OBSERVATIONS OF METEOROIDAL WATER IN THE LUNAR EXOSPHERE BY THE LADEE NMS INSTRUMENT. M. Benna[1] , D. M. Hurley[2], T. J. Stubbs[1], P. R. Mahaffy[1], and R. C. Elphic[3], [1]Solar System Exploration division, NASA's Goddard Space Flight Center, Greenbelt, MD 20771, USA (mehdi.benna@nasa.gov), [2]The Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723, USA, [3]Planetary Systems Branch, NASA Ames Research Center, Moffett Field, CA 94035, USA.

Introduction: The Neutral Mass Spectrometer (NMS) of the Lunar Atmosphere and Dust Environment Explorer (LADEE) Mission was designed to measure the composition and variability of the tenuous lunar atmosphere [1]. The NMS (Figure 1) complements two other instruments on the LADEE spacecraft designed to secure spectroscopic measurements of lunar composition and in situ measurement of lunar dust over the course of a seven-months mission in order to sample multiple lunation periods [2]. The NMS instrument utilizes a dual ion source designed to measure both surface reactive and inert species and a quadrupole analyzer. Instrument activities were designed and scheduled to provide time resolved measurements of Helium and Argon, but to also determine the abundance or upper limits for many other species either sputtered or thermally evolved from the lunar surface; water being one of these species.

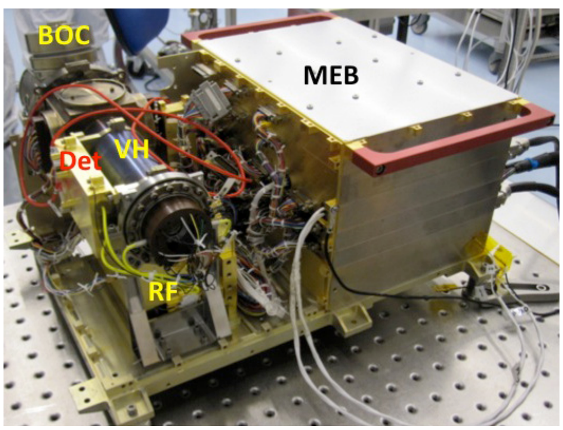

Figure 1. The NMS instrument during integration and testing. Labels identify the main electronics box (MEB), the break off cap (BOC), the vacuum housing (VH), the radio frequency (RF) electronics, and the detector (Det) electronics.

Observations of Exospheric Water: During its seven months in orbit, the NMS instrument has detected signatures of water group neutrals (H_2O and/or OH) in the exosphere of the Moon. The signature of water has been measured as sporadic, short-lived signal increases above instrument background (spikes) (Figure 2). Shortly after the first few detections, a systematic measurement campaign with a cadence of a few hours over four main lunar local time sectors (sunrise, midnight, sunset, and noon) was put in place and continued to the end of the mission.

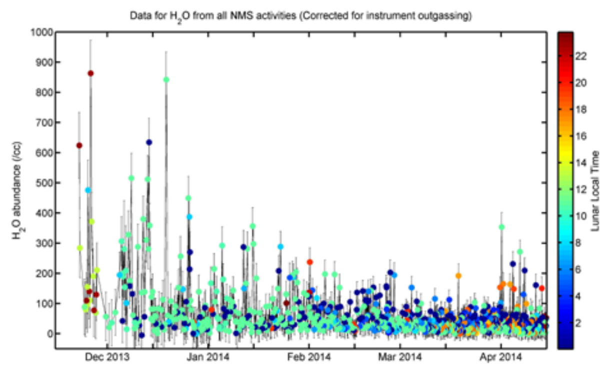

Figure 2. NMS observations of sporadic signatures of water group neutrals suring the course of the LADEE mission. Observations occurred at various local times and spacecraft altitudes.

Initial data analysis revealed that the occurrence rate of the high signal water "spikes" (corresponding to desnities of several hundred per cc) is correleated with periods of major annual meteoroid streams [3]. Moreover, the daily water detection rate is in agreement with the expected evolution of the incoming meteoroidal impact flux at the Moon.

Monte Carlo modeling of the evolution of vaporized water was conducted to constrain the evolution of the impact vapor as a function of time after the impact and distance from the impact site. The model [4] also provides the velocity of the water molecules, enabling comparison with NMS's field of view. Assuming the initial velocity of each water molecules is distributed according to a Maxwell-Boltzmann distribution at T=3000 K, the results indicate that the water signatures detected by the NMS instrument are due to impacts that occurred near the location of the spacecraft within a one hour window from time of detection (Figure 3). The density of water at LADEE altitude is consistent with water releases from impactors with mass, $m \geq 0.1$ kg.

References: [1] Elphic et al. (2014) *Space Sci. Rev.*, 185 3–25. [2] Mahaffy et al (2014) *Space Sci.*

Rev., 185 27–61. [3] Stubbs et al (2015) LPI 46, Abstract #2986. [4] Hurley (2011) *J. Geophys. Res. 116*, E10007.

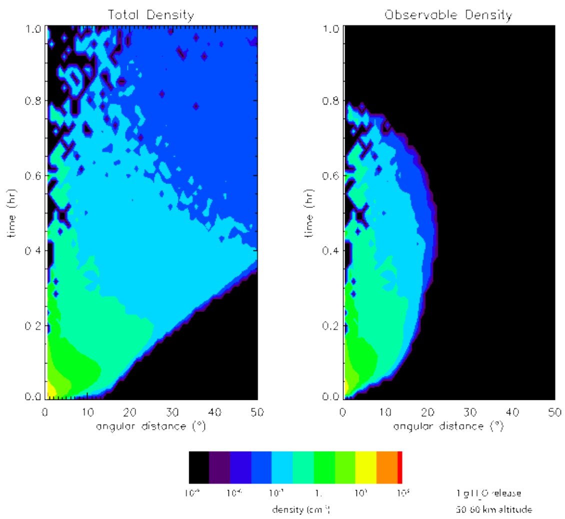

Figure 3. Simulated evolution of water vapor from a meteoroid impact as a function of time and angular distance from the impact site. The left panel shows the density at 50 km altitude for a 1 g water release. The right panel shows the density observable by NMS after factoring in the field of view of the instrument.