Comparison of VLF signals mesured simultaneously on board and ground stations

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Outline

- Motivation
- Measured data
- Methods of the data processing
- Results
- Discussion

Motivation

- Increasing number of AWDA stations
- Increasing number of whistler data
- Using these data for monitoring the plasmasphere
- Still unclear processes in whistler propagation
- Simultaneous onboard (DEMETER) and ground measurements
- Previously developed data processing methods and wave propagation models

Methods

- Observing the conventional spectrograms
- Matched filtering

  obtain accurate frequency – time -amplitude pattern
- FIT – best fit approximation *(Tarcsai)*

  conventional propagation and plasma-model
  fitting Bernard's dispersion curve
- Calculating theoretical waveforms using the full-wave solution of Maxwell equations in inhomogeneous plasma

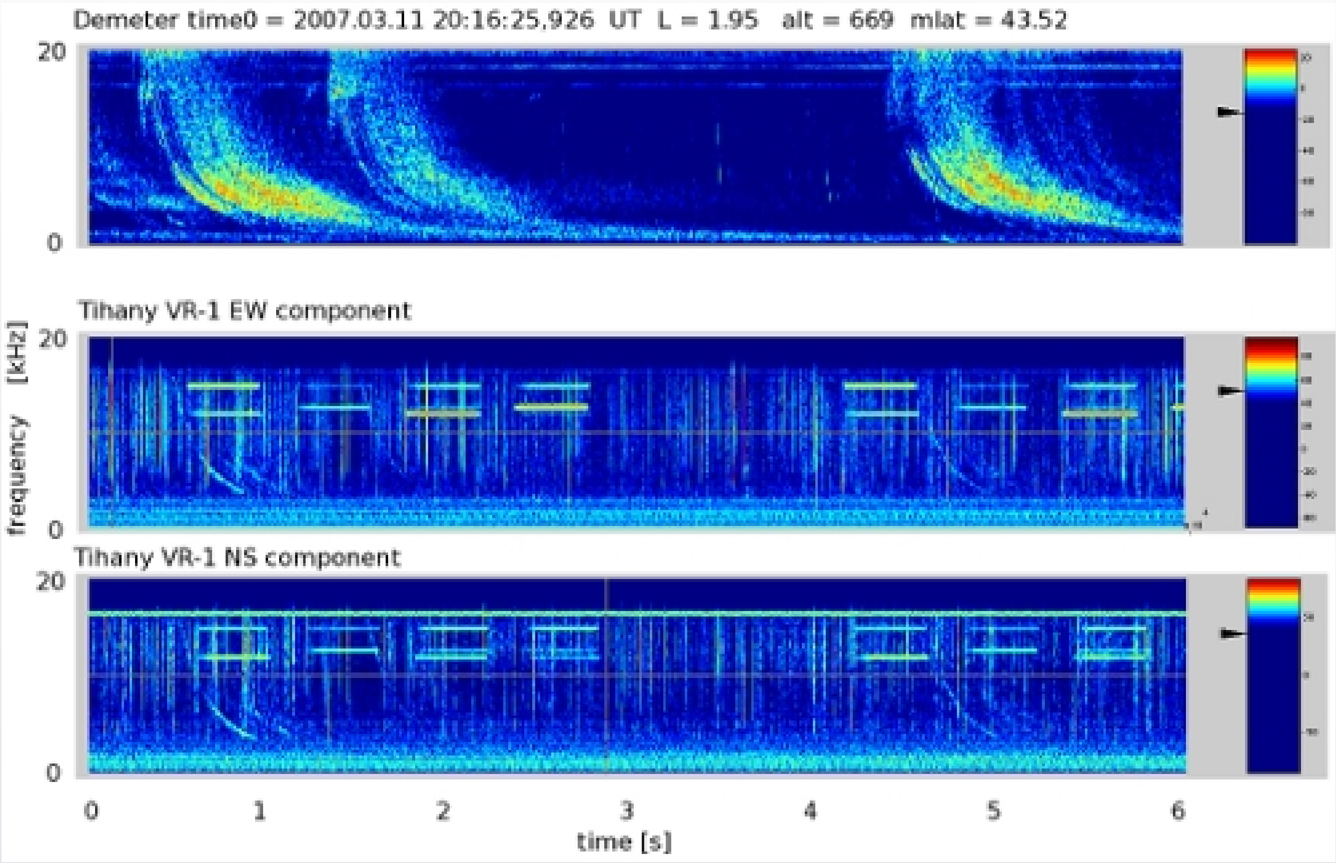
  for accurate and simplified plasma model

Measured data: Tihany-DEMETER ducted whistler

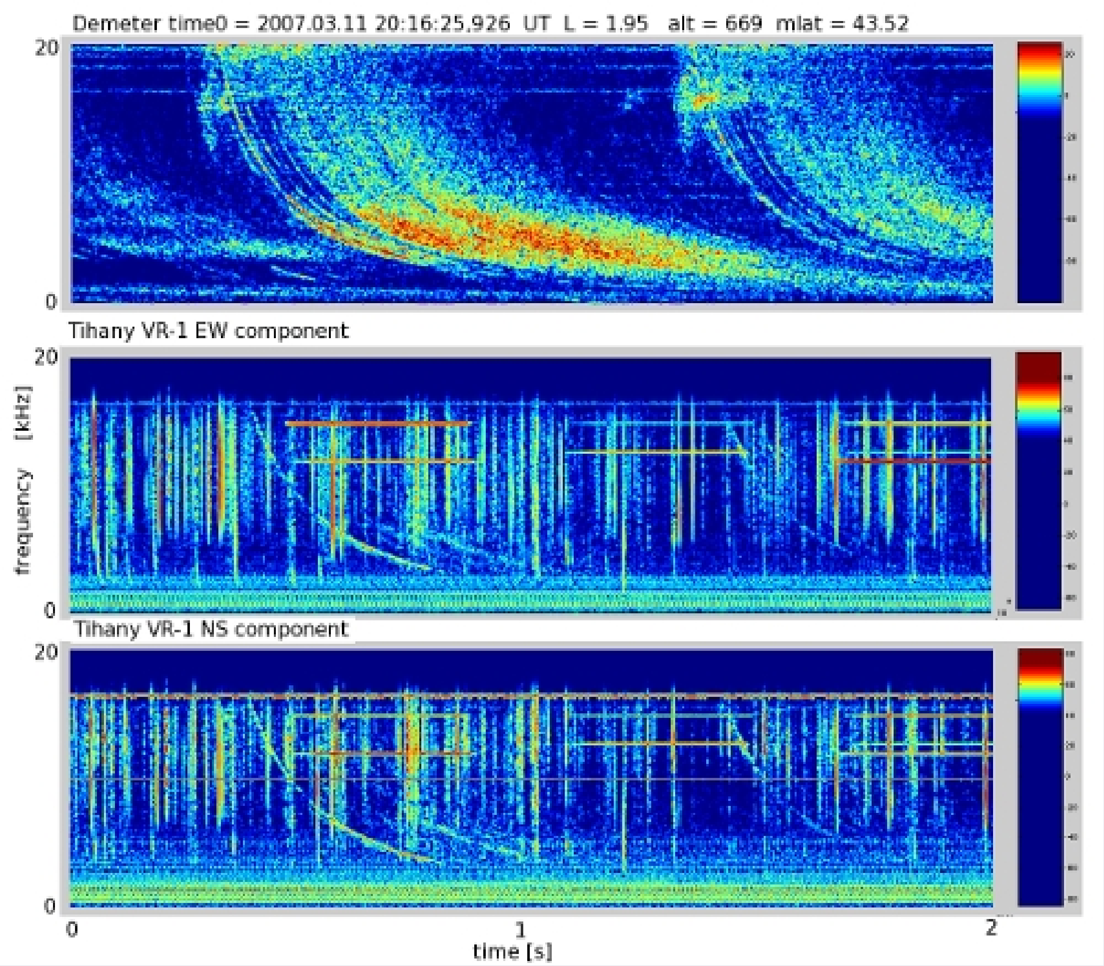
DEMETER VLF "burst mode"

Tihany-AWDA NS, EW comp

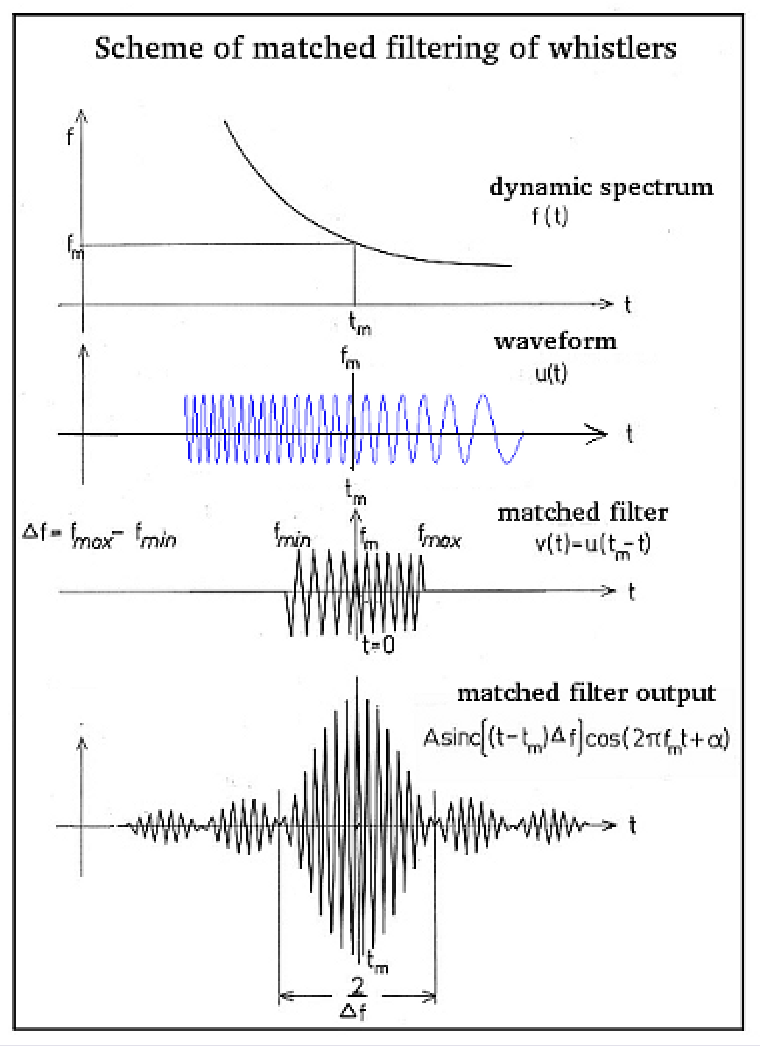
Spectrogram of the selected whistlers



The selected traces



Matched filtering of whistlers - theory



Determine the f-t pattern

Select a given frequency

Calculate the waveform with Δf bandwidth: construct the filter

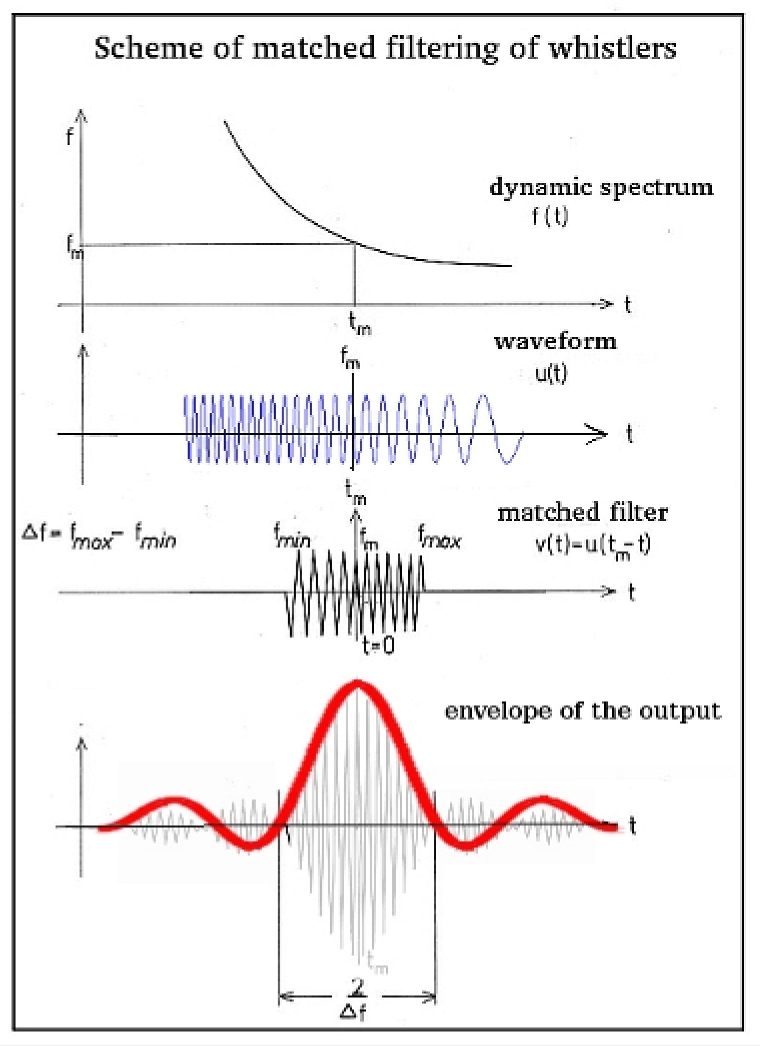
Filtering

Determine the time of the peak of the filter output

Determine the amplitude of the peak

Repeat this process with other frequency throughout the trace

Matched filtering of whistlers - theory



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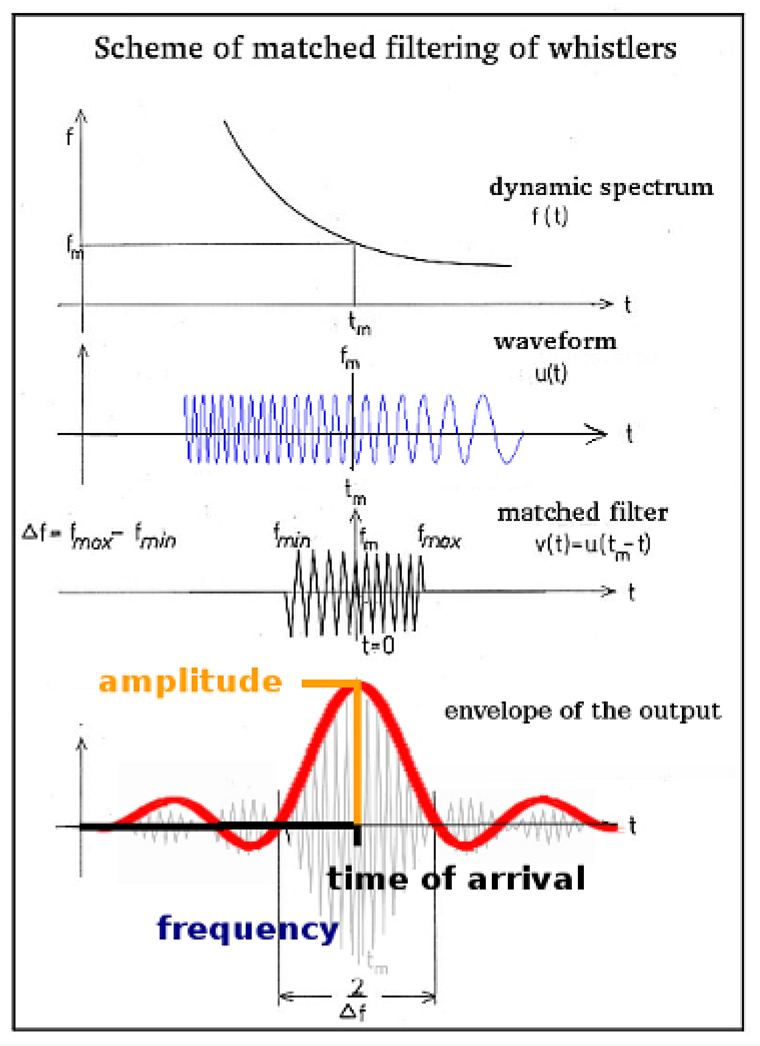

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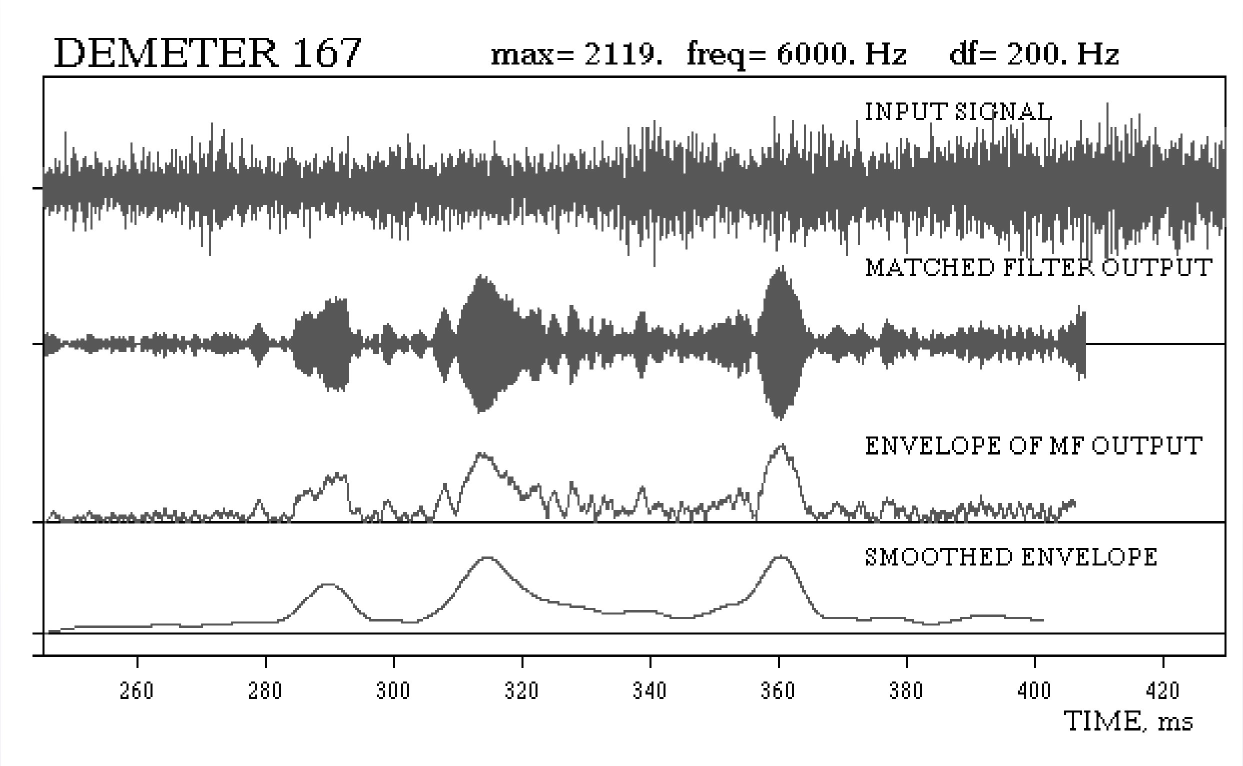
Matched filtering of whistlers – in practice



Filter output for DEMETER **1.** whistler group, trace **B,** frequency: 6000 Hz

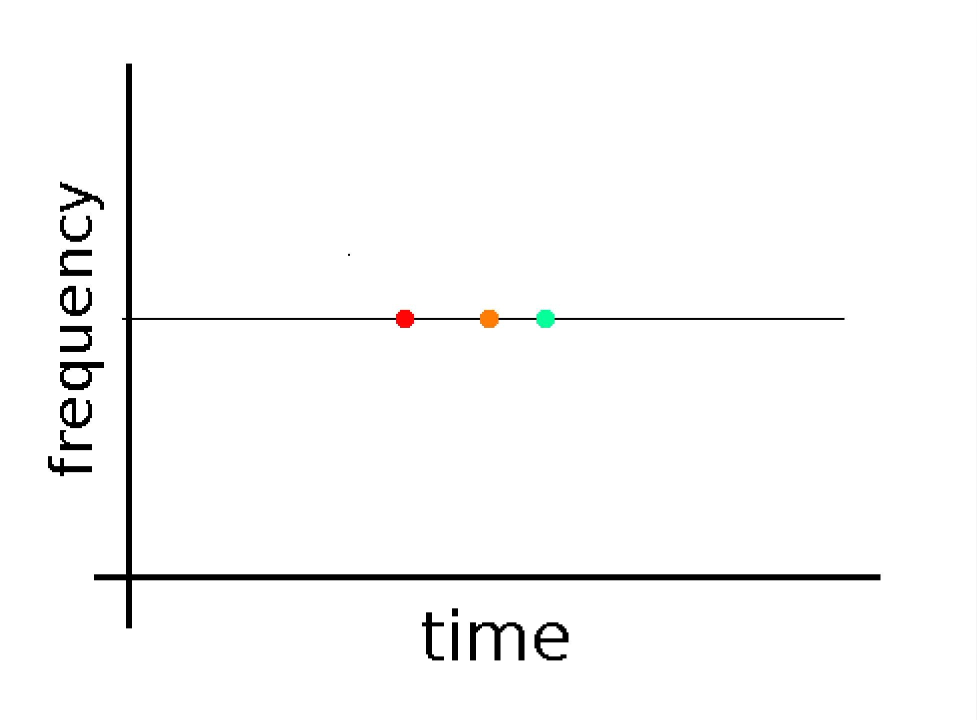
Bernard's approximation with parameters:

D_0 = 48.2 $s^{1/2}$

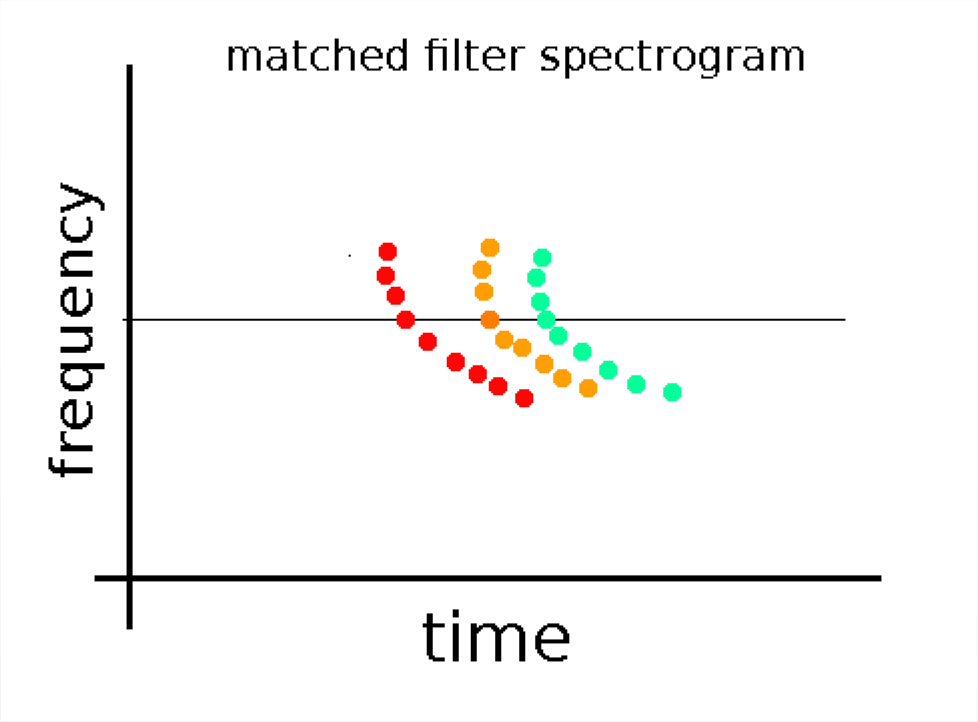
f_{Heq} = 84.2 kHz

f_n = 30.3 kHz

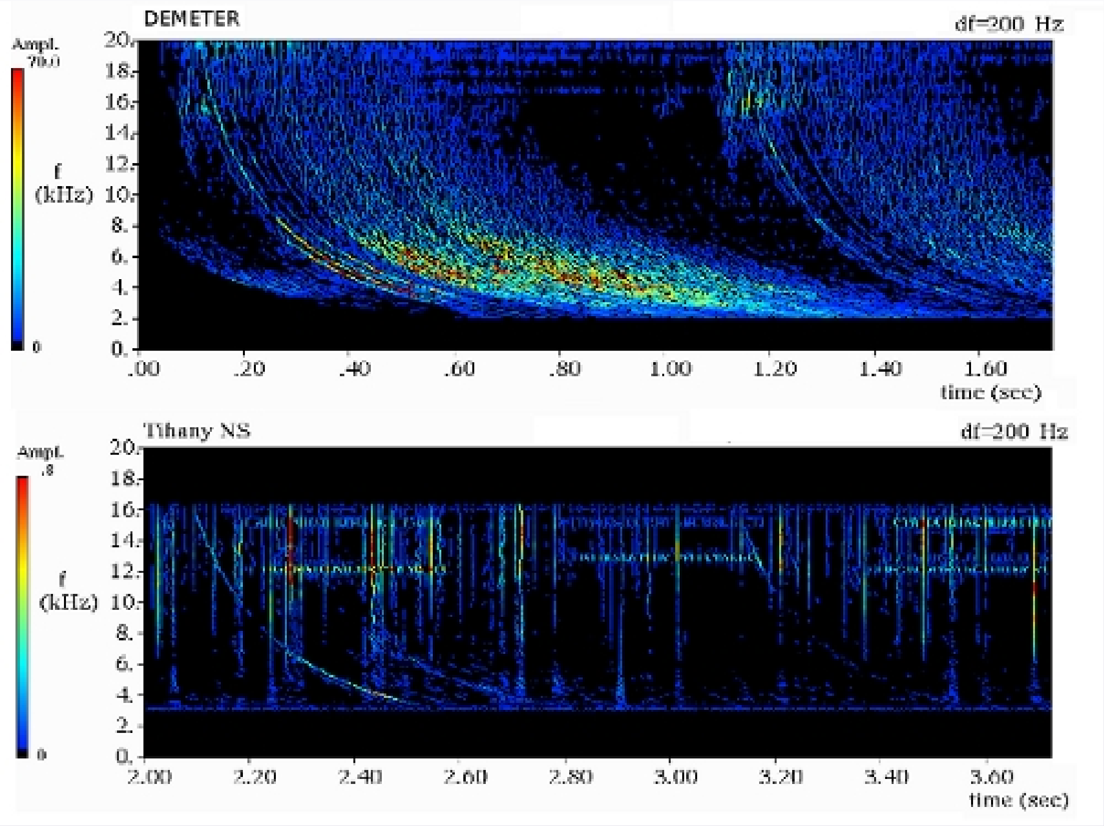
Construct the matched filter spectrogram



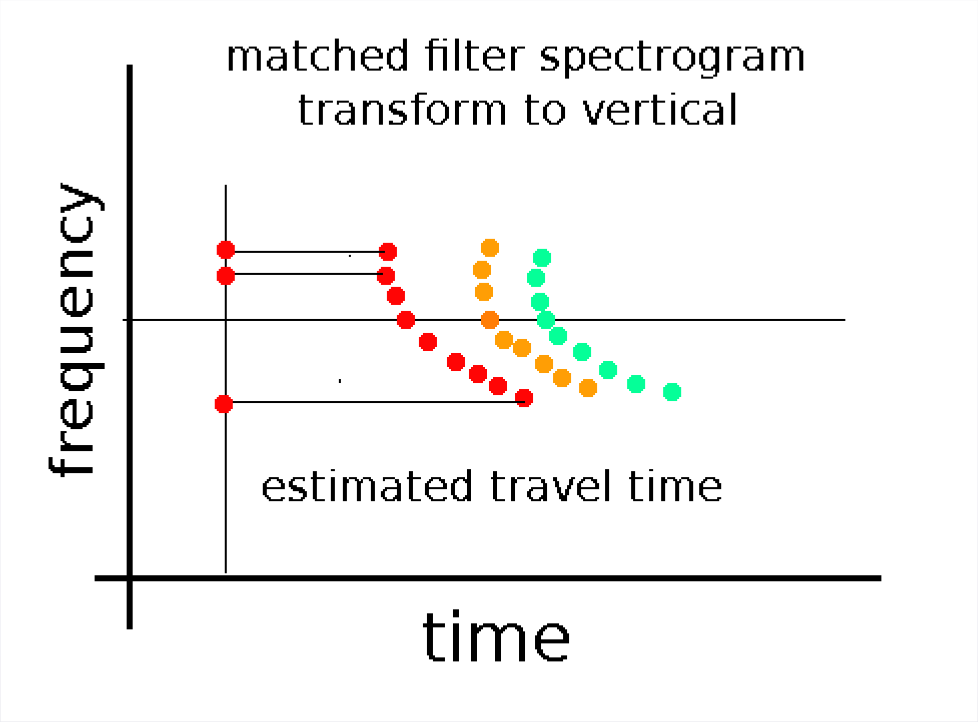
Construct the matched filter spectrogram



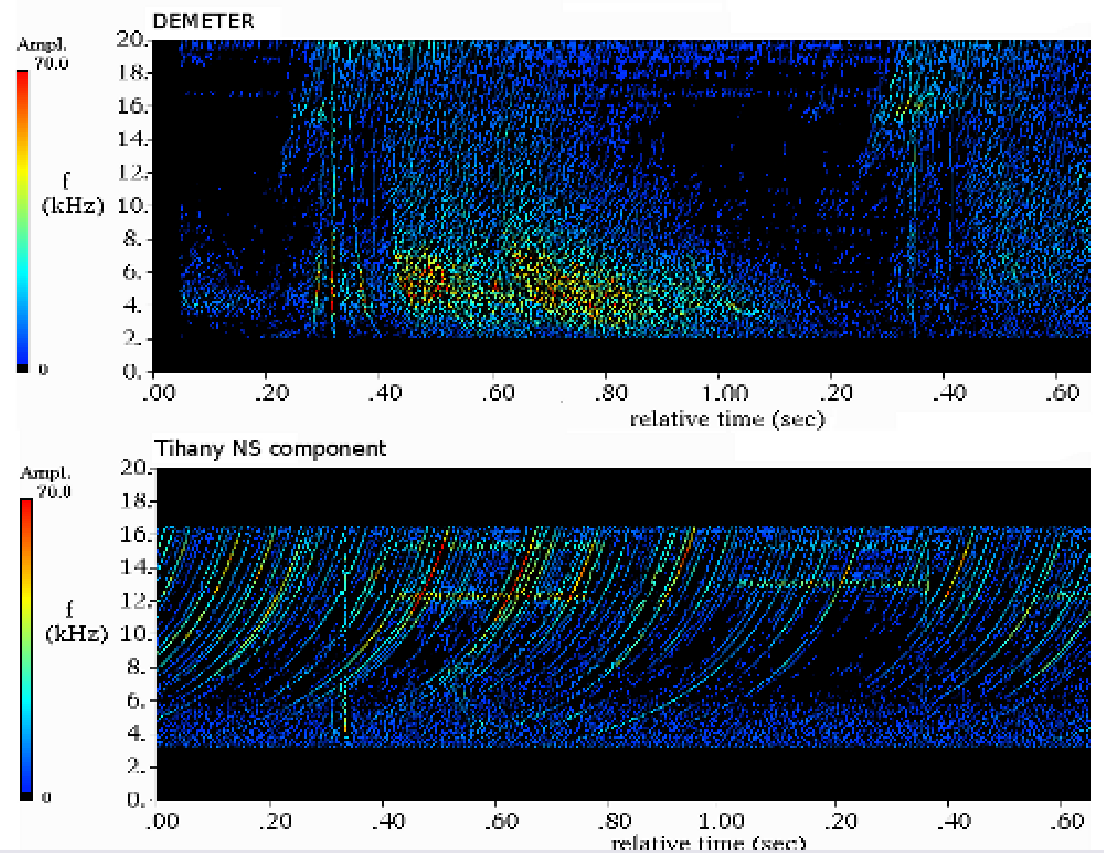
Matched filter spectrogram of the measured data



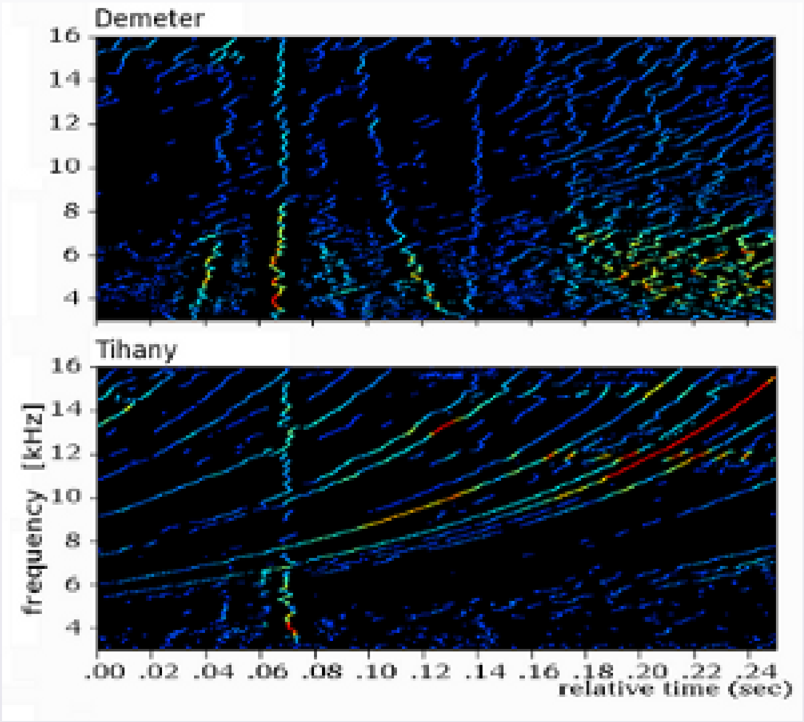
Vertical transformation



Vertical transformation of the measured data



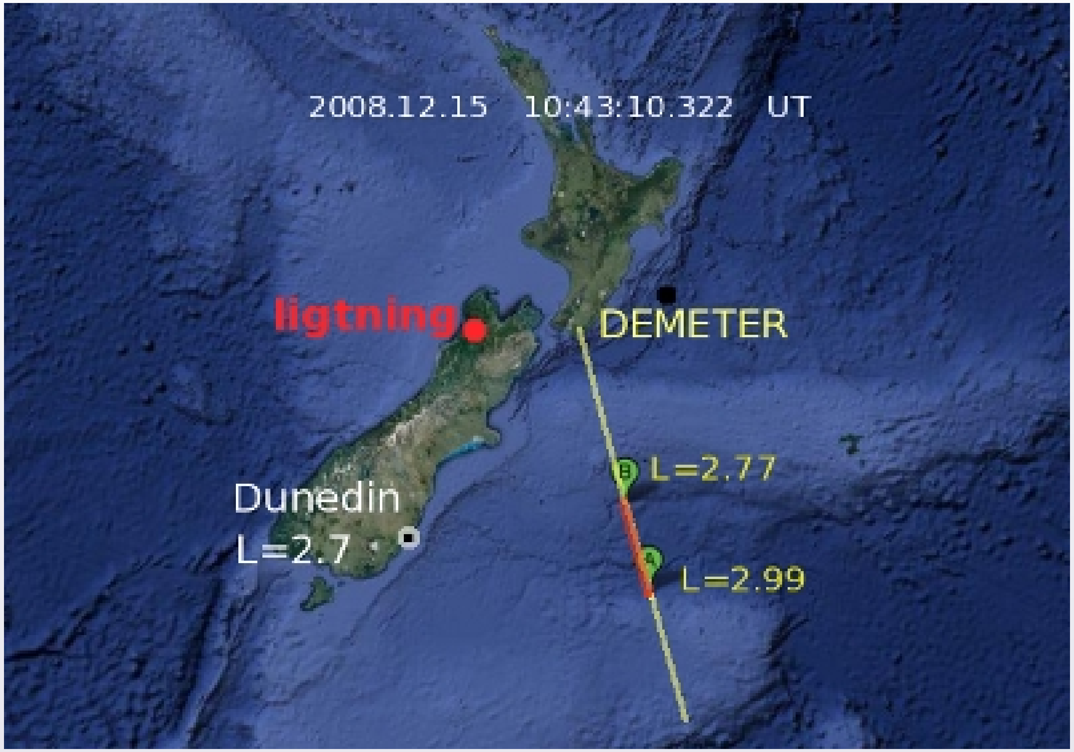
Vertical transformation of the measured data



accuracy: 2-3 ms

resolution: 10 ms

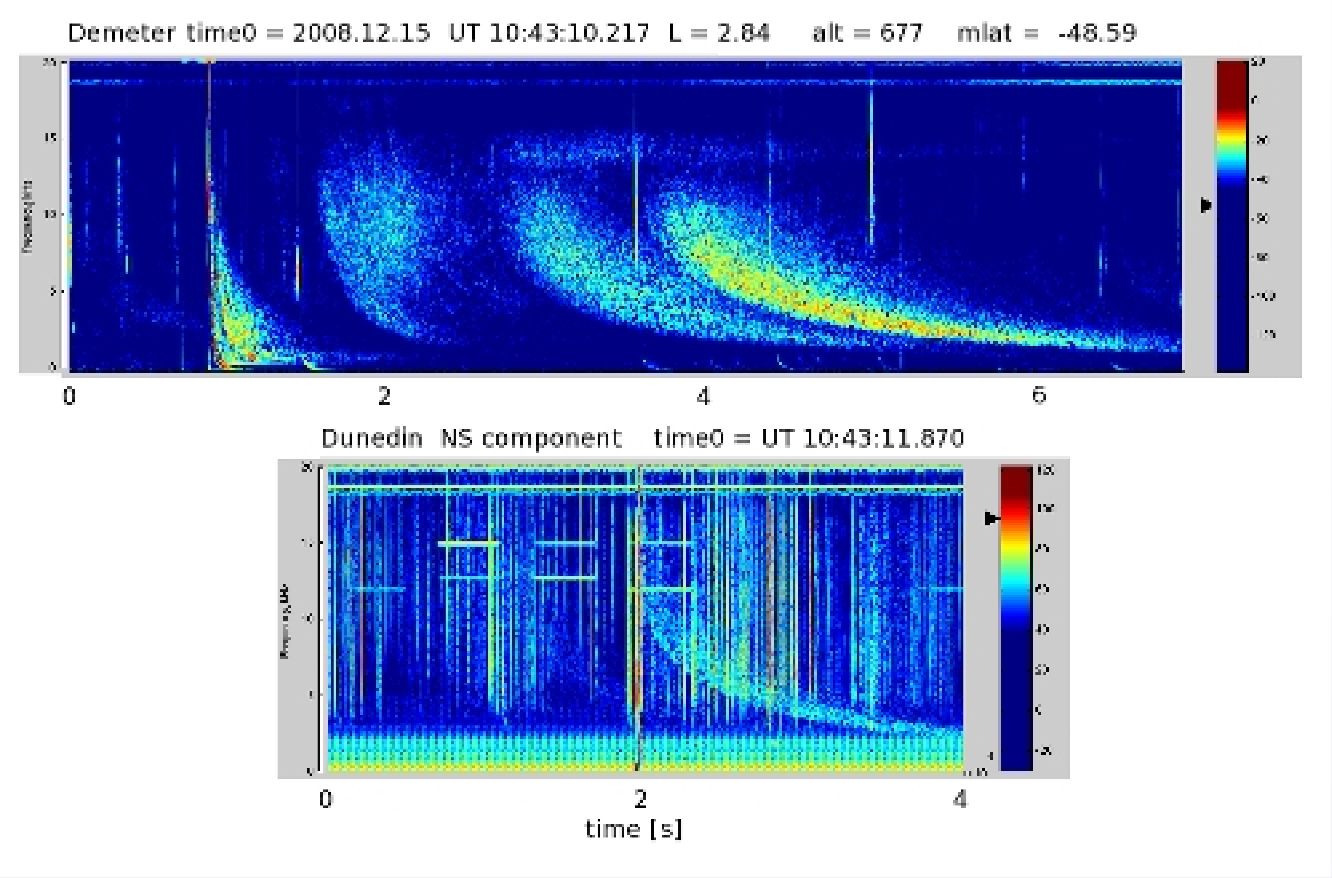
Measured data: Dunedin (N.Z.) - DEMETER fractional hop-whistler



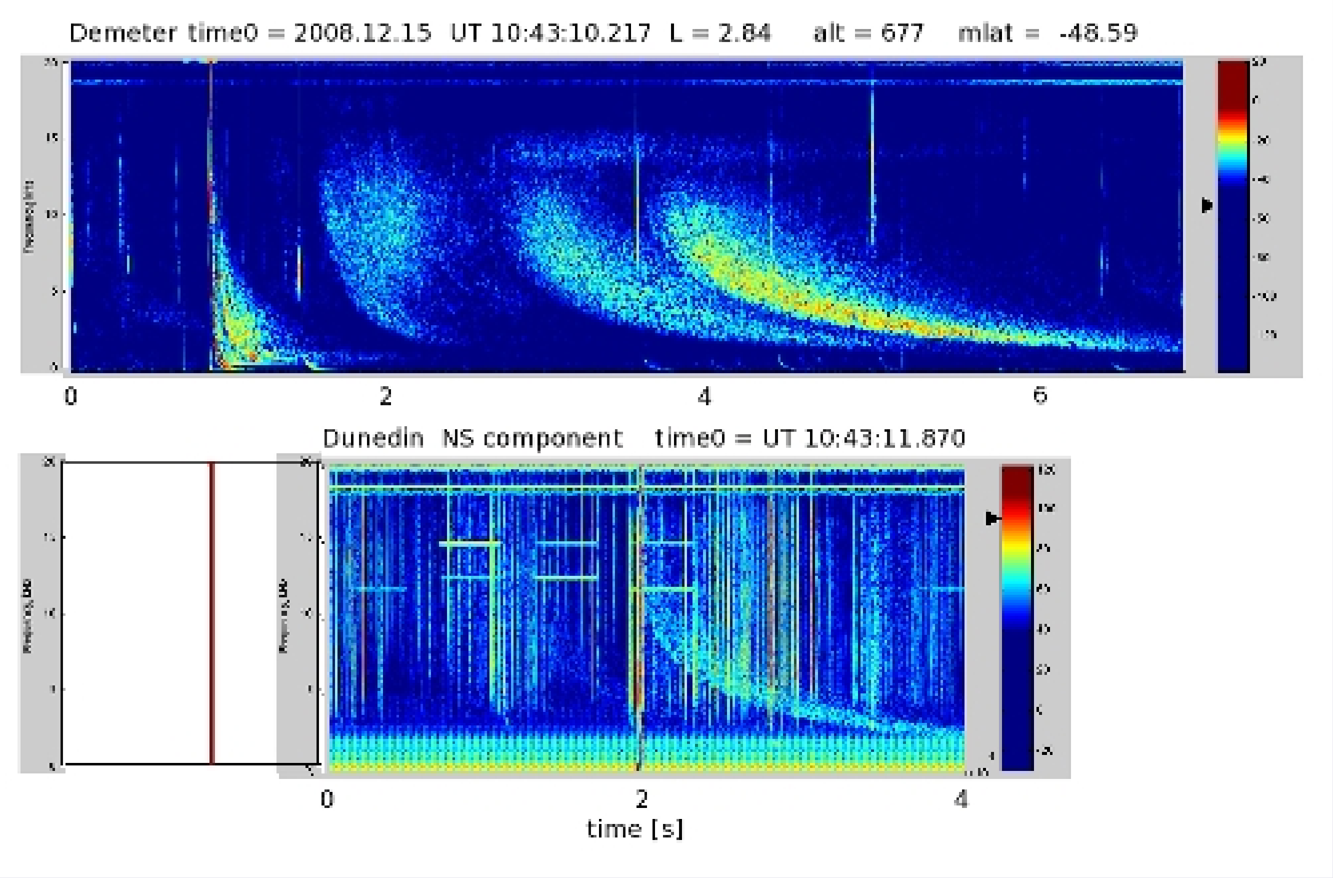
DEMETER VLF “burst mode”

Dunedin -AWDA NS, EW comp

Spectrogram of the selected whistlers



Spectrogram of the selected whistlers



Full-wave solution of short impulses in inhomogeneous plasma

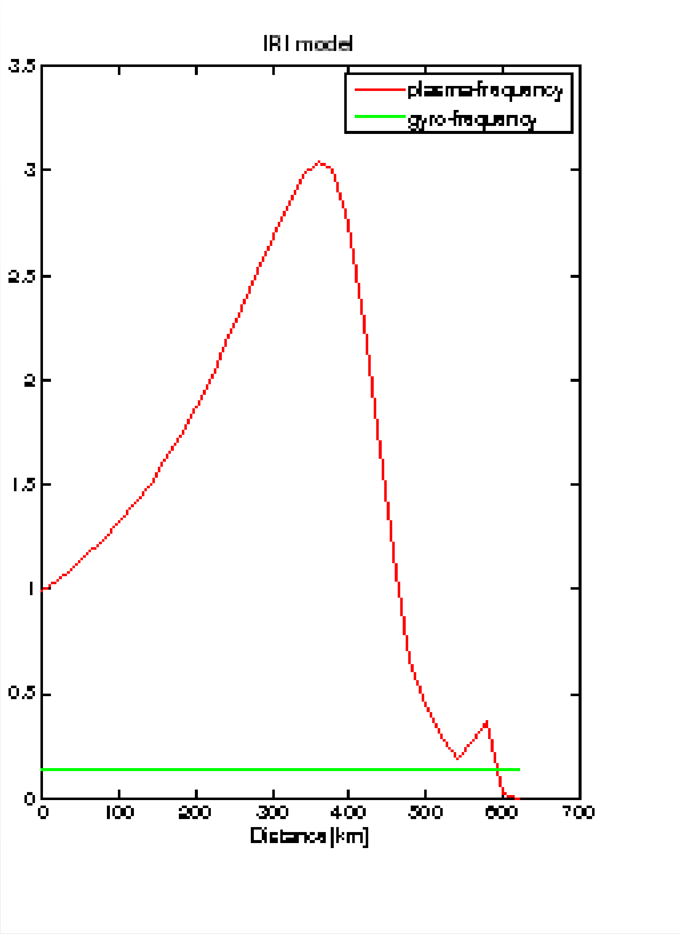
(Ferencz, O.E. 2005)

- Derived from the Maxwell equations
- For arbitrary shaped non-monochromatic signal
- In inhomogeneous, anisotropic, linear, cold plasma

$$E(x,t) = -\frac{1}{4}\mathfrak{F}^{-1}\left\{ \frac{C_0(\omega)}{\sqrt{k(x,\omega)}} \int_{x_{\max}}^{x} \frac{1}{2k(u,\omega)} \frac{\partial k(u,\omega)}{\partial u} \cdot \mathrm{e}^{-2\mathrm{j}\int_0^u k(v,\omega)\mathrm{d}v} \mathrm{d}u \right\}$$

$C_0(\omega)$	arbitrarily shaped exciting signal
$k(x,\omega)$	"propagation factor"
$\mathfrak{F}^{-1}$	inverse Fourier transformation

Calculating the waveform



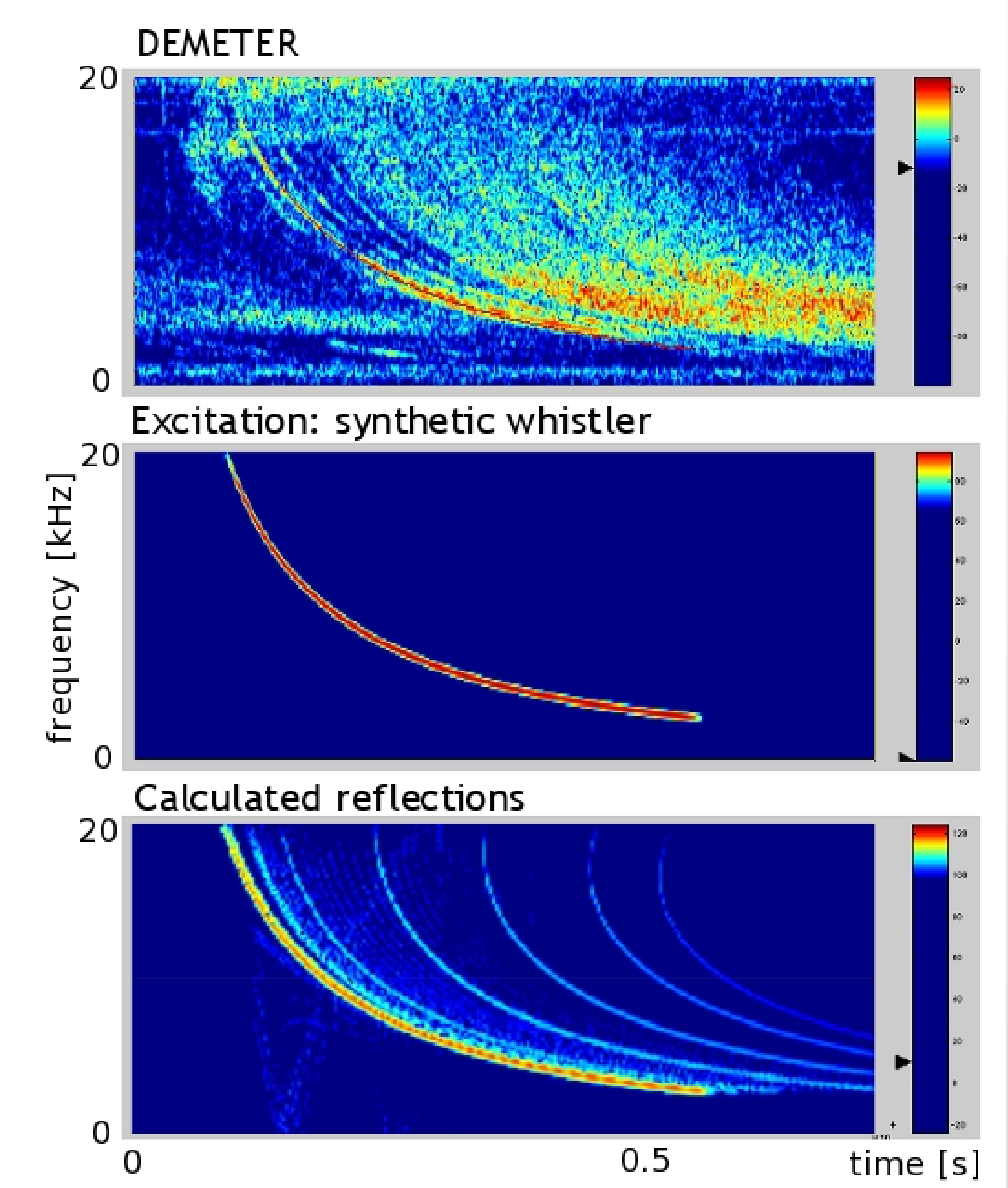
IRI model

L = 1.9

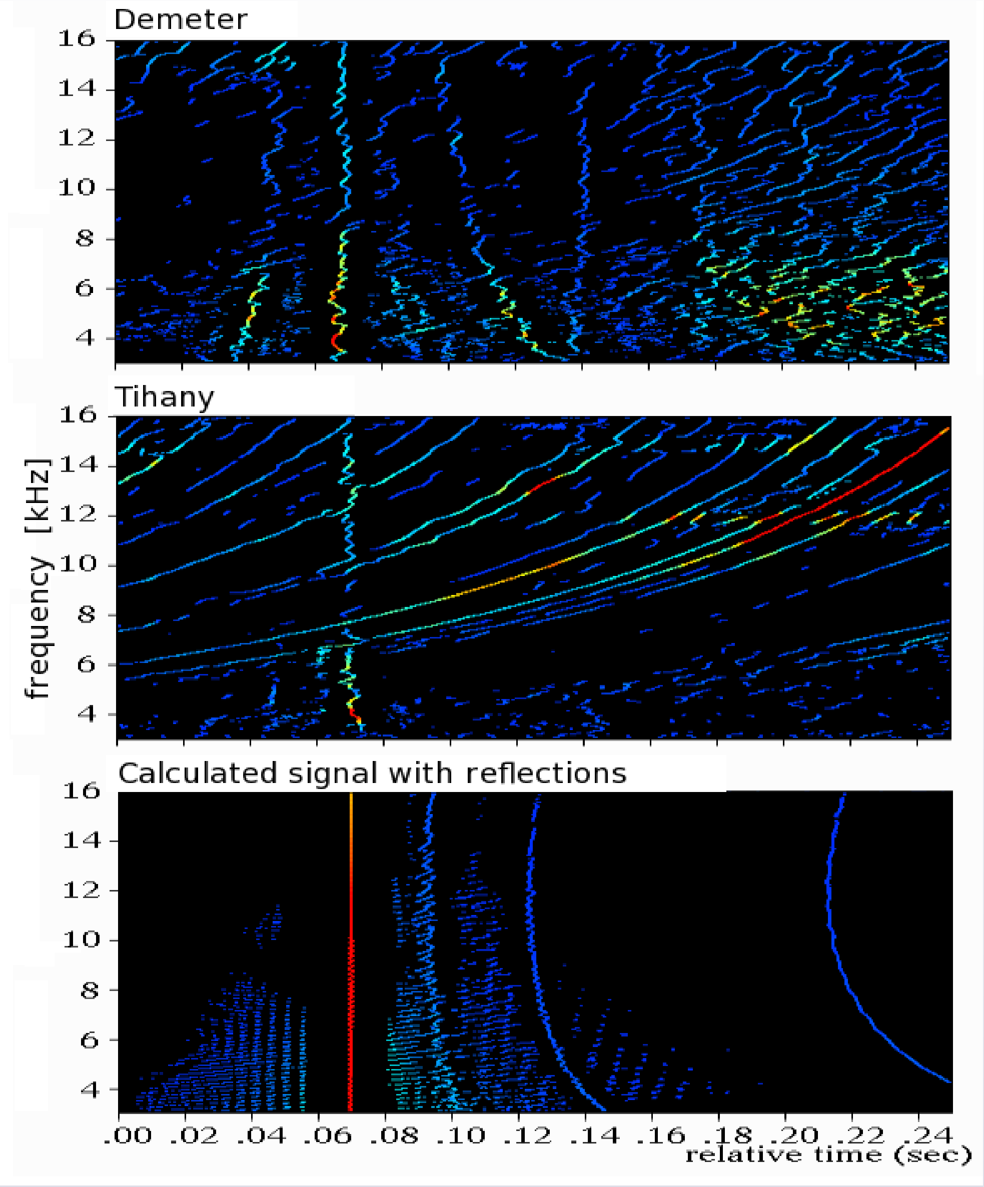
exciting signal: calculated“synthetic” whistler

h = 700 km

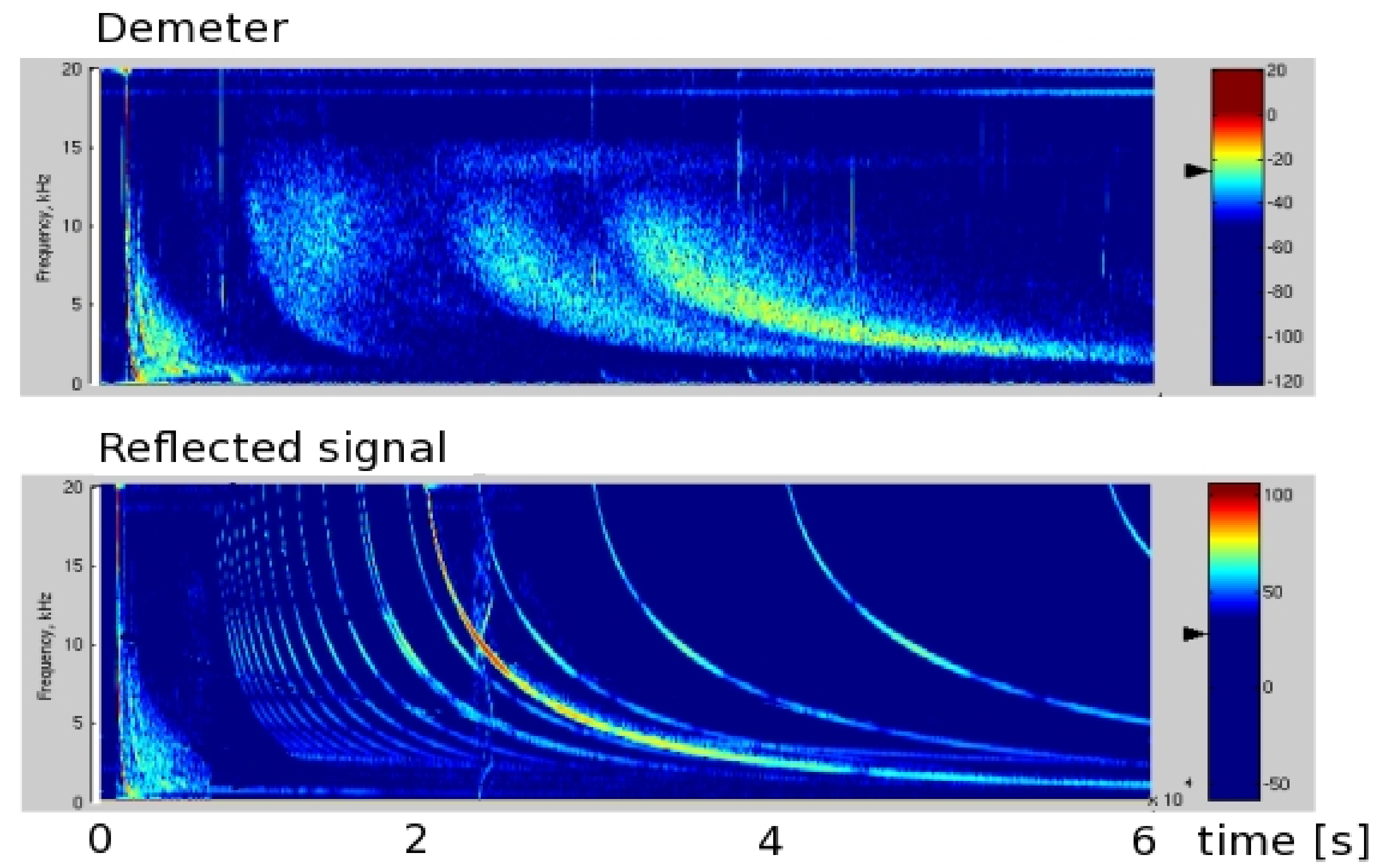
Spectrogram of the calculated signal



Vertically transformed mf spectrograms



Spectrogram of the calculated signal



MODEL: fractional whistler excitation
simplified plasmasphere
full-wave solution
discrete approximation

Conclusions

- Only a part of the signals measured on board can be detected on ground station
- Reflecting / scattering inside the ionosphere result several whistler traces on board
- The average, “smooth” plasmasphere results disperged noise
- The disperged noise can propagate to the ground resulting “false” whistler-detection
- The originating source of the “false” whistlers can be local lightning.
- The source - whistler statistical investigation needs eliminating the “false” signals

Thank you

for your kind attention

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