Water Ice Spectral Signatures and Grain Size Estimates in the Northern Polar Layered Deposits from MRO CRISM Measurements. Robert O. Green[1], Scott Murchie[2], The CRISM Team. [1]Jet Propulsion Laboratory California Institute of Technology, Mail-Stop 306-431, Observational Instruments Division, 4800 Oak Grove Drive, Pasadena, CA 91109 (rog@jpl.nasa.gov); [2]Applied Physics Laboratory, Laurel, MD 20723.

Introduction: The Compact Reconnaissance Infrared Spectrometer for Mars (CRISM) [1] is carried on board the NASA Mars Reconnaissance Orbiter (MRO). The CRISM imaging spectrometer measures the spectral range from 362 nm to 3920 nm with spectral sampling nearly constant at 6.55 nm over the complete spectral range. The spectral response function Full-Width-at-Half-Maximum (FWHM) varies from 8.6 to 10 nm over the range from 360 to 1050 nm and from 9.7 to 17.5 nm from 1000 to 3920 nm. The field-of-view of CRISM is 2.12 degrees giving a nominal image swath 11 km from an altitude of 300 km. The full resolution spatial sampling of CRISM is 15-19 m with variation due to field position, pointing, and surface elevation. CRISM measurements are available calibrated to radiance and also available as I/F. The primary science phase began for MRO in November 2006.

In this work, a portion of the northern polar region is examined with CRISM spectral measurements at full spatial resolution. The polar cap shows layering of mixed ice and dust at different scales. This layering records variation of the environment through time. The combined spectral and spatial characteristics of CRISM allow enhanced investigation of this region and these layered materials. The work presented here builds upon previous and current research of spectral measurements of water ice on Mars [2,3,4,5].

The data set examined here is a CRISM full resolution target observation labeled 2F7F. This image captures the north central edge of Chasma Boreale and is shown in Figure 1. The image was acquired in November of 2006 with an solar longitude of 133 degrees. The image contains a portion of the base of Chasma Boreale as well as a section the polar layered deposits (PLD) including the upper surface.

From this data set a set of average spectra were extracted from the central swath of the data set. From the top to the bottom of the image, these spectra included the upper surface of the PLD, the upper unit, the lower unit as well as the base of Chasma Boreale. The spatial locations of the extracted spectra were optimally matched between the two CRISM spectrometers. Figure 2 shows the calibrated I/F spectra labeled A to I. In each case an average of 10 spectra were extracted and averaged. Spectra A, B, C and E show water ice absorption features at 1050, 1250, 1500, 2000 nm. Spectrum E was extracted from the fine layer on the surface of the upper unit and is likely a spatial mixture even at full CRISM spatial resolution.

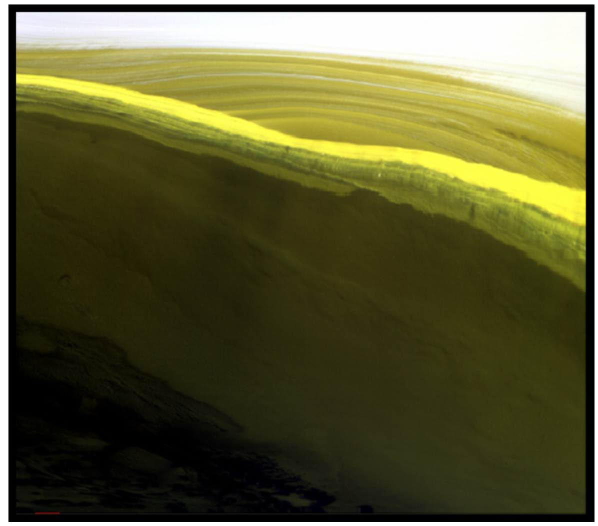

Figure 1. CRISM color composite image FRT_2F7F of the northern edge of Chasma Boreale (RGB, 960,740,510 nm).

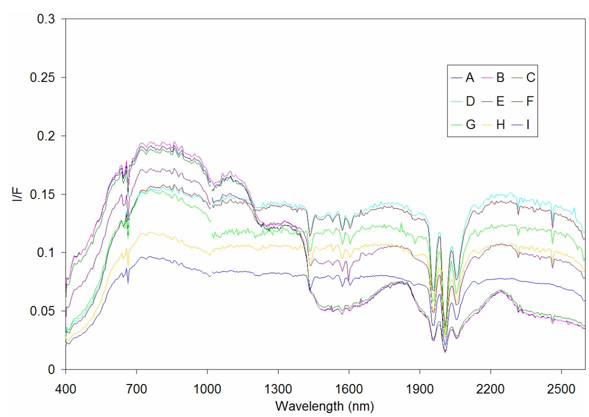

Figure 2. CRISM extracted I/F spectra extending from upper surface of PLD to Chasma Boreale.

An atmospheric correction using a modified MODTRAN [6,7] approach with residual artifact suppression was applied to the I/F data set. Figure 3 shows a selected set of the MODTRAN atmospheric transmittance look-up-table that spans a range of carbon dioxide and water vapor abundances. These modeled transmittance spectra were convolved to the CRISM spectral response functions taking into account the instrumental cross-track spectral variation. Figure 4 shows the atmospherically corrected spectra derived from this approach. Following atmospheric correction, weak water ice absorptions are more clearly observable in spectra D, E and F from the upper unit of the PLD. Absorption features are not observed in spectra G, H and I that extend through the basal layers to the surface of Chasma Boreale.

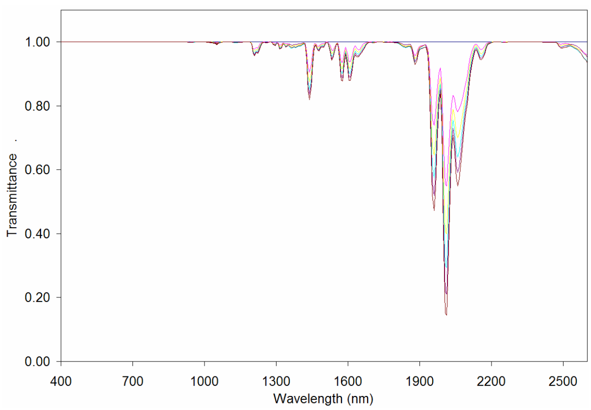

Figure 3. MODTRAN modeled atmospheric transmittance for varying carbon dioxide path. These spectra have been convolved to the CRISM spectral response functions.

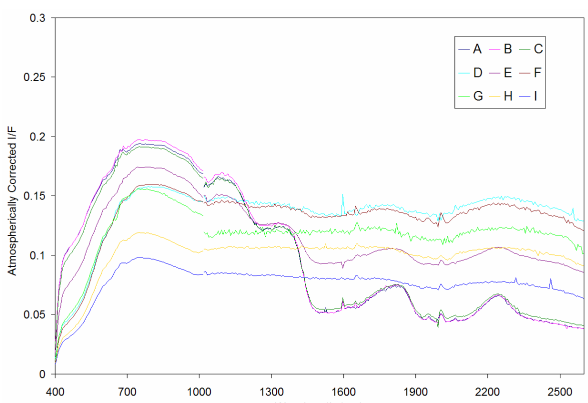

Figure 4. Atmospherically corrected CRSIM spectra from the upper PLD surface to the base of Chasma Boreale. Averages of 10 spectra are used from approximately the same cross-track column region.

To investigate the physical properties of the water ice recorded in these CRISM spectral measurements a radiative transfer grain size forward inversion approach has been used. This approach incorporates the DISORT radiative transfer code with Mie scattering calculations based upon the spectral complex refractive index of water ice. The combined algorithm is used to model the spectral reflectance signature of an ice surface with specified grain size. At this stage in the model development, the grains of ice are modeled as spheres. To test the forward inversion approach, a set of model spectra spanning a range of grain sizes were calculated. Figure 5 shows the best fit between the CRISM spectrum from the upper surface of the PLD and the modeled spectra. The effects of dust are not yet fully integrated in the model, consequently the algorithm was tested only on the range from 900 to 2600 nm. Using a spectral fit of this range, a grain size of 900 micrometers was estimated for the upper surface of the PLD. A future focus of this effort will be to more completely model the physical properties of the ice and dust mixtures of the PLD and apply the forward inversion approach to a range of CRISM full resolution data sets. The derived ice and dust parameters will be used to investigate the diversity of the PLD and pursue understanding of its history in relation to the Mars polar environment.

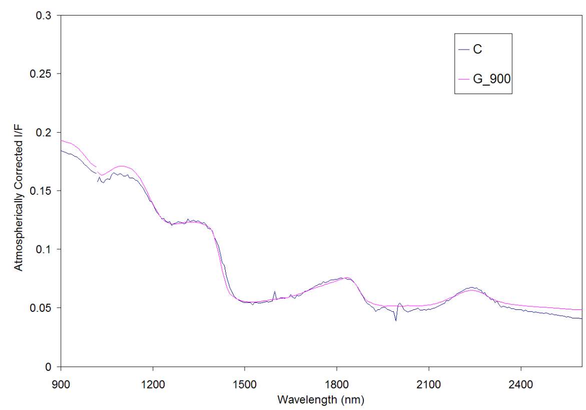

Figure 5. Grain size model fit of 900 micrometer radius with CRISM spectrum C from the upper surface of the PLD.

Acknowledgment: This work is supported by the NASA MRO Project. The broad efforts of the CRISM team are gratefully appreciated. A portion of this research was carried out at the Jet Propulsion Laboratory / California Institute of Technology, Pasadena, California, under contract with the National Aeronautics and Space Administration.

References

[1] Murchie, S. et al., “CRISM on MRO,” J. Geophys. Res., 2007. [2] Langevin et al., Science, Vol. 307, no. 5715, 2005. [3] Murchie et al., Science submitted. [4] Rouch et al., “Modeling Water Ice Surface Deposits near Louth crater using MRO, “ 7th Mars, 2007. [5] Calvin et al., “Evolution and composition of Layered Materials in the Northern Polar Deposits of Mars,” LPSC 2008. [6] Anderson, G.P., et al, “MODTRAN4 Radiative Transfer modeling for remote sensing, SPIE, 4049, 176-183, 2000. [7] Green et al., 7th Mars, 2007