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Lunar Reconnaissance Orbiter Wide Angle Camera Observations of the Moon

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Abstract

The multispectral wide-angle camera (WAC) is one of three instruments that comprise the Lunar Reconnaissance Orbiter Camera (LROC) (*1, 2*). Special in-flight observations were collected to improve calibration, and observations over a wide range of viewing and illumination conditions are used to produce photometrically normalized mosaics, including the first global observations of the Moon in the ultraviolet (UV), which will enhance our understanding of compositional variations on the lunar surface.

1. Introduction

The WAC is a push-frame imager with seven bandpass filters (*2*). Images are obtained through two UV filters at 321 and 360 nm with a cross-track field of view of 60°, and are 4×4 summed on-chip for a resolution of 380 m/pixel from a 50-km orbit. Five visible filters (415, 566, 604, 643 and 689 nm) are imaged with separate optics (90° FOV) and a nadir resolution of 75 m/pixel from a 50-km orbit. In color mode, all filters are exposed simultaneously and 14 lines by 704 samples of each visible filter and 16 lines by 512 samples (summed to 4 lines by 128 samples) of each UV filter are read out. Continuous coverage is obtained by imaging at regular intervals consistent with the spacecraft's motion. The WAC can also be operated in a monochrome mode in which 14 lines by 1024 samples are read out from only one filter. This mode is used primarily within 10° latitude of each pole. Color observations are consistently acquired at latitudes lower than 80° north and south so that the WAC provides global imaging coverage every 28 days. The spacecraft transitions between β = 90° (terminator orbit) and β = 0° (high noon) over a period of three months, resulting in a large range of illumination conditions at the equator. The wide field of view of the camera also means that within a single observation, phase angles can vary by up to ±35° cross-track, and the angular offset between filters results in non-uniform viewing geometries between filters.

2. Calibration

The in-flight calibration has been performed using a series of specialized observations. The dark correction is achieved by collecting nighttime observations at different offset levels, temperatures, and integration times. To correct for pixel sensitivity nonuniformity, the spacecraft was rotated 90° and an observation encompassing ±8° of the photometric equator was collected. The spacecraft rotation ensured that each sample of the push-frame imager observed the same terrain (highlands centered at 1.3° N, 232.2° E). This observation was then corrected for offset using a nighttime observation collected at the same temperature, and photometrically normalized using a WAC-derived photometric function for the highlands (see Section 3). The mean value at each pixel was recorded after a threshold cutoff of one standard deviation was applied (this left ~450 observations at each pixel). Absolute reflectance is obtained via comparison of WAC to ROLO (*3*) observations of the Moon.

3. Photometric Model

An empirical photometric function is used to characterize the varying illumination conditions. The radiance factor (I/F) is described by

$$\frac{I}{F} = \frac{\mu_0}{\mu + \mu_0} f(\alpha) \quad (1)$$

where the dependence on incidence and emission angles are assumed to be fully accounted for by the Lommel-Seeliger factor (*4*). The dependence on phase angle α is described by a second-order exponential function:

$$f(\alpha) = a_0 \exp(b_1\alpha) + a_1 \exp(b_2\alpha) + a_3 \quad (2)$$

where a_n and b_n are wavelength dependent. This function provides a good fit to the data (Fig. 1).

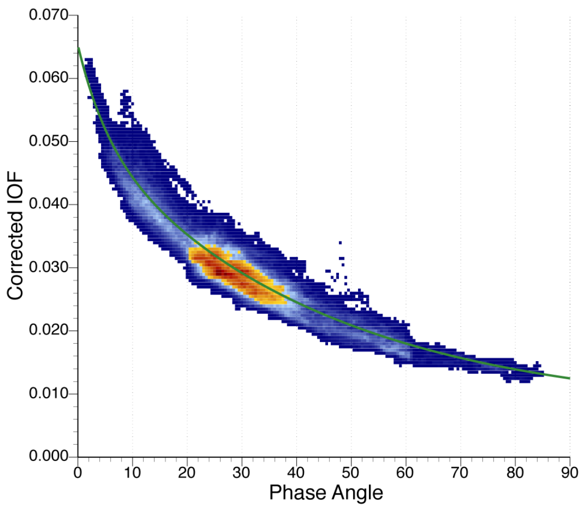

Fig. 1. Example phase curve for the 321 nm filter. IOF has been divided by the Lommel-Seeliger factor ("Corrected IOF"). Data are for Mare Crisium; green line shows the empirical fit (equation 2).

4. Discussion

The WAC provides a rich dataset for photometry as well as compositional studies. Continued improvements to the nonuniformity and offset corrections, as well as refinements to the photometric normalization enable production of high quality color mosaics (e.g., Fig. 2). Preliminary results demonstrate that UV observations help discriminate among subtle mare units and enable improved estimates of composition, especially titanium content.

References

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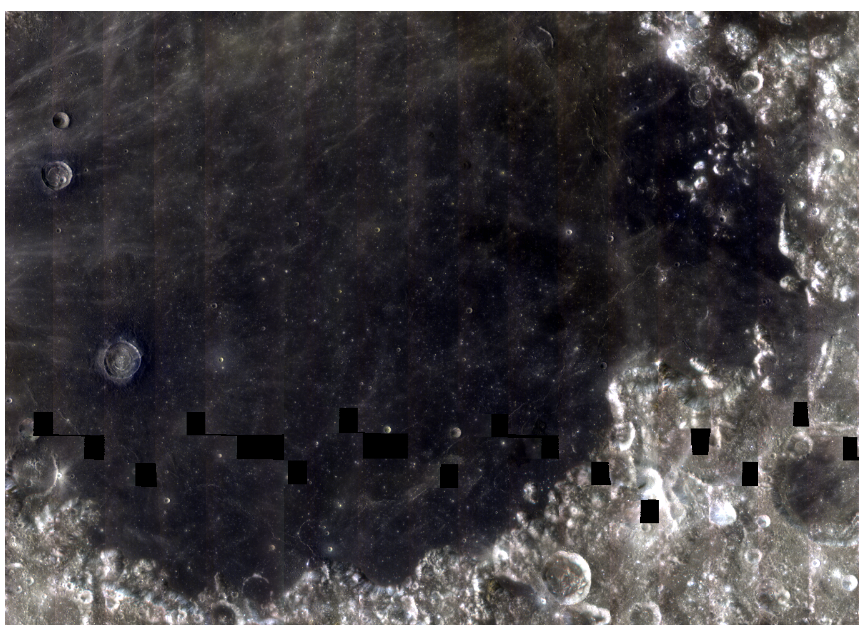

Fig. 2. WAC color mosaic of a portion of Mare Crisium, photometrically corrected with the empirical method described above. The 689, 566, and 321 nm filters are displayed in red, green, and blue, respectively.