Calibration over North Polar Caps of SHARAD data

L. Castaldo (1,2), G. Alberti (1), G. Cirillo (1), A. Frigeri (3), and R. Orosei (3)

(2) S.U.N, Ingegneria, Elettronica, Aversa, Italy (luigi.castaldo@gmail.com), (1) CO.RI.S.T.A., Consorzio di RIcerca sui Sistemi di Telerilevamento Avanzati Viale Kennedy, 4 - 80125 Napoli, Italy, (3) Istituto di Astrofisica e Planetologia Spaziali Istituto Nazionale di Astrofisica Via del Fosso del Cavaliere, 100 I-00133 Roma Italy

Geophysical Research Abstracts Vol. 14, EGU2012-10155, 2012 EGU General Assembly 2012 © Author(s) 2012

This poster participates in OSP

Outstanding Student Poster Contest

Abstract

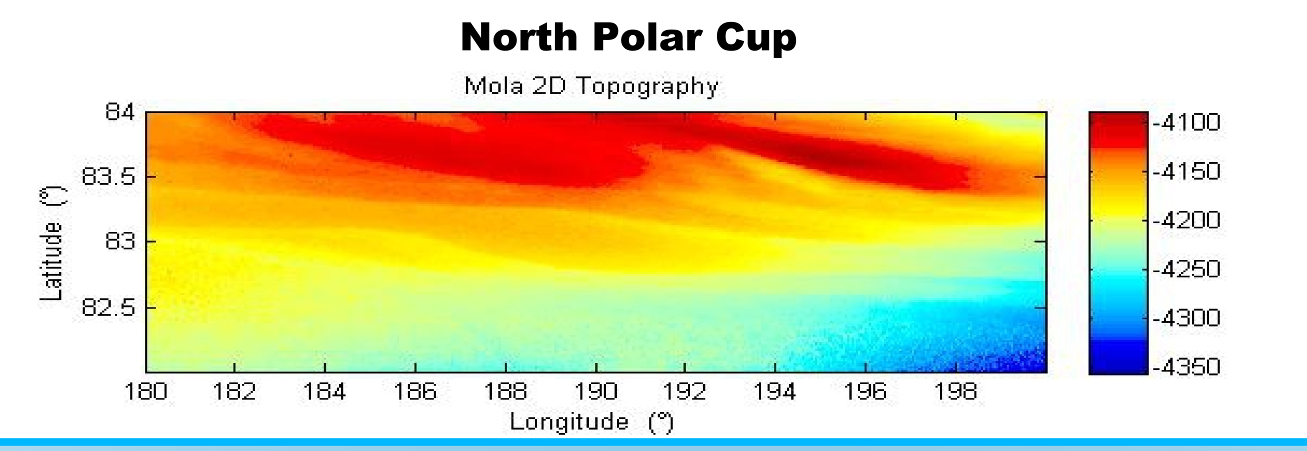
SHARAD (SHAllow RADar) is the sub-surface sounding radar provided by the Italian Space Agency (ASI) as a facility instrument for NASA's 2005 Mars Reconnaissance Orbiter (MRO). The science objective of SHARAD is to map, in selected regions, dielectric interfaces to depths of up to one kilometer in the Martian subsurface and to interpret these interfaces in terms of the occurrence and distribution of materials such as rock, regolith, ice or water[1]. The aim of this paper is to describe a calibration procedure for SHARAD data. No in-situ measurement of the dielectric properties of the Martian surface is available, and thus any attempt to correlate the echo strength from the surface with its dielectric properties requires an hypothesis on surface composition. We considered an area of the North polar cap where available data indicate an almost pure water ice composition, and thus whose dielectric properties are known. We estimated the other factor contributing to surface echo strength, i.e. scattering due to surface roughness, using a theoretical model based on fractal geometry, deriving model parameters from the MOLA topographic dataset. It was thus possible to derive a relationship between the geophysical parameters, dielectric constant, and a set of radar backscatter measurements. We used these results to produce maps of the dielectric constant of the Martian surface.

Goal

The goal is to model the relationship between surface dielectric constant and radar power measurements. In other words, the goal is to obtain "calibrated" radar data. To this aim, Sharad Level1b products have been used, as processed by the ground segment of the SHOC Radar Center in Rome and available on PDS nodes.

Model

The effects of scattering due to surface roughness and slope has been taken into account. The used model is based on the theory of electromagnetic scattering from fractal surfaces and the needed parameters have been estimated from topographic data provided by laser altimeter MOLA [2],[3]. The calibration procedure relies on specific Mars area, where the real part of the dielectric constant is known. The chosen area is part of the north polar cap [82N:84N;180E:200E] which it is supposed to be covered of pure water ice, with dielectric constant equal to 3.14.



The standard radar equation is used for the Calibration

$$P_r = P_t G \sigma_0 \frac{A_{eff}\, a_z}{H^4 (4\pi)^2}$$

Where

$$A_{eff} = \lambda \frac{\sqrt{\left(\frac{c_0 H}{B_w}\right)}}{\sin(\theta_{3dB})}$$

$$a_z = 2\,PRF\,N_{pre} \frac{H}{V_t} \tan\left(\frac{\theta_{3dB}}{2}\right)$$

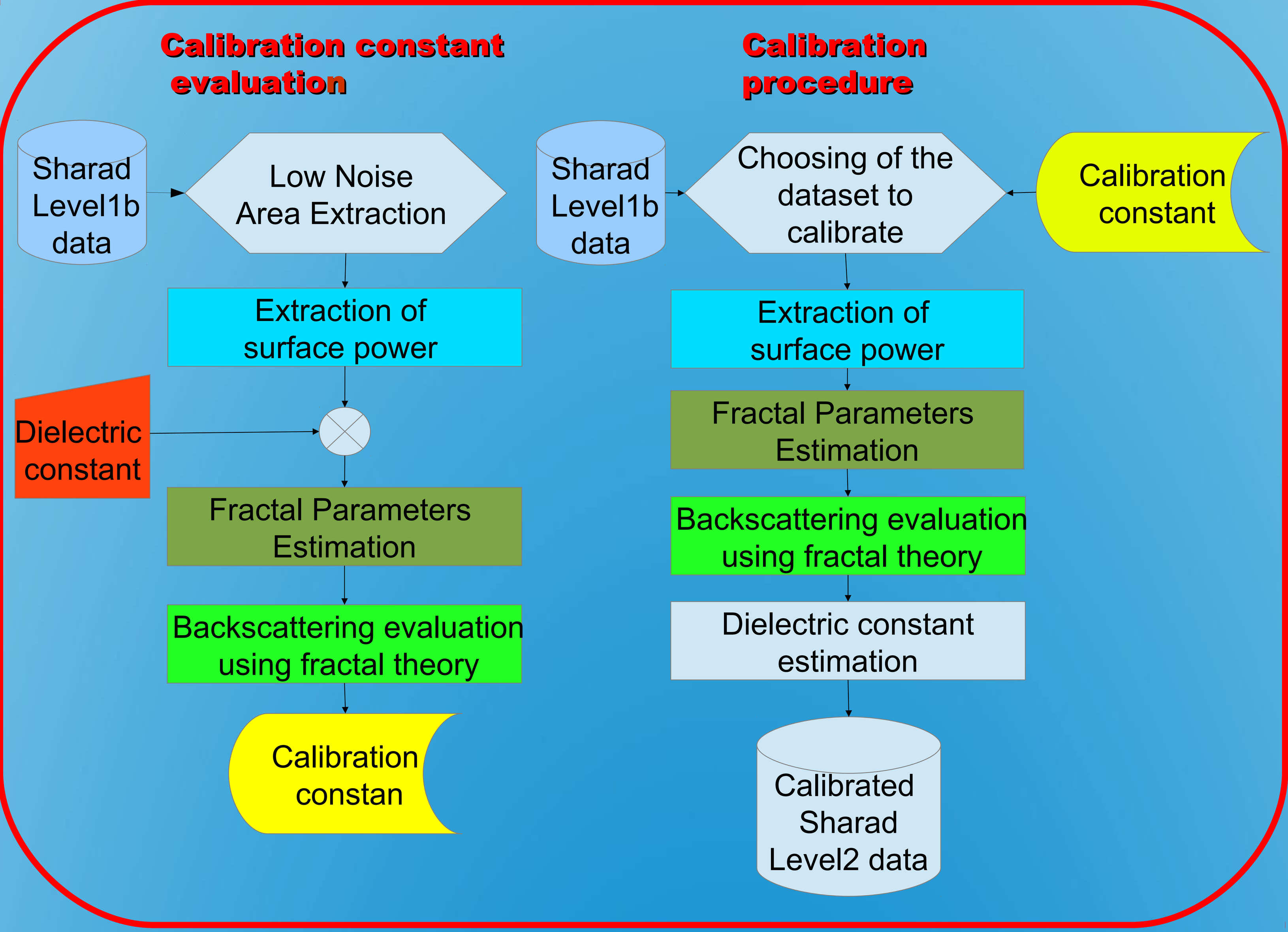
Surface Relative Permittivity is evaluable from the inversion of Fresnel Equation

$$R^2 = K_{ice} \frac{Echo\, H^4}{G^2 \sigma_{0norm} A_{eff}\, a_z}$$

Where

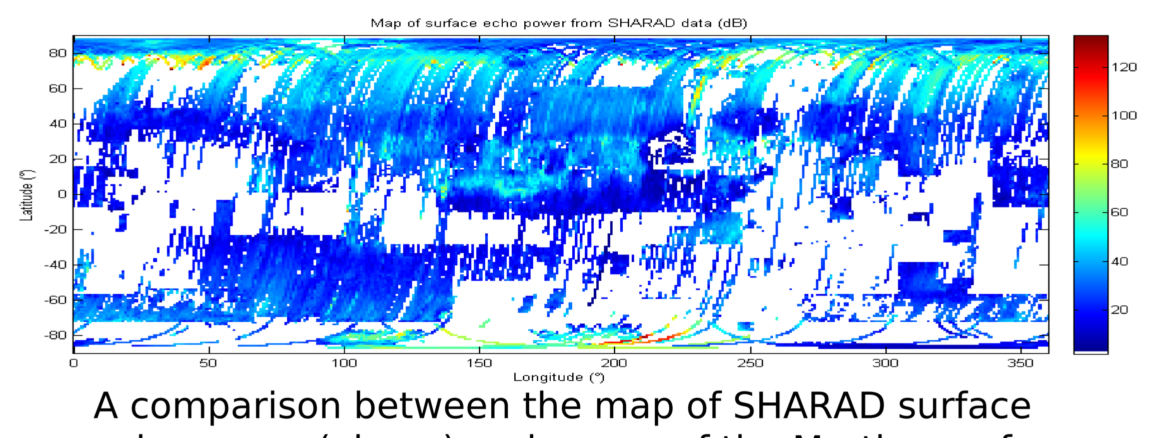
$$K_{ice} = \frac{G_{ice} \sigma_0 A_{eff} A_z}{P_r H^4}$$

$$\epsilon = \left(\frac{1+\sqrt{R^2}}{1-\sqrt{R^2}}\right)^2$$

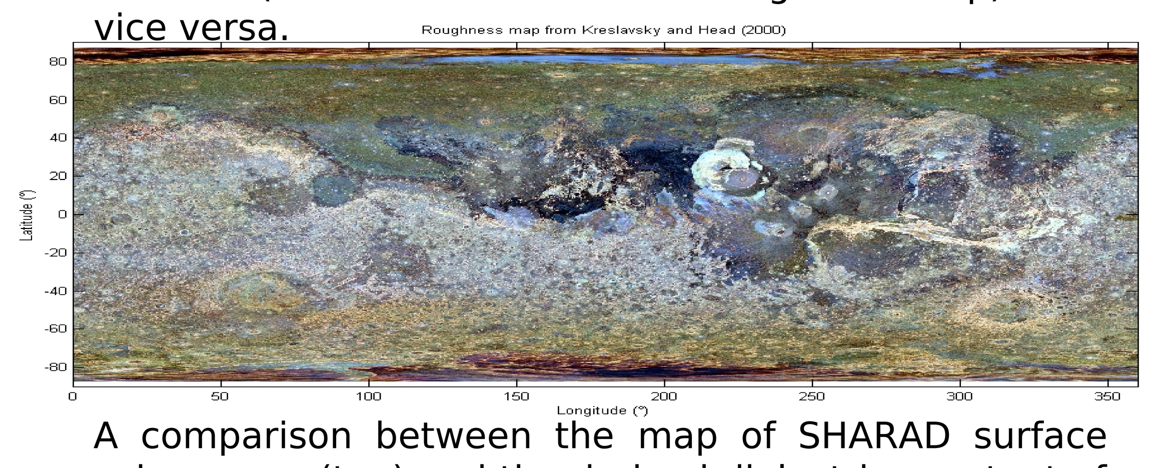


Results

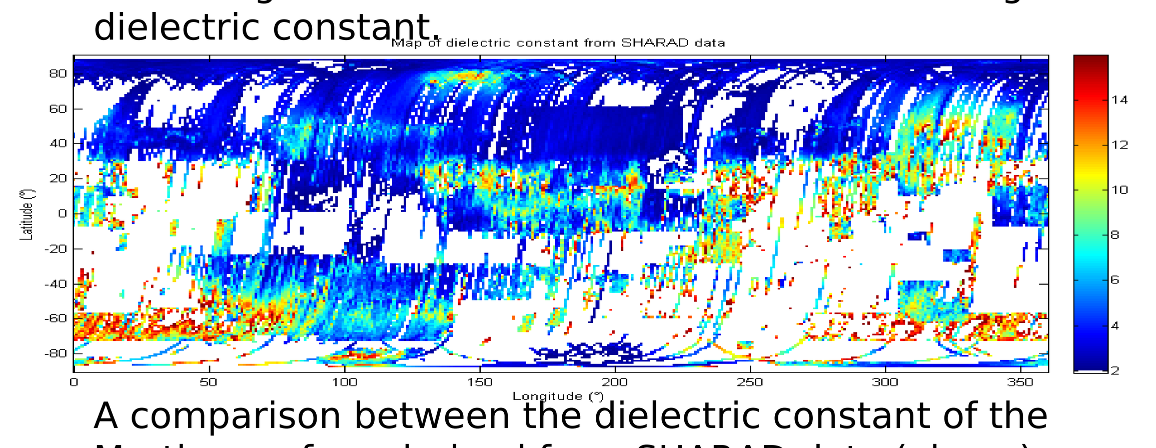
Preliminary results from the inversion procedure are presented below, together with a comparison with other datasets



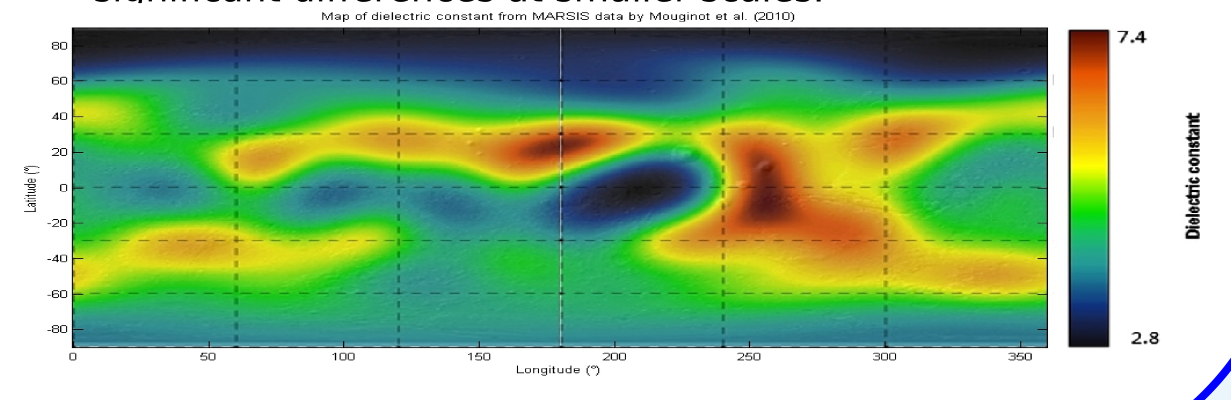
A comparison between the map of SHARAD surface echo power (above) and a map of the Martian surface roughness produced by [3] (below) shows that areas of strong surface reflection are correlated with smoother surfaces (which are darker in the roughness map) and vice versa.



A comparison between the map of SHARAD surface echo power (top) and the derived dielectric constant of the Martian surface (below) shows that areas of low power caused by strong scattering by surface roughness have been corrected and the correlation with roughness has been removed in retrieving the dielectric constant.



A comparison between the dielectric constant of the Martian surface derived from SHARAD data (above) and a map showing the same quantity obtained from MARSIS data by Mouginot [4] (below) reveals similar trends, but it also highlights finer structures and some significant differences at smaller scales.



Discussion

Compared to published estimates of the dielectric constant of the Martian surface, the map presented here appears to be noisier, but could potentially reveal finer structures and important differences w.r.t. MARSIS results.

In particular, significant differences of estimates of the dielectric permittivity between the two radars could be caused by differences in the distribution of ice with depth. MARSIS surface echo strength is determined by the dielectric properties of a layer several tens of meters thick, whereas SHARAD is sensitive to only the first few meters of the Martian ground.

Thus, a low value of the permittivity in MARSIS, indicative of an abundance of ground ice, coupled with a high value derived from SHARAD data could be caused by a thick ice deposit buried beneath a desiccated layer or a lava flow. Conversely, a low value of permittivity seen by SHARAD in an area where MARSIS finds high permittivity could be caused by a layer of ice-rich ground only a few meters thick over a dry bedrock.

Bibliography

[1] R. Seu,D. Biccari, R. Orosei, L.V. Lorenzoni, R.J. Phillips, L. Marinangeli, G. Picardi, A. Masdea, E. Zampolini,SHARAD: The MRO 2005 shallow radar, Volume 52, Issues 1–3, January–MarPlanetary and Space Sciencech 2004, Pages 157–166,Exploring Mars Surface and its Earth Analogues

[2] Kreslavsky, M.A., Head, J.W. (1999), Kilometer-scale slopes on Mars and their correlation with geologic units: initial results from Mars Orbiter Laser Altimeter (MOLA) data. J. Geophys. Res. 104, pp. 21911–21924.

[3] Orosei, R., R. Bianchi, A. Coradini, S. Espinasse, C. Federico, A. Ferriccioni, A. I. Gavrishin, (2003), Self-affine behavior of Martian topography at kilometer scale from Mars Orbital Laser Altimeter data, J. Geophys. Res. 108, Issue E4, pp. GDS 4-1, CiteID 8023, DOI 10.1029/2002JE001883.

[4] Mouginot, J., Pommerol, A., Kofman, W., Beck, P., Schmitt, B., Herique, A., Grima, C., Safaeinili, A., Plaut, J. J. 2010. The 3-5 MHz global reflectivity map of Mars by MARSIS/Mars Express: Implications for the current inventory of subsurface H2O. Icarus 210, 612-625.