ESTIMATING THE MAGNETIZATION DIRECTION OF PLANETARY CRUSTAL MAGNETIC ANOMALIES. R. E. Maxwell[1] and I. Garrick-Bethell[1,2], [1]Dept. of Earth and Planetary Sciences, University of California, Santa Cruz, Santa Cruz, CA, [2]School of Space Research, Kyung Hee University, Yongin, Korea (remaxwell@ucsc.edu).

Introduction: Observations of planetary magnetism provide information on the dynamo history of a body, and thereby insights into its internal and thermal evolution. Though the Moon presently has no dynamo field, many crustal magnetic anomalies have been observed in orbital magnetometer measurements. If these anomalies were magnetized in an ancient, dipolar magnetic field, their magnetization directions contain information about the dynamo that generated them. These anomalies have the potential to inform both the history of true polar wander [1] and the nature of the lunar dynamo [2].

There is no standard method of recovering the best-fit magnetization direction, and no standard method of reporting the uncertainty associated with the results, if any uncertainty is provided at all. The ultimate goal of our work is to determine the best way to describe the uncertainty associated with magnetization direction.

Method: We create synthetic datasets that mimic the limitations of real-world orbital data but avoid outside factors such as noise. We then use common inversion methods to find the best-fit magnetization direction, and compare the ability of these methods to retrieve the actual direction, and the uncertainties associated with each method.

In general, there are two methods to estimate the magnetization direction. The first allows the user to manually place dipoles, guided by the magnetization strength and lunar swirl albedo patterns, if available [3, 4]. The second method is to perform a least squares fit to a sheet of dipoles on the surface, distributed above the anomaly, allowing each dipole to have its own magnetization strength, herein referred to as Parker's method [2, 5].

Results: We have uncovered a bias (Fig. 1) in determining the magnetization directions of crustal anomalies, based on whether the magnetization is vertical or horizontal [6]. This may have implications for determining the history of the lunar dynamo's orientation or the history of true polar wander. For example, in practice one would utilize magnetic anomalies with only well constrained magnetization directions. However, if north-magnetized anomalies generally have lower uncertainty radially-magnetized anomalies, and there are more magnetic anomalies at low latitudes, one may be led to conclude that Moon's magnetic paleopoles are co-located with the current spin-axis.

We test whether this same bias shows up when using Parker's Method, and whether we can combine the best aspects of the two methods in order to gain a better understanding of the uncertainty associated with the results.

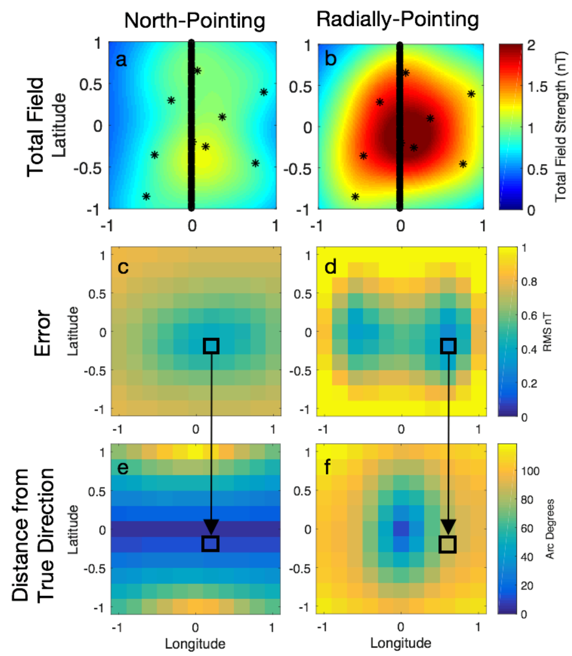

Figure 1. (a, b) Total magnetic field maps for an arrangement of synthetic source dipoles. (c-f) Each pixel represents the results from an inversion using a single model dipole at that location, using data along a single 'observation track' (black line in a, b). Shown are the error (c, d) and distance from the true direction (e, f) for the synthetic anomalies built from north-pointing dipoles (left) or radially-pointing dipoles (right). Outlined in black are the dipole locations with the lowest error. A smaller distance from the true direction is found for the north-pointing case, for a wider range of model dipole locations.

References: [1] Garrick-Bethell, I., et al. (2014), *Nature* 512, 181. [2] Oliveira, J. S. and Wieczorek, M. A. (2017), *JGR* 122, 383. [3] Nayak, M., et al. (2017), *Icarus* 286, 153. [4] Hemingway, D. and Garrick-Bethell, I., (2012), *JGR* 117, E10012. [5] Parker, R. L. (1991), *JGR* 96, 16,101. [6] Maxwell, R. E., et al. (2017), *LPSC 48*, abstract 2486.