EPSC Abstracts
Vol. 5, EPSC2010-371, 2010
European Planetary Science Congress 2010

Effects of Mars Dust Storms on Photoelectron Intensities

M. W. Liemohn (1), M. Trantham (1), Stephen Bougher (1), and D. L. Mitchell (2)
(1) University of Michigan, Ann Arbor, Michigan, USA, (liemohn@umich.edu / Fax: +1-734-647-3083) (2) University of California, Berkeley, California, USA

Abstract

We have conducted a survey of the Mars Global Surveyor electron data for dayside photoelectron observations over regions of strong crustal fields. These data have been correlated with various possible controlling factors, finding that the incoming solar EUV flux is the dominant determinant of photoelectron intensity. However, the relationship between electron flux and EUV flux is distinctly different depending on the state of the lower atmosphere. Specifically, dust storms systematically alter the atmospheric composition and density, resulting a different relationship of electron flux to EUV flux at MGS altitudes (~400 km). This relationship is explored in the MGS data set as well as with a kinetic transport model. We find that lower atmospheric dust storms (as indicated by atmospheric dust opacity) are just as significant as solar EUV flux at controlling the high-altitude photoelectron flux intensity.

1. Introduction

Atmospheric photoelectrons are excellent tracers of not only ionospheric characteristics but also the solar wind interaction with unmagnetized planets. Because they are ubiquitously produced on the dayside yet are relatively fast, their presence at high altitudes or on the nightside can be used for probing magnetic topology and physical processes. However, before proceeding with this usage, their flux intensities on the dayside should be quantified. This study explores the factors controlling the flux intensity levels in the upper ionosphere of Mars. A survey of Mars Global Surveyor (MGS) electron data is presented and interpreted with modeling results.

2. Observations

Data from the MGS magnetometer and electron reflectometer (MAG/ER) instrument [1, 4] have been filtered to select only the observations of atmospheric photoelectrons during passage through the strong crustal field regions on the dayside of Mars. This selection procedure found about 10 minutes per day of usable observations, which, over the lifetime of MGS, is still hundreds of thousands of electron distributions. Figure 1 shows a flux versus time plot over the course of the mapping and extended mission phases of MGS. Because all of these observations are from the southern hemisphere, the seasonal changes due to Mars' eccentricity and axial tilt are evident. However, one peak is significantly higher the others (shown in red).

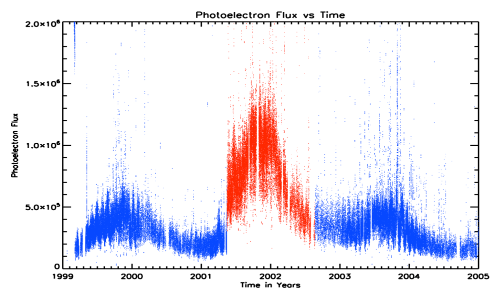

Figure 1: Photoelectron flux versus time at 27 eV and 90˚ pitch angle observed when MGS was over the strong crustal field region.

These data were plotted against a variety of parameters in search of the quantities that best control the intensity of the photoelecton fluxes. It was determined that the incoming solar EUV photon intensity was the best organizer of the electron fluxes, as expected. Figure 2 shows a scatterplot of this relationship (color sorted as is Figure 1). It is clear that this interval has a different relationship to solar EUV than the other times. Not only is the data from the "red" interval shifted up, but the slope is different, indicating that the response of the photoelectrons to solar EUV has been changed during this time interval. This is especially unusual because these are 90˚ pitch angle particles, meaning that they are locally mirroring and in fact are trapped in the magnetic bottle of the local magnetic field lines of the strong crustal fields. That is, something about this time changed the scattering rates above MGS' 400 km altitude orbit to yield a different EUV dependence for these trapped electron fluxes.

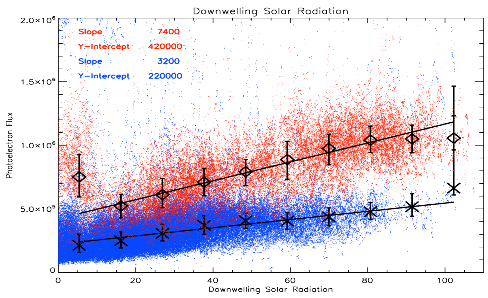

Figure 2. Photoelectron flux versus incoming EUV solar photon (a Mars F10.7 proxy times the cosine of the local solar zenith angle). The data is separated according to the time intervals in Figure 1, as indicated by color. Binned averages and a linear fits are shown for each color grouping.

3. Numerical Modeling

The reason for this change is hypothesized to be the global dust storm that occurred during this interval. Figure 3 shows the dust opacity observations from TES onboard MGS. In mid 2001, a global dust storm arose on Mars, lasting for several months. It is presumed that the change in the lower atmosphere altered the upper atmosphere enough to change the high-altitude scattering of photoelectrons along the closed field lines, therefore changing the relationship of the electron fluxes with EUV intensity.

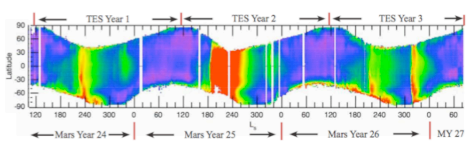

Figure 3. Dust opacities from TES on MGS. Purple is τ=0 and red is τ=0.5, indicating times of regional and global dust storms at Mars.

Numerical modeling was conducted in order to demonstrate this effect. Our superthermal electron transport (STET) model [3], which solves for the velocity space distribution everywhere along a magnetic field line, was used with two different atmosphere profiles from the MTGCM code [2], one for low dust conditions while the other was for high. The incoming EUV was then varied in the electron simulation to yield a curve like that in Figure 2. The model results clearly indicate that the changed atmosphere due to the presence of dust also changes the relationship of the trapped electron fluxes. That is, the dust storm has a noticeable impact on atmospheric densities above 400 km altitude.

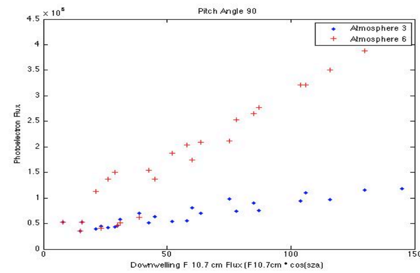

Figure 4. Numerical modeling results from the STET code for two thermospheric profiles, one with low dust (blue) and with high dust (red).

4. Extending the Result

Based on these data-model comparisons, we are going back into the data to sort it according to dust opacity. Rather than defining a time interval for special consideration, we will use the TES data as a parameter for organizing the photoelectron data. We will present results of our investigation into this relationship, as well as additional details of the observations and numerical modeling results.

References

[1] Acuña, M. H., et al., Mars Observer magnetic fields investigation, *J. Geophys. Res., 97*, 7799, 1992.

[2] Bougher, S. W., et al., Mars Global Surveyor Radio Science electron density profiles: Neutral atmosphere implications, *Geophys. Res. Lett., 28*, 3091, 2001.

[3] Liemohn, M. W., et al., Comparisons of electron fluxes measured in the crustal fields at Mars by the MGS MAG/ER instrument with a B-field dependent transport code, *J. Geophys. Res.*, *108*, 5134, 2003.

[4] Mitchell, D. L., et al., Probing Mars' crustal magnetic field and ionosphere with the MGS electron reflectometer, *J. Geophys. Res., 106*, 23,419, 2001.