IONOSPHERIC CURRENT SYSTEMS AT MARS: MAGNETIC PERTURBATIONS ABOVE CRUSTAL FIELDS MEASURED BY MGS AND MAVEN. K. G. Hanley¹, D. A. Brain², T. Weber², J. S. Halekas³, J. Espley⁴, J. Connerney⁴, D. L. Mitchell¹, B. M. Jakosky²
¹University of California Berkeley Space Sciences Laboratory (gwen.hanley@berkeley.edu), ²Laboratory for Atmospheric and Space Physics, University of Colorado Boulder, ³Department of Physics and Astronomy, University of Iowa, ⁴NASA Goddard Space Flight Center

Introduction: Currents in the Martian atmosphere are responsible for plasma transport throughout the upper atmosphere of the planet. Observations of auroral emission [1,2,3,4] and accelerated charged particles [2,3] at Mars suggest that electric fields form parallel to vertical crustal magnetic field lines, similar to Earth’s auroral regions. Particles accelerated by parallel electric fields form currents that may facilitate charged particle escape from these magnetic cusp regions. Signatures of currents near crustal fields can be detected by analyzing disturbances in the local magnetic field (Figure 1).

Locating Magnetic Perturbations: Through systematic study of thousands of events occurring on the planet’s night side, we find that magnetic perturbations are particularly numerous in regions of radial magnetic field or in boundaries between regions of differing magnetic topology (Figure 2). These conditions are consistent with magnetic cusp regions.

We find no correlation between crustal magnetic field strength and the occurrence or magnitude of magnetic perturbations (Figure 2). From the MGS data, which were collected over a longer period of time than the MAVEN data, we find that the occurrence of current systems appears to be affected by Martian season as the...
magnetic cusps rock back and forth with respect to the Sun (Figure 3). It is likely that seasonal escape rates are affected by the presence or absence of current systems. The MAVEN data, collected over a wider range of local times and altitudes than the MGS data, show that current signatures are most numerous at altitudes below the 400 km circular orbit of MGS, near the exobase region at 180-200 km (Figure 4).

Estimating Current Densities: The different orbits of MAVEN and MGS necessitated the development of independent methods of estimating current densities from the magnetic field data collected by each spacecraft. We find that each method yields current densities of consistent magnitude, ranging from ~0.1-1 μA/m² (Figures 5 and 6). The occurrence of current systems does not appear to be influenced by solar wind pressure, interplanetary magnetic field (IMF) direction, or extreme ultraviolet photon (EUV) flux, suggesting that the variability in their occurrence is driven by variation within the Mars system rather than external sources. Further study of these magnetic perturbations is needed to determine how important of a role they play in the escape of charged particles to space, as well as how the presence of neutral species affect the occurrence and characteristics of current systems.

Next Steps: The prevalence of current signatures near the exobase region implies a connection between the formation of currents and the local density of neutral species above crustal fields. The coupling between neutral species and charged particles in cusp regions should be investigated. Additionally, an estimate of current density magnitudes and directions based on electron and ion measurements would also provide insight on the error in the 0.1-1 μA/m² current densities calculated from the magnetic field data. By combining these estimates, it is possible to analyze the importance of ionospheric currents in influencing rates of escape to space and how they affect the Martian climate.