THICKNESS OF SOUTH POLAR RESIDUAL CAP OF MARS BY MARSIS. J. Mouginot[1], W. Kofman[1], A. Safaeinili[2], A.Herique[1], J. Plaut[2] and G. Picardi, [1]Laboratoire de Planétologie de Grenoble, France jeremie.mouginot@obs.ujf-grenoble.fr, [2]Jet Propulsion Laboratory, Pasadena.

Introduction: The southern residual ice cap on Mars has been observed for more than a century. Thermal data from Viking indicate a dominantly CO_2 composition [1]. Infrared spectral mapping from Mars Express Orbiter has detected CO_2-ice in bright areas and H_2O ice darker areas [2]. Mars Global Surveyor Mars Orbiter Camera images show that there are two distinct layered units, an older unit (10 m thick) and a younger unit (few meters). Those CO_2 layers (8-15 meter total thickness) overlap H_2O-ice rich layers [3][4].

From reflectivity maps at 3, 4 and 5 MHz (i.e. 100 - 75 meters wavelength) obtained with the MARSIS radar [5], it appears clearly that the reflectivity is weaker in the residual cap region than the rest of south polar layered deposits.

To understand this phenomenon, we use a simple model of reflectivity with three layers (atmosphere, CO_2 ice and H_2O ice). Next, we statistically estimate the MARSIS reflectivity decrease between a reference region (only H_2O layer+atm) and the southern residual cap. This comparison gives us an estimation of southern residual cap thickness and dielectric constant. Finally we discuss the uncertainties and validity of our approach.

Reflectivity model of a layered medium: As the thickness of residual cap is of the order of 10 meters and as MARSIS wavelength is between 60 to 160 meters (in vacuum medium), the residual CO_2-ice slab/H20 ice echo? is unresolved, but its has an impact surface reflectivity.

Our reflectivity model is composed by three plane overlapping layers as described in Figure 1.

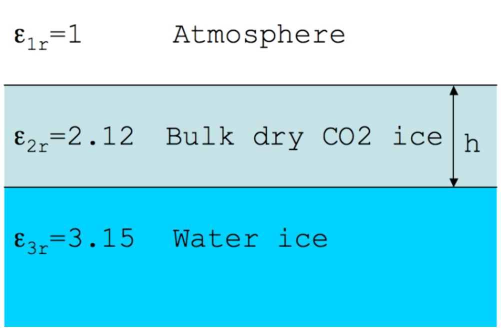

Figure 1: *Description of the layers in our reflectivity model.*

We consider a medium without losses. The two free parameters of our model are the thickness and the dielectric constant of southern residual cap.

The first layer is atmosphere (semi-infinite, dielectric constant equals to 1), the second layer is the residual cap considered as a pure CO_2-ice layer (height : h, dielectric constant between 1.4 and 2.4) and the third layer is a pure H_2O-ice layer (semi-infinite, dielectric constant equals to 3.15 [6][7]). As the porosity and dust content of CO_2 ice is unknown, the dielectric constant can vary from 1.4 (CO_2 powder) to 2.4 (dielectric constant of bulk dry ice is 2.12) [10].

From this simple model of multilayered medium [8][9], it appears that some thickness of CO_2 layer can imply a reflectivity decrease of about 2 orders of magnitude (Figure 2).

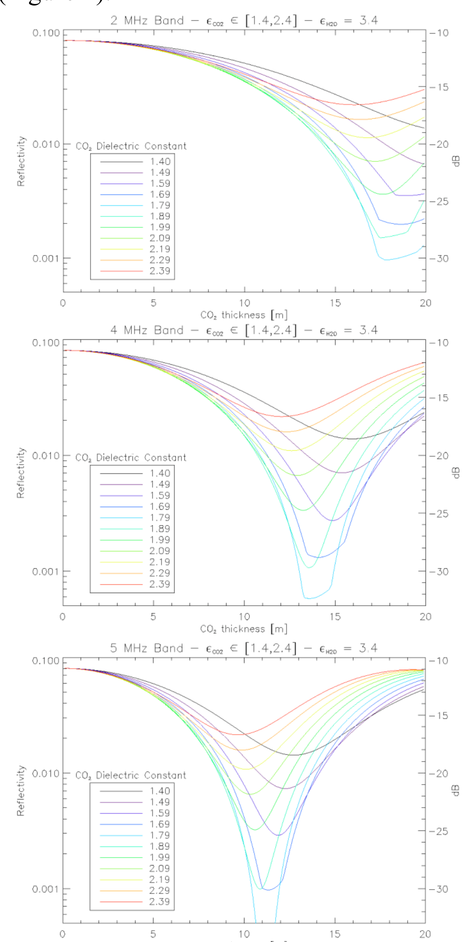

Figure 2: *Reflectivity as function of CO_2 thickness for three MARSIS bands.*

Our model is represented in Figure 2. We plot reflectivity as function of residual cap thickness for different values of CO_2-ice dielectric constant. As can be seen in Figure 2, the CO_2 thickness for minimum reflectivity changes with frequency. Consequently, additional constrains on our model were obtained by using surface reflectivity in 3 MARSIS bands

Southern residual cap reflectivity by MARSIS: We have extracted MARSIS surface echoes located in the southern residual cap for the three bands centered at 3, 4 and 5 MHz. To define residual cap region, we use a Martian geologic map [11]. Since the MARSIS data are not calibrated yet, we had to defined a reference region, where we know a priori the surface composition. This reference region corresponds to a very flat area in the south polar-layered deposits (latitude = [-81°,-85°], longitude = [180°, 205°]), where we assume the composition to be pure water ice.

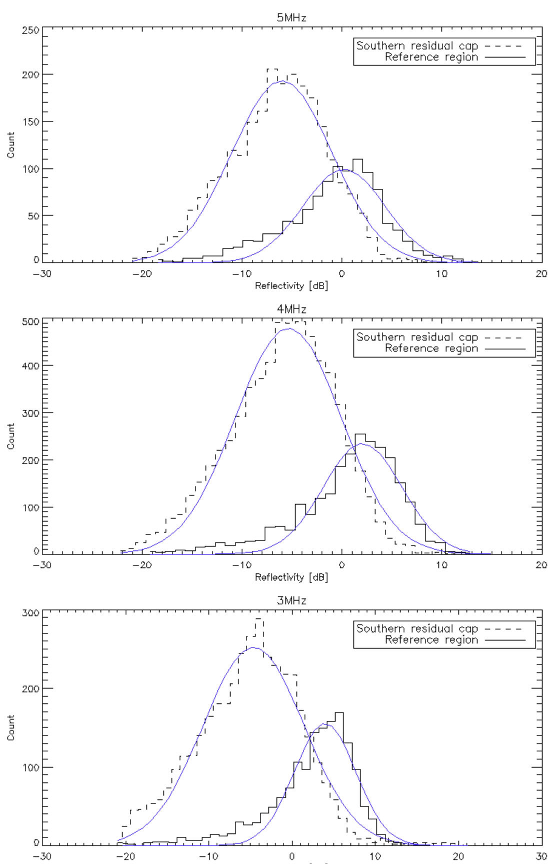

***Figure 3:** Distribution of reflectivity in the southern residual cap of Mars (dashed) and in the reference region (solid). Blue is the Gaussian fit to the data.*

In Figure 3, we can compare the reflectivity distribution in the southern residual cap with regard to our reference region. From top to bottom, MARSIS frequency band at 5, 4 and 3 MHz are presented.

As one can see, each distribution fairly matches a Gaussian distribution. Peak centers were them estimated by a Gaussian fit to the data..

The estimated reflectivity decrease between residual cap and reference at 5, 4 and 3 MHz, are of 6.2, 7.4 and 8.6 dB respectively.

Conclusion and perspectives: As discussed before, we have tentatively tried to understand radar reflectivity of residual cap using a reflectivity model. The best parameters found by a least square minimization method are : residual cap thickness of 14 m and residual cap dielectric constant of 2.1 (with water ice dielectric constant fixed at 3.15). This values are in good agreement with previous estimation [3][4][10]. Although the ice cap was treated globally here, we are developing a more local approach to study geographic variations of the CO_2 slab thickness with the south polar cap.

This work shows the capabilities of MARSIS to look at features much lower than its wavelength. Similarly, the SHARAD radar may be sensitive to a few meter thick CO_2 slab, and may be used to track seasonal variation in CO_2 deposition on the south pole of Mars.

References:

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