A MODELING STUDY ON THE EFFECT OF THE 2018 MARS GLOBAL DUST STORM ON THE IONOSPHERIC PEAK. Vrinda Mukundan[1], Smitha V. Thampi[2], Anil Bhardwaj[3], Xiaohua Fang[4], [1]National Center for Earth Science Studies, Trivandrum, India , [2]Space Physics Laboratory, Vikram Sarabhai Space Center, Trivandrum, India, [3]Physical Research Laboratory, Ahmedabad, India, Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, USA.

Introduction: Dust storms are unique meteorological phenomena that occur on Mars. While many are quite small, the scale of some of the storms can be as large as to cover the entire planet. Such global dust storms, also known as Planet Encircling Dust Events (PEDE), are observed to cause significant atmospheric disturbances that can extend even up to the upper atmosphere [1] despite the dust only reaching altitudes ~60 km. During such events the peak of the Martian ionosphere shifts to higher heights without much change in the peak density [2--3]. This is caused by the expansion of neutral atmosphere due to increased absorption of solar radiation by dust particles.

Such a PEDE occurred in June 2018 (MY 34) during which the Mars Atmosphere Volatile EvolutioN (MAVEN) mission made in-situ measurements of upper atmosphere parameters [4]. But due to the orbital characteristics of the MAVEN satellite, there was no in-situ observations of the ionospheric peak region during the event. However, the Radio Occultation Science (ROSE) Experiment on-board MAVEN, and the Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS) on-board the Mars Express mission measured electron density profiles during this period and reported elevation in the altitude of ionospheric peak [5--6]. But these observations had the limitation that they were mostly confined to the northern hemisphere (NH) where the storm originated. Only 3 electron density profiles are available for the southern hemisphere (SH) during June 2018 and there is lacuna in the understanding on how the ionospheric peak of the SH had been impacted by the PEDE. Hence, in the present study we report the impact of the 2018 PEDE on the Martian ionosphere in the SH, in particular its peak altitude during the onset and growth phases of the event.

Model Description: We used a 1-D photochemical model to calculate the electron density profiles within the altitude range 100--200 km which is primarily a photochemical equilibrium regime. An energy deposition model is developed which describes the absorption of solar UV radiation using Beer Lambert law. The initial inputs to the model are solar UV radiation reaching the top of the atmosphere, the altitudinal distribution of the neutral constituents and the photoabsoption cross sections. The attenuated solar flux, thus obtained is used for calculating photoelectron production rate, which is subsequently used in the calculation of steady state photoelectron flux by employing an Analytical Yield Spectrum approach. The primary production rates of major primary ions due to photons and photoelectron impact are calculated. These are then used as input to the model which includes ion-neutral chemistry. The model calculates the density profiles of three ions viz. O2+, CO2+, and O+. These are added together to get the electron density profile.

Model Inputs: In June 2018 MAVEN in-situ observed the dawn-time equatorial and mid-latitude upper atmosphere region of the SH. The neutral profiles for CO2, N2, O, and CO, are from the observations by the MAVEN Neutral Gas and Ion Mass Spectrometer (NGIMS). Since observations are available only for altitudes >160 km, they are extrapolated down to 100 km using a multi-component fit approach as described in [7]. Solar fluxes are from MAVEN Extreme Ultraviolet Monitor (EUVM). For electron temperature, we use theoretical profiles for the dusty and non-dusty scenario as given in [8]. The cross sections and the reaction rate co-efficients are the same as that given in [9].

Model results: Using the extrapolated NGIMS-measured-neutral atmosphere for the SH, we simulated the electron density profiles for orbits that occurred on 7 selected days in June 2018. The solar zenith angle (SZA) for the simulation of each orbit is set as SZA at the periapsis of the respective orbits. Our model results showed that from 7 to 26 June the peak altitude enhanced by ~26 km. This enhancement include contribution both from the dust storm and the changing SZA which varied by ~20^{o} between 7 and 26 June. Using our model, we isolated the effect of the dust storm in the enhancement of ionospheric peak and could find that storm event alone caused an enhancement of the ionospheric peak altitude in the SH by ∼7–10 km in the dawn region. This calculated enhancement agrees well with the observations reported by ROSE/MAVEN and MARSIS/MEX.

Our simulation results also indicate a time delay in the response of the ionospheric peak of SH to the storm event. The storm originated in the mid-latitude region of NH on 1 June and gradually expanded to other regions. The present study shows that even though the storm developed to a global event by 17 June the pre-storm conditions of the ionospheric peak (subsolar peak altitude and density of 120--123 km, 1.1-1.7 x 10^6 cm^{-3}, respectively) continued to prevail at regions 10°S--20° S until 22 June 2018. A sudden enhancement of ~7-10 km is seen in the subsolar peak altitude simulated for O7255 on 22 June as compared to the previous dates the reason for which could be attributed to the storm event. These results, along with the ROSE egress observations show that it took around 22--26 days for the ionospheric peak altitude of the equatorial and mid-latitude region of the SH to respond to a global storm event that originated in the mid-latitude region of the NH.

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