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Flare Effects in Mars's Ionosphere Observed by Mars Express Topside Sounding

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Since the beginning of Solar Cycle 24, there have been several strong solar flares, one of which, on 22 September 2011, may have contributed to the safing of the Mars Express Spacecraft. The Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS) instrument on board Mars Express, in orbit around Mars, can be used in Active Ionospheric Sounding mode to detect disturbances of the Martian ionosphere. In this presentation, we identify several high-energy particle events at Mars originating in solar flares, including that of 22 September 2011, using in situ particle data from the High-Energy Neutron Detector (HEND). HEND is part of the Gamma Ray Spectrometer on board the Odyssey spacecraft, also in orbit around Mars. Using the timing of the high-energy particle events from HEND, we use MARSIS ionospheric electron density profiles, local electron densities, and surface reflection absorption to track the effect of flare particles on the Martian ionosphere. We incorporate data from the Mars Express particle and plasma instrument ASPERA-3 to show effects on the particle distribution in the ionosphere and to note an extension of the nightside ionosphere to altitudes of several thousand kilometers approximately one day after the particle onset. The flux peak of the 22 September 2011 event coincides with intense spread-F-like echoes near the ionospheric peak and in the "upper layer" ionosphere, implying a predominance of oblique echoes, even in the absence of strong cusplike magnetic topology. As with previous particle events, the nightside surface reflection disappears due to electron collision damping, and the MARSIS Subsurface-mode signal is obscured by noise. During the most intense fluxes of this flare, the peak of the upper layer structure of the Martian ionosphere remains stable, although less pronounced than during less intense fluxes, suggesting a filling-in of undercut or shelflike structures in the electron density profile above the main layer.