A NEAR-INFRARED (NIR) GLOBAL MULTISPECTRAL MAP OF THE MOON FROM CLEMENTINE. E.M. Eliason[1], E.M. Lee[1], T.L. Becker[1], L.A. Weller[1], C.E. Isbell[1], M.I. Staid[1], L.R. Gaddis[1], A. S. McEwen[2], M. S. Robinson[3], T. Duxbury[4], D. Steutel[5], D. T. Blewett[5], P.G. Lucey[5], [1]USGS, 2255 N. Gemini Drive, Flagstaff, AZ, [2]Lunar and Planetary Laboratory, Univ. Arizona, Tucson, AZ, [3]Northwestern Univ., Evanston, IL, [4]Jet Propulsion Laboratory, Pasadena, CA, [5]Univ. Hawaii, Honolulu, HI. (eeliason@usgs.gov).

Introduction: In May and June of 1994, the NASA/DoD Clementine Mission acquired global, 11-band, multispectral observations of the lunar surface using the ultraviolet-visible (UVVIS) and near-infrared (NIR) camera systems [1, 2]. The global 5-band UVVIS Digital Image Model (DIM) of the Moon at 100 m/pixel was released to the Planetary Data System (PDS) in 2000 [3]. The corresponding NIR DIM has been compiled by the U.S. Geological Survey for distribution to the lunar science community. The recently released NIR DIM has six spectral bands (1100, 1250, 1500, 2000, 2600, and 2780 nm) and is delivered in 996 quads at 100 m/pixel (303 pixels/degree). The NIR data were radiometrically corrected, geometrically controlled, and photometrically normalized to form seamless, uniformly illuminated mosaics of the lunar surface (**Figure 1**).

Radiometric Calibration: Radiometric calibration for the NIR data [4] provides correction for camera gain and offset operating modes, pixel dependent nonuniformity in bias, dark current rate, and responsivity, dark-current dependence on temperature, removal of thermal background contamination, and conversion to radiometric units. Two calibration issues specific to the NIR data were addressed in detail before processing could begin: 1) characterization of the instrument operating modes, and 2) characterization of the instrument thermal background changes during an orbital observation pass over the Moon.

Instrument Operating Modes. The objective was to determine an optimum set of calibration constants to minimize the difference between calibrated values for portions of the Moon imaged sequentially with different camera settings [5]. Statistics were acquired for all images collected during systematic mapping that straddled camera-state boundaries (~19,800 cases). The calibration equation from [4] was applied to the entire set of data, an error function was refined iteratively, calibration constants were updated, and the process was repeated until little change occurred in the error function. In this manner the gain, exposure duration, digital offset, offset multiplier, and global bias were simultaneously optimized.

Thermal Background. Instrument thermal background problems were first observed when the initial pre-launch calibration algorithms were not satisfactorily modeling the NIR deep-space observations during cool-down tests [4]. The objective was to characterize the thermal background changes during an orbital pass and to define a set of corrections for each orbit. To characterize these effects, the NIR 1100 nm data were compared to the highly correlated UVVIS 1000 nm data held as "truth". The UVVIS and NIR images were radiometrically corrected (with the thermal background remaining in the NIR imaging) and geometrically coregistered. UVVIS radiance values were scaled to the NIR data, and the averages of the UVVIS and NIR images in areas of overlap were computed for all color sets and plotted as a function of the cryocooler duration. A simple difference of the NIR and UVVIS bands (NIR/1100 band subtracted from the scaled UVVIS/1000 band) characterizes the change in thermal background in an orbit, and a 3rd order least-squares fit to the data is a valid model of time-dependent thermal background for each orbit.

Geometric Control: The 750-nm global map from the UVVIS mosaic provides the geometric control for the NIR multispectral DIM [6]. This base map underwent rigorous cartographic processing to tie the imaging to a lunar geodetic network resulting in an absolute positional accuracy of better than 0.5 km/pixel for 95% of the surface. The 6 NIR spectral bands are coregistered to a precision of a fractional pixel.

Photometric Normalization: The Clementine data have large changes in brightness because they were acquired under a broad range of viewing conditions, with phase, emission, and incidence angles varying from 0° to 90°. To create NIR mosaics with uniform scene brightness a photometric normalization procedure was applied [7] to the individual images before compiling the global mosaic.

Orbit-to-orbit Corrections: After these major issues were addressed, smaller corrections were applied to adjust for problems in the characterization of the camera modes and drift of the radiometric properties over the two month Clementine observation period. Such problem areas were identified in ratio images of each NIR channel and the UVVIS 750 nm band and were typically associated with ten-degree latitude strips where a specific set of camera settings were poorly characterized. Such areas were adjusted by computing an offset for each NIR band based on color differences between the frame being corrected and surrounding NIR images (**Figure 2**).

Apollo 16 Normalization: Apollo 16 soil measurements previously used to calibrate the UVVIS data [8] were convolved through the first four NIR filter transmission curves. The longest NIR wavelengths (2600 and 2780 nm bands) were not normalized to these soil measurements because reflectance information was not available at these wavelengths and may be complicated by the presence of thermal emission signatures. The values obtained from the soil spectra were then compared with the same Apollo 16 landing site location used to calibrate the UVVIS data [8] to obtain a reflectance normalization for the first four bands of the NIR data (1100 - 2000 nm).

References: [1] Nozette et al. (1994), Science, 266, 1835-1838. [2] McEwen and Robinson (1997), Adv. Space Res., 19, 1523-1527. [3] Eliason et al. (1999) Mission to the Moon, The Clementine UVVIS Global Mosaic, PDS CL_4001-4078. [4] Lucey et al. (1998), LPS XXIX, #1576. [5] Lucey et al. (2000), LPS XXXI, Abstract #1273. [6] Edwards et al. (1996), LPSC XXVII, 335-336. [7] McEwen, A., (1996), A Precise Lunar Photometric Function, LPSC XXVII, 841-842. [8] Pieters, C.M. et al, (1980). New Views of the Moon II LPI Contrib. 980

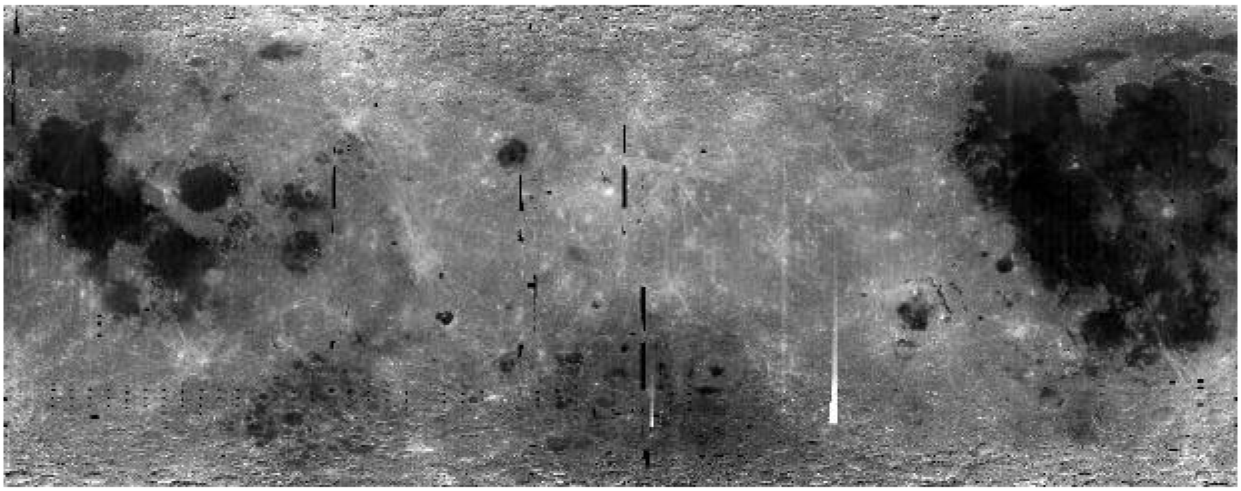

Figure 1. Global view of Earth's moon using the NIR 1100 nm band. The full resolution global multispectral map is made up of six spectral bands (1100, 1250, 1500, 2000, 2600, and 2780 nm) and is delivered in 966 quads at 100 m/pixel. The full resolution map has approximately 110,000 pixels in longitude and 55,000 pixels in latitude.

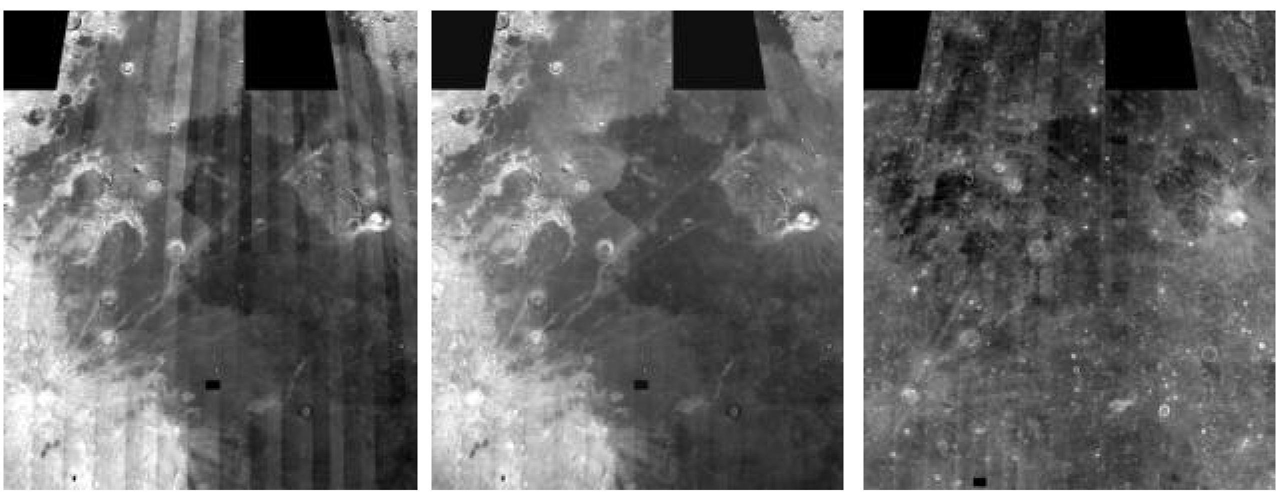

Figure 2. Before and after orbit-to-orbit corrections illustrated in an area over western Procellarum. The first image (left) is the 2800 nm band containing residual interorbit variations due to improper characterization of the camera modes and thermal background corrections. The second image (middle) shows the same scene with the interorbit corrections applied. The third image (right) shows the 1500/2000 nm ratio delineating compositional differences over the region.