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The Study of Variation of hmF2 at Low Latitude During Declining Phase of 24 Solar Cycle

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ABSTRACT:
Background: Variations of maximum height of F2 ionospheric layer are analysed over ionospheric station Austin ($30^{\circ}16^{'}11^{''}$ *N* $97^{\circ}45^{'}25^{''}$ *W*) during year 2018. An analysis was performed on the hmF2 data collected at Austin Station during the 24 solar cycle's declining phase.
Purpose: Measurements made during several seasons are included in the database. The diurnal, monthly and seasonal variations of hmF2 are analyzed.
Method: We have derived hourly values of hmF2 (the real height corresponding to the peak electron density in the F2-region. The maximum height of F2 layer during the daytime show variation with the solar activity. It is higher during the higher activity periods and lower during the periods of low activity.
Conclusions: Solar radiation, Neutral winds and ionospheric electric fields influence hmF2. For diurnal variation, the peak value of hmF2 is at 00:00 hrs (LT) and dips at 09:00 hrs (LT). In this paper, results showed that hmF2 in equinox is higher than in winter. During April hmF2 has maximum value and minimum in December. During nighttime value of peak height decreases and then increases.

Keywords: hmF2, Ionosphere, low latitude, diurnal and seasonal variation, 24 solar cycle

1. Introduction

The height of the peak density of F2-layer (hmF2) is of great importance for ionospheric radio-wave propagation studies, as well as for understanding the physics of the F2 region. Ionospheric parameter, the peak height of the F2 layer (hmF2) have been proved to have regional variations [1, 2]. The hmF2 values also provide useful information from which the meridional winds may be deduced for understanding ionospheric behaviour and also for validating thermospheric general circulation models [3, 4]. The F2 layer peak height (hmF2) is the highest point within the F2 layer, which contains the maximum electron density in the ionosphere. This parameter is crucial for studying ionospheric electrodynamics and high-frequency (HF) wireless communication.

The F2 layer is the highest density part of the ionosphere and plays a significant role in reflecting HF radio waves back to Earth, which is essential for long-distance communication. The ionospheric F2-layer is primarily responsible for the reflection of high frequency (HF) radio waves in the ionosphere. Thus, the F2-layer peak density height hmF2 is one of the most important parameters needed for radio frequency planning and spectrum management. The regular variation of the solar radiation causes temporal and spatial variations of hmF2. Additionally, there is a strong dependency of hmF2 on dynamic forces such as electric fields and neutral winds. Due to regular and irregular variations of the bottom side plasma density closely related to the hmF2 variations, the terrestrial signal transmission may be interrupted or even lost; moreover, the transmission coverage may be affected

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due to up or down lifting of the ionospheric plasma, changing the hmF2 height. Furthermore, the Earth-space transionospheric communication can also benefit from the knowledge of the hmF2. Depending on the solar activity, daytime and season, the peak density height may range from 350 to 500 km at equatorial latitudes and from 250 to 350 km at mid-latitudes.

A few of the workers [5, 6, 7], have compared observed hmF2 with the IRI-90 [8], during low and high solar activity periods at low latitude stations. They have shown that in general, the IRI model predictions are quite reasonable for both levels of solar activity, except for post-sunset conditions during high solar activity, when the IRI highly underestimates the observed hmF2. At all latitudes, the diurnal-seasonal variations of ionospheric parameters corresponding to features of the electron density [9] are considered to be caused by a change of the ion production rate controlled by the solar zenith angle, the neutral composition affected by global thermospheric circulation and temperature, and by plasma transport related to the neutral wind. The common features of the variations of ionospheric parameters shown in this study can be explained by these factors. As for the features at different latitudes, they might be affected by other factors. The low-latitude features can be explained by the influence of the vertical and zonal plasma drifts associated with the low-latitude system of electric fields. The ionospheric parameter, the peak height of the F2 layer (hmF2) with local time (LT) were obtained from manually scaled ionogram data. We also discuss common and specific features of diurnal-seasonal variations of this parameter measured at low latitude during descending phase (2018 year) of solar cycle 24. The aim of this paper is study of diurnal, monthly and seasonal variation and identify peak and dip values of hmF2 during year 2018 at Austin Station.

2. Methods and Material

Data in this paper hmF2 is collected from GIRO (Global Ionospheric Radio Observatory) (uml.edu).

2.1. Data analysis

The collected data is used to study the diurnal and seasonal variations of hmF2 with local time during the year 2018 at station Austin. Data reveals many fluctuations. Here we have looked for patterns and trends in the hmF2 values at hourly of a day during the year 2018 for diurnal variation, monthly and across different seasons (Summer, Winter & Equinox). Also we have analysed peak and dip values of hmF2.

We have used statistical techniques to analyse the data, such as calculating hourly day to day, monthly and seasonal average values of hmF2 during 2018 at Austin Station.

3. Results and Discussion

3.1. Diurnal variation of hmF2

Diurnal variation refers to the changes that occur over a 24- hour period. From the graph plotted in fig. 1, we observe how hmF2 fluctuate throughout the day. The diurnal curves of hmF2 shown in fig.1, are obtained by the procedure mentioned above. It can be seen from the graph that hmF2 has peak value at 00:00 hrs (LT) and dip value around 09:00 hrs (LT) to 10:00 hrs (LT). There appears to be a gradual decrease in hmF2 from 00:00 hrs (LT) to around 10:00 hrs (LT) followed by increase in hmF2 from 11:00 hrs (LT) to 23:00 hrs (LT). During nighttime value of peak height decreases and then increases. There are some fluctuations throughout the day with some periods showing higher values and others minimum values. This variation pattern is due to the diurnal variation of ionospheric conductivities.

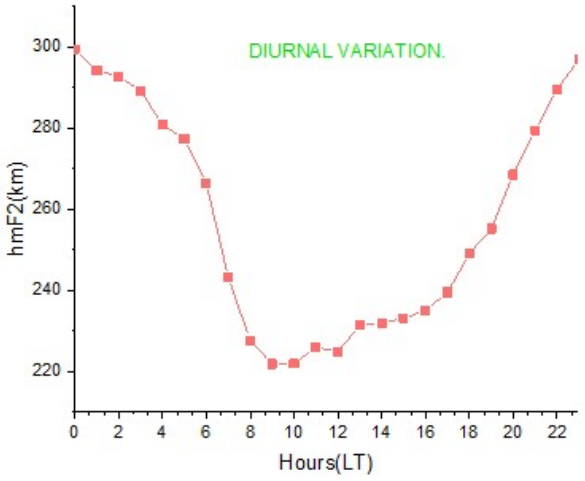


Figure 1: Shows diurnal variation of hmF2 with local time.

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3.2. Monthly variation of hmF2

Since the winter anomaly is observed mainly at the peak height of the F2 layer therefore it is important and interesting to know the monthly variation of hmF2. Monthly hmF2 values averaged over 2018 year is used in this section. Fron graph (Fig 2), it is clearly shown that variation of hmF2 has peak value in April and dips in December. It is clearly shown in graph that hmF2 value increases from January to April and decreases to July thereafter again increases to October then reaches to dip value in December.

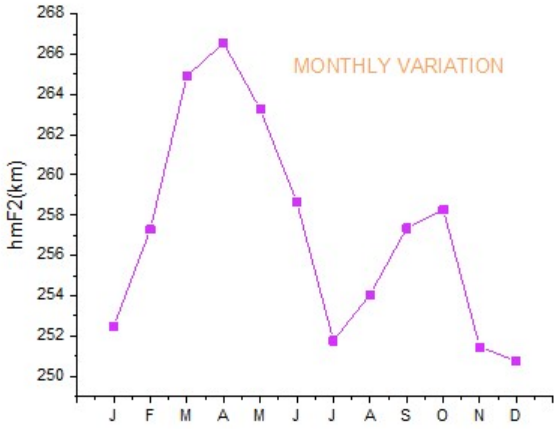


Figure 2: Shows monthly variation of hmF2 during 2018.

3.3. Seasonal variation of hmF2

The below graphs, Fig 3(a), 3(b) and 3(c) are plotted during 2018 for three different seasons, Summer (May, June, July, August), Winter (January, February, November, December) and Equinox (March, April, September, October). It is seen from graph fig. 3(a) that in summer hmF2 is maximum during May and minimum during July. There is a decrease from May to July then gradual increase during August in peak height of F2 layer. Also from graph fig.3(b) in Winter hmF2 value is maximum during February and minimum during December. During Equinox hmF2 is maximum in April and minimum in September as shown in graph fig 3(c).

Fig 3(d) shows the seasonal variation of hmF2 during 2018. The value of hmF2 is maximum during Equinox and minimum during Winter. The hmF2 values obtained are averaged over the respective months to represent the seasonal predicted value. It can be observed from the graph below that hmF2 shows a large

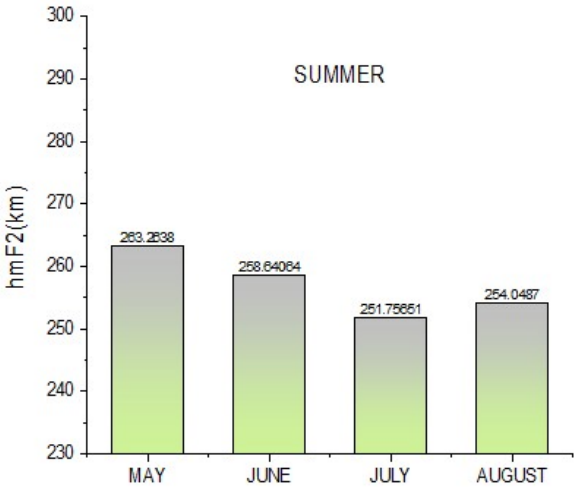


Figure 3(a) shows summer variation of hmF2 during 2018.

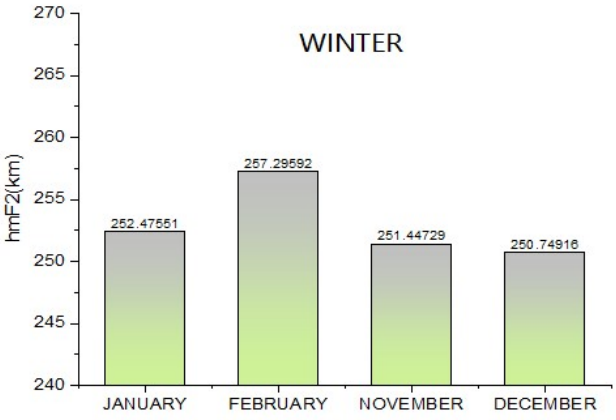


Figure 3(b) shows winter variation of hmF2 during 2018.

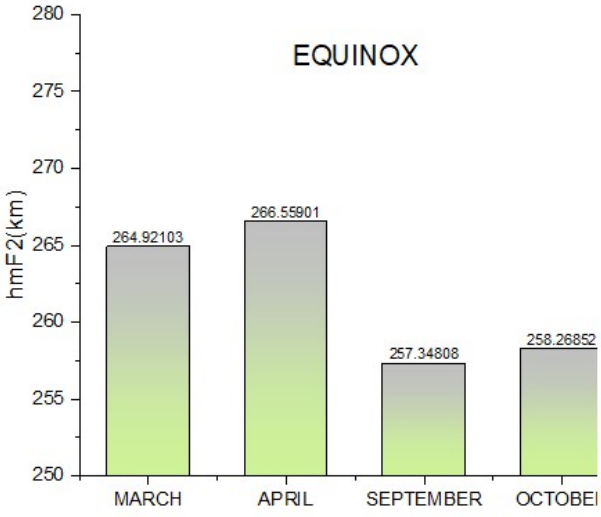


Figure 3(c) shows equinox variation of hmF2 during 2018.

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seasonal variation with peak value during Equinox and dip value during Winter.

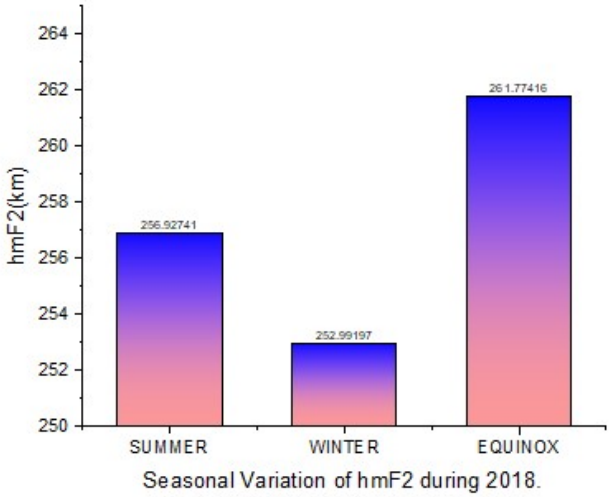


Figure 3(d) shows seasonal variation of hmF2 during 2018.

The present study describes the variation of hmF2 at Austin station which lies on low latitude hence, will be effected by equatorial E × B drift, as well as by thermospheric neutral winds. Therefore, the results described above are explained both in terms of E × B drifts and thermospheric winds. The maximum values of hmF2 around midnight are caused by an increase of upward drifts produced by meridional winds in the neutral air [10, 11], while around sunrise hours, with the beginning of intensive ionization, the electron concentration near the F2-peak increases at a rate which depends primarily upon the production rate, and thus, the layer maximum shifts downwards due to rapid production of ionization in the lower F-region [12]. In the daytime, as the temperature increases, the concentration of atomic oxygen and loss coefficient, which is proportional to the molecular components, both increase, resulting in higher altitudes of layer maximum; accordingly, the increase of hmF2 from morning to afternoon is due to an increase in the temperature. In the evening as the rate of ion formation decreases, a transitional period follows during which the height of layer maximum increases to its nighttime value, and this process is enhanced by a change in the direction of the thermospheric winds, since an upward drift causes an additional uplift of the layer. The drift rate increases towards midnight, resulting in a rise in the F2-layer around midnight. Thus, thermospheric winds play a significant role in the diurnal variation of hmF2.Studies of hmF2 diurnal, monthly and seasonal variations continue those made earlier for low latitudes. As for diurnal variation at Austin station, it is decreasing during nighttime and then increases. To summarize, we mention that, the variation of hmF2 at Austin is found to be similar to those observed at two low-latitude stations, shown by [7, 13]. The value of hmF2 during daytime increases as (a) solar radiation increases ionization and heating. (b) Neutral wind and temperature increases. The hmF2 value mainly exhibits annual variations which are larger at low latitudes than at high ones, and are larger in summer than in winter [14].

4. Conclusion

From above results and discussion we conclude that 1) For diurnal variation, the peak value of hmF2 is at 00:00 hrs (LT) and dips at 09:00 hrs (LT). During nighttime value of peak height decreases and then increases. 2) For monthly variation, the value of of hmF2 is maximum in April and minimum in December. 3) For seasonal variation, the value of hmF2 is maximum in Equinox and minimum in Winter.

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