INTERMAGNET Meeting, Ottawa, 25-27 September 2012

PLASMON - Determine the state of the plasmasphere on the basis of ground observations

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(11) Los Alamos National Laboratory

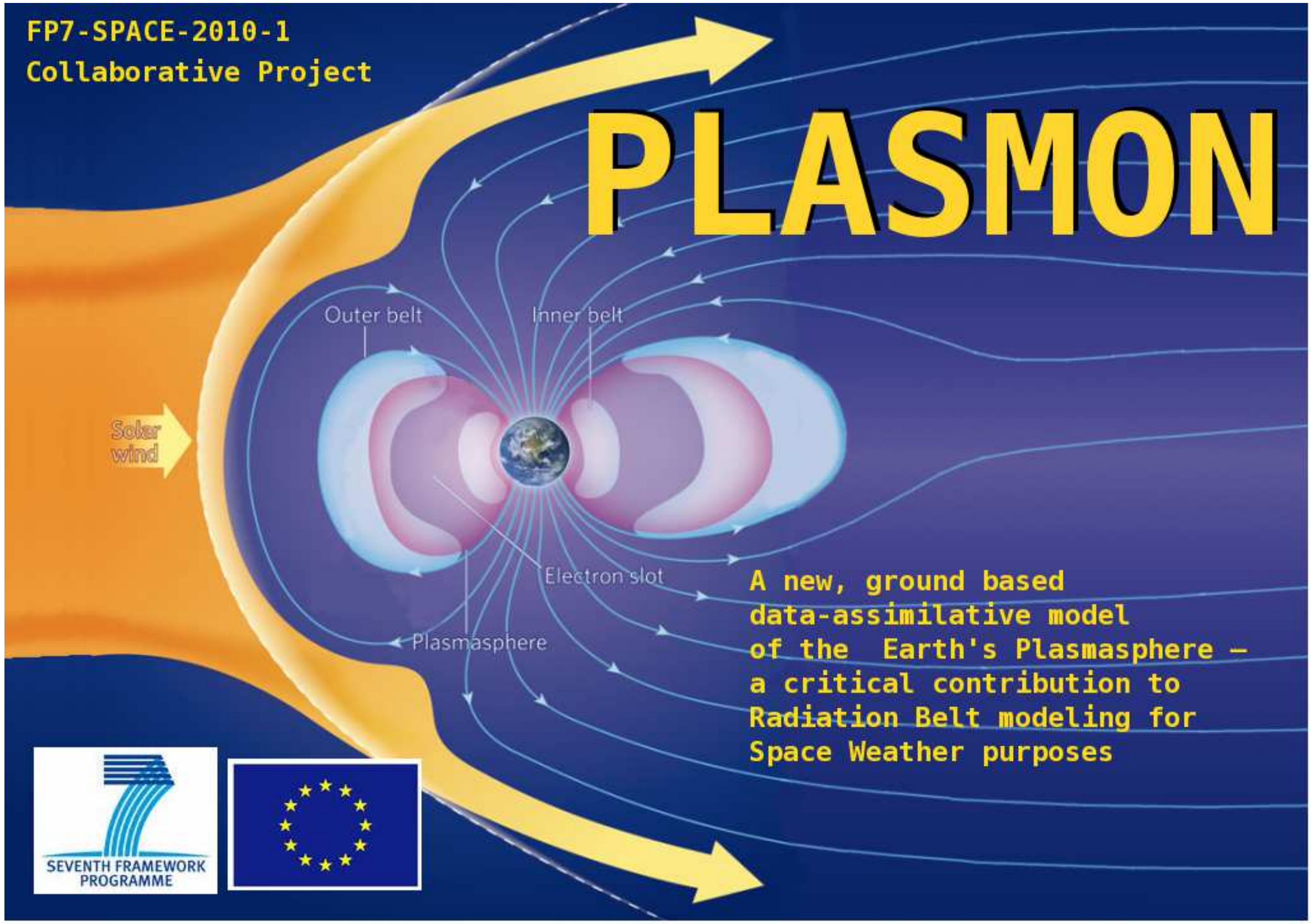
PLASMON

A new, ground based data-assimilative model of the Earth's Plasmasphere – a critical contribution to Radiation Belt modeling for Space Weather purposes

Eötvös Loránd University (Coordinator)

Eötvös Loránd Geophysical Institute

University of Washington



University of L'Aquila

University of Otago

Inst. of Geoph, Polish Ac. of Sc.

British Antarctic Survey – Natural Environment Research Council

Oulun Yliopisto – University of Oulu

Los Alamos National Laboratory

New Mexico Tech

SANSA – South African National Space Agency

Participants

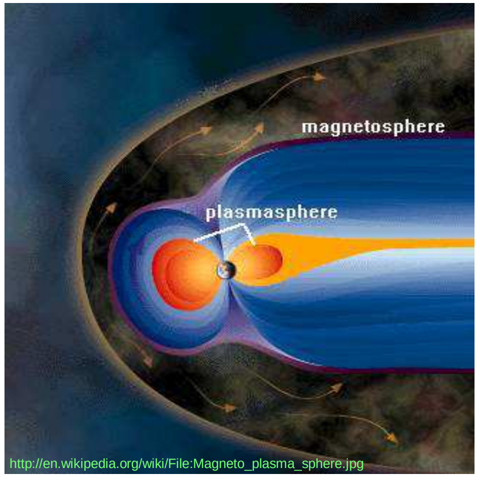
	Short name	Participant organisation name	Country
1	ELTE (Coordinator)	Eötvös Loránd University	Hungary
2	NERC-BAS	British Antarctic Survey	UK
3	ELGI	Eötvös Loránd Geophysical Institute	Hungary
4	UNIVAQ	University of L'Aquila	Italy
5	SGO	Sodankyla Geophysical Observatory (University of Oulu)	Finland
6	UO	University of Otago	New Zealand
7	SANSA	South African National Space Agency	South Africa
8	NMT	New Mexico Institute of Mining and Technology	USA
9	IGPAS	Institute of Geophysics, Polish Academy of Sciences	Poland
10	UW	University of Washington	USA
11	LANL	Los Alamos National Laboratory	USA

Duration of the project: February 1, 2011 … July 31, 2014 (42 months)

Work Packages

No Pckg	Topics WP	Ground observation network	Lead Institution
WP1	Automatic retrieval of equatorial elektron densities	**AWDANet** Ground based observation of whistlers (Very Low Frequency band)	Eotvos University
WP2	Retrieval of equatorial plasma mass densities by magnetometer arrays and cross-calibration	**EMMA + SANSA points** Ground based observations of geomagnetic field in Ultra Low Frequency band	L'Aquila University
WP3	Data assimilative modeling of the Earth's plasmasphere		New Mexico Inst.
WP4	Modeling REP (Relativistic Electron Precipitation) losses in radiation belts	**AARDDVARK** Narrowband VLF receivers are monitoring transmitters.	British Antarctic Survey
WP5	Dissemination and exploitation of the results		Otago University
WP6	Management of the consortium		Eotvos University

Introduction and objectives



Plasmasphere

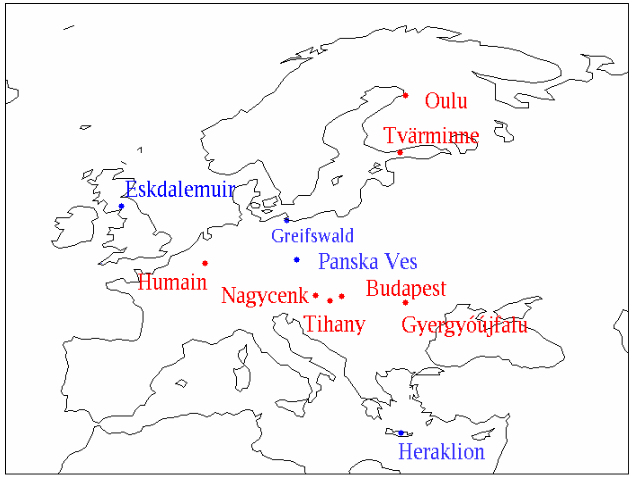
- inner magnetosphere above ionosphere

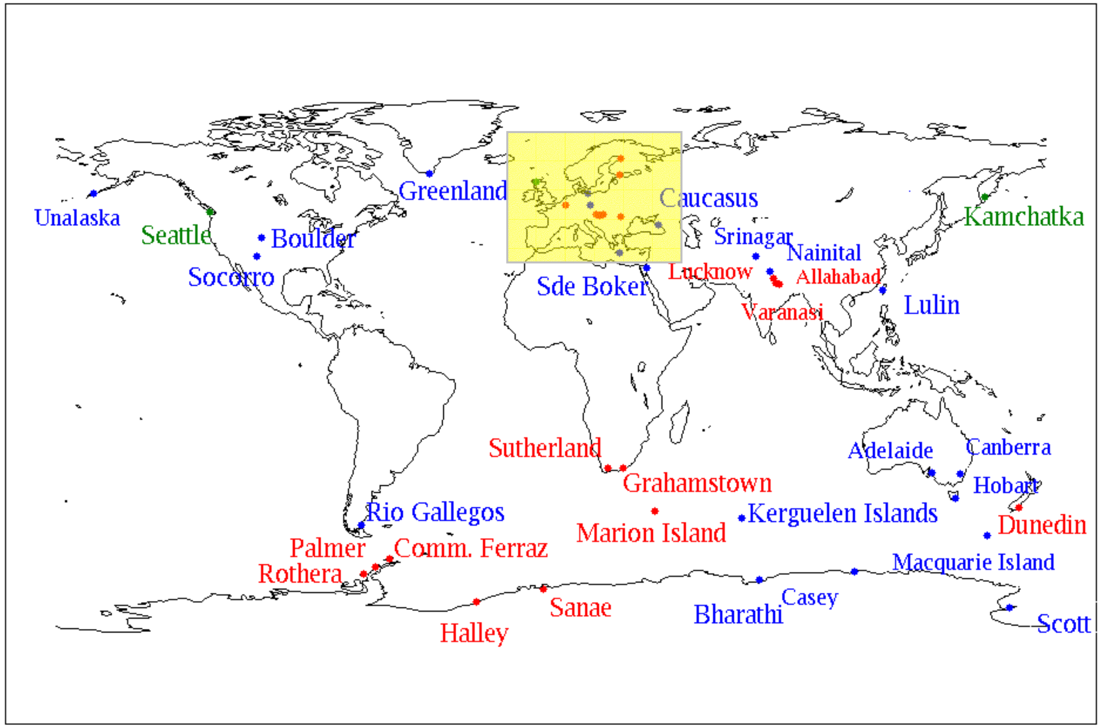
- consisting of low energy (cold) plasma

- The plasmasphere plays a central role in magnetosphere-ionosphere dynamics. The plasmashere is influenced by the ionosphere and outer magnetosphere.
- The security of space assets is affected by the high energy charged particle environment in Earth's radiation belts. The plasmasphere strongly impacts this environment, yet currently, we lack adequate knowledge regarding its structure. The PLASMON project attempts to uncover hidden properties of the plasmasphere.
- PLASMON will measure plasmaspheric electron and mass densities to monitor the changing composition of the plasmasphere.

- The main objective of PLASMON is to extend and fully establish the AWDANet, EMMA and AARDDVARK networks to provide real-time data for mapping and modelling the plasmasphere and the REP phenomenon in the Radiation Belts.
- Perform regular measurements of plasmaspheric electron and mass densities.
- Develop a data assimilative model of the plasmasphere.
- Monitor the occurrence of Relativistic Electron Precipitation (REP), and link their occurrence to changes in plasmaspheric densities.

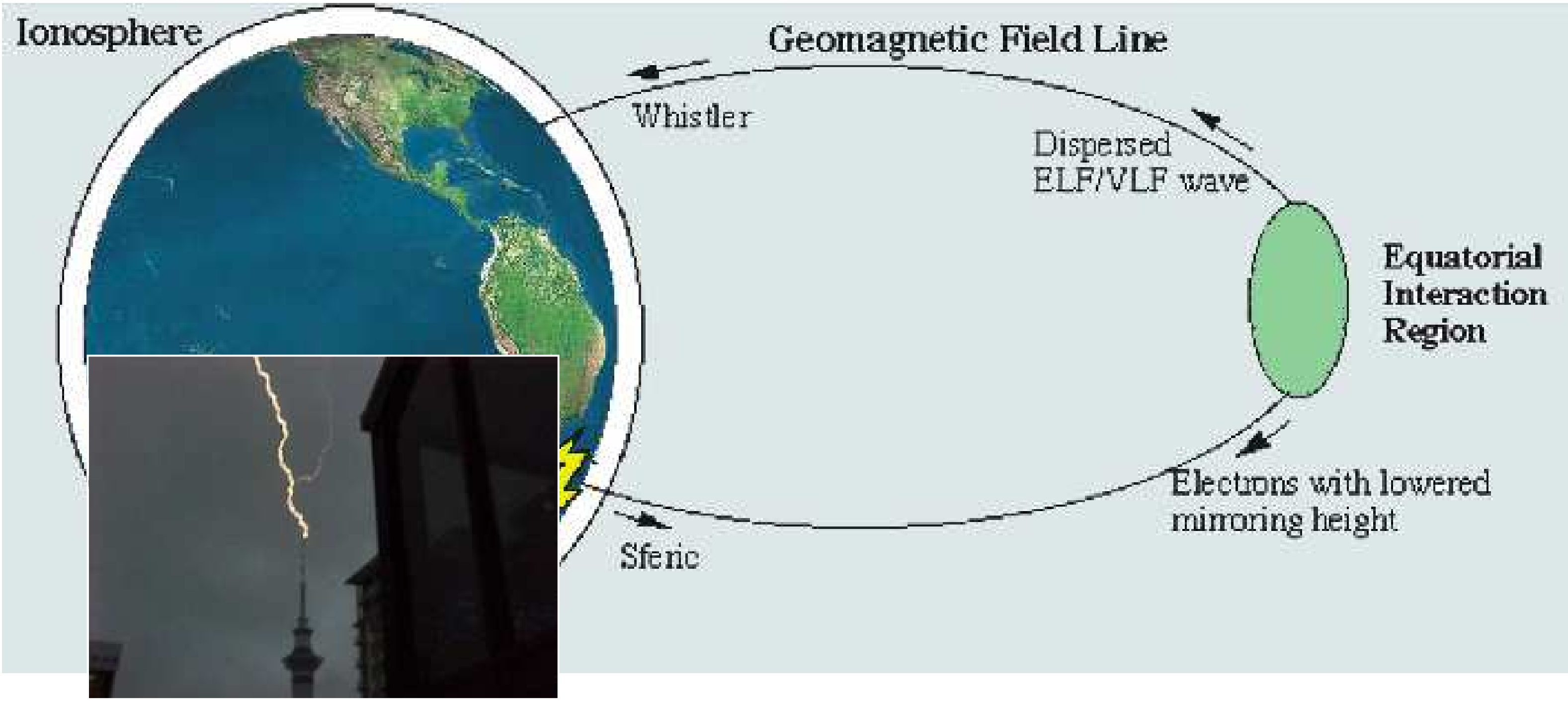
AWDANet – observation of whistlers





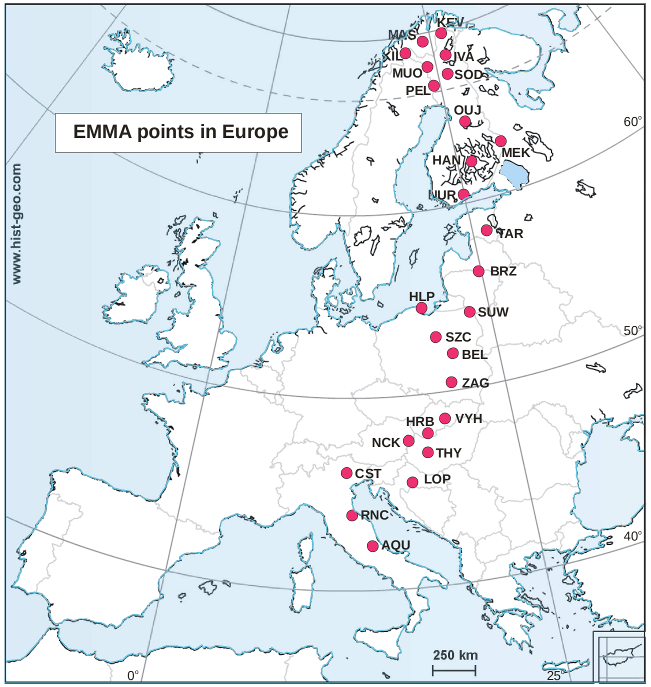
Automatic Whistler Detector and Analyzer systems' Network

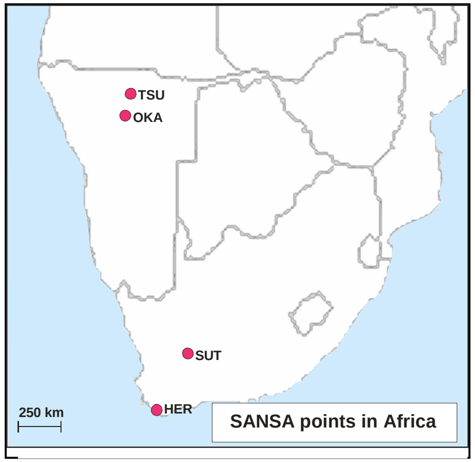
Whistlers



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

EMMA and SA network – observation of FLR phenomenon



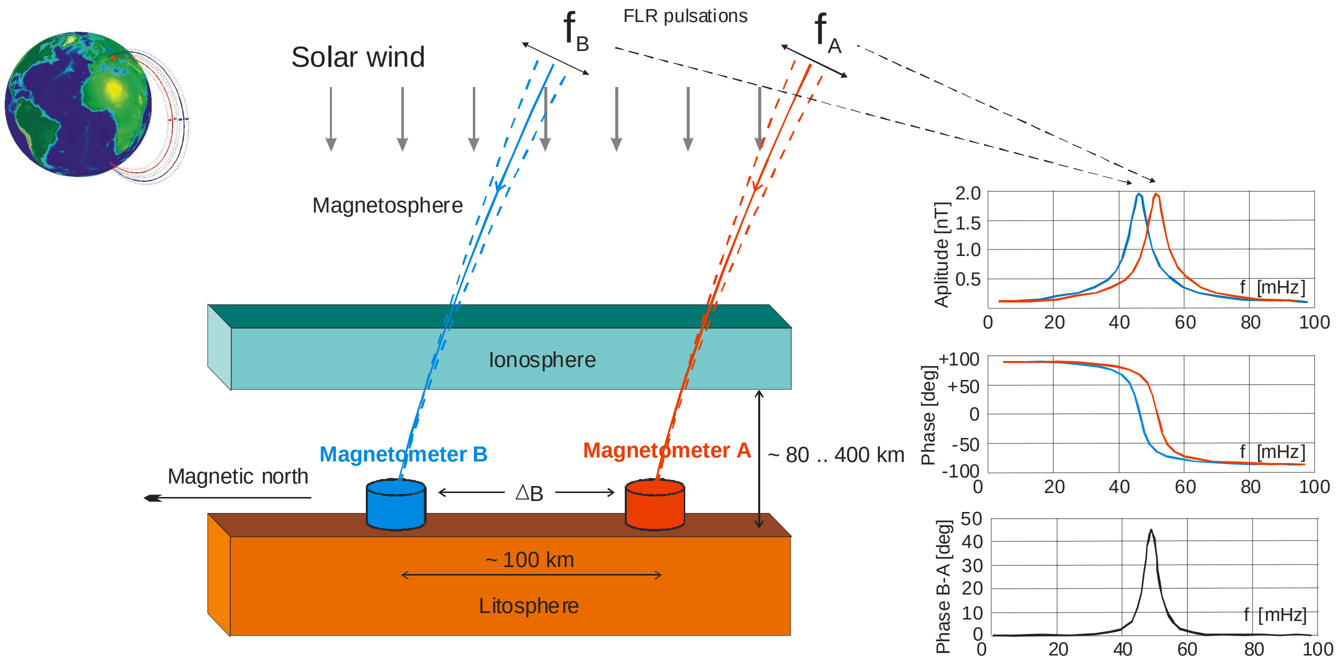


The quasi-meridional European MagnetoMeter Array + South African stations

- EMMA and SA network - quasi-meridional European MagnetoMeter Array + South African stations

- The quasi-meridional magnetometer network will provide Field Line Resonance (FLR) observations for L = 1.3 .. 6.4
- The inversion will yield equatorial plasma mass densities.

Method of FLR detection applied in PLASMON



Cross-phase method of detection the FLR resonant frequency

The relations between the frequency of FLR phenomenon and plasma density are the following:

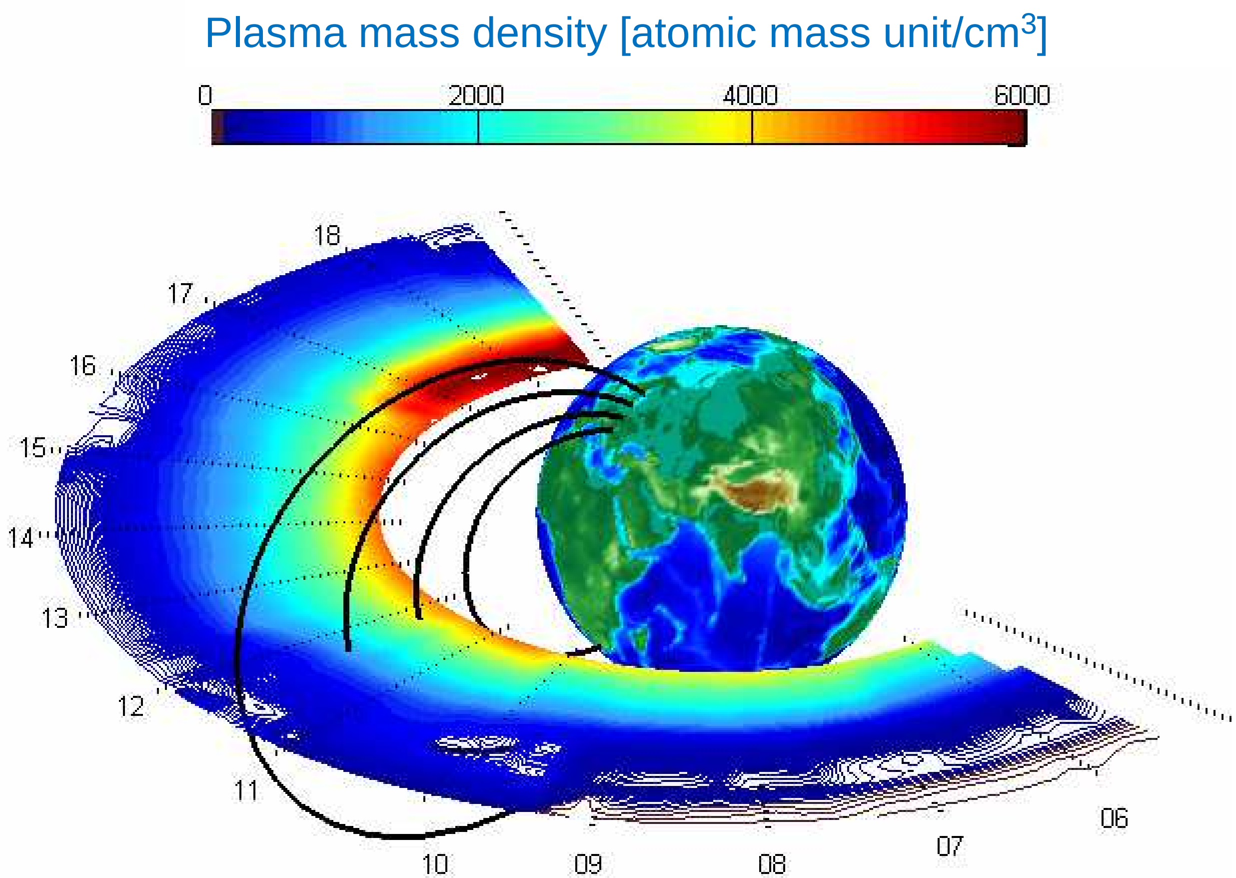
$$f_{FLR} = \frac{V_A}{2l} \qquad V_A = \frac{B}{\sqrt{\mu \cdot \rho}}$$

V_A **- Alfven velocity** l **- field line length** B **- magnetic field**

μ **- magnetic permeability** ρ **- plasma density**

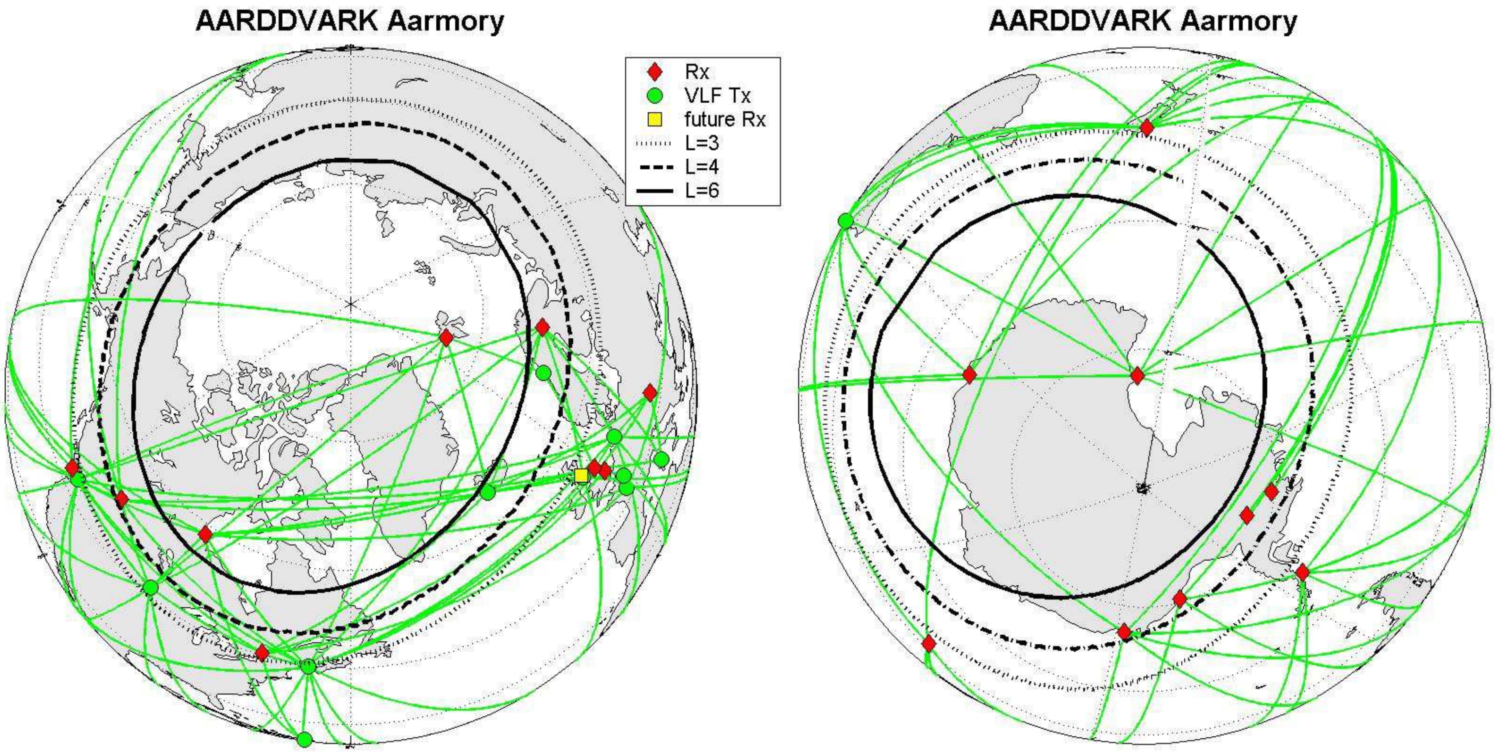
Comparison 1-sec data standards: INTERMAGNET vs EMMA-PLASMON

Parameter	**INTERMAGNET** (draft standard, apply to definitive data)	**EMMA – PLASMON**
Resolution	1 pT	1 pT, 10 pT acceptable
Output sampling rate	1 sec.	1 sec.
Noise	10pT/√Hz at 0.1 Hz	10 pT @ 1 Hz
Instrument amplitude range:	≥±4000nT High Lat., ≥±3000nT Mid/Equat. Lat.	≥ 2000 nT, higher at high latitudes
Pass band	DC to 0.2 Hz	DC-0.4 Hz (for DAQ)
Analogue anti-alias filter	Minimum attenuation in the stop band (≥ 0.5Hz): 50dB Natural signal (i.e. above the Nyquist) will be attenuated to below the specified noise level of 10pT	Butterworth cutoff freq.: between 3 Hz - 30 Hz slope: 24/18 dB/octave
Timing Accuracy	10 ms Samples may be time-shifted to correct for latency	10 ms
Digital filtration	Gaussian, centered on UT seconds	Gaussian, centered on UT seconds phase response: linear cutoff frequency: 0.4 Hz
Phase response	Linear Maximum group delay ±0.01s	Linear
Mains frequency filter	Non-natural signal (e.g. 50/60 Hz) must be separately attenuated to below 10pT	50/60 Hz mains frequency notch filter



Map of the equatorial plasma mass density based on ULF field line resonance observations made along the MM100 chain on 30 April, 2003. Field lines starting from 45°, 50°, 55°, 60° mag. lat. and the local time of the observations are also plotted as solid and dotted line, respectively.

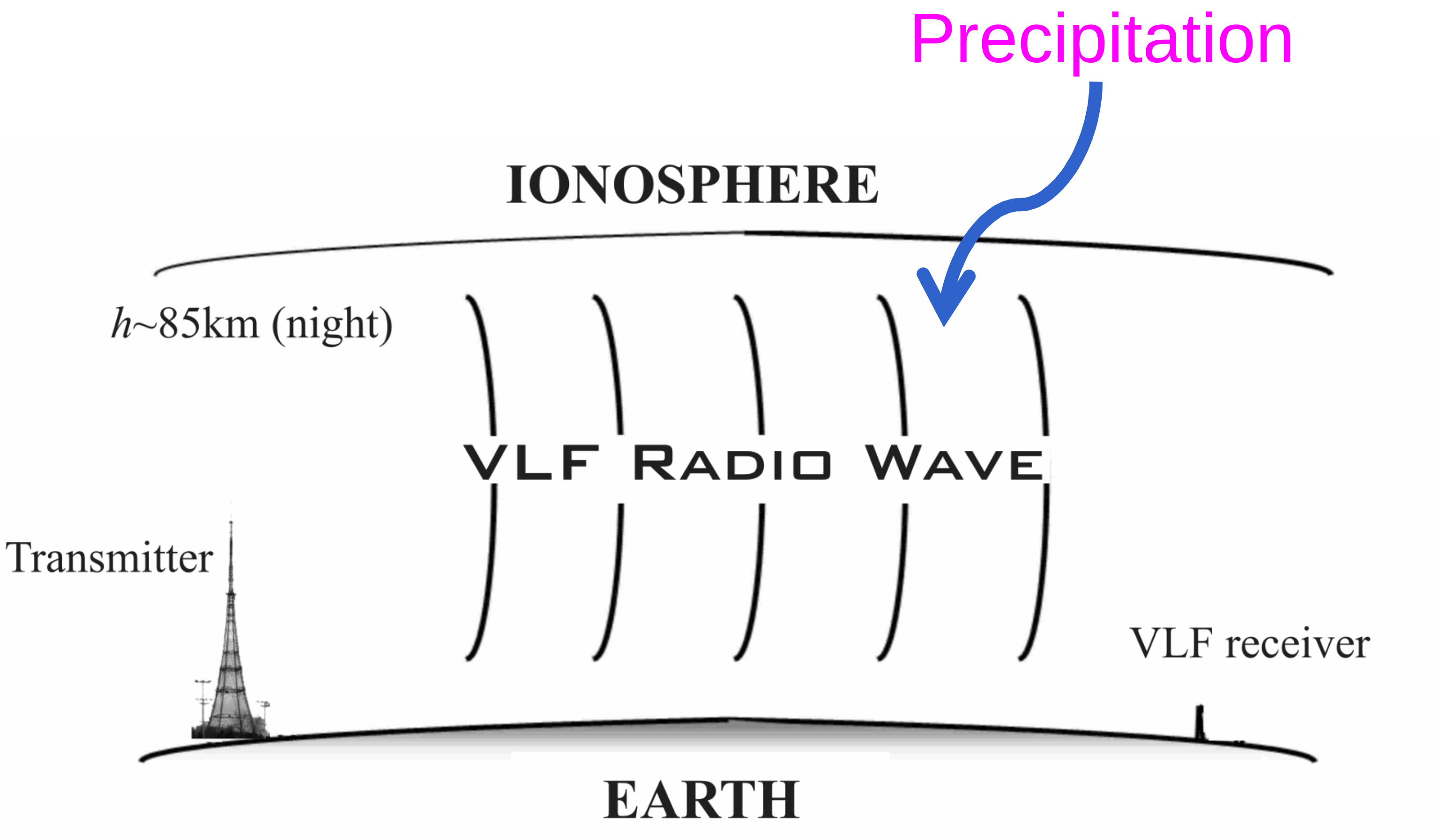
AARDDVARK - observations of the lower-ionosphere in polar regions



The Antarctic-Arctic Radiation-belt (Dynamic) Deposition - VLF Atmospheric Research Konsortium

- Narrowband VLF receivers are monitoring transmitters.
- Provides continuous long-range observations of the lower-ionosphere.
- Changes in the ionosphere cause changes in the received signal.
- Monitoring the occurrence and properties of REP (relativistic electron precipitation).

Ionosphere as a precipitation detector



Energetic Precipitation from the radiation belts affects the lower ionosphere. For electrons >100keV, the bulk of the precipitated energy is deposited into the middle and upper atmosphere (30-100km), and can be detected through changes in subionospheric VLF propagation.

References:

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- Magnetoseismic Research through the Observations by Ground Magnetometer Networks (PPT presentation), Peter Chi, Institute of Geophysics and Planetary Physics, UCLA, IAGA Workshop on Magnetic Observatories, Golden, Colorado, June 16, 2008
- Comparison of Three Techniques of Determining the Resonant Frequency of Geomagnetic Pulsations C. T. Russell , P. J. Chi , V. Angelopoulos , W. Goedecke , F. K. Chun , G. Le (1), M. B. Moldwin and E. G. Reeves , http://www-ssc.igpp.ucla.edu/personnel/russell/papers/compare_three/
- A significant mass density increase during a large magnetic storm in October 2003 obtained by ground-based ULF observations at L □ 1.4, Satoko Takasaki, Hideaki Kawano, Yoshimasa Tanaka, Akimasa Yoshikawa, Masahiro Seto, Masahide Iizima, Yuki Obana, Natsuo Sato, and Kiyohumi Yumoto
- http://www.richardclegg.org/htdocs/flr.html

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Thank you for your attention !