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Effects of Tidal Winds on the Dynamics of the Intermediate Descending Layers at Low Latitudes in the Brazilian Sector: Observational Data and Simulations

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Intermediate descending layers (ILs) are regions of thin and enhanced ionization that form between around 150-200 km. Their formation is mainly associated with the vertical shears in the horizontal neutral winds, which are driven by tidal motions [1]. The ILs tend to have a descending movement to lower heights, where they can merge with the sporadic-E layers (120-140 km). Observations of ILs have been reported for over seven decades by using different experimental techniques, such as ionosondes and radars. In terms of modeling, several studies have also led us to a current understanding of the processes involved in the formation and dynamics of these layers.

The present work investigates the characteristics of the ILs observed by ionosondes installed at two stations located in the Brazilian sector, São José dos Campos (23.2°S; 45.8°W; dip lat. -21.0°), and Palmas (10.2°S; 48.3°W; dip lat. -8.3°). Then, we examined from numerical simulations the role of the tidal winds on the descending motion of the ILs. For this, we employ an extended version of the Ionospheric E-Region Model (MIRE), which incorporates neutral wind data and atmospheric tides inferred from meteor radar data. The wind shearing is analyzed in the MIRE model by computing the vertical velocity of the ions, as follows [2]:

$$\boldsymbol{V}_{iz} = \frac{\omega_i^2}{(\nu_{in}^2+\omega_i^2)}\left[cosI.sinI.U_x + \frac{\nu_{in}}{\omega_i}.cosI.U_y\right], \quad (1)$$

where ω_i is the gyrofrequency, ν_{in} is the ion-neutral collision frequency, I is the magnetic inclination angle, and U_x and U_y denote, respectively, the meridional (southward) and zonal (eastward) components of the neutral winds.

The ionosonde data collected in the years of 2008-2009 from each observatory were grouped to represent each seasonal period. The observational results revealed that the ILs occurs predominantly during daytime, with a peak rate between about 09-11 LT. The height variability of the ILs over both stations ranged mostly between around 130-190 km for all seasonal periods, with the highest average critical frequencies attaining values from ~4.0 to 4.5 MHz. The MIRE simulations showed that the ILs result primarily from wind shear ion converging effect of the semidiurnal tidal oscillation in the meridional component of the neutral winds. However, for the observatory of Palmas, the amplitude of the winds into the model was adjusted by a factor of 1.5 to find results more consistent with the observations. We may conclude from this work that the prevailing wind direction and tidal oscillation affecting ion motion and controlling the ILs altitude descent is associate to the shearing in the meridional component of the neutral winds, with the semidiurnal tide being the dominant tidal mode.

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