An international initiative for atmospheric research at the poles

L. Alfonsi[1], Nicolas Bergeot[2], Emilia Correia[3], Domenico Di Mauro[1], Pierre Cilliers[4], Mark Lester[5], Maria Federica Marcucci[6], Cathryn N. Mitchell[7], Monia Negusini[8], Maurizio Candidi[6], Paul Prikryl[9], Sonya Lyatsky[10] Adriana Maria Gulisano[11], Mark Clilverd[12], Georg Heygster[13], Allan Weatherwax[14], Andy Gerrard[15], Angeline G. Burrell[16]

1 Istituto Nazionale di Geofisica e Vulcanologia, Italy
2 Royal Observatory of Belgium, Belgium
3 National Institute of Space Research, Brazil
4 South African National Space Agency, South Africa
5 University of Leicester, UK
6 Istituto di Astrofisica e Planetologia Spaziali-INAF, Italy
7 University of Bath, UK
8 Istituto di Radioastronomia-INAF, Italy
9 University of New Brunswick, Canada
10 National Science Foundation – Division of Polar Programs, USA
11 Instituto Antártico Argentino /DNA
12 British Antarctic Survey, UK
13 University of Bremen, Germany
14 Merrimack College, USA
15 New Jersey Institute of Technology, USA
16 The University of Texas, USA

Workshop - Mutual benefits between atmospheric research and radio based science over polar regions

RESOURCE
Radio Sciences Research on AntarctiC AtmospherE

A task force of radio scientists, formed within the Scientific Committee of Antarctic Research (SCAR) Expert Group GRAPE (GNSS Research and Application for Polar Environment, http://www.grape.scar.org/), has proposed a new scientific research programme: RESOURCE (Radio Sciences Research on AntarctiC AtmospherE).

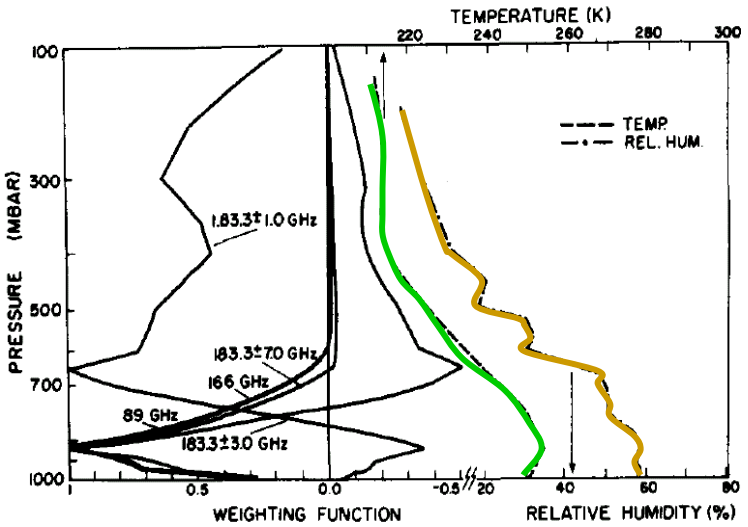
RESOURCE wish to represent:

- the need of the scientists that **investigate the atmosphere** by means of radio observation,
- the requirement of the scientists that want **to remove or to mitigate the atmospheric noise** from their radio measurements.

THE IDEA IS TO BUILD UP A SYNERGISTIC APPROACH OF MUTUAL BENEFITS FOR THE VARIOUS RESEARCH GROUPS

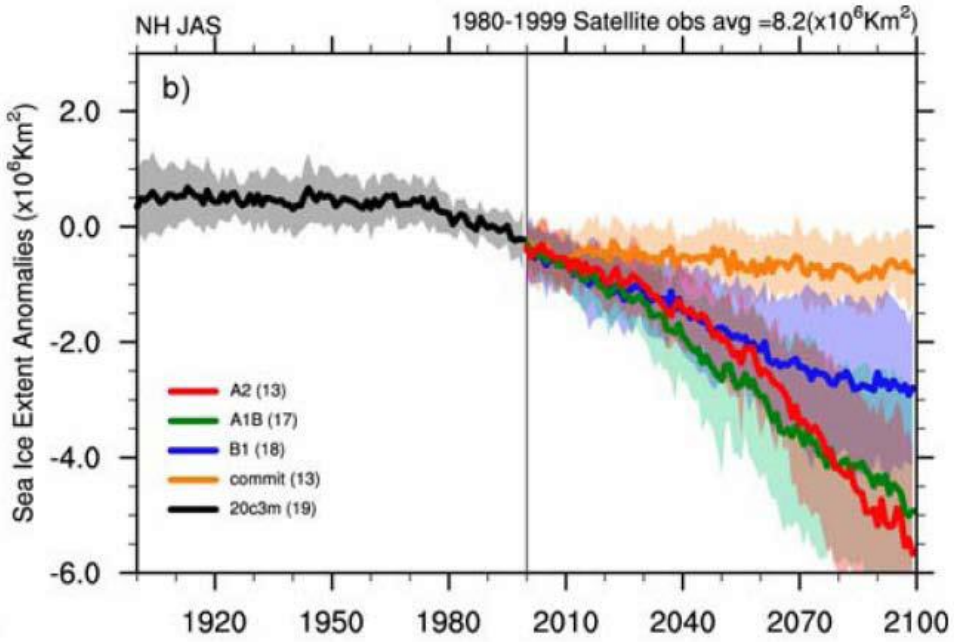
INVESTIGATE THE ATMOSPHERE BY RADIO OBSERVATIONS
Remote sensing of Precipitable Water Vapor (PWV) by microwave radiometers

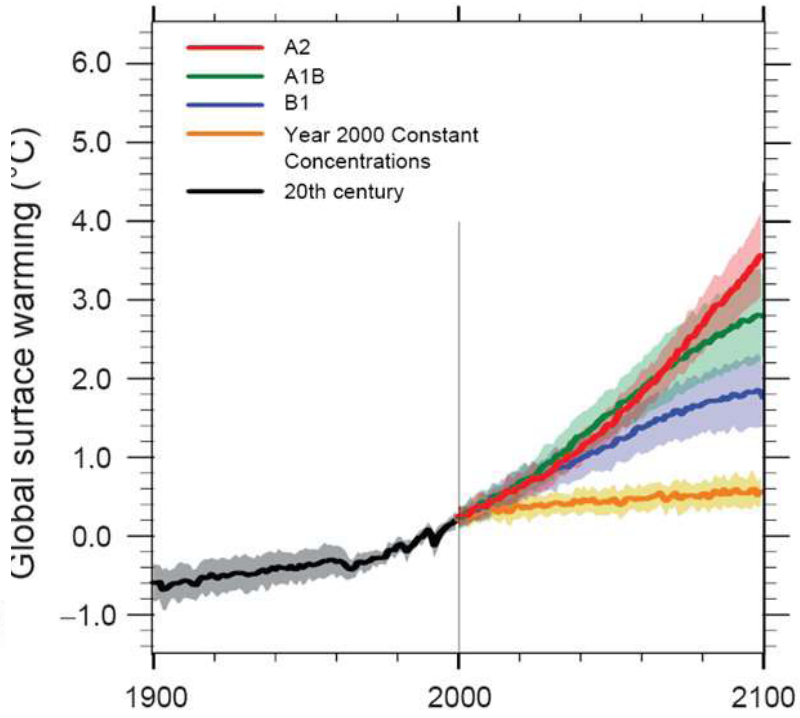
PWV is required for numerical weather prediciton, climate studies, and correcting GPS signal for wet delay.
In polar regions the microwave are succesfully used to derive the PWV, using the 183 GHz absorption line for column PWV.



Arctic winter

Kuo et al. 1994



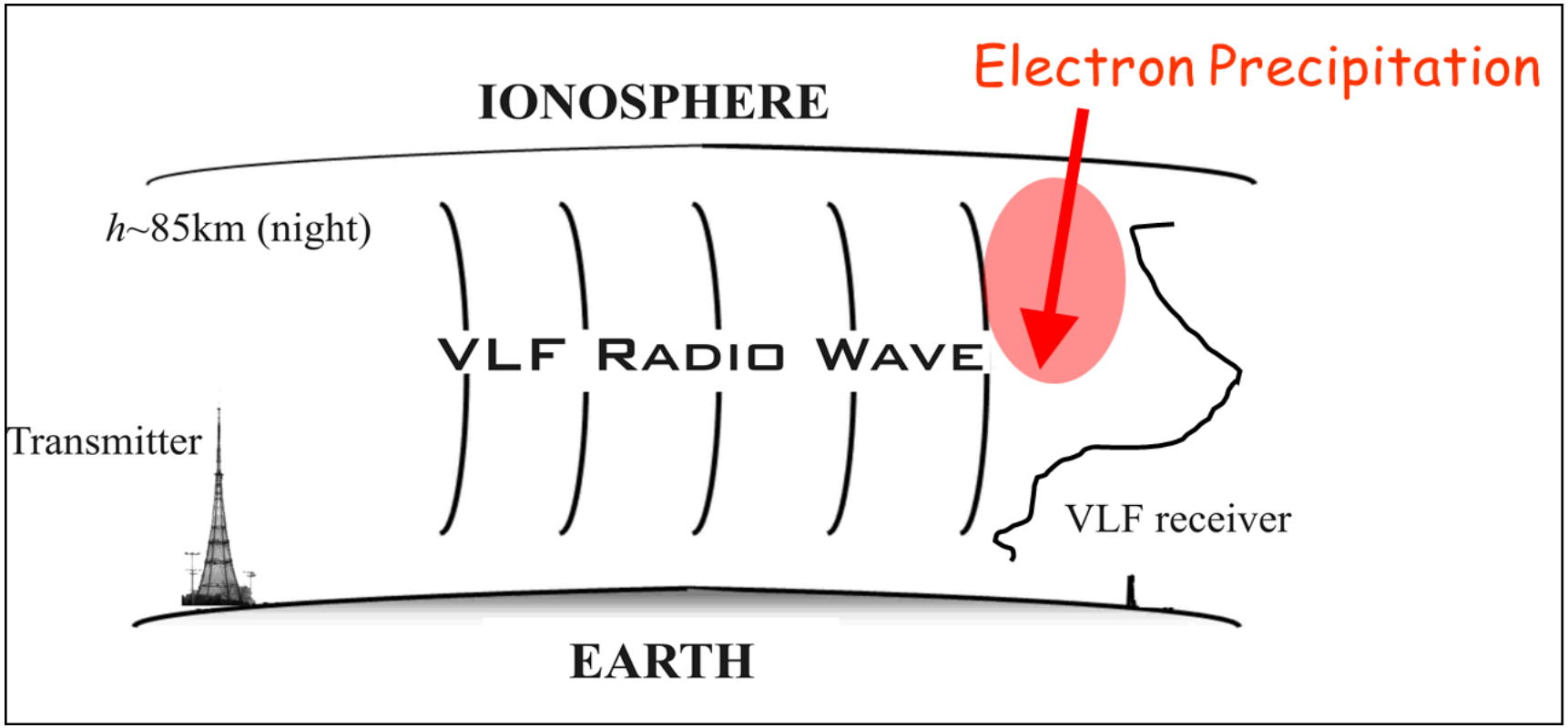


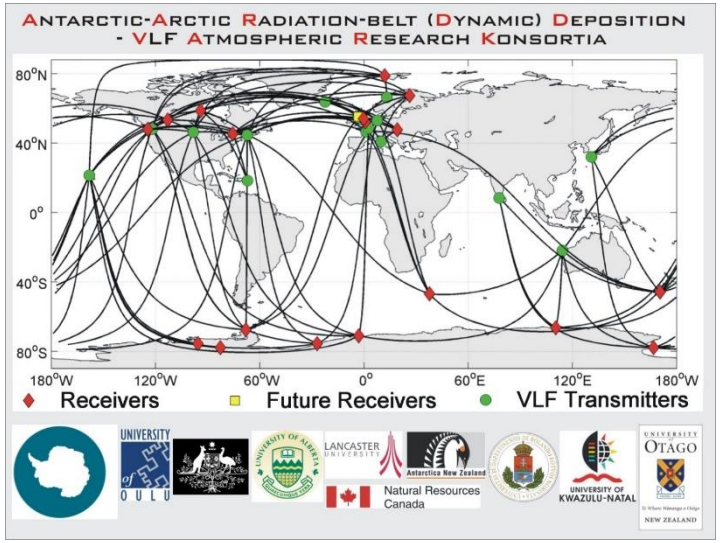
Thanks to the PWV measurements is possible to derive projections of sea ice extent and surface warming to assess the **Global Change**. The two examples refer to projections till to 2100.

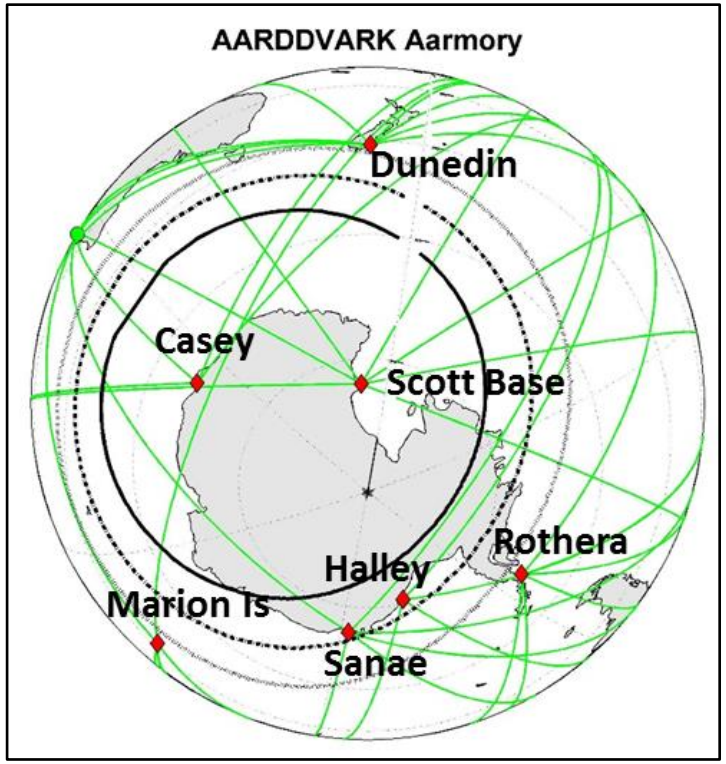
INVESTIGATE THE IONOSPHERE BY RADIO OBSERVATIONS

VLF wave observations

AARDDVARK: Subionospheric Radio Wave Propagation





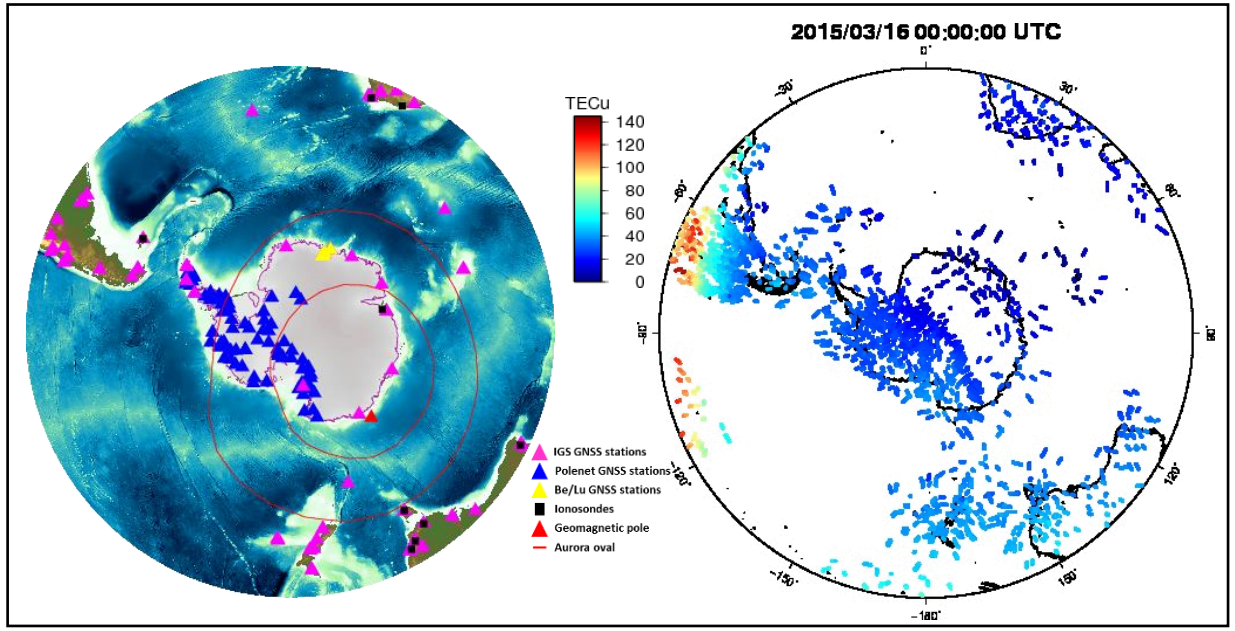


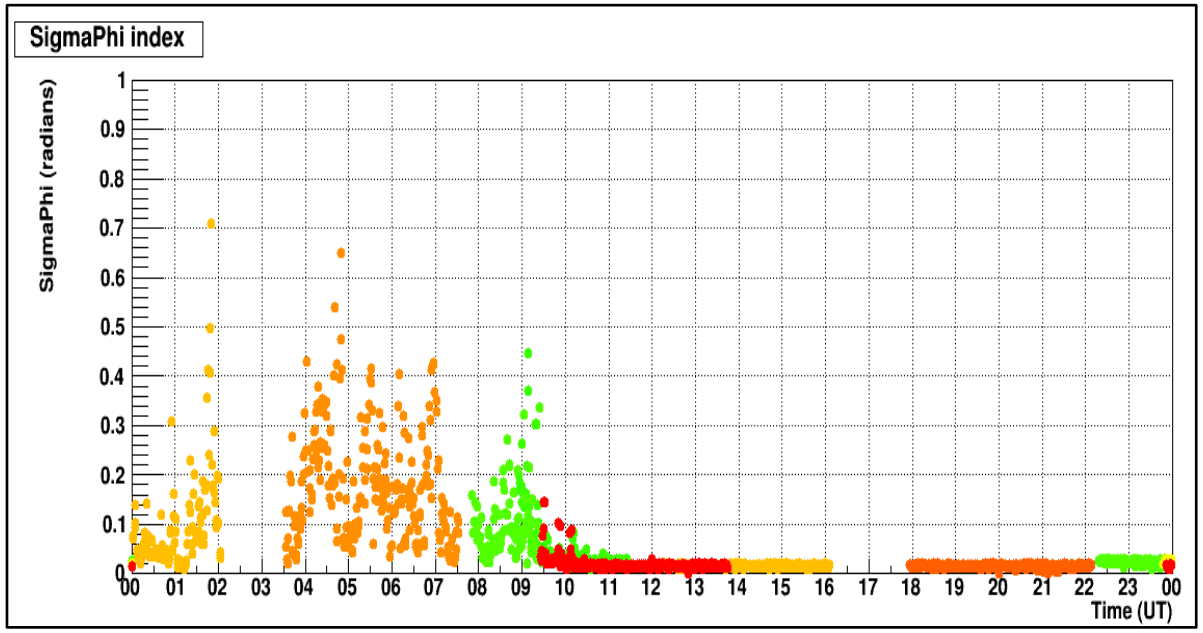
Radio transmissions at Very Low Frequencies (VLF) largely trapped between the conducting ground (or sea) and the lower part of the ionosphere (70-90 km) , forming the Earth-ionosphere waveguide.

Changes in the ionosphere cause changes in the received signal. There is very low attenuation in this frequency range, such that transmissions can propagate for many 1000km's - long range sensing of the upper atmosphere!

INVESTIGATE THE IONOSPHERE BY RADIO OBSERVATIONS

Ground-based GNSS data



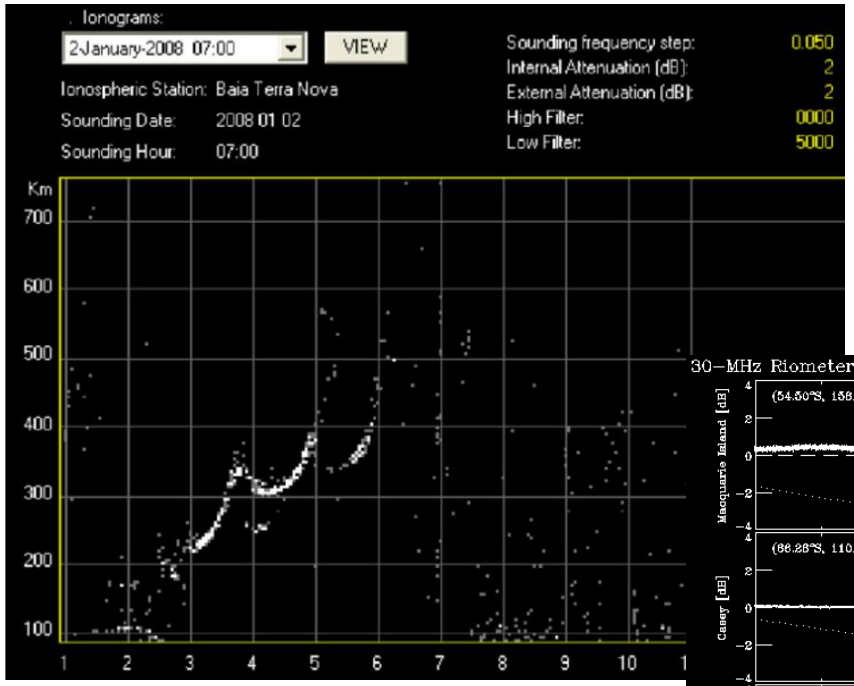


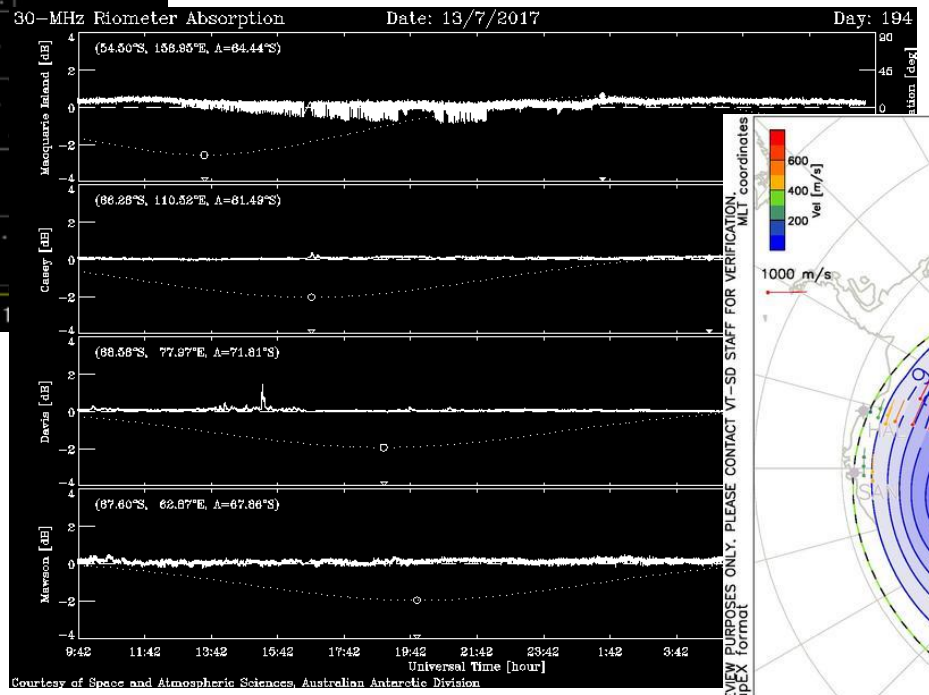
Global GNSS networks (e.g. IGS) integrated with other networks (e.g. POLENET or local) can contribute to derive **TEC maps** in the uneven covered regions of Antarctica.

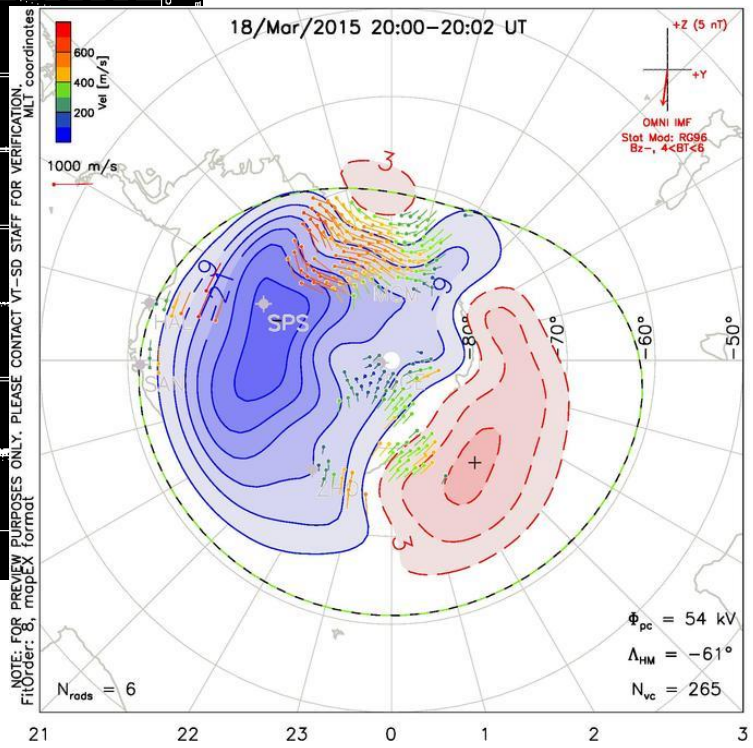
Ionospheric scintillations can be monitored by 50/100 Hz sampling frequency GNSS receivers or deriving scintillation proxies from RINEX data.

INVESTIGATE THE IONOSPHERE BY RADIO OBSERVATIONS

Ground-based HF data







Ionosondes, riometers, backscattering radars provide measurements of bottomside ionosphere:

- Critical frequency, virtual heights of the layers
- Cosmic noise absorption
- Plasma velocity, electric potential

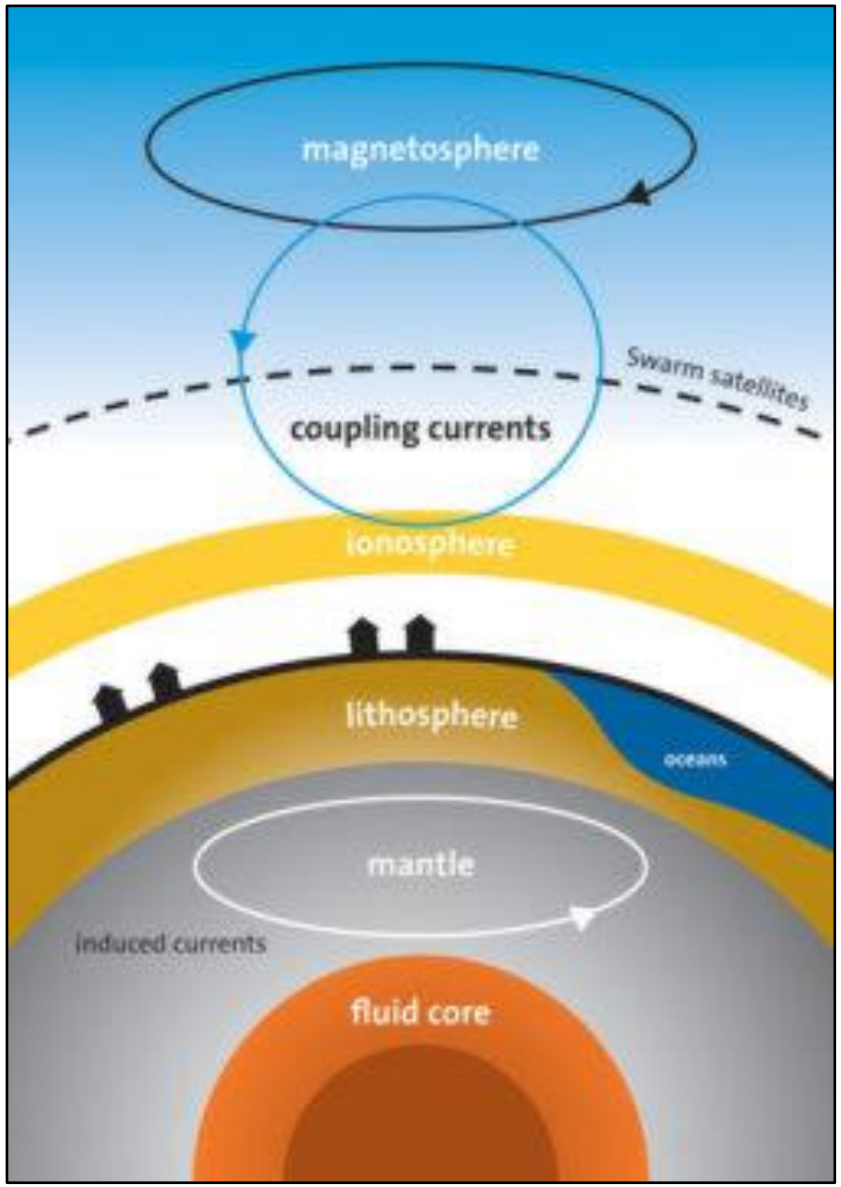
ANCILLARY DATA TO SUPPORT THE RADIO SCIENCES

Investigate the ionosphere through the ground (and satellite) magnetic observations at the polar regions

Magnetic observatories (ground level, observatories) and dedicated satellites (currently, Swarm) are equipped with both scalar and vector magnetometers which cover field variations from the DC to 1000 Hz. Such variations are generated by internal and external (ionospheric and magnetospheric) processes.

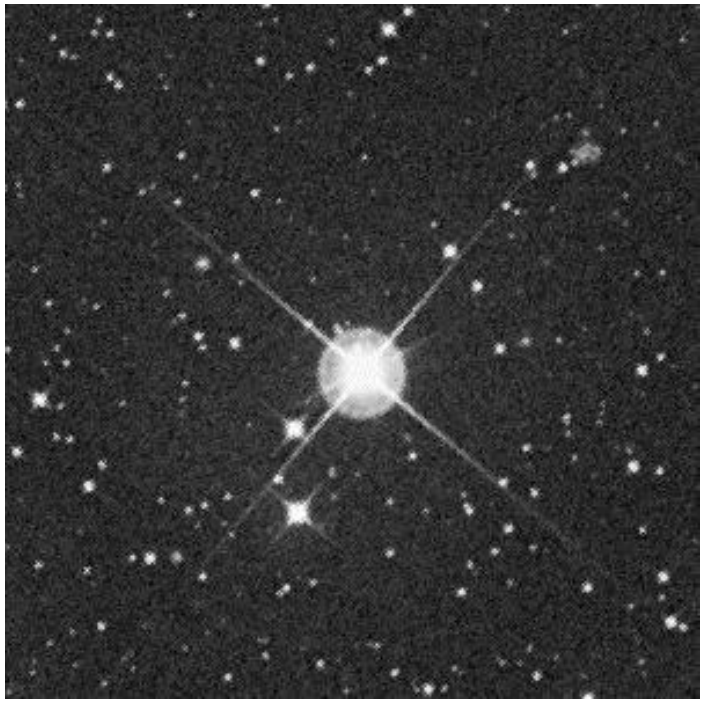
Finding the relations between ground and satellite geomagnetic assessment in relation to the ionospheric and atmospheric variations and inter-hemispheric phenomena for a better definition and identification of linked sources and/or effects.

Stating new definition of more efficient geomagnetic related indices for better characterization of the global conditions at polar regions (including parameters related to the ionospheric conditions).



INVESTIGATE THE IMPACT OF THE IONOSPHERE ON RADIO ASTRONOMY

The free electrons rotate the phase of incoming rays of light. The ionospheric phase gradient translates into a change in source position for observations of a source through the ionosphere, eg. Observations with radio continuum towards Virgo A and the VLSS have this problem (Bemmel & Röttgering, 2007).



Data taken by ROE and AAO, CalTech, Compression and distribution by Space Telescope Science Institute.

www.lofar.org

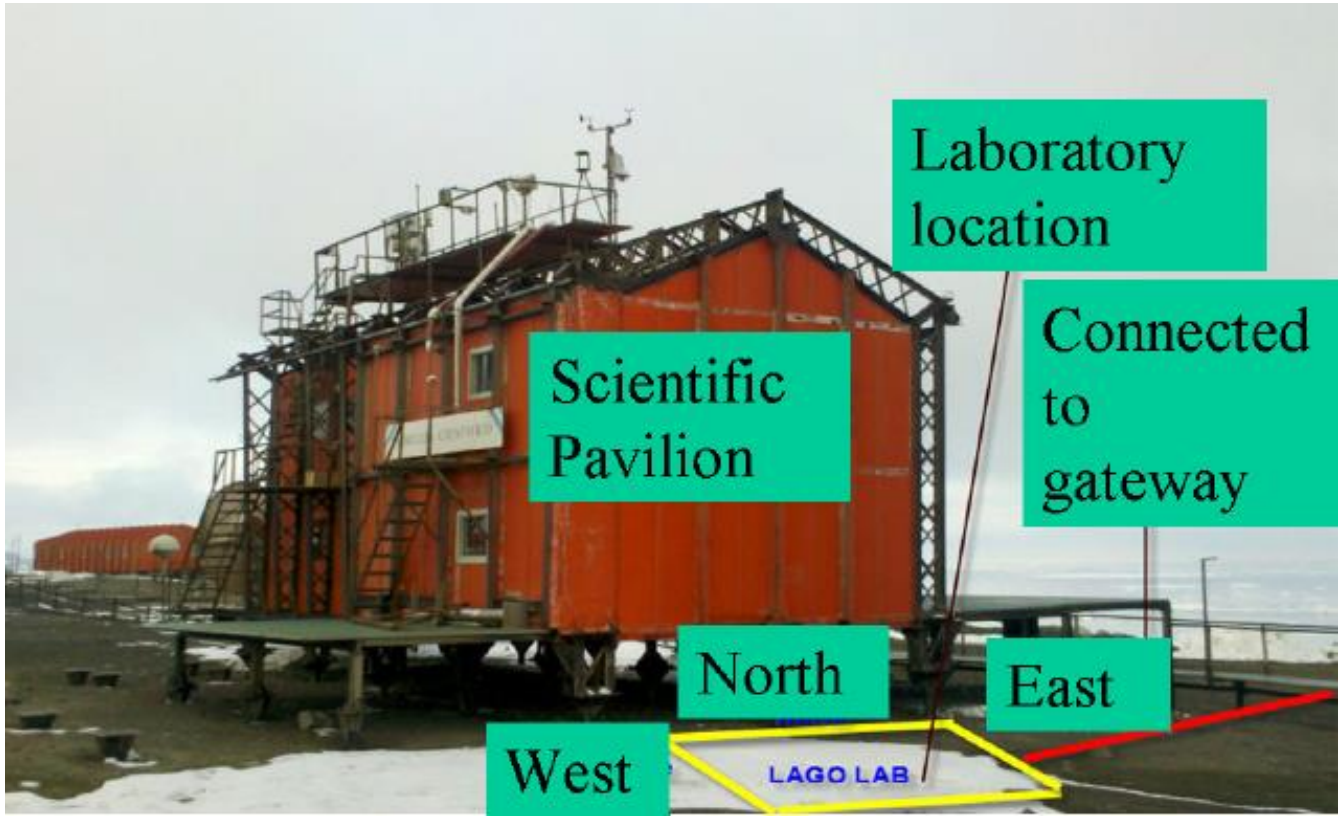
The Curvature in the ionosphere causes sources to be deformed and in extreme cases coherency is lost.
The High-frequency radio telescopes have a small field of view (FOV), and in each integration every station sees a constant phase offset due to the ionosphere.
Phase scintillation has a significant impact on SKA/LOFAR telescopes.

INVESTIGATE THE IMPACT OF THE IONOSPHERE ON RADIO ASTRONOMY

Cosmic ray astronomy

Cosmic Ray detection of shower particles on the ground using water Cherenkov detectors can reconstruct the shower direction using timing information (eg. The High-Altitude Water-Cherenkov Experiment (HAWC) HAWC (http://hawc.umd.edu/). In case of scintillation due to ionospheric perturbations this timing information can be biased, so it is crucial to conduct research on GNSS propagation , propagation and plasma bubbles.

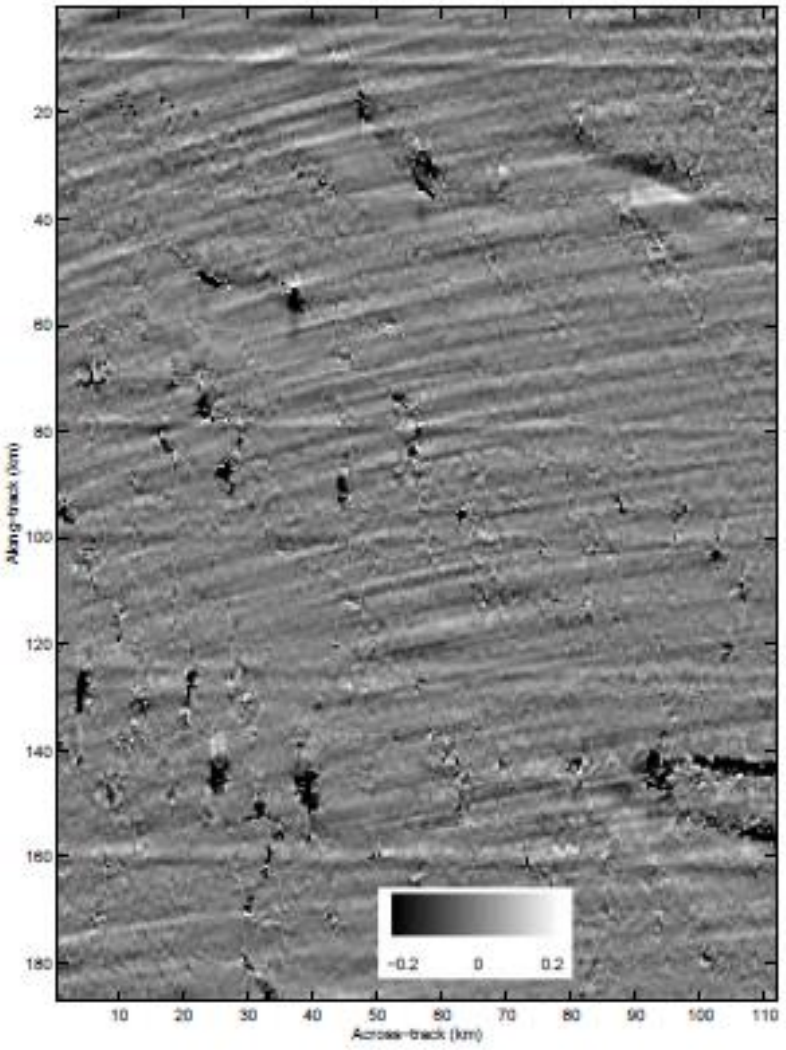
The polar studies of ionospheric scintillation in auroral precipitation regions are very important to understand signal to noise ratios at high latitudes.

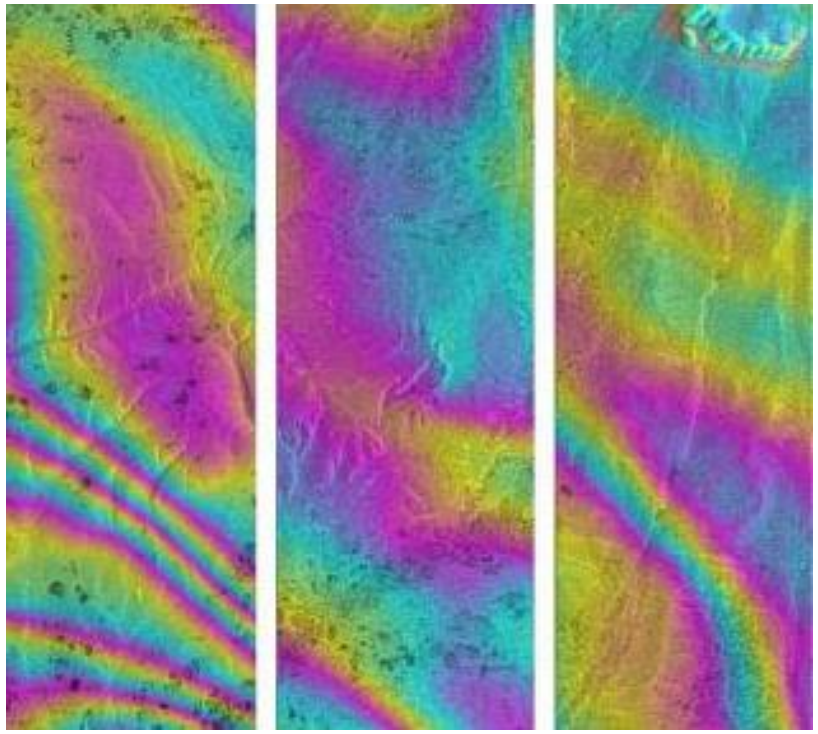


Latin American Giant Observatory (LAGO)

INVESTIGATE THE IMPACT OF THE IONOSPHERE ON SYNTHETIC APERTURE RADAR

Ionospheric propagation effects cause significant distortions in the data of low-frequency synthetic aperture radar (SAR) systems, whose severity is increasing with decreasing system frequency.





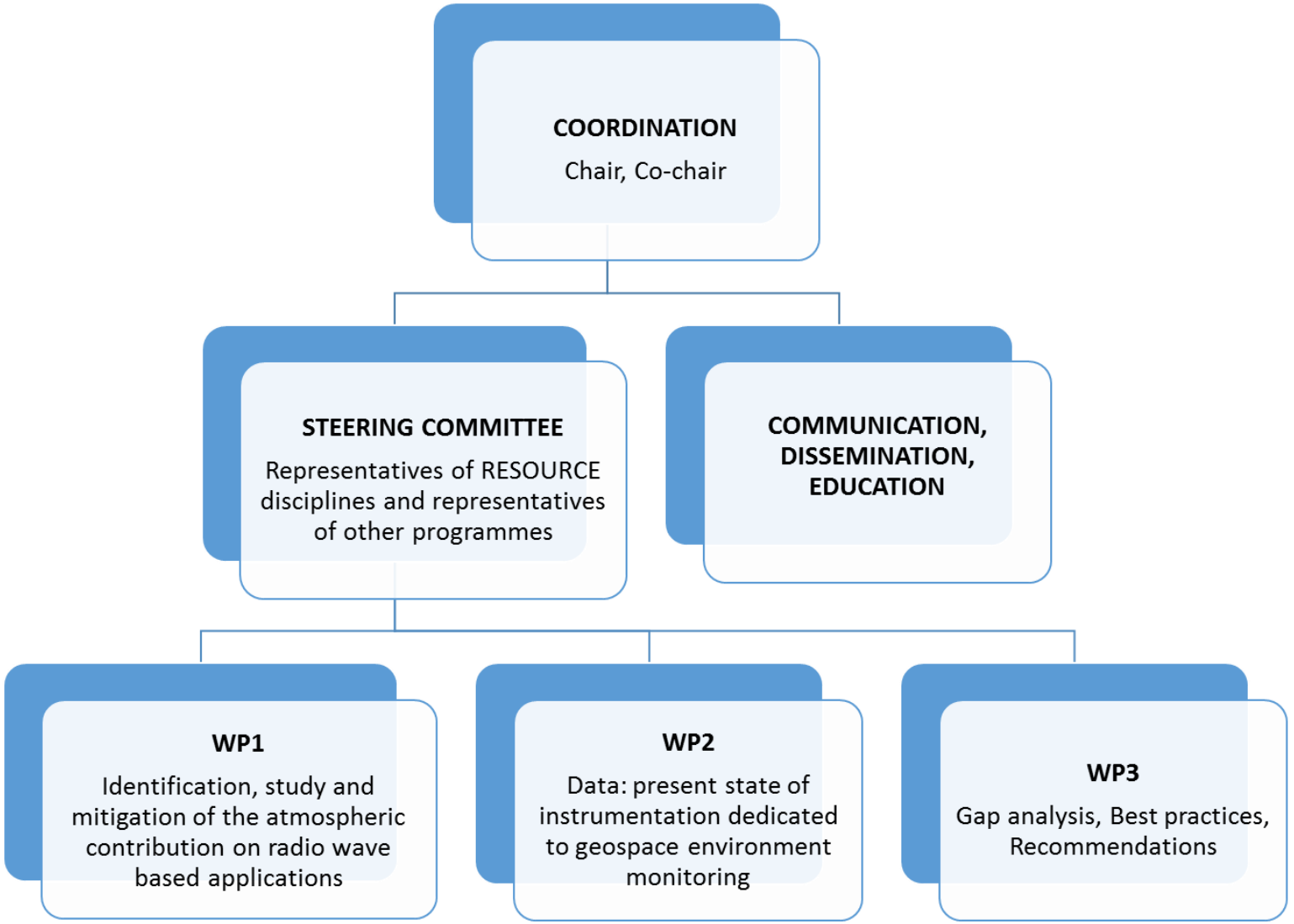
***Left**:*
C-band azimuth streaks from part of a RADARSAT Antarctic satellite radar interferometry due to auroral ionospheric disturbances.

From:
Gray, A. Laurence, Karim E. Mattar, and George Sofko, Influence of ionospheric electron density fluctuations on satellite radar interferometry, Geophysical Research Letters 27, no. 10 (2000): 1451-1454.

***Right**:*
Examples of ionospheric phase screens in L-band InSAR data observed by the ALOS PALSAR system in the Arctic (Alaska).

From:
Carrano et al., Geoscience and Remote Sensing Symposium (IGARSS), 2010 IEEE International, 2010.

RESOURCE
Implementation



Timeline

- May 2017: **Submission**
- June 2018: **Possible approval and Kickoff** (SCAR/IASC Open Science Conference, 19-23 June 2018, Davos, Switzerland)
- June 2018-January 2019: **Ad-interim Chairship of Lucilla Alfonsi (INGV, Italy) and Nicolas Bergeot (ROB, Belgium)**
- February 2018: **Elections of Chair, Co-Chair, Dissemination Manager, WP Leaders**
- June 2018-May 2021: **Expected duration of the project**

RESOURCE
Expected results

- Joint scientific publications and presentations of the results to national and international meetings;
- Reports summarizing best practices and recommendations for science and applications addressed to stakeholders;
- Academic research outputs in the form of Master's and PhD theses linked to RESOURCE activities
- Common initiatives of outreach and education of pupils and public;
- Submission of collaborative proposals to look for additional funds on specific themes.

Join us!

lucilla.alfonsi@ingv.it
nicolas.bergeot@oma.be