EPSC Abstracts
Vol. 12, EPSC2018-319-1, 2018
European Planetary Science Congress 2018
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Variability of the precipitating fluxes during September 2017 event

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Abstract

We here study the influence of several solar atmospheric and magnetospheric forcing drivers, during September 2017 solar event. We focus on the fluxes of precipitating heavy ion towards Mars' atmosphere as seen by MAVEN: SWIA (cs product), an energy and angular ion spectrometer and by STATIC (d1 and c6 products), an energy, mass and angular ion spectrometer. [1]

1. Introduction

Although atmospheric sputtering is a minor component of atmospheric escape today, it is thought to have been much more important four billion years ago [2]. Heavy ion precipitating is the primary driver of atmospheric sputtering. September 2017 solar event provides a unique opportunity to study the role of several solar potential drivers of heavy ion precipitation. In this presentation, we will present how the precipitating flux changed all along September 2017 solar event and will discuss what can be derived on the dependency of this precipitation with respect to our Sun.

1.1 Background trouble

During September 2017 event, Solar Energetic Particles (SEPs) induce a strong background on SWIA measurements. In the case of STATIC, its technic of measurements allows it to significantly reduce the impact of SEP event on its measurements. We therefore develop a numerical treatment to subtract it to SWIA.

2. Methodology of background value reconstruction

The background is characterized by a flat energy spectrum of the energy differential flux (in $eV/cm^2/s/eV/str$). We therefore used this characteristic in order to estimate it. For instance, we observed on the 12^{th} September a background value around 3×10^5, instead of 6×10^3 during nominal period. To correct SWIA data, we therefore perform the following steps:

1 – Calculation of the flux measured by each anode of SWIA on 10 min intervals (144 intervals per day). The background is reconstructed from the highest energy range of SWIA (>5 keV) if the energy flux is constant within this range.
2 – The set of reconstructed backgrounds 40 min before and after is then used to estimate the background within 200 and 350 km in altitude.
3 – We then subtract the value of this background to SWIA.

3. Maven Measurements

There are five periods in September 2017, as represented on the figure 1, during which the precipitating flux exceeds by more than 3 sigma the average value measured during the 30-31 August and 25-26 September (considered as reference periods for nominal solar conditions). During this period, MAVEN's periapsis drifts slowly in longitude/latitude. However, when reconstructing the precipitating flux (between 200 and 350 km in altitude), we only considered the inbound portion of the orbits to further limit the range of SZA and latitude/longitude covered by MAVEN during September 2017.

In order to explain this variability, we have to consider the main potential solar drivers for the precipitating flux which are:

- the EUV flux,
- the SEPs flux,
- the solar wind parameters which can be partially represented by the electric field of convection. Here, we used the |VxB| as measured at MAVEN apoapsis.

Another driver is the solar wind dynamic pressure which is however difficult to reconstruct without direct solar wind measurements. The increase of the dynamic pressure between late 12th to 14th September compressed Mars' magnetosphere and favored the acceleration and precipitation of the planetary picked-up ions. [3]. As a consequence, a sharp increase in precipitating flux could be seen in STATIC measurements at low energy and in SWIA measurements at high energy. But, we believe that it is probably the combination of the preceding SEPs event, the flare and of the ICME arrival which leads to the maximum of precipitating flux observed during September 2017 event.

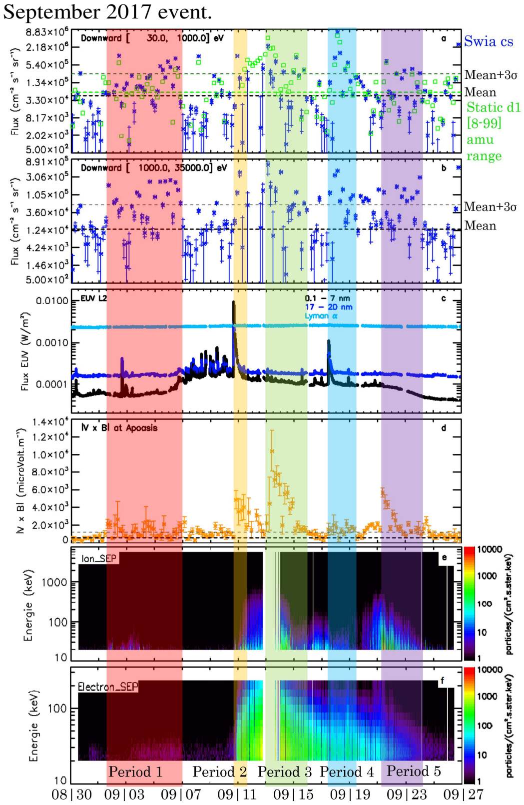

Figure 1: Measured SWIA integrated precipitating flux and few potential drivers for the precipitating flux during September 2017 period. Integrated precipitating flux of September 2017 **(a)** 30 and 1000 eV energy range, **(b)** 1 and 25 keV energy range. Green square: Static d1 8-99 amu mass range. Blue star:_Swia cs. The horizontal black (green) thick dashed line corresponds to the average value of SWIA (STATIC D1) precipitating flux during the two periods encompassing September 2017 event. The thin dashed horizontal line corresponds to the average value plus 3 times the standard deviation with respect to this average during these two periods. Errors bars on panels a and b correspond to 1 sigma deviation of the corresponding reconstructed background. **(c)** Value of the EUV photon flux as measured by EUV instrument/MAVEN, blue light line: 121-122 nm band, blue line: 17-22 nm range and black line 0.1-7 nm range. **(d)** Intensity of $\|\vec{V} \times \vec{B}\|$ reconstructed from SWIA moments and MAG measurements at MAVEN apoapsis. **(e)** Ion flux measured by SEP/MAVEN F1 detector within 20 keV and 70 MeV. **(f)** Electron flux measured by SEP/MAVEN F1 detector within 20 keV and 300 keV.

4. Summary and Future work

September 2017 solar event is a unique opportunity to analyze what could be the respective role of the solar drivers inducing intense heavy ion precipitation into Mars' atmosphere.

After a careful reconstruction of the background induced by the SEPs event on SWIA spectrometer, we were able to investigate the precipitating flux responses to the solar energetic event of September 2017. This study shows an increase in precipitation flux of more than one order of magnitude during solar events compared to the average flux of a similar period but for quiet solar.

Acknowledgements

AM acknowledges the support of DIM ACAV and ESA/ESTEC. This work was also supported by CNES "Système Solaire" program and by the Programme National de Planétologie and Programme National Soleil-Terre. This work is also part of HELIOSARES Project supported by the ANR (ANR-09-BLAN-0223) and ANR MARMITE (ANR-13-BS05-0012-02).

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