INSTITUTE OF SOLAR-TERRESTRIAL PHYSICS
OF SIBERIAN BRANCH OF THE RUSSIAN ACADEMY OF SCIENCES

FEATURES OF DETERMINING THE ELECTRON DENSITY PROFILE, PLASMASPHERE ELECTRON CONTENT AND TRANSITION HEIGHT AT IRKUTSK INCOHERENT SCATTER RADAR

Denis Khabituev, Vladimir Ivonin, Valentin Lebedev

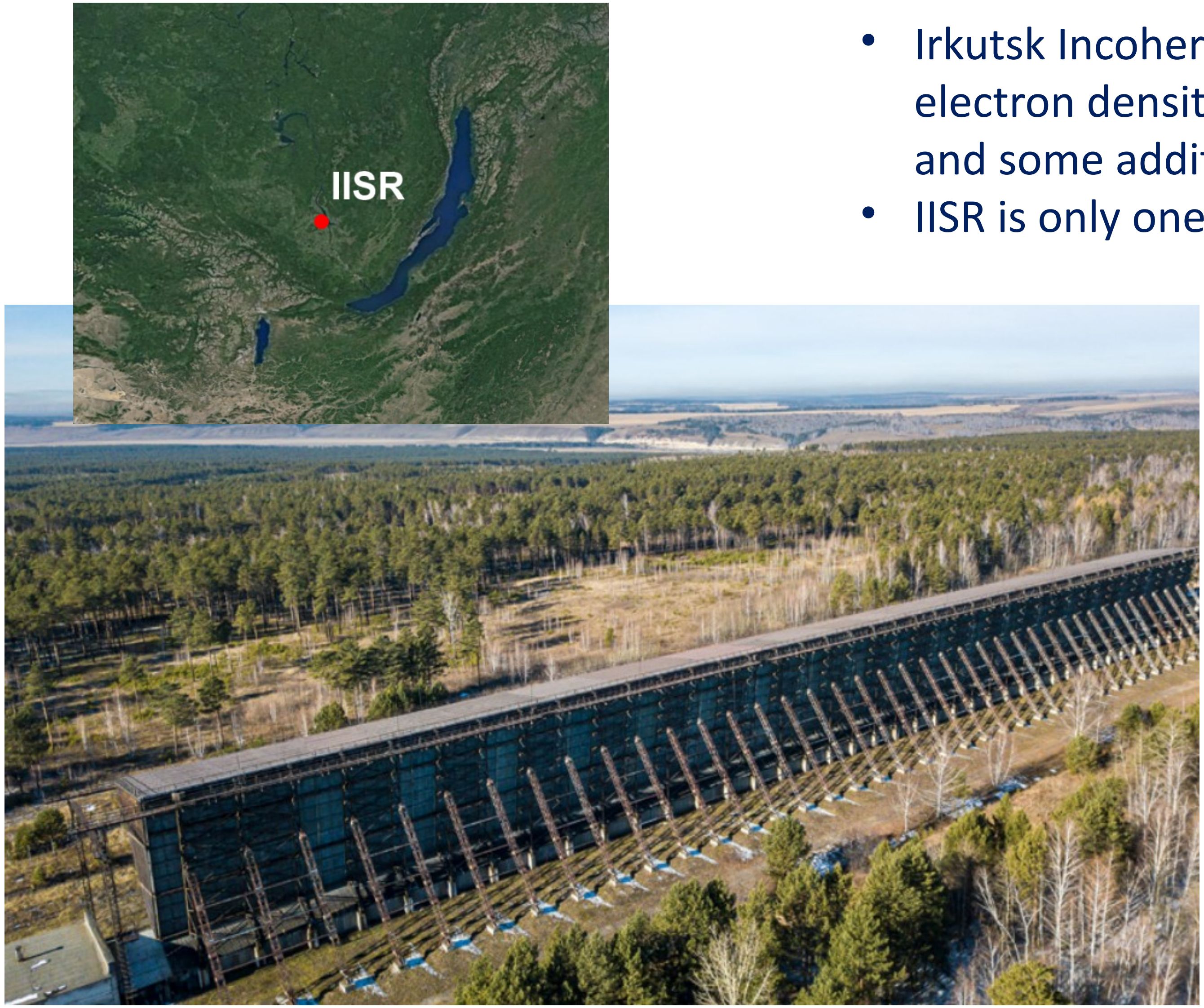
Introduction

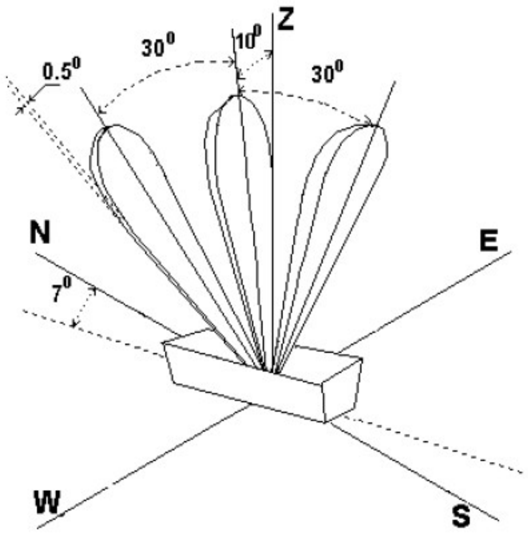
Electron density profile above HmF2 is not available to direct measurements by ionosondes.

The single ground base facility that can measure electron density profile above HmF2 layer is the incoherent scatter radars.

Irkutsk Incoherent scatter radar (IISR) perform quasi-regular measurements since 1993 year.

- Irkutsk Incoherent Scattering Radar can measure profile of electron density, Electron and ion temperature, plasma speed and some additional parameters.
- IISR is only one radar of this type in Russia.



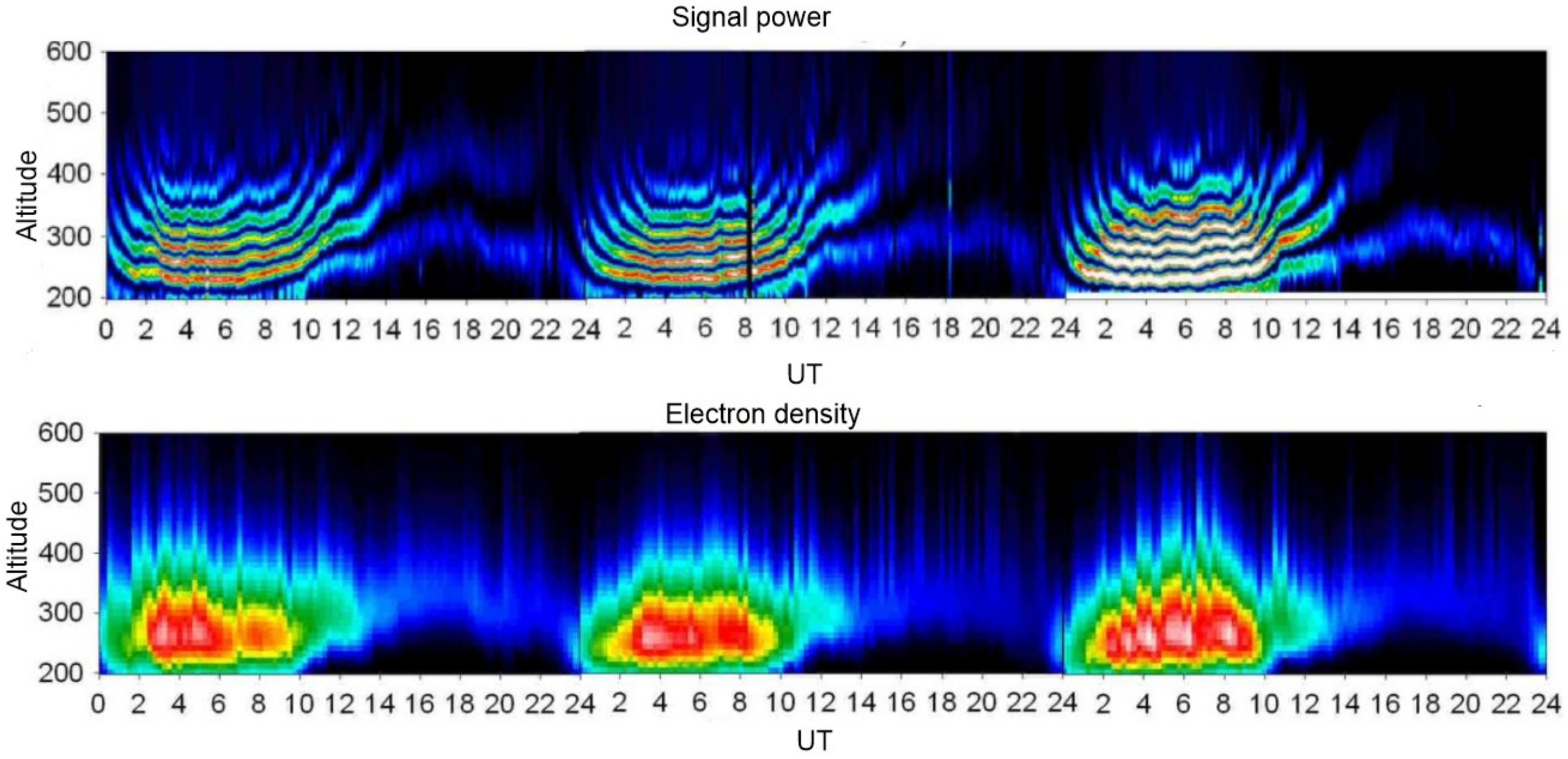


Altitude range of measurements 0 - 600km

Automatic fitting procedure for Ne profile

b-Chapman model

Example of IISR data



$$N_i(h) = N_i(h_m)\exp\left\{c\left[1 - \frac{h-h_m}{H_i} - \exp\left(-\frac{h-h_m}{H_i}\right)\right]\right\}$$

$$c = \begin{cases} 0.5\,,\ \alpha - Chapman \\ 1.0\,,\ \beta - Chapman \end{cases}$$

$$N_i(h) = N_i(h_{mF2})exp\left(-\frac{h-h_{mF2}}{H_{T_i}}\right),$$ ***Exponential***

$$N_i(h) = N_i(h_{mF2})\,\mathrm{sech}^2\left(\frac{h-h_{mF2}}{2H_{T_i}}\right),$$ ***Epstein***

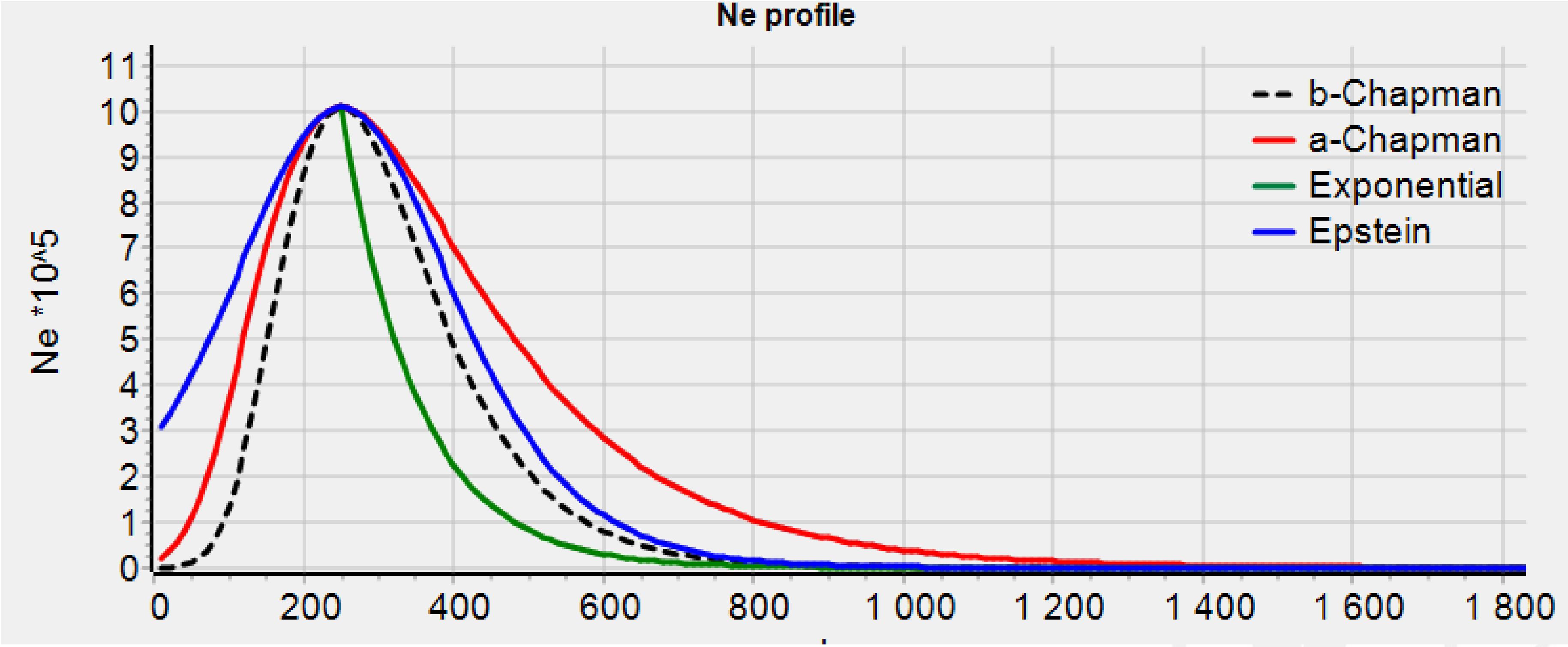
$$H = \frac{RT}{Mg}$$ Scale height (constant)

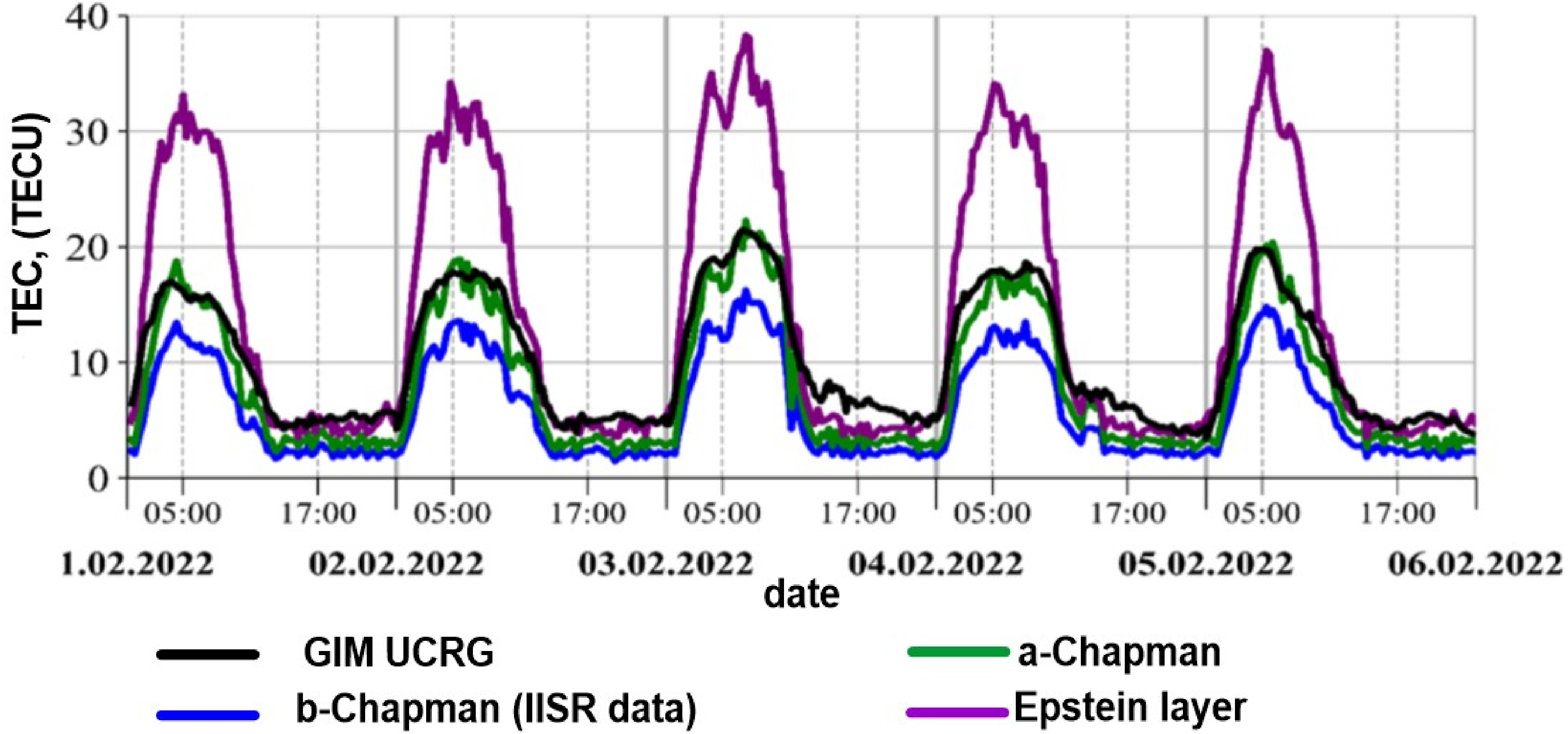
$$N_e(h) = 4N_{mF2}\frac{exp\left(\frac{h-h_{mF2}}{H_T(h)}\right)}{\left(1+exp\left(\frac{h-h_{mF2}}{H_T(h)}\right)\right)^2},$$

$$H_T(h) = H_0\left(1+\frac{rg(h-h_{mF2})}{rH_0+g(h-h_{mF2})}\right),$$

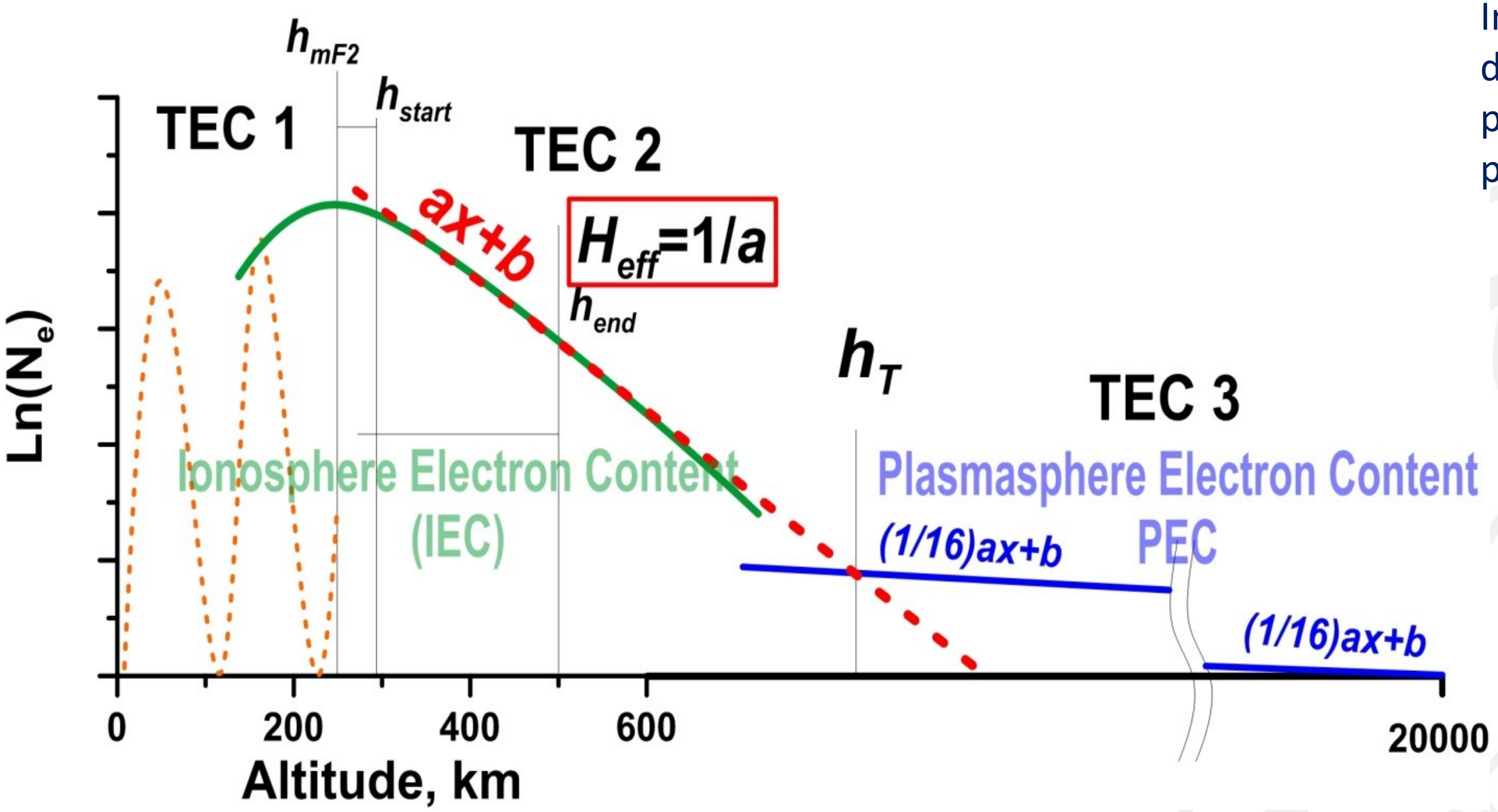
NeQuick2 model

H(h) – function of height

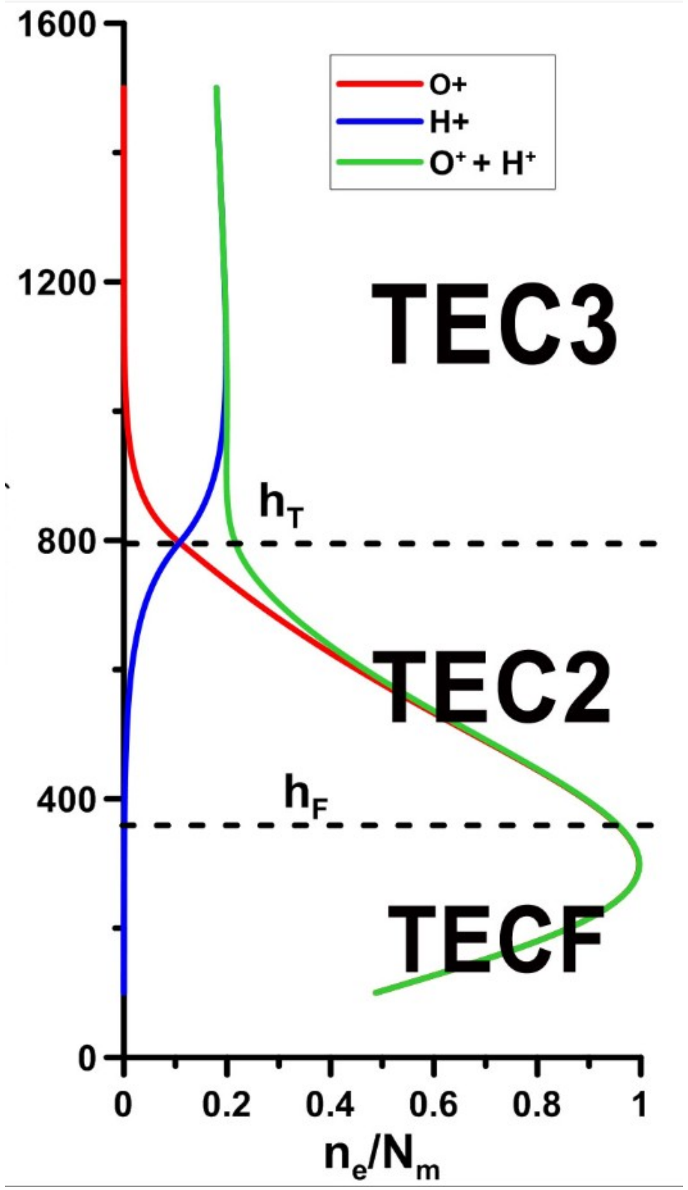

Ne profile
Ne *10^5
11
10
9
8
7
6
5
4
3
2
1
0
0
200
400
600
800
1 000
1 200
1 400
1 600
1 800
b-Chapman
a-Chapman
Exponential
Epstein


40
30
20
10
0
TEC, (TECU)
05:00
17:00
1.02.2022
02.02.2022
03.02.2022
04.02.2022
05.02.2022
06.02.2022
date
GIM UCRG
a-Chapman
b-Chapman (IISR data)
Epstein layer

Shpynev-Khabituev technique (conceptual sketch)



In 1993-2005 IISR operated in different mode and other fitting procedure used to obtain density profile.



O+ and H+ ion distribution according to S-K model.

O^+

$$n_{O^+}(h)=\begin{cases} n_0(h)\left(1-\frac{1}{2}e^{z_T}\right); & h\le h_T \\ n_0(h_T)\cdot\frac{1}{2}e^{-z_T}; & h>h_T \end{cases}.$$

H^+

$$n_{H^+}(h)=\begin{cases} n_0(h)\cdot\frac{1}{2}e^{z_T}; & h\le h_T \\ n_0(h_T)\cdot\left(\exp\left(-\frac{h-h_T}{H_{H^+}}\right)-\frac{1}{2}e^{-z_T}\right); & h>h_T \end{cases}.$$

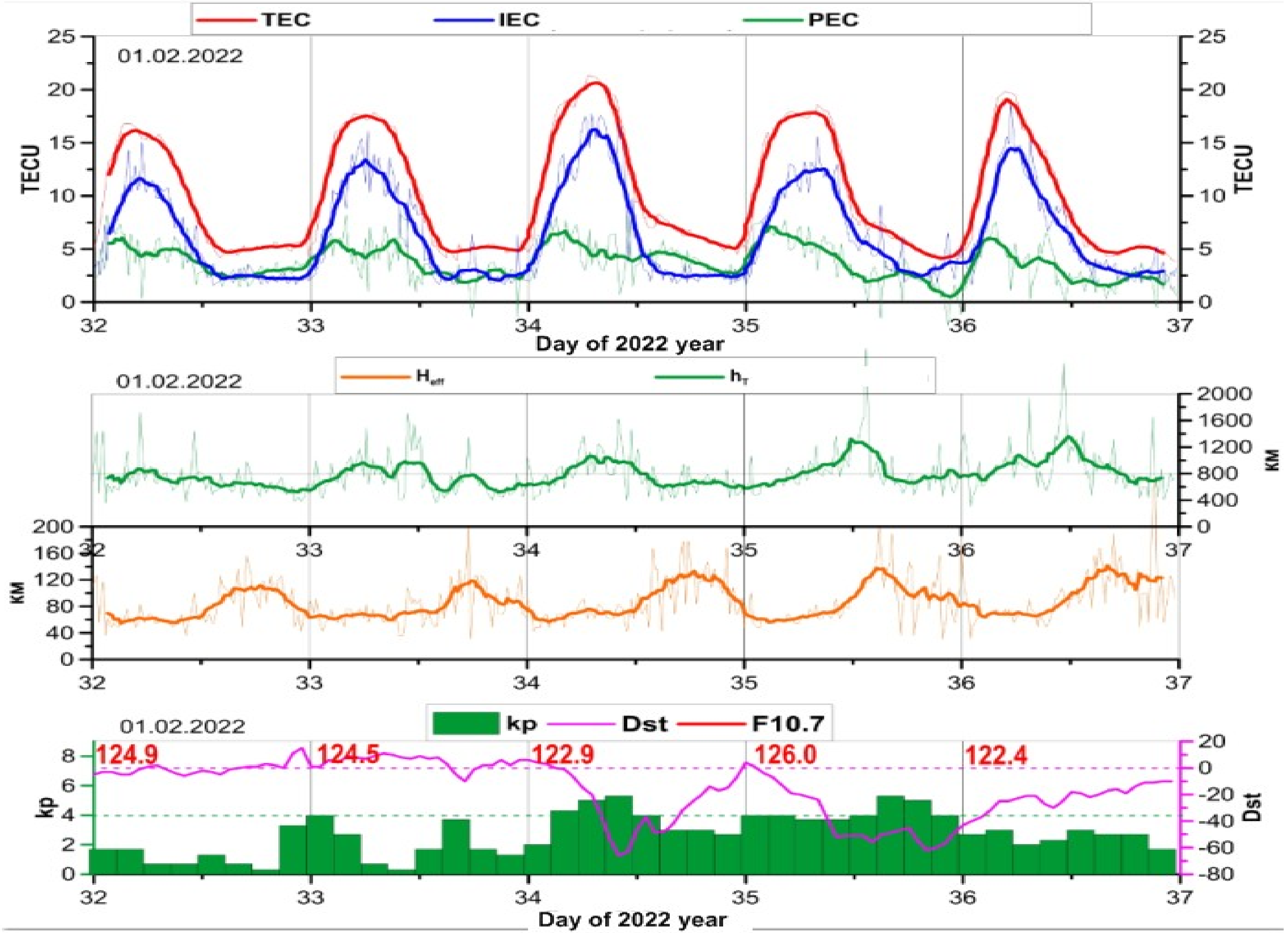
$N_e=O^++H^+$

$$n_{O^++H^+}(h)=\begin{cases} n_0(h); & h\le h_T \\ n_0(h_T)\cdot\exp\left(-\frac{h-h_T}{H_{H^+}}\right); & h>h_T \end{cases}.$$

$$h_T = \frac{1}{a}\ln\left(\frac{a(TEC_{GPS}-TEC1)+exp(ah_{mF2+60}+b)}{exp(b)\left(1+M-\frac{a}{M}h_{GPS}\right)}\right),$$

$$r_{temp} = \frac{T_p(h_{end})}{T_p(h_{start})},\quad T_p=T_i+T_e$$

$$h_T = \frac{r_{temp}}{a}\ln\left(\frac{\frac{a}{r_{temp}}(TEC_{GPS}-TEC1)+exp\left(\frac{a}{r_{temp}}h_{start}+b\right)}{exp(b)\left(1+Mr_{temp}-\frac{a}{Mr_{temp}}h_{GPS}\right)}\right),$$


TEC
IEC
PEC
01.02.2022
TECU
Day of 2022 year
H_{eff}
h_T
KM
kp
Dst
F10.7
124.9
124.5
122.9
126.0
122.4

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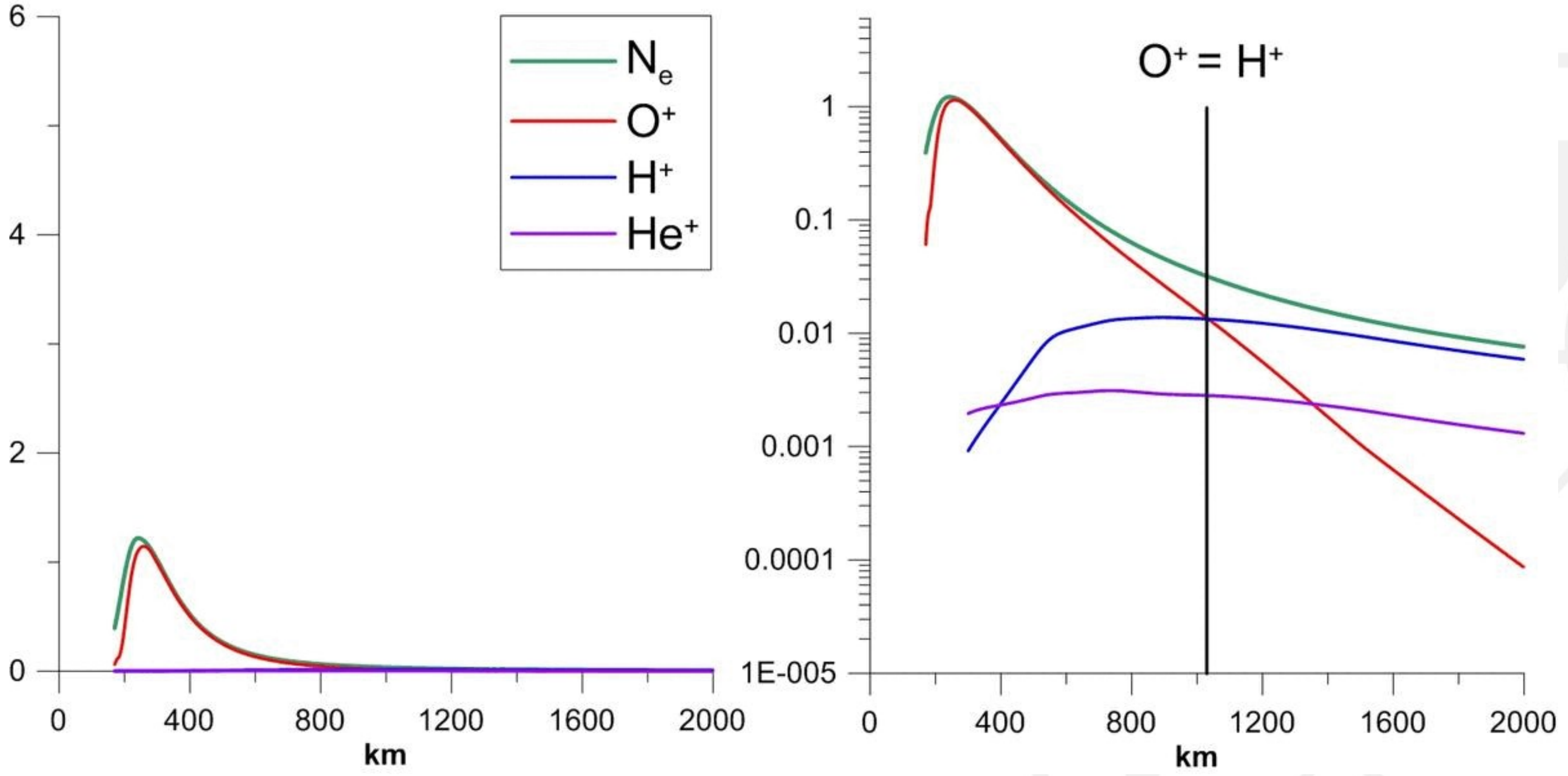
The 15th Russian-Chinese Workshop on Space Weather

IRI 2016 data

date: 2022 February 1

Time: 00 UT



Conclusions

The possibility of approximation topside ionosphere Ne profile by several model was performed. Our work shows that all available models must be used in the fitting procedure.

The S-K method was adjusted to work with IISR radar data based on the b-Chapman profile

Using the S-K method, the transition height values were calculated and the electron content of the plasmasphere was estimated during the geomagnetic disturbed period in 2022 year.

Thank you for your attention