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Mapping Minerals on Mars with CRISM: Atmospheric, Thermal, and Photometric Correction for MRDR Map Tiles and Comparison to OMEGA

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Abstract We assess the current state of photometric, atmospheric, and thermal corrections applied to 72-band multispectral mapping data from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) on the Mars Reconnaissance Orbiter (MRO). The corrections account for effects of varying observational conditions, including atmospheric CO_2 absorption, scattering by ice and dust aerosols, thermal emission, and photometric geometry. We will discuss differences between versions of these corrections that are released and under development, and compare derived indicator maps for mafic, hydrated and/or sulfate, and phyllosilicate minerals covering the Nili Fossae, Mawrth Vallis, Olympus Mons, Tyrrhena Terra, and Juventae Chasma regions with similar indicator maps derived using data from the Observatoire pour la Minéralogie l'Eau, les Glaces et l'Activité (OMEGA) instrument on Mars Express.

1. Introduction

The CRISM instrument has been operating at Mars since the autumn of 2006 [5] and acquires data in one of two modes, hyperspectral or multispectral. The hyperspectral mode returns up to 544 bands of spectral data in the visible/near-infrared wavelength range (0.4-3.92 μm) with 6.5 nm/channel spectral sampling; at full resolution, this mode provides ~18 m/pixel spatial sampling and image footprints that are roughly 10 x 10 km in size. High-resolution hyperspectral images are acquired by continuously gimbaling the instrument as it passes over a target, resulting in an hourglass footprint.

In this work, we focus on CRISM's multispectral mapping (MSP) operating mode. MSP images return 72 selected bands of spectral data over the same wavelength range and at the same spectral resolution as the hyperspectral data. However MSP data are acquired in push-broom mode, resulting in ~200 m/pixel spatial sampling and image strips ~10 km wide and several hundred km long. Systematic multispectral imaging over the course of the mission has yielded 10,000's of strips, which are assembled into 1,964 5x5 degree Multispectral Reduced Data Record (MRDR) tiles for global coverage.

Mineral indicator maps can be assembled from these data by calculating the strengths of characteristic absorption features in each pixel of the mapped data. These features occur at 1.9-2.5 μm in hydrated sulfate and phyllosilicate minerals, near 1 and/or 1.8-2.3 μm in mafic minerals such as olivine and pyroxene, near 1.5 and 2.0 μm in H_2O ice, and near 1.4, 2.0, and 2.2-2.3 μm in CO_2 ice. The indicators we use are "summary parameters" developed for OMEGA and CRISM data by Pelkey *et al.* [7].

The OMEGA instrument [1], also a visible/near-infrared hyperspectral spectrometer operating at ~0.4-5 μm, has been conducting similar orbital mapping of Mars since 2003, though normally at spatial sampling >1000 m/pixel. CRISM's MRDR map tiles provide broad spatial coverage similar to OMEGA's, but at an improved 200 m/pixel resolution.

2. Data reduction

The basic version of the MRDRs released to and available from the Planetary Data System (PDS) consists of composites of many multispectral strips, in which radiance-on-sensor is divided by solar flux times π to yield "I/F." Interpretability of surface mineralogy is improved by correcting for variable observing conditions [3]. Version 1 of these corrections assumes Lambertian scattering by the surface. Radiative transfer calculations to model observing conditions are pre-computed to create a multi-dimensional lookup table of corrections for each spectral band. This table models effects of scattering by different abundances of ice or dust aerosols (estimated from climatological patterns), attenuation by atmospheric CO_2 (estimated from climatological patterns [3]), and thermal emission (estimated from a physical thermal model). This version of the corrections has been used to generate a global set of "Lambert albedo" MRDR map tiles that estimate surface reflectivity at a normal solar incidence angle in the absence of an atmosphere [2,3,5], which is also released to and available from the PDS.

Version 2 of the corrections is under development, and includes several improvements: (a) the correction for attenuation by atmospheric CO_2 is scaled from the observed strength of the 2.0-µm CO_2 absorption for each pixel [4,8] instead of being estimated from climatology; (b) the correction also models small changes in CRISM's wavelength calibration with temperature of the instrument optics, reducing artifacts [4,8]; and (c) the estimate of aerosol scattering is based on derived abundances during the actual time of CRISM's operation, instead of from climatological averages. Prototype 'v2' Lambert albedo MRDR map tiles cover test areas in the Nili Fossae, Mawrth Vallis, Olympus Mons, Tyrrhena Terra and Juventae Chasma regions. A broad overview of the spectral contents of these prototype tiles is afforded by combining spectral summary parameters into thematic RGB composites, or "browse products," i.e., IRA, MAF, HYD, and PHY (Table 1, Fig.1A).

3. Results

Fig. 1A shows multiple browse products of a single test tile to illustrate the current status of the v2 corrections. These maps are consistent in their phyllosilicate (D2300) distributions, as mapped with hyperspectral CRISM and OMEGA data [6]. We show MAF and PHY maps for OMEGA in Fig.1B. In the IRA tile some strips are anomalously dark after correction, due to the estimates for ice or dust aerosols being too different from the actual values. However, generally the match between adjacent strips is good. The high-calcium pyroxene index (HCPINDEX) in the MAF map tile tends to be high in these same darker strips, but the olivine (OLINDEX) and low-calcium pyroxene (LCPINDEX) indicators appear to be more robust. Detections of Fe/Mg-rich phyllosilicates from the D2300 indicator in the PHY map is rather clean for most of the 'normal' IRA strips. However parameters related to molecular water in minerals (BD1900 and SINDEX in the PHY and HYD tiles) can be systematically too high or too low, perhaps due to incorrect estimation of the effects of ice aerosols. Generally, for this 'v2' tile and for other 'v2' tiles, correction for CO_2 absorption is much improved compared to the 'v1' tiles, allowing for cleaner detections of spectral structure in the 2-micron region, for example with BD2100. Currently we are exploring modifications to 'v2' that preserve its improvements while correcting its residual errors.

Table 1: Summary parameter RGB (Browse) composites shown in Figure 1. R=Reflectance, BD=Band-depth; D=Drop-off; SINDEX=Sulfate-Index; OLINDEX=Olivine-index; LCPINDEX=Low-Calcium-Pyroxene-index; HCP-INDEX=High-Calcium-Pyroxene-Index. The 4-digit numbers are the wavelengths in nm. The min/max stretches are also indicated for each of the three color bands.

Browse Product	R	G	B
IR Albedo	**R**1330 0.03-0.14	**R**1330 0.03-0.14	**R**1330 0.03-0.14
MAFic minerals	**OLINDEX** 0.005-0.015	**LCPINDEX** 0.005-0.015	**HCPINDEX** 0.01-0.03
HYDrated sulfates	**SINDEX** 0.00-0.03	**BD**2100 0.01-0.03	**BD**1900 0.01-0.03
PHYllosilicates	**D**2300 0.005-0.015	**BD**2210 0.005-0.015	**BD**1900 0.01-0.03

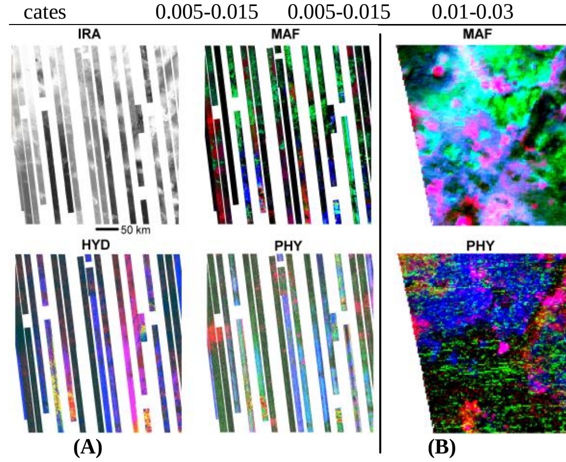

Figure 1: Nili Fossae, 17.5-22.5°N, 70-75°E:
(A) CRISM V2 browse tiles for MRDR#1249.
(B) OMEGA #424_4 MAF and PHY (diff. stretches).

References

[1] Bibring, J.-P. *et al*. *Science* 307, 1576–1581 (2005). [2] Malaret, E., *et al*, *LPSCXXXIX*, League City, #2081 (2008). [3] McGuire, P.C., *et al.*, *Trans. Geosci. Remote Sensing*, 46(12) 4020-4040 (2008). [4] McGuire, P.C., *et al.*, *Planet. Space Sci.* 57, 809-815 (2009). [5] Murchie, S.L., *et al.*, *JGR* 114, E00D07 (2009). [6] Mustard, J.F. *et al.* Nature, 454, 305-309 (2008). [7] Pelkey, S., *et al.*, *JGR* 112, E08S14 (2007). [8] Wiseman, S.M., *et al.*, *LPSCXLI*, Houston, #2461 (2010).