Geophysical Research Abstracts
Vol. 19, EGU2017-10928-1, 2017
EGU General Assembly 2017

The impact of the early Sun and space weather events on the Martian atmosphere

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Observations of Sun-like stars have indicated that the early Sun can be characterized by extreme EUV and X-ray fluxes, as well as a more intense solar wind and higher occurrences of powerful solar transient events. The nature of the early Sun is a critical aspect for understanding atmospheric evolution among the terrestrial planets. In particular, the interaction of the solar wind with Mars has been a topic of recent interest with the arrival of the Mars Atmosphere and Volatile EvolutioN (MAVEN) mission. The MAVEN spacecraft has observed the upper atmosphere and magnetic topology of Mars during solar transient events such as Interplanetary Coronal Mass Ejections (ICMEs) and Stream Interaction Regions (SIRs) spanning from November 2014 to the present. Observations include dramatic changes in heavy ion acceleration along open, closed and draped magnetic field lines, and significant enhancements of escaping and precipitating planetary ions. We will present MAVEN observations of ICMEs and SIRs within the context of the current declining phase of solar cycle 24. With the use of global MHD and test particle simulations, we will also discuss the influence of the observed space weather events on the global loss rates of the Martian atmosphere. Finally, using observations of the magnitude and frequency of M and X class flares at younger, Sun-like stars, we have extrapolated the frequency of ICMEs at earlier stages of the Sun and will present simulations of the Mars-early solar wind interaction. The extreme conditions in the Sun's early history may have had a significant influence on the evolution of the Martian atmosphere and may also have implications for exoplanets interacting with the stellar winds of younger, more active stars.