ARTEMIS OBSERVATIONS OF THE SPACE ENVIRONMENT AROUND THE MOON AND ITS INTERACTION WITH THE ATMOSPHERE AND SURFACE. J. S. Halekas[1] and the ARTEMIS Team, [1]Department of Physics and Astronomy, University of Iowa, jasper-halekas@uiowa.edu.

Introduction: The two ARTEMIS probes continue their successful extended mission around the Moon, studying the interaction of terrestrial and solar plasma with the lunar environment. ARTEMIS provides continuous monitoring of the incoming plasma, including protons and doubly ionized helium in the solar wind, and magnetospheric plasma during the Moon's passage through the geomagnetic tail.

The Moon is a heavily driven system, almost completely exposed to the influence of the space environment. As a result, the lunar atmosphere and surface respond to plasma inputs. In turn, the secondary particles produced from the surface and atmosphere affect the plasma environment around the Moon. ARTEMIS observes both the plasma drivers of the lunar system, and the perturbations that the Moon induces in the interplanetary environment.

ARTEMIS and LADEE: ARTEMIS observations are critical to developing a complete understanding of the dynamics of the complex neutral exosphere revealed by LADEE. ARTEMIS provides key observations of both sources and sinks of the neutral exosphere observed by LADEE. The highly variable plasma influx directly supplies some species to the lunar exosphere, most notably helium. The flowing plasma also liberates other exospheric species from the surface through charged particle sputtering. Finally, the plasma acts as the final sink for a large proportion of the exosphere, by picking up ionized constituents and sweeping them away from the Moon. ARTEMIS observes both the influx of protons and helium to the Moon. In addition, it observes the convection electric field of the plasma, which determines whether newly born pickup ions escape, or re-impact the surface. And, finally, when properly situated, ARTEMIS observes the escaping pickup ions themselves.

ARTEMIS Low-Altitude Measurements: The incoming plasma measured by ARTEMIS also contributes to space weathering of the surface. Lunar magnetic fields, though small in scale and comparatively weak, have surprisingly significant effects on the incoming plasma, and a number of observations suggest that their presence may locally alter the space weathering of the surface. Recent data from Kaguya and Chandrayaan have shown that lunar magnetic anomalies efficiently reflect incoming solar wind protons, providing substantial shielding of portions of the crust, with potential implications for both space weathering and surface sputtering.

The two ARTEMIS probes have made a number of low-altitude (tens of kilometers) passes over regions with moderately strong crustal magnetic fields, at local times both near the sub-solar point and at the terminator. Several such passes occurred over a region of the surface containing unusual albedo markings - or "swirls" - that could indicate a local reduction in space weathering. Fig. 2 shows observations from one such pass, demonstrating the highly distorted magnetic fields encountered near periapsis, and reflected protons emanating from a strong crustal magnetic field region. During this observation, >30% of the solar wind reflected before reaching the surface, with possibly much

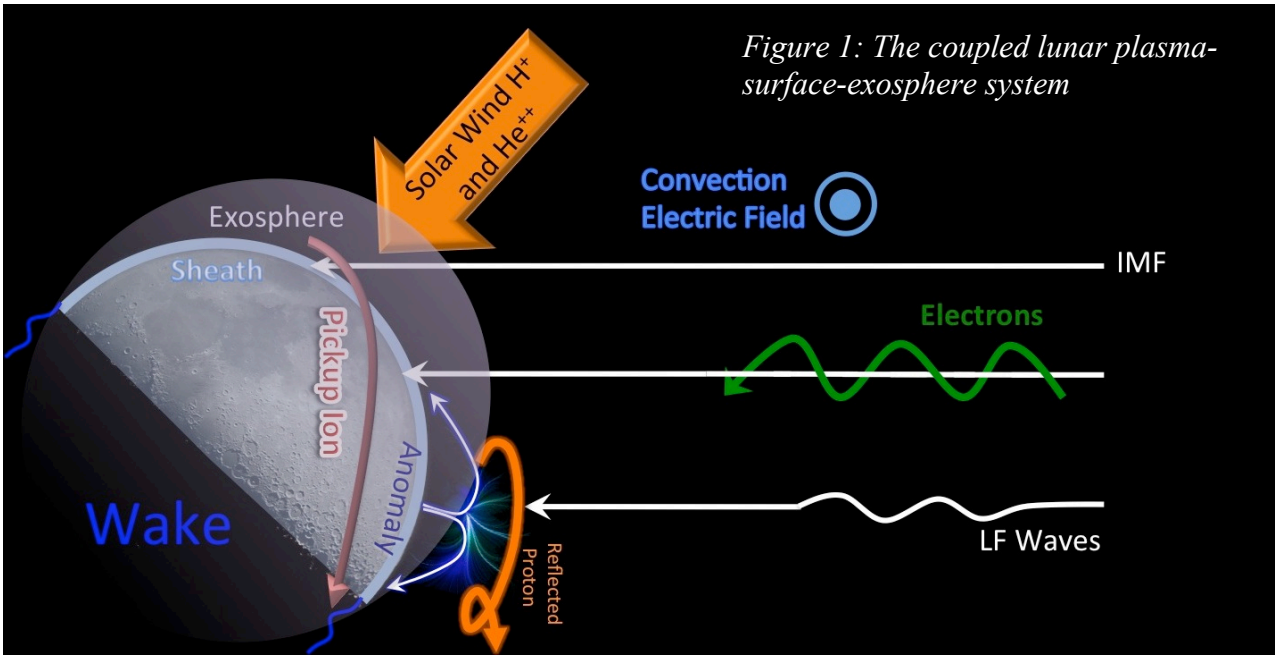

Figure 1: The coupled lunar plasma-surface-exosphere system

higher reflection percentages in localized regions.

We investigate the ARTEMIS low-altitude passes in detail, focusing on how the observed reflected protons and other local modifications of charged particle distributions and electromagnetic fields relate to the properties of the surface. ARTEMIS observations cast new light on the physics of the plasma-magnetic field interaction, with implications for both the surface and the exosphere.

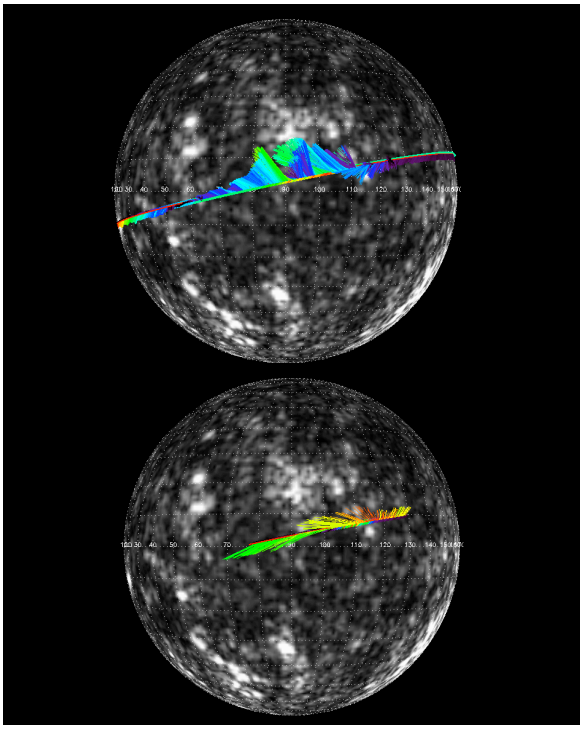

Figure 2: Magnetic field vectors (top) and reflected proton velocities (bottom) observed by ARTEMIS near periapsis.

ARTEMIS Observations of Moon-Related Perturbations to the Ambient Environment: As the ambient plasma affects the Moon, it in turn affects the plasma environment. Recent observations from ARTEMIS demonstrate the numerous ways in which this can occur. Not surprisingly, the Moon blocks the plasma flow, resulting in a downstream wake which can extend to tens or even hundreds of thousands of kilometers. However, the presence of the Moon also generates perturbations that can extend thousands and sometimes even tens of thousands of kilometers upstream from the dayside surface. Reflected protons from the surface and crustal magnetic field regions can travel well upstream from the Moon for some magnetic field geometries, generating large-scale perturbations to the interplanetary environment. Electrons, meanwhile, can travel upstream even more easily, and generate more subtle perturbations. Finally, in some situations, even the pickup ions from the lunar atmosphere represent a significant enough impulse to drive observable perturbations in the ambient plasma.

Conclusions: The present day represents a golden age for the study of Moon-plasma interactions. With measurements from a flotilla of international probes, and the recent collaborative efforts between LADEE, LRO, and the ARTEMIS probes, we are learning more than ever before about the coupled lunar plasma-surface-exosphere system.