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Effects of the Northern Hemisphere sudden stratospheric warmings on the Sporadic-E layers in the Brazilian sector

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ABSTRACT

Tidal and Planetary Wave (PWs) amplitudes are strongly influenced by Sudden Stratospheric Warming (SSW) events. A nonlinear interaction between the tidal winds and planetary waves during the SSW may contribute to the intensification of sporadic-E (*Es*) layers in the lower thermosphere. This work investigated the relationship between SSW events in the Northern Hemisphere and the *Es* layer occurrence at low latitudes in the Brazilian sector. We used data from digital ionosondes installed in the observatories of Araguatins (ARA, 5.65° S; 48.12° W; dip lat. −5.44°) and São José dos Campos (SJC, 23.18° S; 45.89° W; dip lat. −21.37°) to analyze the *Es* layers. Additionally, we used the temperature, zonal wind, and PWs data at high latitudes in the Northern Hemisphere during the major SSW event that occurred in February/2018 and during the events of Dec/2018–Jan/2019 and Dec/2020–Jan/2021. The results showed a maximum frequency peak of 20 MHz (~5 × 10^6 electrons.cm^{-3}) at ARA and SJC during these SSW events. The large values of *ftEs*, *fbEs*, and electronic densities were observed between 100 and 115 km height in the $Es_{f/l}$ type layers during daytime or nighttime periods. The results also showed that the number of large values of *ftEs*, *fbEs*, and electronic density of the *Es* layer was much higher in ARA than in SJC, in general. The wavelet power spectrum analyses of the *ftEs* and *fbEs* showed a periodicity of 2-days before and after the central day of the SSWs events at the station of ARA, with three prominent peaks in the 2018/2019 event. At the SJC station the quasi-2-day periodicity in the wavelet analyses of the *ftEs* was observed after the central day in all three SSW events, with a peak before the central day during the 2020/2021 event.

1. Introduction

The sporadic-E (*Es*) layers at low- and mid-latitudes are formed by a vertical thickening of molecular and metallic ions density through the movement of zonal and meridional winds in opposite directions (shearing effect) between 100 and 140 km altitude. The theory of the neutral wind shears postulates that the horizontal motion of winds in opposite directions, in the presence of the Earth's magnetic field, generates a Lorentz force that induces ions to converge through the vertical component of the winds to a height where the amplitude velocity is zero (Whitehead, 1989; Mathews, 1998; Mathews et al., 2001; Haldoupis et al., 2006; Arras et al., 2008; Haldoupis, 2012; Chu et al., 2014). It also requires the presence of a vertical component of the magnetic field through which the electrons follow the ions to ensure the neutrality of the plasma during the formation of the *Es* layers. The majority of molecular and metallic ions in the formation of the *Es* layers are NO^+, O_2^+, O^+, N_2^+, Fe^+, and Mg^+ (Plane et al., 2015, 2018; Lin and Chu, 2017). In general, the main types of *Es* layers found at low latitudes are Es_f (flat), Es_l (low), Es_c (cusp) and Es_h (high). The $Es_{f/l}$ types are formed between 100 and 120 km, with Es_f formed during the nighttime period and Es_l formed during the daytime period. The Es_h type is formed at higher altitudes between about 120 and 140 km, and eventually they may disappear or descend to form the Es_c type (Conceição-Santos et al., 2020).

Solar tides are formed by the absorption of infrared and extreme

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