INFLUENCE OF METEOROID STREAMS ON THE LUNAR ENVIRONMENT: RESULTS FROM LADEE.  T. J. Stubbs1, D. A. Glenar2,1, Y. Wang2,1, M. Sarantos2,1, A. Colaprete3, D. H. Wooden1, M. Benna2,1, A. M. Cook4, B. Hermalyn2, D. M. Hurley3, and R. C. Elphic1, 1NASA Goddard Space Flight Center, Greenbelt, MD 20771, 2University of Maryland, Baltimore County, Baltimore, MD 21250, 3NASA Ames Research Center, Moffett Field, CA 94035, 4Millenium Engineering and Integration Company, Moffett Field, CA 94035, 5The Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723. (Timothy.J.Stubbs@NASA.gov)

Introduction: The scientific objectives of the Lunar Atmosphere and Dust Environment Explorer (LADEE) mission are: (1) determine the composition of the lunar atmosphere, investigate processes controlling distribution and variability – sources, sinks, and surface interactions; and (2) characterize the lunar exospheric dust environment, measure spatial and temporal variability, and influences on the lunar atmosphere [1]. Impacts on the lunar surface from meteoroid streams encountered by the Earth-Moon system result in enhancements in the both the lunar atmosphere and dust environment [2–9]. Using the IAU list of established meteor showers [10,11], we predict the incident mass flux of meteoroids from streams incident at the Moon and the associated ejecta production rates [12,13]. We discuss some of the evidence for exospheric enhancements related to meteoroid stream encounters with the Moon and compare with the predicted ejecta production rates.

LADEE Mission Overview: The LADEE science payload consists of three instruments: the Ultraviolet/Visible Spectrometer (UVS) for measuring emission lines from exospheric species and scattered light from exospheric dust [14]; the Neutral Mass Spectrometer (NMS) for in situ measurement of exospheric species [15]; and the Lunar Dust Experiment (LDEX) for in situ measurement of exospheric dust [16]. LADEE nominally had a 100-day science mission in which its retrograde equatorial orbit (inclination ≈ 157°) took it below 50 km altitude at periapsis near lunar sunrise. Lunar Orbit Insertion (LOI) occurred on 6 October 2013 and the End-of-Mission (EOM) occurred on 18 April 2014 with lunar impact.

Meteoroid Streams: The Earth-Moon system frequently encounters debris trails from short- and long-period comets, as well as asteroids, which are referred to as meteoroid streams [17,18]. The meteoroids in these streams have similar velocities and are on near-parallel trajectories, such that when they enter the Earth’s atmosphere the resulting shower of meteors (or shooting stars) appears to be emanating from a virtual point on the sky called the radiant. Meteor (and meteoroid) rates vary as a function of the Earth’s position in its orbit, with an activity curve that increases to a peak and then decreases. Annual streams are those that regularly encounter the Earth each year. The 18 IAU established annual streams that encountered the Moon during the LADEE mission are listed in ref. [11]. These streams are relatively well characterized and are broad enough that it is reasonable to assume that both the Earth and Moon will pass through them.

In the IAU list the established showers are characterized by a few key parameters, including: the zenithal hourly rate (ZHR), which is the hourly rate of meteors seen by standard observer on the Earth under optimum viewing conditions; the magnitude distribution index, which describes the range of meteor brightnesses; and the stream velocity relative the Earth. Using the methods described in refs. [17,18] we use these shower parameters to determine the meteoroid mass fluxes at the Earth as a function of time. By accounting for the effects of gravitational focusing and the different impact velocities, we can then estimate the mass flux incident at the Moon in units of kg/hr (integrated over the target cross-section of the Moon). Using the formula from ref. [12] we then estimate the total ejecta production rates, and similarly use the formulas from ref. [13] to estimate melt and vapor production rates.

Results from LADEE: Possible evidence for enhancements in the lunar exosphere was detected by all three instruments aboard LADEE. UVS observed an enhancement in exospheric sodium coincident with individual meteoroid streams, as well as a possible long-term trend due to the cumulative effect of sodium produced by meteoroid impacts [3]. LDEX observed an increased concentrations in the ejecta cloud coincident with at least six meteoroid streams [7]. From NMS measurements, there also appears to be a possible relationship between meteoroid streams and H2O detected in the lunar exosphere [6].