UNDERSTANDING AMBIGUITIES IN BACKSCATTERD ORBITAL RADAR SOUNDING DATA FROM THE MARTIAN POLAR LAYERED DEPOSITS USING FINITE DIFFERENCE TIME DOMAIN SIMULATIONS. E. Heggy[1], S. M. Clifford[1], D. Card [2], [1]Lunar and Planetary Institute, Houston, Texas, USA (heggy@lpi.usra.edu and clifford@lpi.usra.edu), [2] University of Manitoba, Department of Geological Sciences, Canada,

The MARSIS orbital radar sounding data has provided our first insights into the internal structure, stratigraphy, and basal topography of the polar-layered deposits (PLD) [1]. In order to evaluate the impact of the various geoelectrical and structural characteristics of the deposits on the sounding data obtained by MARSIS and anticipated from SHARAD, we have constructed representative geoelectrical profiles of the Martian PLD using new laboratory dielectric measurements of ice and ice-dust mixtures over the frequency range of 1-20 MHz [2]. These models address the impact of variable dust content, dust composition, layer thickness and spacing (including sub-resolution effects), near-surface porosity, and the size, density, and orientation of near-surface fractures We used expected subsurface geophysical conditions such as temperature gradient, porosity that may exist for the PLD to construct representative laboratory samples for each layer. Those frequency dependent geoelectrical models include interface roughness and volume scatterers for applications where these characteristics are likely to be important (e.g., at the higher sounding frequencies utilized by SHARAD). We then used the Finite Difference Time Domain (FDTD) simulation method to investigate three specific, but poorly undersood, characterisitics of the MARSIS polar radar data: (1) the relative weakness of the initial reflection form the surface of the PLD (vs. its apparent strength outside the PLD), (2) the effect of the number of resolvable and subresolution stratigraphic layers, as well as their composition, thickness and spacing on the layering evident in MARSIS radargrams, and (3) the potential suite of PLD characteristics (including basal topography, layering, and the potential presence of gas hydrates or thin films of super-cooled water) that might account for the observed enhancement of polar deposit basal reflectivity.

In order to simulate the radar echo for the layered stratigraphy, we used the FDTD algorithm, which is very general in terms of material electrical properties, geometry and frequency definition [3]. We evaluated the scattered electric field in two cross polarizations at the surface of our geoelectrical models. Simulations were performed in the time domain to observe reflections at each interface. In FDTD modeling, the material properties and geometry are constructed using the Yee cell method [4]. For each frequency, each cell is characterized by the complex permittivity of the investigated layer. We used the Perfect Matching Layer (PML) algorithm as boundary condition to reduce signal reflections at the column boundaries to decrease simulation noise.

For the 2 MHz simulations that correspond to the MARSIS case, the necessary dimensions of the Yee cell are 5x5x5 m in order to insure sufficient accuracy and stability in the FDTD calculations. To describe the roughness at the layer interfaces, and the scatterers in the first layer, we use a local grid with smaller cells of 1 m. The radar pulse emitter and receiver are placed at the same point above the surface. The vertically emitted pulse is simulated as a plane wave with maximum amplitude of 1 V/m. The emitted waveform is a vertically polarized (in the x direction) and modulated Gaussian, with a central frequency of 2 MHz and 2 MHz bandwidth. The receiver can measure the backscattered echos in the Ex and Ey cross polarizations. For SHARAD 20-MHz simulations, the size of the Yee cell is reduced to 1 m.

In order to evaluate the effect of the first layer on electromagnetic attenuation, we changed its complex permittivity according to the measured range, and then observed the effect on the radar echo. To evaluate the volume scattering effect, particularly their potential contribution to the observed reduction in relfectivity associated with the surface of the SPLD, we considered randomly oriented 150-m wide fractures (with a horizontal density of 1/2250 m^2) with dips ranging from $30^o – 80^o$, that penetrated to a vertical depth of 150 m. These characteristics where investigated only to provides a first order understanding of the effect of surface fractures on signal dispersion and depolarization. A more comprehensive range of fracture characteristics is currently being investigated Our initial results indicate that fracture geometry and orientation can significantly affect surface reflectivity at 20 MHz, but that the effect is reduced at 2 MHz.

At the conference, the results of these simulations will be summarized and compared with the actual MARSIS SPLD data, identifying what we believe to be the most plausible explanations for the observed surface and basal reflectivity of the deposits, as well as the range of characterisitics capable of explaining the differences between the visual- and radar-determined stratigraphy.

References [1] Picardi et al (2005), *Science*, pp 1925. [2] Heggy et al. (2006), these abstracts. [3] K.Kunz and Luebbers R. J. (1993) The Finite Difference Time Domaine Method for Electromagnetics, 3-11. [4] Yee, K.S.*(1966), IEEE Trans. Antennas propagation*, 14, no. 3, p. 302-307.