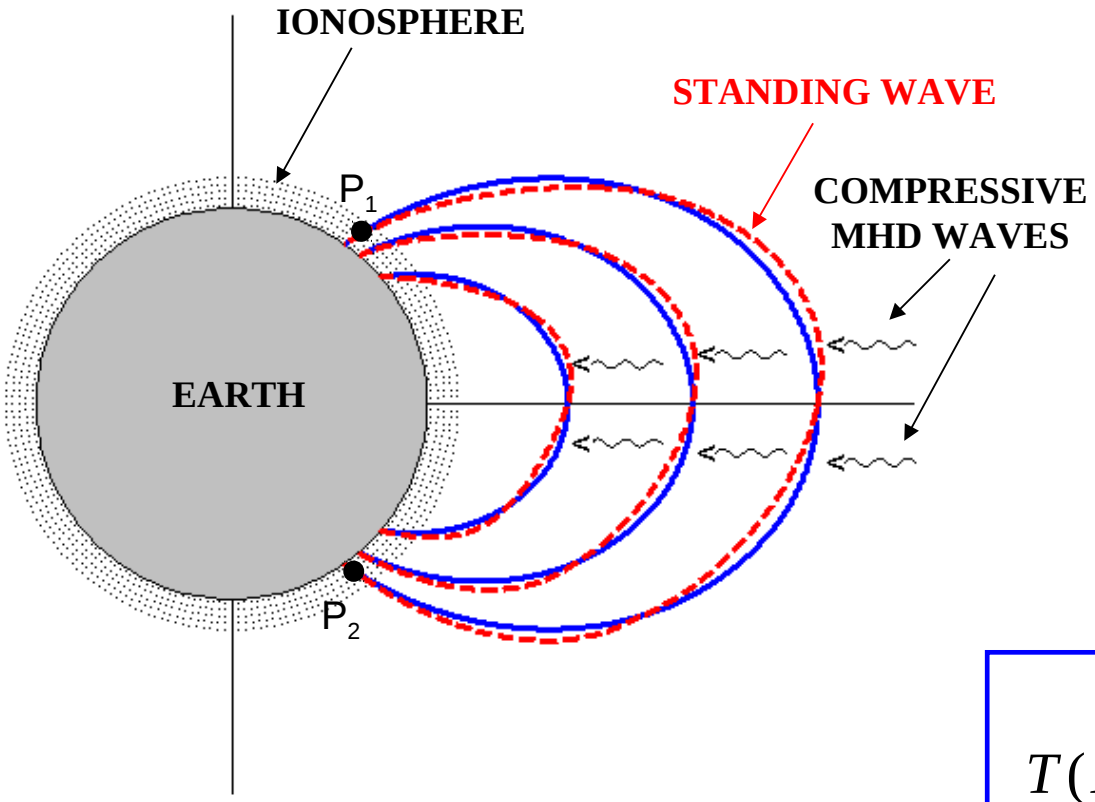
WP2: Retrieval of equatorial plasma mass densities by magnetometer arrays and cross-calibration

Main institutions involved:

- UNIVAQ
- ELGI + FMI
- IGFPAS
- SANSA (formerly HMO)

Geomagnetic Field Line Resonances (FLR)

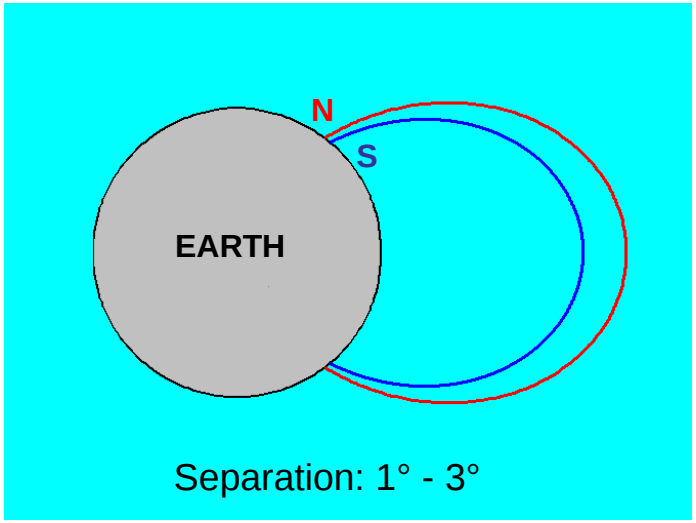


$$T(L) \cong \int_{P_1}^{P_2} \frac{ds}{V_A(s)}$$

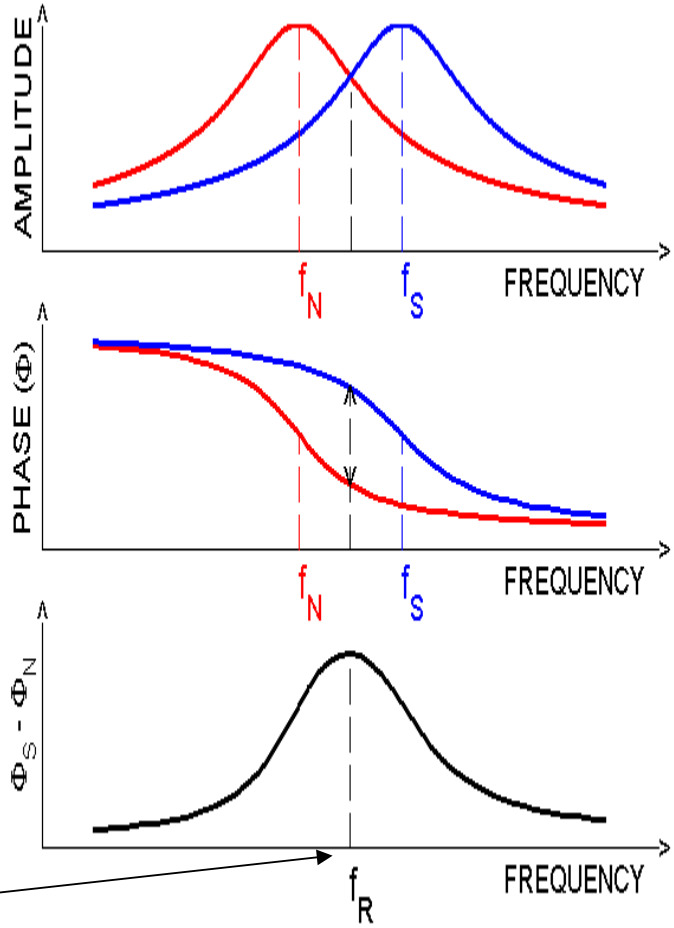
$\mathbf{V_A}$: Alfvén velocity

$$T(L) = 2\mu_o \int_{P_1}^{P_2} \frac{\rho^{1/2}(s)}{B(s)}\, ds$$

GRADIENT METHOD FOR DETECTING FIELD LINE RESONANCES FROM GROUND-BASED ULF MEASUREMENTS



FREQUENCY RESPONSE OF TWO OSCILLATORS



Higher latitude field line → Lower resonance frequency (f_N)

Lower latitude field line → Higher resonance frequency (f_S)

CROSS-PHASE TECHNIQUE

Resonance frequency at the middle point.
Identified by a maximum in the phase difference

WP2 objectives

1. Unify and extend SEGMA, MM100 and IMAGE networks into EMMA (+ S.Africa stations) to have better latitudinal coverage (3 new stations by month 12, other 4 new stations by month 24): ELGI, IGFPAS, SANSA

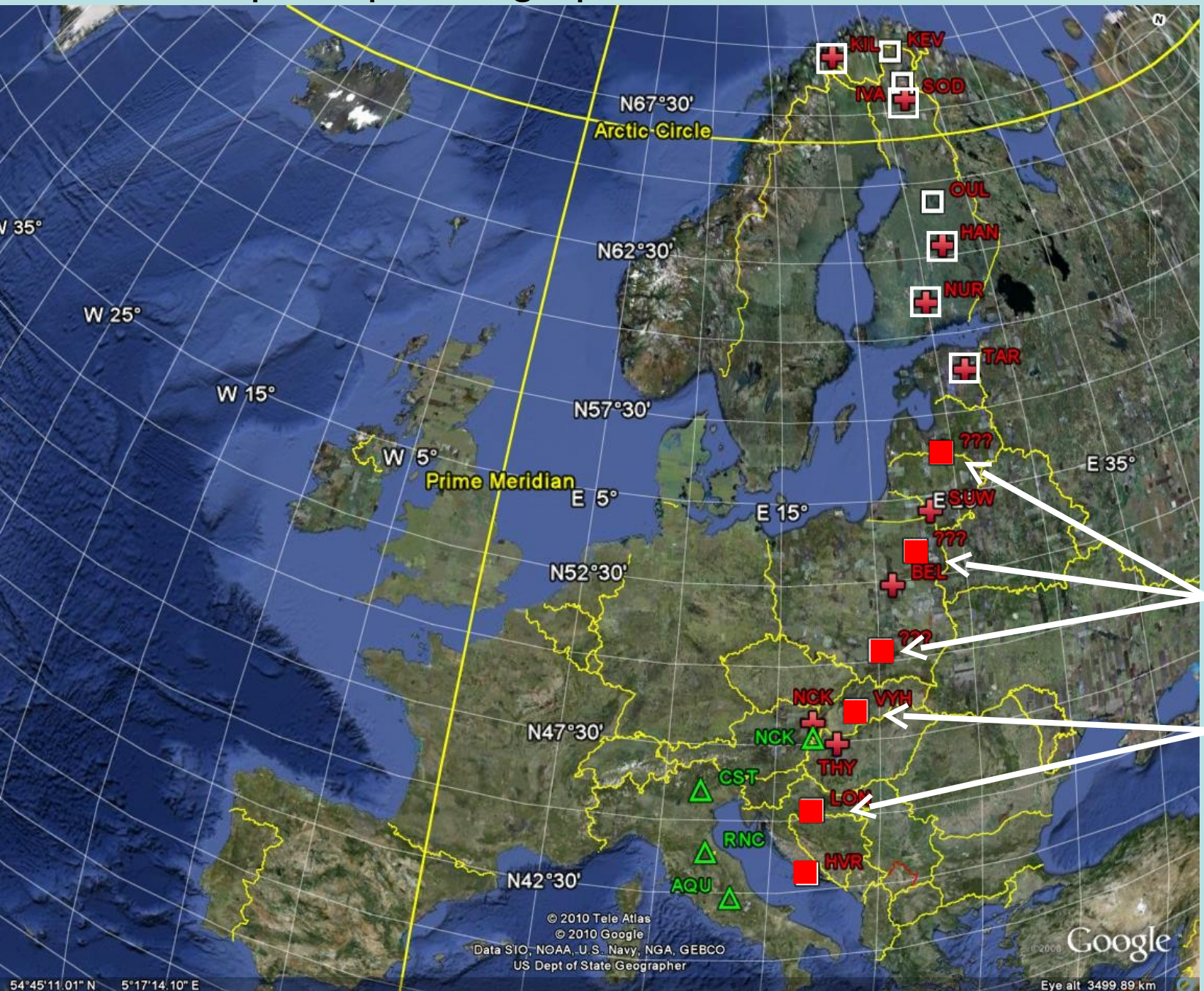
2. Develop an automatic FLR identification method [month 24]: UNIVAQ, ELGI, IGFPAS

3. Develop an automatic FLR inversion method [month 24]: UNIVAQ, ELGI, SANSA, (NMT)

4. Develop all EMMA stations to work in quasi-real-time mode of operation [month 42]:
   ELGI+FMI, IGFPAS, SANSA, UNIVAQ

5. Evaluate relative abundances of heavy ions in the plasma composition from simultaneous determinations of mass density (FLR method) and elect. density (whistler met.) [month 42]:
   ELGI, UNIVAQ, ELTE, (LANL, NERC-BAS, NMT, UO, SANSA, UOULU)

Map of operating / planned EMMA stations



Δ SEGMA

\+ MM100

□ IMAGE

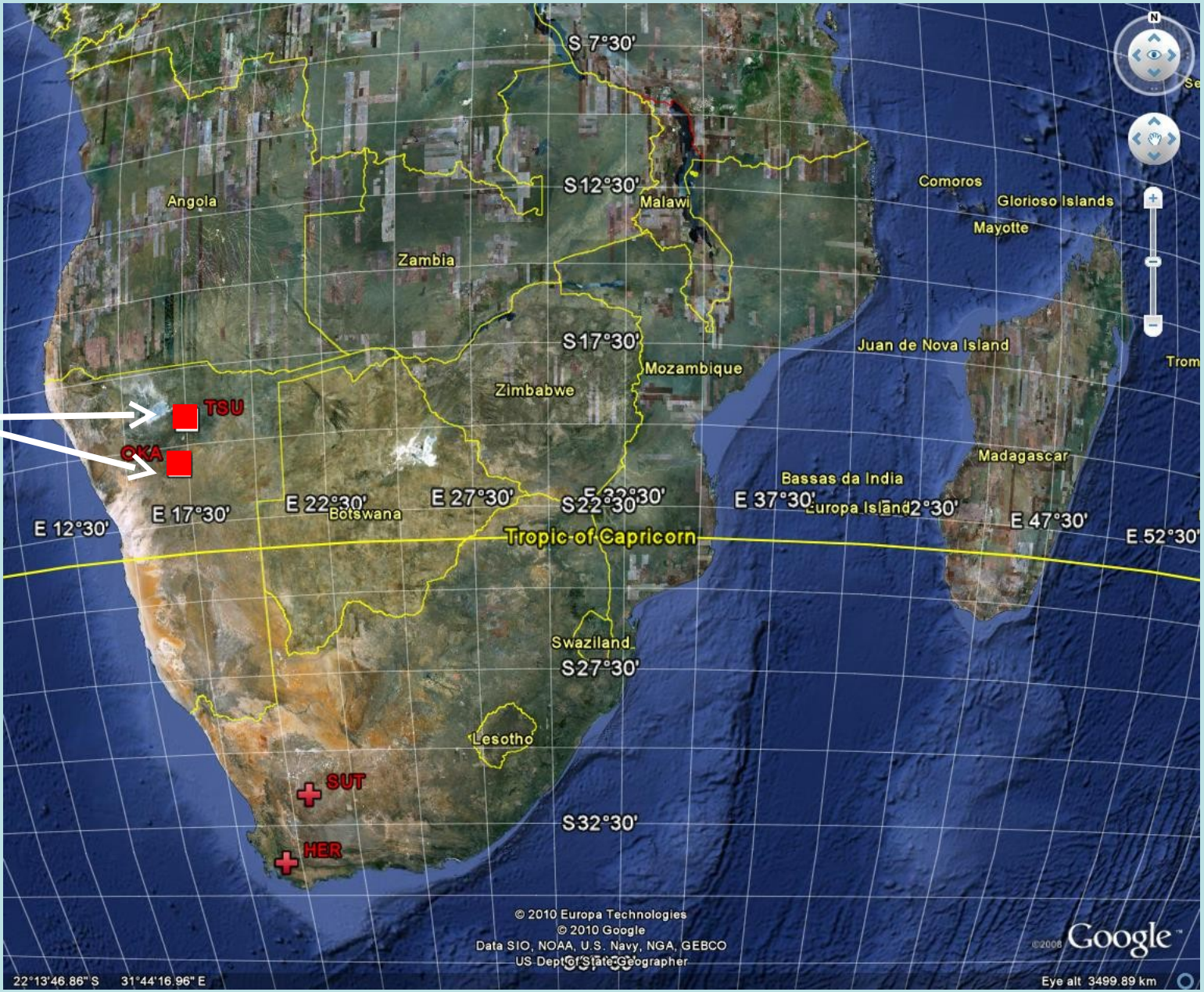
■ planned new stations

Jan. 2012

Jan. 2013

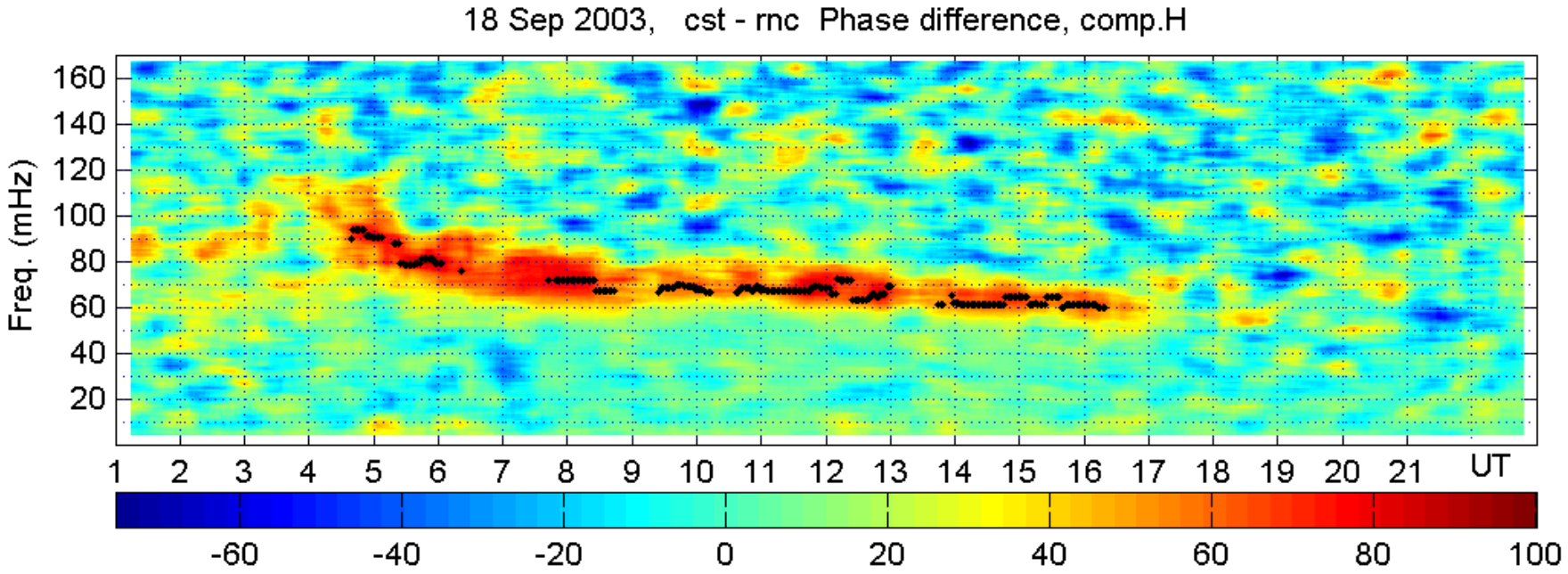
Map of operating (+) / planned (■) South Africa stations

Jan 2013



Automated selection of FLR frequencies (objective 2)

UNIVAQ, ELGI, IGFPAS delivery date: month 24



- Current algorithms (from *Berube et al. 2003*) used by UNIVAQ and ELGI: to be improved, and fully automatized.
- ~1 mHz frequency resolution, ~ 20 min time resolution.
- Specific version for each station pair (because of different latitude, interstation separation, ground conductivity, noise level, etc.).
- All versions running on a central server where data must arrive in quasi-real time.

Automatic FLR inversion (objective 3)

UNIVAQ, ELGI, SANSA, (NMT) delivery date: month 24

The inversion algorithm has to convert FLR frequencies into estimates of the equatorial plasma mass density ($1.6 < L < 6.7$).

Need to consider geomagnetic field geometry (*Tsyganenko, Singer et al., 1981*) more realistic than dipole geometry; important at high latitudes,
and even at middle latitudes during severe geomagnetic storms.

Realistic plasma distribution models for low latitudes (power law not quite good).

All magnetometer stations working in quasi-real-time (objective 4)

ELGI+FMI, IGFPAS, SANSA, UNIVAQ delivery date: month 42

Upgrading the DAQ hardware and software to provide real-time accessibility of the data.

Data from each station transferred every 15 min to the central server, where they will be processed to get FLR frequencies and plasma mass densities.

Cross-calibration method for whistlers and FLRs (objective 5)

ELGI, UNIVAQ, ELTE, (LANL, NERC-BAS, NMT, UO, SANSA, UOULU) delivery date: month 42

When simultaneously available, plasma mass densities from FLRs and electron densities from whistlers will be cross-correlated (for separate magnetospheric activity conditions), both for validating the two methods, and for obtaining evaluations on the relative abundances of heavy ions.

In addition, comparisons with in-situ satellite measurements (e.g., MPA data from LANL) will be extremely useful for a direct validation.

At the end, a procedure has to be developed for weighting the data from the two methods.