GENERATION OF UV RADIATION DATA AT GALE CRATER BY CORRECTING REMS UV MEASUREMENTS FROM DUST DEPOSITION AND SENSOR'S ANGULAR RESPONSE. G. M. Martínez[1], A. Vicente-Retortillo[1,2], N.O. Renno[1] and J. Gómez-Elvira[3], [1]University of Michigan, Ann Arbor, Michigan, USA (gemartin@umich.edu; nrenno@umich.edu), [2]Universidad Complutense de Madrid, Madrid, Spain (avicente-retortillo@gmail.com), [3]Centro de Astrobiologia, (CSIC-INTA), 28850 Madrid, Spain (gomezej@cab.inta-csic.es).

Introduction: The Rover Environmental Monitoring Station (REMS) onboard the Mars Science Laboratory (MSL) mission contains a UV sensor (UVS) that for the first time is measuring the UV radiation flux at the surface of Mars [1]. The UVS is comprised of six photodiodes to measure the UV flux in different bands of the spectral region 200-380 nm. The UVS has completed more than two Martian years of measurements at Gale Crater (4.6°S, 137.4°E), providing coverage ranging from diurnal to interannual time scales.

Degradation of the UVS due to dust deposition: Due to its location on the rover deck, the UVS has been exposed to dust deposition. Fig. 1 shows the UVS at the beginning of the mission (sol 36, left panel) and approximately two Martian years later (sol 1314, right panel).

Figure 1. MAHLI images of the REMS UVS on sols 36 (left) and 1314 (right).

Dust deposited on the UVS causes underestimation in measured UV fluxes and complicates the analyses of the seasonal and interannual evolution of UV radiation at the surface of Gale Crater. As an example, we show in Fig. 2 UVA fluxes (stored as ENVRDR products in the NASA PDS) measured on sols 76 and 745. Since Mastcam dust opacity values and Sun-Mars distance were roughly the same on both sols (τ = 0.78 and L_s ~ 193º), similar UVA levels are expected. However, UVA fluxes measured during the second Martian year of the mission (blue curve) are significantly lower than during the first year (red curve).

The angular response calibration function of the UVS: Discrepancies between measured and physically-consistent UV fluxes are found when the solar zenith angle (θ) relative to the rover frame is between 20º and 55º. In particular, high-level UVS fluxes in units of W/m^2 (ENVRDR products) present a non-physical discontinuity at θ = 30º caused by a discontinuity in the calibration function.

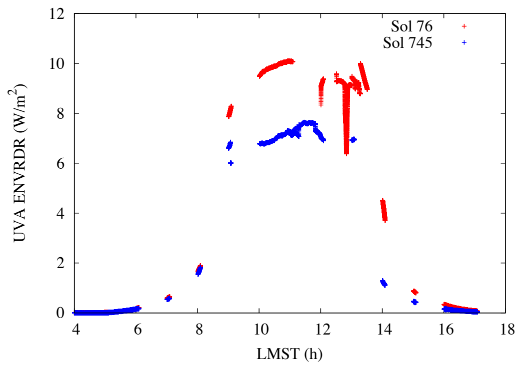

Figure 2. Diurnal evolution of UVA ENVRDR data on sols 76 and 745, separated by one Martian year and with roughly the same atmospheric opacity. Despite the fact that similar values of UV fluxes are expected, UVA fluxes on sol 745 are significantly lower because of the effects of dust deposited on the sensor.

The current angular response calibration function for the UVA channel is shown in the top panel of Fig. 3. As an example, high-level UVA fluxes on sol 91 obtained when this angular response calibration function is applied to the measured output currents (stored as lower-level TELRDR products in the NASA PDS) are shown in the bottom panel of Figure 3. The discontinuity in the UVA fluxes (red curve) at θ = 30º is caused by the discontinuity in the angular response calibration function. However, values of the photodiode output current (blue curve) show a consistent behavior when θ = 30º, and thus can be used in combination with empirical models of the sensor for the retrieval of aerosol properties [2,3].

The highest-level REMS UVS products, stored as MODRDR in the NASA PDS, are similar to the ENVRDR products (UV fluxes in units of W/m^2), but with values of UV fluxes removed when θ is between 20º and 55º and when the rover or its arm are moving. Measurements acquired when 20º < θ < 55º represent ~45% of the whole set of UVS data with θ < 90º. This is shown in Fig. 4, where the current ENVRDR data set is shown in red as a function of the sol number and Local Mean Solar Time (LMST), with missing MODRDR data when 20º < θ < 55º overlaid in gray.

Generation of corrected data: We have developed a methodology to obtain empirical calibration functions for each UVS channel that do not show discontinuities at θ = 30º. These functions are obtained using lower-level REMS UVS photodiode output currents (TELRDR products), the position of the Sun relative to the rover deck (contained in ADR products) and UV fluxes simulated with a radiative transfer model

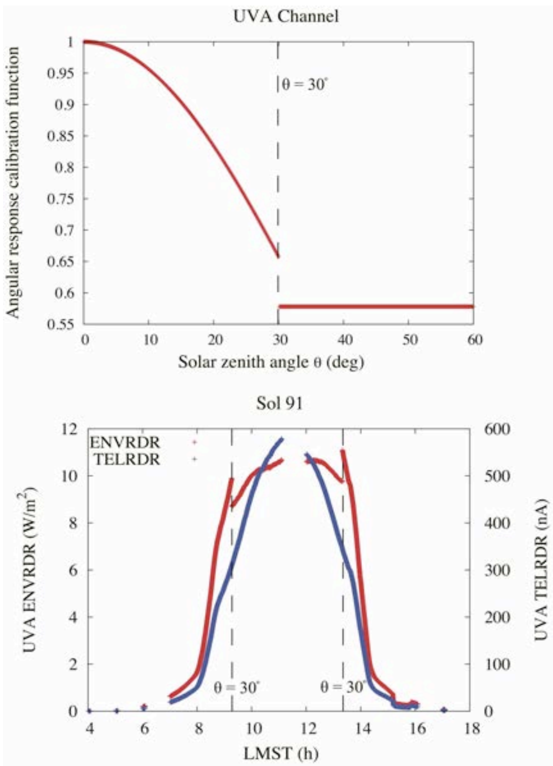

Figure 3. (Top): Current UVA angular response calibration function as a function of the solar zenith angle. A similar qualitative behavior is found for the other UVS channels, with a discontinuity at θ = 30º and a constant value beyond. (Bottom): Lower-level UVA output currents measured on sol 91 (blue curve) vary smoothly with solar zenith angle, but high-level UVA fluxes in units of W/m^2 (red curve) contain a discontinuity when θ = 30º.

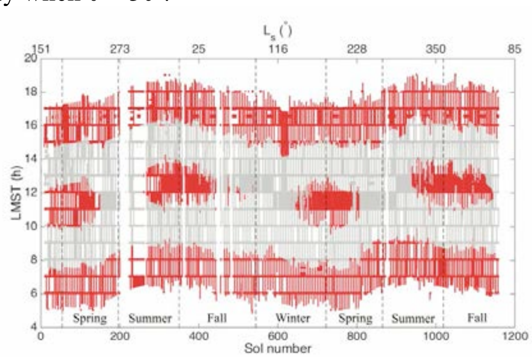

Figure 4. Temporal coverage of REMS UVS ENVRDR data shown in red, with missing MODRDR data (20º < θ < 55º) overlaid in gray.

that includes radiative properties calculated from refractive indices provided in [4]. We have also developed a methodology to correct UV fluxes from the effect of dust deposition by calculating a dust attenuation factor that depends only on the amount of dust deposited on the UVS and thus can be used to quantify this effect. This time-dependent parameter is estimated using TELRDR and ADR products in combination with UV fluxes calculated with the radiative transfer model COMIMART [5] fed with Mastcam opacities at 880 nm [3].

As an example of the performance of our methodology after correcting from the effects of dust deposition and applying empirically-obtained angular responses, Fig. 5 shows current and corrected high-level ENVRDR UVA fluxes on sol 730. The corrected values do not present discontinuities at θ = 30º and result in UVA fluxes around 60% larger than current values.

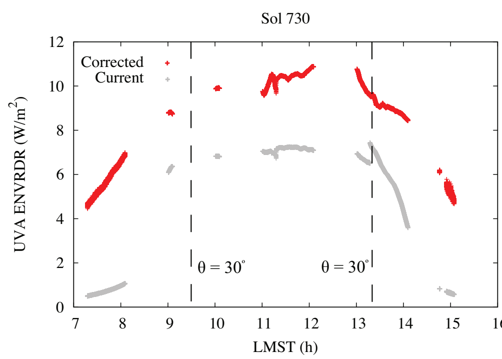

Figure 5. Corrected (red) and current (gray) UVA fluxes on sol 730. The red curve is obtained by correcting the gray curve from the effects of dust deposition and applying empirically-obtained angular responses.

Future work includes the analysis of TELRDR and ADR products in REMS UVS channels ABC, B, C, D and E to obtain physically-consistent empirical angular responses and functions that quantify the UVS degradation due to dust deposition. Data products generated by this study are important to analyze the apparent relationship between seasonal changes in UV radiation at Gale Crater and seasonal patterns discovered in the background methane concentration [6], and to compare the UV radiation environment at different locations in prepration for future missions.

References:

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