

VLF research at SANAE and Marion Island

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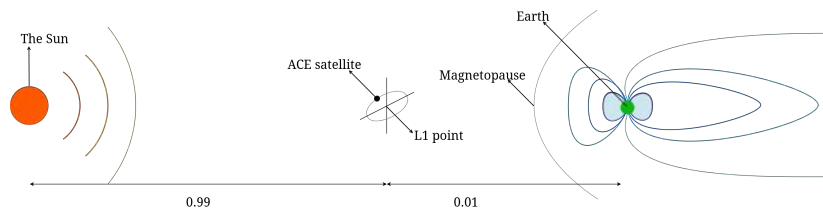
²SANAE IV Base, Antarctica

³Marion Island Research Base, Marion Island

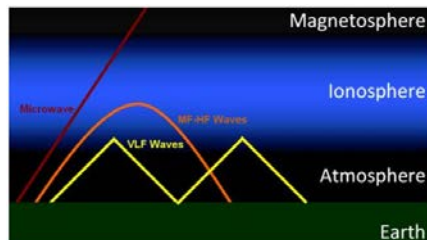
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Rhodes University, Grahamstown

Introduction: Sun - Magnetosphere - Earth



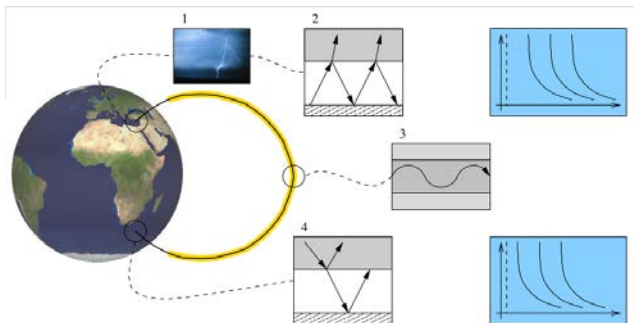
Introduction: VLF



<http://vlf.stanford.edu>

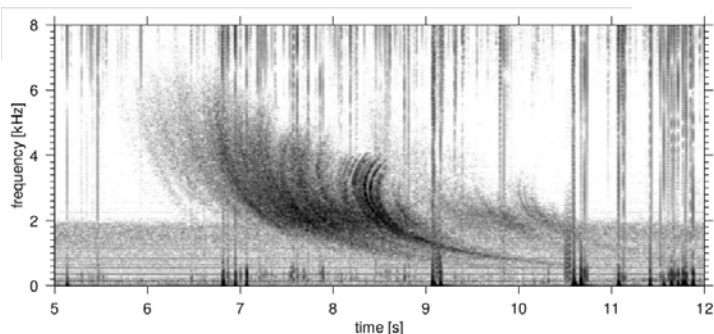
- Very low frequency (3-30 kHz) waves propagating in earth-ionosphere waveguide
- Man-made and natural sources
- Wave characteristics used to study magnetosphere and ionosphere
 - Energetic particle precipitation
 - Lightning location
 - Communication

Introduction: Whistlers



- 1 Broadband EM pulse produced
- 2 Signal propagates between Earth surface and bottom-side ionosphere (Earth-ionosphere waveguide), some energy penetrating into magnetosphere
- 3 Propagation along field lines in magnetosphere
- 4 At conjugate point some energy penetrates back into ionosphere

Introduction: Whistlers

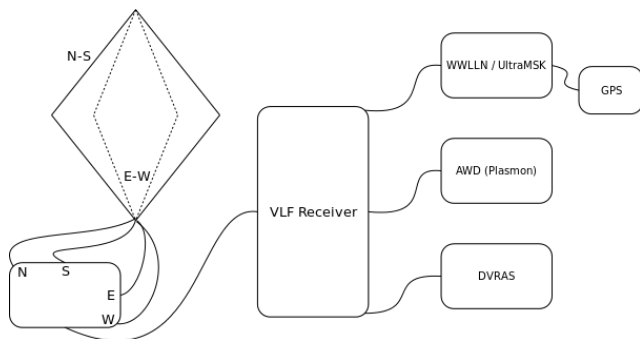


- Dispersion due to delay of lower frequency components
- Inversion of density – frequency relationship allows estimation of electron density
- Scattering by whistler-mode waves acts as loss process for energetic particles injected into magnetosphere during solar activity

Introduction: Hardware

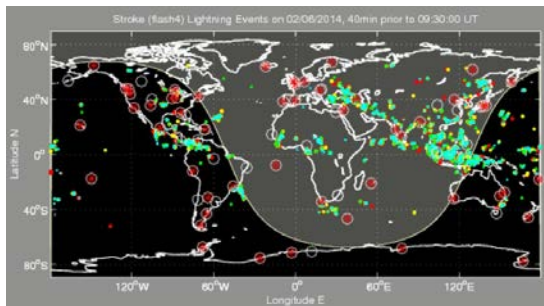


Introduction: Hardware



Similar setups at SANAE IV and Marion Island Base

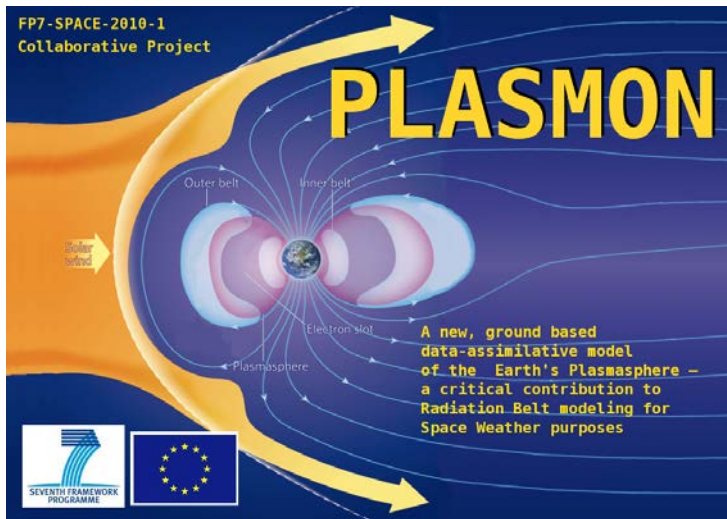
Current research: WWLLN



<http://wwlln.net>

- Lightning strikes produce broadband energy that drive VLF waves (about 45/s)
- 50 VLF receivers world-wide monitor lightning activity
- All data sent to centralised servers that estimate time and locations of lightning strokes
- Antennas at HER, SNA, MI contribute to global network

Current research: PLASMON

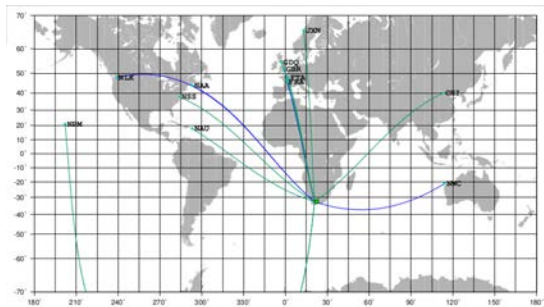


Objective: real-time model of plasmasphere

Current research: PLASMON

- EU FP7 project with collaborators from Hungary, NZ, UK, USA, Finland, Poland, Italy, RSA
- Feb 2011 – Aug 2014
- VLF whistler waves, ULF pulsations due to field line resonances recorded, used to estimate plasma density
 - $T_g = T_{wg1} + T_{i1} + T_m + T_{i2} + T_{wg2}$
 - $T_m = \frac{1}{2c} \int_{path} \frac{f_p f_H}{(f_H - f)^{3/2} \sqrt{f}} ds$
 - Density along magnetospheric part of field line estimated by inverting T_m
- VLF/ULF data ingested into assimilation model to calibrate an analytical model via Kalman filter

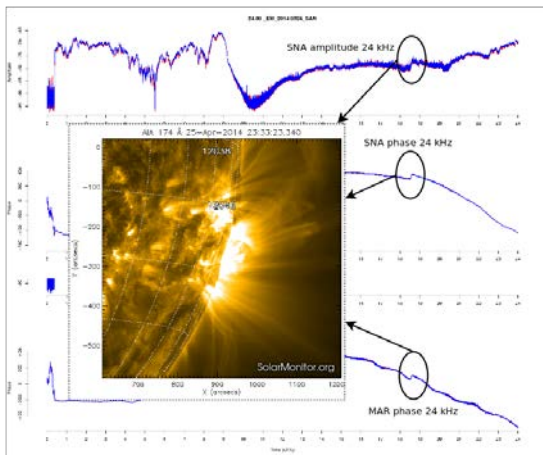
Current research: ultraMSK



- Narrowband VLF receivers monitoring encrypted military signals
- Only phase and amplitude is monitored, signal content not important
- D-region fluctuations may be used to identify solar flares – yielding valuable ground-based observations of solar activity

Current research: ultraMSK

2014/05/24: M-class flare observed at SANAE and Marion Island



Planned research: Study EEP events from SW drivers to loss mechanisms

- Satellites in various orbital configurations (including geosynchronous orbit) cross the radiation belts where high energy particles can cause damage
- Source, acceleration and loss processes involved are critical in understanding the dynamics of these populations
- Build database and analyse suite of carefully selected events, tracing evolution from solar wind to precipitation in ionosphere
- Post-doc project with international collaboration (NZ, USA)

Planned research: WWLLN and PLASMON

- Ongoing data provision for both projects
- Current SANSA MSc project using WWLLN data
 - Recently, Scott, et al (2014) showed connection between space weather and lightning occurrence
 - Important evidence of long-postulated link between space weather and terrestrial weather
- Possibilities for further collaboration with PLASMON group exists, in VLF and ULF

