MAVEN-VALIDATED MODEL IMPLICATIONS FOR INSIGHT MEASUREMENTS. J.G. Luhmann[1], Y.J. Ma[2], C. Dong[3], P. J. Chi[2], C. T. Russell[2], S.M. Curry[1], J. Espley[4], J. E. Connerney[4], B.M. Jakosky[5], [1]Space Sciences Laboratory, University of California, Berkeley, jgluhman@ssl.berkeley.edu, smcurry@ssl.berkeley.edu, [2]Department of Earth, Planetary, and Space Sciences, UCLA, Los Angeles, yingjuan@igpp.ucla.edu, pchi@igpp.ucla.edu, ctrussell@igpp.ucla.edu, [3]Space Sciences Laboratory, University of Michigan, Ann Arbor, dcfy@umich.edu. [4]NASA GSFC, Greenbelt, jared.espley@nasa.gov, jack.connerney@nasa.gov, [5]LASP, University of Colorado, Boulder, bruce.jakosky@lasp.colorado.edu.

Introduction: The Mars obstacle to the solar wind is produced by a combination of planetary magnetic fields and fields from induced ionospheric currents. The latter have signatures that vary with solar wind conditions and crustal magnetic field locations. Although they are complicated, they are apparently well-modeled in the BATS-R-US simulations of the Mars-solar wind interaction that have been successfully compared to both MGS and MAVEN orbiter magnetometer data [1, 2, 3]. One question that arises, given these successful comparisons, is the depth to which these variable induced fields might be observed- and in particular, how they might appear at the surface where they might induce some body field response. Such responses provide a unique capability to carry out sounding of the interior conductivity of a body, including its core size (e.g. see P. Chi et al. abstract, this conference). MAVEN's magnetometer observes significant departures (in some cases up to ~100 nT) from the MGS-based crustal magnetic field model down to its deep-dip orbit periapsis altitudes of ~120 km [4]. As these induced currents vary with time with both solar wind and planetary rotation, they can potentially provide an interior sounding source if properly interpreted.

The Insight lander carries an engineering system magnetometer that offers the first opportunity to measure the field variations on the surface of Mars from both external and internally induced contributions. If the induced field variations described above are regularly present, and produce a detectable signal and planetary response, there is potential for additional science from the lander. We know that regular variations in the fields will be present, but to be useful for sounding their frequency spectra and amplitudes need to meet certain criteria. Of course, in addition to 'typical' variations, the occurrence of interplanetary disturbances from solar wind stream interactions and coronal mass ejection debris impacts might produce particulary strong surface responses due to the expected enhanced penetration of interplanetary magnetic field into the ionosphere at these times. In this study we use some models in a library developed for MAVEN magnetic field data comparisons to estimate the low altitude solar wind interaction-related induced field variations. The results provide a pre-Insight mission idea of the magnitudes and spatial distributions of field variations at the surface without the interior induction contribution, as well as food for thought regarding Mars counterparts of 'Sq' ionospheric currents and 'magnetic storm' analogies of both scientific and technical interest.

Methodology: The single fluid BATS-R-US MHD models of the Mars solar wind interaction of the type used in this study are described in detail in the literature, e.g. see references in [1], and have been applied in sufficient numbers of data comparisons [1],[2],[3] to provide confidence that they incorporate the main physics and photochemistry for the Mars situation. Briefly, these models include a description of the basic Mars obstacle composed of its main neutral atmosphere, ionosphere, and crustal magnetic fields, plus a variety of external (solar wind) plasma and field conditions. The solar wind interaction simulation produces a self consistent magnetosheath and magnetotail with many of the associated currents and structures observed in-situ by spacecraft.

Our approach uses snapshots of quasi-steady state models with sets of typical solar wind conditions and for solar EUV fluxes characteristic of nominal solar maximum and solar minimum states of the Sun (affecting neutral atmosphere scale heights, ionospheric structure, and solar wind mass loading by ionospheric ions), for both average interplanetary magnetic field polarities (Parker Spiral fields toward and away from the Sun), and different local times of the strong crustal magnetic fields (noon, dusk, midnight, dawn). For each crustal field position and EUV case we difference model map results (see [5] for examples) for the opposite external fields at altitudes near the inner model boundary (which is at 100 km) to eliminate the steady crustal field contributions and evaluate the range of departure from those fields that would occur globally (and at the Insight landing site) as the interplanetary field sectors reverse from one polarity to the other, and/or the planet's crustal fields rotate to new locations. Both radial and horizontal field components are considered. These results give us a first-order evaluation of the magnitude of the externally induced field variations detectable below the ionospheric peak.

Results: The 'difference' field maps that we obtain (at 120 km and 150 km) for each case are all distinctive, indicative of the different time histories of the externally induced fields at each location. The deviations in the horizontal components are largest at several 10s of nT on the dayside at low to mid latitudes. Note that these are in cases in addition to local crustal fields of >500 nT when the latter are also on the dayside. However, the footprint area of the largest field variations extends beyond the strongest crustal field regions.

An Insight candidate landing site is located at low northern latitudes to the west of the strongest crustal magnetic fields. The question of whether the field variations these models represent are present at the surface and if so, whether they induce a detectable interior response, is still TBD. There may also be other sources of magnetic noise (natural and technical in origin) that exist at the surface at similar and higher strengths.

Future Prospects: Time dependent versions of the models used here with rotating crustal fields have been run [4] as well as time dependent cases with disturbed solar wind conditions [5]. These can potentially give a better idea of the actual harmonic content of low altitude field variability at each geographical location than the snapshots used here. The weakening solar EUV flux as the solar cycle proceeds toward its next solar minimum may also affect the relative magnitude of the induced field variations compared to the crustal fields. Many other numerical experiments are possible prior to Insight arrival at Mars. However, these will also be of more general interest in studies considering participation of body interiors in weakly magnetized planet- plasma interactions.

References: [1] Ma, Y.J. et al. (2015) *GRL 42*, 9113-9120. [2] Ma Y. J et al. (2014) *GRL 41*, 6563-6569. [3] Jakosky, B.M. et al. (2015) *Science*, 350, doi:10.1126/science.aad0210. [4] Bougher et al. (2015) Science, 350, doi:10.1126/science.aad045. [5] Luhmann et al. (2015) *Planetary and Space Sci. 117*, 15-23..