MAPPING THE WATER CONTENT OF THE MARTIAN SURFACE USING MARS EXPRESS OMEGA DATA. R. E. Milliken[1], J. F. Mustard[1], F. Poulet[2] J.-P. Bibring[2], Y. Langevin[2], B. Gondet[2], S. Pelkey[1] and the Mars Express OMEGA team, [1]Dept. Geological Science, Brown University, Providence RI 02912 USA, [2]Institut d'Astrophysique Spatiale, Baitment 121, Orsay, France. Email: ralph_milliken@brown.edu

Introduction: The detection of sulfates on the surface of Mars by the Mars Exploration Rovers [1] has shown that liquid water once interacted with the near-surface to produce hydrated minerals. Data from previous Mars missions, including the Mariner 6 IRS [2], Phobos 2 ISM [3,4], Mars Odyssey GRS [5] and MGS TES instruments [6], have been used to estimate the water content of the surface at relatively low spatial resolutions. Current and upcoming instruments (ESA's Mars Express OMEGA and NASA MRO's CRISM, respectively) will provide unprecedented high spatial and spectral resolution VIS-NIR data that will cover the 3.0 µm fundamental H_2O stretching absorptions as well as the 1.9 µm H_2O combination overtone absorption, which are due to adsorbed or bound water. To date, most estimates of surface hydration rely partly on the ground-truth observations of soil water content as measured by the Viking landers (~1-2 wt.%), which have large uncertainties [7]. In this study, we apply our laboratory-derived models relating water absorption strengths and absolute water content [8] to the 3.0 µm water absorption in the OMEGA VIS-NIR data. This model requires no *a priori* knowledge of surface composition [8] and provides an estimate of the absolute H_2O content of the martian surface, independent of the Viking lander observations.

Methods: The OMEGA instrument consists of 3 detectors (VIS, SWIR-C, and SWIR-L) with a total of 352 channels covering the ~0.3 - 5.0 µm wavelength region [9]. For this study, the data have been converted from DN to reflectance, corrected for incidence angle using a simple cosine correction, corrected for atmospheric gases by dividing each spectrum by a scaled atmospheric gas absorption spectrum, and corrected for a 1-pixel spatial offset between the SWIR-C and SWIR-L detectors. Effects of aerosols, water ice clouds, and thermal emission on the spectra have not been accounted for. These effects can result in an apparent increase in the 1.9 µm and 3.0 µm water absorption strength, which may lead our model to overestimate the actual water content of the surface. We used data acquired during the first 600 orbits and excluded polar cap and early high-latitude observations to avoid effects of surface H_2O and CO_2 ice. During this period, the atmosphere was relatively clear of H_2O ice clouds.

The model first finds a linear continuum fit over the 3 µm region. The left continuum point is the reflectance maximum between 2.2 - 2.5 µm. To avoid anomalously large reflectance values for wavelengths >3.5 µm due to thermal effects, the right continuum point is set at 3.8 µm and is assumed to be 70% of the value of the left continuum point. This percentage is an estimate based on the laboratory measurements used to determine the model [8]. The maximum absorption point (minimum reflectance) is then fit with an exponential model to determine the optical path length, d, which is then converted to weight percent water using the relationship: $\mathbf{H_2O = 0.0253 \cdot e^{7.08 \cdot d}}$. Resulting H_2O values currently have an expected error of ±1 wt.% [8].

Results: The 3.0 µm water absorption is present in all OMEGA spectra acquired thus far, whereas the 1.9 µm combination overtone is only present in specific locales, including deposits in Valles Marineris, Aram Chaos, Mawrth Vallis, and Terra Meridiani [10]. These regions of increased hydration commonly correspond to geological or geomorphological boundaries, suggesting they are compositionally unique areas and not a result of the effects described above. The estimated water content is often, though not always, correlated to albedo. Of interest are those areas that lie outside of this trend, which include the regions listed above. Dividing the estimated water content by the albedo highlights these areas of increased H_2O and is useful in areas with strong albedo variations. Figure 1 shows the results of this method applied to northern Syrtis Major. The normalization minimizes the strong albedo boundaries present in this area, revealing localized outcrops of hydrated materials in the Noachian terrain along the northern edge of Syrtis Major. These areas of increased hydration range from ~2-4 wt.% H_2O, whereas the surrounding terrain ranges from ~0.5-2.0 wt.%. Future laboratory work will test our model using low-albedo materials (reflectance < 0.4) to determine how much, if any, of this correlation is an artificial effect caused by low reflectance values. The global hydration map shows that the southern highland water content ranges from ~1-3 wt.%, whereas the brighter northern plains have a range of ~1-5 wt.%. The Viking landers measured the water content of the local soil to be 1-2 wt.%. Our model predicts slightly higher values of 3-4 wt.% for the Viking 1 site and 1.5-5.0 wt.% for the Viking 2 site, well within the expected range considering the uncertainties in the Viking measurements [7].

The region including Mawrth Vallis (Fig. 2) is one of several areas of interest. The light-toned, layered plateaus of Noachian-aged cratered and etched terrain centered at 20°W, 25°N [11] show an increase of 3-5 wt.% H_2O (6-8 wt.% total) relative to the surrounding terrain. The spectra for these areas as well as Nili Fossae suggest the presence of hydrated Fe-rich clays (such as nontronite), sulfates, or other hydrated alteration products [10,12,13], which have been suggested previously as potential soil components [14,15].

Conclusions: Our laboratory-based model is capable of estimating surface water contents within the expected range defined by previous studies. Global hydration patterns have yet to be corrected for thermal effects, aerosols, and water ice clouds, but show promising results and suggest the hydration state of the surface is quite variable. High-resolution regional maps show several areas of increased water abundance that often correspond to light-toned, layered outcrops with a distinct 1.9 µm absorption. These hydrated areas range from 3-8 wt.% H_2O. Future work includes correcting the OMEGA data for thermal and atmospheric effects,

determining which mineral species account for the increased hydration signatures, and refining the model to account for albedo variations.

References: [1] Squyres, S. et al. (2004) *Science* 306, 1709-1714; [2] Calvin, W. (1997) *JGR* 102, 9097-9107; [3] Murchie, S. et al. (2000) *Icarus* 147, 444-471; [4] Yen, A. et al. (1998) JGR 103, 11125-11133; [5] Feldman, W. et al. (2002) *Science* 297, 75-78.; [6] Kuzmin, R. et al. (2004) LPSC 35, #1810; [7] Biemann, K. et al (1997) *JGR* 82, 4641-4658; [8] Milliken et al. (2005) *this conference* ; [9] Bibring, J. et al. (2004) *ESA SP* 1240 ; [10] Bibring, J. et al. (2005) *submitted*; [11] Scott, D. and Tanaka, K (1986) USGS MAP I-1802-A; [12] Poulet, F. et al. (2005) *this conference*; [13] Gendrin, A. et al. (2004) 2nd Conf. Early Mars #8030; [14] Bishop, J. et al. (1995) *Icarus* 117, 101-119; [15] Bish, D. et al. (2003) *Icarus* 164,96-103.

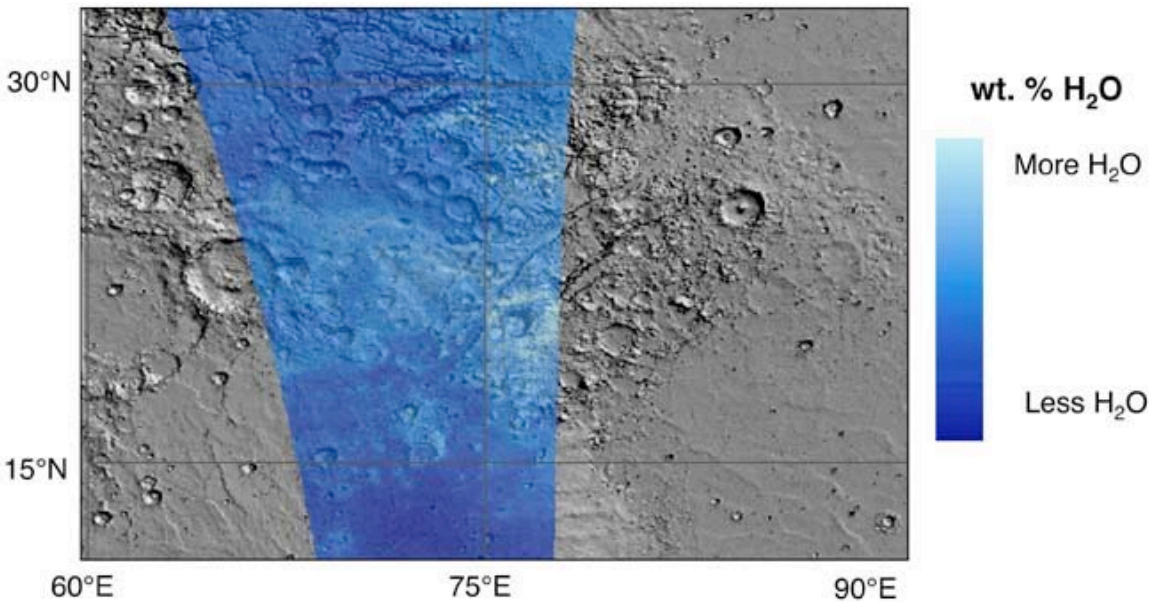

Figure 1. Map of surface H_2O content normalized by albedo overlain on MOLA topography. To a first order, water content is correlated to albedo, but this normalization reveals several areas of increased hydration (2-4 wt.% H_2O) relative to the surrounding terrain. The resolution of this grid is 64 pixels per degree.

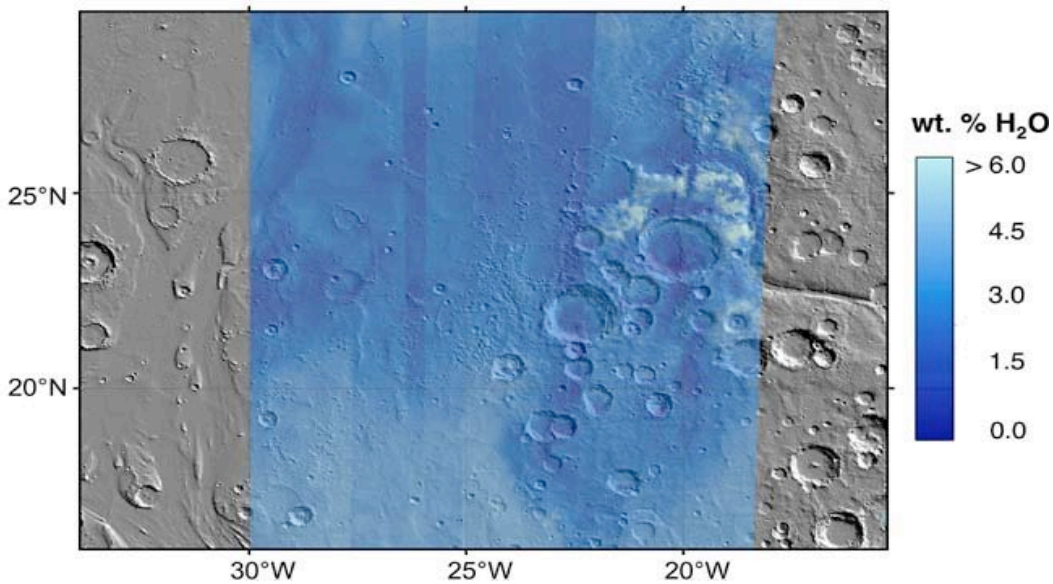

Figure 2. Map of estimated surface H_2O content overlain on MOLA topography for a region in Oxia Palus. Values are not normalized by albedo. The ancient terrain near the mouth of Mawrth Vallis has an increased water content (5-8 wt. %) relative to the surrounding region, which has an average water content of 1-3 wt. %. A clearly defined area of increased hydration is also visible in the lower part of the image. The resolution of this grid is 128 pixels per degree.