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AN IONOSPHERIC NUMERICAL MODEL AND SOME RESULTS FOR THE ELECTRON DENSITY STRUCTURE BELOW THE F_2 PEAK

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ABSTRACT

An aeronomical theoretical model fitted to the observed peak data reproduces many observed features including the appearance of an F_1-ledge.

SUMMARY OF THEORY AND RESULTS

A numerical model for the mid-latitude ionospheric profile below the F_2 -peak is constructed /1,2/, based on solving a set of equations for the multi-composition system involving O^+, NO^+, $O_2{}^+$ and $N_2{}^+$, as well as electrons. Dynamic processes of diffusion and wind, and also photo-chemical processes, with 21 reactions for stable as well as meta-stable ions of atomic oxygen are taken into account. The EUV91 model /3/ is used to specify the solar irradiance. Neutral atmospheric density and temperature are provided by the MSIS86 model /4/. The topside O^+ density has been taken from empirical models, e. g., IRI90 /5/, and the neutral meridional wind from HWM90 /6/. Moreover, in order to gain a further realistic ionospheric profile, the model uses the observed foF_2 and the derived hmF_2 (from $M3000F_2$) as input so that the key point on the simulated vertical distribution curve of electron density, namely the F_2-layer peak is the observed value. The model values for the topside density and the meridional wind can be adjusted and even replaced. Thus the resultant profile may be used readily for comparison with the observed ionospheric profile without normalization, and provide useful information for the ionogram inversion when valleys exist and for the empirical modelling of the profile shape like IRI. With the help of the servo model /7/, vertical drifts can be derived from ionosonde data while assuming an equilibrium state of the ionosphere /8/. Using this ionosonde data based drift helps to obtain a more reliable ionospheric profile than using an empirical horizontal wind model like HWM90.

Figure 1 (a) shows the diurnal variation of the electron density profile for Wakkanai (45.6°N, 141.7°E), June 1982 . The F_1-ledge becomes evident with the foF_1 increase and the hmF_1 decrease toward noon. The seasonal change of the profile, as shown in Figure 2(b) where the observed foF_2 and hmF_2 are introduced (i. e. the topside density is modified according to foF_2, and derived vertical drifts are used instead of HWM90), reveals that the F_1-ledge disappears in winter and is much more pronounced in summer under this high solar activity condition. It has been found also the ledge is fully developed near noon in summer for low solar activity.

Peak heights hmF_2 are compared for two set-ups: (1) when HWM90 is used; (2) when the derived vertical drift is used. It appears (see, for example, Figure 2) that there exists much better agreement between the simulated hmF_2 and the observation when derived drifts are used than when HWM90 is used. This implies that the servo model based drift contains very practical information on the ionospheric dynamics so that it can be used to reproduce the hmF_2.

Vertical distributions of the atomic ion O^+ and molecular ions share a common density at the ion transition level situated by day around 180 to 190 km (Figure 3). The present model gives an obvious diurnal change, while the seasonal and the solar activity changes are not so strong as expected.

The model gives also results for the E-F valley size, the width and the depth of the valley. It is found that the width is by day generally around 12 km for low solar activity and slightly wider for high solar activity. The depth, defined as the ratio between the plasma frequency at the bottom of the valley and the critical frequency of the E-layer, is about 0.985 to 0.990 with a larger value at high solar activity.

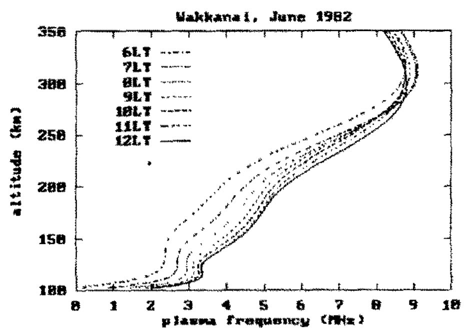

Fig. 1 (a) Diurnal variation of the electron density profile

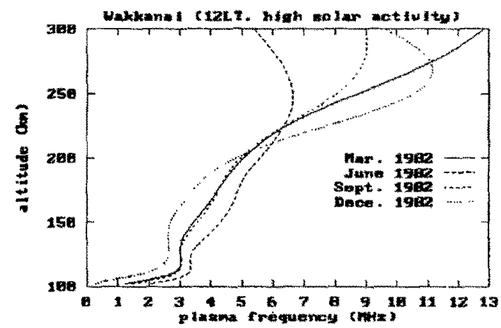

Fig. 1(b) Seasonal variation of computed profile (foF2 and hmF2 are used)

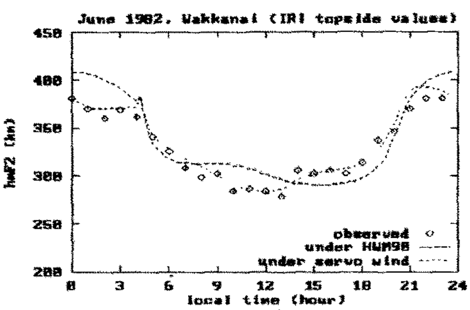

Fig. 2 hmF2 diurnal variation observed vs. computed using HWM90 wind and servo model based drifts

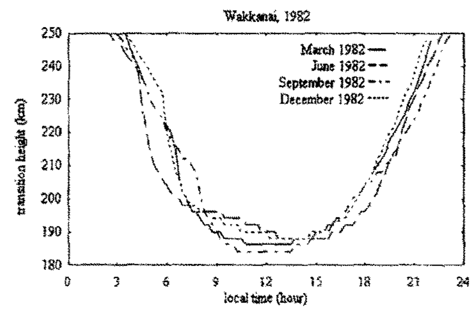

Fig. 3 Variation of the ion transition height with local time for Wakkanai, 1982

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