DISPEC

Scientific exploitation of space Data for improved Ionospheric SPECification

SDA1

Revised electron density distribution maps using DISPEC corrected data

Anna Belehaki, Konstantinos Koutroumbas, Themistocles Herekakis, George Stamatakis

National Observatory of Athens

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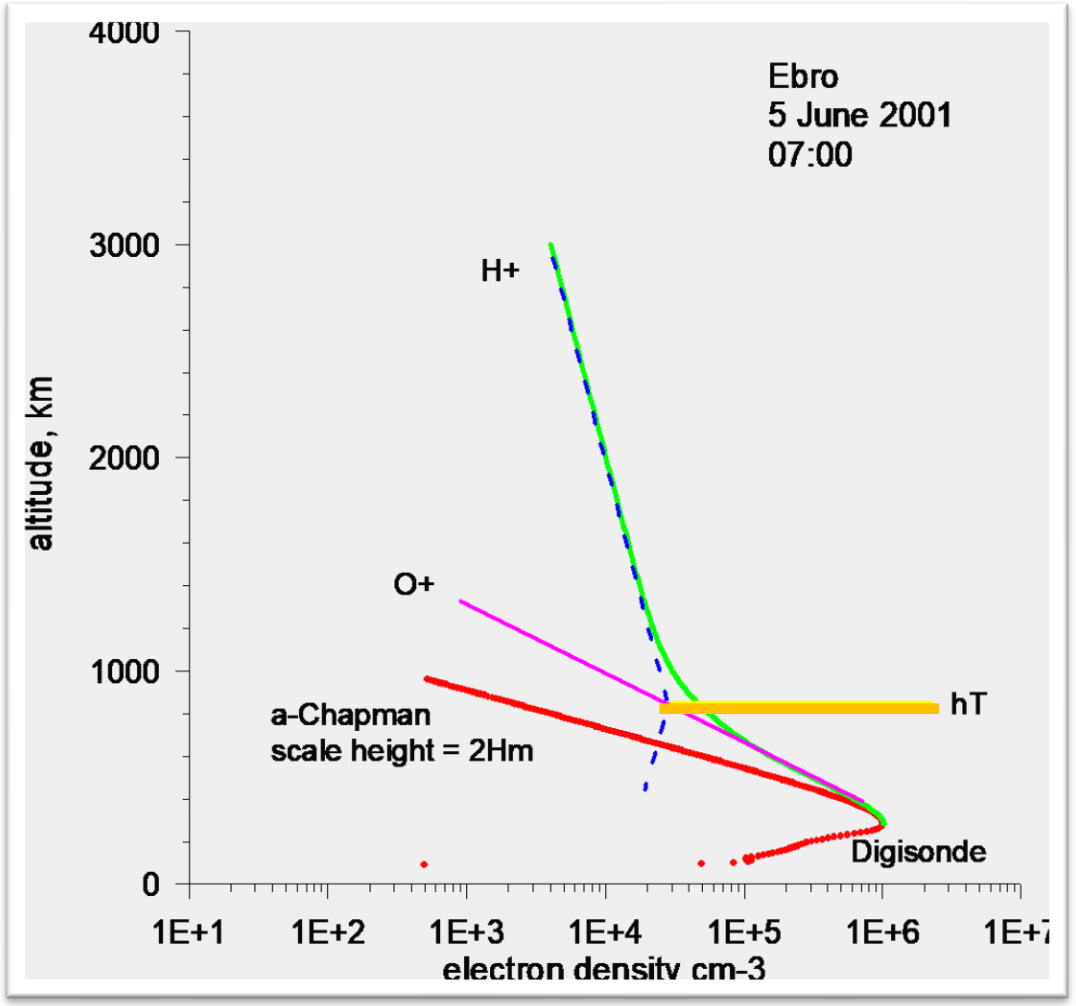
Topside Sounder Model assisted Digisonde (TaD) Electron Density Profile (EDP)

Step 4: Adjust the TaD EDP to the GNSS-TEC measured at the Digisonde location

Step 3: Link TSMP to Digisonde Profiler: modify the Digisonde Hm neutral scale height to comply with H_T

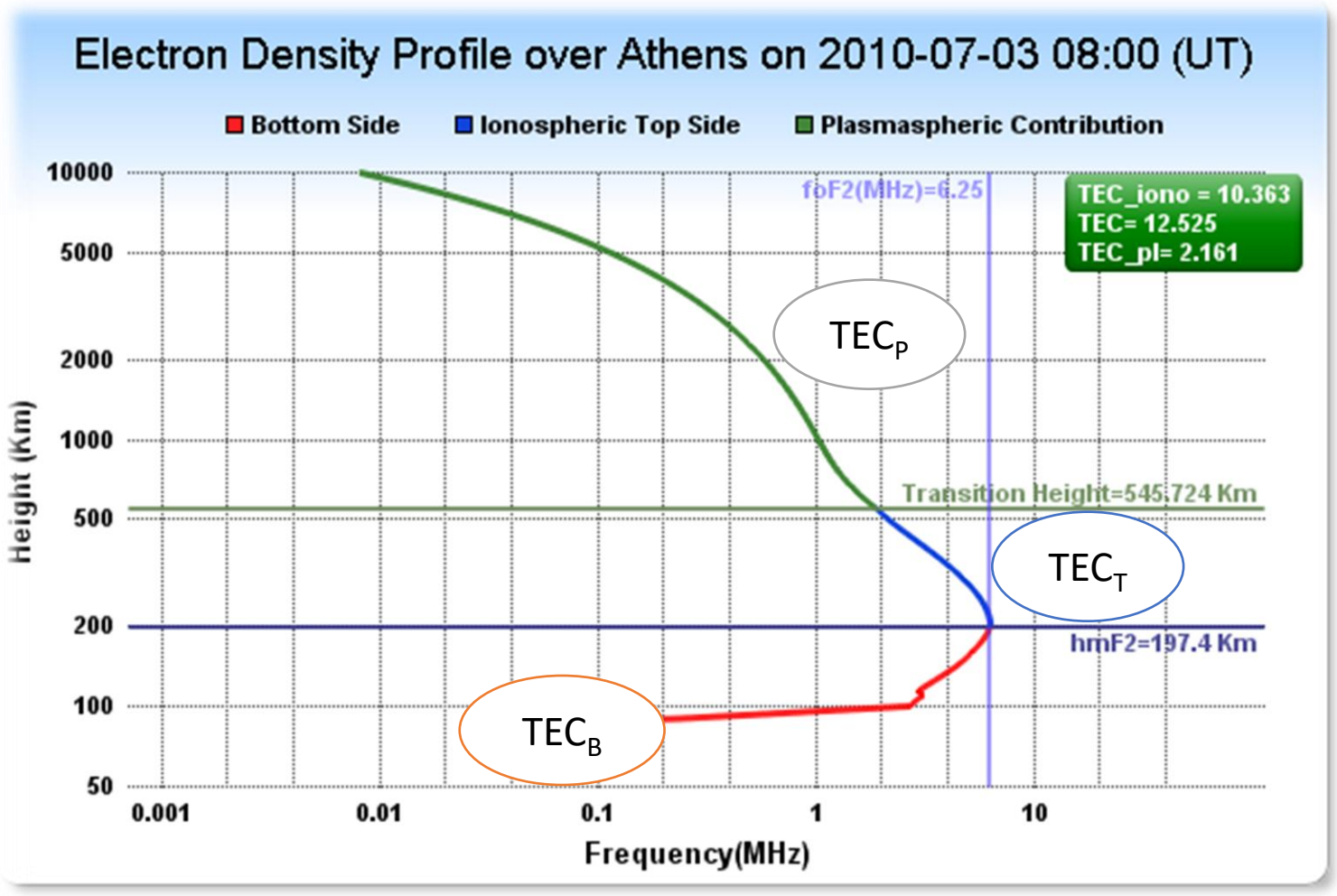
Step 2: TSMP defines the shape:
α-Chapman for O^+
exponential for H^+

Step 1: TSM provides: H_T, h_T, and their ratio R_T depending on gm lat, DoY, LT, solar flux and Kp



Input Parameters	Code	Output
Month, LT, glat, f10.7, Kp	TSM: Topside Sounders Model Analysis of Alouette, ISIS-1,-2 topside profiles (Bilitza, 2001)	Empirical functions of H_T: topside scale height h_T : transition height R_T: ratio H_T/h_T
H_T ($\equiv H_{O+}$), h_T, H_m, N_m and *glat*	TSMP: Topside Sounders Model Profiler Analysis of ISIS-1 topside profiles to model plasmaspheric scale height	Empirical functions of H_P: plasmaspheric scale height ($\equiv H_{H+}$) $H_P=H_T(9cos^2 glat+4)$ *Ne*: electron density profile in the topside ionosphere and plasmasphere $Ne = N_O(h) + gN_O(h_T)\exp\left(-\frac{\lvert h-h_T\rvert}{Hp}\right) + (1-g)N_O(h_T)\exp\left(-\frac{\lvert h-h_T\rvert}{4H_T}\right)$ and $N_O(h) = Nm\exp\left\{-\frac{1}{2}\left[\frac{h-hm}{Hm}+1-\exp\left(\frac{h-hm}{Hm}\right)\right]\right\}$ g is the ratio N_H+ / N_O+ at h_T
Digisonde parameters at the height of maximum density (*hmF2*, *foF2*, H_m) and vTEC (GNSS) at the Digisonde location	TaD: TSM-assisted Digisonde Profiler Calculation of the actual profile over each Digisonde location to update TSMP with current Digisonde and TEC (GNSS) parameters	$Ne = N_O(h) + gN_O(h_T)\exp\left(-\frac{\lvert h-h_T\rvert}{Hp}\right) + (1-g)N_O(h_T)\exp\left(-\frac{\lvert h-h_T\rvert}{skH_m}\right)$ where $s=H_{He+}/kH_m$ k is the correction parameter that converts H_m (the neutral scale height) to make it compliant with H_T The integral of the Ne profile can be adjusted to the measured vTEC by varying solely the correction parameter k

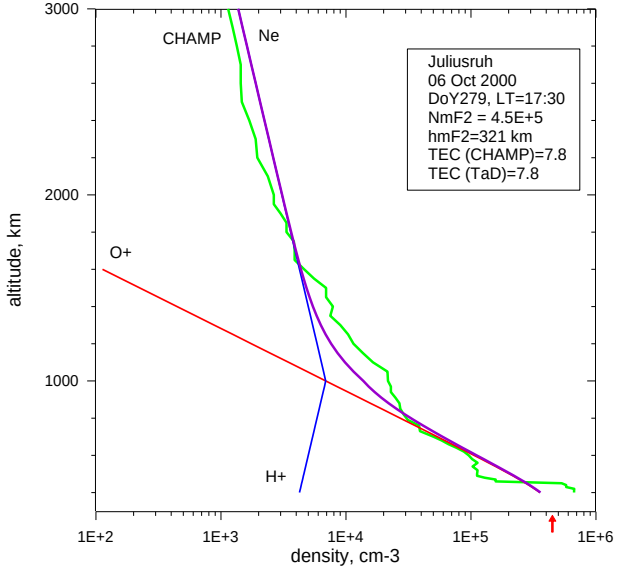
TaD EDP and products

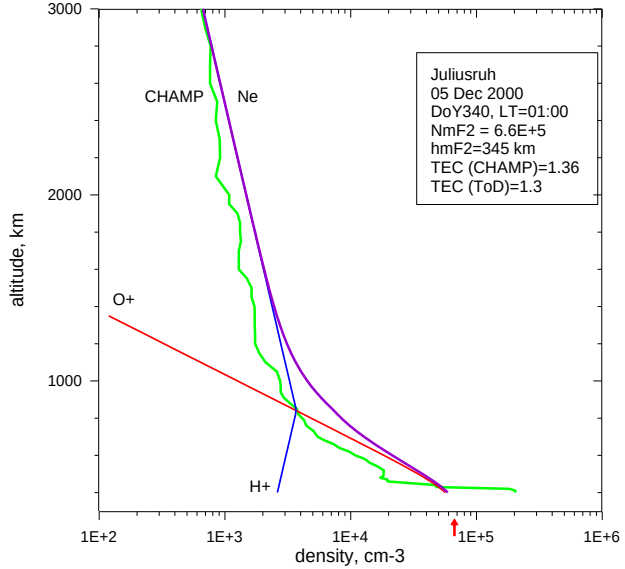


TaD verification results

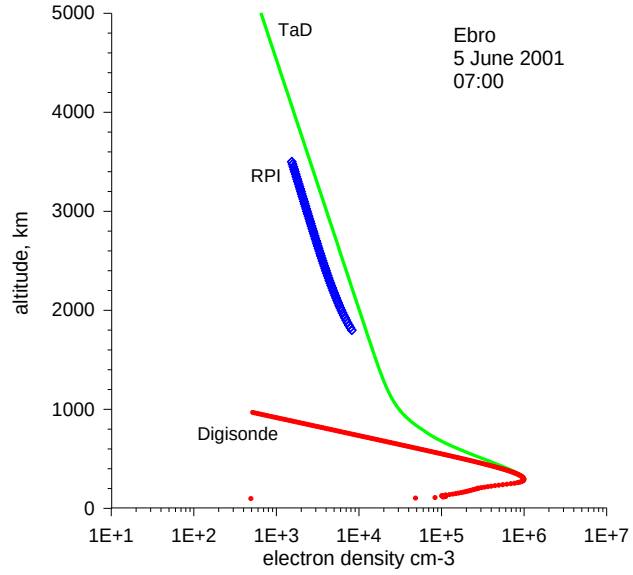
Comparison with CHAMP and IMAGE/RPI derived profiles

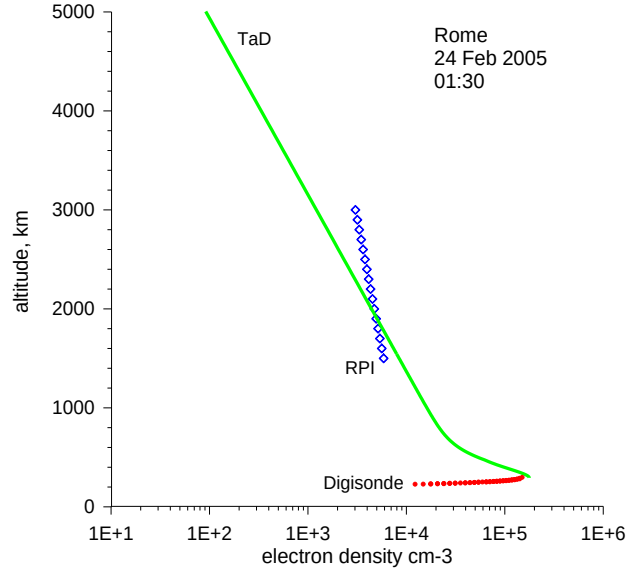
CHAMP





IMAGE





From 1D EDD to 3D EDD

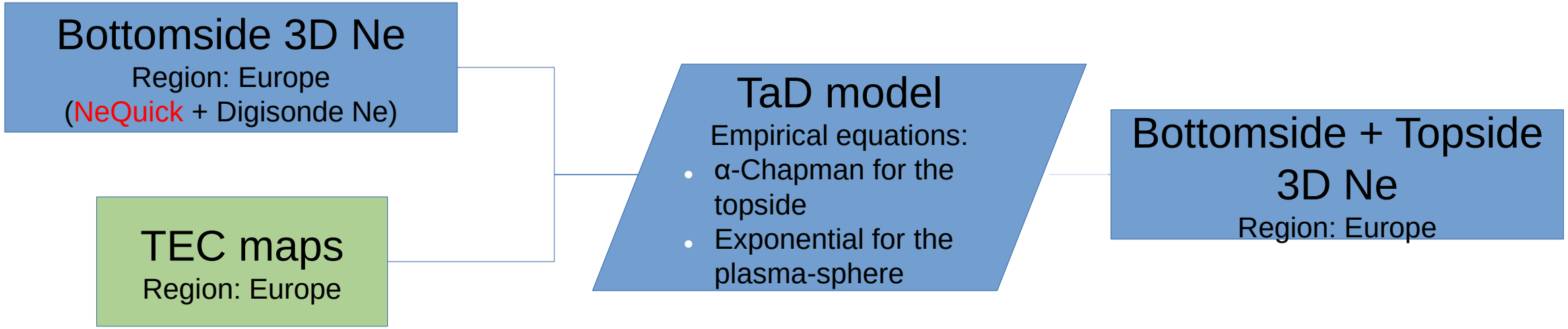
1D EDD (for a geographic location) requires

TEC from GNSS receiver
Electron Density Profile from Digisonde station

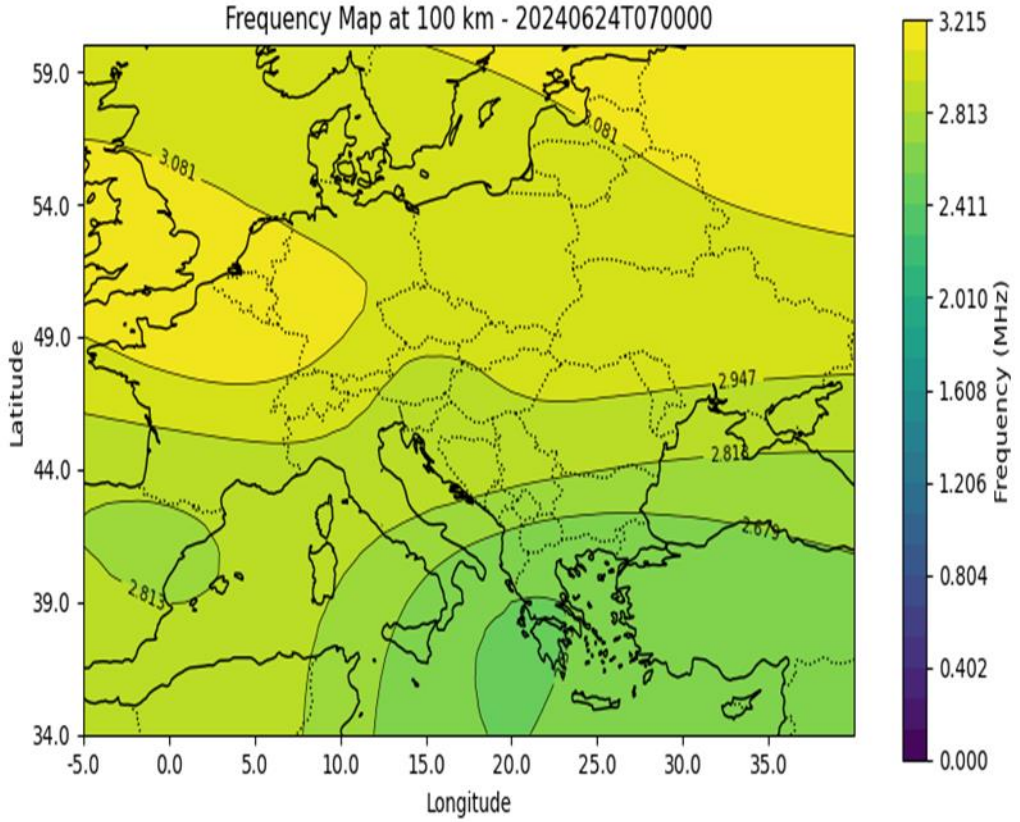
3D EDD (for a geographic region) requires

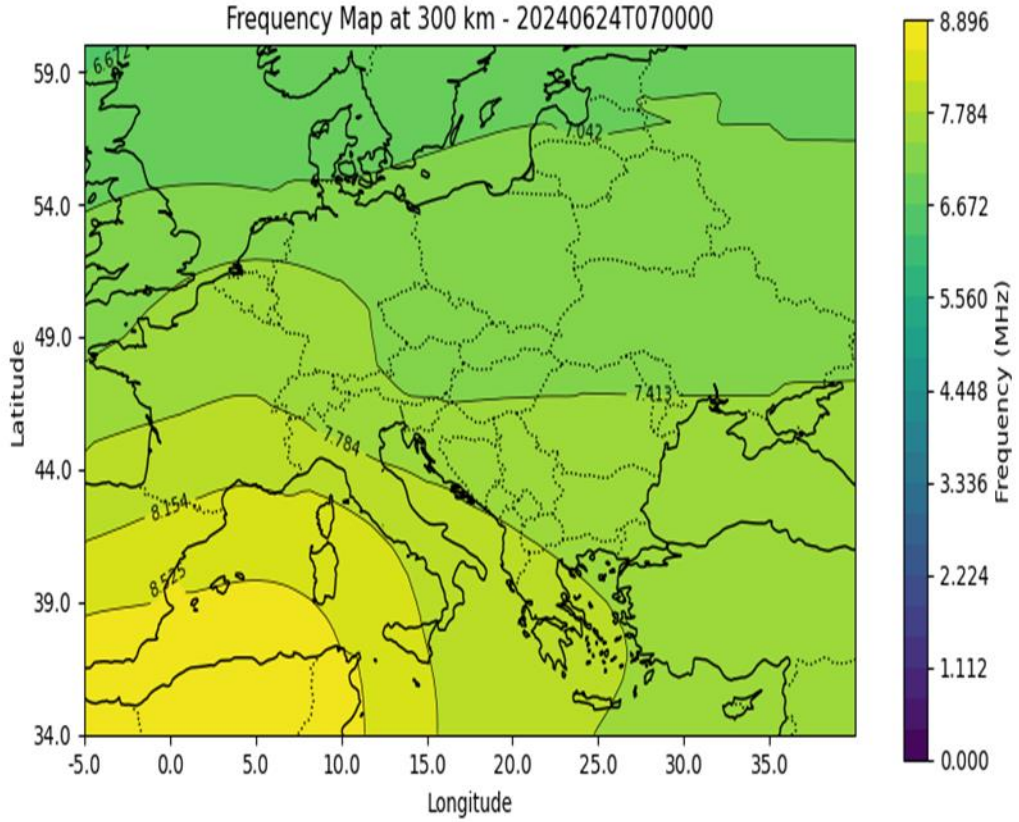
TEC map from GNSS receivers > 100 of GNSS receivers in Europe
→ Maps of Electron Density Profiles from Digisonde stations < 12 Digisonde stations in Europe

From 1D EDD to 3D EDD



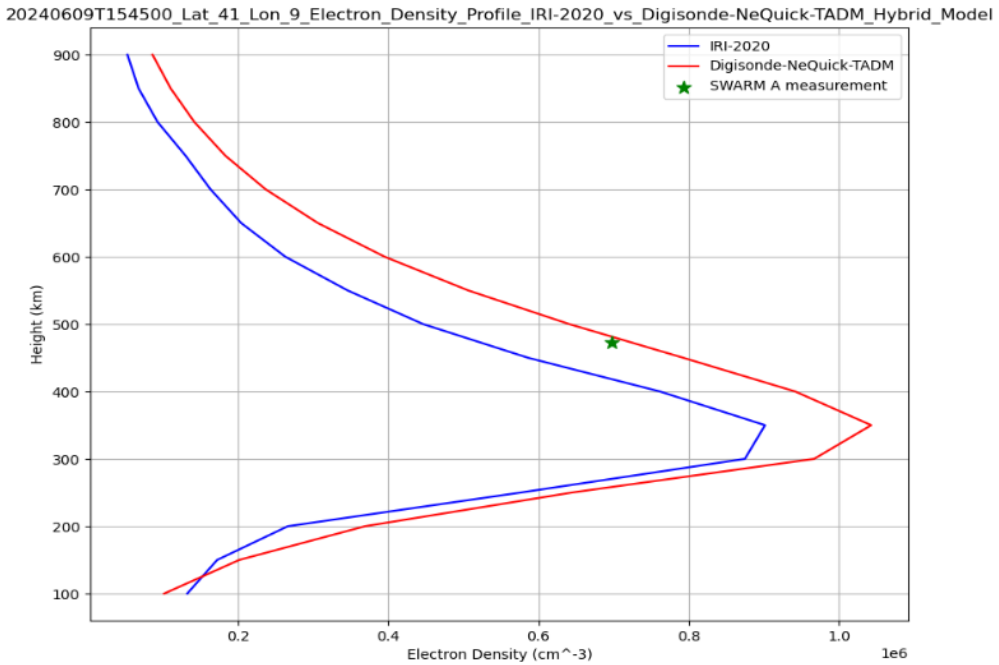
3D EDD maps

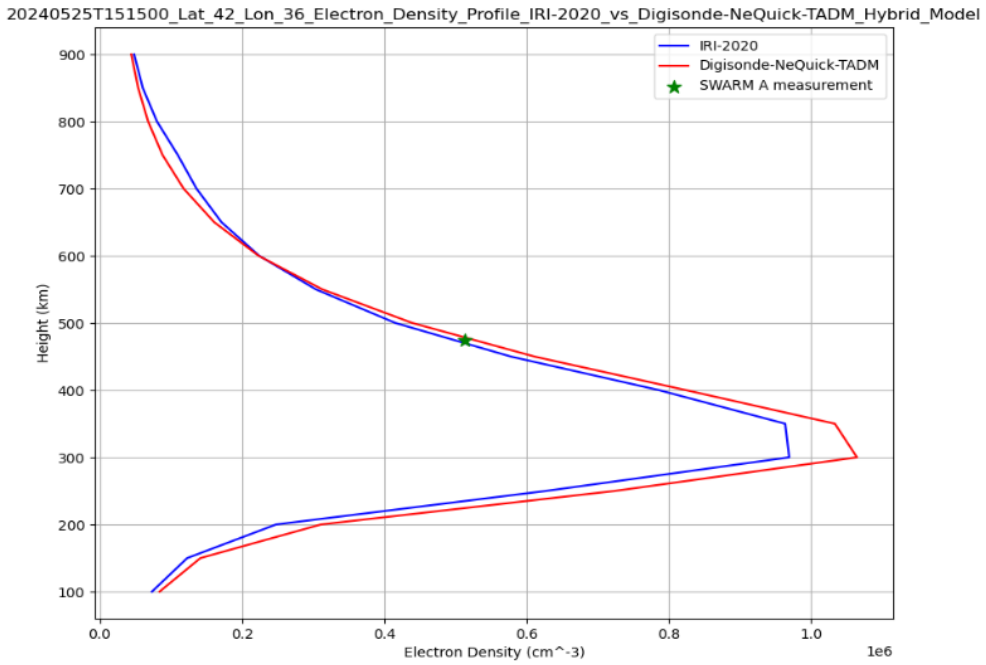

Frequency Map at 100 km - 20240624T070000
Latitude
Longitude
Frequency (MHz)
3.215
2.813
2.411
2.010
1.608
1.206
0.804
0.402
0.000
3.081
2.947
2.818
2.679
2.813


Frequency Map at 300 km - 20240624T070000
Latitude
Longitude
Frequency (MHz)
8.896
7.784
6.672
5.560
4.448
3.336
2.224
1.112
0.000
7.042
7.413
7.784
8.154

Verification of the 3D EDD maps

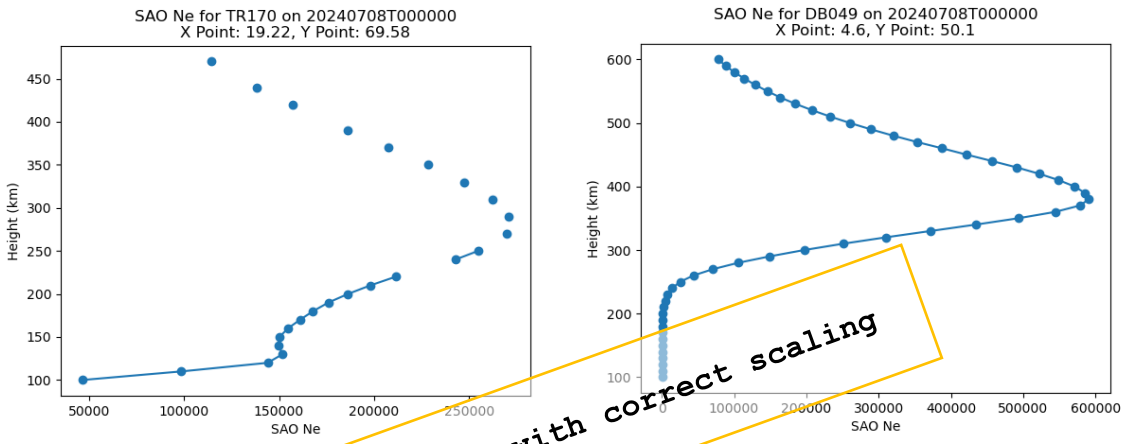
- NOA 3D EDD [bottomside + topside] map
- Validation with Swarm data

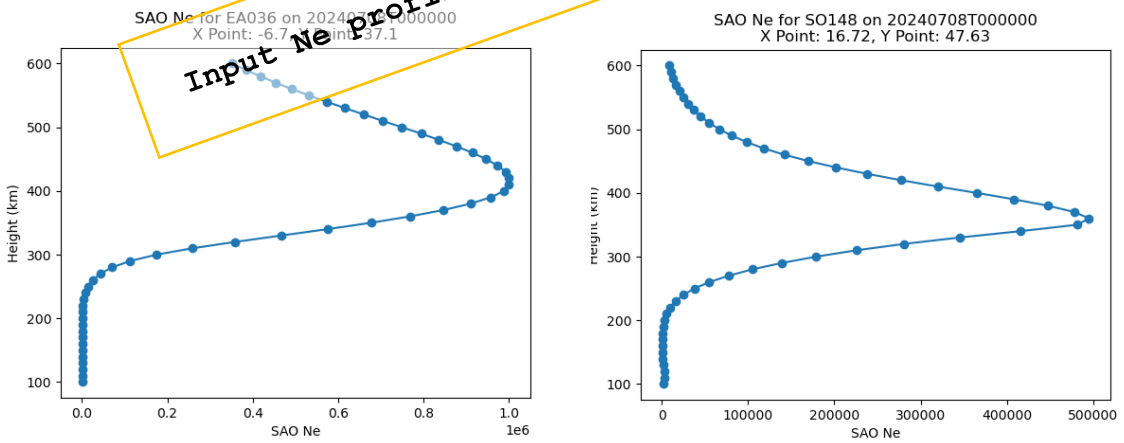




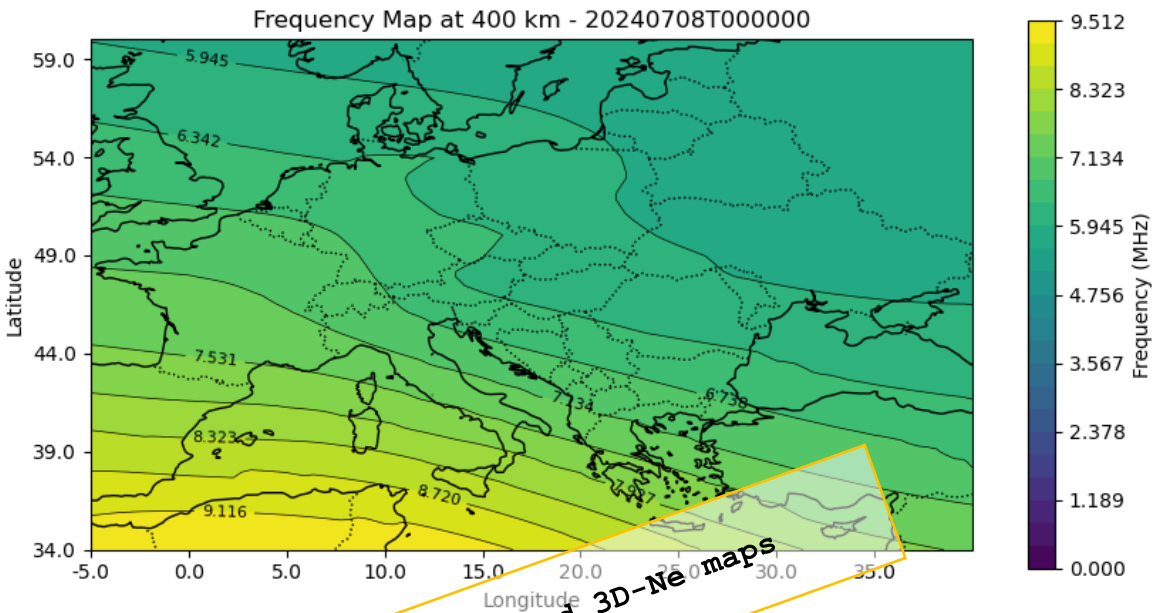
Conducting tests to verify the model with results of the IRI2020 ionospheric model and Swarm satellite observations of the topside ionosphere.

Digisonde data-driven electron density reconstruction model





Input Ne profiles with correct scaling



Output reconstructed 3D-Ne maps

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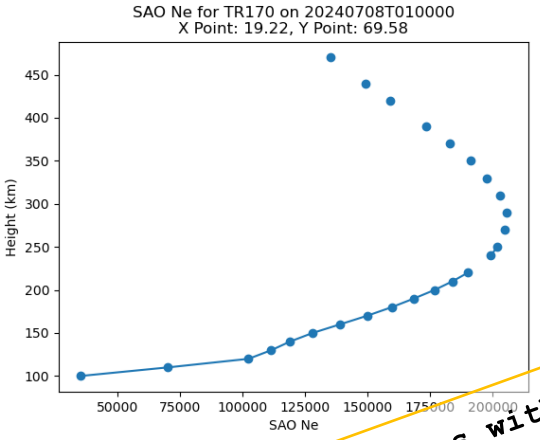
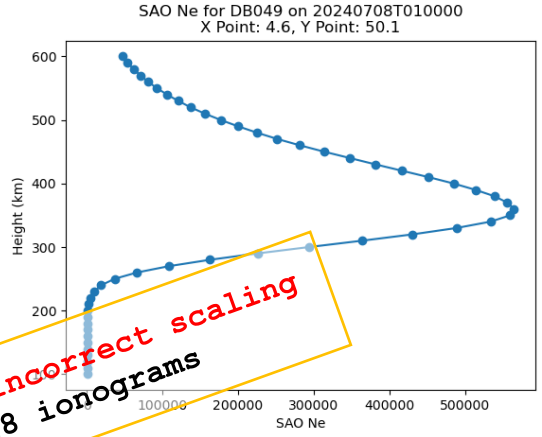
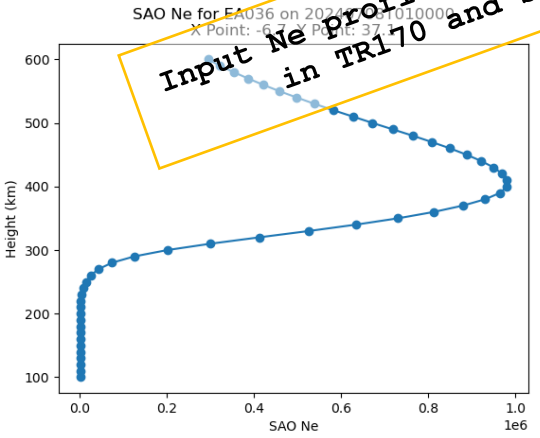
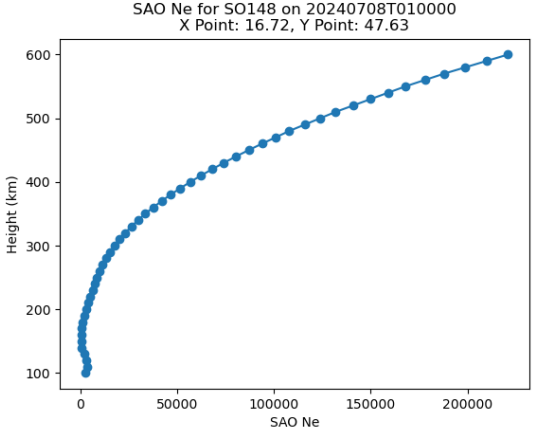
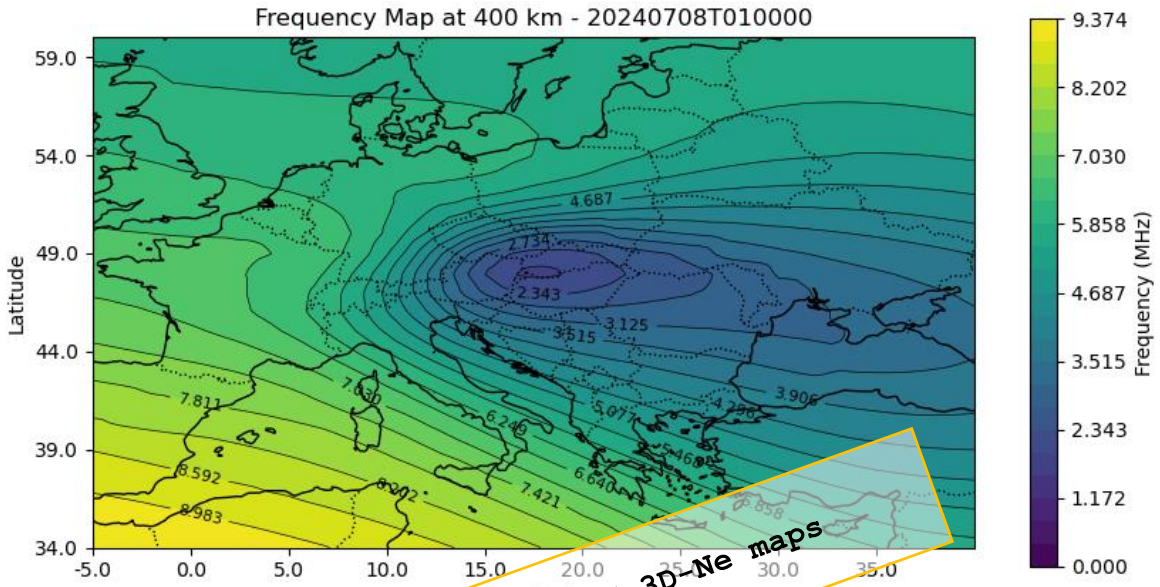








Input Ne profiles with incorrect scaling in TR170 and SO148 ionograms



Output reconstructed 3D-Ne maps

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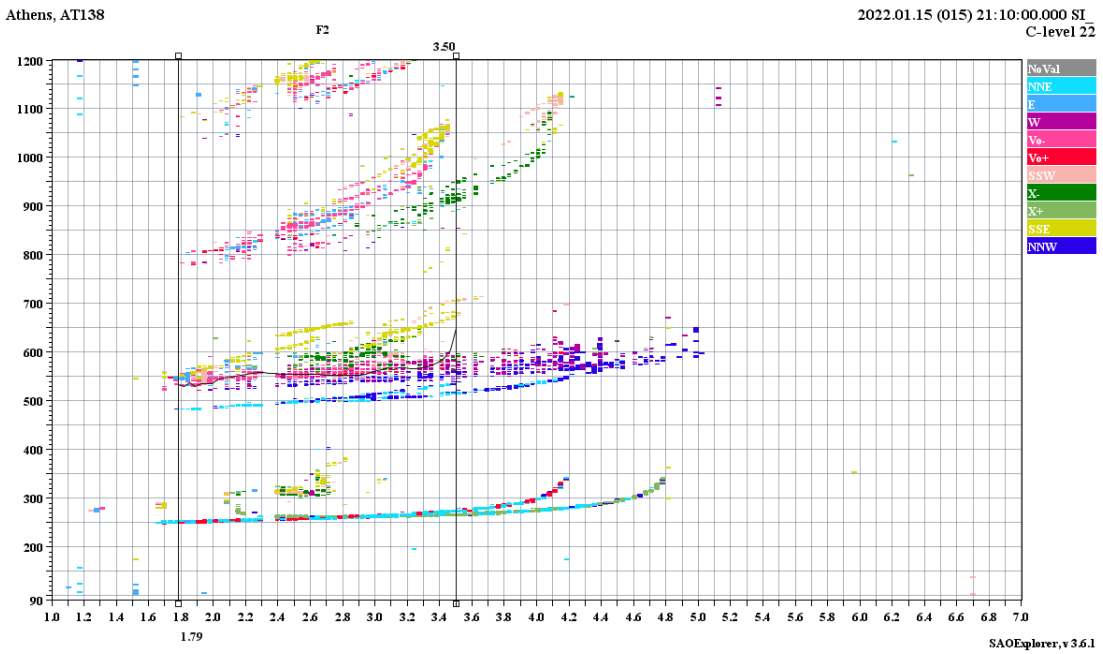
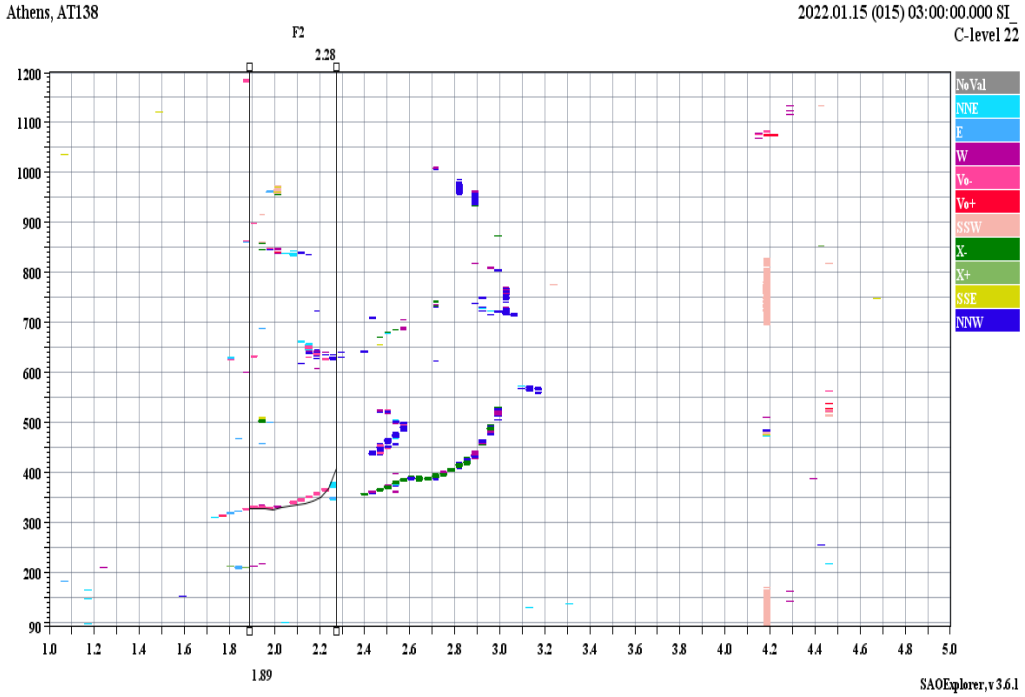
Can we get automatic improved scaling in ionograms?





DISPEC automatic scaling

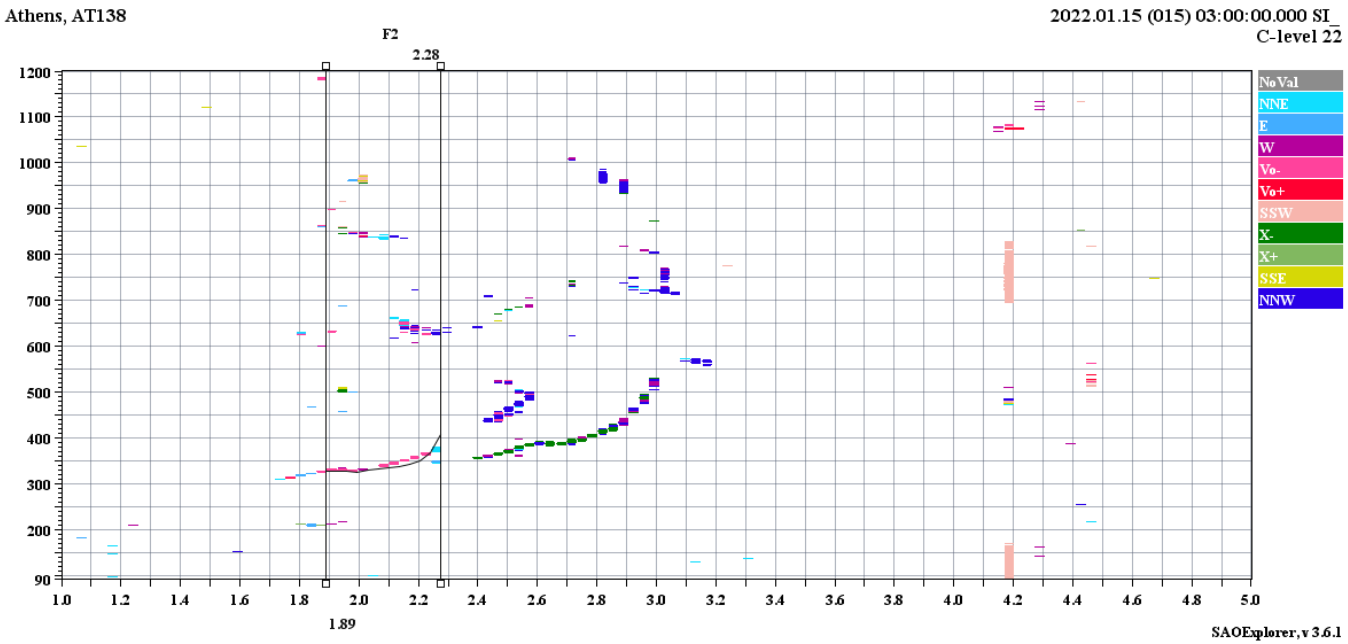
Three-step methodology for the automatic scaling of ionograms:

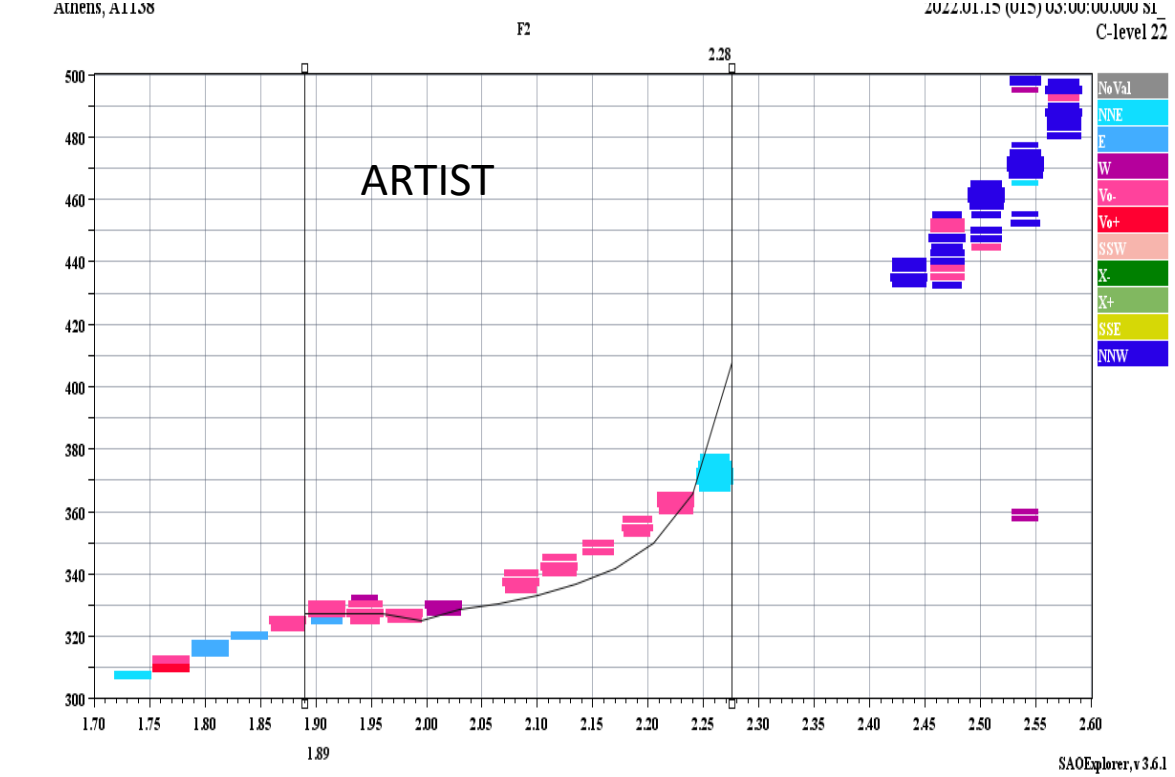
1. The foF2 frequency is specified, based on the concept adopted by human scalers, and automated here in Matlab code. The method takes advantage of both O and X waves reflections and on the half gyrofrequency, which separates the foF2 from the fxF2.
2. Using a clustering methodology, the O-trace is extracted, based on the use of the single link (SL) hierarchical clustering algorithm.
3. The h’(f) is inverted to the true height profile using the POLAN.

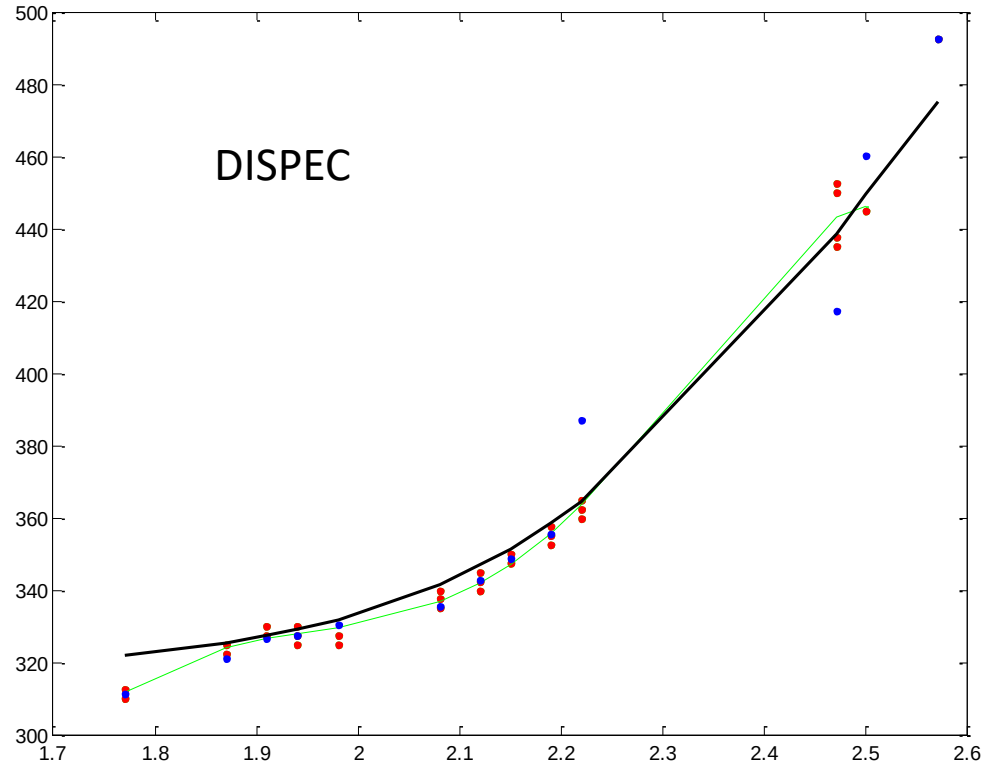
Regarding the **foF2 estimation**:

Case with large gap and mixture of vertical and oblique echoes

foF2 ARTIST	foF2 DISPEC	foF2 Manual
2.28	2.57	2.58



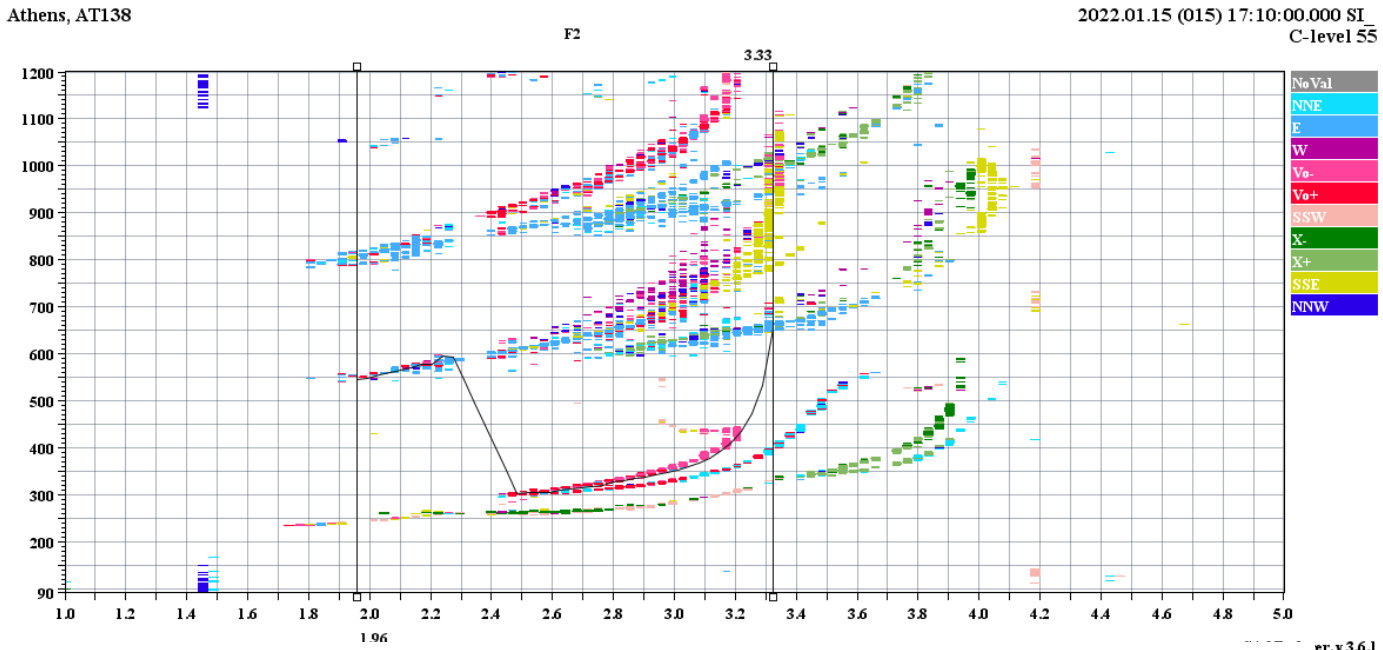


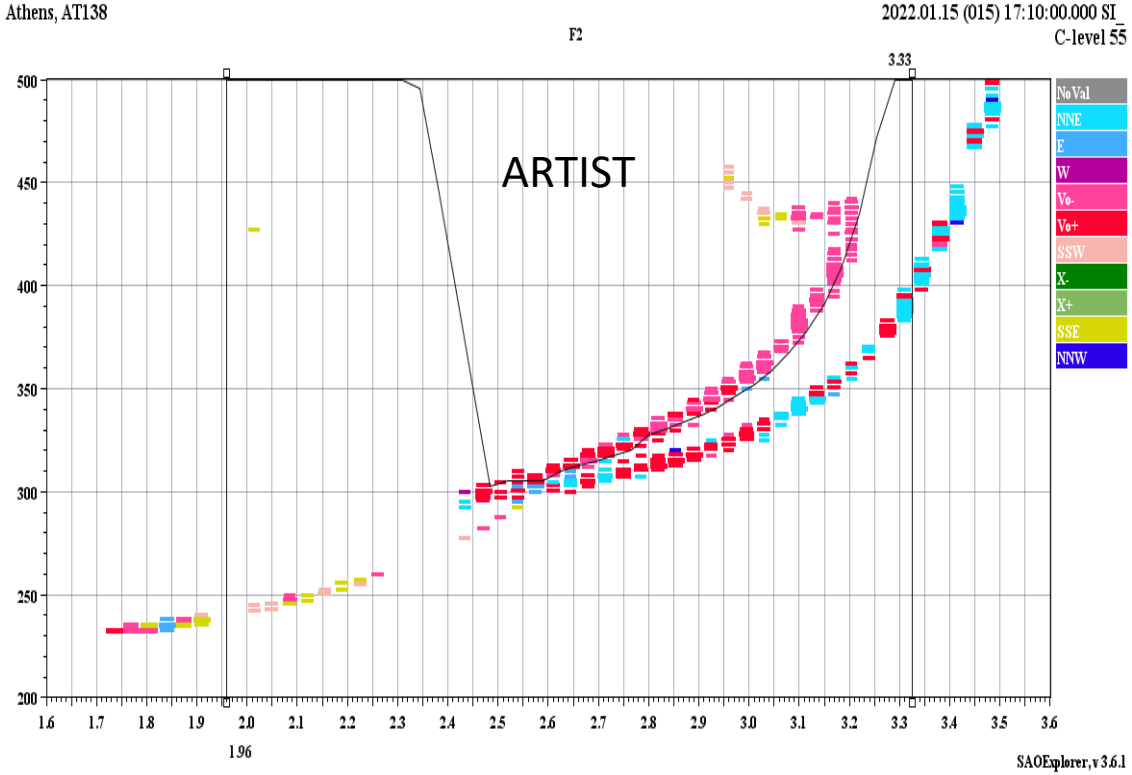


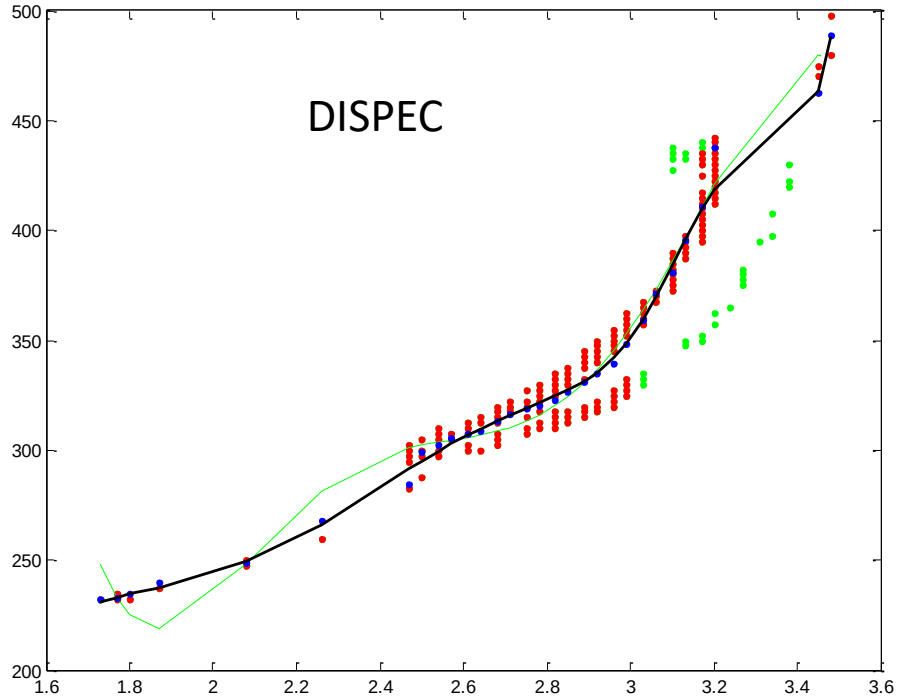
Regarding the **foF2 estimation**:

Case of ionograms with multiple-hop F traces

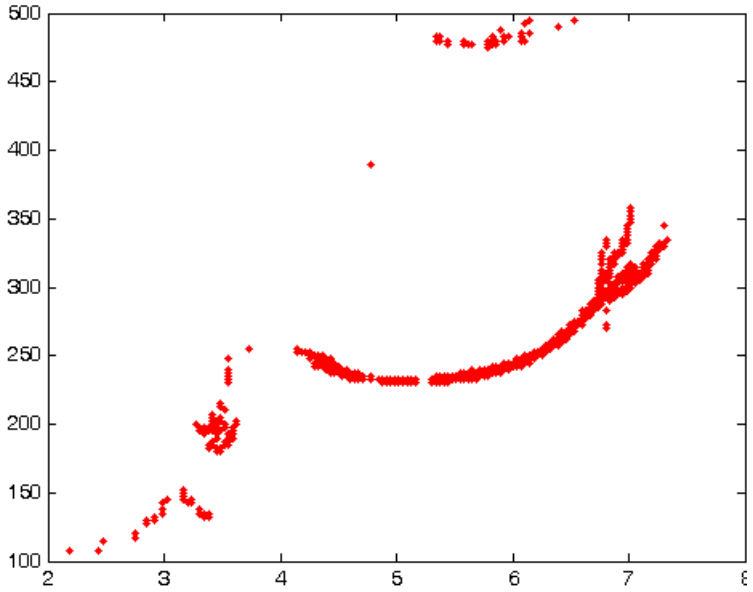
foF2 ARTIST	foF2 DISPEC	foF2 Manual
3.33	3.48	3.5

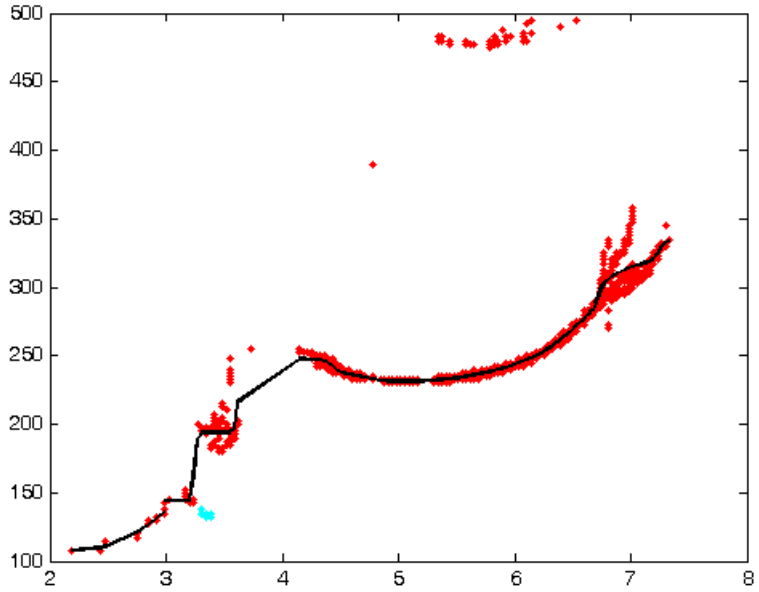


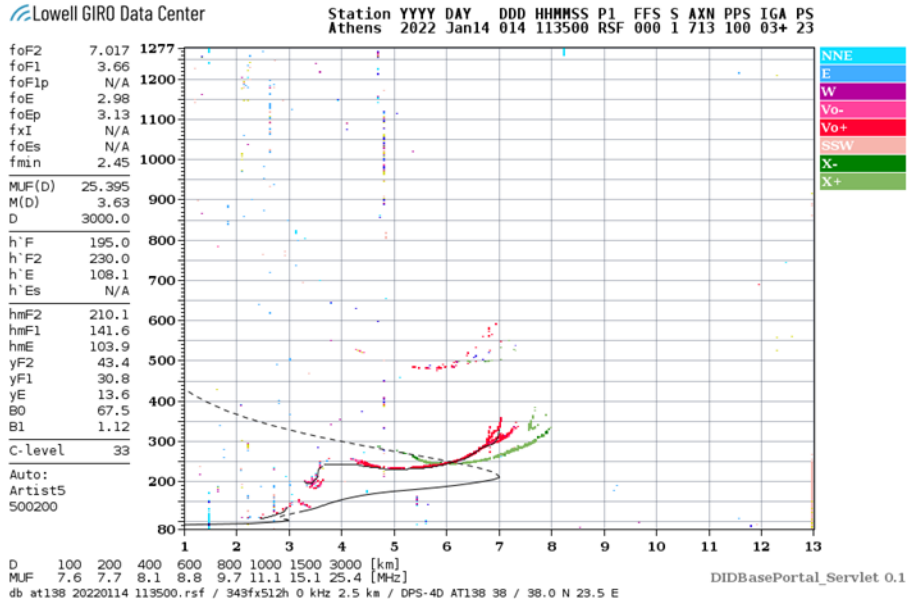


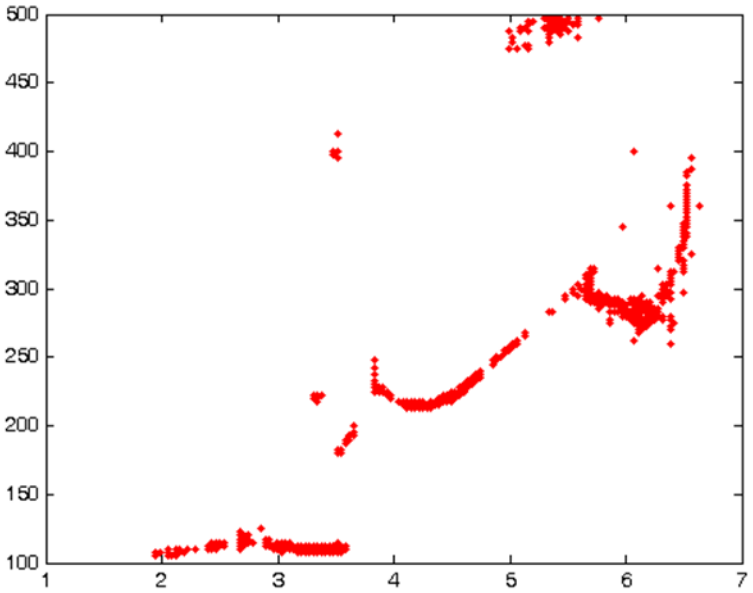


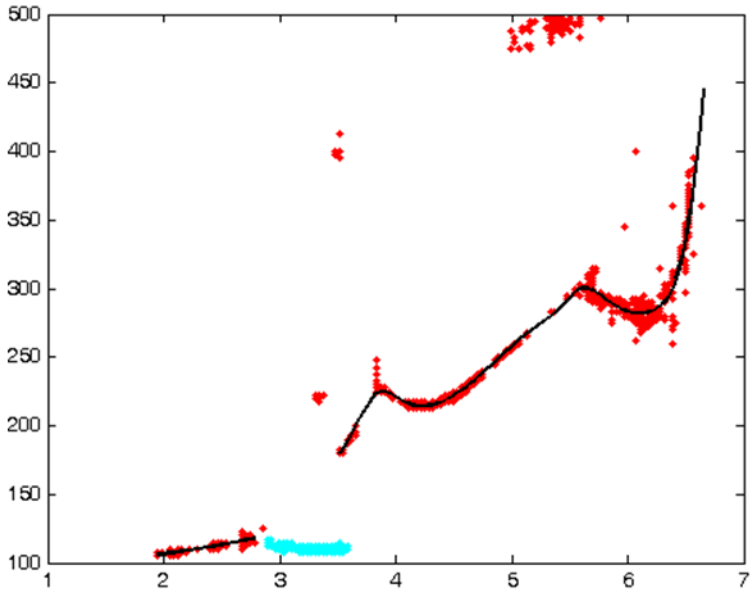
Regarding the **hmF2 estimation**:

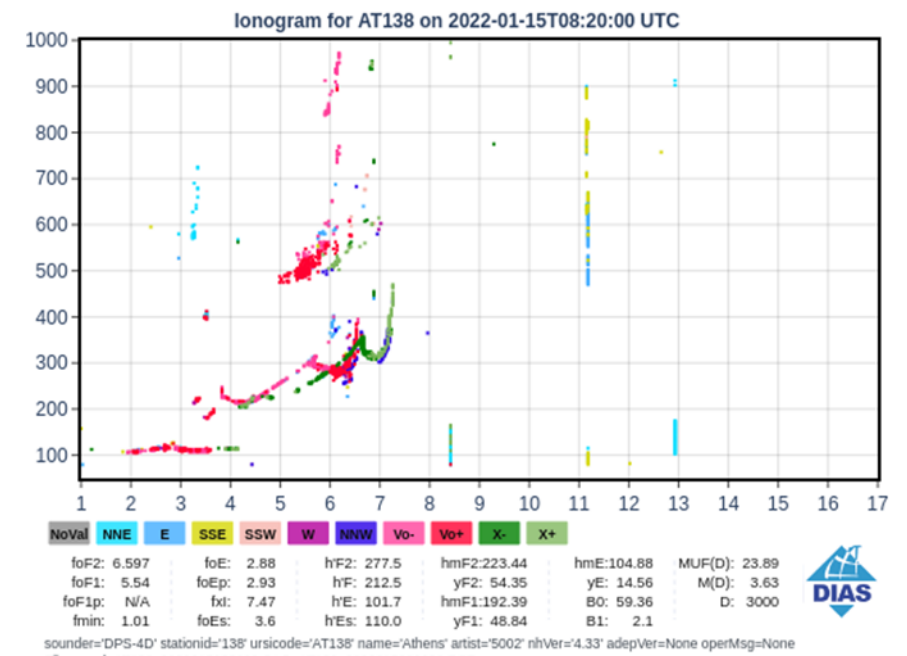


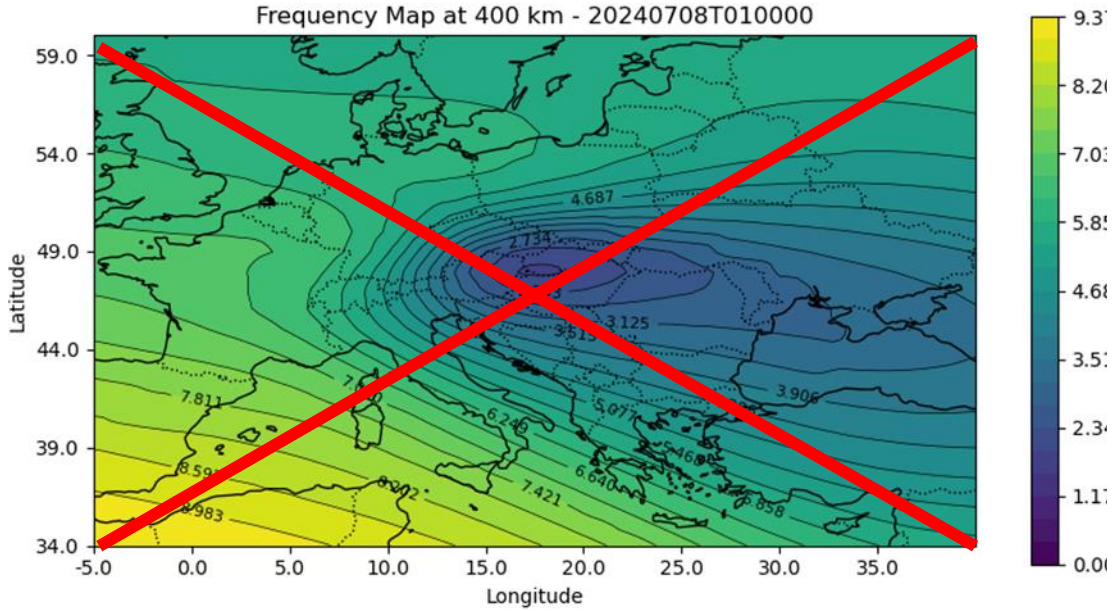


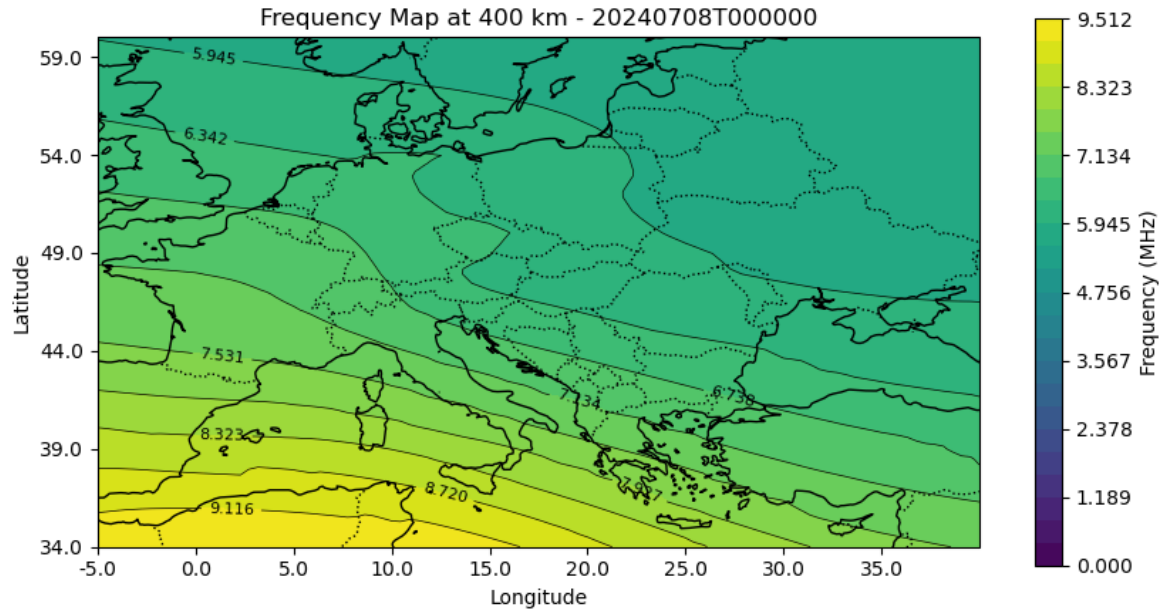









Frequency Map at 400 km - 20240708T010000
Latitude
Longitude
59.0
54.0
49.0
44.0
39.0
34.0
-5.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
4.687
2.734
3.125
3.906
7.811
6.246
7.421
6.640
8.983


Frequency Map at 400 km - 20240708T000000
Latitude
Longitude
Frequency (MHz)
59.0
54.0
49.0
44.0
39.0
34.0
-5.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
5.945
6.342
7.531
8.323
9.116
8.720
9.512
8.323
7.134
5.945
4.756
3.567
2.378
1.189
0.000

Proposed High Level Data Products

- Corrected time series of foF2 and hmF2 characteristics over Digisonde stations
- 3D EDD grids over the European region for the bottomside ionosphere
- 3D EDD grids over the European region for the topside ionosphere

Thank you for your attention!

WEB: https://dispec.eu

Funded by the European Union

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