Electron density topside profile estimate with NeQuick model ingesting bottomside parameters

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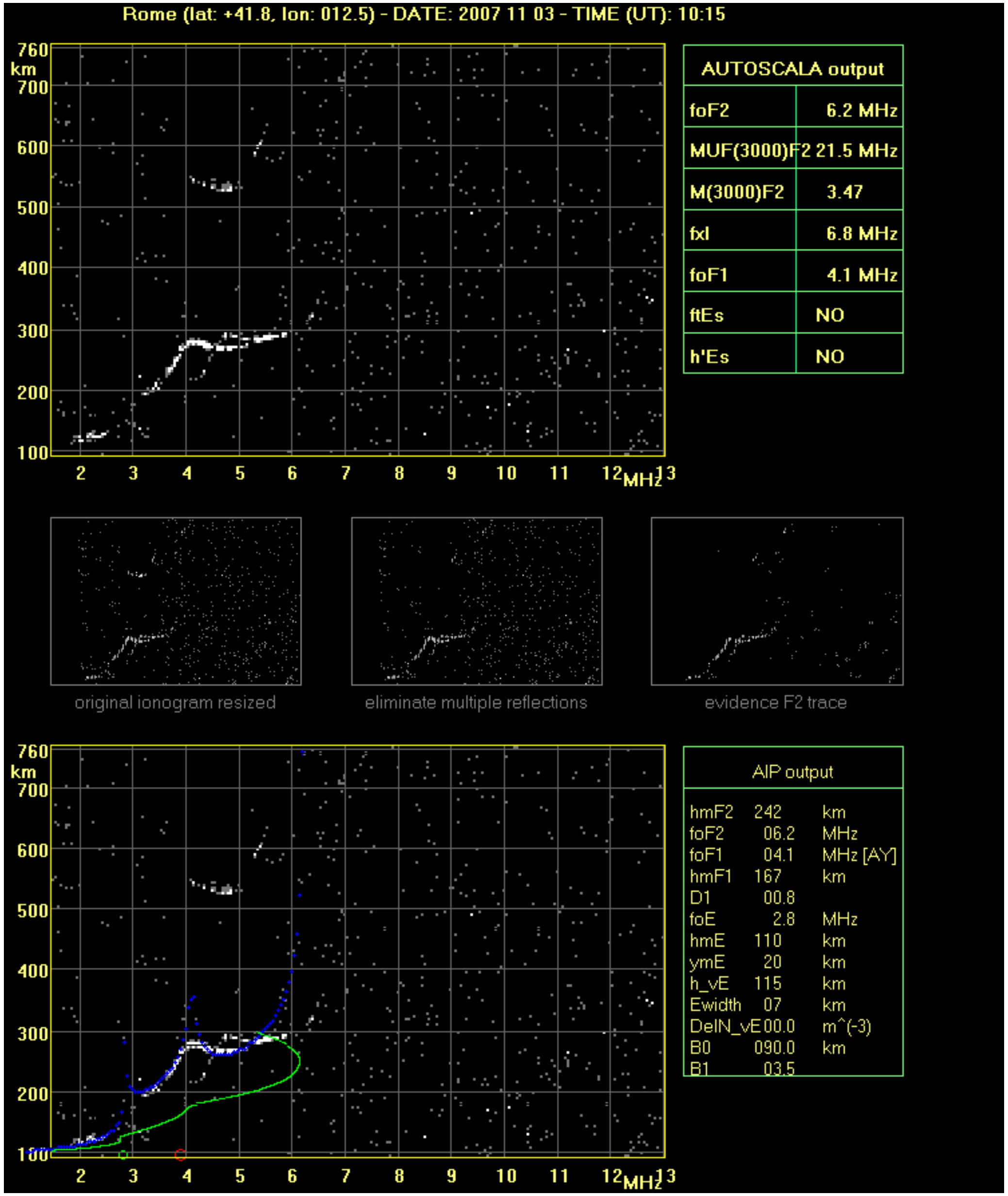
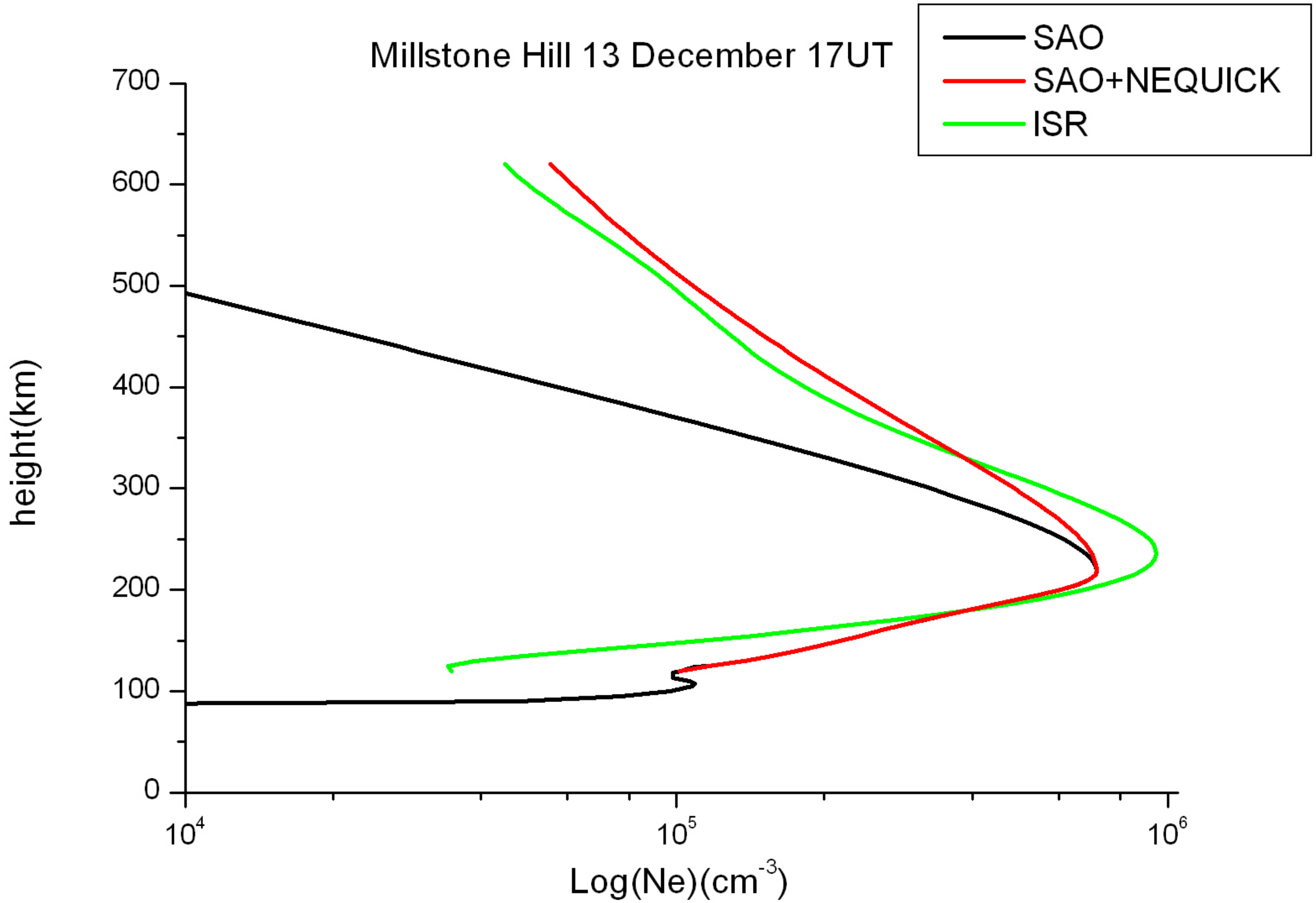
Topside from ionosonde current status in Autoscala



Topside from ionosonde: using Nequick



NeQuick model

The NeQuick is an ionospheric electron density model developed at the former Aeronomy and Radiopropagation Laboratory of The Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy, and at the Institute for Geophysics, Astrophysics and Meteorology (IGAM) of the University of Graz, Austria.

- **It is based on the DGR "profiler" proposed by Di Giovanni and Radicella [1990] and subsequently modified by Radicella and Zhang [1995] and is a quick run model particularly tailored for transionospheric propagation applications.**

- **The DGR "profiler" was originally designed for ingestion of ionosonde data**

NeQuick 2

- **Further improvements have been implemented by Radicella and Leitinger [2001].**

- **A modified bottomside has been introduced by Leitinger, Zhang, and Radicella [2005].**

- **A modified topside has been proposed by Coïsson, Radicella, Leitinger and Nava [2006].**

- **All these efforts, directed toward the developments of a new version of the model, have led to the implementation of the NeQuick2.**

NeQuick 2

- **The model profile formulation includes semi-Epstein layers with modeled thickness parameters and is based on anchor points defined by foE, foF1, foF2 and M(3000)F2 values.**

- **These values can be modeled (e.g. ITU-R coefficients for foF2 M(3000)F2) or experimentally derived.**

- **NeQuick inputs are: position, time and solar flux; the output is the electron concentration at the given location and time**

$$N_{\rm bot}(h) = N_{\rm E}(h) + N_{\rm F1}(h) + N_{\rm F2}(h),$$

where

$$N_{\rm E}(h) = \frac{4Nm^*E}{\left(1+\exp\left(\frac{h-hmE}{BE}\xi(h)\right)\right)^2} \times \exp\left(\frac{h-hmE}{BE}\xi(h)\right),$$

$$N_{\rm F1}(h) = \frac{4Nm^*F1}{\left(1+\exp\left(\frac{h-hmF1}{B1}\xi(h)\right)\right)^2} \times \exp\left(\frac{h-hmF1}{B1}\xi(h)\right),$$

$$N_{\rm F2}(h) = \frac{4NmF2}{\left(1+\exp\left(\frac{h-hmF2}{B2}\right)\right)^2} \times \exp\left(\frac{h-hmF2}{B2}\right)$$

with

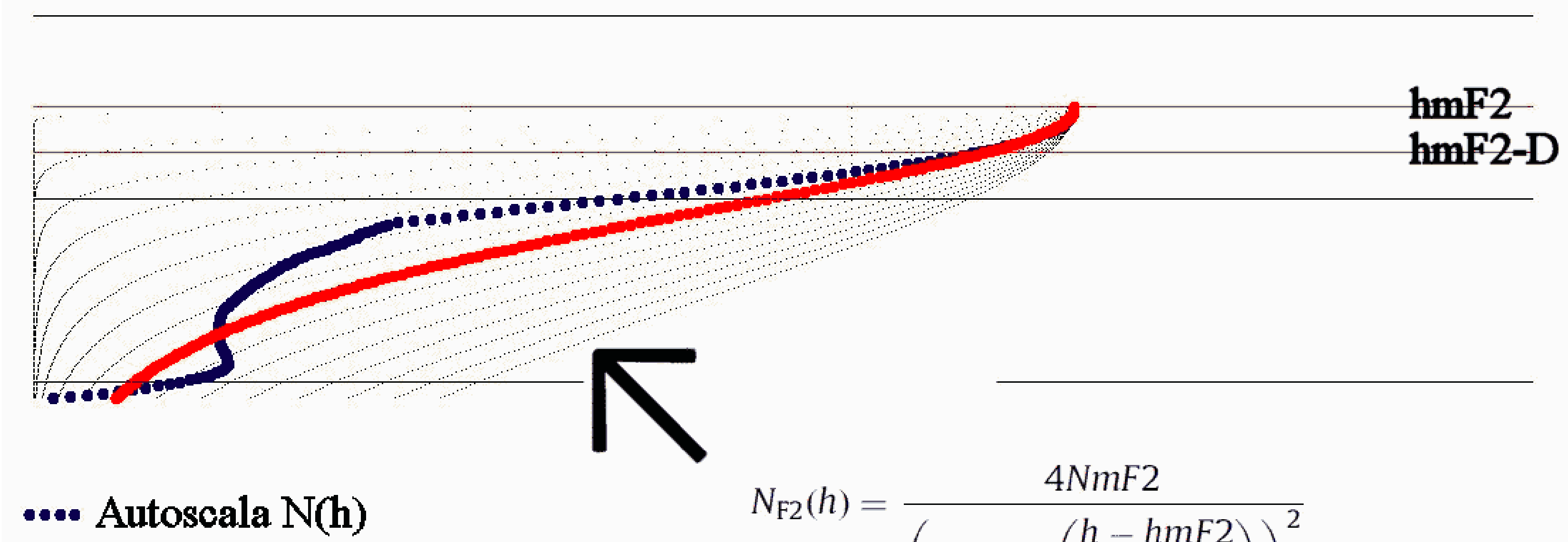
$$Nm^*E = NmE - N_{\rm F1}(hmE) - N_{\rm F2}(hmE),$$

$$Nm^*F1 = NmF1 - N_{\rm E}(hmF1) - N_{\rm F2}(hmF1)$$

and

$$\xi(h) = \exp\left(\frac{10}{1+1|h-hmF2|}\right)$$

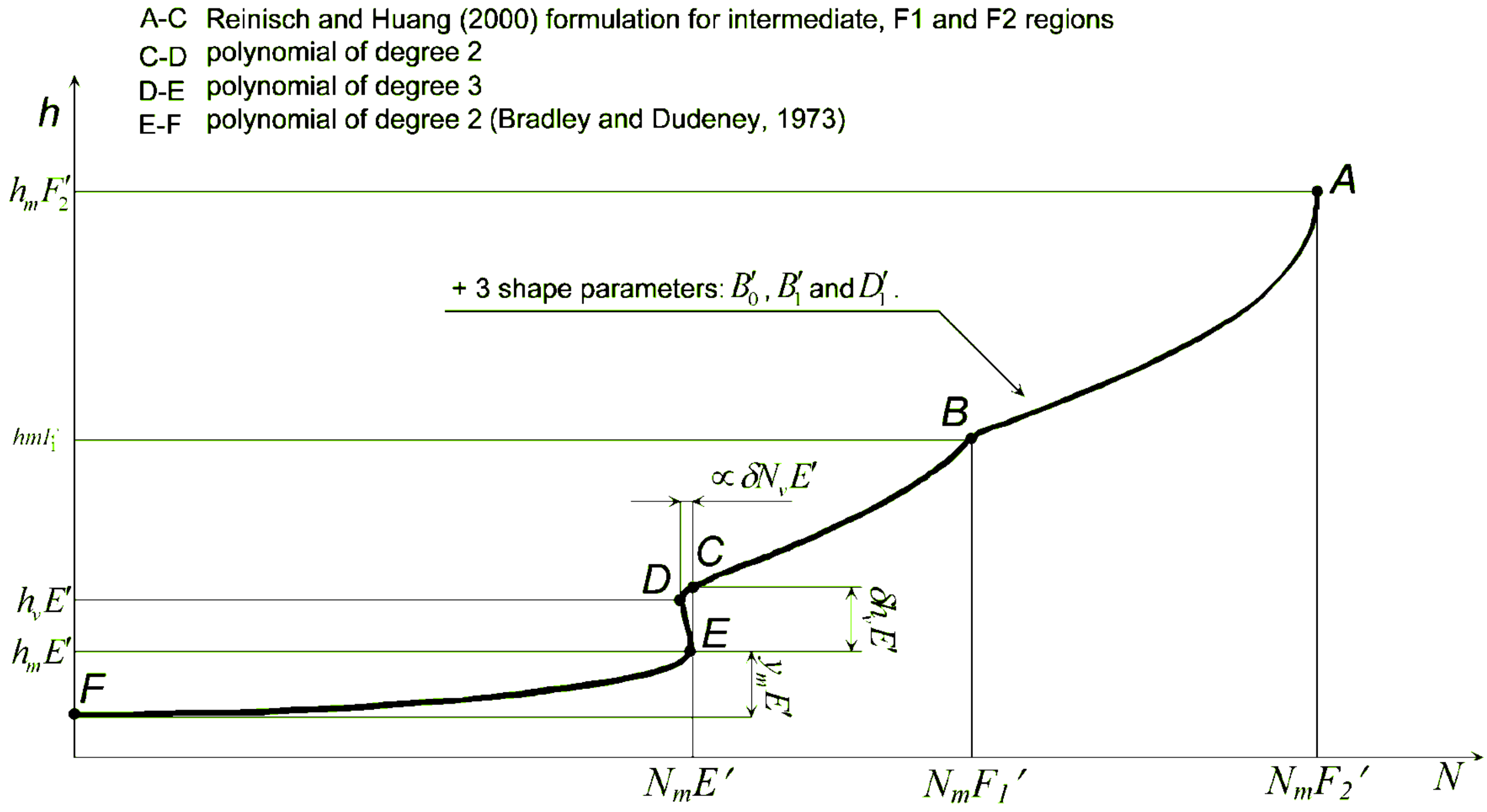
Instead of $B2_{bot} = \frac{0.385 NmF2}{(dN/dh)_{max}}$ is ingested B_2 from Autoscala $N(h)$



$$N_{F2}(h) = \frac{4NmF2}{\left(1 + \exp\left(\frac{h - hmF2}{B2}\right)\right)^2} \times \exp\left(\frac{h - hmF2}{B2}\right)$$

What are we assimilation?

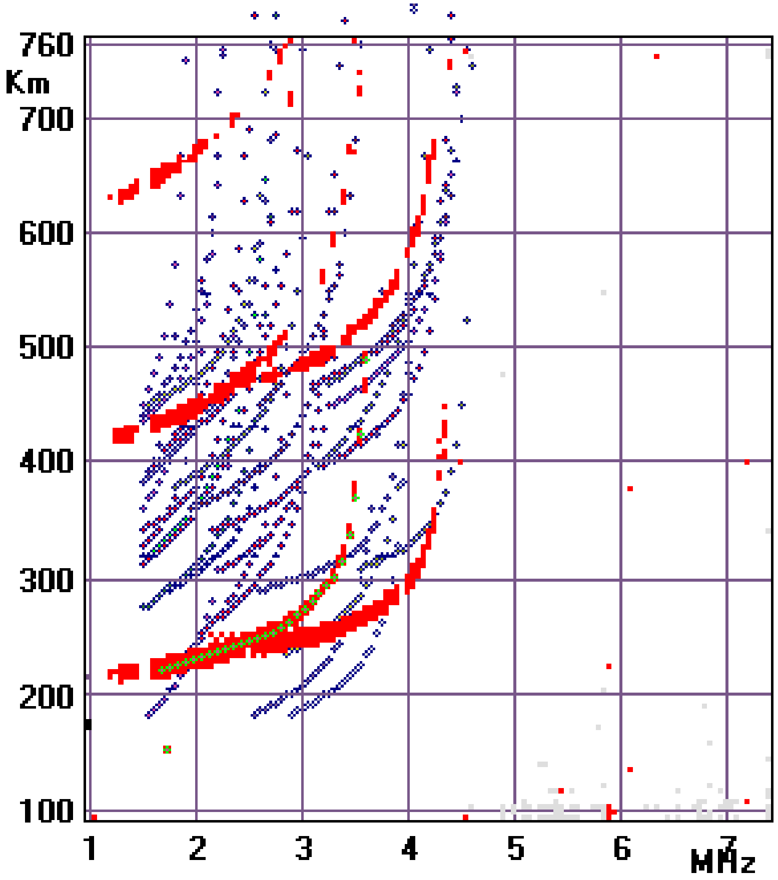
- For F1 and F2 region Autoscala N(h) is based on Reinish and Huang (2000) formulation.
- Autoscala adjusts 12 free parameters.



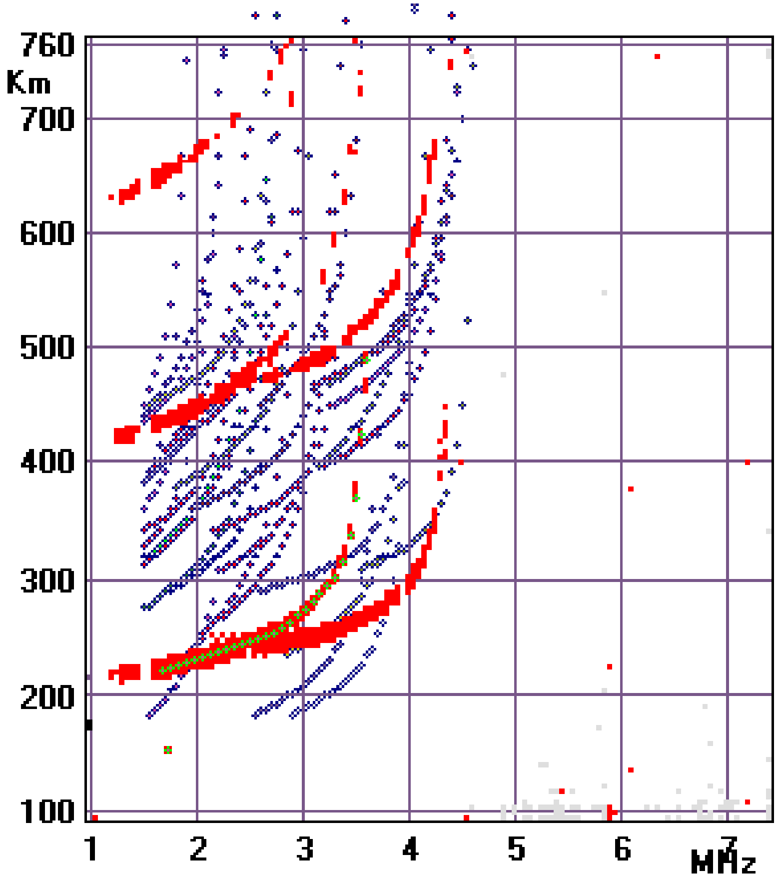
What are we ingesting?

The parameters defining the curves are: *H*par, *a*par, *A*par and *Δ*par.

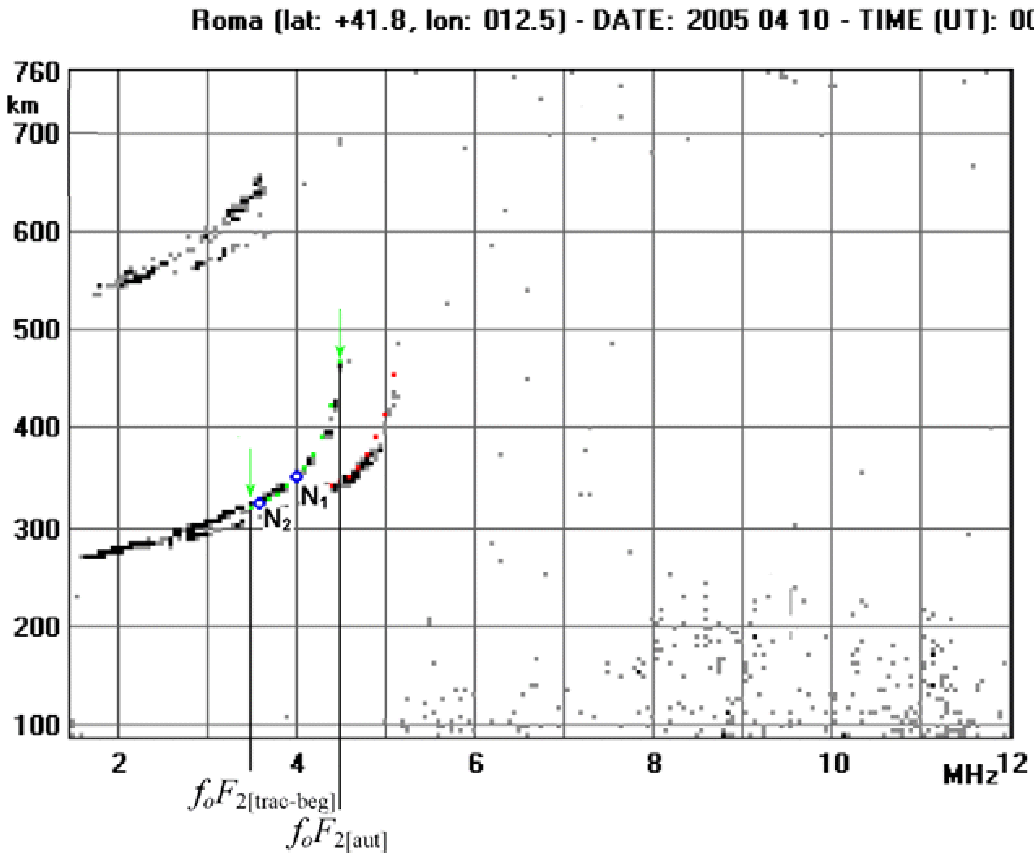
For each curve of the set *T* the local correlation *C(Hpar, apar, Apar,Δpar)* with the recorded ionogram is calculated. The curve belonging to the set *T* having the maximum value of *C* is then selected



What are we ingesting?



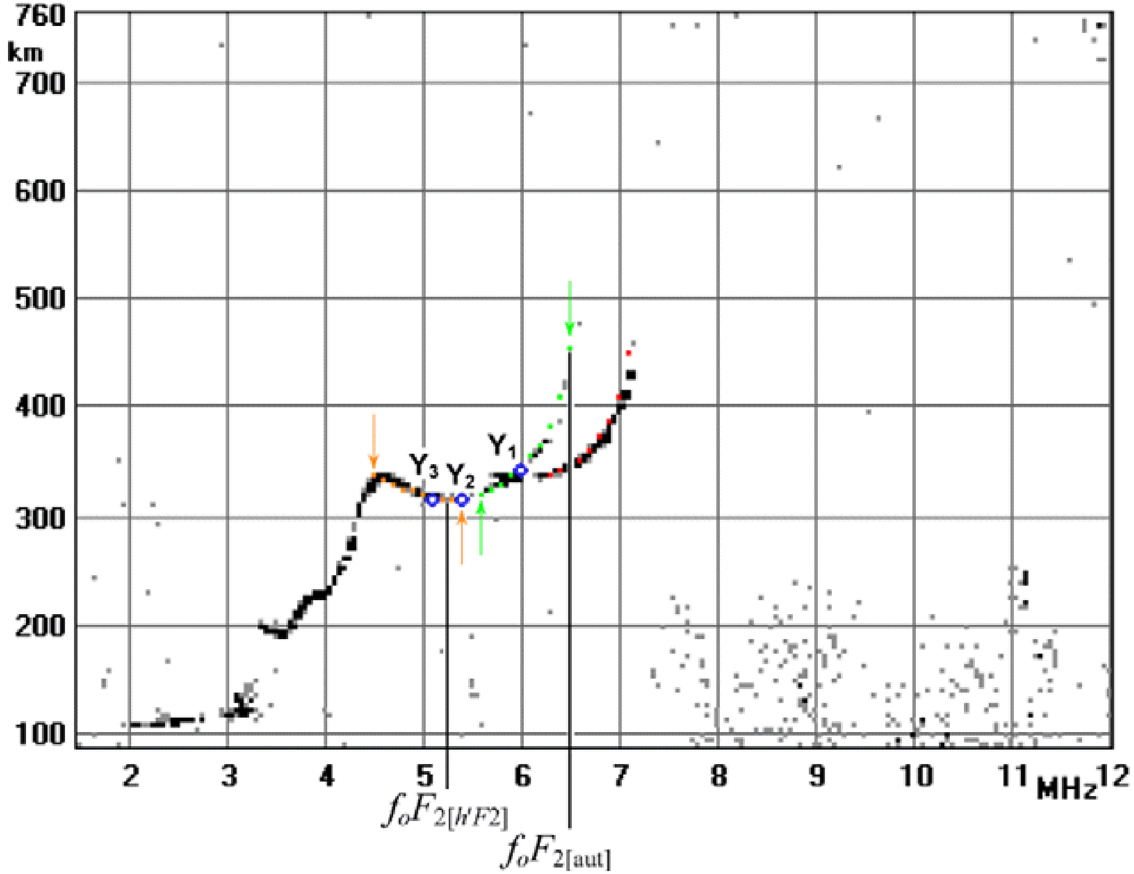
Some empirical curves used to fit by maximum correlation technique the ionogram F2 trace (in blue). The empirical curve which best fit the ionogram trace (in green). Only the ordinary trace (and the corresponding empirical curve) are illustrated in this picture



foF2	4,5 MHz
MUF(3000)F2	13,8 MHz
M(3000)F2	3,07
fxI	5,1 MHz
foF1	NO
ftEs	NO
h'Es	NO

Actually we are assimilating just two points during nighttime....
(besides foF2, and hmF2)

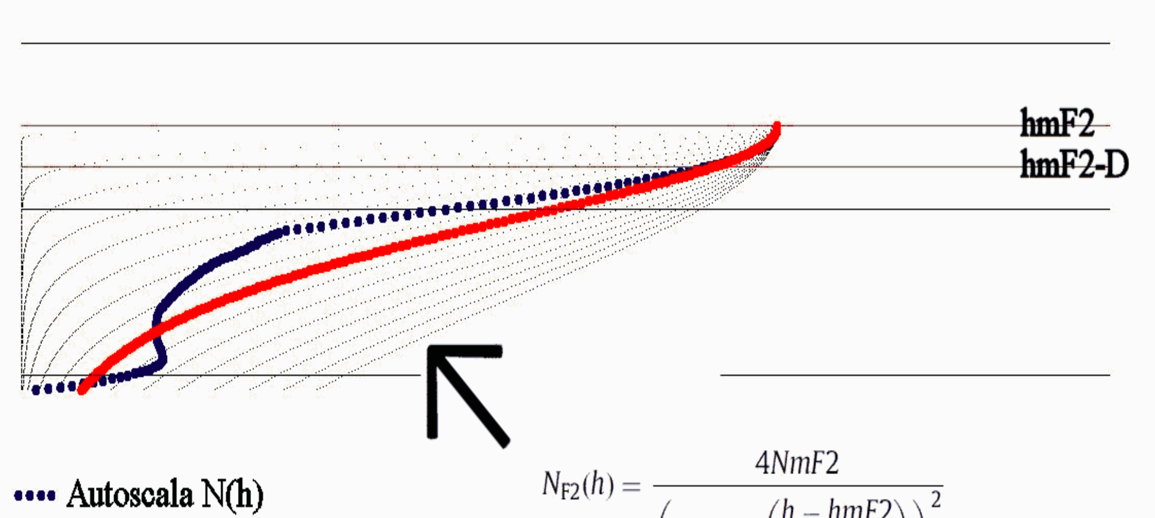
Roma (lat: +41.8, lon: 012.5) - DATE: 2005 03 31 - TIME (UT): 11:00



foF2	6,5 MHz
MUF(3000)F2	20,6 MHz
M(3000)F2	3,17
fxl	7,1 MHz
foF1	4,5 MHz
ftEs	NO
h'Es	NO

...and three points during daytime.
(besides foF2, and hmF2)

Ionosonde->B2bot->B2topside and…we try to adjust



$$N_{F2}(h) = \frac{4NmF2}{\left(1 + \exp\left(\frac{h - hmF2}{B2}\right)\right)^2} \times \exp\left(\frac{h - hmF2}{B2}\right)$$

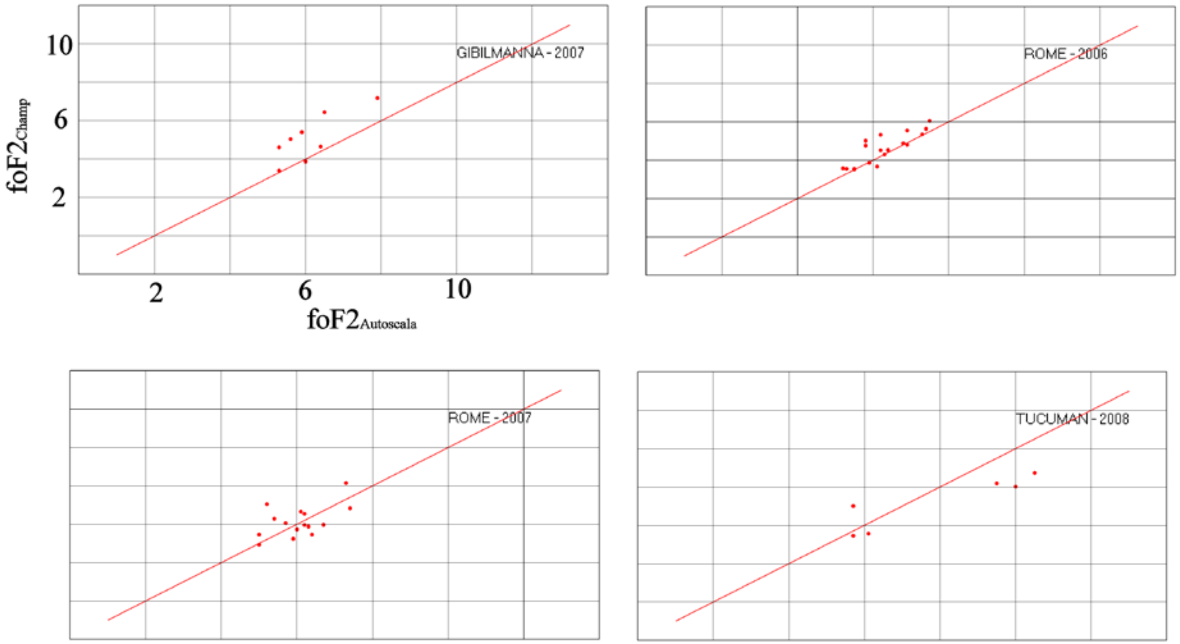
B2 topside computed by Nequick has been modified and some tests have been permode using:

B2topside*0.5
B2topside*0.6
B2topside*0.7
B2topside*0.8
…
…
…
B2topside*1.5

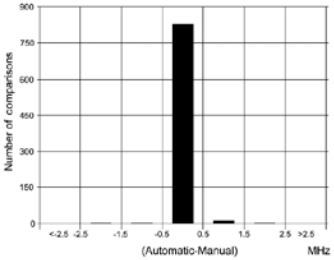
The standard deviation between the Nequick modeled topside and the CHAMP radio occultation profile has been computed

Scotto, et al. "*Ne(h) estimate with NeQuick model ingesting bottomside parameters*" INGV-ICTP Beacon Satellyte Symposium 2016, Trieste, June 27 – July 1, 2016

A problem for this test is that ionosonde fof2 is fof2_CHAMP



A problem for assimilation are errors in fof2 for Autoscala (but here we use validated data)



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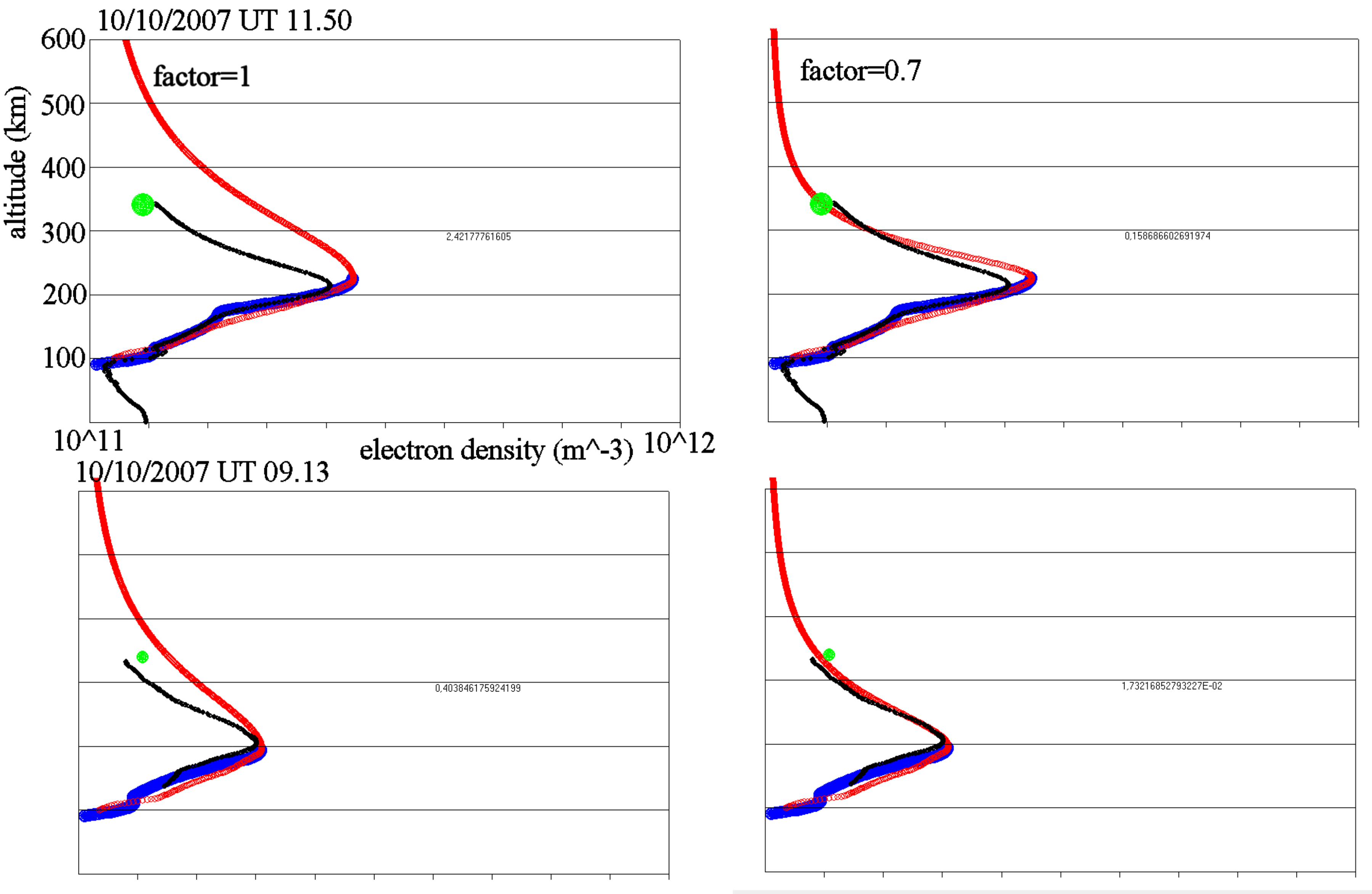
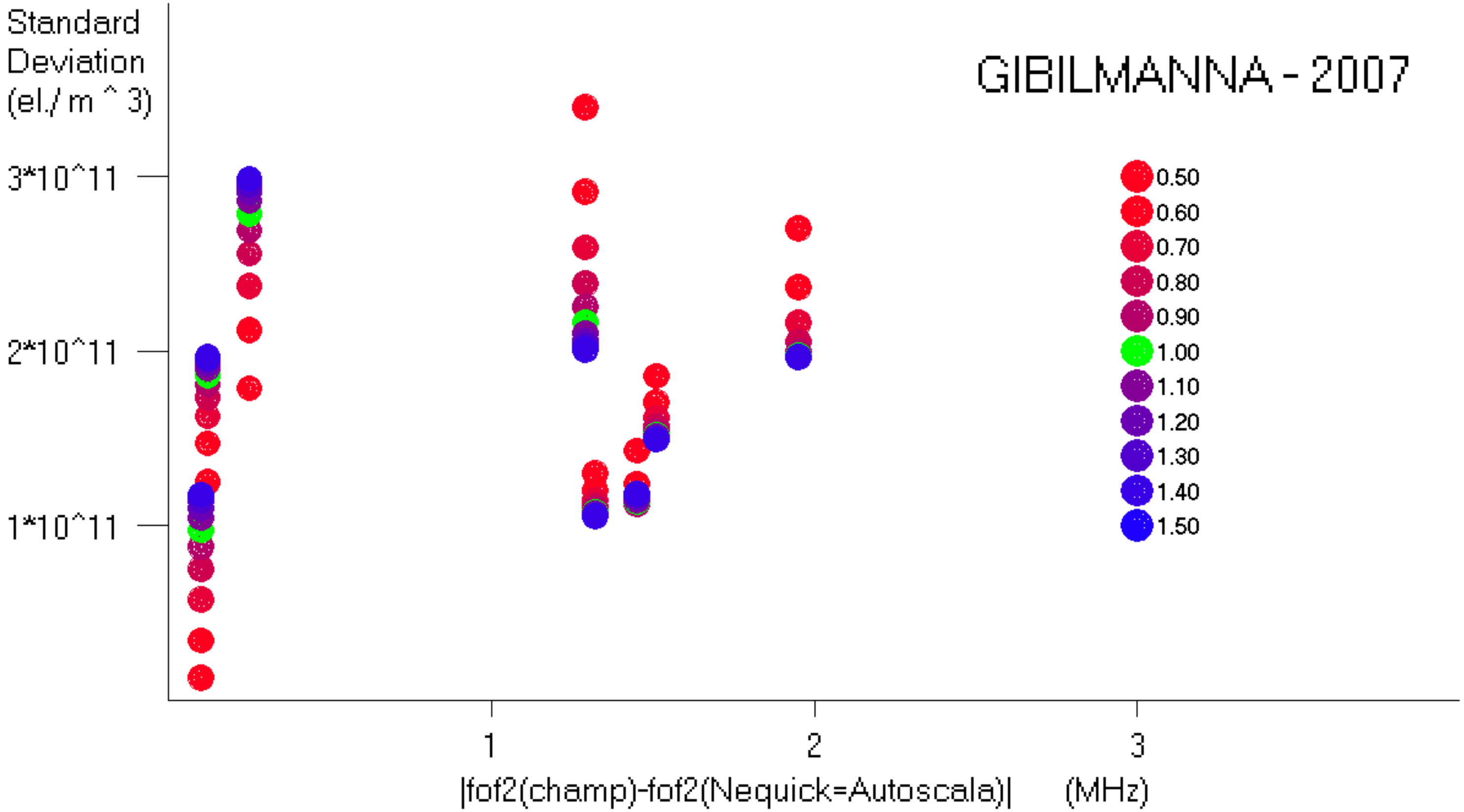
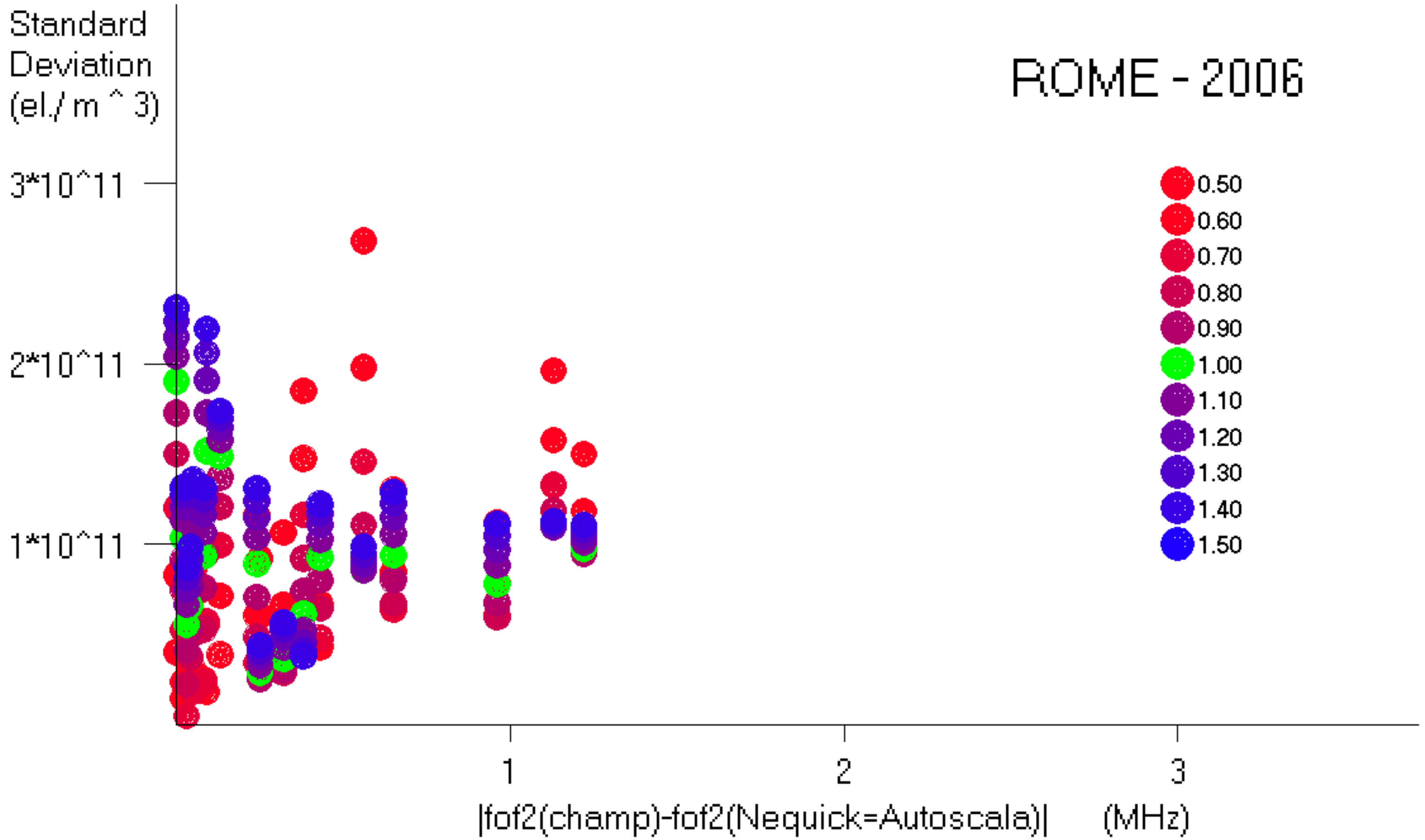
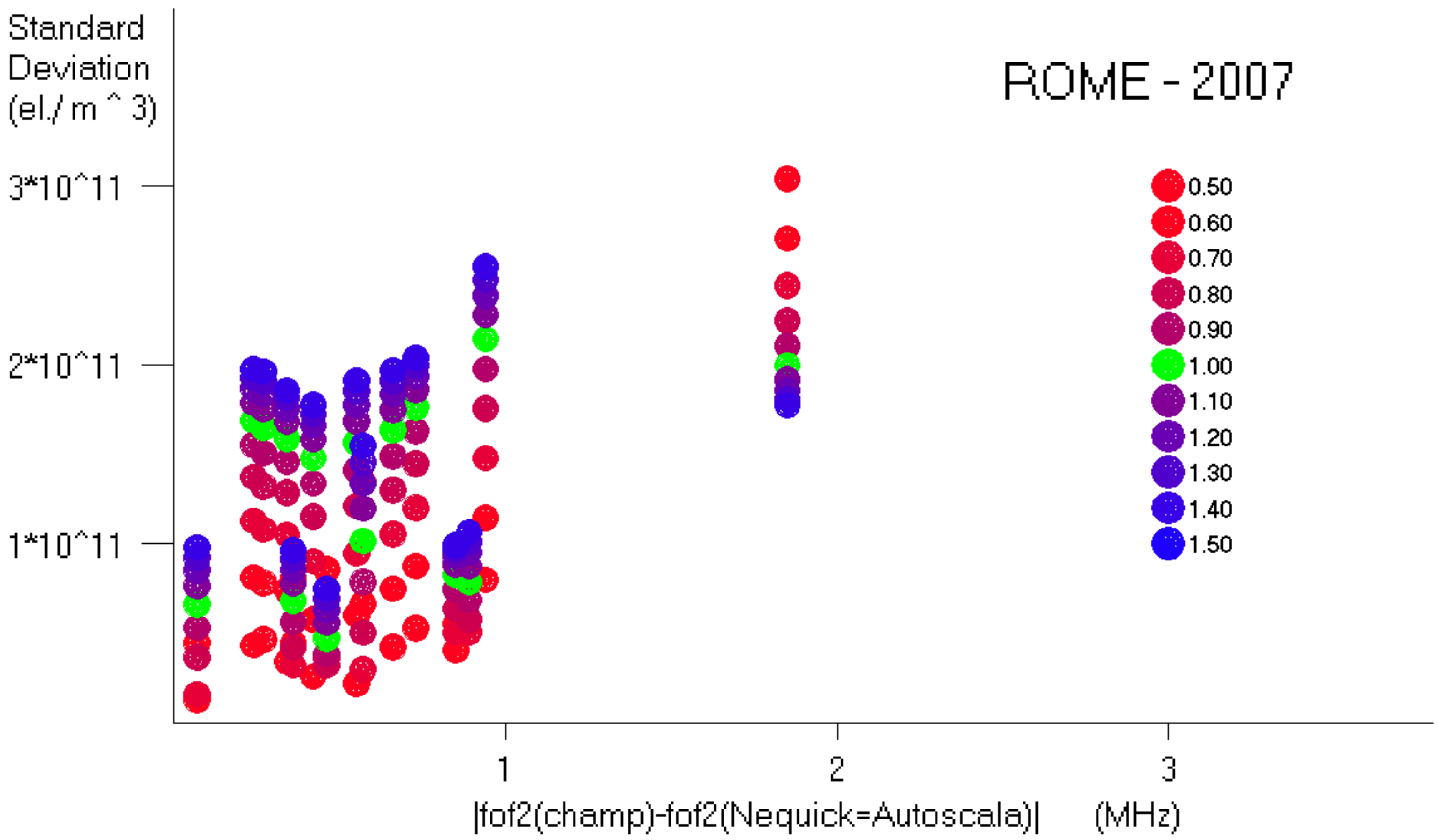
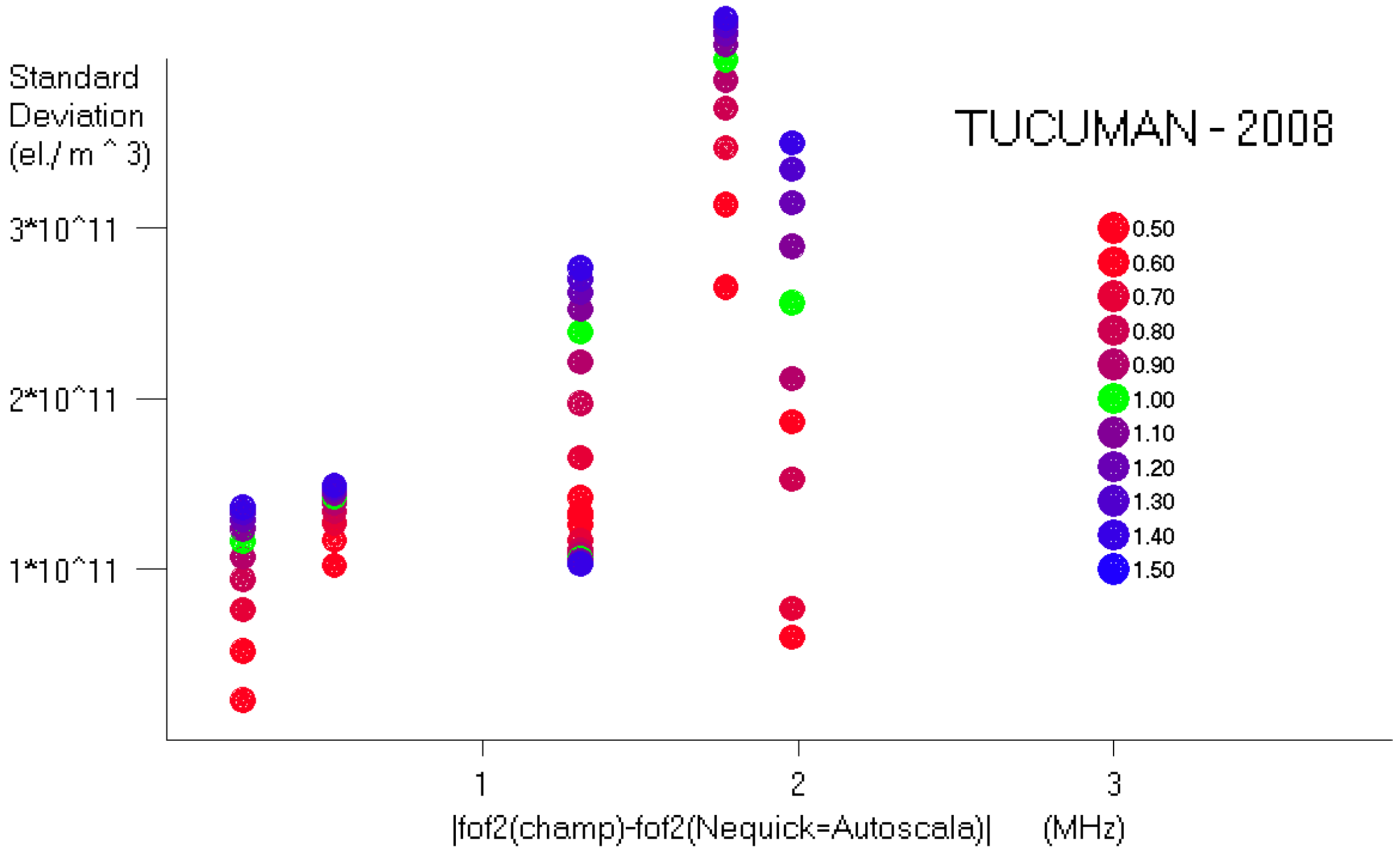



Standard
Deviation
(el./ m ^ 3)
3*10^11
2*10^11
1*10^11
GIBILMANNA - 2007
0.50
0.60
0.70
0.80
0.90
1.00
1.10
1.20
1.30
1.40
1.50
1
2
3
|fof2(champ)-fof2(Nequick=Autoscala)|
(MHz)



Standard Deviation (el./ m ^ 3)
3*10^11
2*10^11
1*10^11
ROME - 2006
0.50
0.60
0.70
0.80
0.90
1.00
1.10
1.20
1.30
1.40
1.50
1
2
3
|fof2(champ)-fof2(Nequick=Autoscala)|
(MHz)


Standard
Deviation
(el./ m ^ 3)
3*10^11
2*10^11
1*10^11
ROME - 2007
0.50
0.60
0.70
0.80
0.90
1.00
1.10
1.20
1.30
1.40
1.50
1
2
3
|fof2(champ)-fof2(Nequick=Autoscala)| (MHz)


Standard Deviation (el./ m ^ 3)
3*10^11
2*10^11
1*10^11
TUCUMAN - 2008
0.50
0.60
0.70
0.80
0.90
1.00
1.10
1.20
1.30
1.40
1.50
1
2
3
|fof2(champ)-fof2(Nequick=Autoscala)|
(MHz)

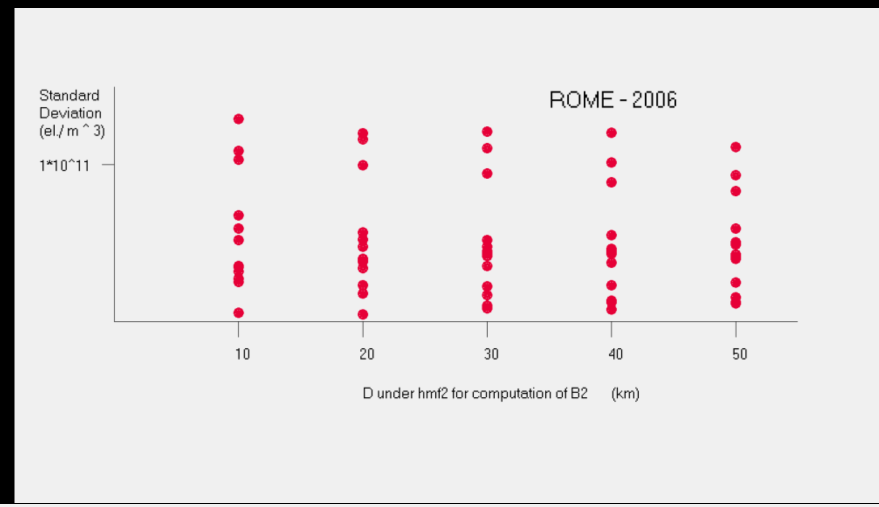
Conclusion 1: **Autoscala data has been assimilated into Nequick 2 to obtain an B2bot model parameter. Subsequently the validity of Nequick topside has been assed with CHAMP data.**

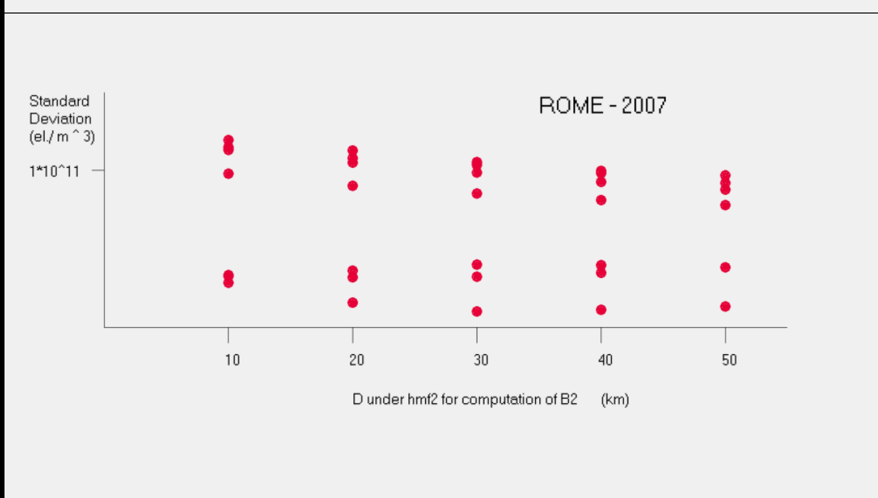
Conclusion 2: **A study on the topside B2topside(Nequick) should be carried out. In particular the comparison with occultation profiles indicates that a a factor 0.7 may be applied.**
The same result has been preliminary obtained using a sample of in situ measurements.

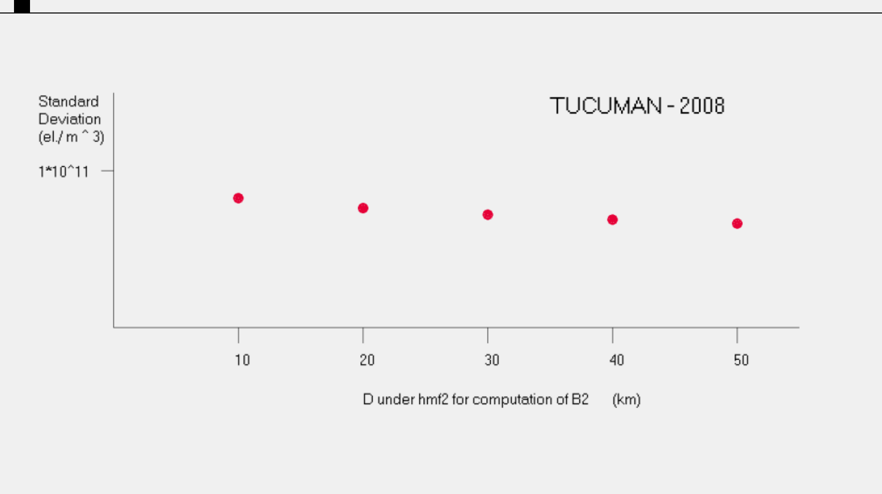
Conclusion 3. **Due to reduced number od radiocultation and ionosonde colocated additional work is required to include more ionosondes/ISR.**

What is the best D to assimilate bottomside Ne(h) assimilation to estimat B2bot?

Conclusion 4: The best D is 50 km.







More problems with assimilation