INVESTIGATION OF MAGNETIC FIELDS ASSOCIATED WITH VARIOUS LUNAR SWIRLS OBSERVED IN THE FAR-ULTRAVIOLET

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Abstract

To explore a possible relationship between low FUV albedo swirl signatures and magnetic anomalies on the Moon, we are examining the modeled at-surface total field and vector components of select anomalies with respect to observations in the ultraviolet. UV wavelengths are extremely sensitive to space weathering and could indicate the presence of uneven weathering even at weak magnetic anomalies. Preliminary results are in agreement with previous work suggesting that swirls may be due to lessened weathering from solar wind deflection by their associated magnetic anomalies, as swirl regions with lower FUV values correlate with at-surface magnetic fields that are potentially capable of standing off some degree of solar wind. However, not all anomalies have magnetic field geometry that support this theory, implying other processes may be at play to create swirl-like morphology in these regions.

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Introduction

The present Moon lacks a global, internally generated magnetic field, but the lunar crust contains areas of magnetized rocks often referred to as "magnetic anomalies" (Hood 1980). These anomalies are frequently correlated with lunar swirls, unusual sinuous markings with atypical reflectance compared to their surroundings (Schultz 1980, Blewett 2011, Denevi 2016, Cahill 2019).

Several hypotheses for the origin of the swirls have been proposed such as: a) magnetic anomaly fields shielding the surface from weathering processes (Hood 1980), b) cometary gas and dust (Schultz 1980, Syal 2015, Pinet 2000) or meteoroid swarm (Starukhina 2004) scouring the uppermost regolith, or c) electromagnetic fields affecting levitated, charged dust particles (Garrick-Bethell 2011, Pieters 2014). Here we focus on the solar wind deflection model.

Objectives

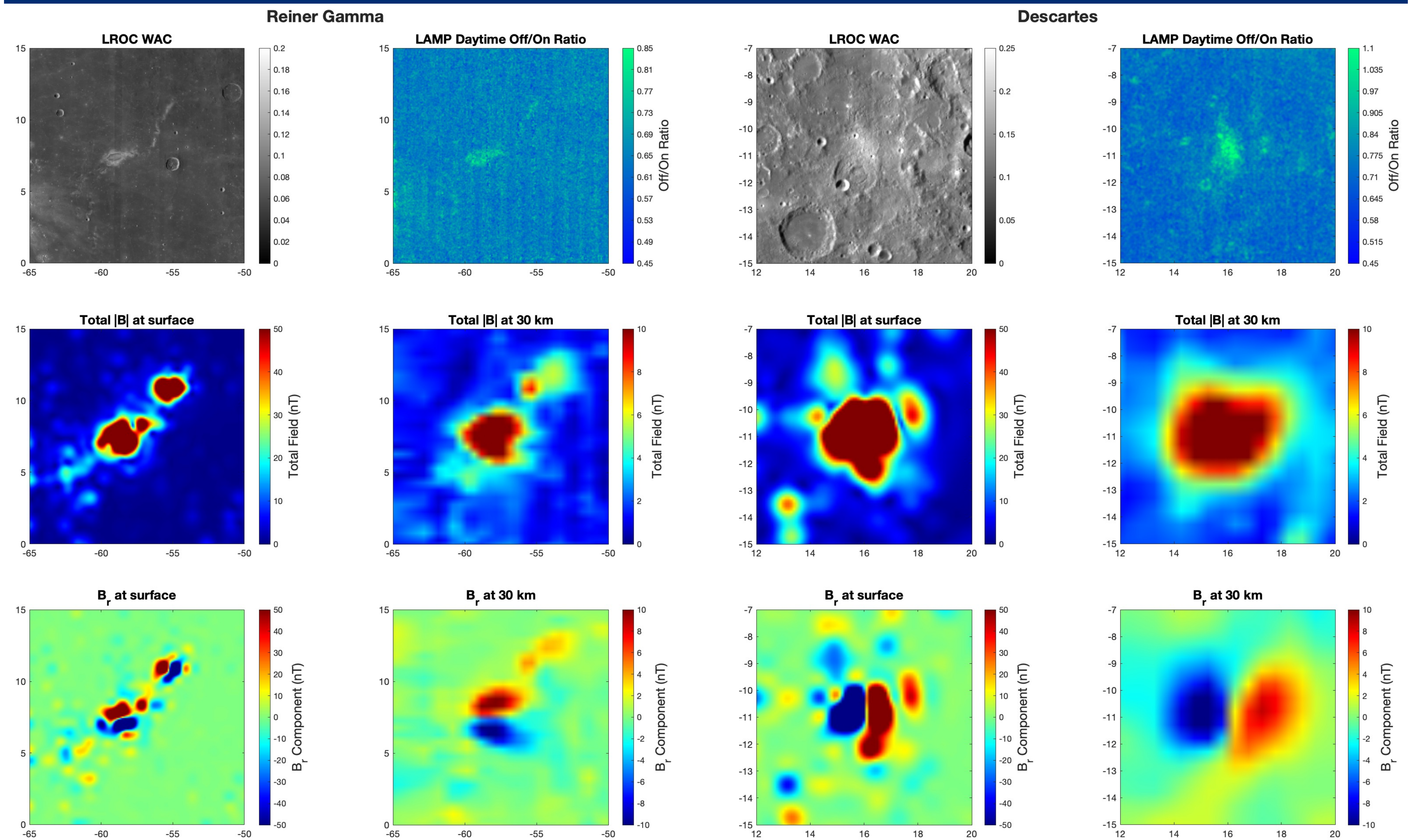
The solar wind deflection model suggests that solar wind particles can be magnetically deflected due to the Lorentz force when incident upon a sufficiently strong magnetic field (Hood 1980). According to the Lorentz force law, the magnetic deflection force is maximized when solar wind particle trajectory is perpendicular to the direction of the magnetic field but zero when parallel (Hemingway 2012). This implies that the surface-normal magnetic field component holds the most influence over weathering-related spectral changes due to solar wind deflection.

Magnetic field strength decreases rapidly with increasing distance from the source, implying swirl morphology should be heavily influenced by the source geometry and strength of the magnetic field. Attenuation is a problem at spacecraft altitude as a significant amount of magnetic field signal could be lost, thus downward continuation of high- altitude magnetic fields may provide more insight into near-surface processes (Hemingway 2012, Ravat 2020).

Materials and Methods

Using Lunar Reconnaissance Orbiter (LRO) Wide Angle Camera imagery (Sato 2014, Boyd 2012), LRO Lyman-Alpha Mapping Project dayside data (Byron, personal comm.), Lunar Prospector magnetometer (LPMAG) derived at-surface maps (Ravat 2020), and LPMAG 30 km altitude maps (Purucker 2010), we created mosaics for comparison of select swirl features in optical and ultraviolet wavelengths to magnetic anomalies from data recorded 30km above the surface and at-surface models.

Results



The LPMAG derived at-surface maps provide more detailed information about the magnetic anomalies than the LPMAG 30km maps, in particular, the surface-normal (B_r) magnetic field component is a very strong contributor to the total magnetic field observed at these swirl locations. This is consistent with previous work and models of standoff, and the photometric anomalies display similar unusual reflectance properties in WAC and LAMP observations, despite their overlay on different terrain.

Conclusion

The selected swirls observed here appear to be influenced as suggested by the radial magnetic field component, which is the dominating contributor to total field observed at these anomalies. Further studies are being conducted on all swirls identified in Cahill et al. (2019) to analyze global statistics of magnetic field component strength and reflectance properties.