Variability of the ion precipitating fluxes on Mars during September 2017 event

Martinez Antoine [1], Leblanc F. [1], Modolo R. [2], Chaufray J.Y. [2], Romanelli N. [2] and MAVEN team

[1]LATMOS/IPSL, Sorbonne Université, CNRS, Paris, France, [2]LATMOS/IPSL, UVSQ Université Paris-Saclay, CNRS, Guyancourt, France

Introduction

We study the influence of September 2017 solar event on the precipitating fluxes with the instruments of MAVEN: SWIA (cs product), an energy and angular ion spectrometer and STATIC (d1 product), an energy, mass and angular ion spectrometer. [1] 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.

Background subtraction

- **Motivation:** During September 2017 event, Solar Energetic Particles (SEPs) induce a strong background on SWIA data. STATIC is less sensitive to SEP induced background than SWIA. We therefore develop a numerical treatment to subtract it to SWIA.

- **Method:** The background is characterized by a flat energy spectrum of the count rate (also in energy differential flux as illustrated in figure 1 by the constant high energy flux around 3×10^5 eV/cm²/s/eV/str in blue) observed on the 12th September.

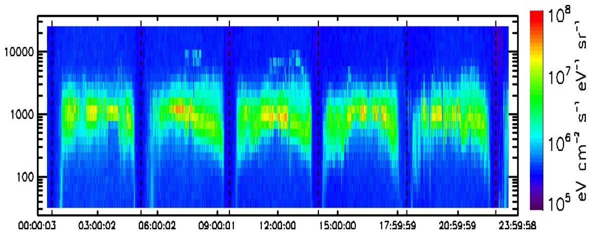

Figure 1: SWIA energy differential flux on September 12th 2017.

- Calculation of the count rate measured by each anode of SWIA for 10 min intervals (144 intervals per day). The background is reconstructed from the highest energy range of SWIA (>5 keV) if the count rate is constant within this range.

- The set of reconstructed backgrounds 40 min before and after is then used to estimate the background (in counts/s) for each time step within 200 and 350 km in altitude.

- We then subtract the value of this background to SWIA for each time step and convert the corrected count rate into particle flux.

- The high background value on SWIA data is probably induced by energetic particles (above 50-200 MeV as measured on Curiosity). Indeed, it is seen during September 11th event (period 2) but not during September 21st event (period 5).

MAVEN measurements

The main drivers for the precipitating flux are:

- the EUV flux (Fig. 2c),
- the SEPs flux (Fig. 2f and g),
- the solar wind parameters (Fig. 2d and e). A key driver is the solar wind dynamic pressure which is difficult to reconstruct without direct solar wind measurements. We therefore reconstructed the proxy of the solar wind parameters at periapsis following Ma's approach [2].

During this period, MAVEN's periapsis drifts slowly in longitude/latitude. However, we only considered the inbound portion of the orbits to further limit the range of latitude/longitude.

There are few periods in September 2017 during which the precipitating flux exceeds by more than 3 sigma the average value measured during the 30-31 August and 25-26 September.

We here focused on two periods to illustrate the possible dependency of the precipitating flux with respect to solar conditions:

- The period 4 (in blue).
- The period 5 (in purple).

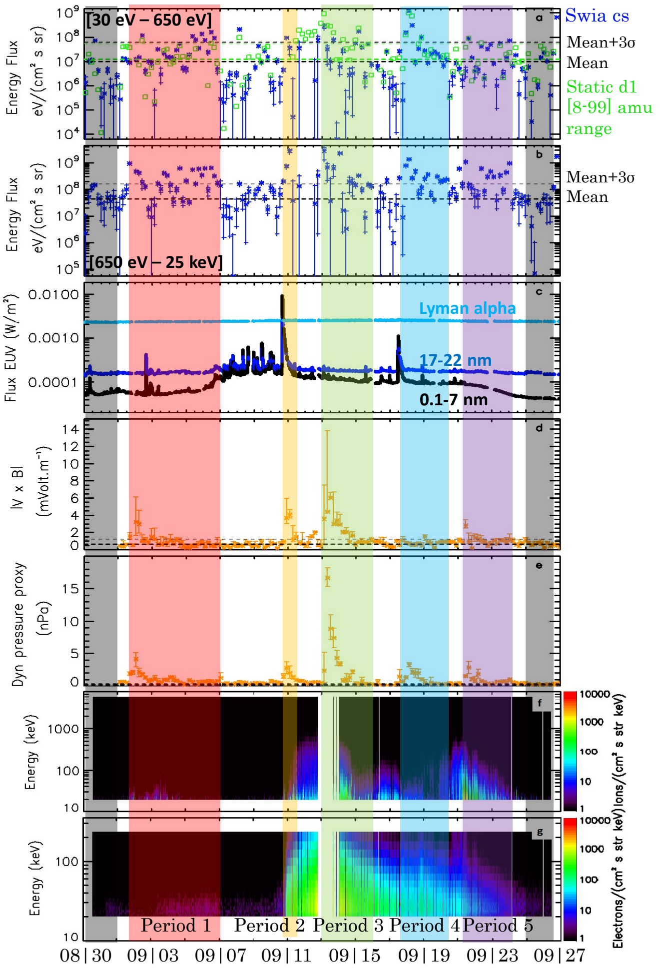

Figure 2: Measured SWIA integrated precipitating flux and potential solar drivers of the precipitating flux during September 2017.

Radiative and plasma events (Period 4)

As shown in Fig. 3, during this period, a radiative solar event (9/17) and a plasma solar event (9/18) occurred.

The increase of the EUV flux is expected to favor the ionization of planetary atoms and therefore the number of precipitating ions. But, the increase of the EUV flux appears not to be correlated with an increase of the precipitating flux (Fig 3.).

In Fig. 3, there is also a clear peak of the solar wind dynamic pressure (9/18), apparently in relation with an increase of the precipitating flux. The increase of the dynamic pressure compresses Mars' magnetosphere and favors the acceleration and precipitation of the planetary picked-up ions. [3]

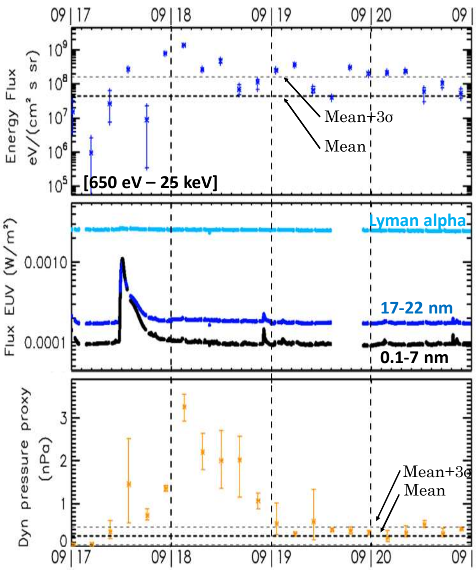

Figure 3: Measured SWIA integrated precipitating flux and potential solar drivers of the precipitating flux (period 4).

Plasma event (Period 5)

During this period, a plasma event occurred on the 09/21.

The increase of the dynamic pressure (Fig. 4d) seems to correspond to a peak of precipitation at high energy (Fig. 4b) as during period 4.

During the following days, the variability of the precipitation seems also to be dependent on the orientation of the solar wind convective electric field (Fig. 4e), in agreement with [4].

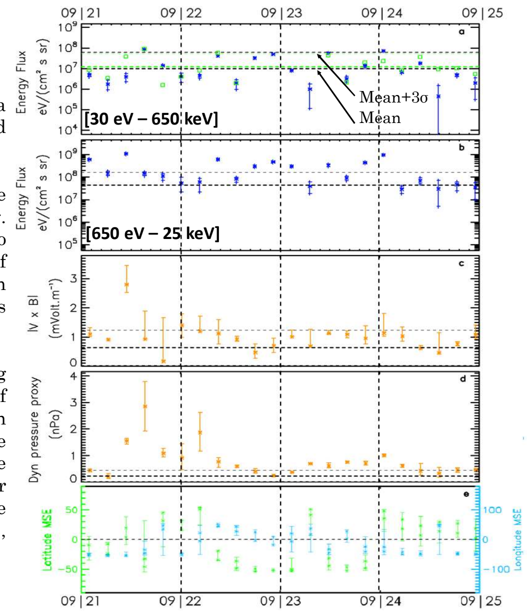

Figure 4: Measured SWIA integrated precipitating flux and potential drivers of the precipitating flux (period 5).

Conclusion

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 quiet solar conditions.

We also demonstrated that, among the possible solar drivers of the precipitating flux, the solar wind dynamic pressure and the convective electric field orientation are the most significant during September 2017.

References [1] F. Leblanc, R. Modolo et al. (2015), *Geophys. Res. Lett*, 42, 9135-9141, doi:10.1002/2015GL066170. [2] Ma, Y., Fang, X. et al (2018), *Geophys. Res. Lett*, doi:10.1029/2018GL077707. [3] S. M. Curry, J. G. Luhmann, and al. (2015), Geophys. Res. Lett, 42, 9095-9102, doi:10.1002/2015GL06304. [4] Hara, T., et al. (2017), *J. Geophys. Res. Space Physics*, 122, 1083–1101, doi: 10.1002/2016JA023348