COMPARISONS OF IMPACT PLUME DETECTIONS IN PUBLICLY ARCHIVED LCROSS TIME SERIES OBSERVATIONS. Jonathan M. Schotte[1], Ruth L. Temme[1], Paul D. Strycker[1], Nancy J. Chanover[2], [1]Concordia University Wisconsin, Mequon, WI, USA, [2]New Mexico State University, Las Cruces, NM, USA.

Introduction: In 2009, NASA conducted the Lunar Crater Observation and Sensing Satellite (LCROSS) mission in which a kinetic impactor was directed into Cabeus Crater [1, 2]. In order to observe ejecta from earth's vantage point, various teams conducted observing campaigns at multiple facilities including Apache Point Observatory (APO), Magdalena Ridge Observatory (MRO), and Fred Lawrence Whipple Multiple Mirror Telescope Observatory (MMT). These locations, discussed in this work, recorded one or more time series of images and archived them in the Planetary Data System. None of the raw images taken showed any signs of an ejecta plume, however, detections have been made via principal component analysis (PCA) filtering in the data from APO and MRO [3, 4]. In this work, we apply PCA filtering to data acquired at MMT with the goal of detecting an ejecta plume here as well. Here we also compare plume signal-to-noise ratios obtained by each camera in order to develop an understanding for why we find detection versus non-detection and differing detection strengths.

Data and Data Reduction: The APO 3.5-m telescope was equipped with neutral density filter and a Johnson-Cousins R filter. Data was recorded with Agile, a frame-transfer CCD. The Agile camera recorded the impact with an exposure time of 0.5 seconds with no latency time between exposures. MRO is a 2.4-m telescope that was equipped with two CCD cameras, GJON and DOC, that used high-speed frame-transfer. The GJON and DOC cameras' exposure time was 0.032 seconds with a gap between exposures of 0.002 seconds. The MRO telescope was fitted with an ultraviolet bandpass (Bessel U) filter as well as a beam splitter where the blue channel was outputted to GJON and the red channel to DOC. MMT is a 6.5-m telescope that was equipped with a high-speed frame-transfer camera named CCD47. The telescope employed a neutral density filter and a broadband filter centered at 700 nm. The images were taken with an exposure time of 0.071 seconds with a gap between exposures of 0.008 seconds. MMT's f/15 adaptive optics were utilized during the LCROSS impact.

Although APO data was previously characterized [3], the field of view originally used was too small to isolate principal components (PCs) containing image stretching and warping. We re-reduced APO data here both with a field of view approximately 8 times larger and using our new procedure for the MRO data [4] to better compare among data sets. The MMT data have never undergone any detailed analysis, and we present the preliminary results using this procedure here.

Before the MMT co-registration could be successfully executed, a flat-field had to be constructed to eliminate a discontinuity in pixel sensitivity between the left and right halves of raw images. Left-right pairs of pixels along the discontinuity line were assumed to have the same photon flux, and the fractional count difference between them was averaged over all raw images. On a row-by-row basis, the left half of the image was then rescaled to match the brightness of the right half.

Detection Methodology and Comparisons: All four data sets had PCA filtering applied to them which removed effects – though not to the full extent – that included aspects of atmospheric blurring, warping, and stretching. We experimented with the number of PCs removed in order to obtain the best signal-to-noise of the ejecta plume for each data set. The number varied among data sets. The method used was a cumulative, sequential elimination of the PCs, which was as follows: {1}, {1, 2}, {1, 2, 3}, ⋯ . Each PCA filtering resulting from this sequence had the average image count values from 15 to 33 seconds after impact compared with the standard deviation of counts during non-impact times.

A specific area in MRO data with a strong plume detection was chosen as the location to consistently compare the signal-to-noise of the plume among all data sets. We also compared count values of locations in the dark area of the crater and the bright foreground outside of the crater to analyze the amount of scattered light and the dynamic range for each time series. We present a method to explore both detection of the plume and removal of unwanted lunar signal through the sequential removal of PCs.

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