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Advances in Space Research 33 (2004) 869–873
ADVANCES IN SPACE RESEARCH (a COSPAR publication)
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Comparative study of ionospheric characteristic parameters obtained by DPS-4 digisonde with IRI2000 for low latitude station in China

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Received 19 October 2002; received in revised form 6 May 2003; accepted 17 July 2003

Abstract

Data of f_oF2, h_mF2, B0 and B1 with half hourly interval resolution, which are scaled and deduced from ionograms recorded by DPS-4 digisonde at the low latitude station Hainan, China for the time period of March–August 2002, are analyzed for the diurnal and seasonal variation behavior of the ionosphere using the calculated monthly medians. Comparisons between the observational result and that of the International Reference Ionosphere model (IRI2000) are made. Our present study showed that: (1) For f_oF2, both CCIR and URSI choices in the IRI model produced reasonably good result during daytime hours, but they underestimated f_oF2 value for nighttime hours and in some cases also in the afternoon hours. (2) For the peak height h_mF2, when the CCIR model for M(3000)F2 is chosen, IRI model results are in a poor agreement with observations, especially during hours spanning from afternoon to pre-sunrise; When the measured M(3000)F2 value is used as the F2 peak input, the IRI-produced h_mF2 has a much better agreement with the observed value than when the CCIR model for M(3000)F2 is used. With the measured M(3000)F2, IRI can reproduce quite well the observed features such as the three peaks occurring in the pre-sunrise, near local noon and in the evening hours. However, it still underestimates the observed value during nighttime hours. (3) The bottomside F2 layer thickness parameter B0 given by B0-Gulyaeva choice in IRI2000 is generally in a better agreement with observations than when the newly updated B0-Table choice is used.
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Keywords: Low latitude ionosphere; DPS-4 digisonde; Diurnal variations; Seasonal variations

1. Introduction

The International Reference Ionosphere (IRI) model has been available for more than 20 years. Improvements to this model have been always in progress since its first release in 1978 (Rawer et al., 1978; Bilitza, 1990, 1997, 2001). In the most updated version of it (IRI2000), many new changes have been made to this model (Bilitza, 2001). For the electron density profile part of it, improvement was made regarding the low latitude ionosphere (Radicella et al., 1998; Bilitza et al., 2000). A validation study of the updated model compared to observational results from low latitude ionospheric stations, where no data were included, is necessary. In the beginning of 2002, a DPS-4 digisonde was installed in the low latitude station at Hainan, China. Its geographical coordinates are 19.4°N/109.0°E (geomagnetic coordinates: 8.0°N/178.9°E, DIP = 22.8°). The instrument has been operating since the end of February 2002. In this paper, we will use the ionospheric data obtained by this digisonde to make a comparative study between the observational results and the IRI2000 model. The IRI electron density profile for the bottomside F2 layer is described by an analytic function (Ramakrishnan and Rawer, 1972) in terms of the F2 peak electron density N_mF2 (or the F2 layer critical frequency f_oF2), the peak height h_mF2, the thickness parameter B0 and the shape

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0273-1177/$30. Published by Elsevier Ltd on behalf of COSPAR.
doi:10.1016/j.asr.2003.07.013

parameter B1. Hence, the present study will focus on these four parameters.

2. Data used and analysis method

Data used for the present study are half hourly interval resolution data of f_oF2, h_mF2, B0 and B1 parameters. The time period covered is from March to August 2002. For each month, all days of the month with available data are used. These parameters are scaled and deduced from the ionograms recorded by the DPS-4 digisonde at Hainan. The recorded ionograms, after manually quality control, are converted to the true height electron density profiles by the NHPC program (Huang and Reinisch, 1996), which is embodied in the SAO-explorer software developed by University of Lowell Massachusetts, Center for Atmospheric Research. The thickness parameter B0 and the shape parameter Bl are obtained by best fitting, in a least-square-fitting approach, the observational profiles with the formula used in IRI model (Ramakrishnan and Rawer, 1972)

$$N(h)/N_m\mathrm{F2} = \exp(-x^{\mathrm{B1}})/\cosh(x), \quad x = (h_m\mathrm{F2} - h)/\mathrm{B0}. \tag{1}$$

The profile fitting is made from h_mF2 to h0.24 (the altitude where the electron density equals to 0.24NmF2) if no Fl-layer exists or to the Fl peak if Fl-layer occurs.

Since IRI model represents an average ionosphere, we use the monthly median values of f_oF2, h_mF2, B0 and Bl for the present comparative study.

3. Results

3.1. F2 peak parameters f_oF2 and h_mF2

Fig. 1 shows the diurnal variations of f_oF2 and h_mF2 at Hainan station for the spring (March–April) and summer (May–August) seasons in 2002. Both observational results and those given by IRI model are plotted. For each month, the upper panel shows the plots of f_oF2 and the lower panel shows the plots of h_mF2. For f_oF2, the line with points is the observational result and the IRI model results are plotted with the solid line (CCIR choice) and dashed line (URSI choice). For h_mF2, the observational result is plotted using the line with points. The IRI model uses a formula (Bilitza, 1990) to calculate h_mF2 from the propagation factor M(3000)F2 based on the strong anti-correlation between these two parameters. It offers two options for the IRI users to chose the M(3000)F2: (1) the CCIR M(3000)F2 model value and (2) the measured M(3000)F2. In Fig. 1, IRI results with option (1) and (2) are plotted, respectively, with solid lines and dashed lines.

From Fig. 1, it can be seen that although f_oF2 reached a minimum value at the same local time (around 05:00LT) both for the spring (March, April) and summer (May–August) seasons, the diurnal variation behavior of f_oF2 has some differences between the spring and summer seasons. For the spring season, f_oF2 remains very high and at almost constant value between local noon and midnight time; while for the summer season, it does not remain at a constant high value-two peaks occur in the afternoon and around midnight time. From Fig. 1, it is seen that the results given by IRI model with both CCIR and URSI choices are reasonably good during daytime hours, but they underestimate f_oF2 value for nighttime hours and in some cases also in the afternoon hours.

For h_mF2, the morphology of the diurnal variation is very similar both for spring and summer seasons, with three peak values occurring in pre-sunrise, around local noon and in the evening hours. The most outstanding peak occurs in the evening, especially for the spring season. Apparently this is related to the so-called evening pre-reversal enhancement phenomena often observed in equatorial and low latitude ionosphere. By comparing the observational result of h_mF2 with that given by IRI model, it can be seen that when the CCIR model for M(3000)F2 is chosen, IRI model results are in a poor agreement with observations, especially during hours spanning from afternoon to pre-sunrise; However, when the measured M(3000)F2 value is used, the IRI-produced h_mF2 has a much better agreement with the observational value. With the measured M(3000)F2, IRI can reproduce quite well the observed features such as the three peak values occurring in pre-sunrise, around local noon and in the evening hours. However, it still underestimates the observed value during nighttime hours.

3.2. Bottomside F2 layer thickness and shape parameters (B0, B1)

Fig. 2 shows the diurnal variations of the thickness parameter B0 and the shape parameter B1 given by IRI2000 and those obtained by best fitting the observational profiles to the bottomside F region with Eq. (1). For each month, the upper panel shows the plots of B0 and the lower panel shows the plots of Bl. IRI2000 offers two options for IRI users to chose B0 and B1: (1) The newly updated B0-Table value and B1 and (2) the B0 value based on Gulyaeva-h0.5 (Gulyaeva, 1987; Bilitza, 1990) with B1 = 3. In Fig. 2, lines with points are the observational results. IRI model results are plotted, respectively, with the solid lines (B0 based on Gulyaeva-h0.5) and dashed lines (newly updated B0-Table choice and B1). From the observational results it can be seen that the best-fitted B0 has a high value during daytime and a low value during nighttime, whereas B1 has a low

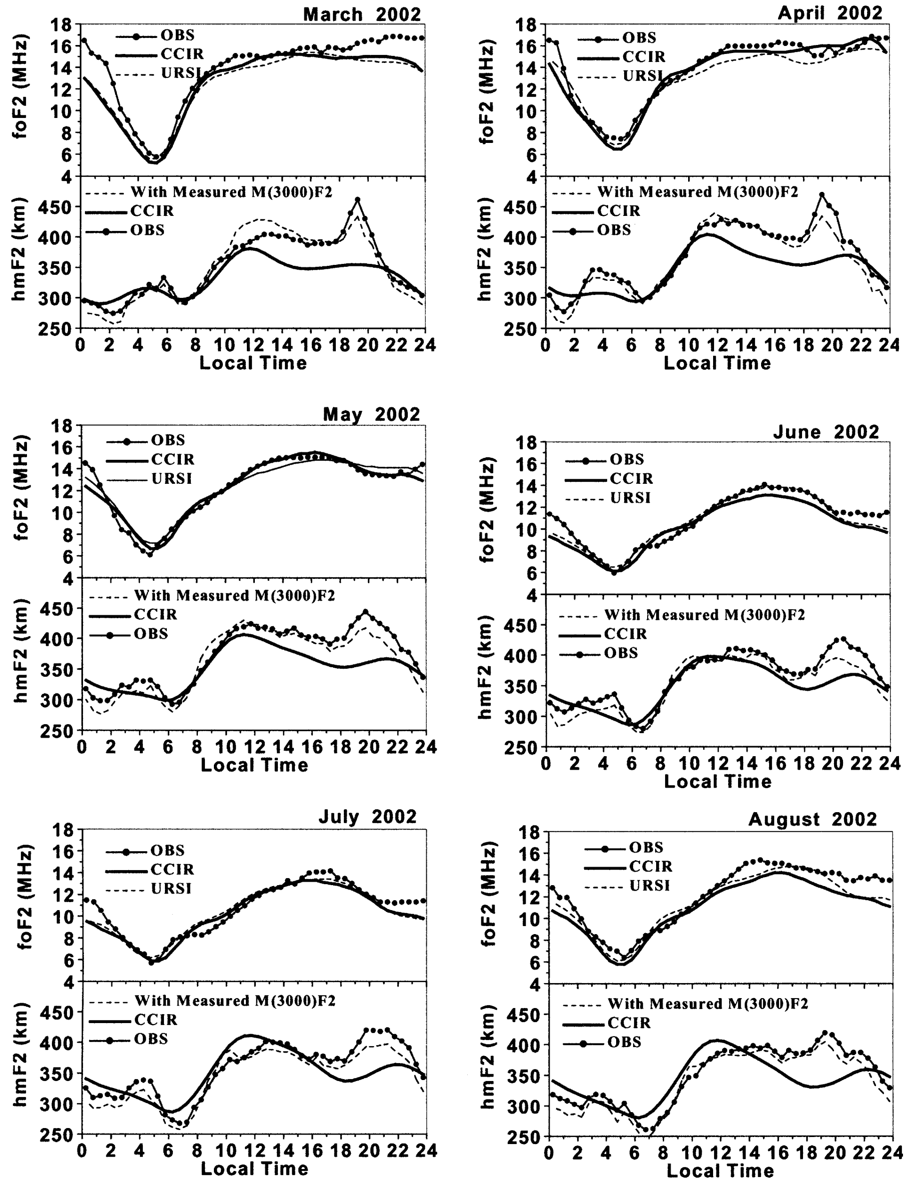

Fig. 1. Diurnal variations of f_oF2 and h_mF2 given by IRI2000 and those observed at Hainan (19.4°N, 109.0°E), China for the months of March–August 2002.

value during daytime and a high value of about 3 during nighttime. The maximum B0 occurred around local noontime in spring months and shifted to earlier (pre-noon) hours when time goes from spring toward summer. By comparing the observational result of B0 and B1 with that given by IRI model, it can be seen that, with the newly updated B0-Table choice, the IRI model result overestimated the observations during nighttime and underestimated the observations during daytime for the months of March–May. While for the months of June–August, the B0-Table choice provided a reasonably good result during 12:00–24:00LT but it overestimated the observations during 04:00–08:00LT and underestimated the observations during 08:00–12:00LT. These results are quite different from those obtained in a similar study by Sethi and Mahajan (2002) for another low latitude station Arecibo (18.4°N, 66.7°W), in which they found during summer, the IRI values agree fairly well with the Arecibo values, but during winter and equinox, IRI underestimates B0 and B1 for the local times from about 12:00LT to about 20:00LT. From Fig. 2, it can be seen that with the B0 based on Gulyaeva-h0.5 choice, the IRI model results are generally in a better agreement with observations than when the B0-Table choice is used.

4. Summary and conclusions

The monthly median data of f_oF2, h_mF2, B0 and B1 with half hourly interval resolution, which are scaled and deduced from ionograms recorded by DPS-4

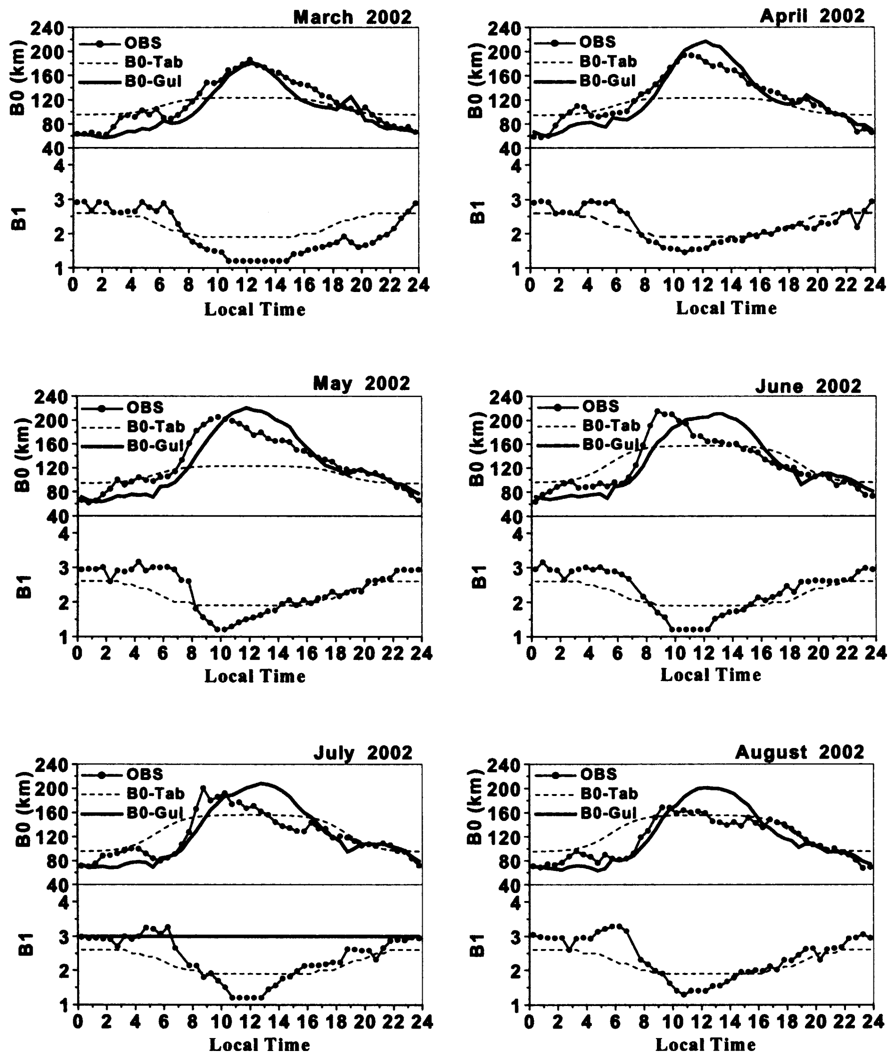

Fig. 2. Diurnal variations of B0 and B1 deduced from observations at Hainan (19.4°N, 109.0°E), China for the months of March–August 2002. The results given by IRI2000 model with B0-Table choice (dashed lines) and B0-Gulyaeva choice (solid lines) are also plotted for comparison.

digisonde at Hainan station in China for the time period of March–August 2002, are used to make a comparative study with the newly updated International Reference Ionosphere model (IRI2000) for the diurnal and seasonal variation behavior of the ionosphere. Our present study showed that for the time period studied:

(1) The IRI model with both CCIR and URSI choices produced reasonably good result on f_oF2 during daytime hours, but it underestimated f_oF2 value for nighttime hours and in some cases also in the afternoon hours.
(2) For the h_mF2 parameter, when the CCIR model for M(3000)F2 is chosen, IRI model results are in poor agreement with observations, especially during hours spanning from afternoon to pre-sunrise; When the measured M(3000)F2 value is used as the F2 peak input, the IRI-produced h_mF2 has much better agreement with the observed value than when the CCIR model for M(3000)F2 is used. With the measured M(3000)F2, IRI can reproduce quite well the observed features such as the three peaks occurring in the pre-sunrise, around local noon and in the evening hours. However, it still underestimated the observed value during nighttime hours.
(3) The results of the bottomside F2 layer thickness parameter B0 given by IRI2000 with B0-Gulyaeva choice are generally in a better agreement with observations than when the newly updated B0-Table choice is used.

Acknowledgements

This work is supported by the Major Program of National Natural Science Foundation of China (NSFC grant no. 40390150) and the Knowledge Innovation Program of Chinese Academy of Sciences (CAS).

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