.) generate surfaces whose topological dimension is larger than 2 [4]. The fractal geometry has been used to match a mathematical abstraction of fractal physics and electromagnetic field. Under those assumptions a model has been developed to use fractal geometry parameters from MOLA altimetry data [5, 6].

Calibration modelling: The signals extracted from the RDR need still several corrections in power in order to be comparable. These corrections show the influence of orbitographic phenomena (changes of altitude), technical issues (satellite orientation, acquisition mode) geometry of the acquisition signal. In order to handle the SHARAD data, some problems need to be solved:

- Tracking of the surface echo position in the recorded echoes in a simple and fast enough, but also robust way in order to minimize the number of errors in surface detection.
- Estimation of the power losses due to the shape of the geometry.

The calibration of the signal requires the determination of a constant that takes into account the backscattering gain due to the radar system and the surface in order to compensate the power losses due to the orbitographic phenomena [7]. The constant has been calculating starting from the power backscattered on a particular area on Mars where the permittivity constant is known, taking care to neglect all the terms depending on the geometry, ground and orbit.

Results: Signal calibration made possible the realization of mapping the real part of the permittivity constant for the Martian surface (Figure 1). Such map provide a look into the nature of the materials constituting the Martian surface and to the statistical presence of ice. In particular, low values of surface permittivity indicate either a very loose, porous regolith or an ice-rich terrain, whereas high values are characteristic of solid rock. The permittivity constant maps can eventually be used to help identify the areas where ice can be found. The map shows the values of the real part of the permittivity constant of the Martian surface penetrating in the first layer till a maximum of 15 m. The value of the permittivity of water ice i.e. ε_{ice} , can be selected in the map using Mätzler model [8] for pure ice as follows:

$$\varepsilon_{ice} = \varepsilon_M \pm std(\varepsilon_{\text{mod}}) \quad (1)$$

Where respectively ε_M is the value of the permittivity of pure water ice by the Mätzler model, while ε_{mod} indicate the different values of the real part of permittivity for each resolution cell in the map.

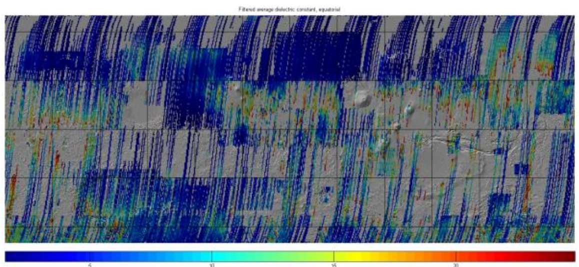

Figure 1 Permittivity constant equatorial map of Mars [-70° 70°; 0° 360°]. The permittivity constant goes from the lowest value, assimilable to pure Co2 ice or very porous regolith, to higher values, characteristic of solid rock. The water ice can be located in areas using (1).

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