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Time-History Effect of Mars Dust Storms on Ionospheric Photoelectron Intensities

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Abstract

Our survey of the Mars Global Surveyor (MGS) electron data for dayside photoelectron observations over regions of strong crustal fields revealed an unusual bimodal solar flux dependence. The upper population in the scatter plot was associated with the timing of a large global dust storm in late 2001. However, many other short-lived spikes in the electron fluxes are seen in the time series, perhaps also associated with lower-atmospheric dust storms. A systematic study parameterizing the photoelectron flux intensities against a solar flux proxy and MGS-observed atmospheric dust opacity was conducted. Instantaneous dust opacities were used as well as time-history averages and maximal values. The result is a functional form for the photoelectron fluxes against these parameters. The inclusion of dust in the function significantly enhances the linear correlation coefficient and explains the bimodal distribution in the electron fluxes. While the best relationship was obtained with time-history dust opacity variables included in the function, this was only a marginal improvement over using only the instantaneous values.

1. Introduction

A survey was conducted [6] of dayside photoelectron observations from the Mars Global Surveyor (MGS) magnetometer and electron reflectometer (MAG/ER) [1, 4]. The observations from the MGS mapping and extended mission phases (~400 km altitude circular orbit) were culled to isolate the photoelectron observations on closed magnetic field lines. These data were compared against a number of solar, solar wind, magnetic, and planetary parameters to understand what processes dominate the photoelectron flux intensities along these field lines. It was found that, not surprisingly, the local solar EUV flux dominated the photoelectron values. However, a bimodal structure was seen in the relationship, with two distinct linear trends in the scatter plot, as see the photoelectron flux plots in Figure 1 [6].

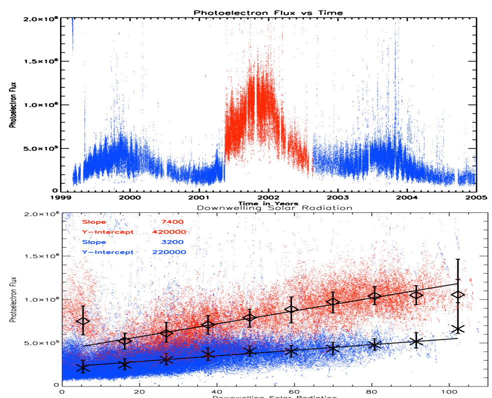

Figure 1. (Top) Time series of photoelectron flux observed when MGS was over the strong crustal field region. (Bottom) Electron fluxes versus EUV flux (a Mars F10.7 proxy times the cosine of the local solar zenith angle). Binned averages and linear fits are shown per grouping.

The timing of the enhanced electron flux population coincides with a large global dust storm at Mars. While the influence of lower atmospheric dust storms have been observed in thermospheric observations [2, 3], and even ionospheric electron densities [7], the MGS observations are at 400 km altitude, far above the peak production layer in the ionosphere. Furthermore, the influence is seen in the locally mirroring electrons [6], implying that the influence of dust storms extends into the exosphere.

2. Results

Based on these initial results, the electron fluxes were sorted according to dust opacity, as seen by the Thermal Emission Spectrometer (TES) instrument on MGS [5]. Rather than defining a time interval for special consideration, the TES data were used as a parameter for organizing the photoelectron data.

TES dust opacity time series are shown in Figure 2 (at the latitude of MGS, a global average, a 7-month time-history running average of the global value, and a 7-month maximal value of the global average). Each has its own features that may or may not align with the electron time series in Figure 1.

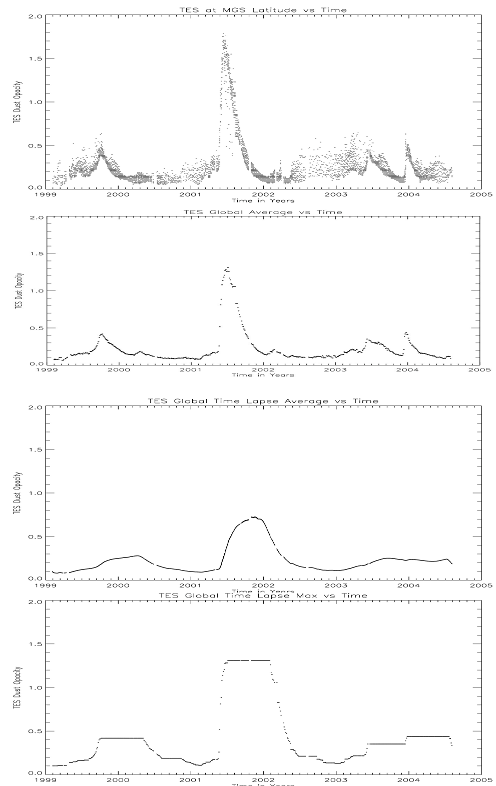

Figure 2. Mars dust opacities from MGS TES, for (top) the latitude of the electron measurement, (second) a global average, (third) a 7-month time-history average of the global opacity, and (fourth) a 7-month time-history maximum of the global opacity.

These values were used with the solar EUV flux proxy to create a new controlling function to specify the photoelectron flux observations. Figure 3 shows the best fit of these functional forms. The correlation coefficient with no TES dust opacity in the function is 0.30. The inclusion of the local dust opacity actually worsens the correlation to 0.27, while the inclusion of the global dust opacity value raises it to 0.33. However, the use of a time-history global dust value, either a time-average or a maximal value, increases the correlation coefficient into the 0.45 range. The results were not that sensitive to the exact length of this window, nor to the linear combination of various TES dust parameters.

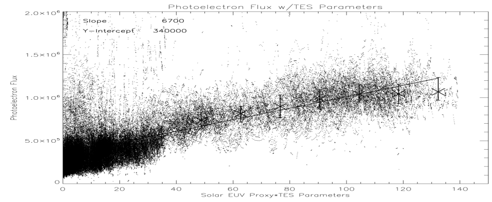

Figure 3. Best-fit functional form for the photoelectron flux intensity, given as the solar RUV proxy times the 7-month time-history window maximal TES global dust opacity value.

3. Conclusions

A survey of photoelectrons at Mars revealed a bimodal relationship with solar EUV flux, the timing of which was related to a strong global dust storm. It was determined that the inclusion of the global dust opacity in the photoelectron flux dependency function greatly improves the correlation coefficient. Various time-history dust opacity values improved the correlation even further, albeit only by a small amount.

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