



Evidence of anti-correlation between sporadic (*Es*) layers occurrence and solar activity observed at low latitudes over the Brazilian sector

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Abstract

Sporadic E-layers (*Es*) are thin and denser layers with high ionization observed at about 100–140 km altitude in the E region. Their formation is mainly associated with the tidal components of the diurnal and semidiurnal winds with the convergence of ions driven by the wind shear mechanism. This present work shows evidence of the relationship between the occurrence of *Es* layers and the solar activity at two observatories located in the Brazilian sector, the near-equatorial site of Palmas (PAL, 10.17° S; 48.33° W; dip lat. -7.31°) and the low latitude station of São José dos Campos (SJC, 23.18° S; 45.89° W; dip lat. -19.35°). The analysis was performed from December/2008 to November/2009 (a period of low solar activity) and from December/2013 to November/2014 (a period of high solar activity) using data collected from two digital ionosondes. Our results show an anti-correlation of the *Es* layer occurrence concerning the solar activity over both stations studied here. A more clearly observed anti-correlation at the SJC station can be attributed to a greater tidal amplitude at low latitudes. Other relevant aspects of the observations associated with the formation of the *Es* layers are highlighted and discussed.

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1. Introduction

Sporadic E-layers (*Es*) occur at most latitudes and longitudes around the globe at altitudes ranging from 100 to 140 km. The *Es* layers may have different formation mechanisms that depend mainly on their location (Kirkwood and Nilsson, 2000; Wu et al., 2005). The most accepted theory on their formation is the wind shear mechanism, which can be related to tidal wind components (Whitehead, 1961;

1989; Mathews, 1998; Pancheva et al., 2010; Haldoupis, 2012; Oikonomou et al., 2014; Andoh et al., 2020). The wind shear mechanism is characterized by the wind components in opposite directions that move the molecular/metallic ions vertically due to Lorentz's force, and they can be converged in a thin layer. The electrons follow the magnetic field lines to maintain plasma neutrality, allowing a new layer. At the magnetic equator and poles, the wind shear is not a favorable mechanism owing to the configuration of the magnetic field lines, thus inhibiting a layer formation (e.g., Arras et al., 2022 and references cited therein). The *Es* layer density is associated with the molecular and metallic ions present in the E region. Metallic ions

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