THE EISCAT TROMSO DYNASONDE

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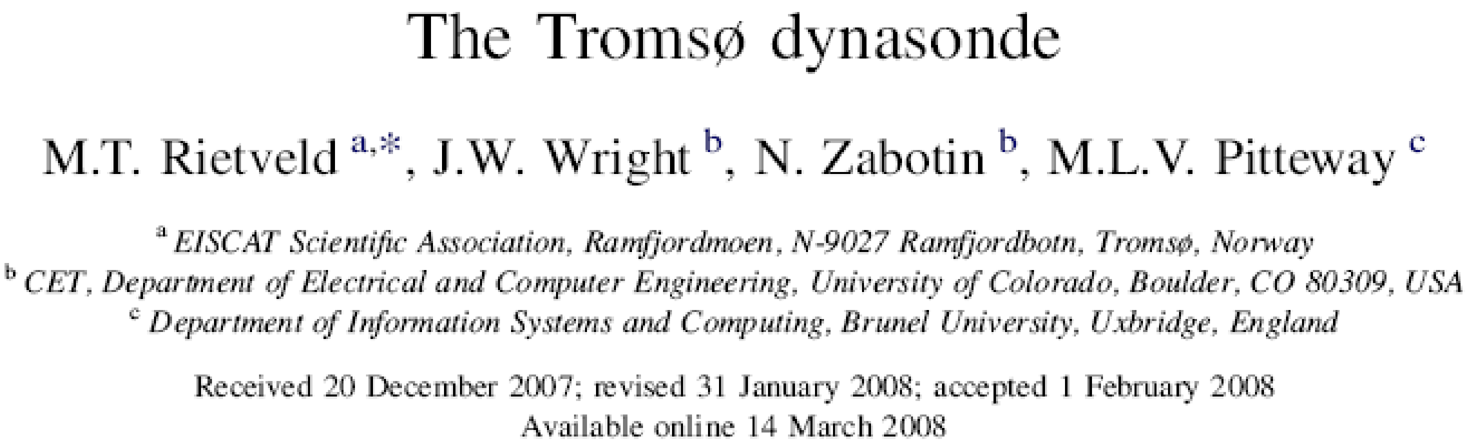
Introduction

- A Dynasonde is an advanced ionospheric sounder (also known as AIS). 6 were built by NOAA in the late 1970's. One came to Tromsø to support the Heating facility in 1980.
- The present capabilities of the instrument are described in a recently published paper: *Rietveld, M.T., J. W. Wright, N. Zabotin, M. L.V. Pitteway, The Tromsø Dynasonde, Polar Science, 2, 1, 55-71, doi:10.1016/j.polar.2008.02.001, 2008.*



The Tromsø dynasonde

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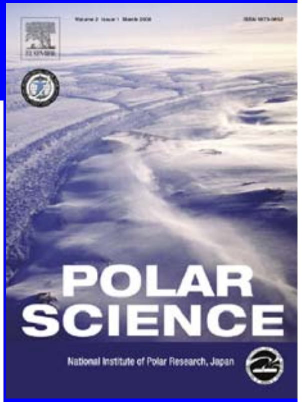
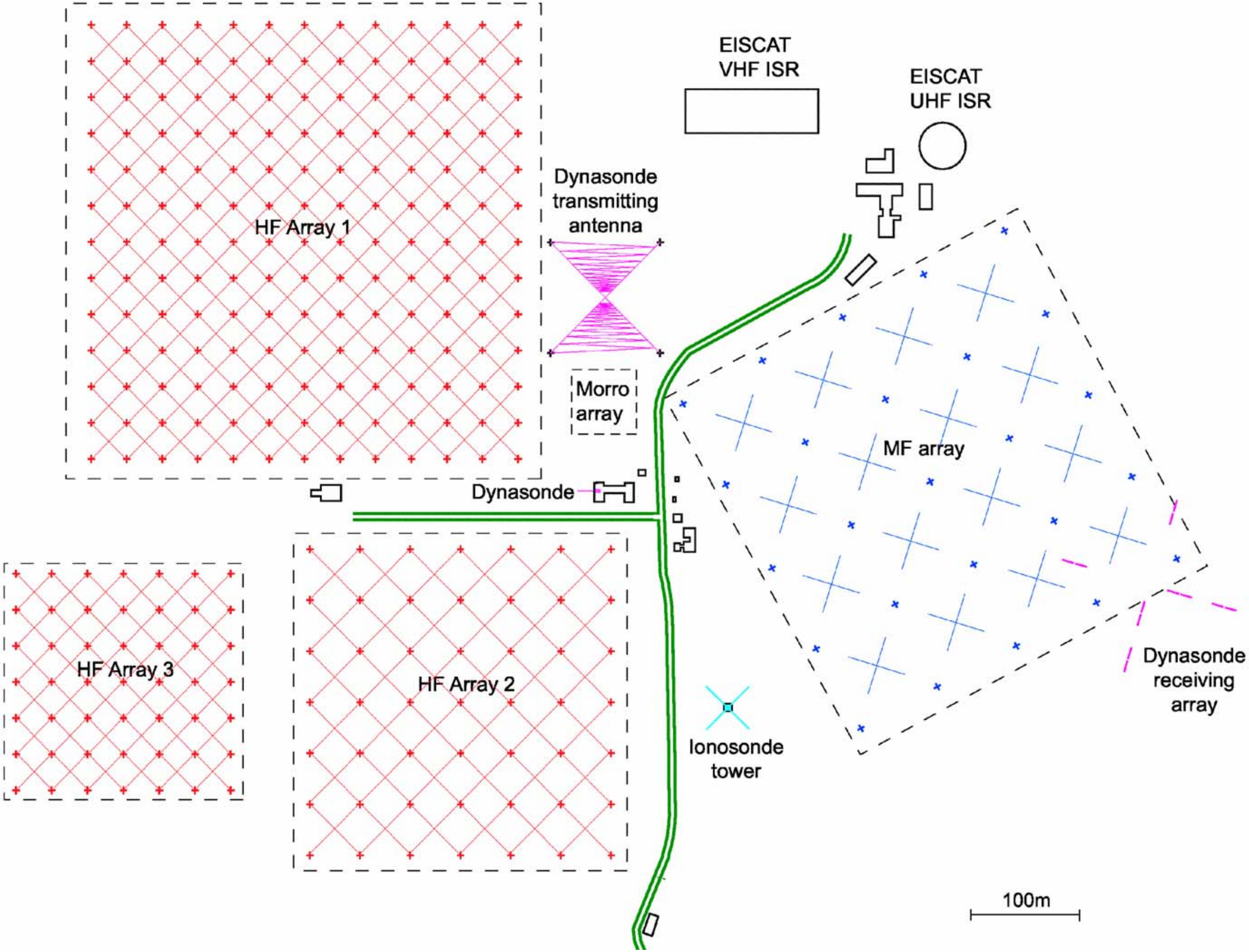


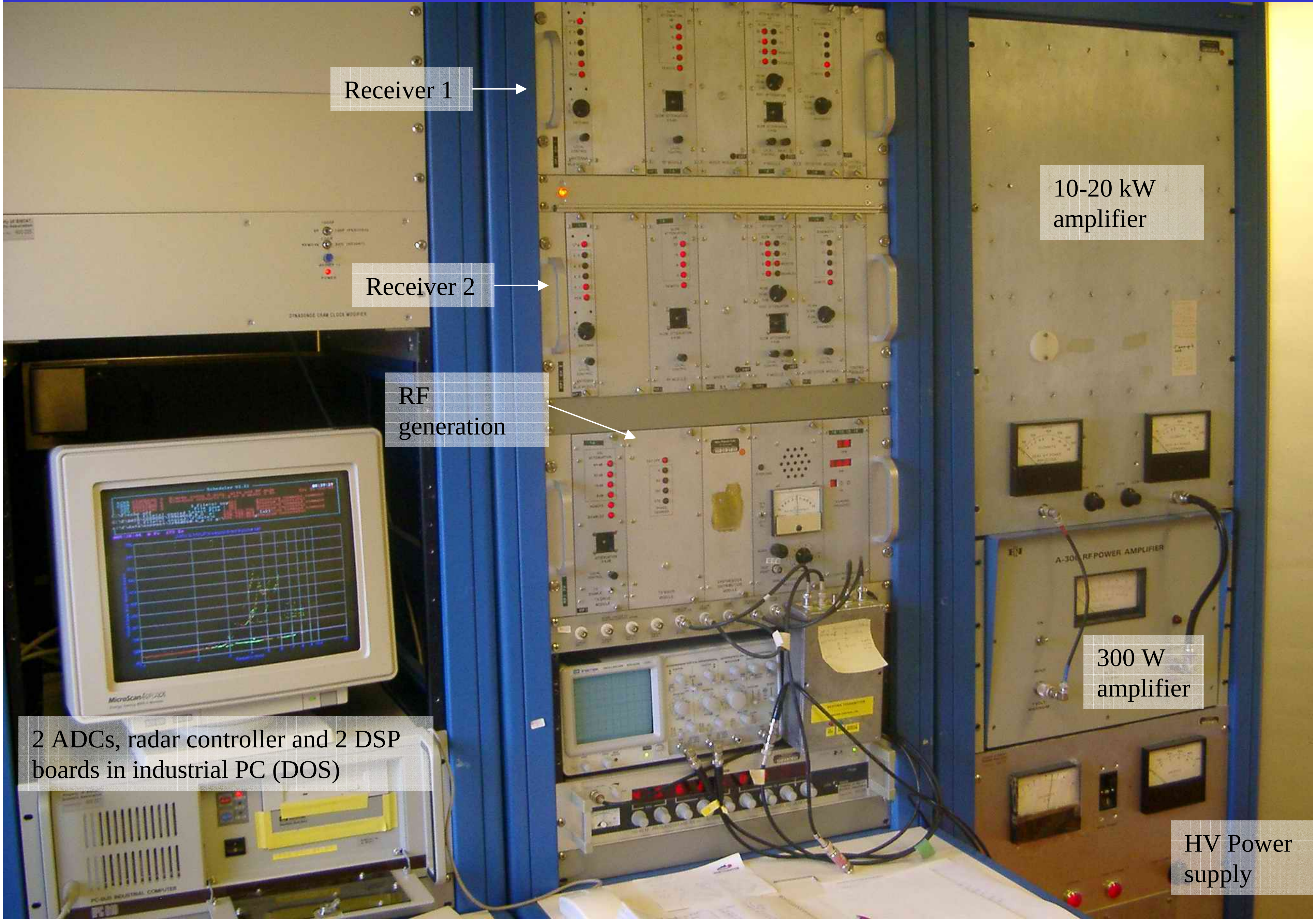
- In addition to the long term ionosonde recordings made by the Auroral Observatory in Tromsø, Norway (Hall and Hansen, 2003), a Dynasonde has been in regular operation since the 1980’s.
- 1980-1992 Max Planck Institute for Aeronomie ran the sounder primarily as an ionospheric heating diagnostic. One of 6 sounders built.
- 1993-present EISCAT operates the sounder continuously, typically every 6 minutes. Upgrade of the computer to PC-based system (DOS).
- Since about 1989, it has been used to test and implement various innovations in ionospheric sounding:

  1. Refinements of the earliest 4-pulse-set concept: tests of alternate frequency-offset vectors; tests of 8-pulse sets, and their frequency-offset vector choices;
  2. Tests of alternate choices by which the dynasonde’s receiving array (6-dipoles) is commutated within a pulse set between the dynasonde’s two receivers;
  3. Evolution of a practical scheme for calibrating the 6-dipole, 2-receiver system for precision phase and amplitude measurements;
  4. Studies of “Radio-Frequency Interference Excision” in dynasonde data acquisition;
  5. Development and testing of a new, largely phase-based method (‘PRETEC’) for the dual and related purposes of rejecting impulsive interference and recognizing valid echoes;
  6. Development and testing of an ionogram-based extension of sounding capability for mesospheric observations.
  7. Collaboration in the installation and testing of a real-time data analysis system, first at the EISCAT dynasonde and later in more advanced form at the National Geophysical Data Center, NOAA, Boulder.

Radio research systems at the EISCAT Ramfjordmoen site near Tromsø, Norway

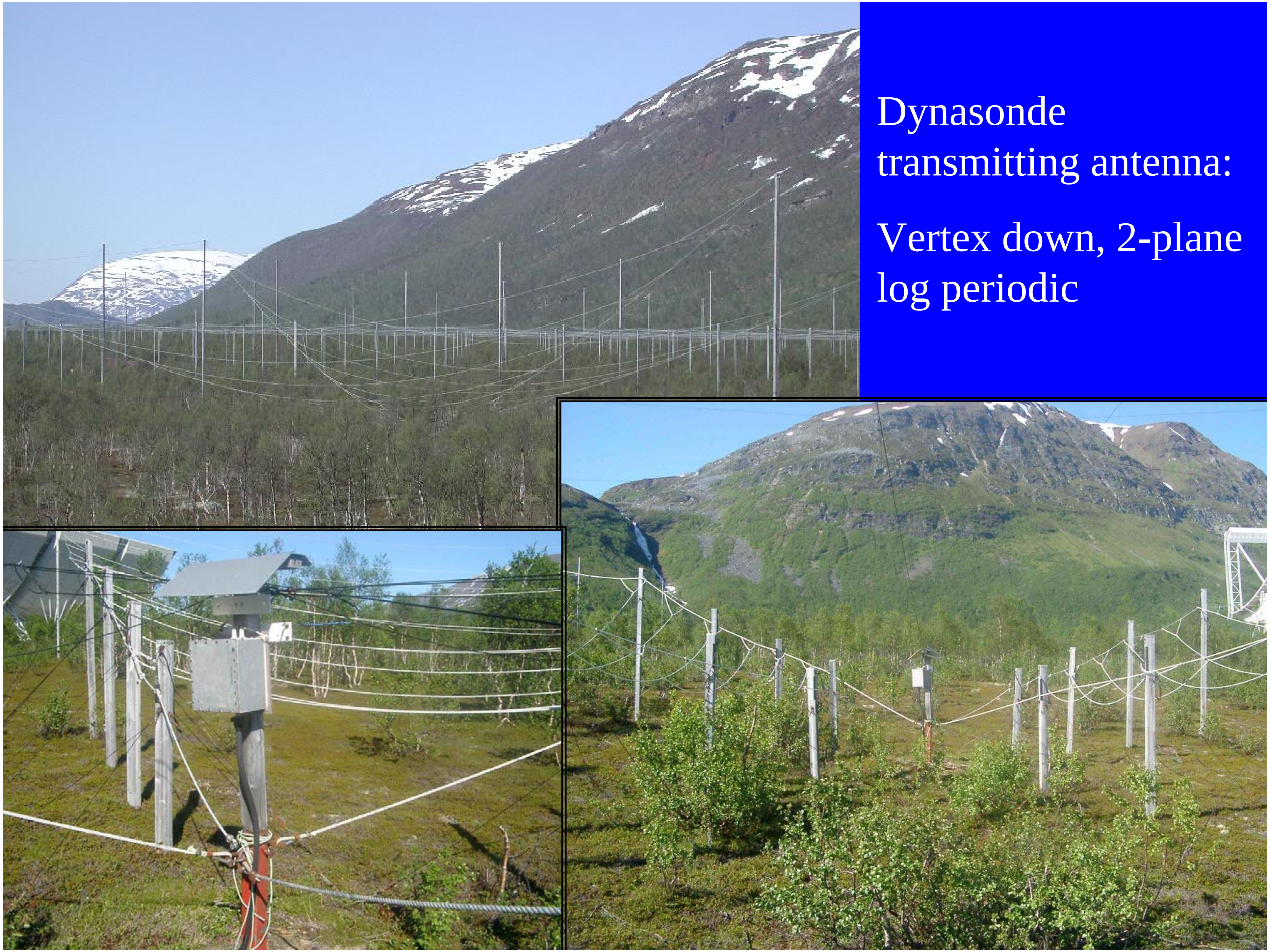


The present Tromsø Dynasonde



Dynasonde transmitting antenna:

Vertex down, 2-plane log periodic



One of 6 receiving dipoles

Principles of Dynasonde philosophy are given by **Zabotin and Wright**, ”***Principles of Dynasonde data acquisition and processing***” later in this session.

Main Principles of Dynasonde Sounding and Data Processing

► The *Radio Echo* is the basic physical object in ionospheric sounding. An echo is defined by 6 precisely determined parameters, each with its individual error estimate. There is no use of the artificial notion of “frequency-range bins”.

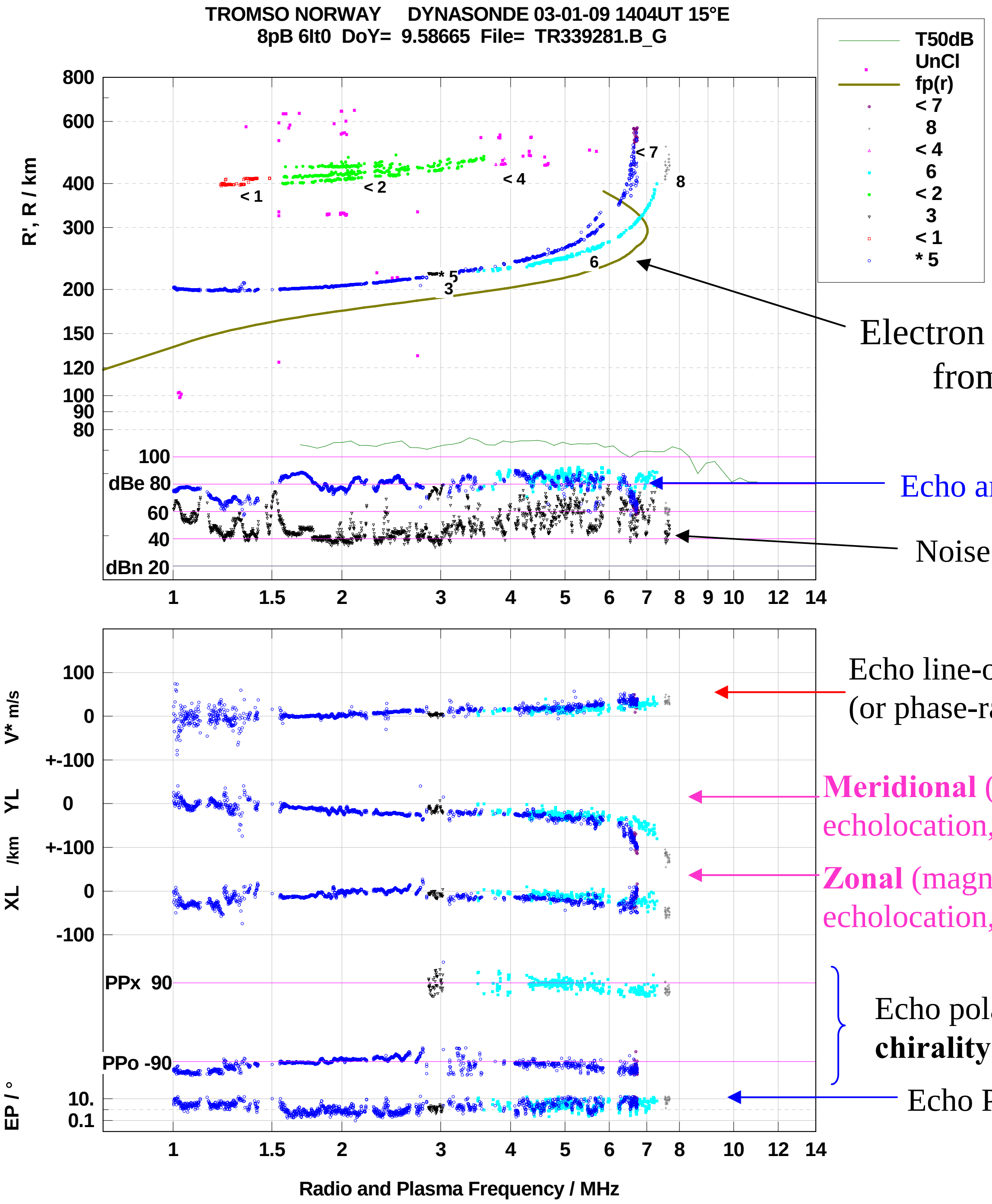
► Group ranges of high precision by the Stationary Phase principle. In (e.g.) 8-pulse sets the radio frequencies are slightly offset (by 1-4 kHz) from the base frequency in a carefully designed pattern to enable precision range measurements (to within a few tens of meters).

► Direct attention to physical properties of the raw data. No Fourier transforms; no pulse coding; no coherent summations. The phase and amplitude of received signals (from raw I & Q) are used directly. Consequence: excellent statistics of recognized echoes. The same echo recognition and characterization process rejects false echoes and noise.

► Diverse and sophisticated methods of higher-level data processing. An autonomous classification of the echoes into traces and subsequent inversion procedures are accomplished based on physics-based criteria rather than using indirect and subjective procedures (such as image analysis).

► Limited impact to other uses of the radio spectrum. No long sequences of pulses at the same base frequency. Instead, short sequences (3 to 8) of narrowband (30 kHz) pulses are used.

Simple 'quiet' ionogram and the physical derived parameters of each 'echo'



Colours: Echo classification into traces based on **physical criteria**

Electron density profile from POLAN

Echo amplitude

Noise level

Echo line-of-sight **Doppler** (or phase-range speed), *V** in m/s

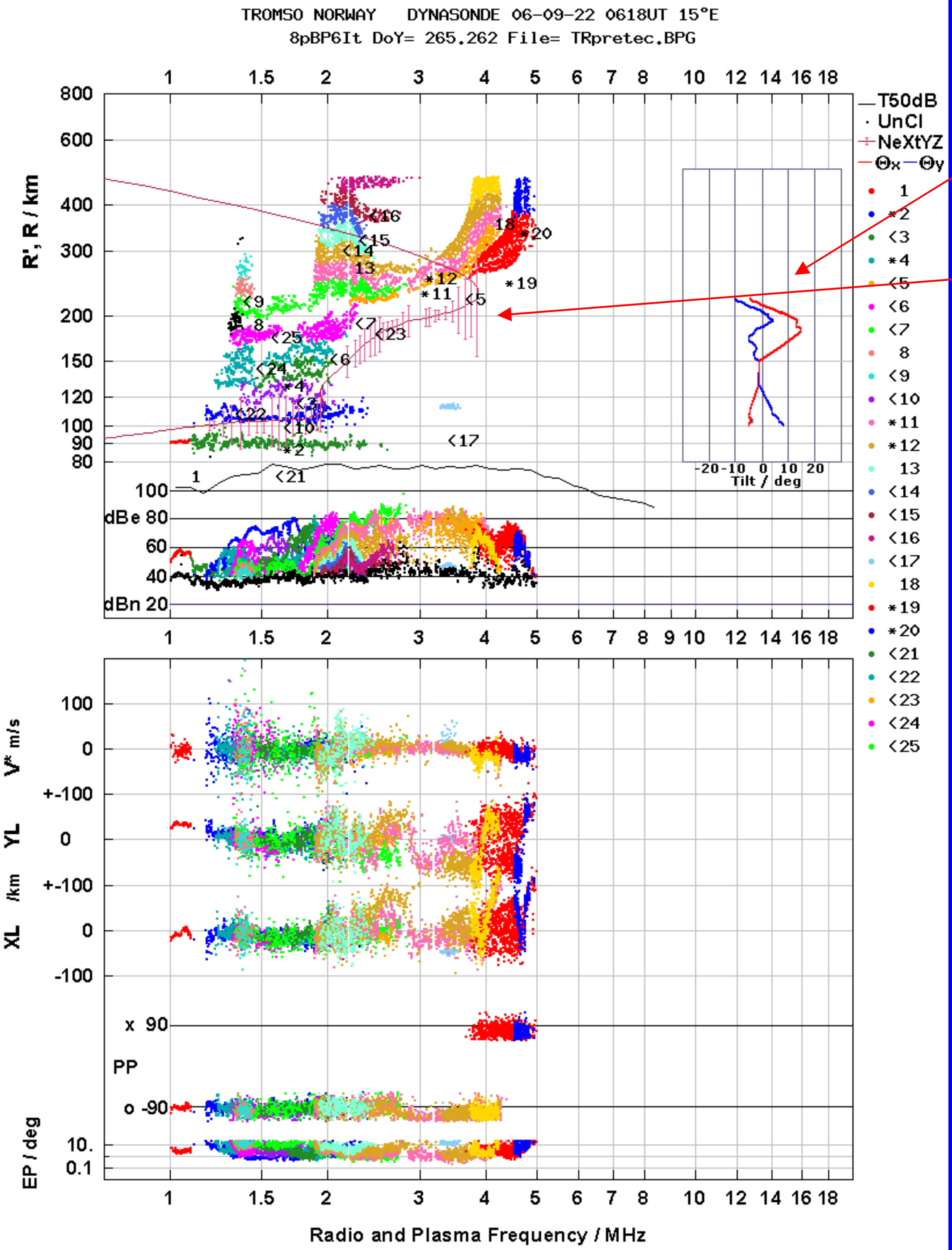
Meridional (magnetic) component of echolocation, in km from the zenith

Zonal (magnetic) component of echolocation, in km from the zenith

Echo polarization rotation, or **chirality**

Echo Phase Error

Complex ’disturbed’ ionogram and the physical derived parameters of each ’echo’



NeXtYZ:

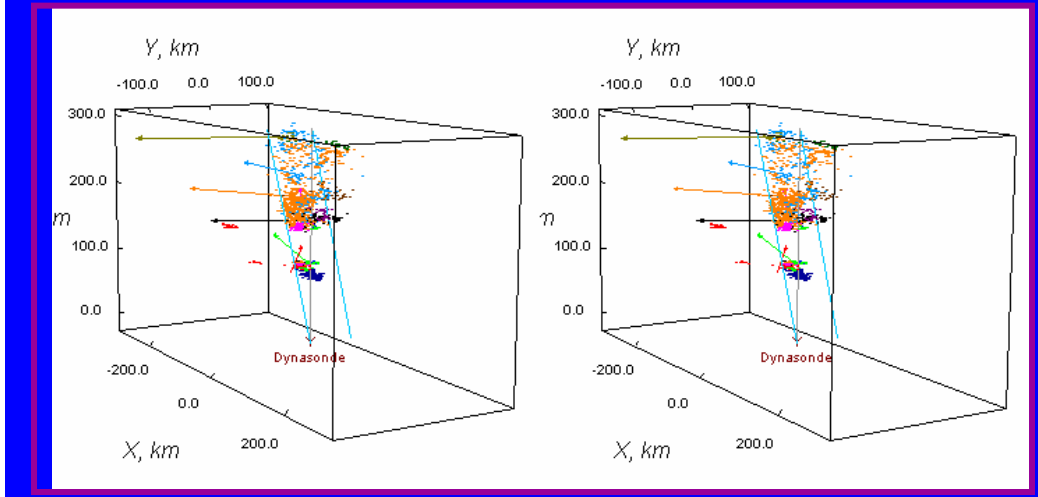
3-dimensional Ne inversion allowing for ionospheric tilts, with error bars

The inversion is done using wedge stratified ionospheric layers. The variations of northward (red) and eastward (blue) tilts are shown vs. altitude in the insert.

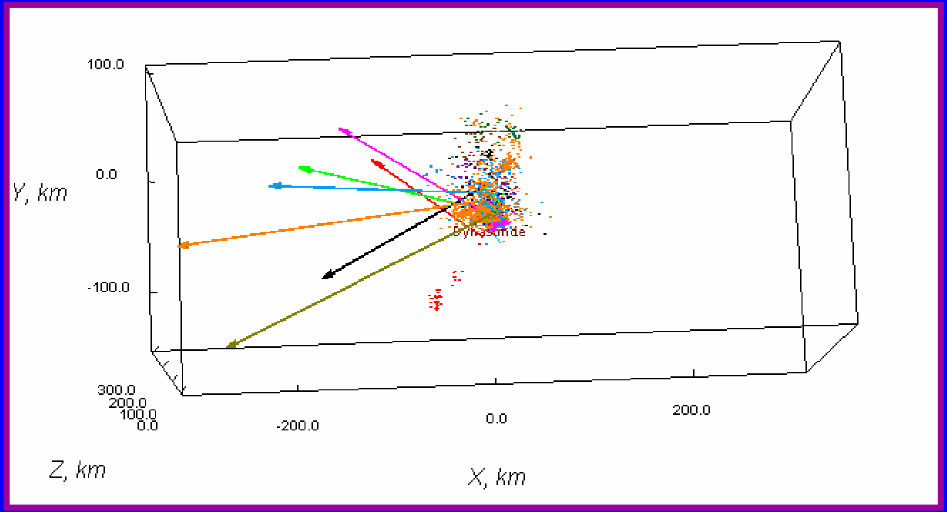
(Zabotin, N. A., J. W. Wright and G. A. Zhbankov, “NeXtYZ: Three-dimensional electron density inversion for dynasonde ionograms”, Radio Sci., 41, 2006)

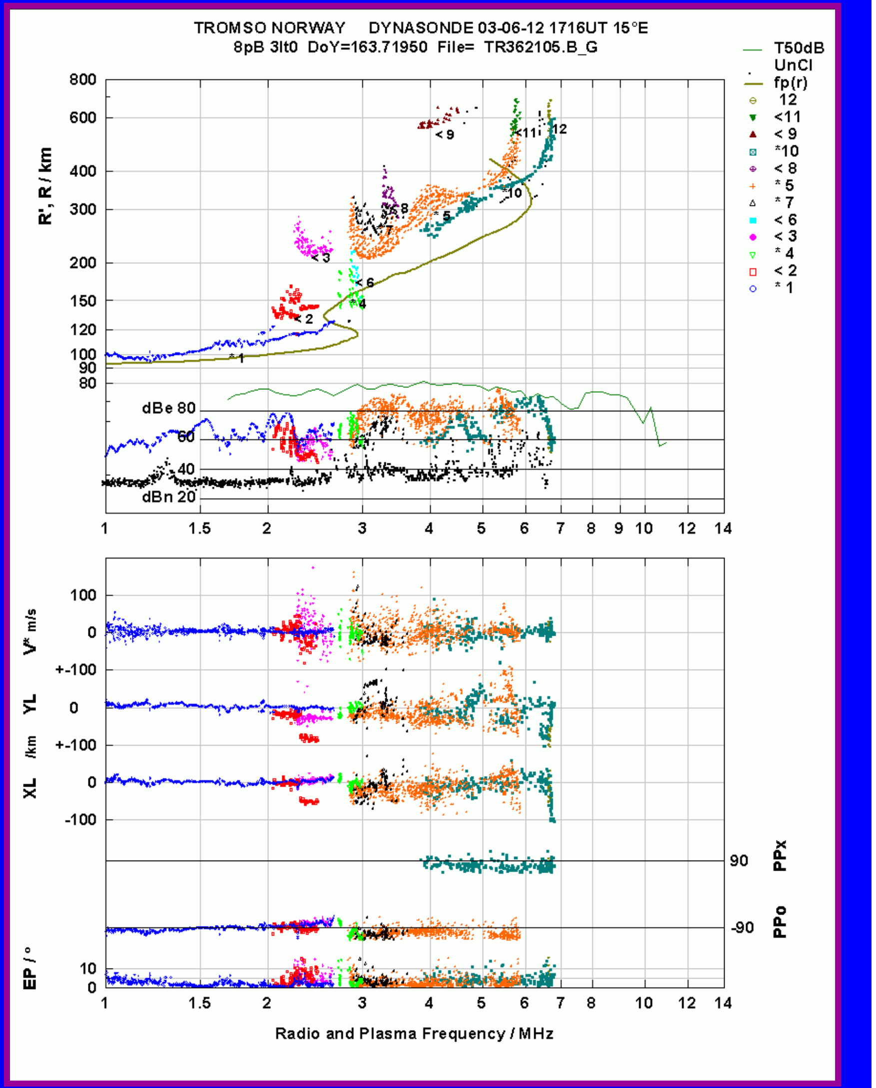
3D Visualization of Dynasonde Ionograms, and Spatially-Diverse Vector Velocities

Stereo View …

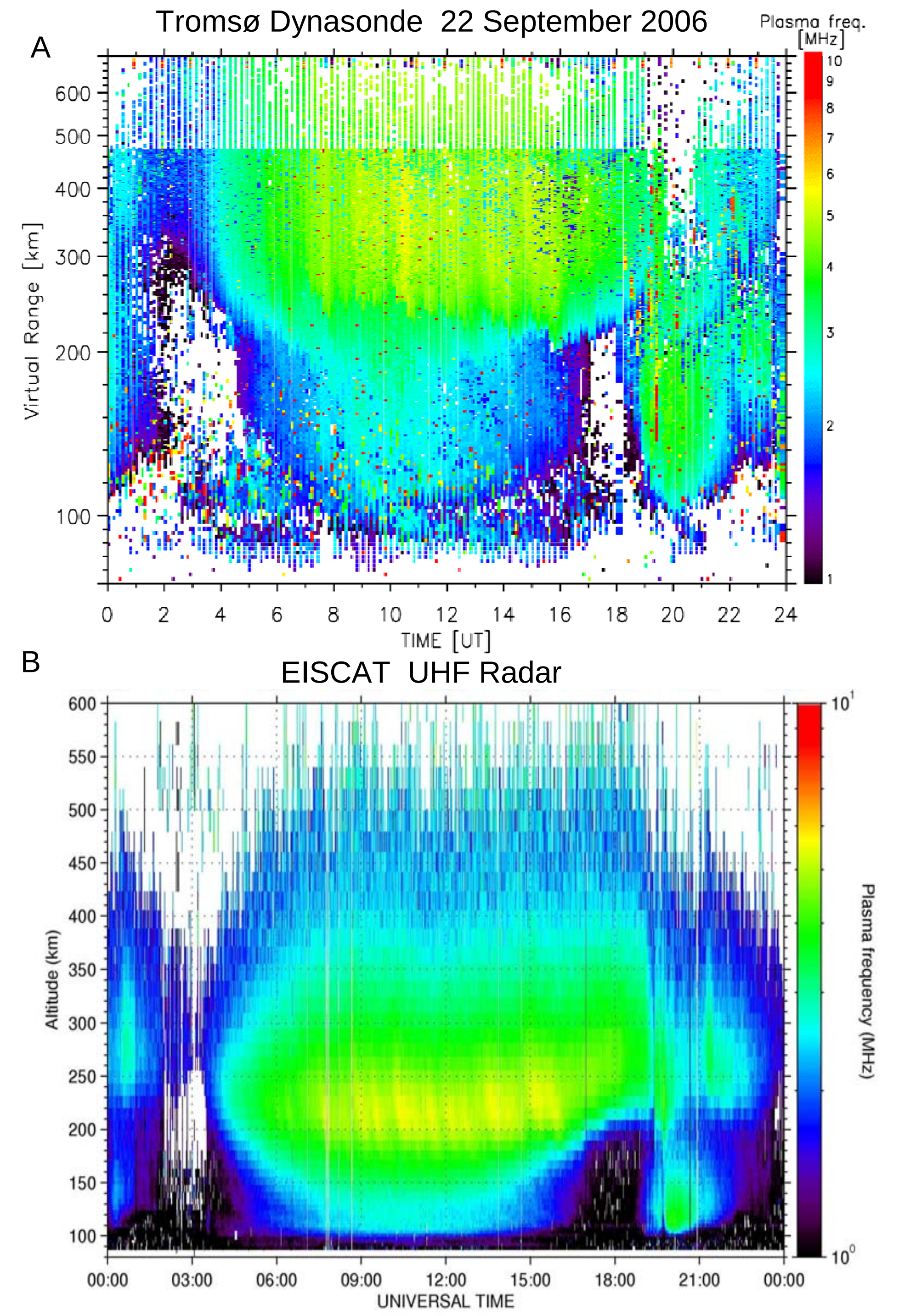


… and from Above





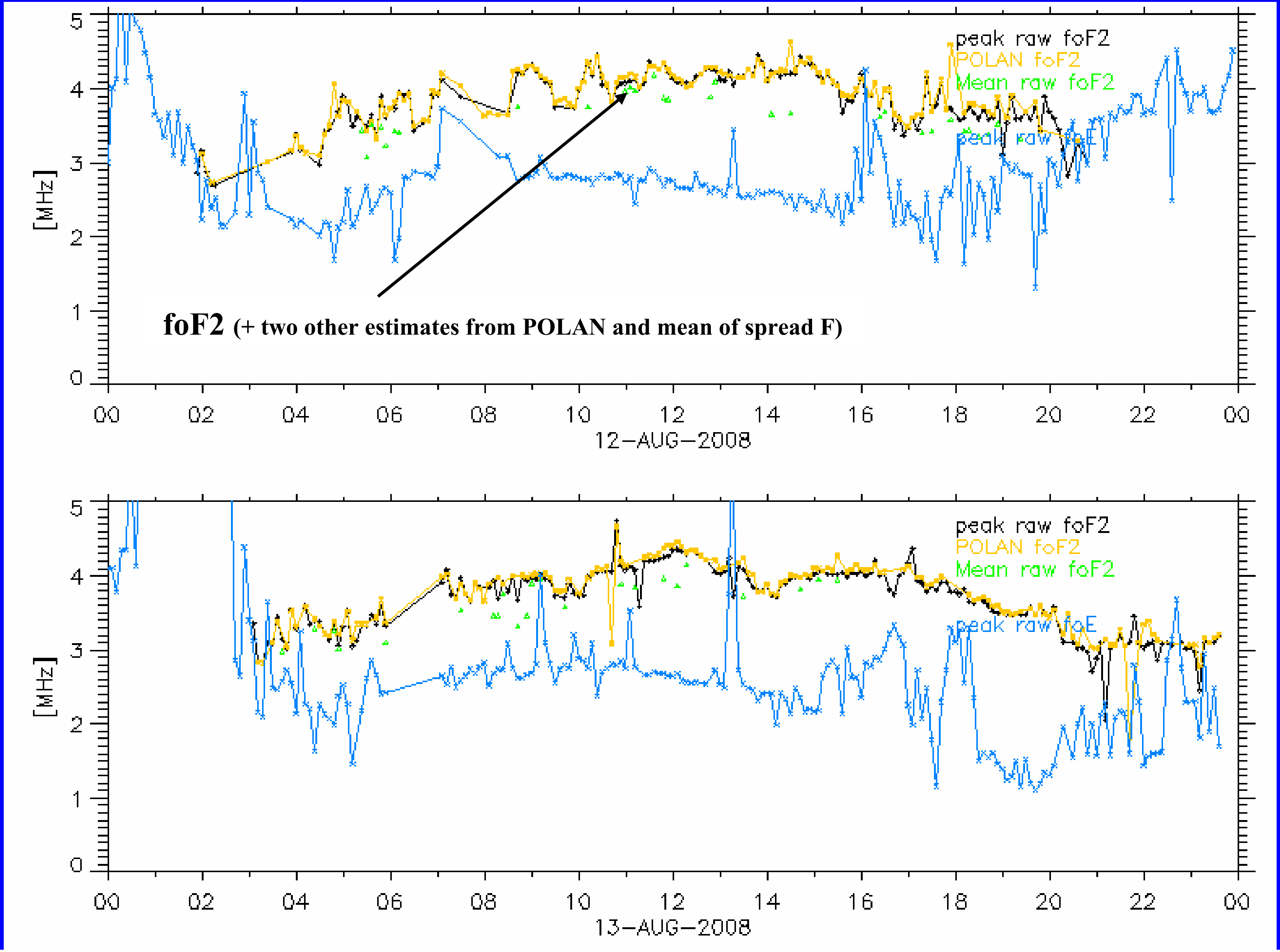
Overview plots and comparison with the EISCAT incoherent scatter radar



Plasma frequency plot from (a) the dynasonde and (b) the EISCAT UHF (931 MHz) incoherent scatter radar for a 24-hour interval. The vertical striping effect near the top in (a) is caused by every second sounding being a 'PRETEC' sounding where the sampling range is limited to below 500 km.

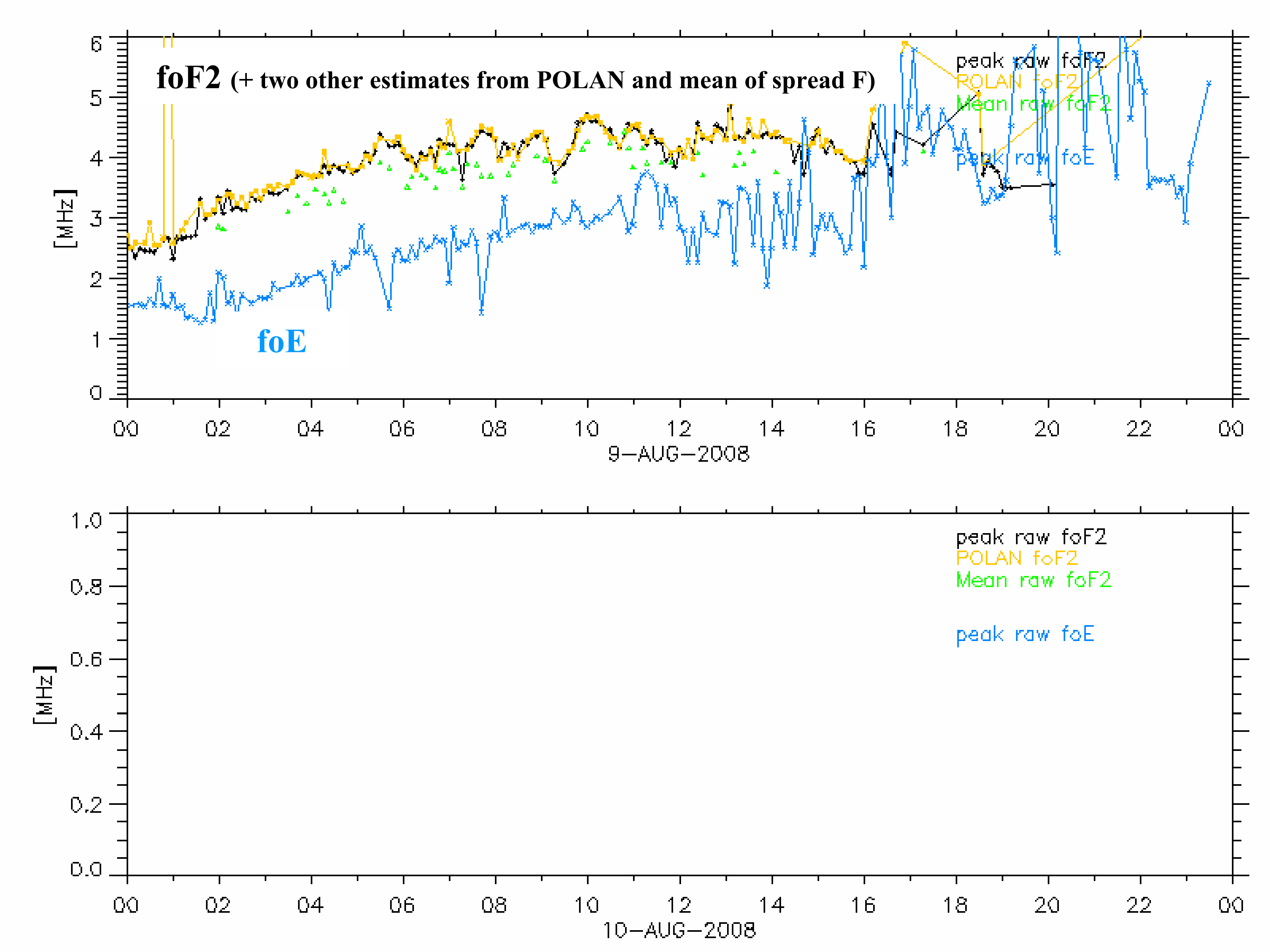
Updating critical freq plot (Tromsø)

http://dynamite.eiscat.uit.no/Latest24hrcrf.htm

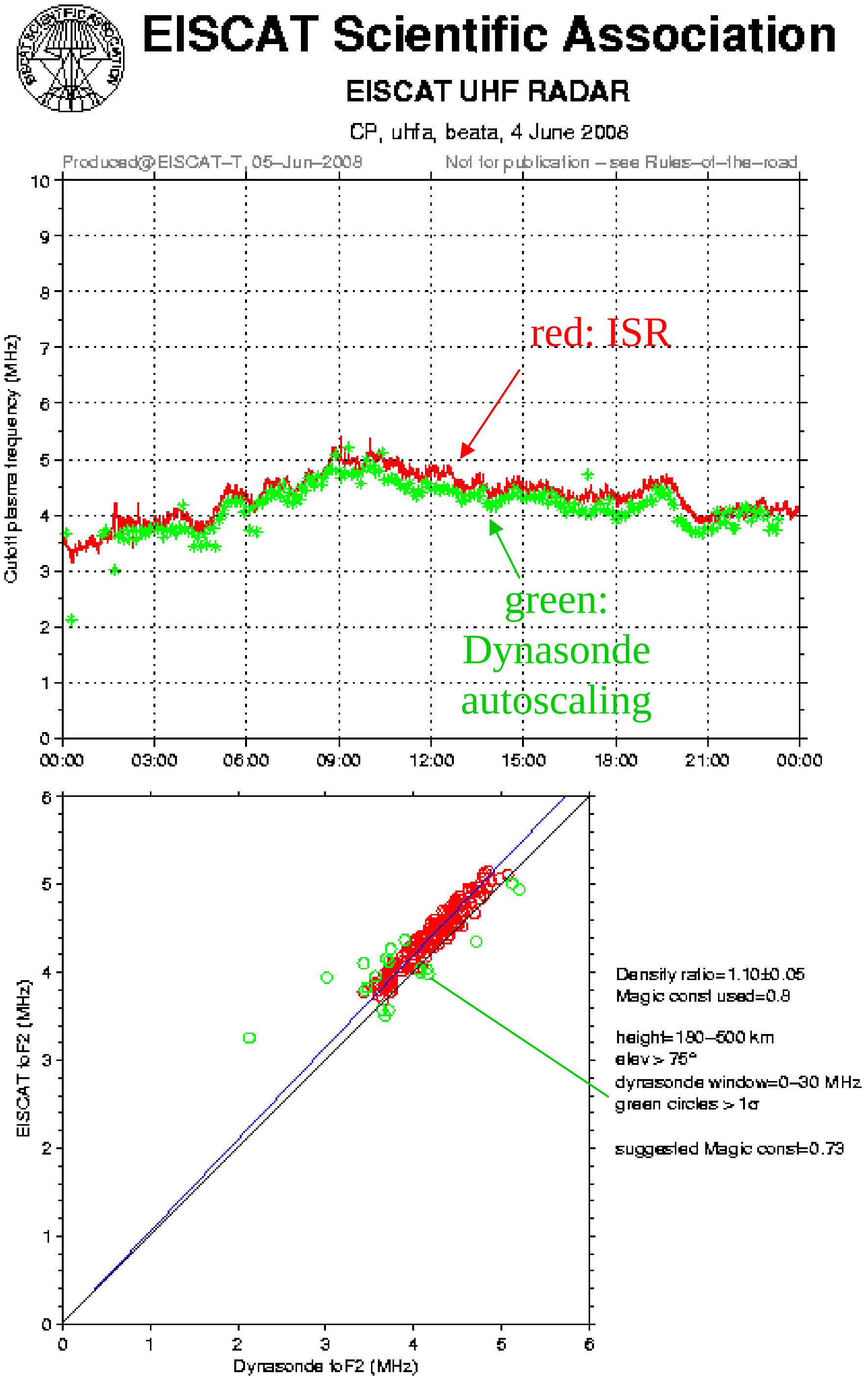

foF2 **(+ two other estimates from POLAN and mean of spread F)**

Updating critical freq plot (Tromsø)

http://dynamite.eiscat.uit.no/Latest24hrcrf.htm



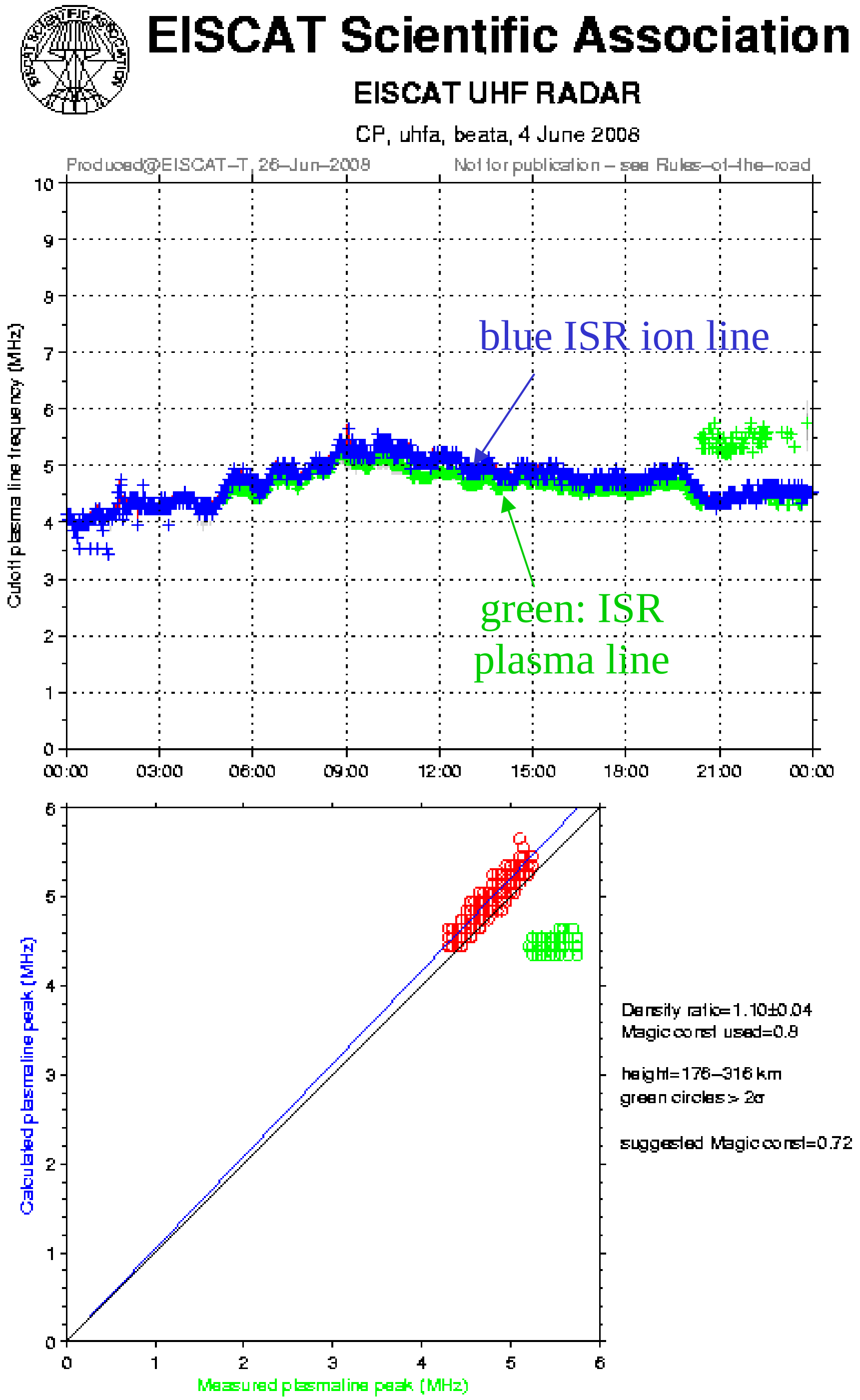
Comparison of ISR peak F-region plasma frequencies with autoscaled foF2 data, using DSND (prototype Dynasonde21 software)



red: ISR

green: Dynasonde autoscaling

Comparison of ISR peak F-region plasma frequencies with plasma-line data



EISCAT Scientific Association

EISCAT UHF RADAR

CP, uhfa, beata, 4 June 2008

Produced@EISCAT-T, 26-Jun-2008

Not for publication – see Rules-of-the-road

blue ISR ion line

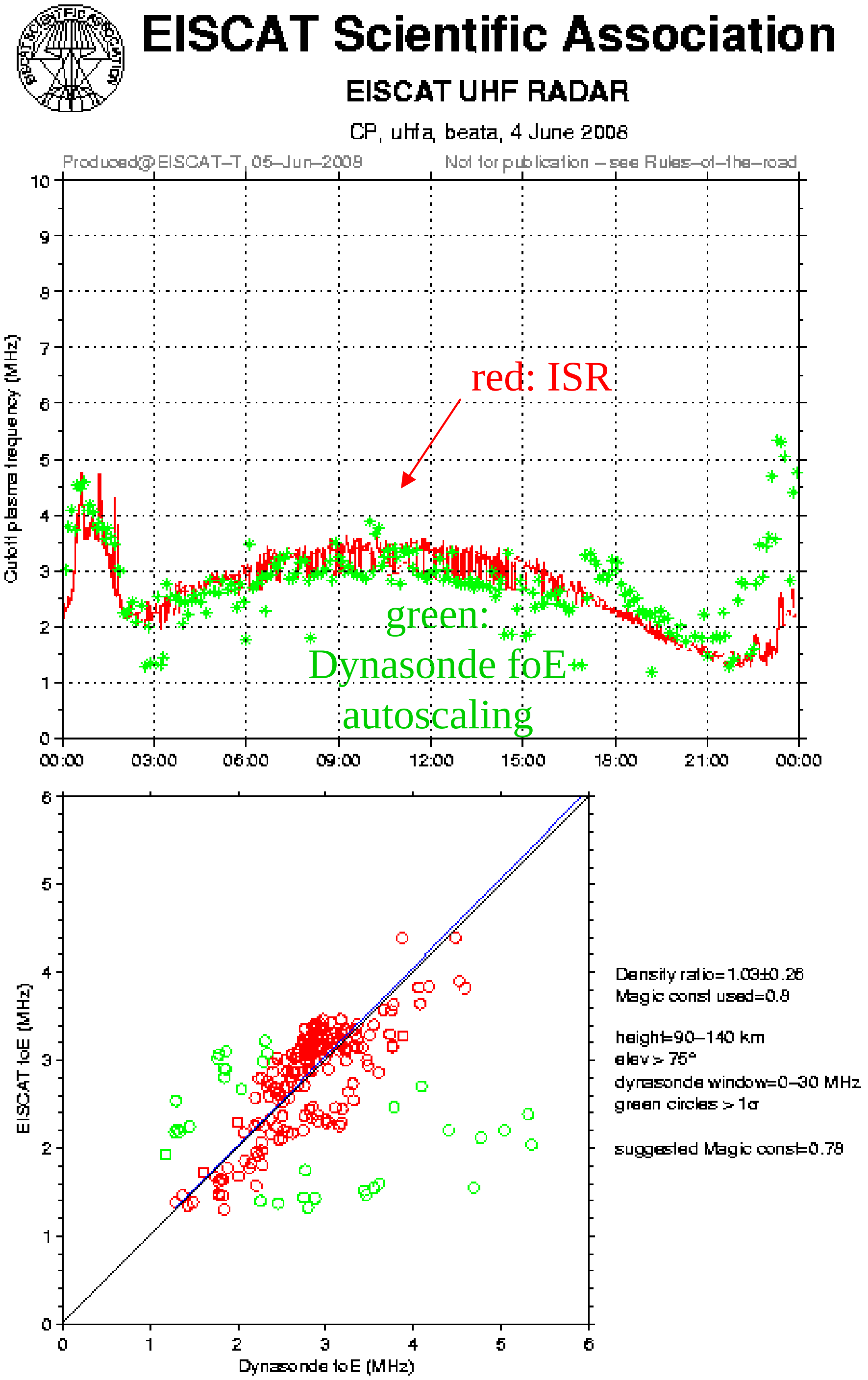
green: ISR plasma line

Density ratio=1.10±0.04
Magic const used=0.8

height=176–316 km
green circles > 2σ

suggested Magic const=0.72

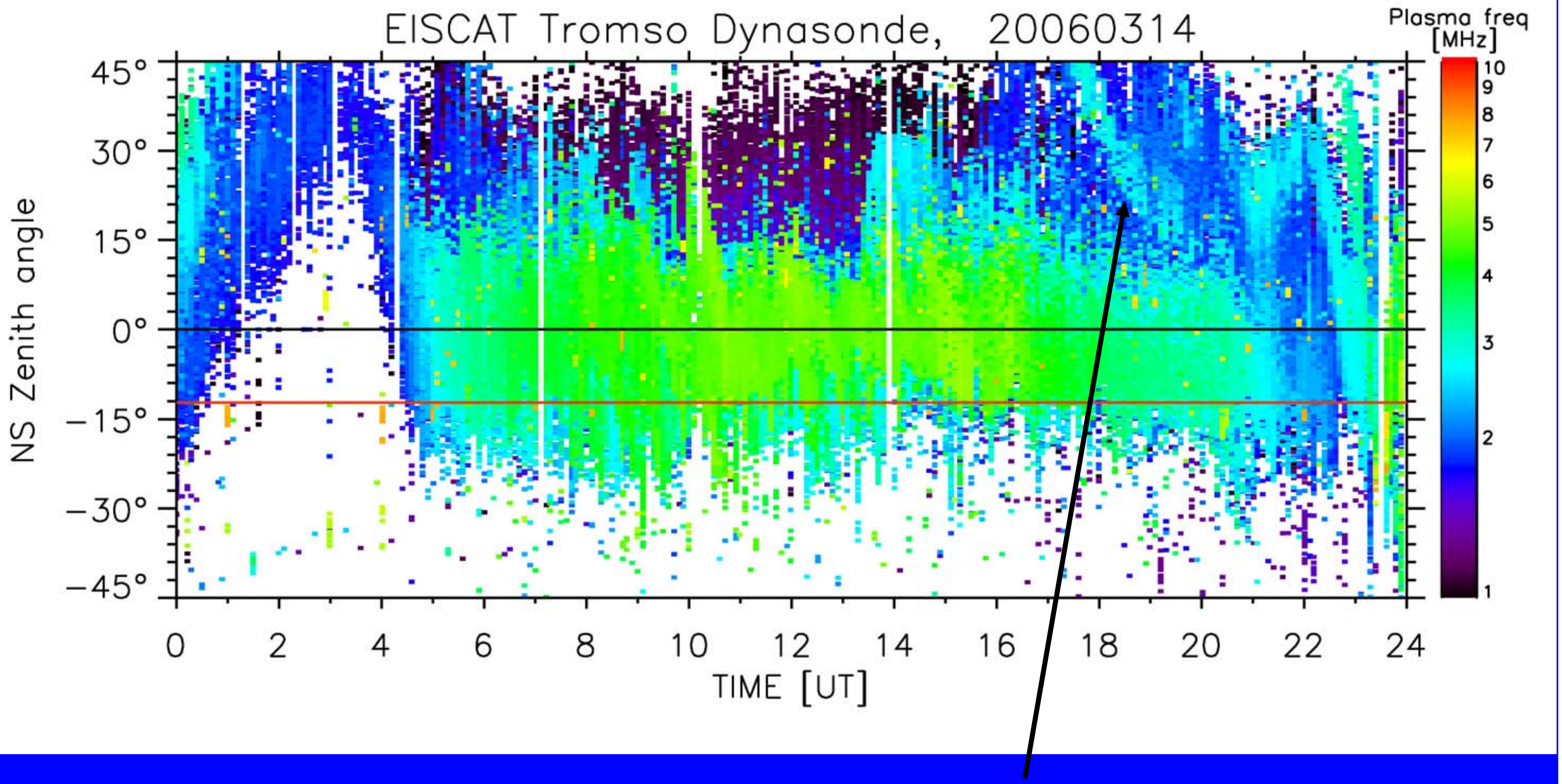
Comparison of ISR peak E-region plasma frequencies with autoscaled foE data, using DSND (prototype Dynasonde21 software)



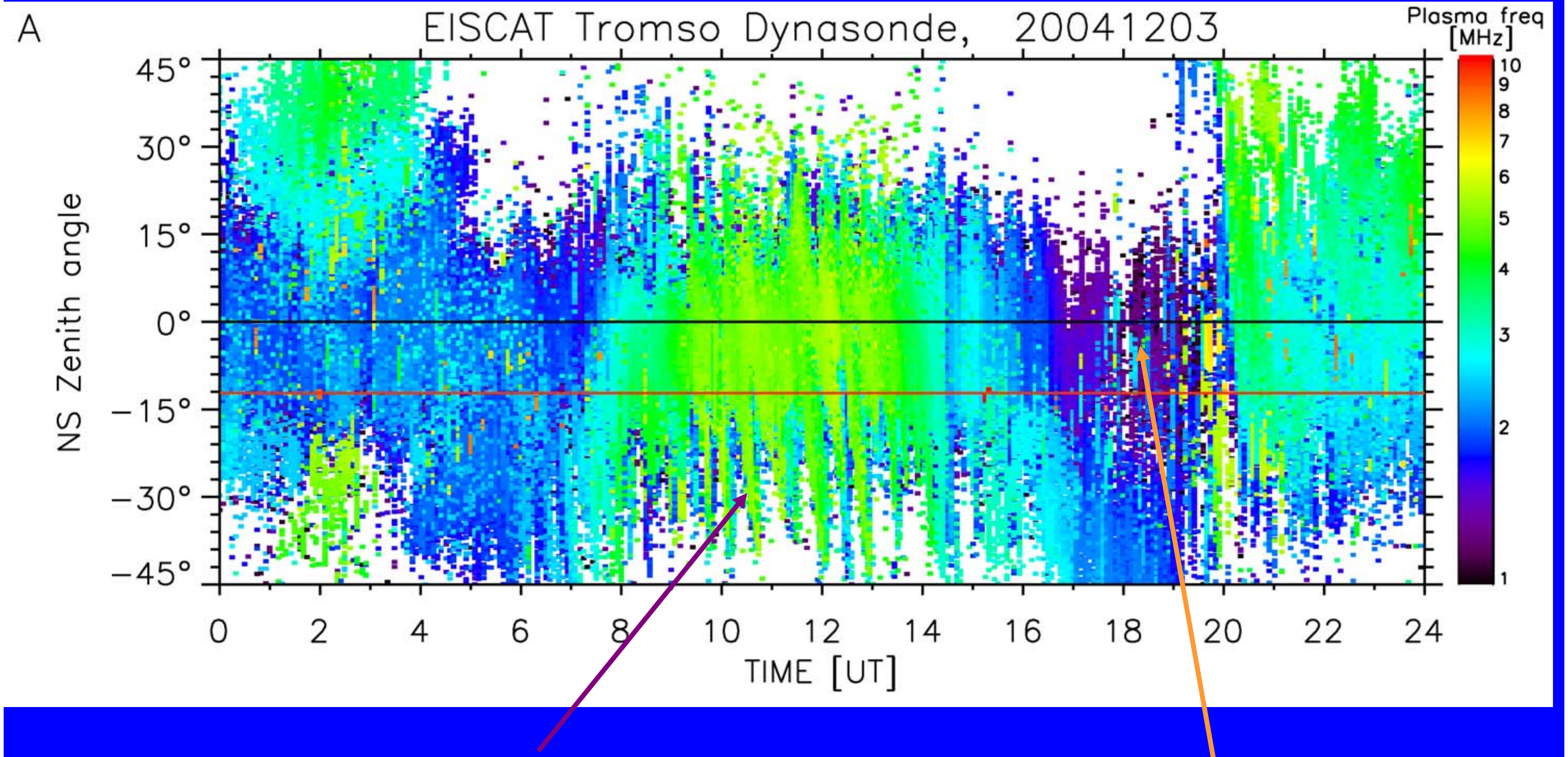
red: ISR

green: Dynasonde foE autoscaling

Maximum plasma frequency (o-mode echo) in colour shown as a function of north-south zenith angle and time. The black line shows the vertical while the red line shows the magnetic field direction.

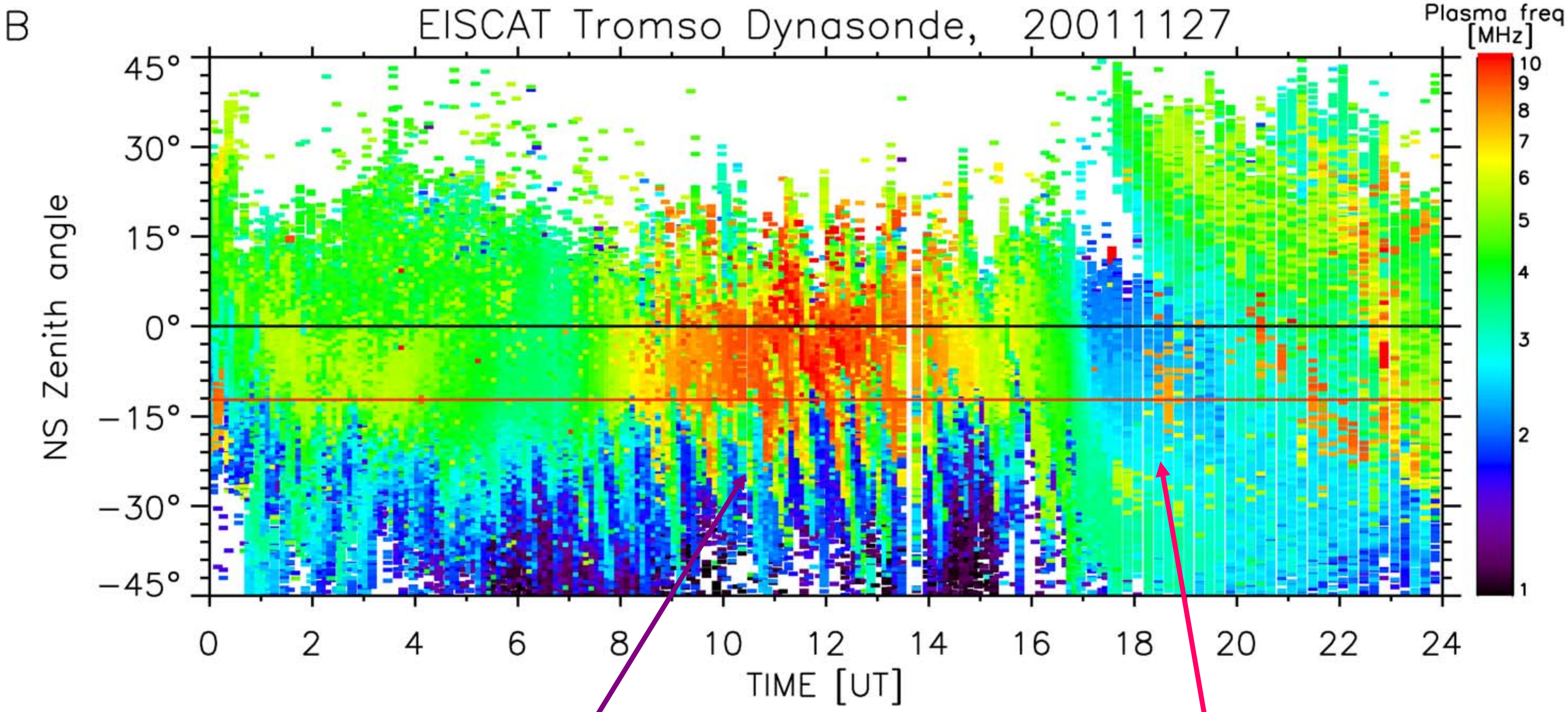


Note the motion of a plasma blob



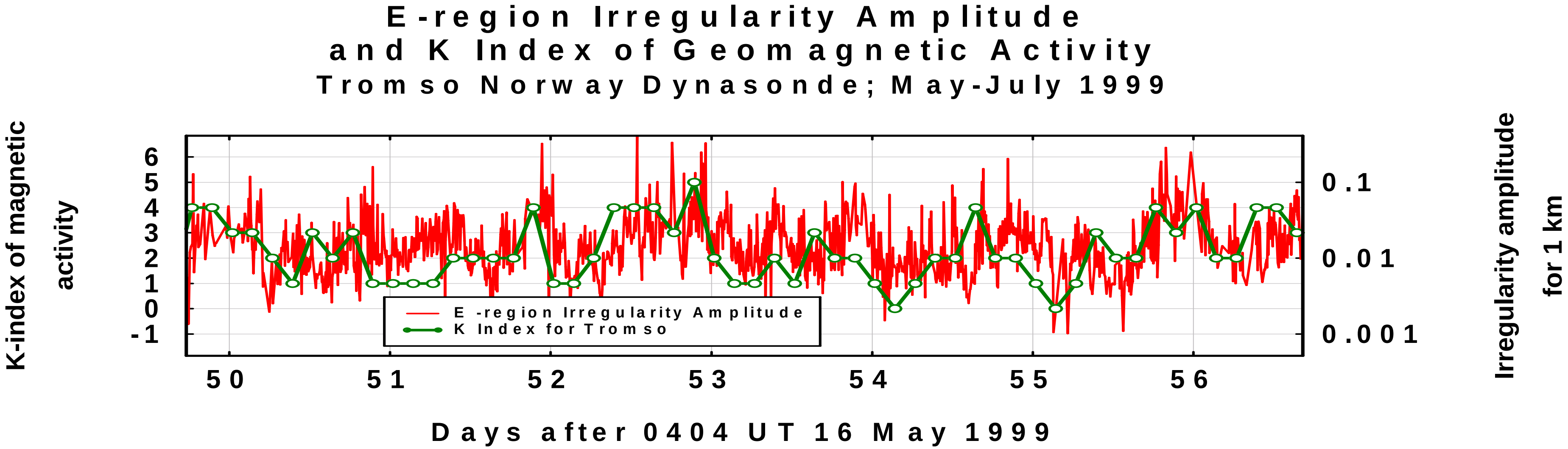
travelling ionospheric disturbances (TIDs) propagating southward,

ionospheric trough



ionospheric trough

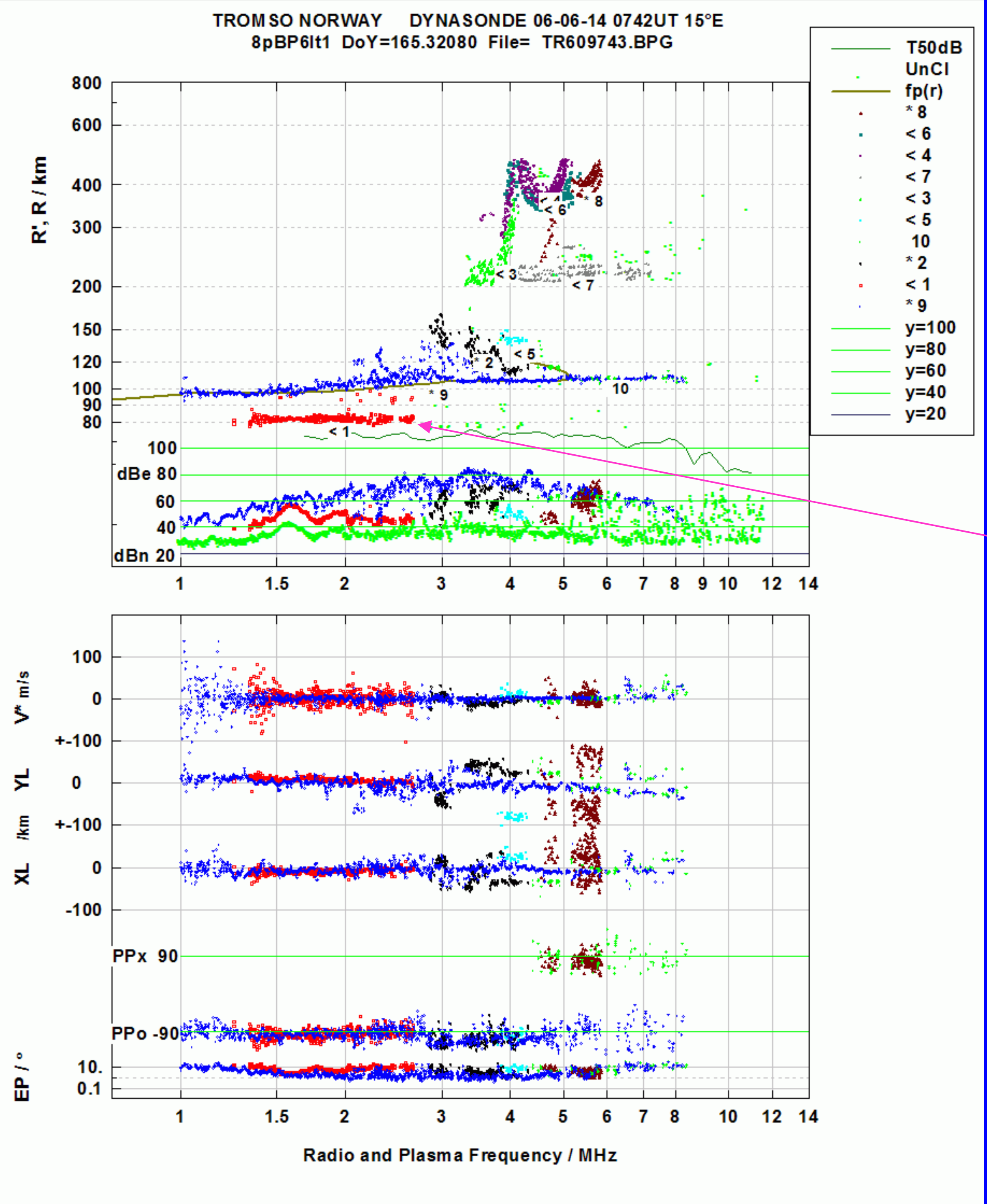
travelling ionospheric disturbances (TIDs) propagating southward,



E-region irregularity amplitude (dN/N) for 1 km scale derived from the echo mean phase compared with the local K-index of magnetic activity for a six-day interval.

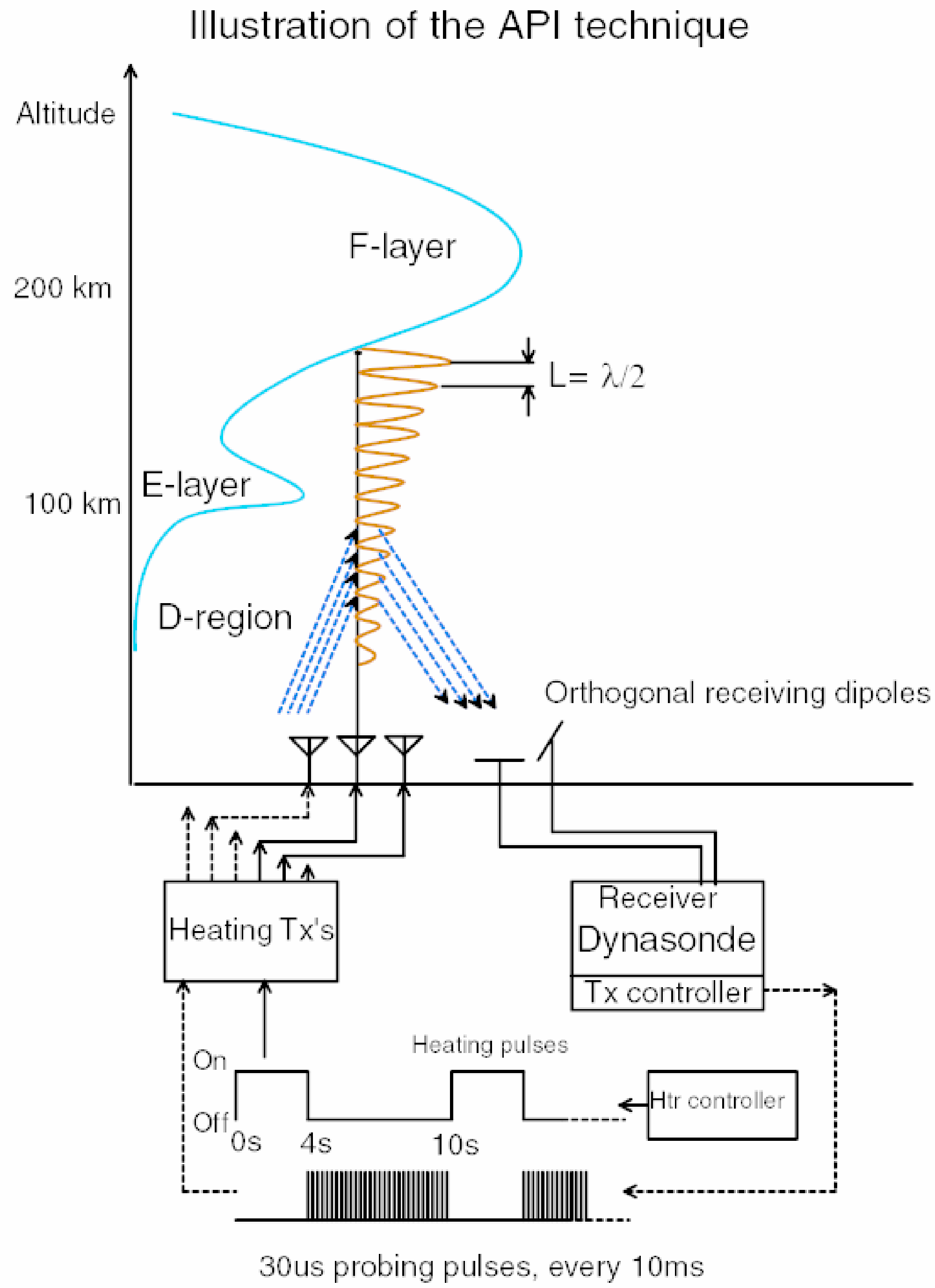
(See Zabotin N.A., and J.W. Wright, Ionospheric irregularity diagnostics from the phase structure functions of MF/HF radio echoes, Radio Sci., 36, 4, 757-772, 2001)

Mesospheric echoes



An ionogram showing mesospheric echoes (red trace).

Artificial Periodic Irregularities (API)



The API technique was discovered at SURA and allows any HF pump and ionosonde to probe the ionosphere. API are formed by a standing wave due to interference between the upward radiated wave and its own reflection from the ionosphere.

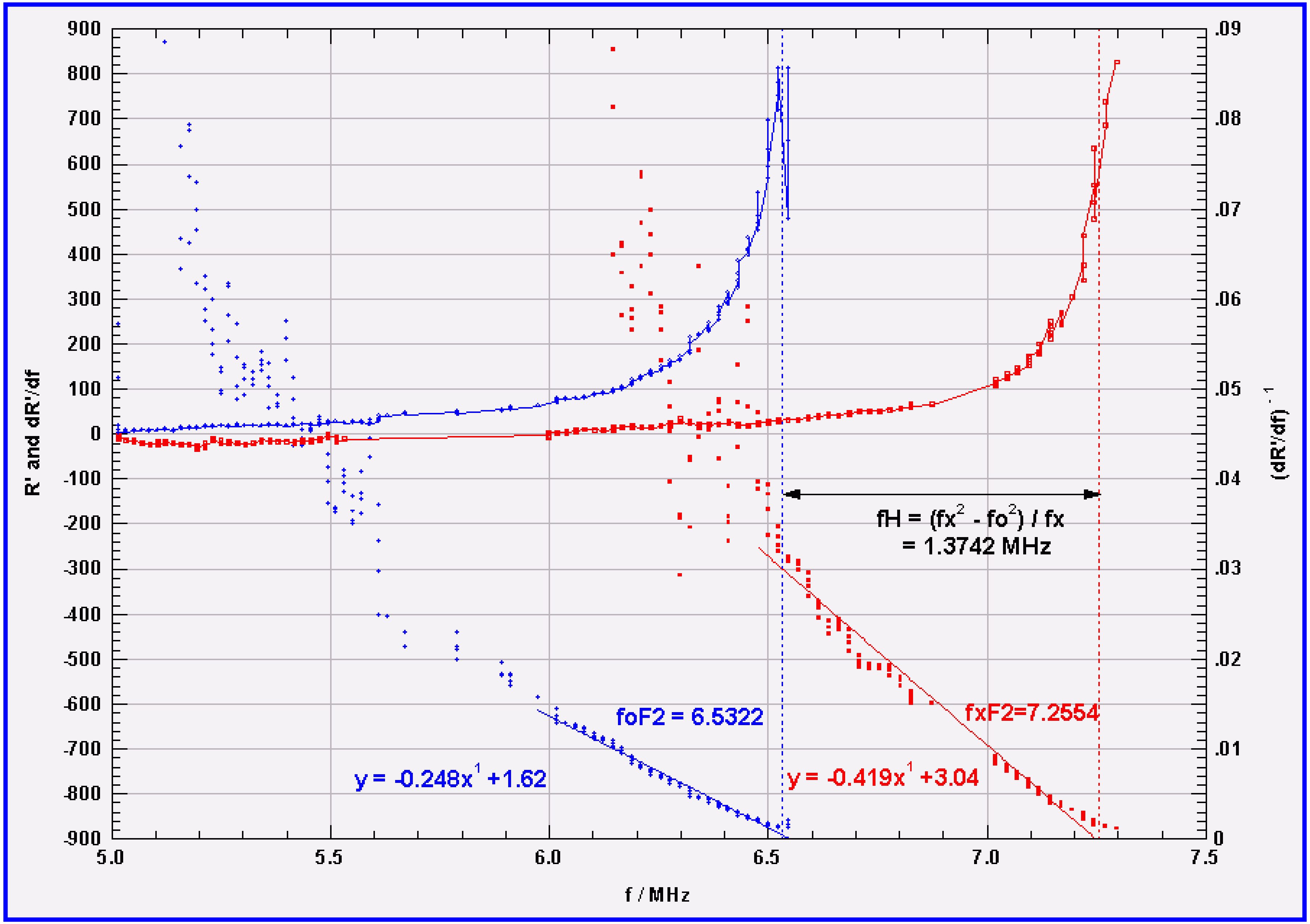
(See book by Belikovich et al., 2001)

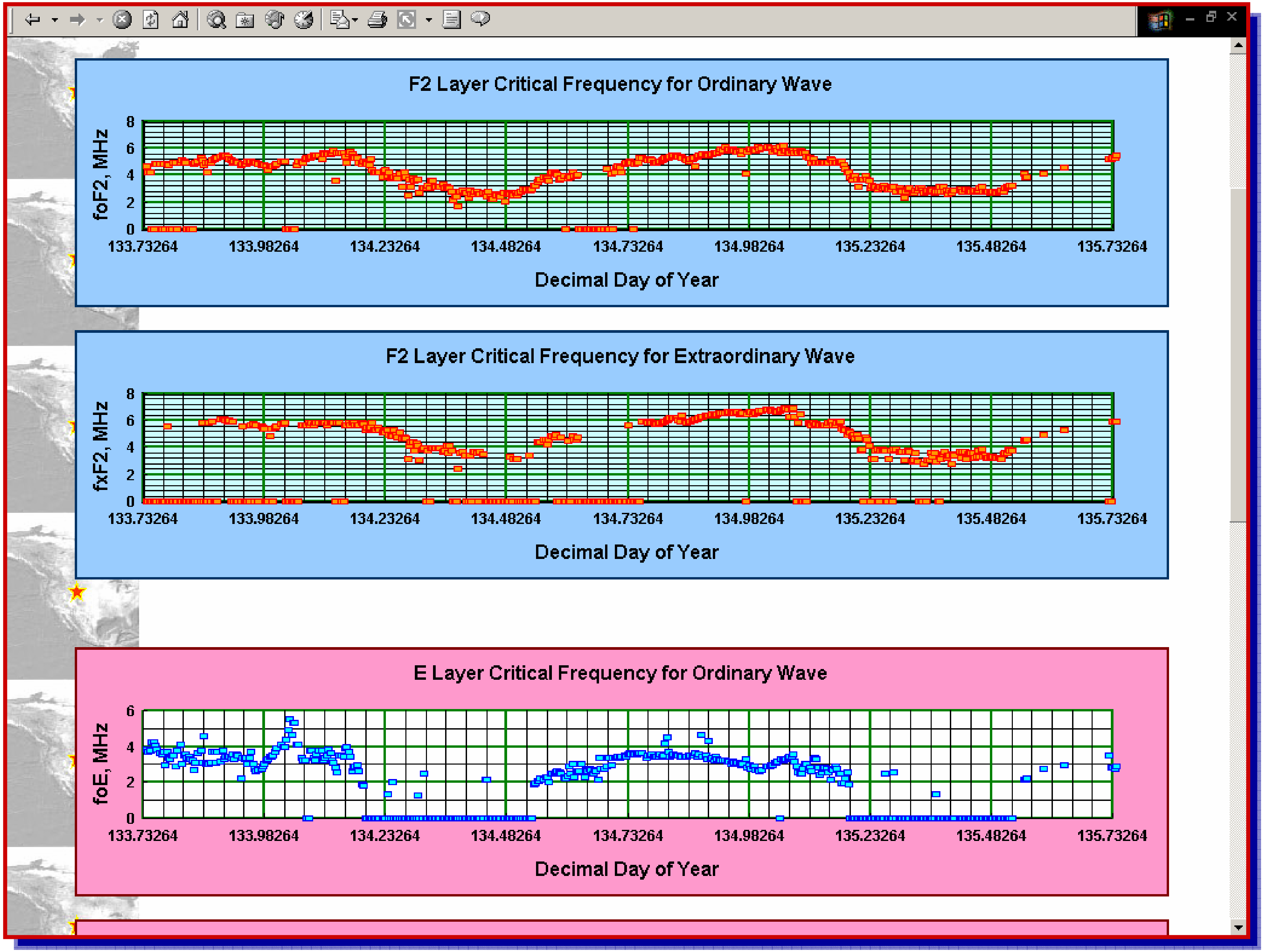
Measured parameters include: N(n), N(e), N(O-), vertical V(i), T(n), T(i) & T(e)

ex-BAS Dynasonde in Tromsø, in preparation for being shipped to Longyearbyen on Svalbard

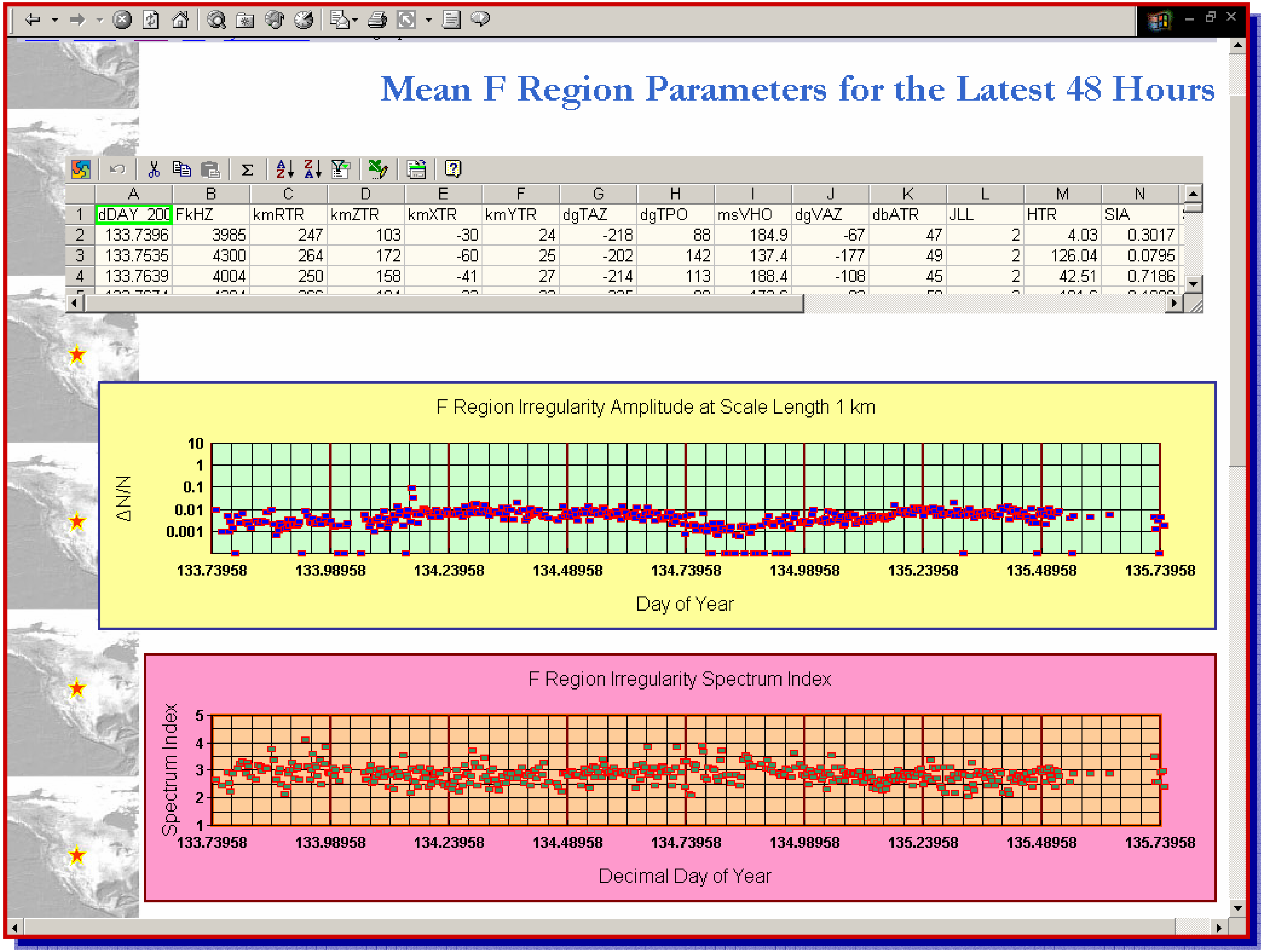
http://www.eiscat.uit.no/dynasond.html

Extrapolation of (Group-Range Slope)$^{-1}$ *vs* f, for Precise foF2, fxF2




F2 Layer Critical Frequency for Ordinary Wave
foF2, MHz
0
2
4
6
8
133.73264
133.98264
134.23264
134.48264
134.73264
134.98264
135.23264
135.48264
135.73264
Decimal Day of Year
F2 Layer Critical Frequency for Extraordinary Wave
fxF2, MHz
0
2
4
6
8
133.73264
133.98264
134.23264
134.48264
134.73264
134.98264
135.23264
135.48264
135.73264
Decimal Day of Year
E Layer Critical Frequency for Ordinary Wave
foE, MHz
0
2
4
6
133.73264
133.98264
134.23264
134.48264
134.73264
134.98264
135.23264
135.48264
135.73264
Decimal Day of Year


F2 Layer Peak Plasma Frequency
FMXF, MHz
20
15
10
5
0
133.73611
133.98611
134.23611
134.48611
134.73611
134.98611
135.23611
135.48611
135.73611
Decimal Day of Year
F2 Layer Peak Height
HMXF, km
500
400
300
200
100
133.73611
133.98611
134.23611
134.48611
134.73611
134.98611
135.23611
135.48611
135.73611
Decimal Day of Year
F2 Layer "Chapman" Scale Height
SHF, km
150
100
50
0
133.73611
133.98611
134.23611
134.48611
134.73611
134.98611
135.23611
135.48611
135.73611
Decimal Day of Year



Mean F Region Parameters for the Latest 48 Hours

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	dDAY_200	FkHZ	kmRTR	kmZTR	kmXTR	kmYTR	dgTAZ	dgTPO	msVHO	dgVAZ	dbATR	JLL	HTR	SIA
2	133.7396	3985	247	103	-30	24	-218	88	184.9	-67	47	2	4.03	0.3017
3	133.7535	4300	264	172	-60	25	-202	142	137.4	-177	49	2	126.04	0.0795
4	133.7639	4004	250	158	-41	27	-214	113	188.4	-108	45	2	42.51	0.7186

F Region Irregularity Amplitude at Scale Length 1 km

F Region Irregularity Spectrum Index