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DATA VALIDATION OF IONOSPHERIC MODELS AND MAPS (VIM)

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SATELLITE DATA FOR USE IN THE IONOSPHERIC MAPPING

Ivan Kutiev, Stanimir Stankov

Geophysical Institute, Bulgarian Academy of Sciences
Acad. G.Bonchev str., block 3, Sofia 1113, Bulgaria

The satellites which measure the local parameters of the ionosphere and the thermosphere can be of help to ionospheric mapping. Those of them which have topside sounders on board can be used directly, while the local measurements need an inderect approach to be converted to foF2 and hmF.

This paper will briefly discuss the possibility of using the local measurements to obtain the distribution of the ion density along the magnetic field lines and respectively, foF2 and hmF. In spite of the variety of models which can construct the ion profiles, the problem by itself is not an easy one. There is no unique solution to the problem and the construction of an ion profile along the magnetic field lines (and the extraction of foF2 and hmF) has to be regarded as a possibility which depends on the preset limitations and the number of measured parameters used. For the purpose of studying the possibilities for obtaining an ion profile, a steady-state F-region code is used, which includes the equations of continuity and momentum for O^+, H^+ and He^+ ions. These equations are decoupled by introducing a separate equation the polarization field. In this way, seven first order differential equations are obtained and solved along the magnetic field lines. The temperature profiles are obtained by expressions including only the thermal conductivity. The boundary conditions are applied to only one point along the field line and a shooting method is used, by which the preset conditions are achieved.

In order to reduce the uncertainty, the following limitations are introduced:

DAYTIME: The diffusion flow of O^+ is negative (directed downward) below hmF and positive above it. The upward O^+ flow at 1000 km has to be within 0 and 1×10^9 cm^2s^{-1}.

NIGHTTIME: The diffusion flow nV is equal to $C \int (P - L)\, ds$, where C is a function of the volume of the magnetic flux tube and the time t after sunset.

In this paper only daytime conditions are considered. The results presented are merely evaluative in character and reflect separate factors along the order of magnitude. The integration of equations starts from 200 km (or 250 km, depending on neutral atmosphere density) only for O^+. The boundary $V(O^+)$ value has no influence on the computing and that is why it is taken to be equal to zero. In the lower two panels on Fig. 1, a series of O^+ profiles is presented along with their diffusion velocities by using MSIS in DAY 173, LT = 15, LAT = 45° with Ap = 20 and $F_{10.7}$ = 100. For the whole positive range of $V(O^+)$, the corresponding O^+ profiles (curves 3 and 6) lie very close each to other. What's more, the profiles with negative velocities till 10^4 at 1000 km (curves 5 and 6) are also in close proximity to curves 3 and 4, which is of importance to the nighttime case. The conclusion is that the preset condition (the O^+ flux changing its sign around hmF and above) drastically reduces the uncertainty gap and the acquired profile is practically unique. In the upper four panels on Fig. 1 the results of the shooting method are shown, giving the maximal error in defining NmF and hmF for this particular case. The range (0 - $5x10^5$) for $V(O^+)$ at 1000 km (the upper left panel) results in starting values of O^+ at 200 km between $1.673x10^5$ and $1.680x10^5$. This interval correspondingly gives values for NmF between $2.91x10^5$ and $3.66x10^5$, giving 22% relative difference. For hmF, the range is between 250 and 275 km, which gives 10% relative difference. The F-region code and the described technique are applied to a real measurement taken from DE-2 - at 01:32 UT in Feb. 1982, orbit 2966. The local time is 11:45, the altitude - 470 km, the geomagnetic latitude is 45°.Neutral densities at 300 km are: n(N2) = $6.8x10^8 cm^{-3}$ and n(O) = $1.55x10^9\ cm^{-3}$. The O^+ profile obtained is shown on Fig.2. At 470 km the O^+ density coincides with the measured density from DE-2. The change of $V(O^+)$ direction occurs at 460 km, close to hmF. In the lower-right panel the diffusive flow $[O^+]$. $V(O^+)$ is plotted. The escaping O^+ flux is $4X10^8\ cm^{-2}s^{-1}$. Although Fig.2 shows an excellent coincidence, several factors can bring significant errors. These factors are:

1. Accuracy of the measurements.

2. Uncertainty of the actual photoionization rate.

3. Presence of ExB drift.

4. Presence of neutral winds.

5. Uncertainty of the temperature profiles.

Fig. 3 gives an idea how the uncertainties in the neutral densities would result on the determination of NmF and hmF. In the lower panel, these quantities are plotted against the relative variation TD/TD_0 of the total density (n(N2) + n(O)). The ratio $n(N_2)/n(O)$ is kept constant in order to eliminate the influence of the composition. If we consider a measurement accuracy of 30%, then TD/TD_0 will be uncertain in the range 0.85 -1.15. From the Figure we find that the error in determining NmF will be 44% and those of hmF - 3%. In the upper panel the same quantities are plotted against the ratio $n(N_2)/n(O)$ with constant total density. The same type of error can also be extracted here, resulting in 21% for NmF and 3% for hmF. These figures can be regarded as a contribution of the measurement inaccuracy to the computed ion profile. A detailed study of the contribution of the other factors on the accuracy of modeled profiles will give a similar presentation. The results of such a study will be presented in a next paper.

Acknowledgments

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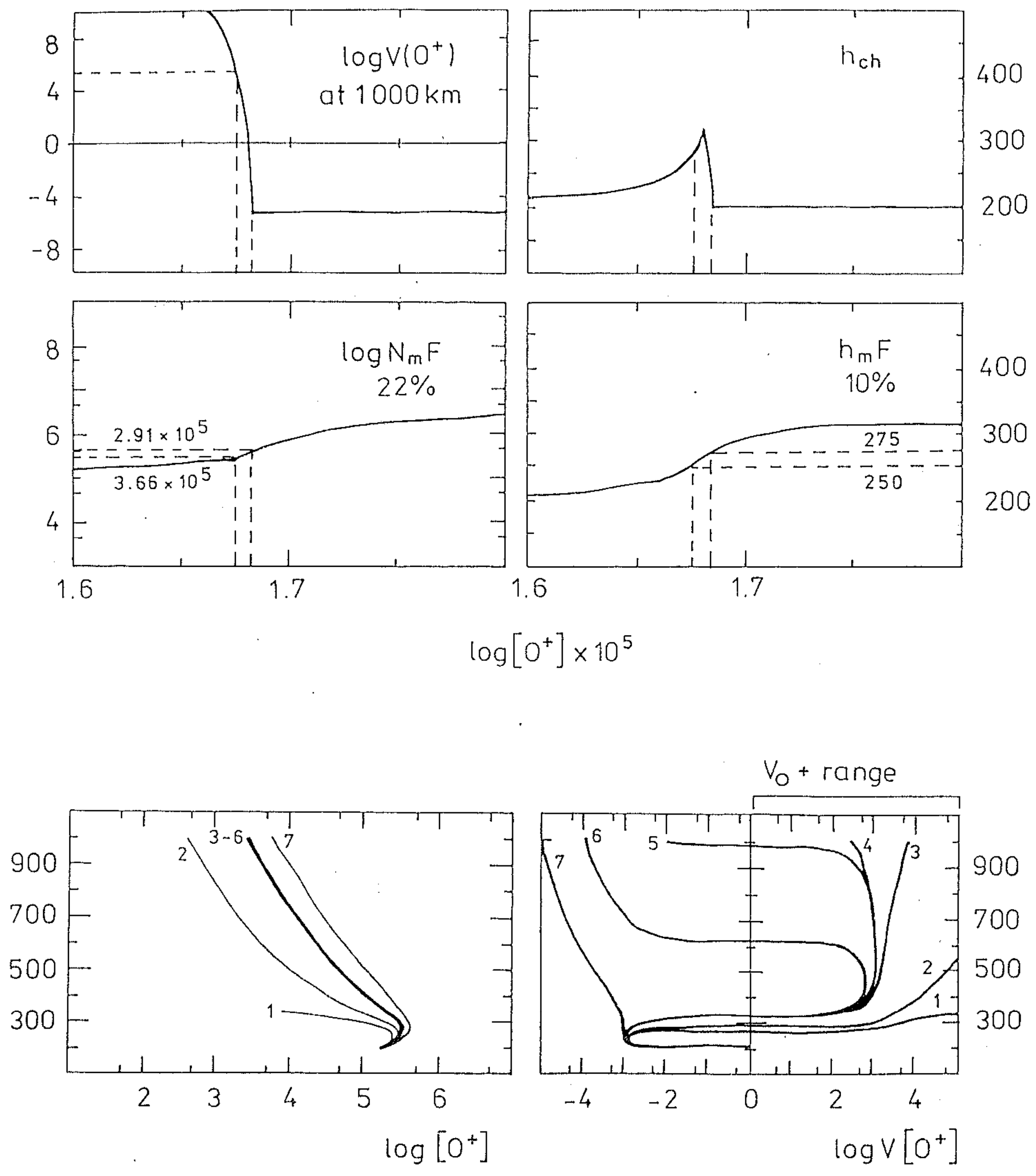
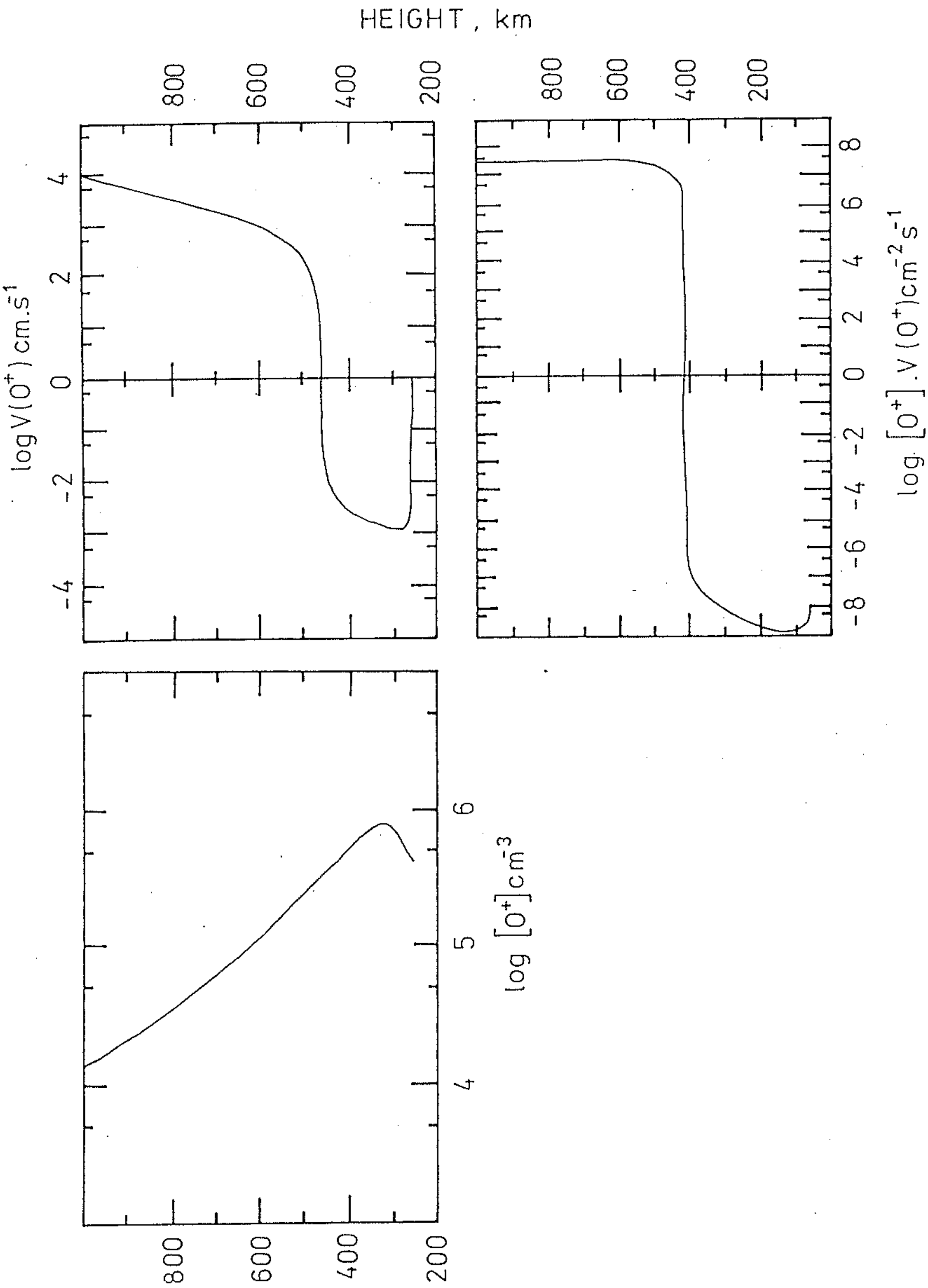
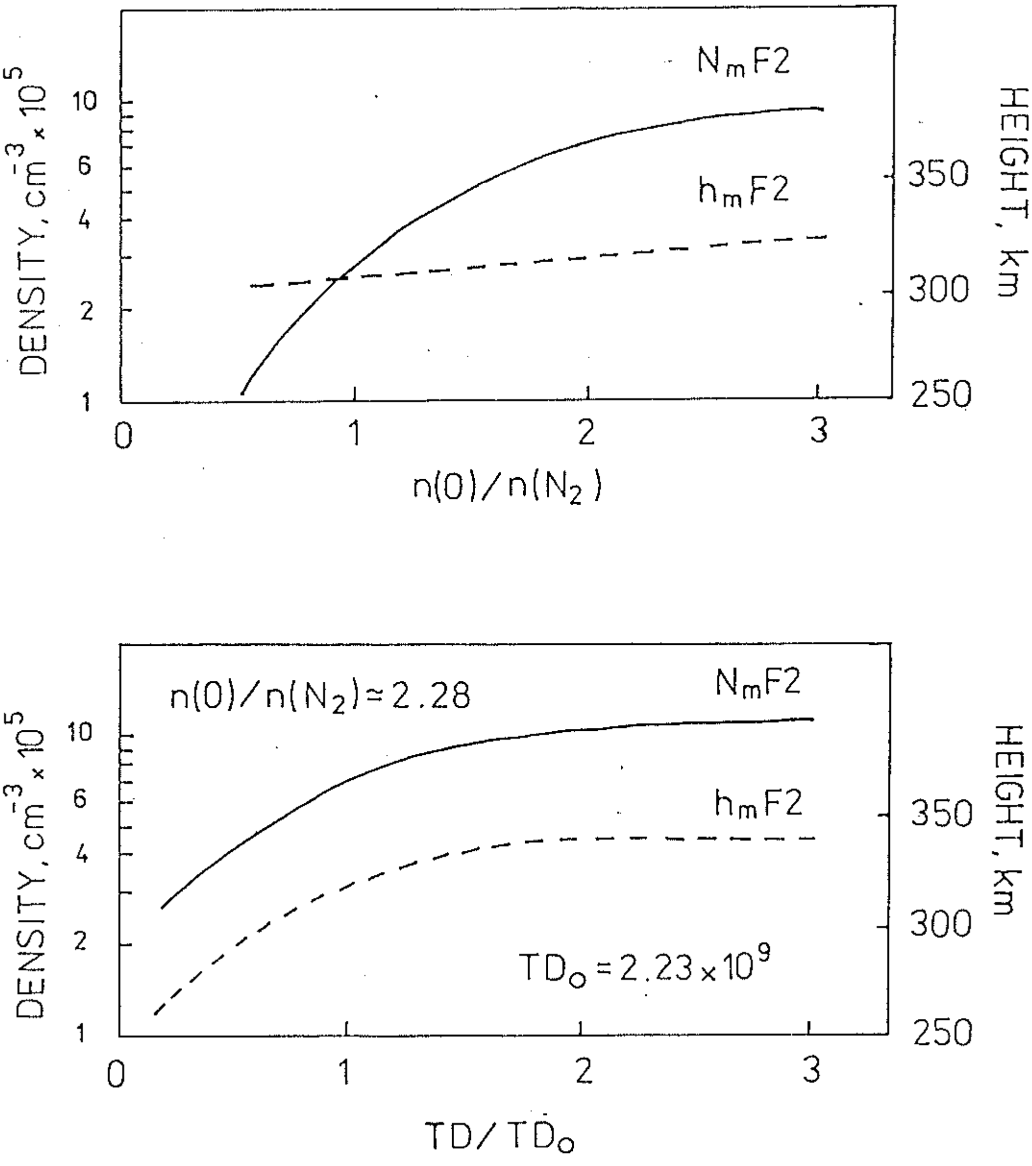

log V(O+)
at 1000 km
hch
log NmF
22%
2.91 × 10^5
3.66 × 10^5
hmF
10%
275
250
log[O+] × 10^5
Vo+ range
log [O+]
log V [O+]

Fig.1



HEIGHT, km
800
600
400
200
$\log V(O^+)\ cm.s^{-1}$
4
2
0
-2
-4
$\log [O^+].V(O^+) cm^{-2}s^{-1}$
8
6
4
2
0
-2
-4
-6
-8
$\log [O^+] cm^{-3}$
4
5
6

Fig. 2



NmF2
hmF2
DENSITY, cm-3 x 10^5
HEIGHT, km
n(0)/n(N2)
n(0)/n(N2)≈2.28
TDo=2.23x10^9
TD/TDo

Fig. 3