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Formation of V0 Layer in Venus' Nightside Ionosphere Induced by SEP Events

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The V0 layer of the Venusian ionosphere is a sporadic electron-density peak detectable on both the dayside and nightside by radio occultation experiments. Based on the Venus Express Radio Science Experiment (VEx/VeRa) and the Radio Science Experiment onboard Akatsuki measurements, we find the dayside V0 peak typically near ~110 km while the nightside peak lies near ~120 km, yet the formation mechanisms of both remain unclear and nightside studies are scarce (Tripathi et al., 2024). Here, we investigate the relationship between V0 occurrence and solar activity, with emphasis on solar energetic particle events (SEPs). We quantify solar activity using fluctuations in VEx/MAG data and evaluate the association between the nightside V0 occurrences ($\text{SZA} > 110^\circ$) and magnetic-field fluctuations at 3-day and 5-day periods: a chi-square test for the 3-day period yields $p = 0.0004$, indicating a highly significant correlation, whereas the 5-day period yields $p \approx 0.05$ and is less significant. We further analyze the interval 2 – 21 March 2011, when STEREO-A was closely connected to Venus along Parker spiral, using its electron and proton fluxes to represent SEP inputs to the Particles TRansport In Planetary atmosphere (PTRIP) model (Nakamura et al., 2022) to simulate the atmospheric ionization rates, which were then fed into the Photochemical and RadiatiOn Transport Model for Extensive Use (PROTEUS) model to simulate the V0 peak altitude and electron density (Nakamura et al., 2023). The modeled peak heights and densities agree with VEx/VeRa measurements, supporting the proposition that SEPs may be a contributing mechanism for the nightside V0 formation and providing a basis for deeper investigation of Venusian ionospheric dynamics and chemistry.