LRO DIVINER NONLINEAR DETECTOR RESPONSE CORRECTION. S. Gyalay[1], M. Aye[2], D. A. Paige[1], [1]University of California, Los Angeles (szilard3@ucla.edu), [2]University of Colorado, Boulder

Introduction: Aboard the Lunar Reconnaissance Orbiter (LRO), the Diviner Lunar Radiometer Experiment measures thermal radiation to determine the brightness temperature of the lunar surface [1]. Some channels (particularly B3) exhibited unexpectedly high brightness temperatures close to the equator, as well as nonuniformity between detectors. We are investigating the extent to which these issues can be corrected by accounting for the nonlinear response in Diviner's detectors as measured during pre-flight radiometric calibration.

In-flight calibration. Diviner's routine two-point in-flight calibrations use space as a zero reference and the internal blackbody calibration target to calculate signal gain [1]. The zero reference is subtracted from the signal counts, and this difference is multiplied by the gain to determine the lunar surface's radiance, which is then referenced to brightness temperature.

Pre-flight radiometric calibration. Two external blackbodies were used to simulate space and the lunar surface during Diviner's laboratory radiometric calibration, with the former "fixed" blackbody held constant at about 90 K, and the latter "variable" blackbody varying in temperature from about 20 to 410 K. Diviner's internal blackbodies were held constant at about 289 K [1]. As the variable blackbody temperature was ramped up, the instrument scanned between the two external blackbodies and the internal blackbody multiple times [1]. Figure 1 shows this temperature ramp as seen by detector 11 of all Diviner's thermal channels.

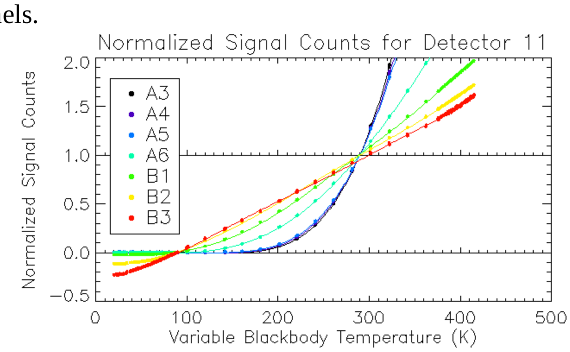

Figure 1: An example of signal counts as observed by detector 11 of each thermal channel at each temperature of the variable blackbody (data points), with a model of this data (line). The signal counts of the variable blackbody have been normalized by signal counts from the internal blackbody. Counts from both variable and internal blackbodies have been offset by signal counts from the fixed blackbody.

Determining Nonlinear Response: Figure 2 shows the nonlinear response for channel B3. The Mars Reconaissance Orbiter (MRO)'s Mars Climate Sounder (MCS) similarly applies a nonlinearity correction to its detected radiances [2].

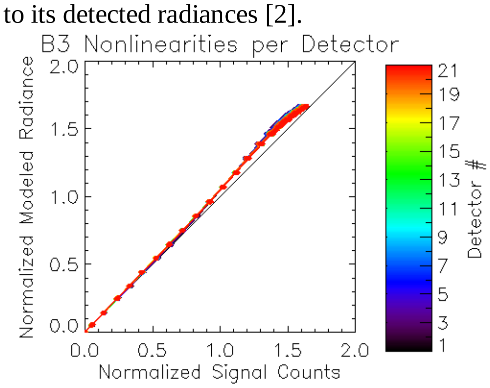

Figure 2: The nonlinear response of all Diviner's channel B3 detectors from lab calibration. Plotted is modeled radiance (derived from the temperature of the variable blackbody and normalized to 289 K) against measured signal counts (also normalized to 289 K). The line fits are polynomial functions that will take normalized detected radiance and return normalized corrected radiances, which can then be used to find a corrected brightness temperature.

Once the nonlinear response curves have been fit, Diviner's detected radiances can correct for this nonlinearity, and brightness temperatures can be corrected. However, this does not account for effects of relative emissivity of the variable blackbody to the internal blackbody.

Determining relative emissivity of variable blackbodies. We observed that when signal counts from the variable blackbody during pre-flight radiometric calibration are normalized by signal counts of the internal blackbody, the relative signal of the variable blackbody (at the temperature of the internal blackbody) to the internal blackbody is as low as 94% in some channels. We have not yet constrained the fraction of this signal reduction that is due to the relative emissivity of the variable blackbody to the internal blackbody or the fraction that is due to nonlinearity in the detection of radiance from these blackbodies. By finding the relative emissivity of the variable blackbody to the internal blackbody, we would be able to scale modeled radiance by this emissivity, to produce an accurate nonlinearity derivation. If we assume all of the signal reduction was due to a low relative emissivity, we can calculate this relative emissivity using a polynomial fit of variable blackbody temperature to normalized signal counts of this variable blackbody, and finding the normalized counts at the temperature of the internal blackbody. Scaling modeled radiance by this assumed relative emissivity produces Figure 3.

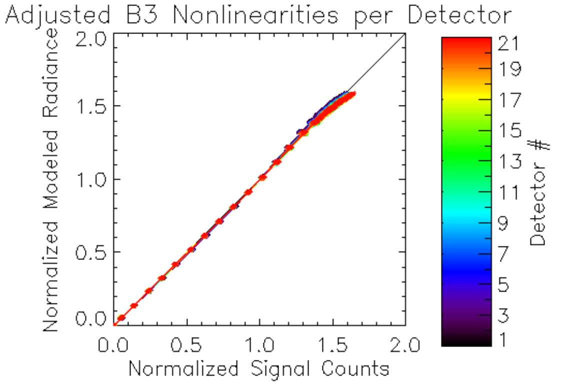

Figure 3: As with Figure 2, with the modeled radiances scaled by the variable blackbody's assumed relative emissivity to the internal blackbody per detector per channel.

Correcting Brightness Temperatures: Figure 4 demonstrates that by applying the nonlinearity correction to a series of radiances, we can find the change in temperature as determined by the original detected radiance, and as determined by the corrected radiance.

This change in temperature can be fitted for and then used to correct previously collected brightness temperature data collected by Diviner.

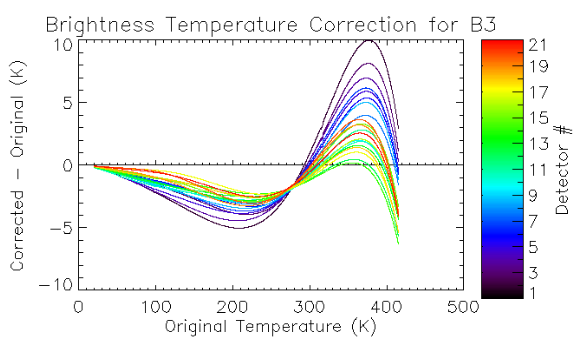

Figure 4: Difference between brightness temperature of corrected radiance, and brightness temperature of originally detected radiance, as a function of the original brightness temperature. Features the temperature adjustment for all detectors of Diviner's channel B3. Assumes the nonlinearity in Figure 3.

By applying the temperature changes seen in Figure 4 (which assume the relative emissivity discussed in the previous section), brightness temperatures measured on LRO orbit 12957 can be adjusted as seen in Figure 5.

Conclusions: While this correction partially reduces the extreme temperatures we see in the equator, these temperatures stay extreme. More accurately constraining the nonlinearity will further reduce these extremities. Accurately constraining the nonlinearity includes accurately deducing the relative emissivity of the variable blackbody to the internal blackbody for each detector of each channel. The temperature of the fixed blackbody (90 K) used to offset the measured and modeled radiances during pre-flight radiometric calibration further confounds constraint of the nonlinearity, as the radiance of this fixed blackbody is not insignificant as compared to the variable or internal blackbodies in the longer wavelength channels.

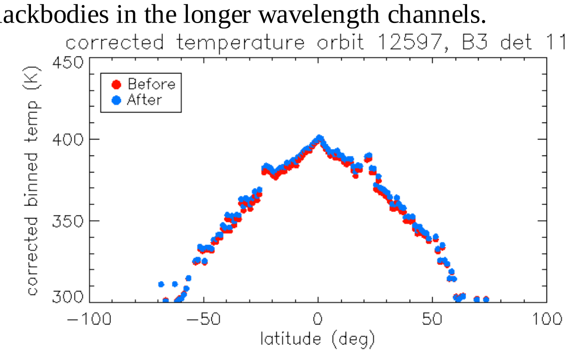

Figure 5: The relation between brightness temperature and lunar latitude, with temperatures averaged in latitude bins. Temperatures have been corrected as per Figure 4.

References: [1] Paige, D. A. et al. (2009) *Space Sci Rev 150*, 125-160. [2] McCleese, D. J. et al. (2005) *JGR 112*(E5S06), 1-16.