Whistlers recorded simultaneously on board Demeter and ground stations - a case study

2nd International Demeter Workshop

Speaker: D.Hamar, spaceg@sas.elte.hu
## Project Consortium

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Whistlers recorded simultaneously on board DEMETER and ground stations - a case study

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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
Whistler propagation

- Earth
- Geomagnetic field lines
- Equator
- Dispersion
- Ionosphere
- Lightning exchange
- Whistler mode propagation
- Whistler
- Ground receiver
- DEMETER
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 $\Delta f$ 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

Determine the f-t pattern
Select a given frequency
Calculate the waveform with $\Delta f$ 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

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
Construct the matched filter spectrogram
Construct the matched filter spectrogram
Matched filter spectrogram of the measured data
Vertical transformation

matched filter spectrogram transform to vertical

estimated travel time
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
Whistler propagation
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

\[ E(x,t) = -\frac{1}{4} \mathcal{F}^{-1} \left\{ \frac{C_0(\omega)}{\sqrt{k(x,\omega)}} \int_{x_{\text{max}}}^{x} \frac{1}{2k(u,\omega)} \frac{\partial k(u,\omega)}{\partial u} \cdot e^{-2j\int_{0}^{u} k(v,\omega)dv} \, du \right\} \]

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

IRI model

L = 1.9

exciting signal: ducted whistler

h = 700 km
Spectrogram of the calculated signal
Vertically transformed mf spectrograms
Spectrogram of the calculated signal

MODEL:
- fractional hop
- 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 dispersed noise
- The dispersed 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

Any question about this subject
or
about the Hungarian traditional music?
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