EFFECTS OF MORELIAN METEOROID ON THE IONOSPHERE

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Abstract:

On February 19, 2020, a meteoroid passed and exploded in the atmosphere near the city of Morelia, Mexico. We present the results of analysis of its effects on the ionosphere. First, the meteoroid trajectory, velocity and time of occurrence were calculated. Furthermore, the object's initial diameter, density, mass, velocity, energy and their change in time during the meteoroid flight in the atmosphere were estimated using modeling. Finally, two approaches were used to study the spatial-temporal propagation of ionospheric disturbances. High-rate (10-50Hz) L1C and L2PY GPS observations from local GNSS receivers were used for scintillation indices (d2fi, $\sigma\varphi$, S4 and ROTI) calculation which is a new approach. The lower resolution data (15-30s) was used to obtain filtered slant Total Electron Content (sTEC) values which is a "classical" approach. sTEC series were detrended with splines, filtered with the centered moving average and converted to equivalent vertical variations (dIv).

The analysis of parameter variations showed that the revealed ionospheric disturbances were generated by shock waves excited by the meteoroid flight and explosion and not by the geomagnetic perturbations or solar terminator passage which were close in time. The first ionospheric effects were registered (2.5-3.5) min after the explosion and have the amplitudes of (0.1-0.2) TECU that exceeded the background fluctuations in the previous quiet and geomagnetically disturbed days. Intermediate- (several km size), small- (01.-1km), shock-acoustic-wave-scale (300-400m in our case) and sometimes medium-scale disturbances were detected. These disturbances corresponded to the range of acoustic-gravity waves. They quickly attenuated with distance (almost no response at more than ~600 km from the explosion epicenter). Their propagation was non-uniform: more pronounced northwestward and along the direction of the meteoroid trajectory (including behind it) and less pronounced southeastward and backward from the direction of the flight. This asymmetry could be due to the complex winds picture and maybe the shift of the secondary disturbance source northward from the explosion. Though the Morelian meteoroid was smaller and of less energy than other known meteoroids, it is an interesting case because, to the best of our knowledge, it is the first low-latitude meteoroid with the detected ionospheric effects.

References: Sergeeva et al., Assessment of Morelian Meteoroid Impact on Mexican Environment // Atmosphere, 2021, doi: 10.3390/atmos12020185.

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