The Behavior of the Classical Diffusion Tensor for Mid-Latitude Ionospheric Plasma

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Why is Study of the Ionosphere Important?

- It affects all aspects of radio wave propagation on earth, and any planet with an atmosphere
- Knowledge of how radio waves propagates in plasmas is essential for understanding what's being received on an AWESOME setup
- It is an important tool in understanding how the sun affects the earth's environment

In this study, the relationship between the classical diffusion tensor (D_0 , D_1 , D_2 for steady-state case) and the equatorial anomaly is investigated by taking the geometry of Earth's magnetic field as $\mathbf{B}=B_0\mathbf{z}$ *for both solstices of these two different latitudes of ionospheric plasma. Examination is made for the altitudes (280, 300, 340, 390 and 410 km) where the observations are predominantly referenced to the equatorial anomaly.*

2. The Classical Diffusion Tensor

The behavior of the ionospheric plasma and the neutral thermosphere is subject to the equation of state (perfect gas law) and the general conversion equations for mass, momentum and energy :

a) Continuity equation :

Density change = Production – Loss– Transport

b) Equation of motion :

Acceleration = Force– Drag– Transport

Temperature change = Heating– Cooling– Conduction

If it does not have an impact outside, the transport of particles in the ionosphere plasma from place to place results from the pressure-gradient (∇P). This force occurs in any part of the plasma density to eliminate inhomogeneity. If **B**≠0, the medium is called the anisotropic. Thus, the ionospheric plasma can acceptable anisotropic

If **U** and m are the velocity and mass of the electron, respectively, then the force acting on the electron is as follows:

$$m\frac{d\mathbf{U}}{dt} = -e(\mathbf{U}\times\mathbf{B}) - m\nu\mathbf{U}$$

$$\nu_{ei} = N\left[59 + 4.18\log\left(\frac{T_e^3}{N}\right)\right]\times 10^{-6}T_e^{-3/2}\left[\mathrm{m.k.s}\right]\text{and }\nu_{en} = 5.4\times 10^{-16}N_n T_e^{1/2}\left[\mathrm{m.k.s}\right]$$

the velocity and fields vary as $e^{i(\mathbf{k}\cdot\mathbf{r}-\omega t)}$

where ω is angular wave frequency, and
ω_c is electron angular gyro frequency.
Its vector components are

$$\boldsymbol{\omega}_c = \frac{-e\mathbf{B}}{m}$$

We assumed that the z-axis of the coordinate system with its origin located on the ground is vertical upwards. When the real geometry of the earth’s magnetic field is used for the steady-state (∂/∂t=0, that is, ω=0), the diffusion tensor of the solution of eq.(2) is obtained as the diffusion coefficient, depending on the real geometry of the earth.

From here, the diffusion tensor depending on flux equation as follow

$$\mathbf{\Gamma} = \mu(\mathbf{\Gamma} \times \mathbf{B}) - \mathrm{D}\nabla \mathrm{n}$$

$$D = \begin{bmatrix} D_1 & D_2 & 0 \\ -D_2 & D_1 & 0 \\ 0 & 0 & D_0 \end{bmatrix}$$

$$\mathrm{D_o} = \frac{\mathrm{k_b T}}{\mathrm{m}\nu}$$

$$\mathrm{D}_1 = \frac{\nu^2}{\nu^2 + \omega_c^2}\mathrm{D}_0 \qquad \mathrm{D}_2 = \frac{\nu\ \omega_c}{\nu^2 + \omega_c^2}\mathrm{D}_0$$

NUMERICAL ANALYSIS AND RESULTS

The classical diffusion tensor ($D_{0,}$ D_1 and D_2 for steady case) at the equatorial F2- L-layer of ionosphere plasma is seasonally (both equinox (solstice (June 21 and December 21) investigated by taking ($B = B_0 z$) the geometry of Earth’s magnetic field for local time (LT) 12.00 and 24.00. Examining was made in the height (280,300,340,390 and 410 km) where the observed predominantly to the equatorial anomaly. The ionospheric parameters used for calculations are obtained using the IRI (International Reference Ionosphere) model.

Fig.1. Change with latitude of the difference of diffusion for June-23 day

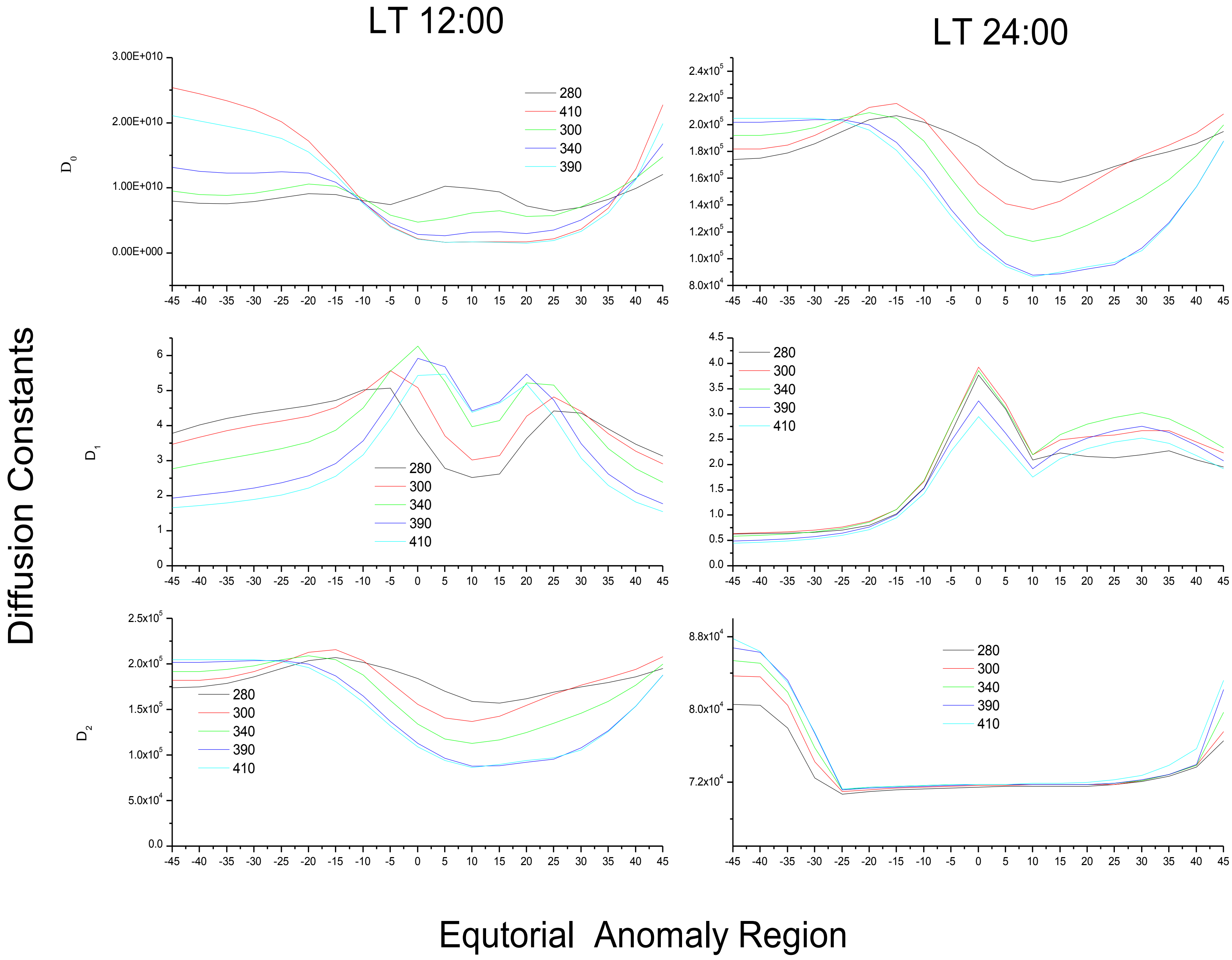
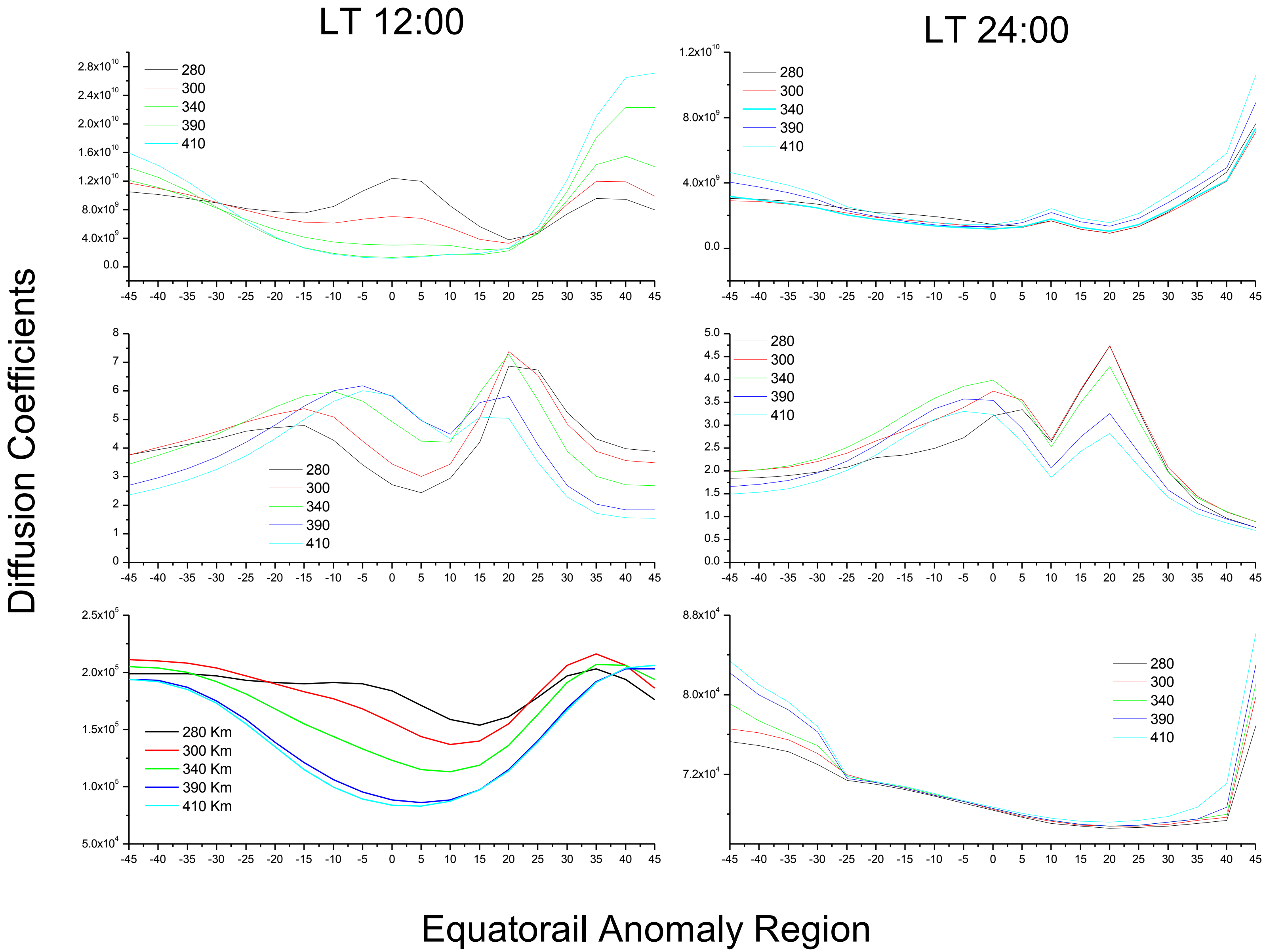


Fig.2. Change with latitude of the difference of diffusion for December-21day



CONCLUSION

The calculated value at 12.00 LT is greater than 24.00 LT in both solstice seasons. This means that no anomaly is observed in the classical diffusion coefficient for the electron density at night. It is seen that all values are higher at 12:00 LT than the values at 24:00 LT for both solstices. This means that the classical diffusion coefficient relates with the night anomaly which is observed with the electron density.

Seasonal (winter) anomaly in the equatorial region (-10^0S, -15^0N) corresponds to 390 and 410 Km for D_0, 280, 300 and 340 Km for D_1 and similar condition to the seasonal anomaly for all altitudes for D_2 (the measured values at 1221 are higher than the measured values at 621) at 12:00 LT. D_0 and D_2 values show seasonal anomaly for all altitudes while D_1 does not show any values for any altitudes at 24:00 LT and dynamo effect.

THANK YOU FOR ATTENTION