Plasmaspheric electron densities: first results form Automatic Whistler Detector and Analyzer Network

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Plasmasphere: why is it important?

Space Weather

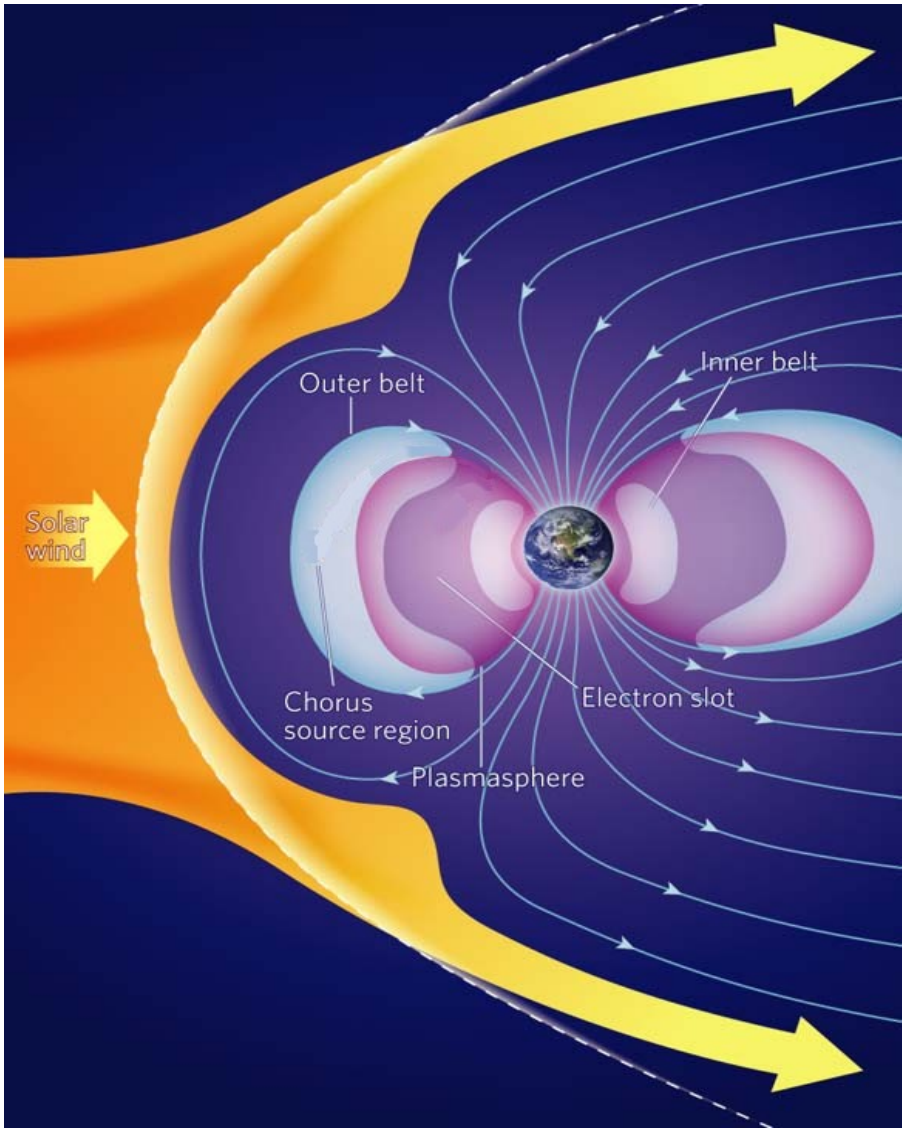
- Radiation Belts dynamics: wave-particle interactions
  - chorus (e.g Horne et al., JGR,2005, Katoh and Omura, GRL, 2007)
  - hiss (e.g. Bortnik et al., Nature,2008)

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*

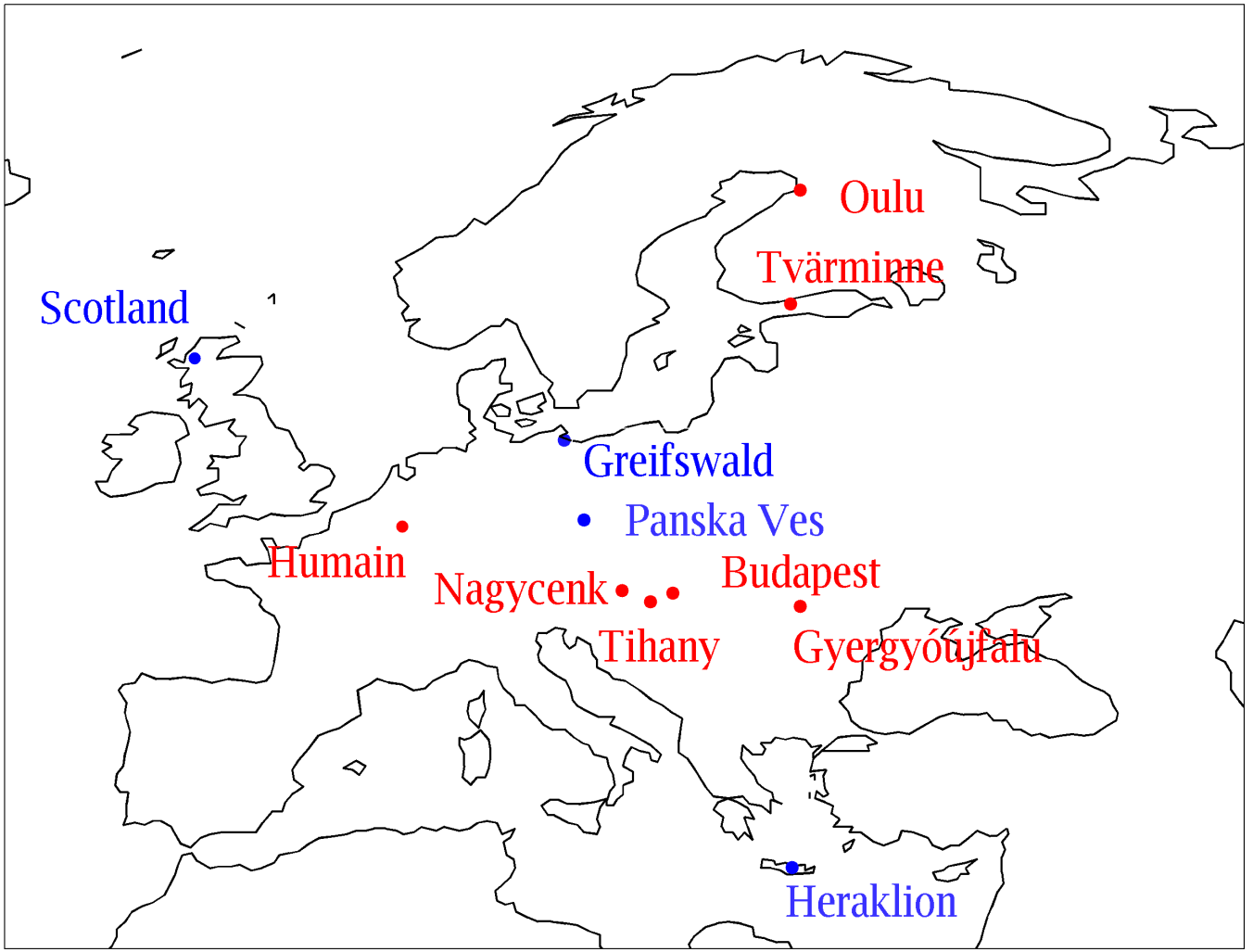
AWDANet

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

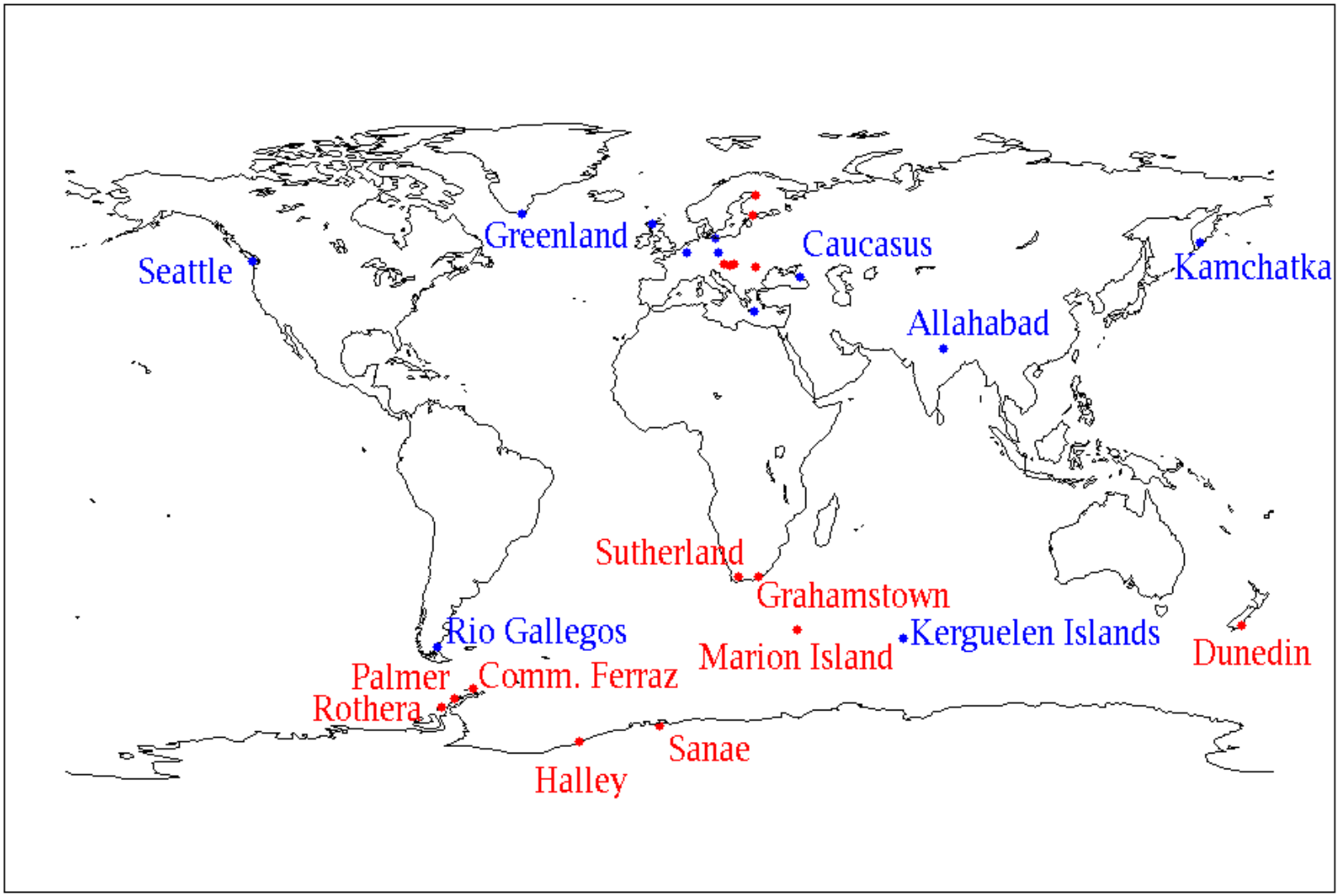
~50 000-10 000 000 traces/year/station

Real time operation is in *experimental* phase

AWDANet -Europe



AWDANet - World

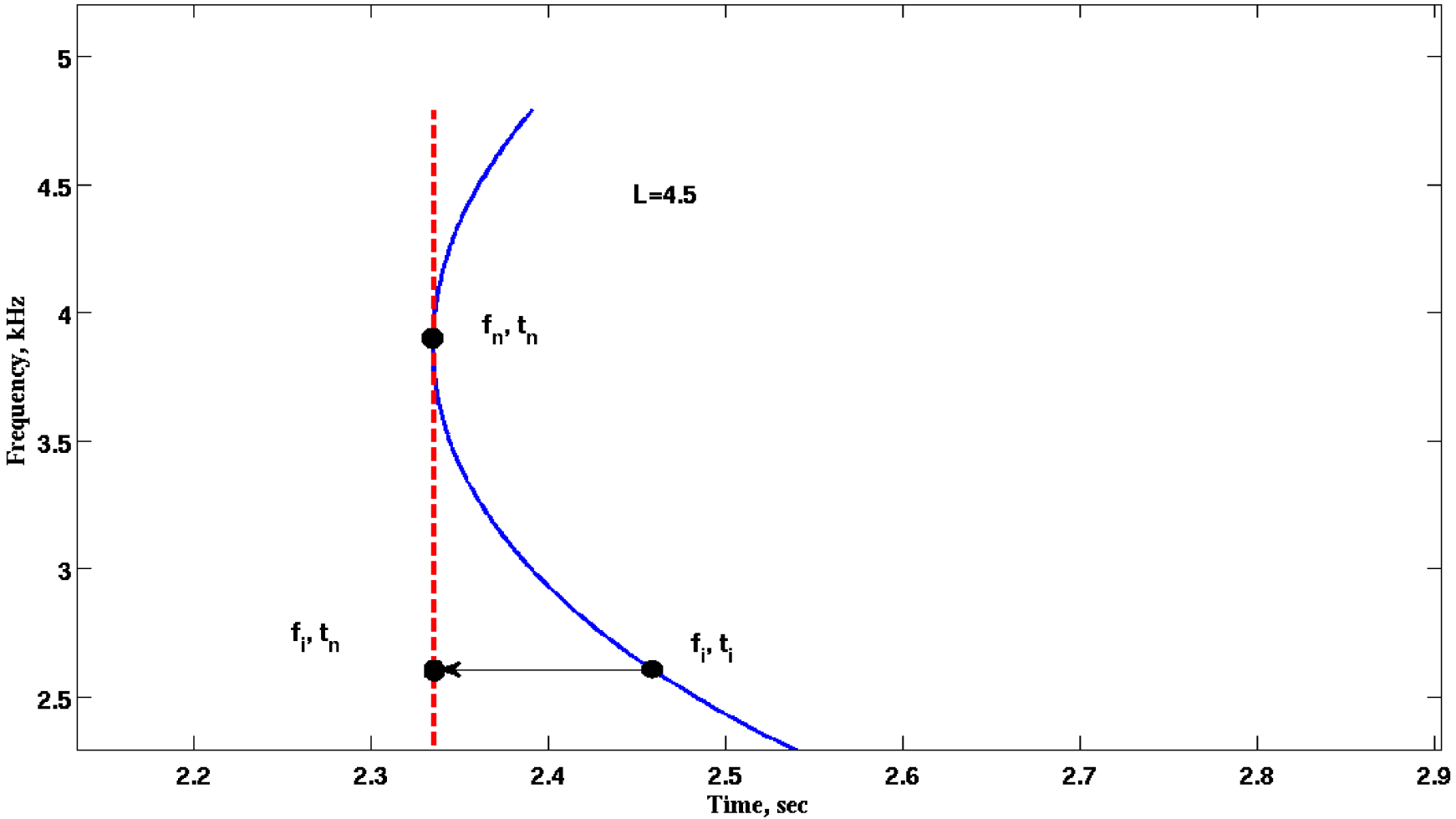


A new *whistler inversion* method

+

Virtual (whistler) Trace Transformation

[Lichtenberger, *JGR*, 2009]

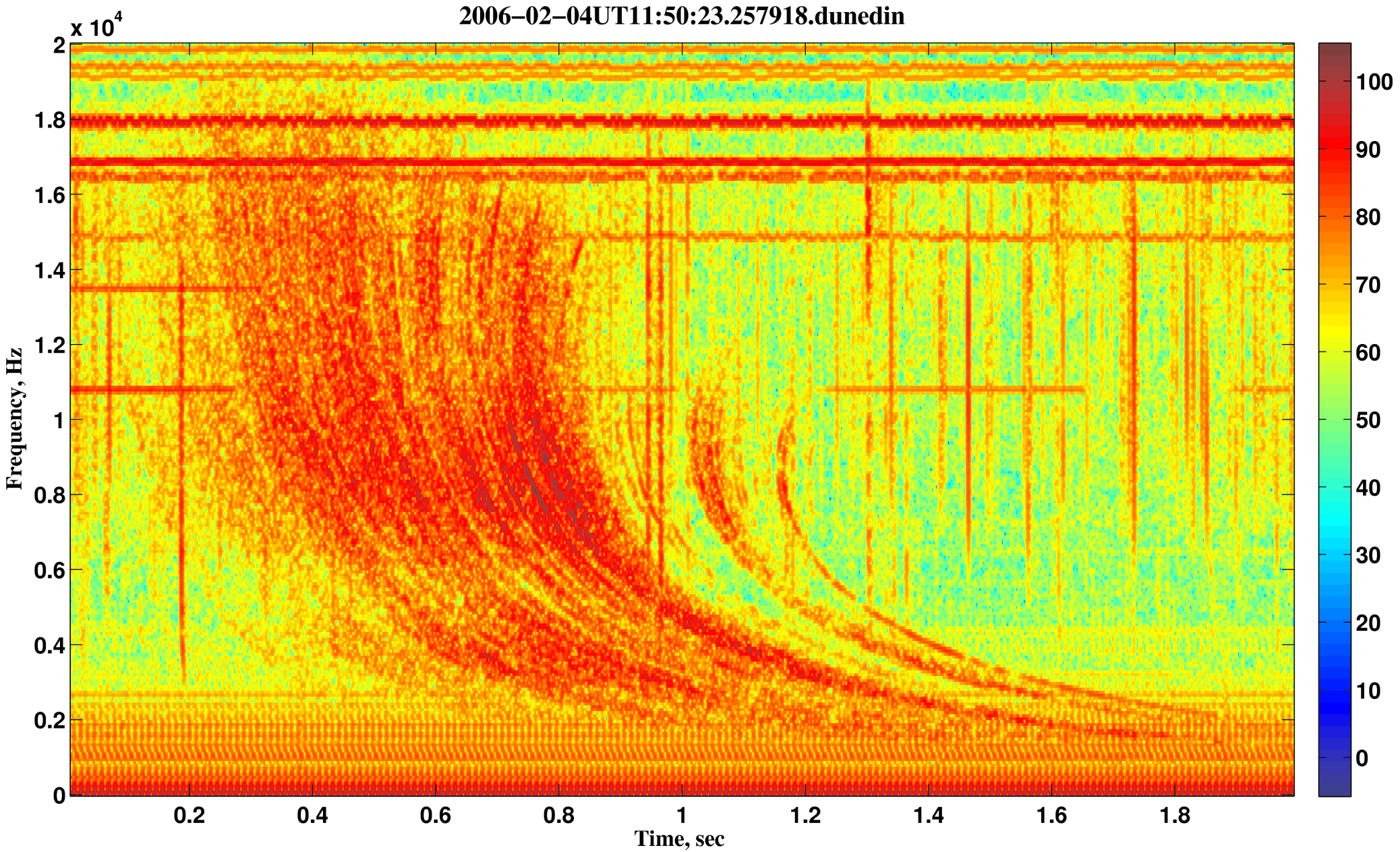


Multiple path whistler group model:

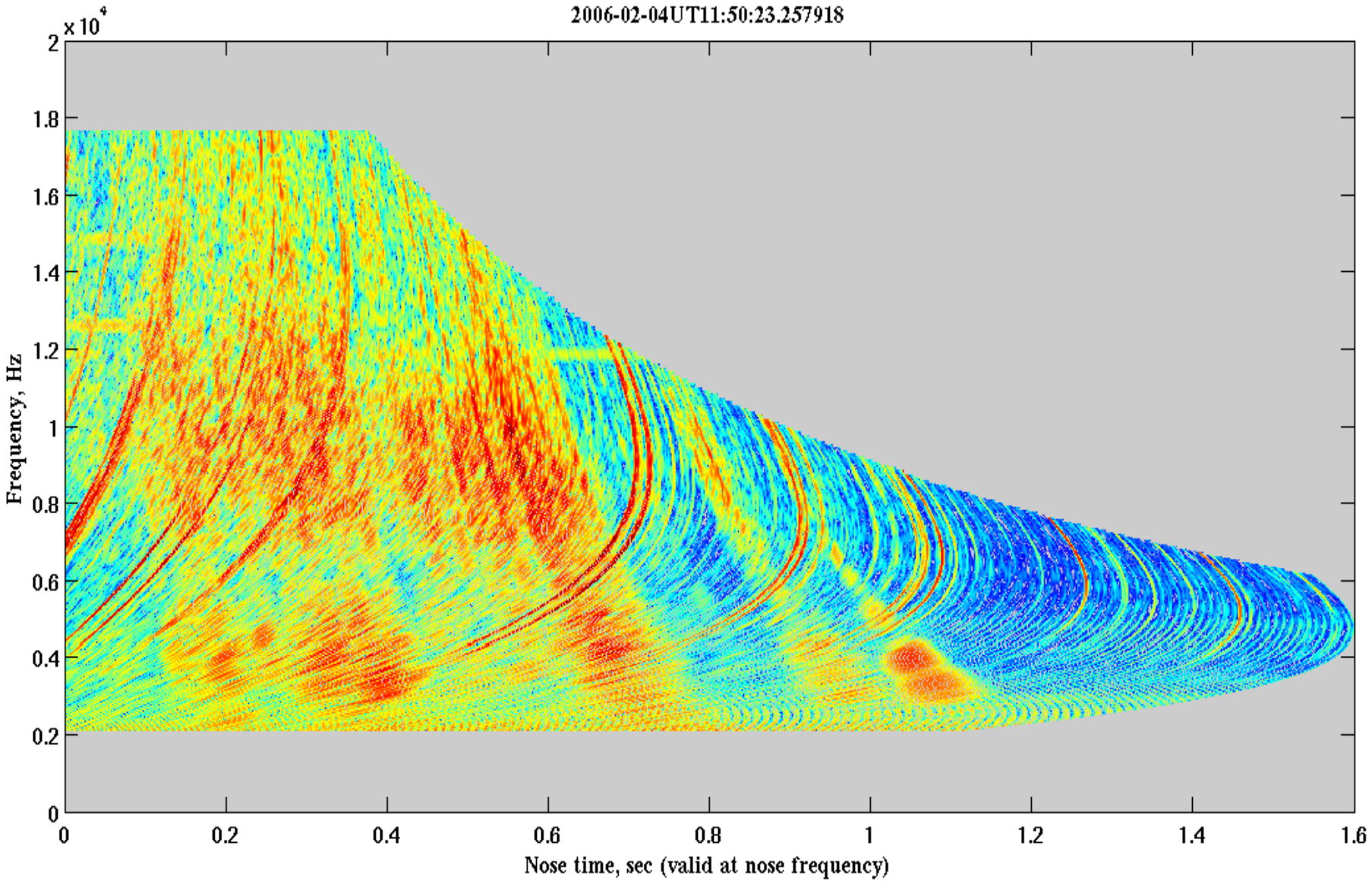
- A new, simplified equatorial electron density profile is introduced in a meridional section of the plasmasphere:

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

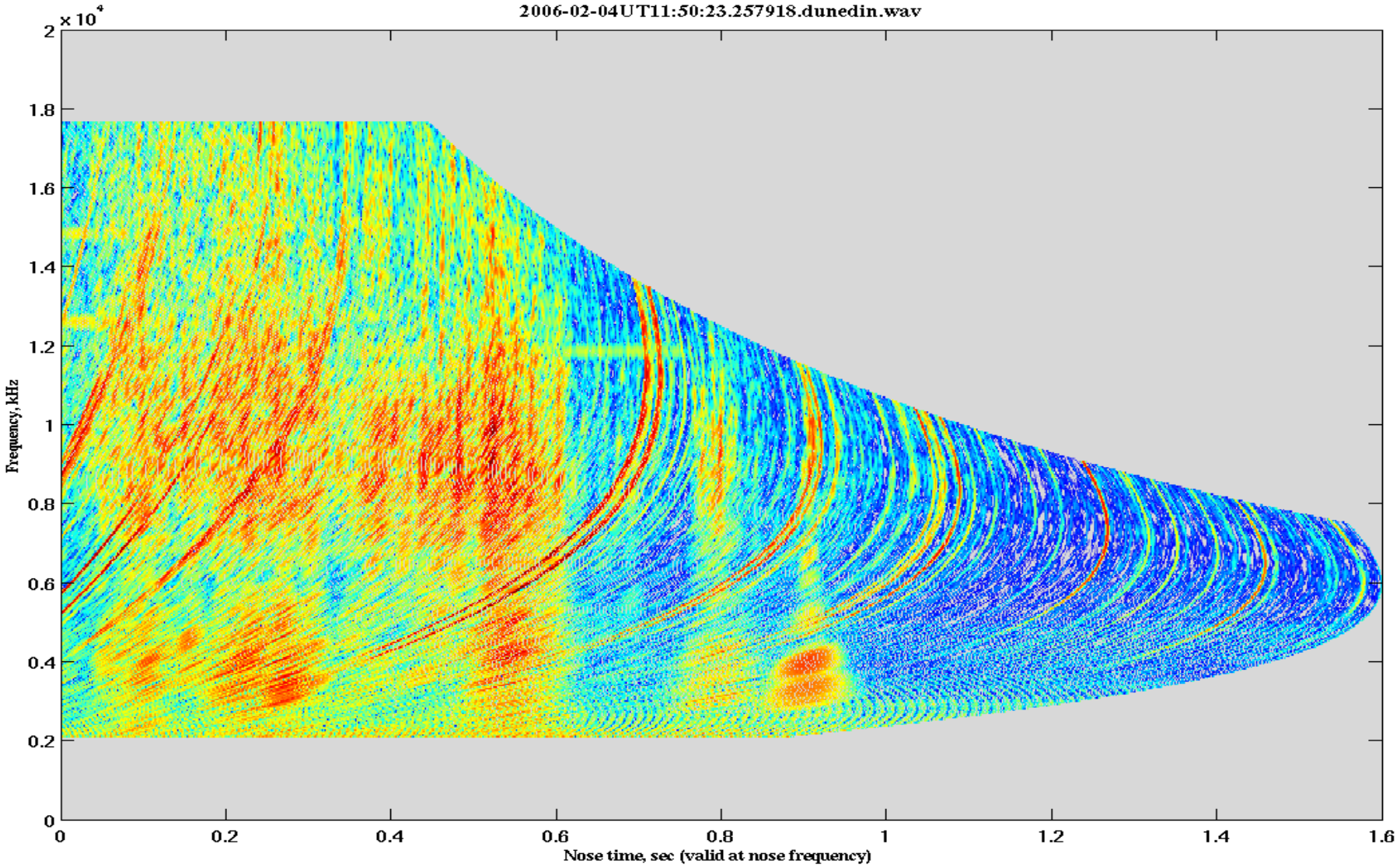
- *A* and *B* are constants for a MP group, but may vary to time and place.
- This approximation is valid between ~ 2 < L < min (8, L_{pp}), where L_{pp} is the location of plasmapause.
- Taking a pair of *(A,B),* the electron density in magnetic equator decreases monotonically. In principle, a whistler 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
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Frequency, Hz
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
Time, sec
100
90
80
70
60
50
40
30
20
10
0

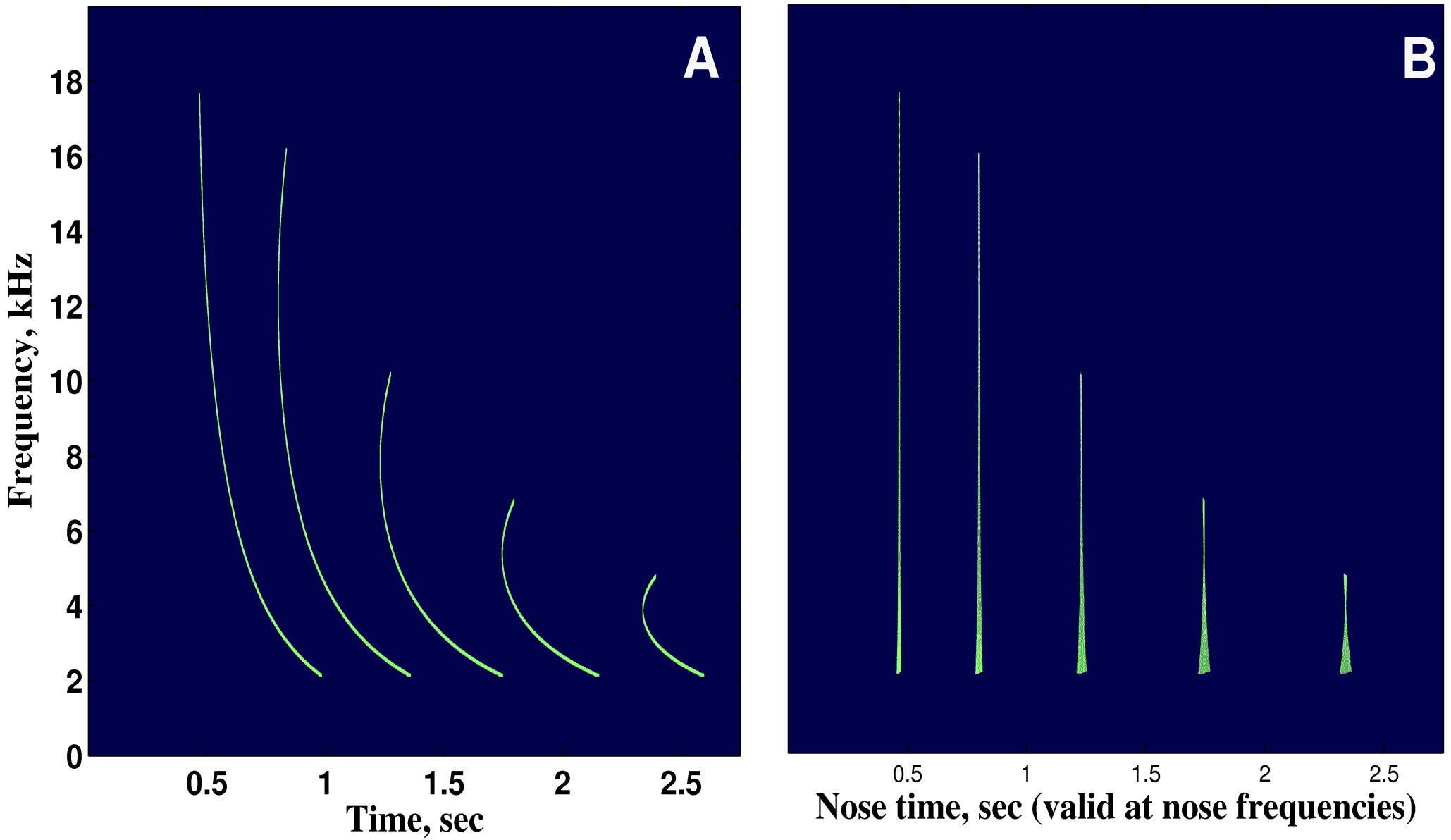
VTT –unmatched parameters



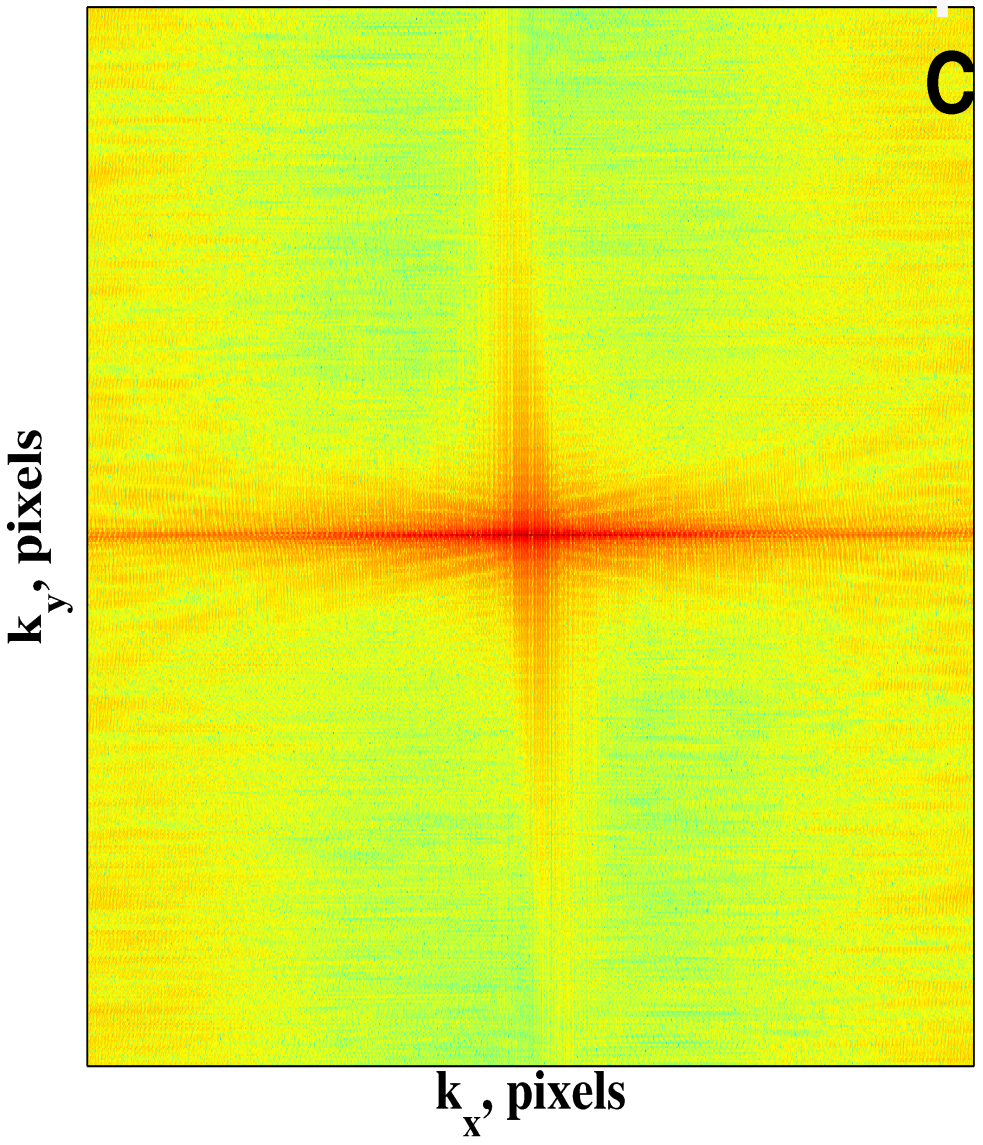
VTT –matched parameters

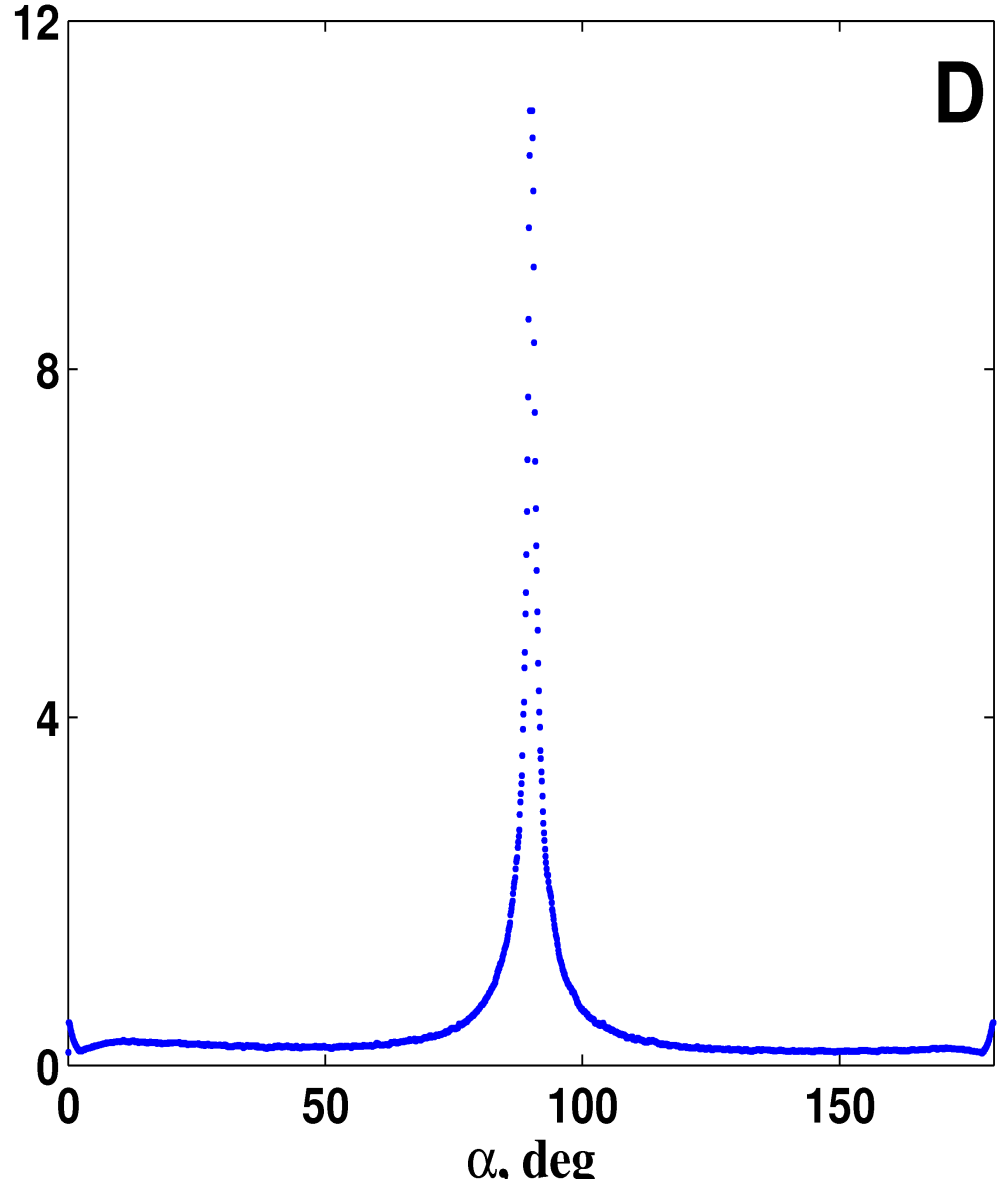


VTT –applied to model MP group

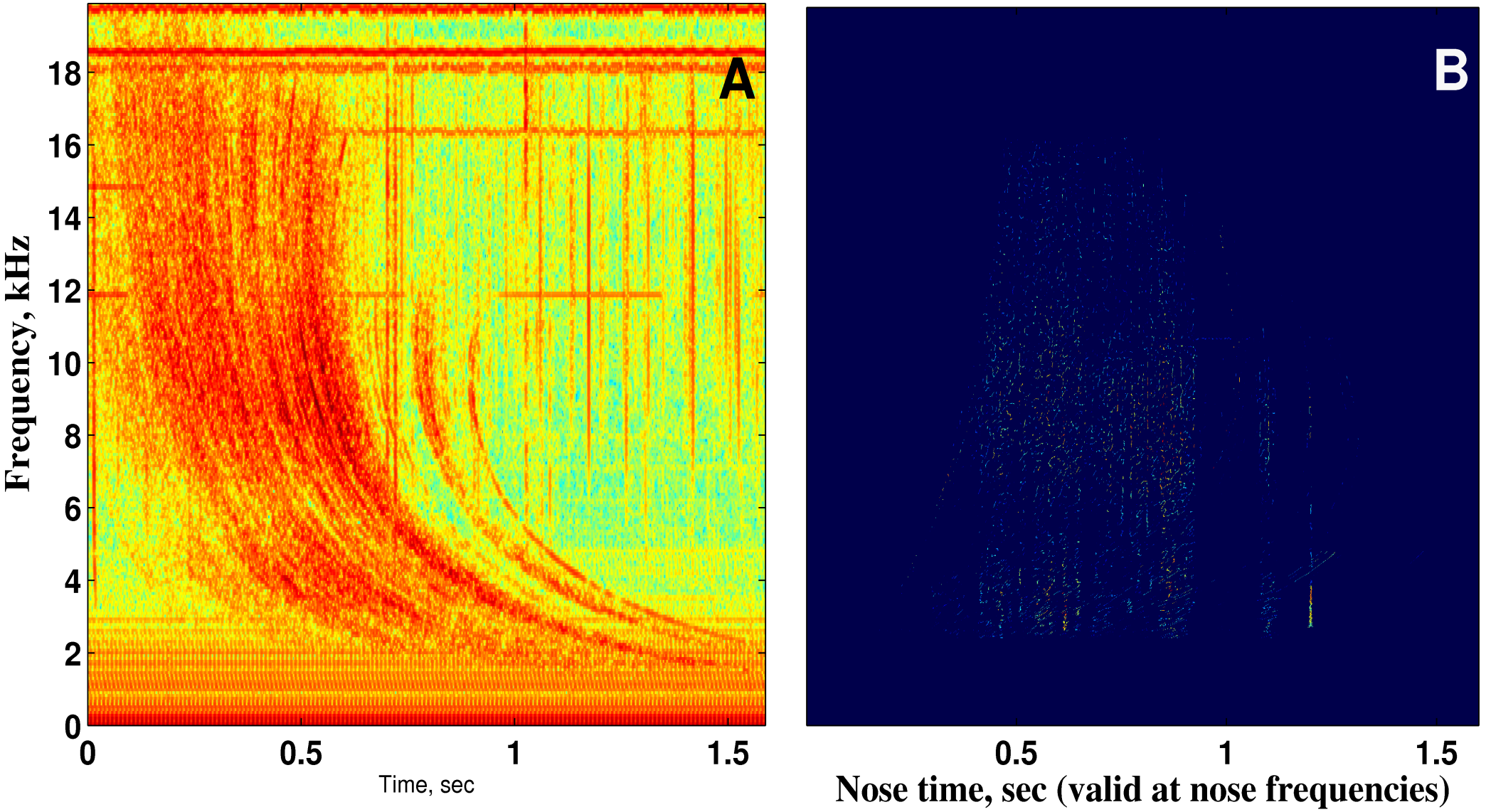


2D FFT of VTT and the "sharpness" plot–applied to model MP group

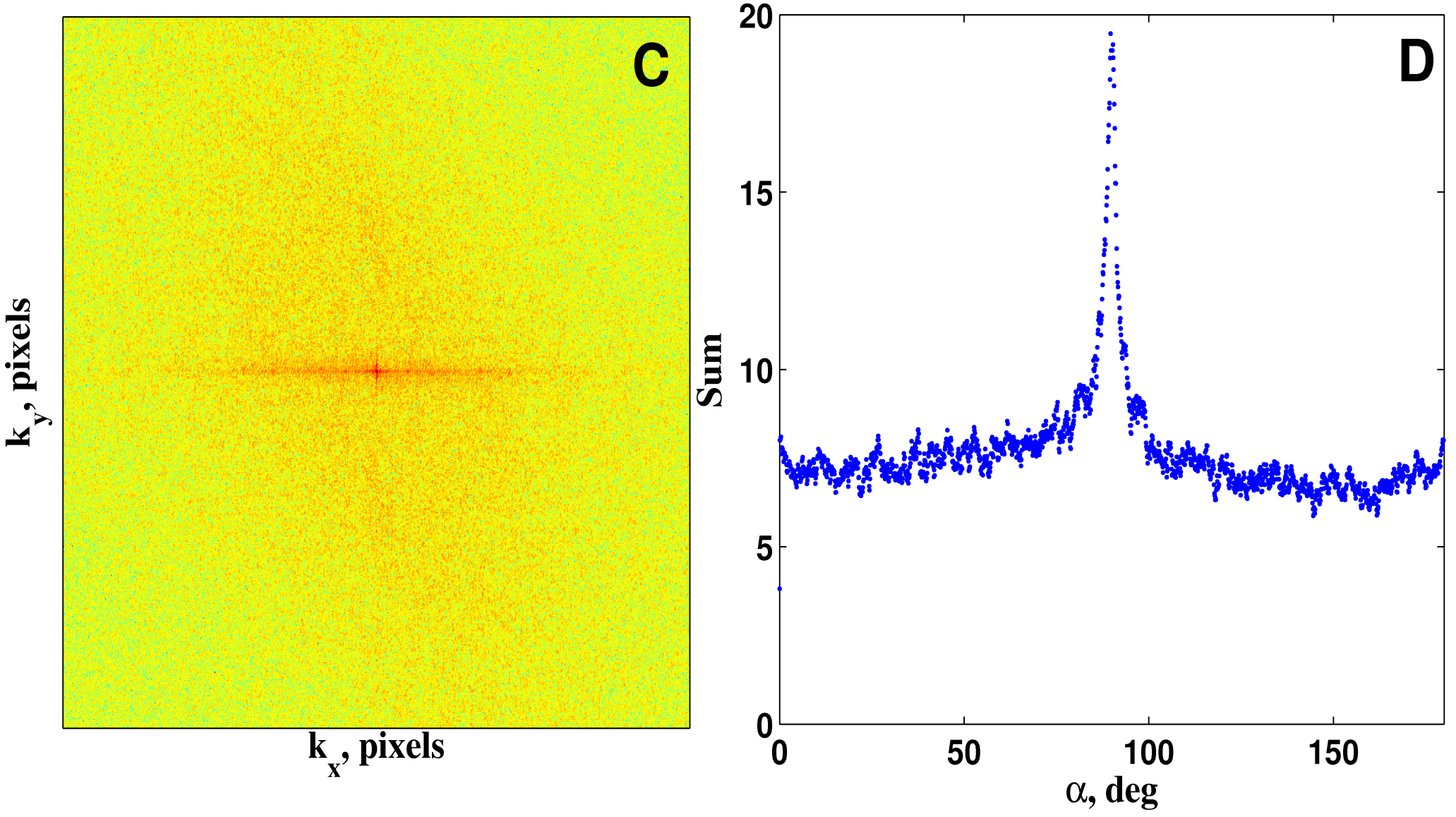




VTT –applied to real MP group



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



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

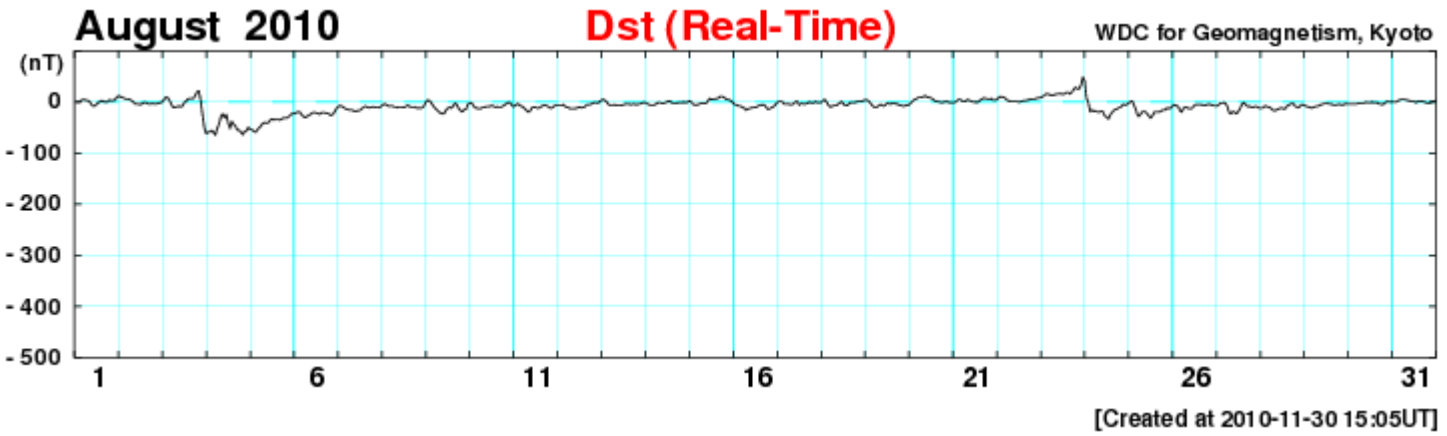
1. Application of VTT to the spectrogram matrix with an initial set of *(dt,A,B)* parameter triplet.
2. Computation of 2D FFT of VTT image.
3. Calculation of sharpness plot for the 2D FFT image and p_{max}, $|\alpha - 90|$ and w from it. The sharpness plot is used as an objective function in the optimiziation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

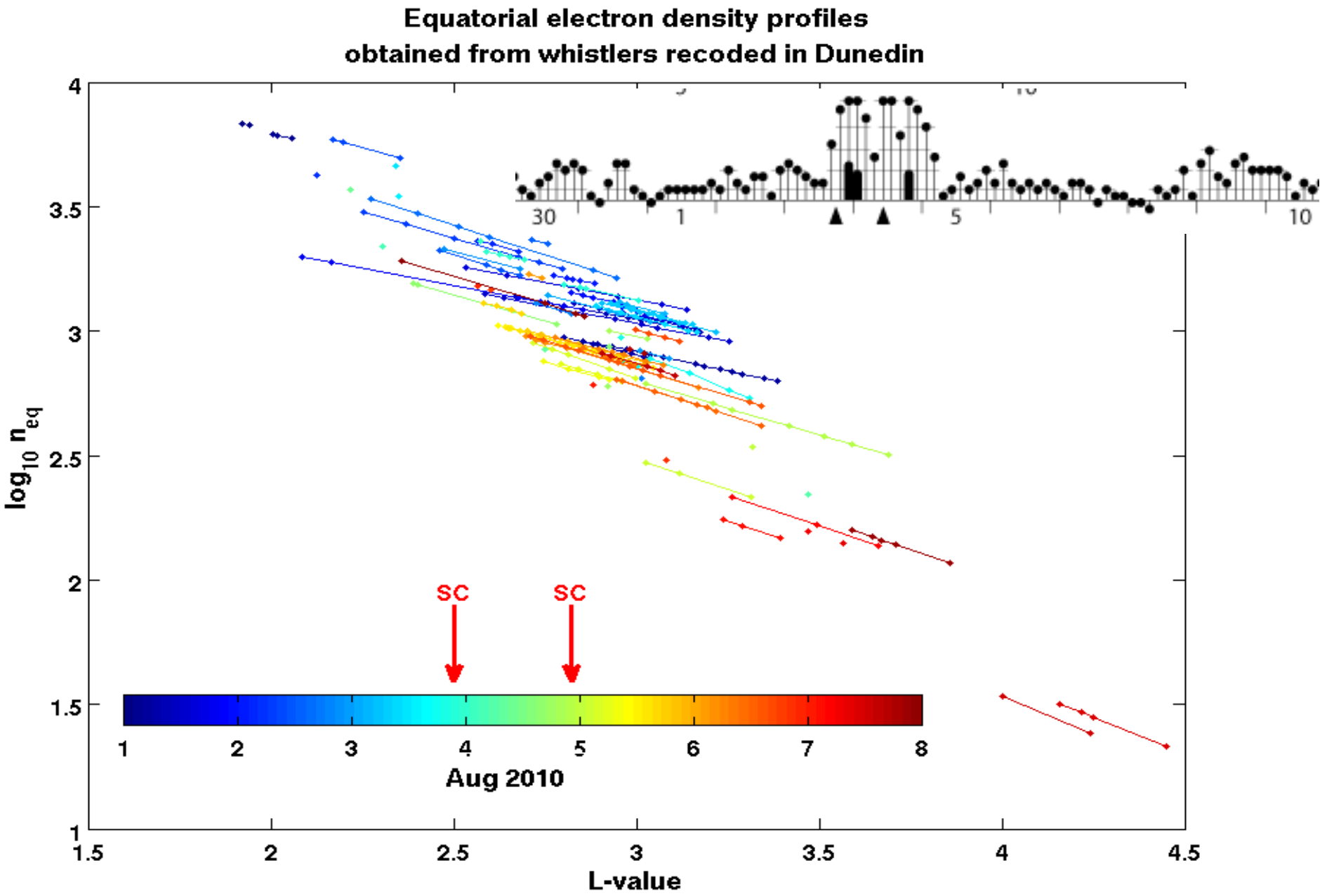
Case study:
double SSC on 3-4 Aug 2010

82 events processed between 1-8 August 2010.

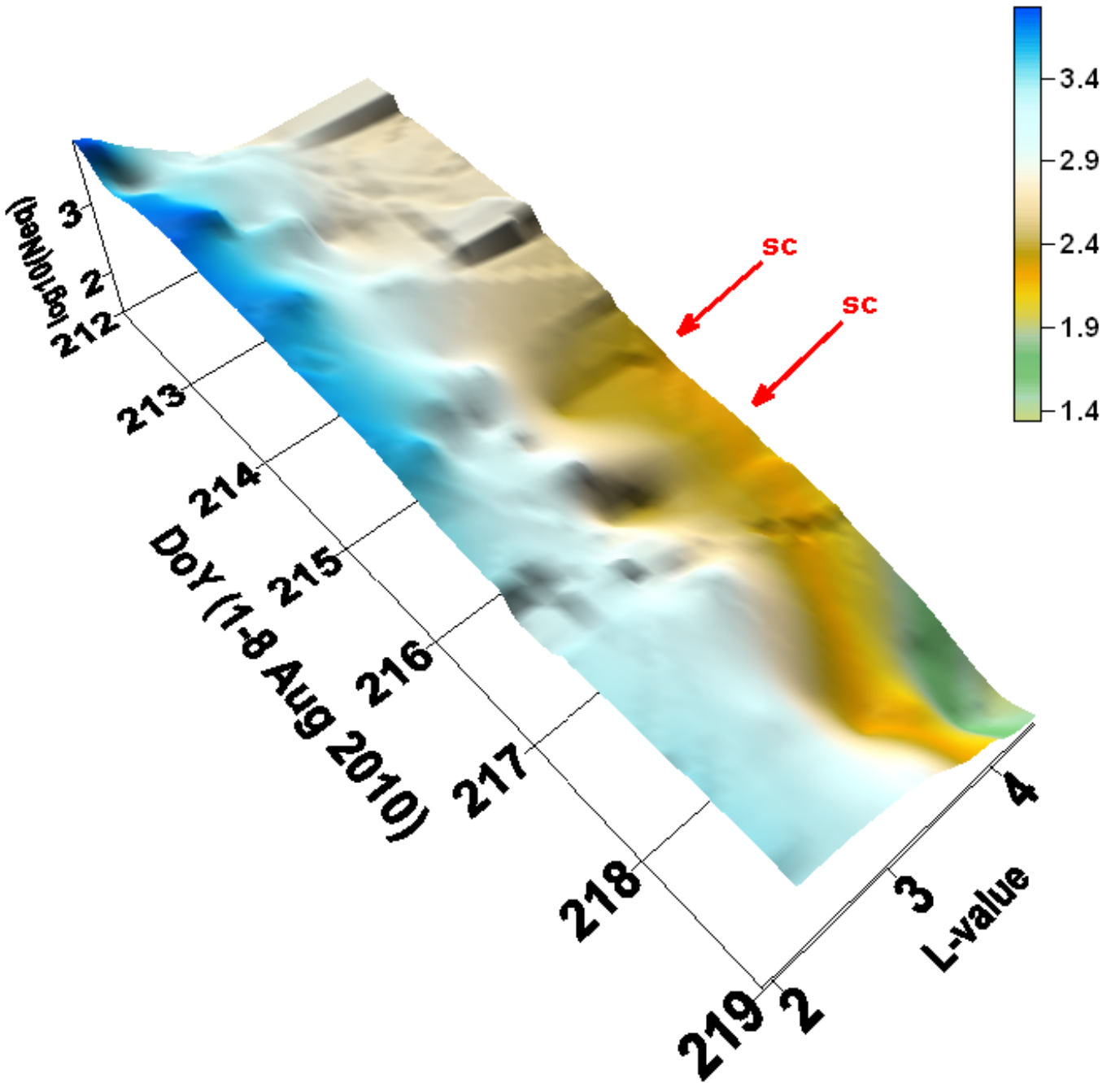
Whistlers recorded in Dunedin (New Zealand)



Case study:
double SSC on 3-4 Aug 2010



Case study:
double SSC on 3-4 Aug 2010



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)