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A global permittivity map of the Martian surface from SHARAD and some geological correlations

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Introduction

We present the first global SHARAD permittivity map of the Martian surface and discussion on geological correlations. The SHARAD synthetic-aperture, orbital sounding radar carried by NASA's Mars Reconnaissance Orbiter, is capable of detecting dielectric discontinuities in the subsurface caused by compositional and/or structural changes. It can inform on the average permittivity over a thickness up to 15 meters below the surface, depending on the material being sounded. The signal is strongly affected by the presence of intersticial water, and, more generally, can help discriminate between rock types. SHARAD data are therefore helpful to constrain the geology of a given area when complementing other datasets.

SHARAD permittivity map

A model has been developed to estimate the effect of surface roughness on echo power, depending on statistical parameters such as RMS height and topothesy. The model is based on the assumption that topography can be characterized as a self-affine fractal, and its use makes possible to estimate the dielectric properties of the first metres of the Martian soil. Methodological details are described in [1].

The SHARAD global permittivity map of Mars after RMS height correction is presented on Figure 1. Figure 2 gives the absolute error based on the dispersion of estimates within the same map resolution cell [1]. The permittivity of non-porous CO_2 ice is 2.1, that of non-porous water ice is 3.1, while that of igneous rocks, such as those found on the Martian surface, ranges between 4 and 10, depending both on composition and porosity [4].

Geological correlations

Regions where the SHARAD permittivity map is especially helpful in constraining geology when checked against other datasets (visible imagery, gamma-ray spectroscopy, MARSIS/MEx permittivity map) include, for instance, the dichotomy boundary, lava flows associated with the huge Elysium Mons volcanic shield, and ice-filled craters in the Martian arctic [1].

Results and conclusion

The dichotomy boundary is accurately followed by SHARAD permittivity contrasts, with higher permittivity south of the boundary. The latitudinal banding observed on GRS hydrogen abundance data is not reproduced, suggesting that the ice-rich 1 m thick surface layer might not be representative of deeper ice distribution. The permittivity boundary does not either follow the permittivity boundary of MARSIS, which gives permittivity averaged over tens of meters, suggesting the dichotomy boundary is not a clear vertical plane, or that MARSIS might not image the same feature (Figure 1).

Although SHARAD does frequently not give exploitable results on the major shield volcanoes, in some instances lava flows can be distinguished, perhaps due to different thickness or alteration.

The permittivity of Korolev and Dokka, two large high-latitude ice-filled impact craters, is significantly higher than the permafrost-rich surrounding lowlands, which could be related to the existence of snow dunes in these craters.

These examples illustrate how permittivity derived from SHARAD can be used to constrain the subsurface geology inferred from other data sources.

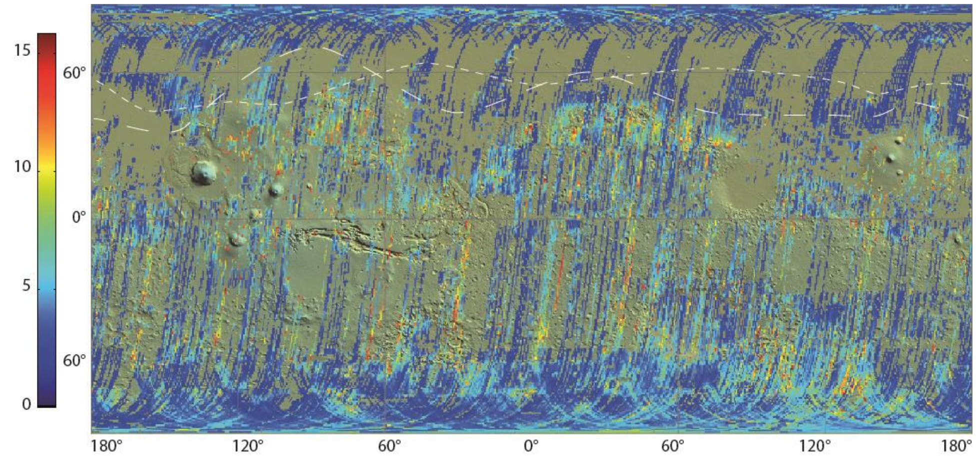

Figure 1: SHARAD global permittivity map of Mars after RMS height correction [1]. The line with long dashes indicates the MARSIS dielectric boundary (6-7) between the highlands and lowlands [2]. The line with short dashes indicates the boundary between mid-latitude areas in the northern hemisphere having equivalent hydrogen abundance < 8% (south) and > 8% (north) after GRS [3].

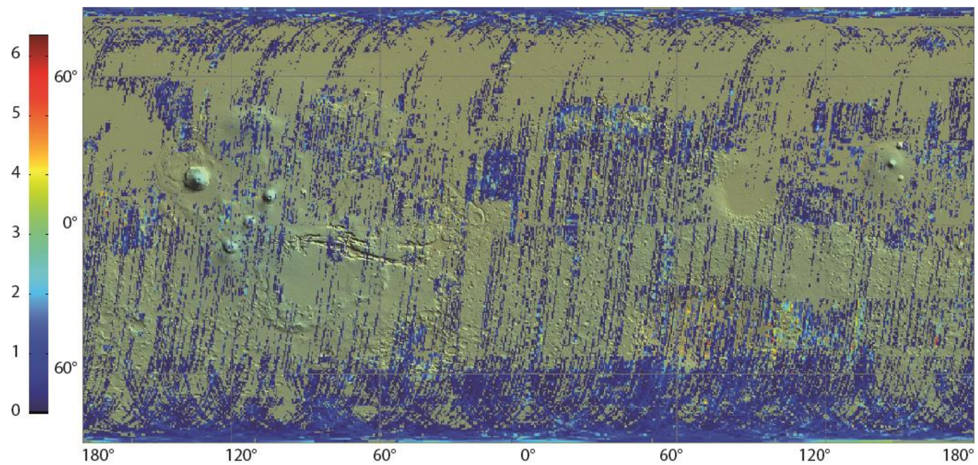

Figure 2: Permittivity standard deviation after RMS height correction [1].

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