Crustal magnetic field advection on Mars from MAVEN observations

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The plasma environment of Mars is highly influenced by regions of remnant magnetism in the planetary crust, above which mini-magnetospheres are created. In this work, we study whether the ionospheric plasma flow can move crustal magnetic field lines, by the process of advection. According to this hypothesis, the magnetic field lines are dragged away in anti-solar direction, westward at dawn and eastward at dusk-side, due to the day-to-night flow of the ionospheric plasma. The altitude of interest is between 200 km and 1000 km, because the plasma flow velocity is significant in this region.

MAVEN (Mars Atmosphere and Volatile EvolutioN) data is used for a direct comparison between magnetic field data and a crustal magnetic field model. The difference between the observed and the model field at each point of the grid is a measure of the sum of the induced day magnetic field and the possible displacement of the crustal field lines by advection. The results of the analysis show that, except for the lowest altitude range, minimum value of this difference is always observed for westward shift at dawn-side and eastward shift at dusk-side, in agreement with the expected motion of the crustal magnetic field lines.

For a general idea of the relative forces between the moving plasma and the crustal fields, we use MAVEN data to analyze the pressures involved in the advection process. These are the dynamic pressure of the ionospheric plasma flow, the magnetic pressure of the field lines and the thermal pressure of the plasma related to the mini-magnetospheres. The balance between these quantities should dictate the occurrence of advection. This analysis suggests that advection could take place at low altitude (up to ~450 km) dawn-side regions above low intensity magnetic fields.

Although the global analysis results showed agreement with our hypothesis, we could not observe evidence of advection from the local observations in order to unambiguously prove the occurrence of this process. Future works include the investigation of single orbit data in regions of low intensity magnetic field, especially at dawn-side, and also magnetohydrodynamic modeling of the process using the plasma conditions prevalent in the Martian ionosphere.
