WHISTLERS DETECTED BY THE BELGIAN VLF ANTENNA OF HUMAIN

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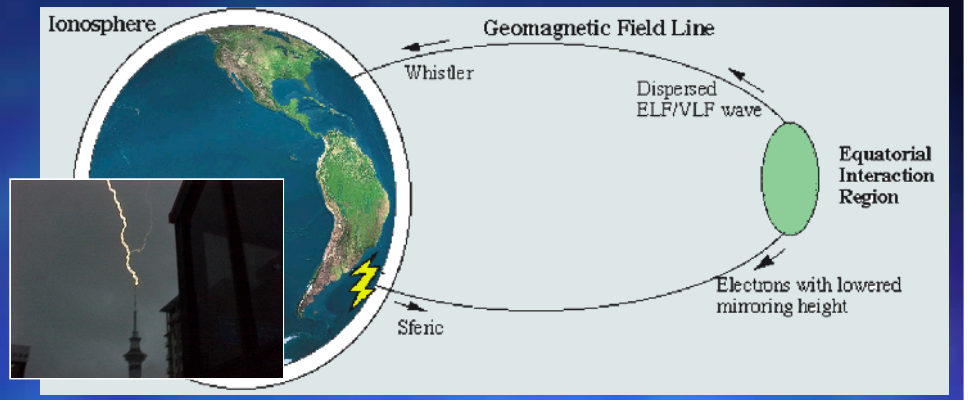
Outline

- **Introduction**
  - Whistlers
  - VLF antenna in Belgium
  - AWDANet Project
- Observations
  - Dataset
  - Examples
- Analysis
  - Whistlers
  - Density
- Summary – Conclusions
- Future Perspectives

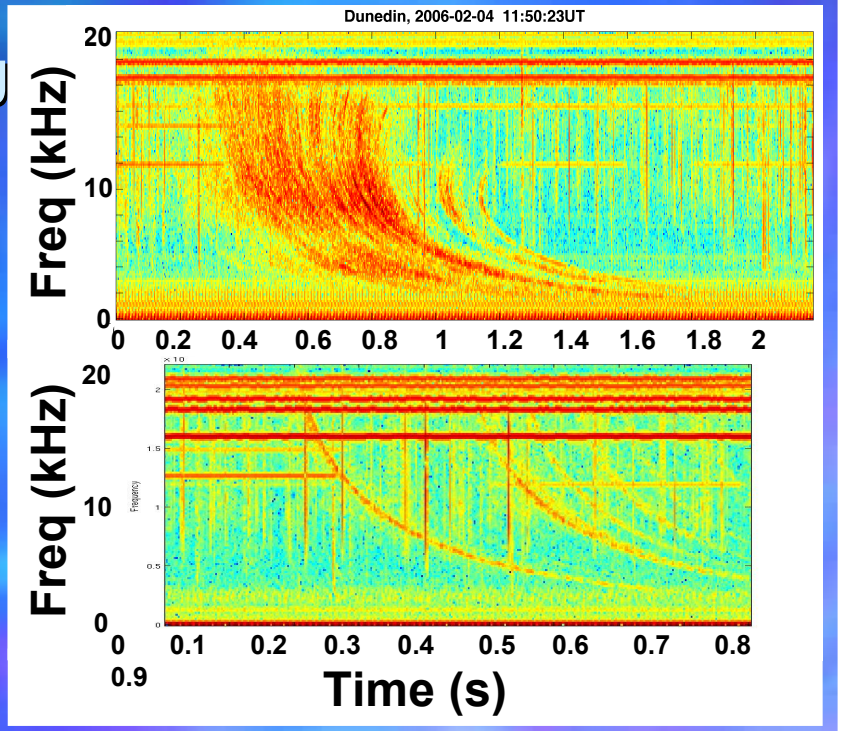
Whistlers

- Whistlers are VLF (3-30 kHz) emissions initiated by lightning, propagating along magnetic field lines, observed on ground and in space



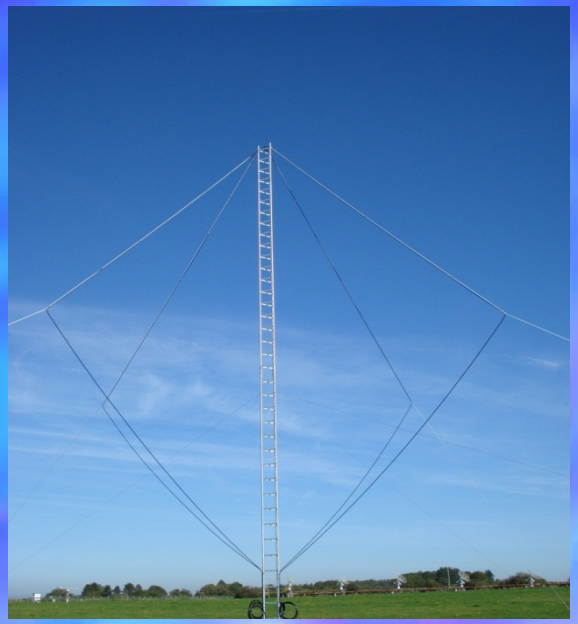
- Whistlers have particular frequency-time characteristics acquired as they propagate throug magnetospheric plasma

- Propagation time delay of whistlers depends on plasma density along propagation paths
  - ⇒ Possibility to derive plasma density (in plasmasphere) from whistlers measurements



VLF Antenna in Humain

- Implementation of the AWDA project in Belgium:
  - November 2009: Meet the responsible of AWDANet project
  - January - October 2010: Selection of material, decision about size of antenna, search for location
  - November 2010: Installation of a 12-meters mast
  - Spring 2011: Installation of all hardware and software
- VLF antenna made of 2 perpendicular magnetic loops (North-South ; East-West), area ~ 50 m^2 each

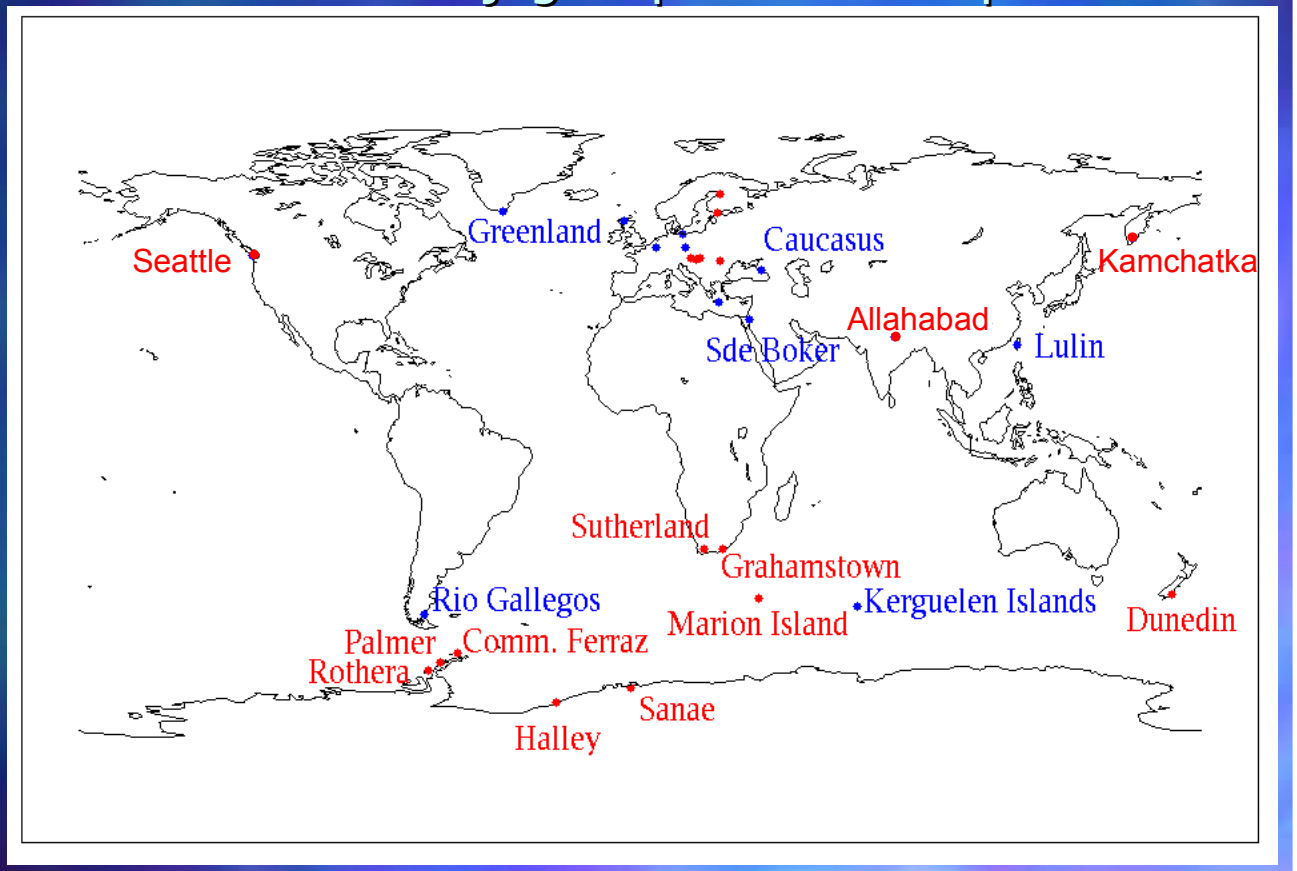


AWDANet in Europe

- AWDANet = Automatic Whistler Detector and Analyzer systems' Network *[Lichtenberger et al., 2008]*
  - Network of AWDA systems covering low-, mid- and high (magnetic) latitudes since 2002 including conjugate locations
  - Network initiated by Dr. Lichtenberger from Hungary
  - Same type of antennas with same data analysis software
  - In Europe:
    - 8 antennas in operations
    - 3 antennas in preparation

AWDANet in the World

- AWDANet
  - In World except Europe: 12 antennas in operations
    6 antennas planned or in preparation
  - Particular search of locations at conjugate points of Europe antennas



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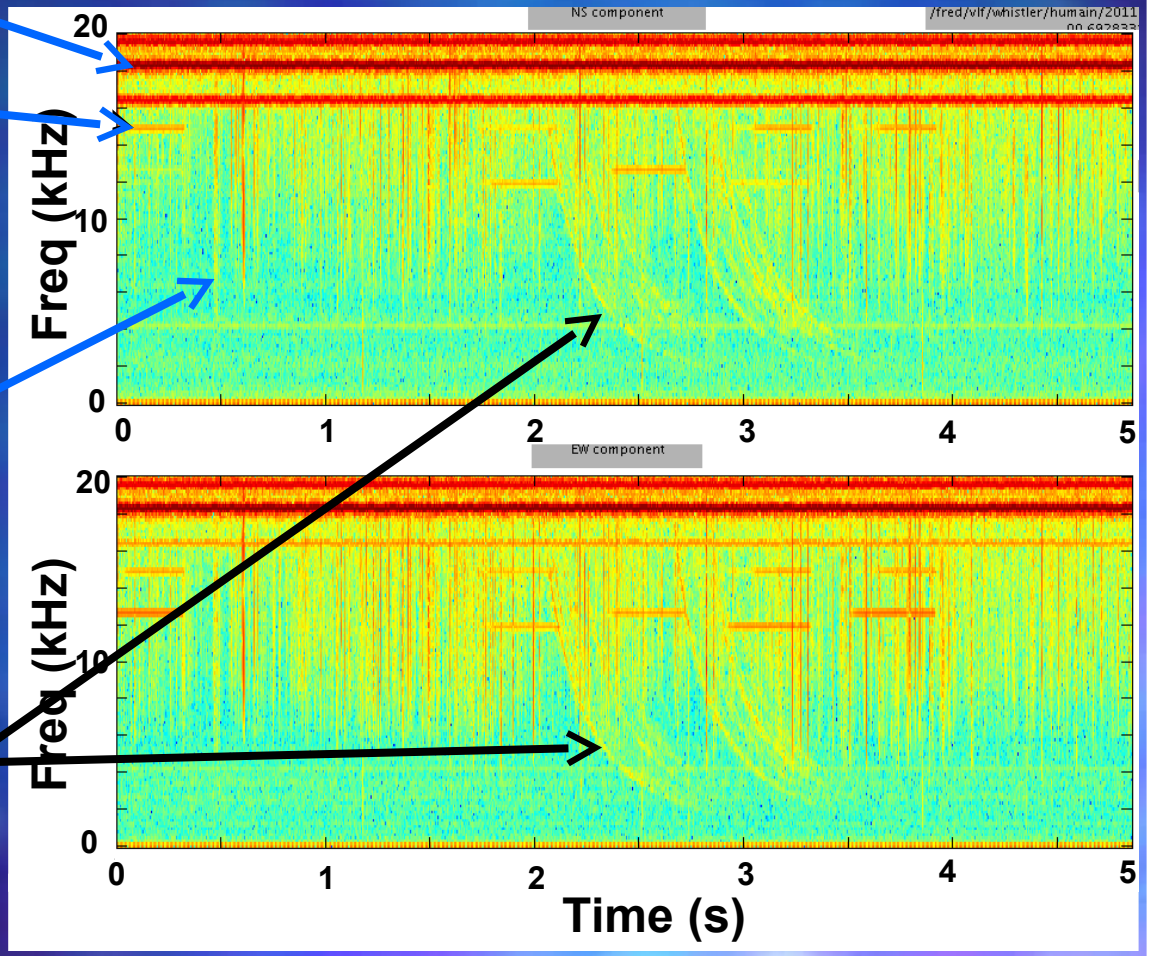
Observations: Dataset

- VLF antenna located in Humain, Belgium: 50.11°N - 5.15°E
- 1st measurements with the antenna in mid-April 2011
  - Some data gaps in 2011 due to software/hardware problems:
    - 15 April - 4 May 2011
    - 16 June – 31 July 2011
    - 24 September - 4 October 2011
    - 9-22 November 2011
    - 1-6 December 2011
  - Full data coverage since January 2012
  - Total duration until now: 13.5 months
- Output: Frequency-time magnetic field spectrograms (0-20 kHz), in two directions (North-South and East-West)
- First Analysis: Automatic pre-detection of whistlers (selected spectrograms of 10 seconds) + manual selection

[Lichtenberger, 2009]

Observations: Examples

- Frequency-time magnetic field spectrograms (0-20 kHz; 5 s; Top: North-South ; Bottom: East-West), but with perturbations:
  - At fixed frequency: e.g. 16, 18, 20 kHz (military transmitters or parasitic sources)
  - During fixed duration (~ 0.5 s): regular, at high frequency (e.g. 12, 15 KHz)
  - During very short duration (~ 0,01 s): wide frequency bandwidth (several kHz), most of the time
- Whistlers detected and clearly observed in both loops



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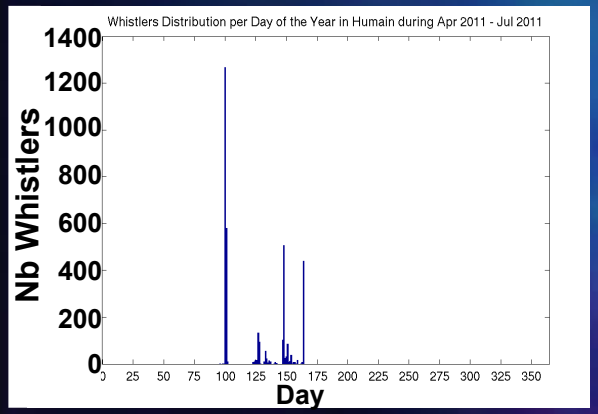
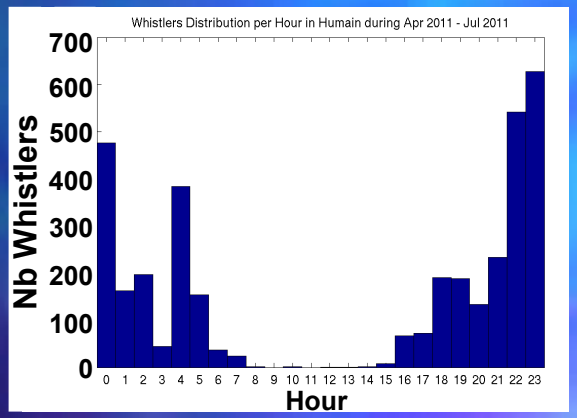
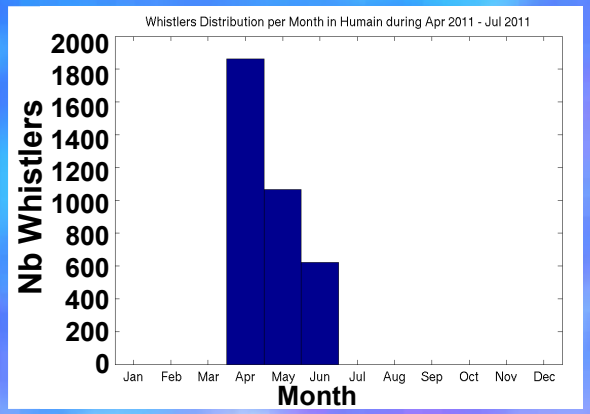
Analysis: Whistlers (1)

- Globally, less whistlers than at other AWDANet stations nearby (e.g. Tihany in Hungary), several possible reasons: *[Collier et al., 2009]*
  - Missing data
  - Antenna area (smaller than at Tihany) / preamp. gain
  - Investigation of thunderstorm activity at conjugate point
- Due to many data gaps at the beginning of the measurements campaign, the dataset is divided in 2 parts:
  - April 2011 – July 2011 (see results below)
    - Maximum during night (22-01 UT) and April
  - August 2011 – July 2012 (see results next slide)

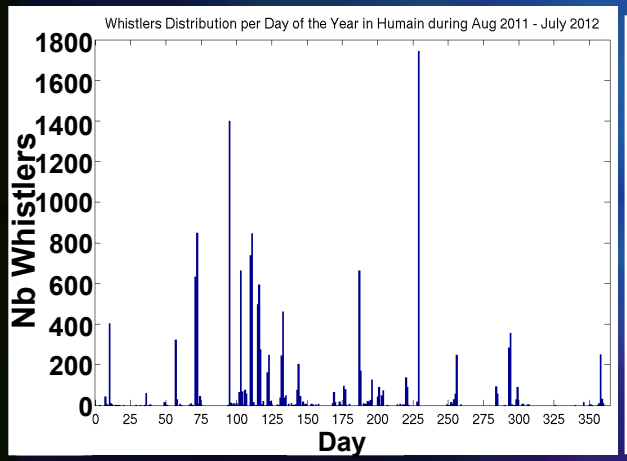


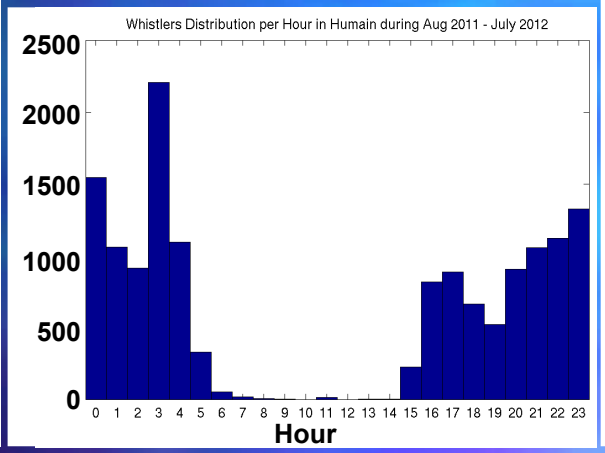


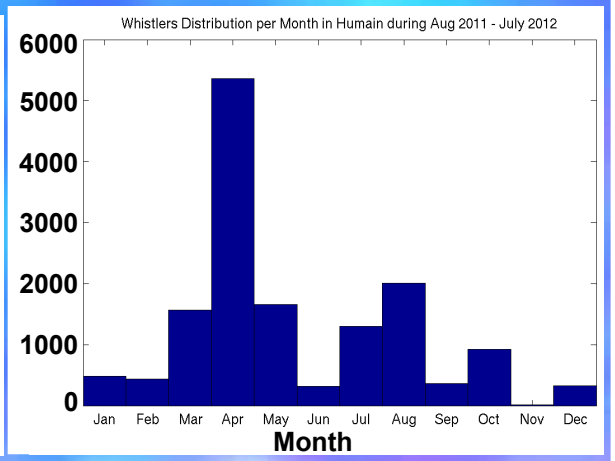


Analysis: Whistlers (2)

- UT Distribution:
  - Whistlers detected mainly during night, especially between 23-01 and 03-04 UT (as reported in other studies)
  - Almost no whistlers detected during morning and mid-day (06-14 UT)
- Seasonal distribution:
  - 1st maximum in spring (similar proportions as in spring 2011): high thunderstorm activity at conjugate point in south hemisphere
  - 2nd maximum in August: half of whistlers recorded during 1 single day (19 Aug 2011); requires further investigations…
  - Global minimum in Winter

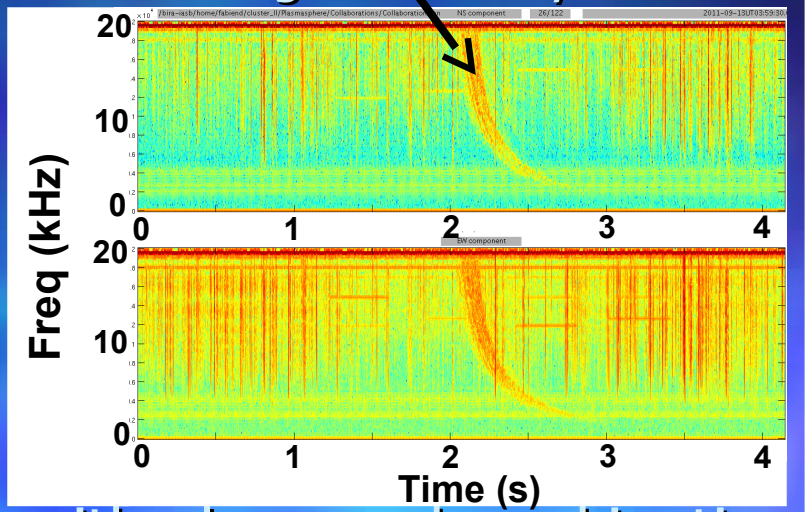






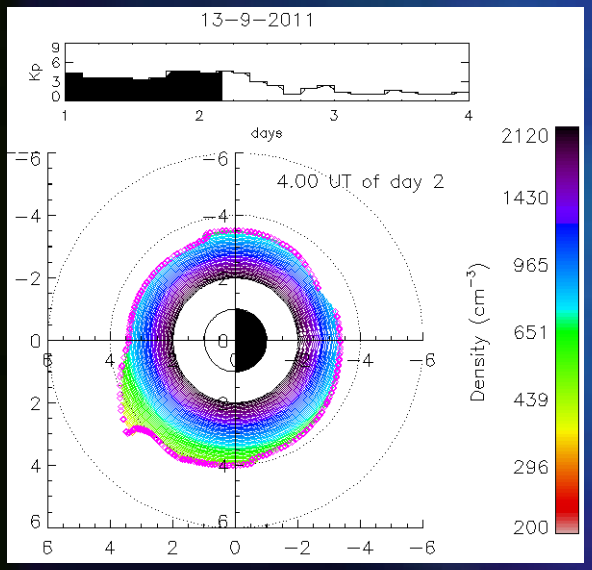
Analysis: Density

- Whistler observed in Humain on 13 Sept 2011 at 03:59 UT
  - Strong intensity, both directions, duration ~ 0.6 s
  - Density determined from inversion with field-aligned density model: *[Lichtenberger, 2009]*



Denton model: L = 2.31 ± 0.02 R_E
[Denton et al., 2002] N_{eq} = 1646 ± 80 cm^{-3}

Angerami model: L = 2.35 ± 0.04 R_E
[Angerami and Thomas, 1964] N_{eq} = 1466 ± 97 cm^{-3}



[Pierrard et al., 2009]

- Comparison with plasmasphere kinetic model of Pierrard (Kp dependent, but not MLT or UT dependent):
  - Plasmaspheric density and plasmapause location (in pink) in the equatorial plane on 13 September 2011 at 04:00 UT
    - L = 2.31 R_E - N_{eq} = 1657 cm^{-3}
    - L = 2.35 R_E - N_{eq} = 1606 cm^{-3}

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Summary – Conclusions

- The VLF measurement system recently installed in Humain is working well and provides good and useful whistler wave observations at this location in Belgium (50.11°N, 5.15°E)
- First statistical results:
  - Less whistlers than at other AWDANet stations nearby (e.g. Tihany in Hungary)
  - Whistlers detected mainly during night, especially between 23-01 and 03-04 UT
  - Larger maximum in spring: thunderstorm activity at conjugate point in south hemisphere
  - Density determined from whistler:
    - Tool works well with clear and strong whistler
    - Good comparison with density obtained from kinetic model of the plasmasphere

Future

- Continue automatic whistlers observation and detection
- Derive plasma density from whistlers observations
- Continue statistical analysis of whistlers
- Compare studies with other AWDANet stations
- Perform conjugated analysis with in-situ measurements of plasma density in plasmasphere (Cluster)
- Develop comparison with density data obtained from numerical simulations
- Study the VLF waves that could be generated by meteors

[Darrouzet et al., 2009]

[Pierrard et al., 2009]

References

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Abstract

Whistlers are VLF (3-30 kHz) emissions initiated by lightning, propagating along magnetic field lines, observed on ground and in space. Whistler wave analysis is an effective tool for studying the plasmasphere.

Whistlers acquire particular frequency-time characteristics while they propagate through the magnetospheric plasma, and in particular through the plasmasphere. Their propagation time depends on the plasma density along their propagation paths. It is possible to derive the plasmaspheric electron density distribution from these propagation times.

We therefore have started a project to detect whistlers with VLF measurements. A VLF antenna has been installed in early 2011 in Humain, Belgium (50.11°N, 5.15°E). The VLF antenna is made of two perpendicular magnetic loops, oriented North-South and East-West, and with an area of approximately 50 m2 each. This antenna is part of AWDAnet, the Automatic Whistler Detector and Analyzer system's network. This network covers low, mid and high magnetic latitudes, including conjugate locations.

We use the AWDA system to retrieve automatically electron density profiles from whistler measurements made in Belgium. In this poster, the first results of whistler occurrence are shown.