SPACE WEATHERING IN THE THERMAL INFRARED: LESSONS FROM LRO DIVINER. B. T. Greenhagen[1], P. G. Lucey[2], T. D. Glotch[3], J. A. Arnold[4], J. L. Bandfield[5], N. E. Bowles[4], K. L. Donaldson Hanna[4], P. O. Hayne[6], M. Lemelin[2], K. A. Shirley[3], E. Song[6], and D. A. Paige[7], [1]Johns Hopkins Applied Physics Laboratory, [2]University of Hawaii at Manoa, [3]Stony Brook University, [4]University of Oxford, [5]Space Science Institute, [6]Jet Propulsion Laboratory, [7]University of California, Los Angeles. Email: benjamin.greenhagen@jhuapl.edu

Introduction: Before the launch of the Lunar Reconnaissance Orbiter (LRO), it was suggested that thermal infrared spectroscopy would be a unique tool for lunar compositional remote sensing in part because evidence indicated this technique was less susceptible to the known optical effects of lunar surface exposure to space [1] than the more widely used visible and near-infrared wavelengths [e.g. 2, 3]. However, with global data from the LRO Diviner Lunar Radiometer (Diviner), it quickly became evident that the Christiansen Feature (CF; a mid-infrared compositional indicator) measured from the lunar surface was affected by space weathering [4, 5]. We will present and discuss hypotheses for the unanticipated space weathering dependence revealed by Diviner.

Observable thermal infrared spectroscopic space weathering effects are most likely caused by variations in the epiregolith thermal gradient due to differences in visible albedo and not composition or bulk thermophysical properties. Young features such as interiors, ejecta and ray deposits of the craters Tycho and Jackson show CF positions at systematically shorter wavelengths than their more space weathered surroundings, as do deposits of the other young rayed craters. Lunar swirls, commonly thought to form as a result of inhibition of the space weathering process, also show shorter CF positions than their surrounding terrains [6]. Diviner and ground-based telescopic data indicate that temperatures observed on- and off-swirl during nighttime and lunar eclipse are consistent with differences in albedo and not thermal inertia [6, 7].

In addition to characterizing and quantifying the degree to which space weathering affects the CF, this presentation presents techniques for the normalization of space weathering effects to enable examination of the underlying composition (Figure 1).

Datasets: We used calibrated radiances from Diviner's three 8 μm-region channels to calculate effective emissivity and then fit the three emissivity values with a parabola. The wavelength maximum of the parabola is the estimated CF wavelength [5]. Our data were "photometrically" corrected by projecting the data onto a topographic grid, calculating photometric geometry, and applying an empirical correction methodology [*after* 5]. Global Diviner data were binned at 32 pixels per degree to produce maps of CF values for latitudes below 60 degrees. We compare the CF to the Clementine-derived optical maturity (OMAT) parameter [8]. For specific regions of interest, Diviner data were binned at 128 pixels per degree and compared to OMAT derived from Kaguya Multiband Imager data.

Conclusions: Diviner CF data have a clear dependence on optical maturity owing to differences in visible albedo. While the near-IR derived OMAT parameter can be used to grossly correct the CF data for the space weathering effect, residual signals remain. Comparisons of CF and OMAT at highest resolution suggest that in the least weathered areas the two parameters diverge in their response to space weathering and the proposed correction is less effective in the lunar maria. Therefore it is likely that Diviner CF contains unique information regarding space weathering [9, 10].

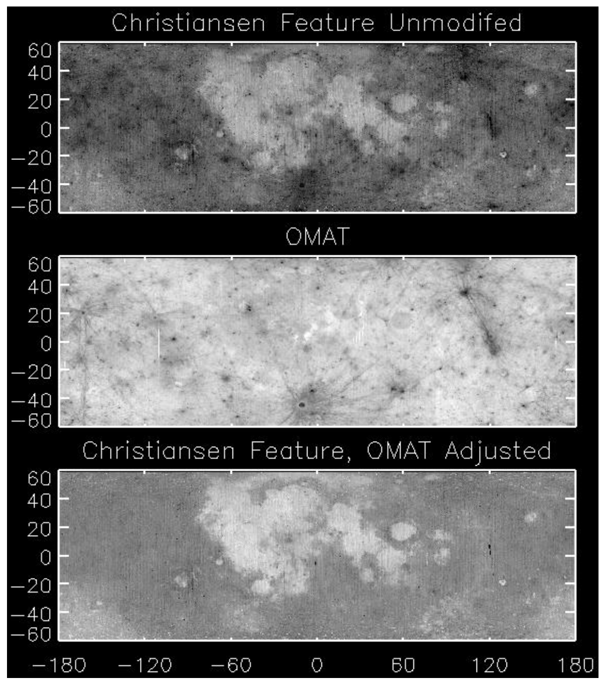

Figure 1. Demonstrating the use of OMAT to correct space weathering effects from Diviner CF data.

References: [1] Nash et al. (1993) *JGR*, *18*, 1151-1154, [2] Pieters et al. (2000) *MPS*, *35*, 1101-1107, [3] Hapke (2001) *JGR*, *106*, 10039-10073, [4] Lucey et al. (2010) *LPSC XLI*, #1600, [5] Greenhagen et al. (2010) *Science*, *329*, 1507, [6] Glotch et al. (2015) NatComm, *6*, 6189, [7] Hayne et al. (2015), *Lunar Planet. Sci. XLVI*, abstract 1997. [8] Lucey et al. (2000) *JGR*, *105*, 20377-20386. [9] Lawrence et al. (2015) *Icarus*, *255*, 127-134. [10] Cahill et al. (2015) *SWAB Workshop*, Abstract #2016.