Automatic retrieval of plasmaspheric electron densities: first results form Automatic Whistler Detector and Analyzer Network

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Plasmasphere: why is it important?

Space Weather

- Radiation Belts dynamics: wave-particle interactions

  - chorus (e.g Horne et al., JGR, 2005, Katoh and Omura, GRL, 2007)

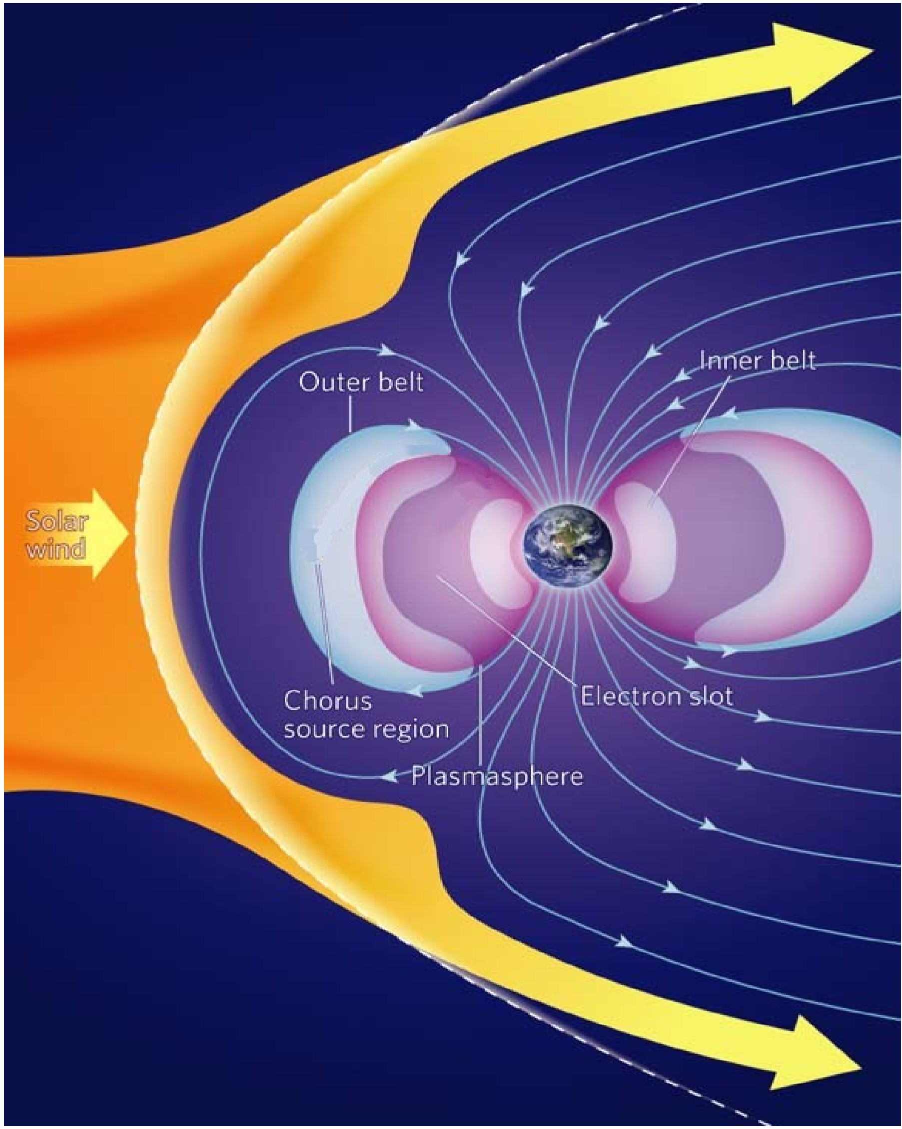
  - hiss (e.g. Bortnik et al., Nature, 2008)

take place in ***plasmasphere***

→ we need a model

of the plasmasphere

/plasmapause location



Automatic Whistler Detector and Analyzer (AWDA) system [Lichtenberger et al., *JGR*, 2008]:

Whistlers are searched in the broad-band VLF signal without human interaction

Automatic whistler analyses yields plasma and propagation parameters → electron density distribution → *Space Weather*

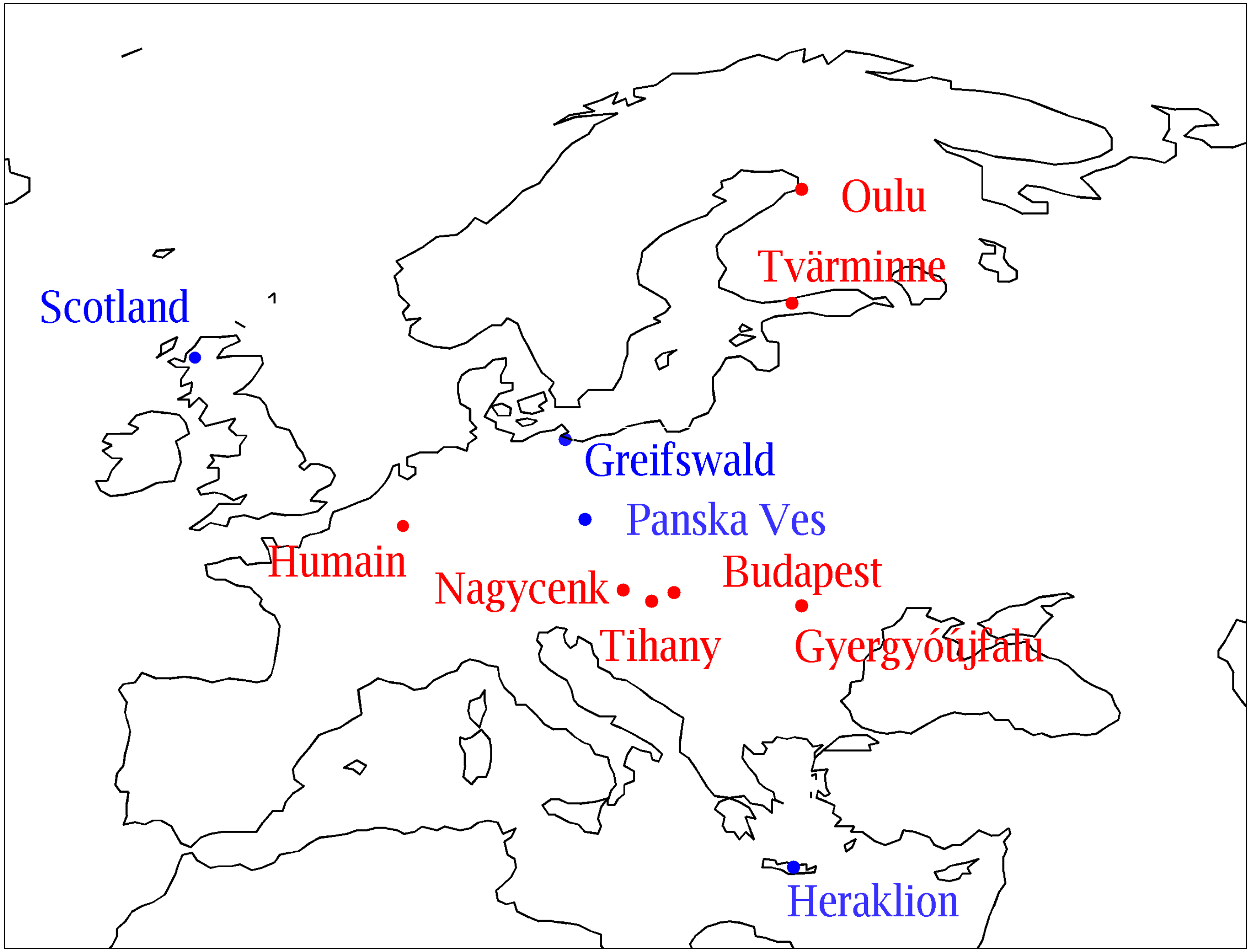
AWDANet

Extending network of AWDA systems covering low-, mid- and high (magnetic) latitudes since 2002 including conjugate locations

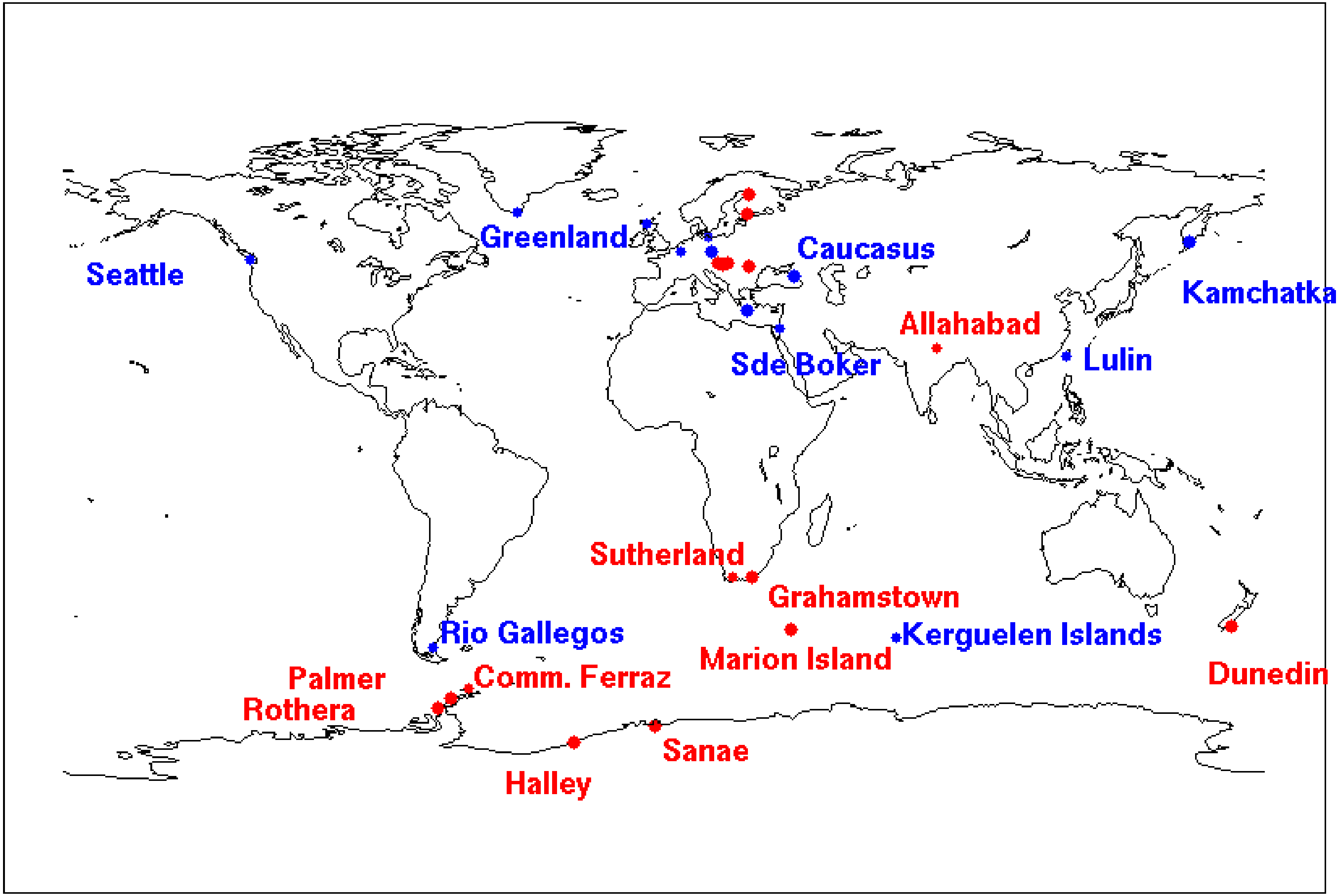
~50 000-10 000 000 traces/year/station

Real time operation is in *experimental* phase

AWDANet -Europe

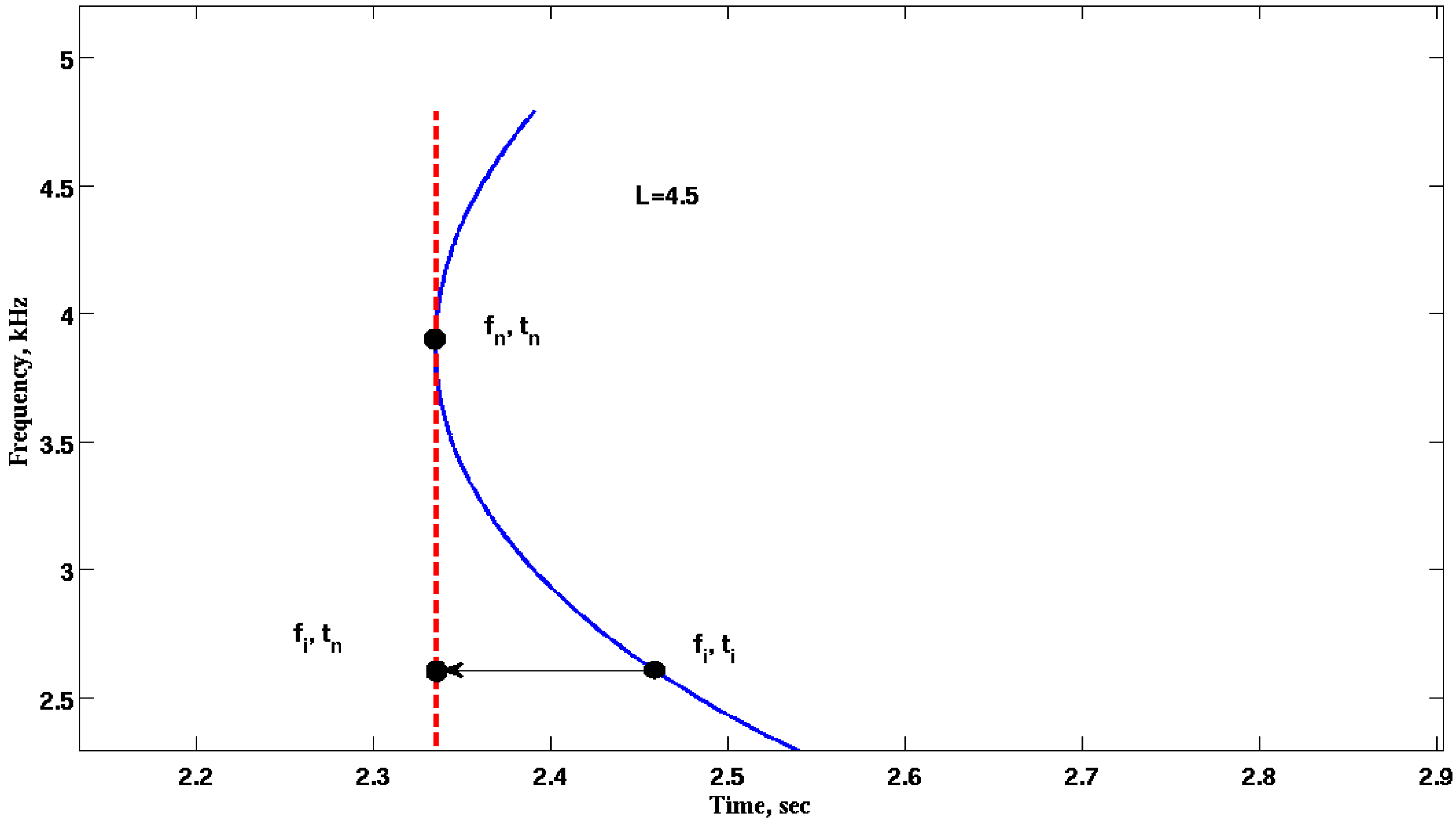


AWDANet - World



A new *whistler inversion* method
+
Virtual (whistler) Trace Transformation

[Lichtenberger, *JGR*, 2009]

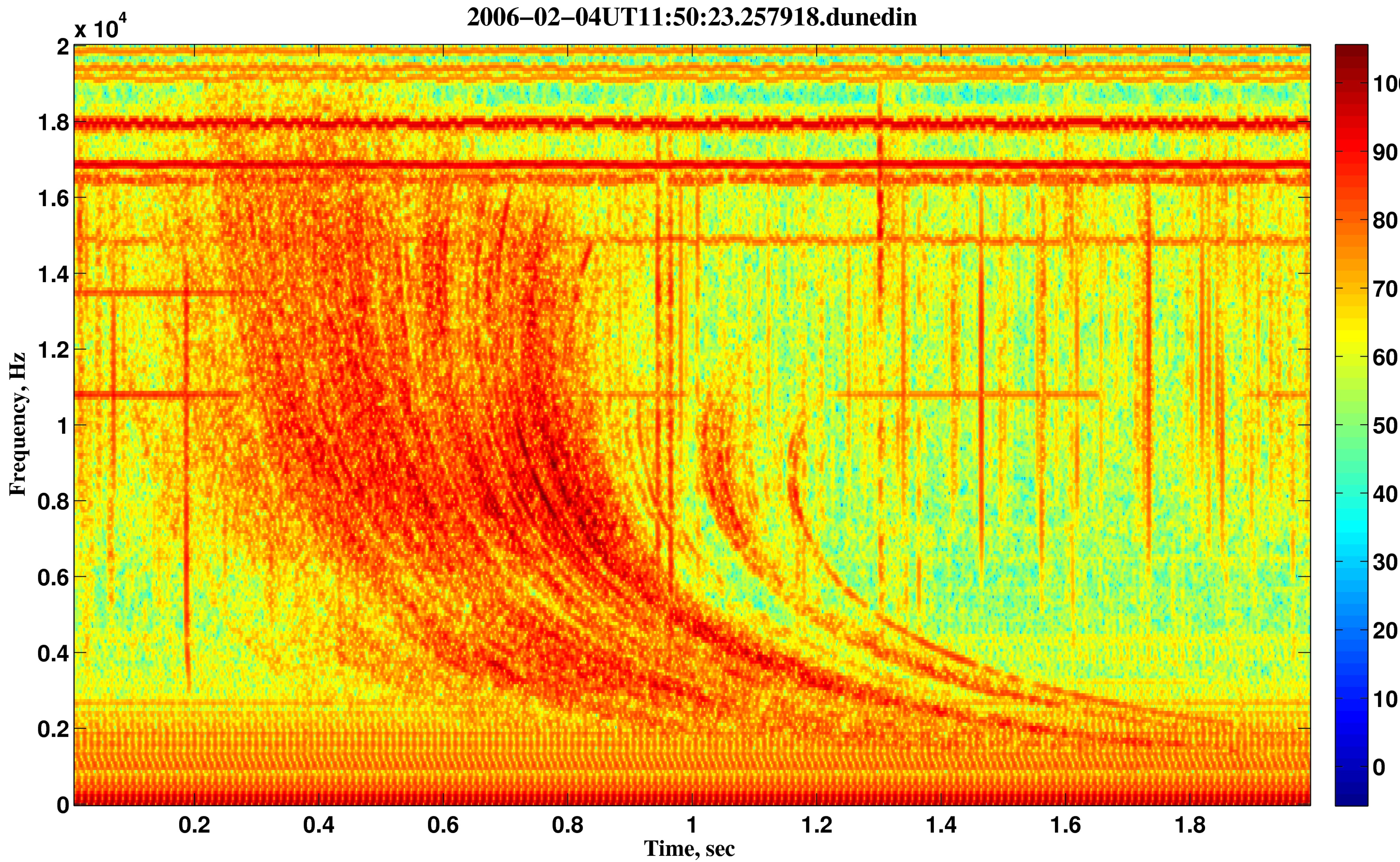


Multiple path whistler group model:

- A new, simplified equatorial electron density profile is introduced in a meridional section of the plasmasphere:

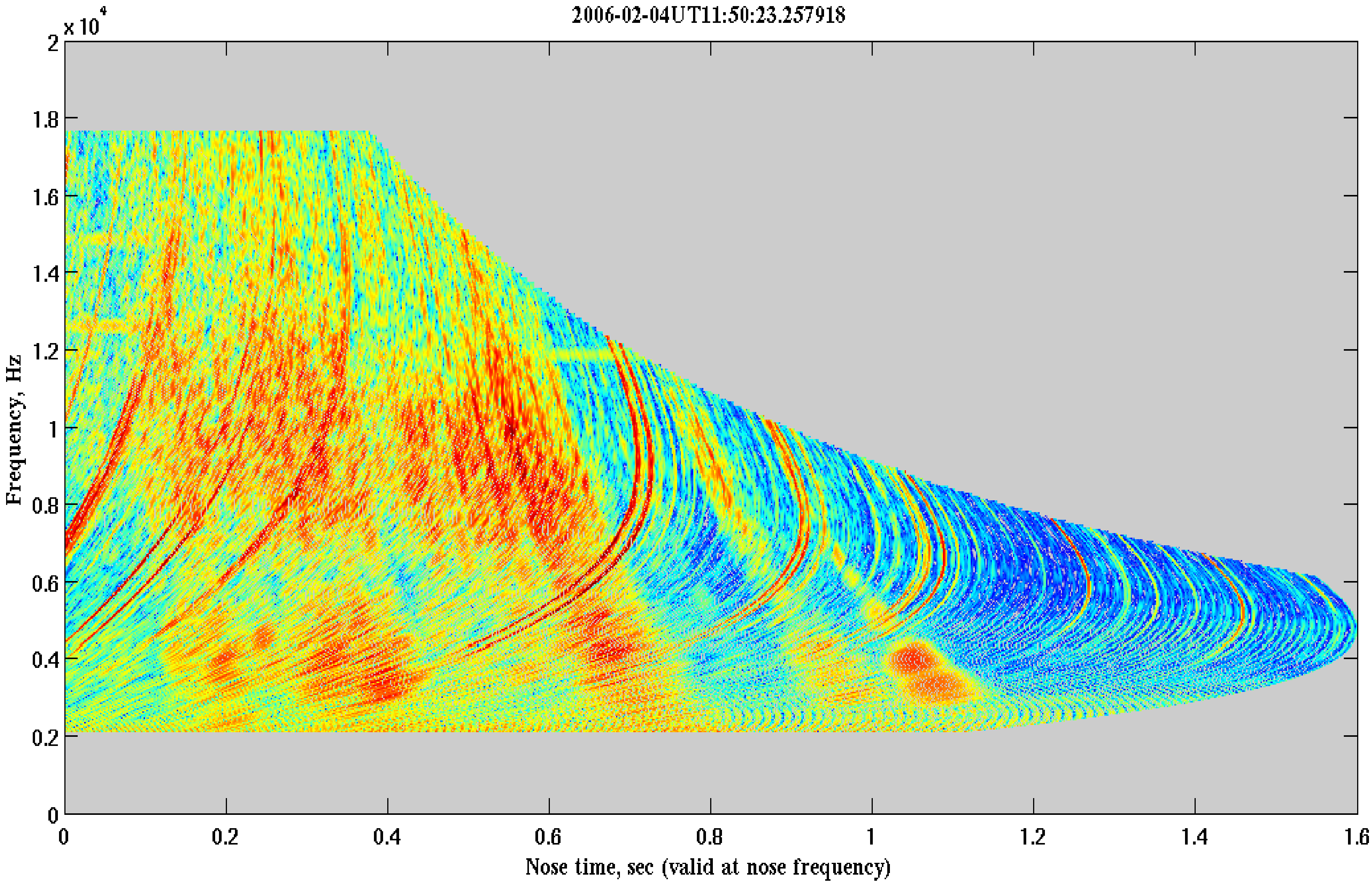
$$\log_{10} n_{eq} = A + B \cdot L$$

- *A* and *B* are constants for a MP group, but may vary to time and place.
- This approximation is valid between ~ $2 < L < \min(8, L_{pp})$, where L_{pp} is the location of plasmapause.
- Taking a pair of *(A,B)*, the electron density in magnetic equator decreases monotonically. In principle, a whistler can propagate along each field line described by an L in this range with corresponding n_{eq} forming a ***virtual whistler continuum***. Of course, in reality only a few whistlers of that continuum may be real.

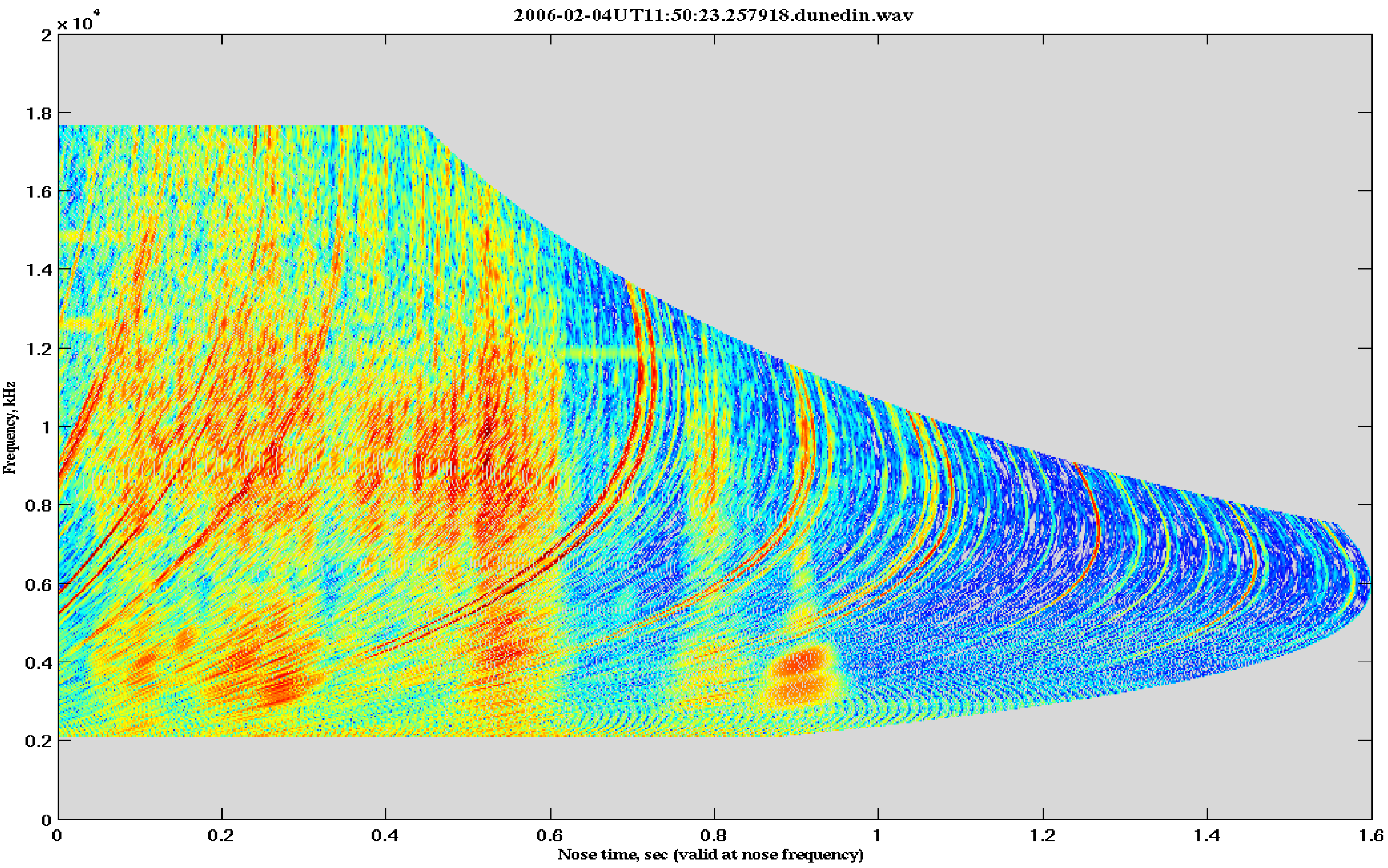


2006−02−04UT11:50:23.257918.dunedin
x 10^4
Frequency, Hz
Time, sec
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0
10
20
30
40
50
60
70
80
90
100

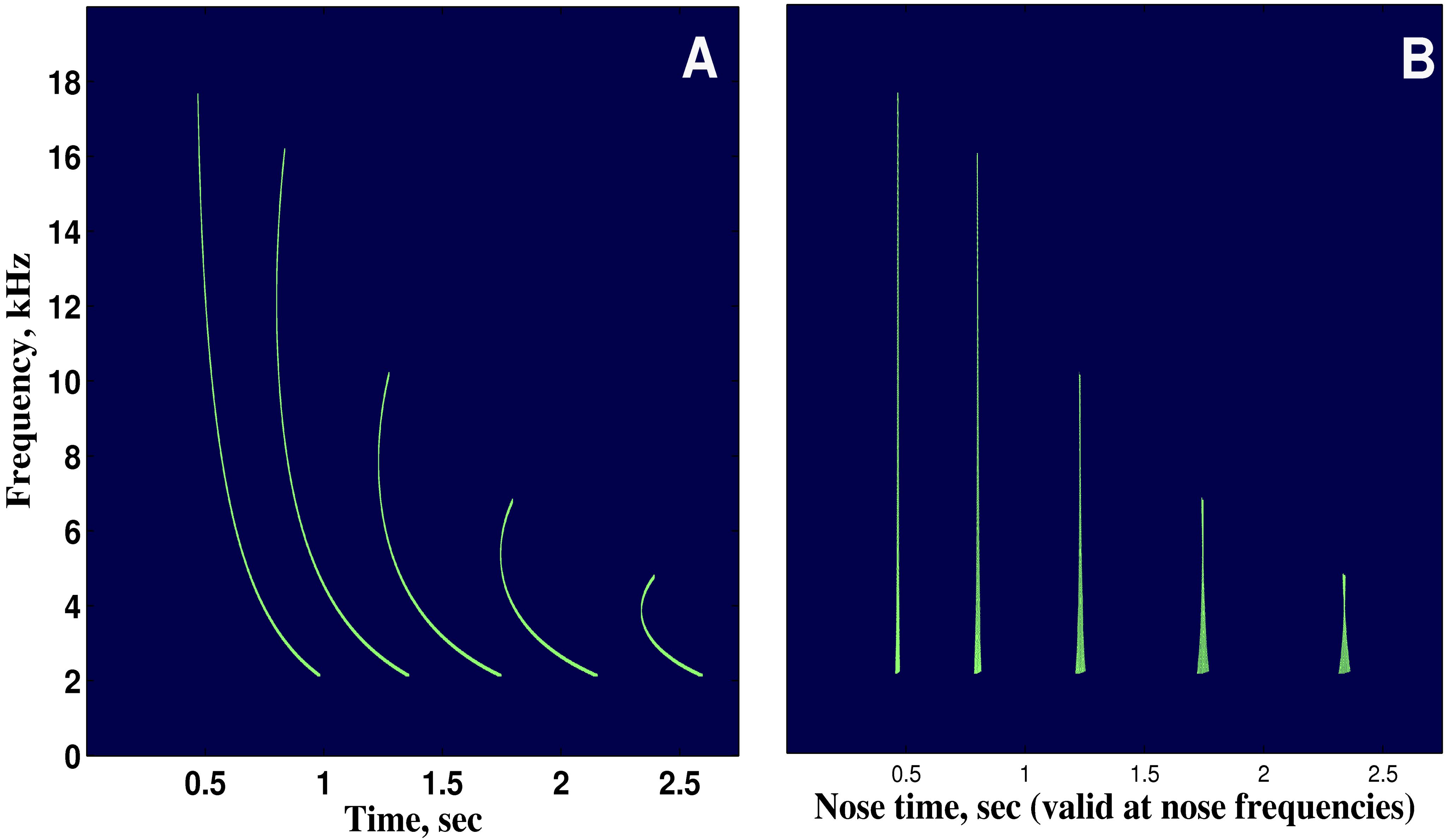
VTT – unmatched parameters



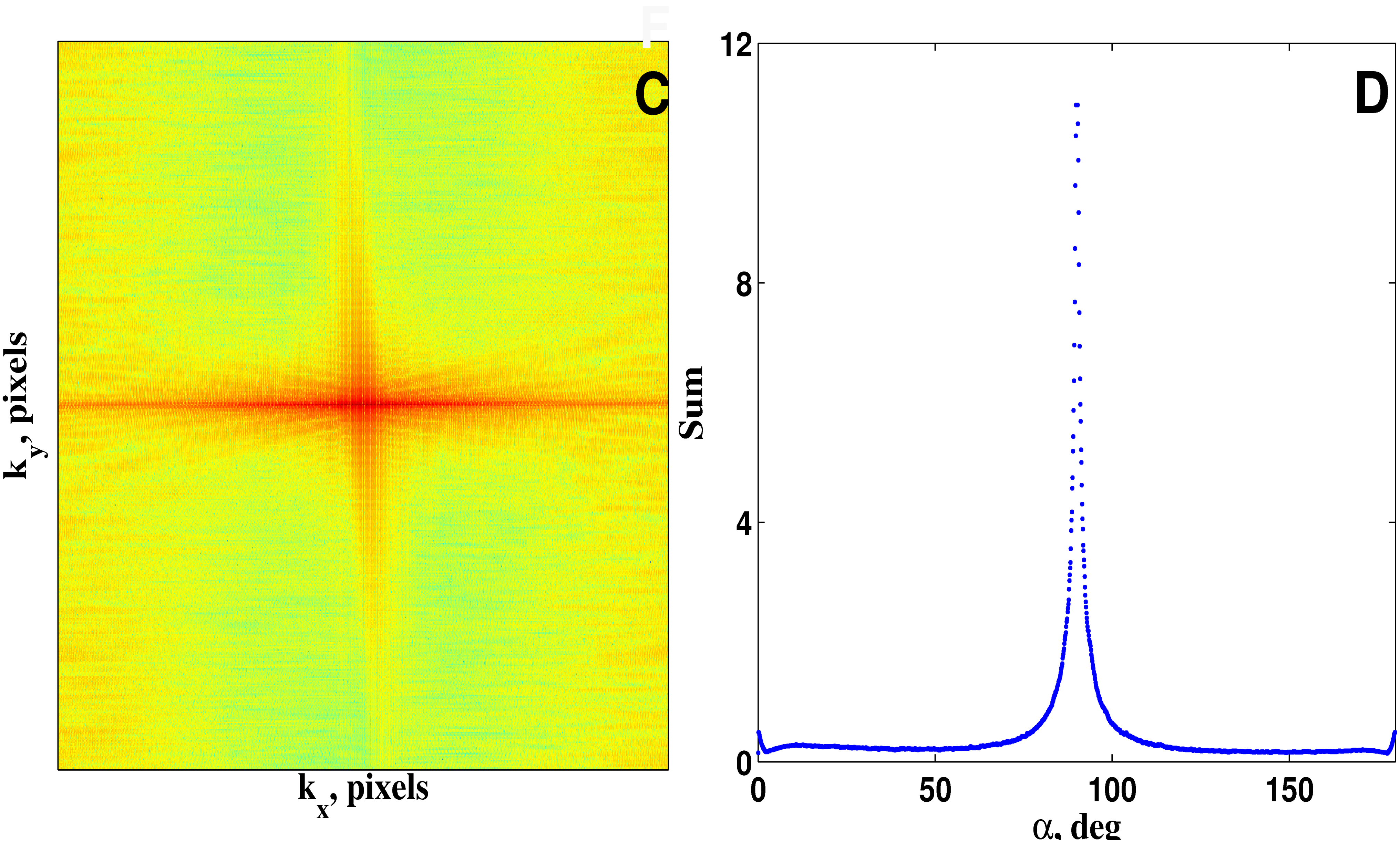
VTT – matched parameters



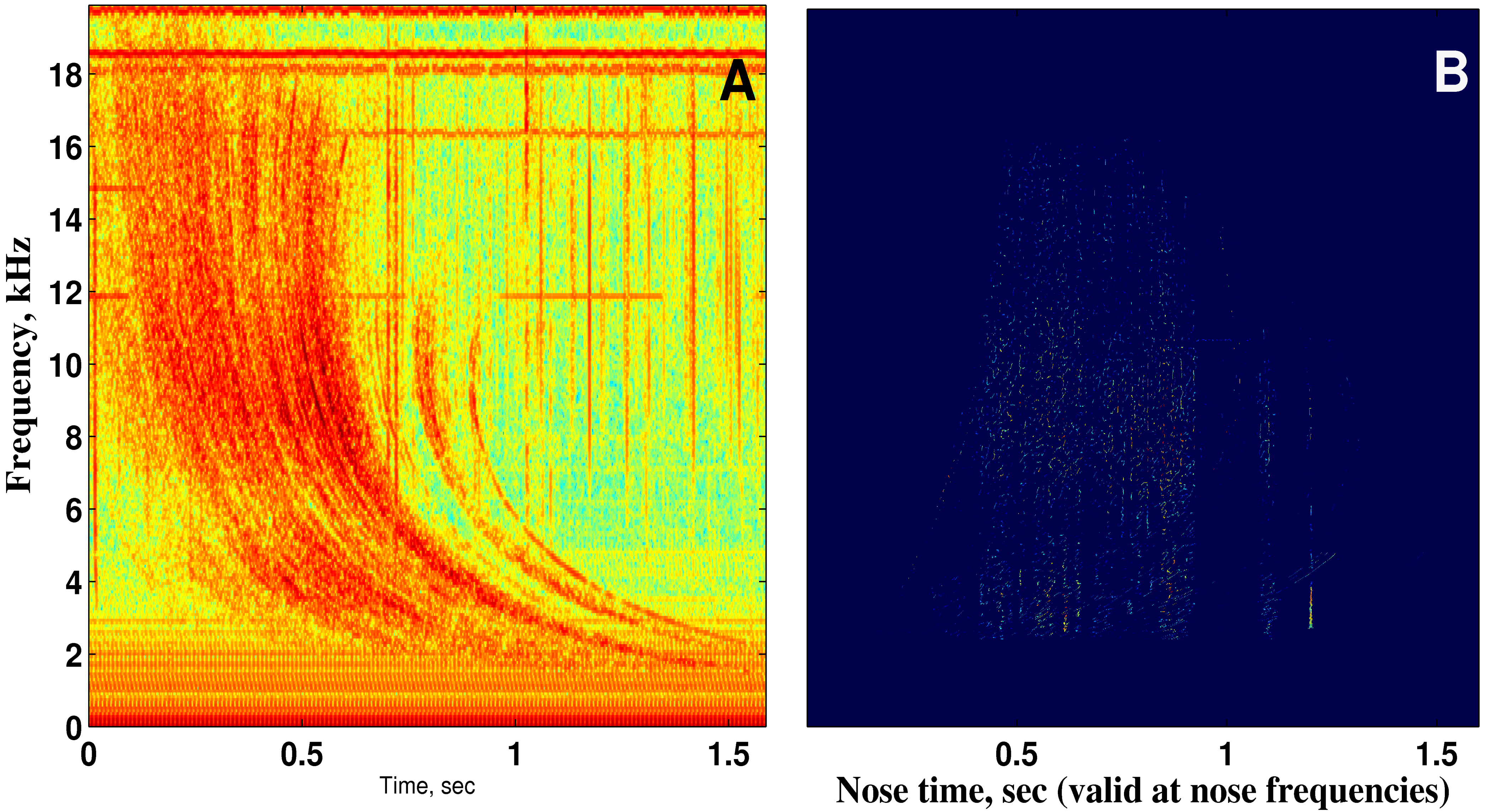
VTT – applied to model MP group



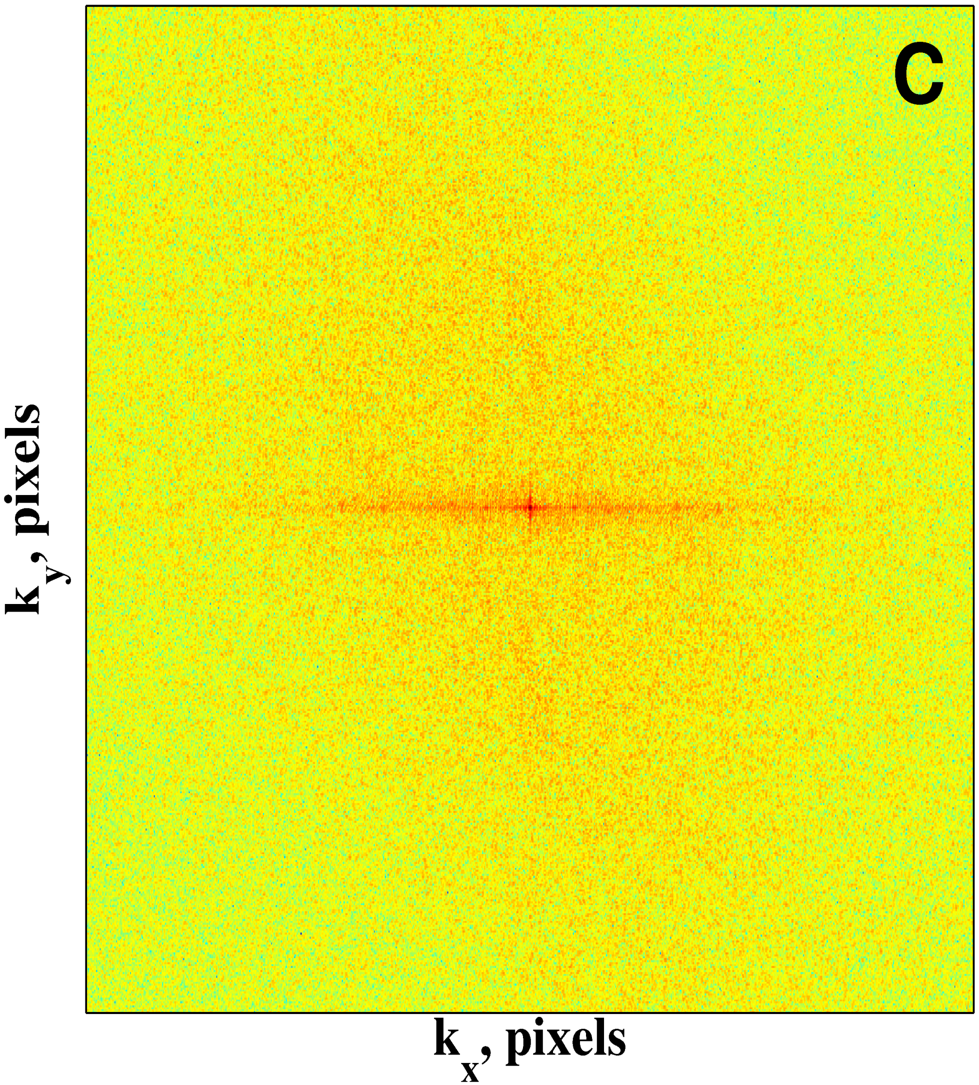
2D FFT of VTT and the "sharpness" plot– applied to model MP group

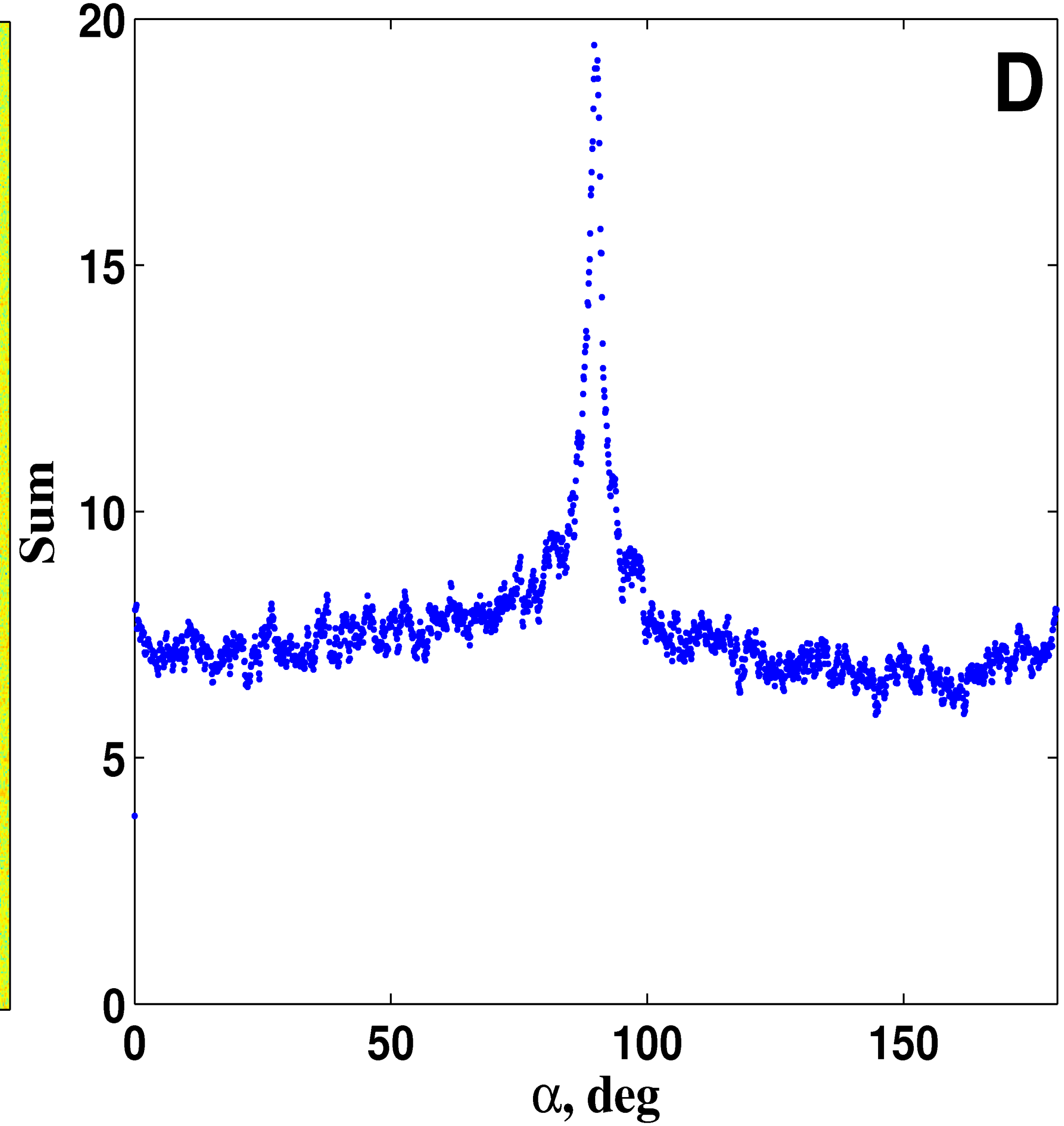


VTT – applied to real MP group



2D FFT of VTT and the "sharpness" plot– applied to real MP group





Implementation of AWA algorithm
[Lichtenberger et al., *JGR*, 2009]

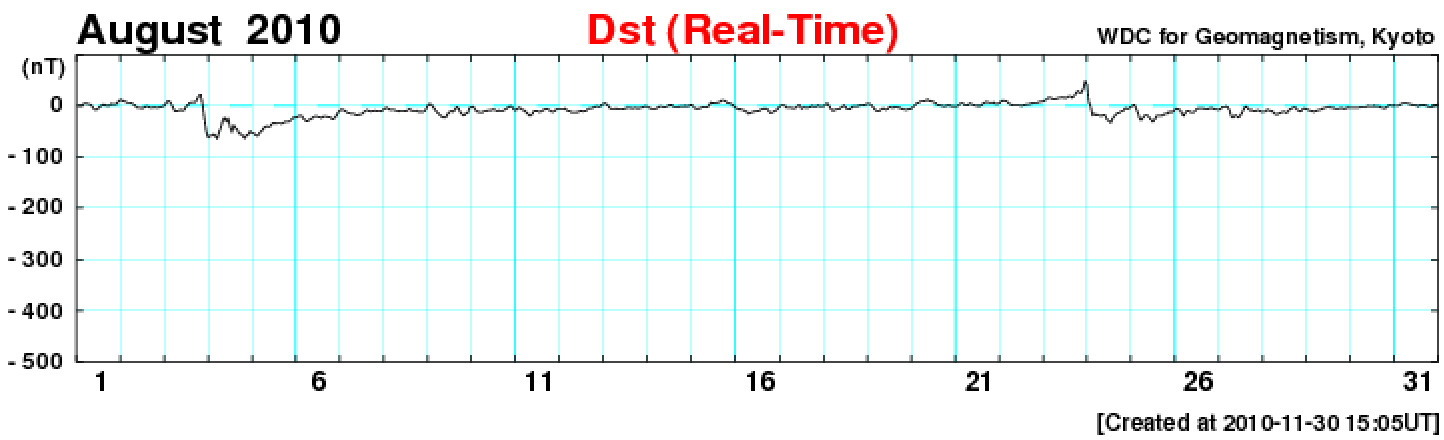
1. Application of VTT to the spectrogram matrix with an initial set of *(dt,A,B)* parameter triplet.
2. Computation of 2D FFT of VTT image.
3. Calculation of sharpness plot for the 2D FFT image and p_{max}, $|\alpha - 90|$ and w from it. The sharpness plot is used as an objective function in the optimiziation procedure
4. Iterate steps 1-3 while tuning the *(dt,A,B)* triplet to simultaneously maximize p_{max} while minimize $|\alpha - 90|$ and w.

- An AWA run on an MP group takes *4.5-5 hours* on a single CPU → PC cluster (100 threads) : 5-15 min
- 10-15 density data per hour as an input for a plasmasphere model
- GPU computing → ~***1000*** times speed up

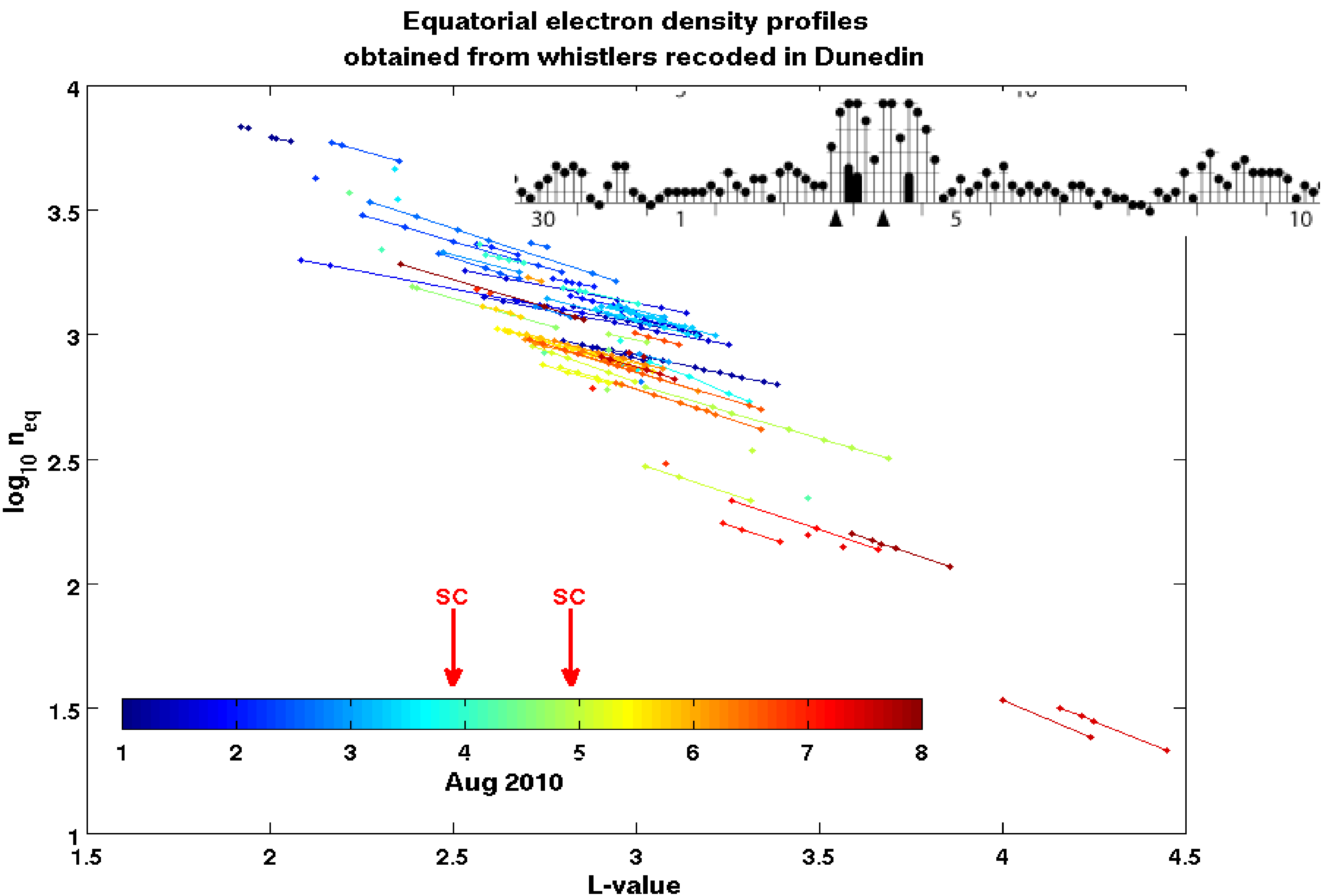
Case study:
double SSC on 3-4 Aug 2010

82 events processed between 1-8 August 2010.

Whistlers recorded in Dunedin (New Zealand)



Case study:
double SSC on 3-4 Aug 2010



Case study:
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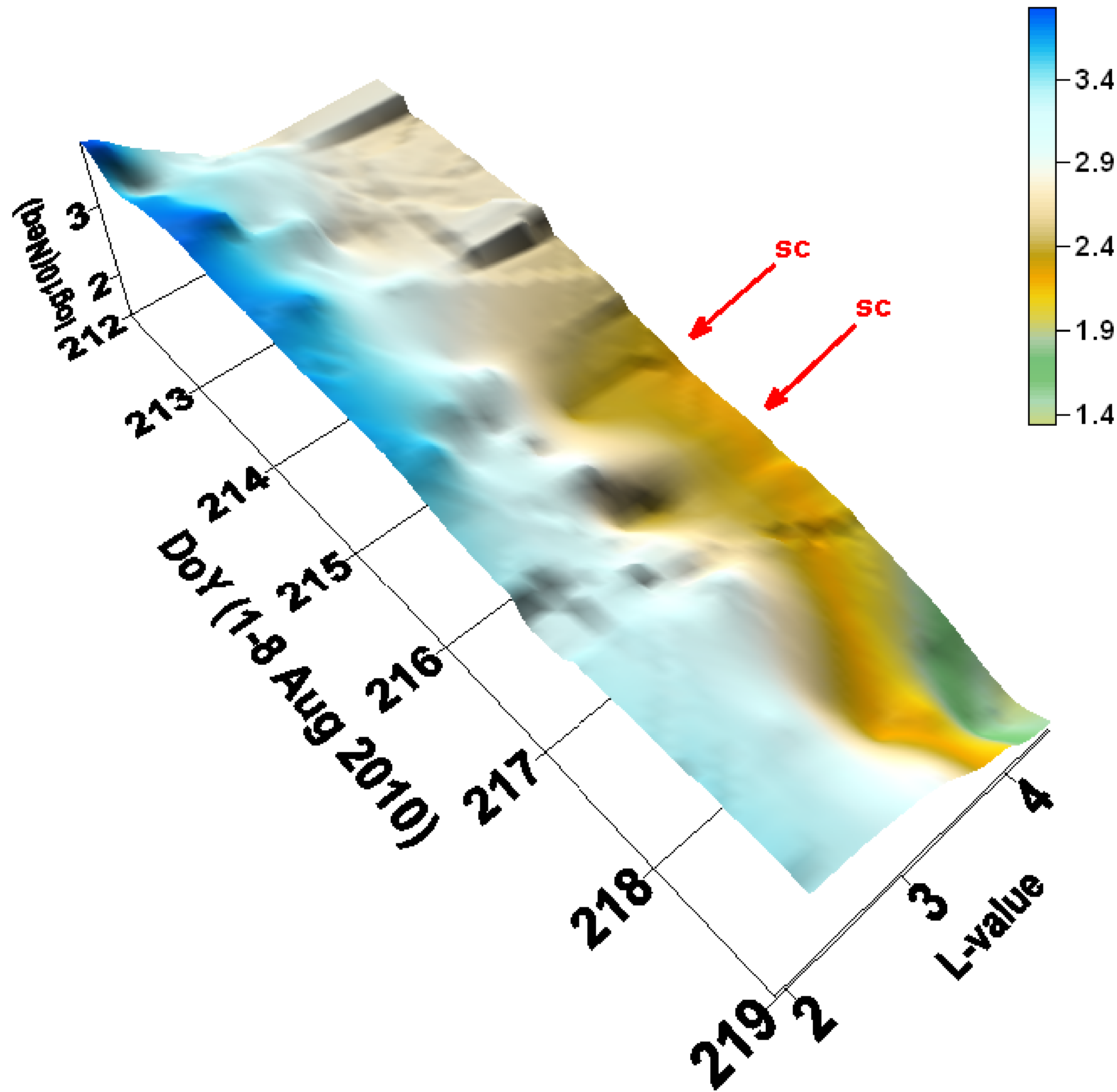
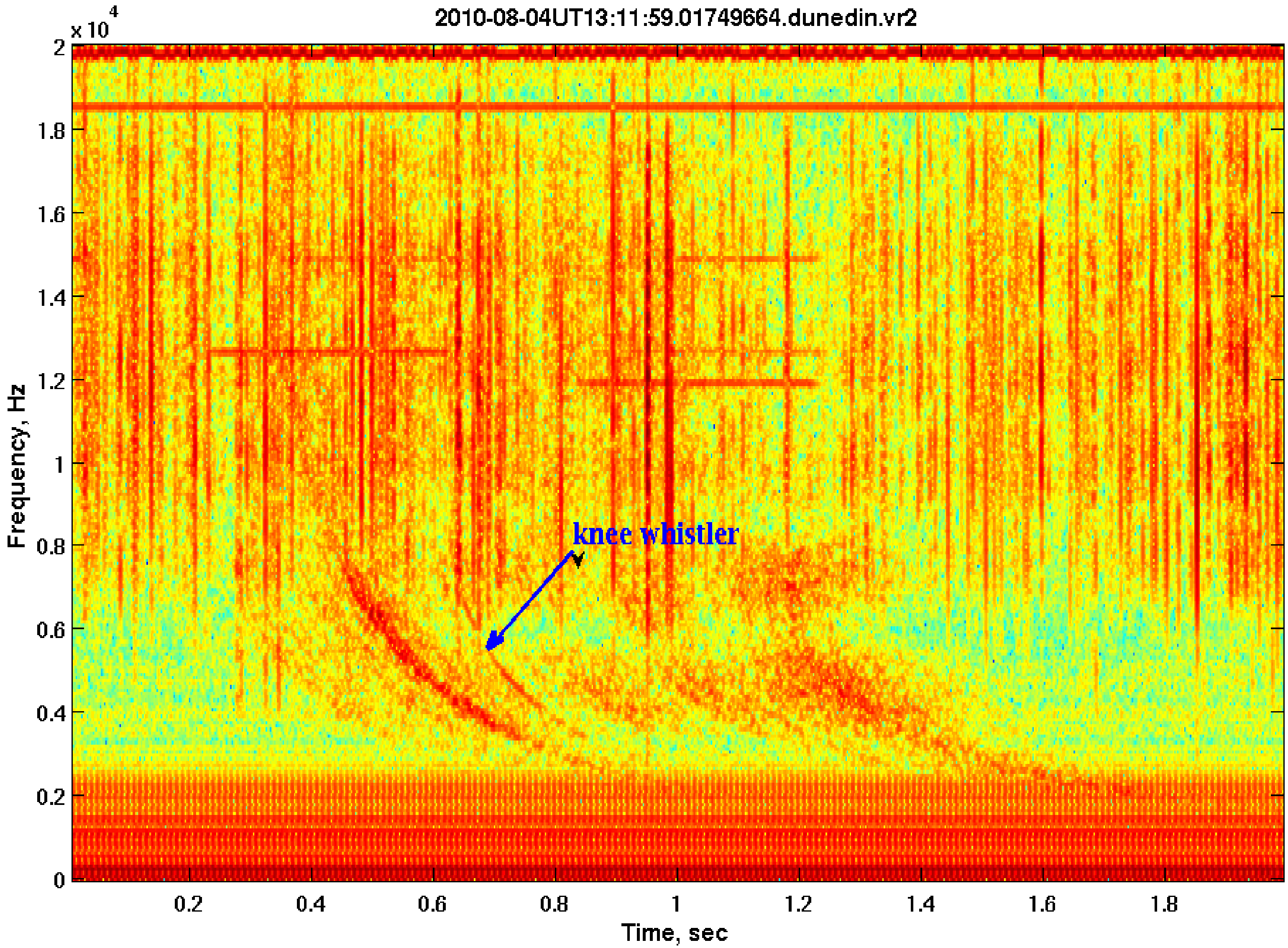


Location of Plasmapause:
Knee whistler on4 Aug 2010



$L=3.46,\ n_{eq}=221/ccm$

Conclusions

1. The Automatic Whistler Analyzer algorithm has been implemented
2. An experimental version operates in quasi real-time on a PC cluster with 100 threads/cores.
3. Final solution: GPU cluster

Implementation in AWDANet is going on in a

FP7-SPACE-2010-1 proposal called

PLASMON

(SPA.2010.2.3-1: Security of space assets from space weather events)

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