TESTING LUNAR NEAR-INFRARED CORRECTIONS WITH DIVINER OBSERVATIONS.
C. J. Tai Udovicic1, J. L. Bandfield2, R. R. Ghent3, W. H. Farrand2, C. S. Edwards1 1Department of Physics and Astronomy, Northern Arizona University, Flagstaff, AZ (cjt347@nau.edu), 2Space Science Institute, Boulder, CO 3Planetary Science Institute, Tucson, AZ

Introduction: The nature of hydration on the lunar surface has been debated since independent measurements revealed a 3 μm absorption feature associated with hydroxyl and potentially water about a decade ago. Because of its high spatial and spectral resolution, Moon Mineralogy Mapper (M3) [1] has been used extensively to study the spatial and diurnal variability of this feature (e.g. [2-3]). The interpretation of the 3 μm feature has varied depending on the method used to correct for the thermal emission component of the near-infrared spectra [4-7]. We aim to develop an independent means of validating published M3 thermal corrections to determine which most accurately describes the emission at 3 μm.

The Diviner Lunar Radiometer has been in operation for a decade aboard the Lunar Reconnaissance Orbiter (LRO) and provides the best currently available characterization of the thermal environment of the lunar surface [8]. We present a methodology for using Diviner observations to test emission predicted by M3 thermal correction models. For this study, we investigate two such models, the Clark (2011) [4], and the Bandfield (2018) [7] models.

Methods: Because Diviner operates in the thermal infrared, it does not measure 3 μm emission outright. Instead, we compare the M3 model-predicted temperatures with the Diviner channel 4 brightness temperature (taken at 8.25 μm) for validation. Diviner channel 4 temperatures are used because they have the highest emissivity and are the closest approximation to the kinetic temperature of the lunar surface. All M3 data were acquired from the NASA Planetary Data System [9].

In order to compare temperatures recorded by independent spacecraft with up to 11 years between observations – Diviner currently active aboard LRO and M3 which ended its mission aboard Chandrayaan-1 in 2009 – we must account for differences in local time and solar distance for each observation of the target region. With hourly Diviner coverage, we can query temperatures collected within half an hour of the local time of each M3 observation. We must then account for the solar distance difference between the pair of observations, and slight local time residuals which can produce a large temperature difference due to steep lunar temperature gradients in the morning and afternoon.
To make this adjustment, we employ a thermal equilibrium model for the lunar surface which computes the expected temperature of a rough surface given the observation geometry [9]. We apply this model at the local solar incidences and solar distances when M³ and Diviner made their respective observations. We take the difference in these idealized equilibrium temperatures between the two observations and naively apply it as a constant mask over the Diviner temperatures. This adjusted Diviner brightness temperature is our best proxy for a concurrent temperature measurement for each M³ image.

For this initial study, we selected a region of interest (ROI) located on the NW Reiner Gamma swirl which had four different local time measurements in the M³ dataset (see Fig. 1). This ROI also provided a high degree of variability in albedo and slope angles across the scene, providing a rigorous first test of the thermal correction models. All M³ data were acquired from the NASA Planetary Data System (PDS) [10].

**Results:** The Bandfield (2018) model predicts higher 3 μm emission than the Clark (2011) across most of the target ROI at all local times (see Fig. 1). The opposite is true on steep slopes and crater interiors which is likely because the Bandfield (2018) model accounts for the slope geometry of the surface and there are challenges in georeferencing available high-resolution digital elevation maps to M³ imagery [11]. When compared to Diviner temperatures over the same region, the Bandfield (2018) model predicts temperatures within one standard deviation of the adjusted Diviner temperature regardless of local time. By contrast, the Clark (2011) model predicts temperatures consistently 5-20 degrees lower than Diviner temperatures (see Fig. 2). In addition, plots of the 3 μm slope over the temperature error show systematic deviations in the 3 μm slope in the Clark (2011) model, but little structure in the Bandfield (2018) model (see Fig. 3). The sensitivity of the 3 μm feature to temperature error appears to depend on the choice of thermal correction. We aim to quantify this sensitivity in future work as it may provide a good metric for understanding bias in the 3 μm range of thermally corrected M³ data.

**Conclusions:** We present a methodology to test thermal corrections of M³ near-infrared spectra using Diviner temperature observations. Initial results on just two of these models suggest that the Bandfield (2018) correction predicts temperatures in better agreement with Diviner temperatures than the Clark (2011) correction used to produce M³ level 2 data products on the NASA PDS [10]. We show that systematic deviations in model-predicted temperature can produce a biased interpretation of the 3 μm feature on the Moon. In future work, we will extend this methodology across a range of latitudes as well as incorporate other thermal corrections for comparison. Of particular interest are regions which have been cited as candidates for endogenic hydration, e.g. lunar pyroclastic deposits [12]. This work highlights the challenges associated with using lunar NIR data to interpret hydration and will benefit next-generation missions like Lunar TrailBLazer which will acquire lunar near-infrared and thermal infrared imagery simultaneously [13].

**Fig. 3:** The 3 μm band ratio (2.98 μm / 2.54 μm) over temperature error (model predicted temperature minus adjusted Diviner temperature) shows the sensitivity of the 3 μm feature to error in predicted local temperature. The Clark (2011) model shows positive correlation between temperature error and predicted 3 μm slope in all four local times. This structure is absent from the Bandfield (2018) model, which predicts a similar 3 μm slope regardless of temperature error.

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**References:**


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