

# Longitudinal variations of the occurrence of F3 and F4 layers within the southern EIA and their dependence on solar cycle

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## Abstract

This investigation presents for the first time the seasonal and solar cycle variations of the daytime F-layer multiple stratifications (F3 and F4 layers) near the southern crest of the EIA in two different longitudinal sectors of South America. To perform the study, the ionograms recorded from 2007 to 2015 at Sao José dos Campos (23.2°S, 45.9°W), Brazil (eastern sector), and at Tucumán (26.9°S, 65.4°W), Argentina (western sector), are considered. Both sites present a frequency of occurrence of the F3 and F4 layers which is directly proportional to the solar activity, and an annual variation with a maximum in spring/summer and a minimum in autumn/winter. The main result that came out from the analysis is that the frequency of occurrence of the F3 and F4 layers is higher in the western sector than in the eastern sector, and this could be attributed to a different gravity waves activity characterizing the two longitudinal sectors.

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## 1. Introduction

The investigations related to F-layer additional stratifications began in the mid 20's (Appleton, 1927). Bailey (1948) studied the daytime F region and observed that the F2 layer split into two layers (F1 and F2), sometimes with the appearance of multiple stratifications. Also Sen (1949) noticed that the F layer, near the magnetic equator, could split into two (F1 and F2) or more layers (F1, F'2, F''2, and F2).

After these early investigations, the study of the F-layer stratification has been the subject of intense research, especially in recent decades. However, its day-to-day variation as a function of latitude, longitude, season, and solar cycle, during quiet and disturbed geomagnetic activity, is still a subject of intense research and has attracted the attention

of many researchers. This interest is mainly due to the generation process at the base of the phenomenon, that is closely related to both the ionospheric electrodynamics and the ionosphere-thermosphere coupling characterizing the low-latitude and equatorial regions (Balan et al., 1998; Fagundes et al., 2007; Klimenko et al., 2011, 2012a, 2012b; Nayak et al., 2014; Balan et al., 2018; Jiang et al., 2019; Mridula and Pant, 2018; Mridula et al., 2019; Tardelli et al., 2018; Venkatesh et al., 2019).

In this sense, Balan et al. (1998) proposed a mechanism to explain the F3-layer formation in the near-equatorial region. This mechanism takes into account the combination of the F-region vertical plasma drift  $\mathbf{E} \times \mathbf{B}$  (where  $\mathbf{E}$  is the equatorial zonal electric field and  $\mathbf{B}$  the geomagnetic field) and the meridional winds blowing from the summer to the winter hemisphere. This joint action acts in a way to upward the F2 layer in height and thus create favorable conditions for the F3-layer generation during daytime. On the other hand, Uemoto et al. (2011) suggested that in the magnetic low-latitude regions, besides the neutral winds

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