Digging Deeper: Further analysis and modelling of the LCROSS debris plume. K. M. Luchsinger[1], N. J. Chanover[1], P. D. Strycker[2], [1]Department of Astronomy, New Mexico State University, Las Cruces, NM, USA, [2]Concordia University Wisconsin, Mequon, WI, USA.

Introduction: The Lunar Crater Observation and Sensing Satellite (LCROSS) mission produced a debris plume by impacting the second stage of the rocket used by the mission into the Cabeus crater, a permanently shadowed crater near the lunar south pole. The detection of this debris plume using the Astrophysical Research Consortium 3.5 m telescope at Apache Point Observatory (APO) was the first ever ground-based detection of an impact plume [1]. This detection was possible only after principal component analysis (PCA) techniques were applied to the data, as initial analysis was not able to detect the plume [1][2]. Modeling of the detected plume enabled Strycker et al. [1] to place constraints on the mass and shape of the plume, allowing for more accurate determination of the mass of water vapor ejected from the crater. The initial modeling effort [1] did not explore a wide range of parameter space, such as variable particle radius and albedo of the plume ejecta. However, initial modeling did indicate the potential presence of depth variation of either particle radius or albedo in the detected plume, due to an absence of detected particles ejected at velocities past a cut off point. This velocity cut off corresponds to a depth cut off, and could be caused by stratification of the lunar sediment. In this work, we expand upon the previous modeling work to include information about the particles, specifically particle radii and albedos as a function of depth.

Improved Model: We developed a new N-body simulation code that reduces the running time and gives us more control over the details of the particles and plume shape. The code assigns both radius and albedo to the particles individually, which allows us to explore different distributions of these variables. A step-function distribution of radius or albedo as a function of depth was suggested by the results of the previous modeling work [1], but we will additionally use the conditions in the lunar crater to inform our selection of possible distributions. We initially selected to explore step-function distributions of radii and albedos as a function of depth; Gaussian distributions, both as a function of depth and independent of depth; and distributions of radius and albedo correlating to the materials we expect to see in a lunar sediment located in a permanently shadowed crater. These three distributions were selected to best reflect the possible conditions in the model domain while exploring a significant portion of the available parameter space.

Comparison to Data: Our plume modeling code produces the light curve that the simulated plume would have produced as seen by the APO Agile camera, the same set up as was used to detect the light curve of the plume [1]. We introduce to our modeled light curve the noise and background seen by the Agile camera prior to the impact, and use the same PCA analysis to extract our modeled light curve as was used to extract the real plume light curve. We then compare the modeled light curve to the real, detected LCROSS light curve to determine the best possible fit to the data. We present initial results of this modeling and comparison, with a preliminary exploration of structure and composition of the ejecta plume.

This work was supported by NASA's Lunar Data Analysis Program through grant number NNX15AP92G.

References: [1] Strycker, P. D. *et al.* (2013) *Nat. Commun*., 4:2620, doi:10.1038/ncomms3620. [2] Chanover, N. J. *et al.* (2011) *J. Geophys. Res. (Planets)* 116, E08003.