

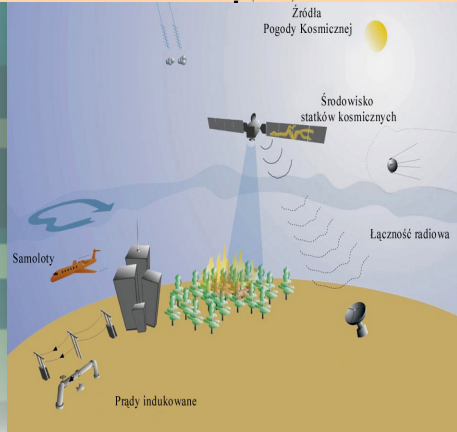
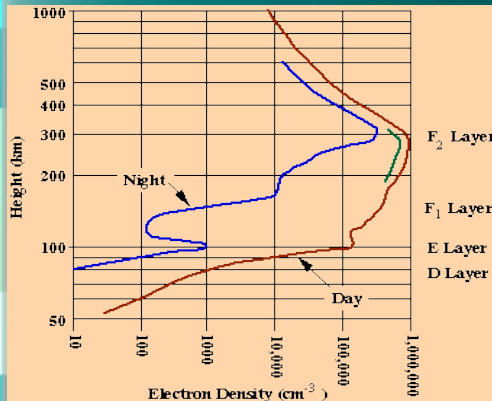
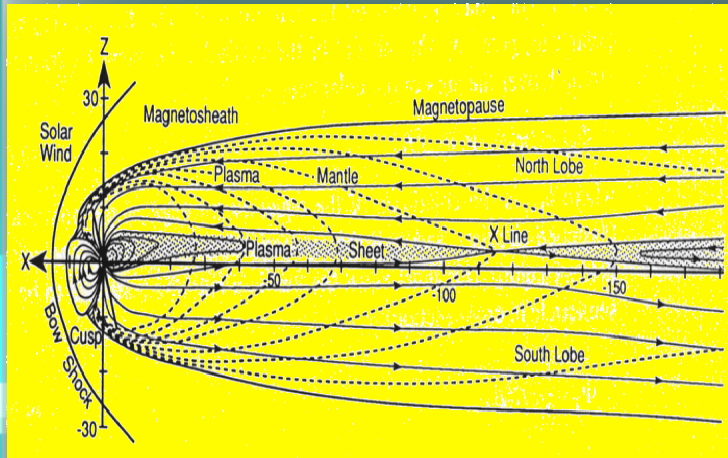
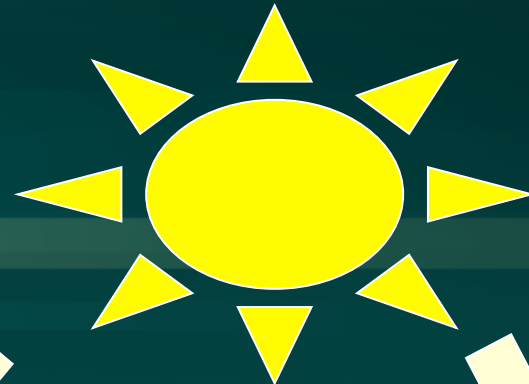
The multi instrument radio diagnostics as a new tool for improved the GNSS services.



*Hanna Rothkaehl¹, Andrzej Krankowski²
D. Przepiórka¹, M Matyjasiak¹ and Marek Morawski¹*

Pasadena 23-28 June 2014

Global chain



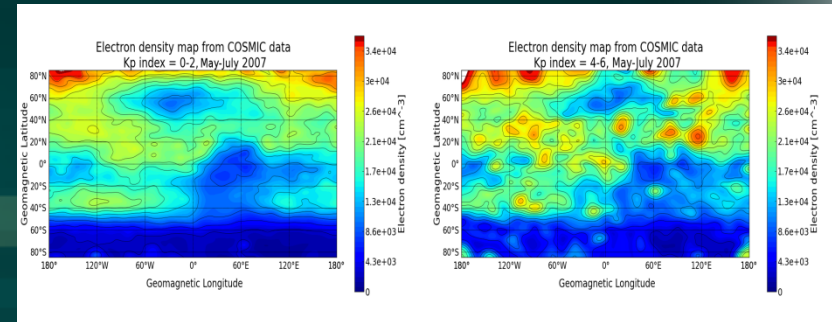
ionosphere

magnetosphere

Earth
natural processes and human activity

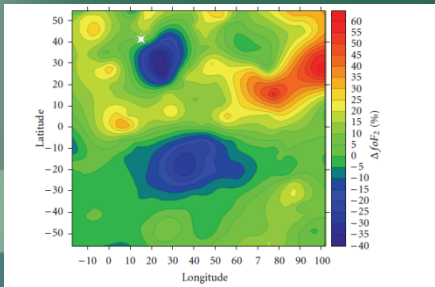
physical processes that cause irregularities and instabilities in Earth's environment

1 Sun activities ---- Geomagnetic storms

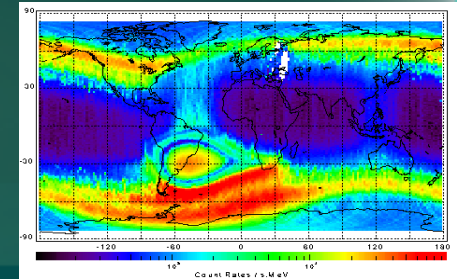
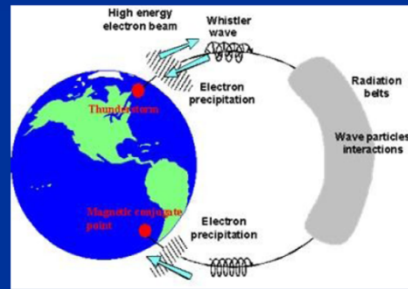


2 Events on Earth ; earthquakes ,

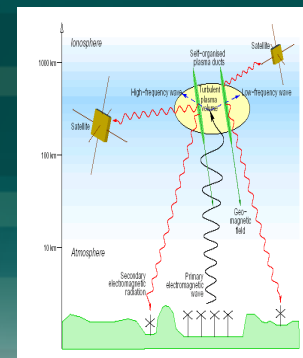
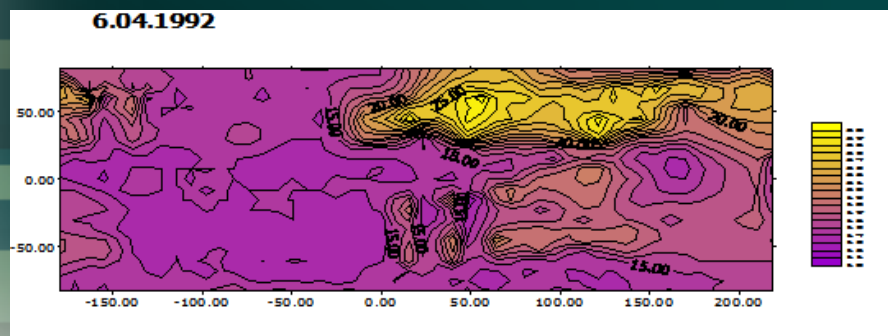
thunderstorm activities



**ESA project
INSPIRE**



3 Human activities



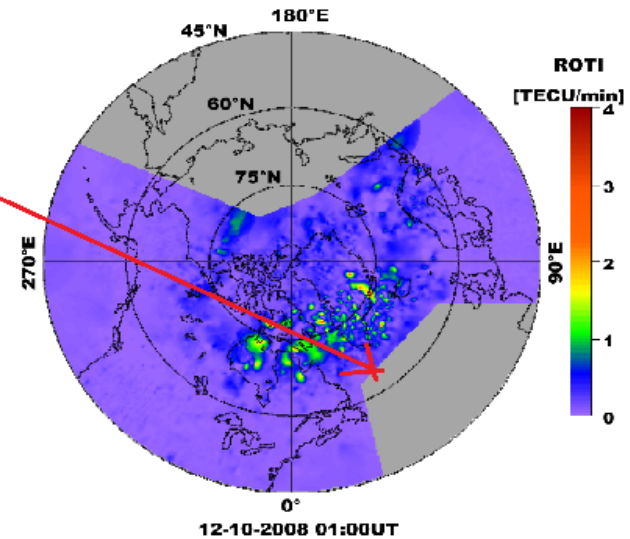
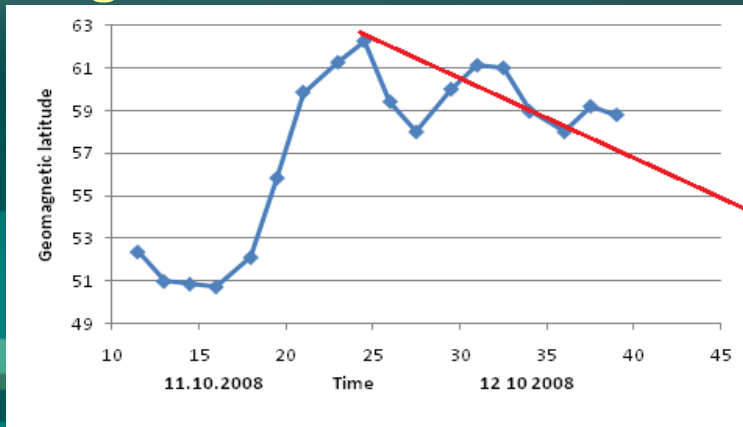
Multi instruments diagnostics

- In situ diagnostics LO satellite; waves and plasma diagnostic
- TEC measurements
- RO satellite diagnostics
- ground based Ionosondes, radars, LOFAR(radio telescope interferometer)
-

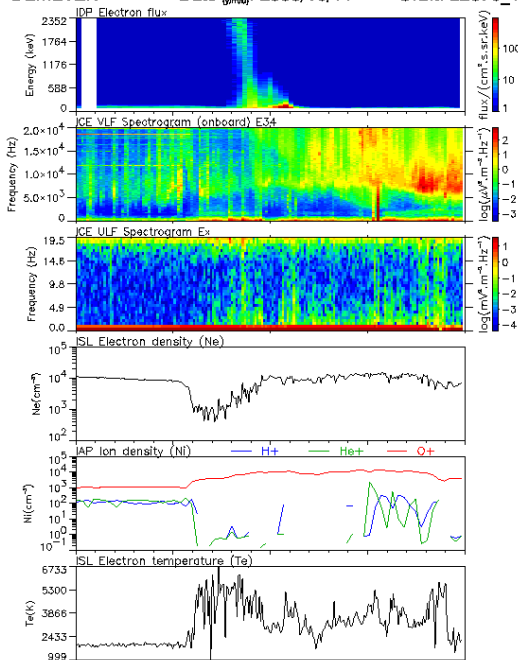
❑ **High temporal and spatial resolution: topside in situ waves and plasma diagnostics, and remote diagnostics (limited area)**

❑ **General description of large scale structures :TEC measurements, ground base ionosonde network**

Geomagnetic storm 11-13 October 2008



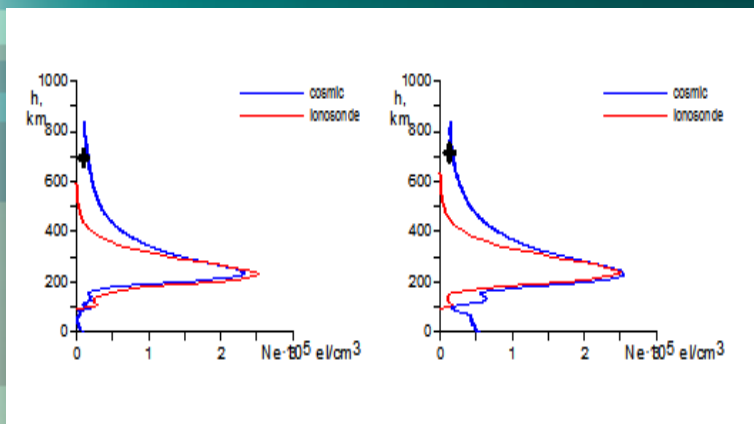
DEMETER Date (yyyy): 2008/10/11 Orbit: 22870_1



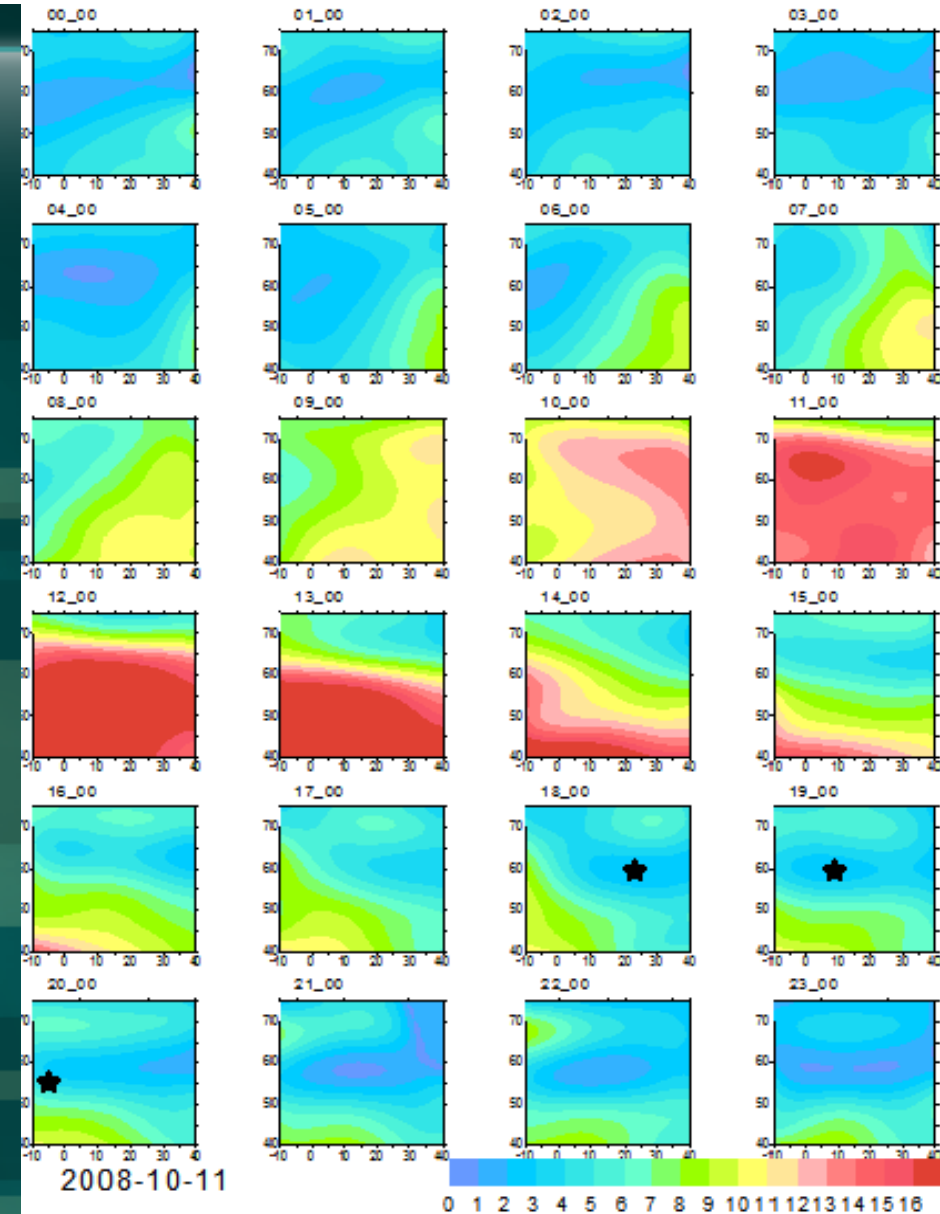
UT	11:18:00	11:20:15	11:21:30	11:22:45	11:24:00
Lat.	56.63	63.07	64.46	63.76	72.32
Long.	148.15	146.55	142.27	137.81	131.50
Inv. Lat.	30.28	24.55	28.96	33.12	37.05
MLT	20.65	20.79	20.26	20.25	19.61

The position of minimum ionospheric trough determined by wave and plasma measurements during geomagnetic storm from 11 till 12 October 2008, (left part), the position of ionospheric irregularities determined by GPS fluctuations measurements integrated during one hour (right side).

GPS observations collected at IGS/EPN network were employed to reconstruct diurnal variations of TEC using all satellite passes over individual GPS stations. More than 150 stations were included in the analysis of the response of TEC to a geomagnetic storm. In order to obtain the spatial and temporal variation of TEC there are created the TEC maps.

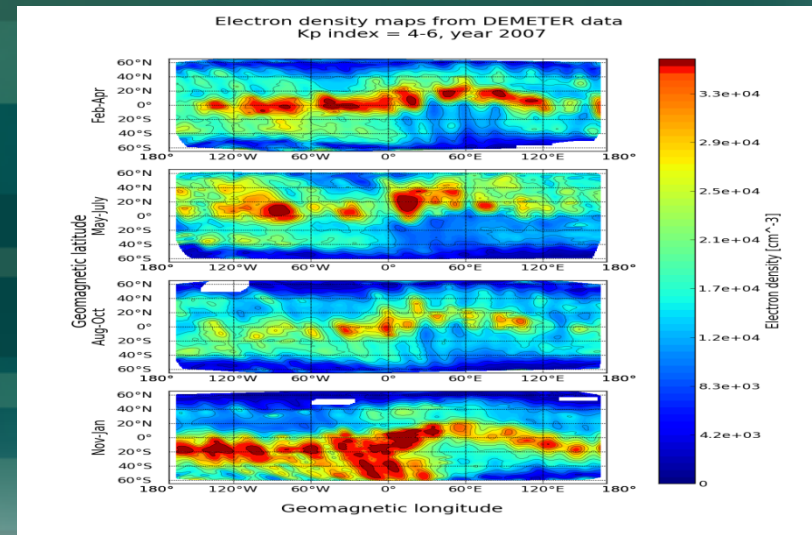
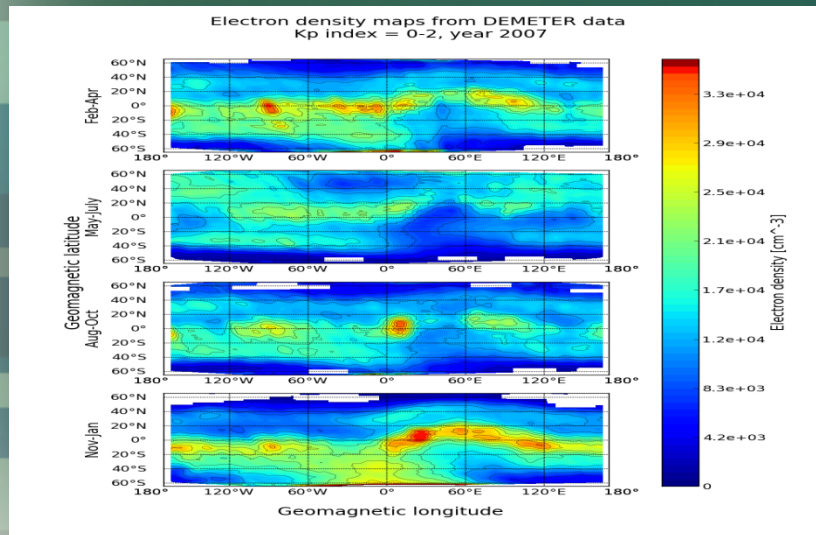
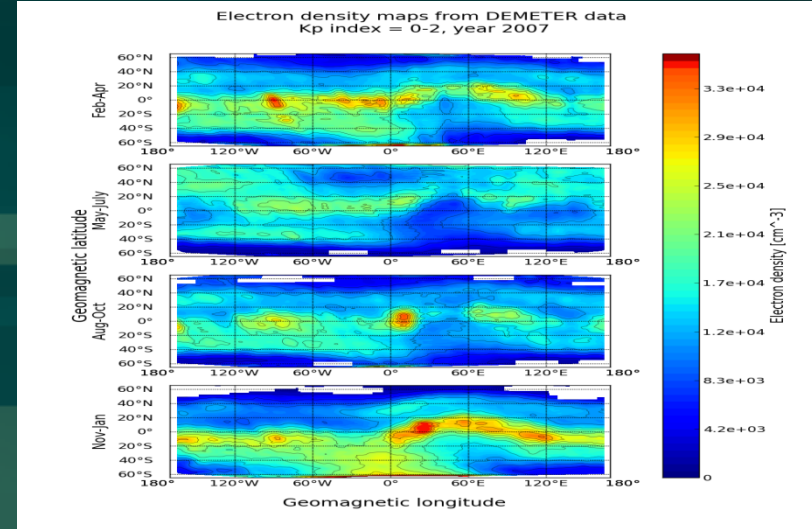
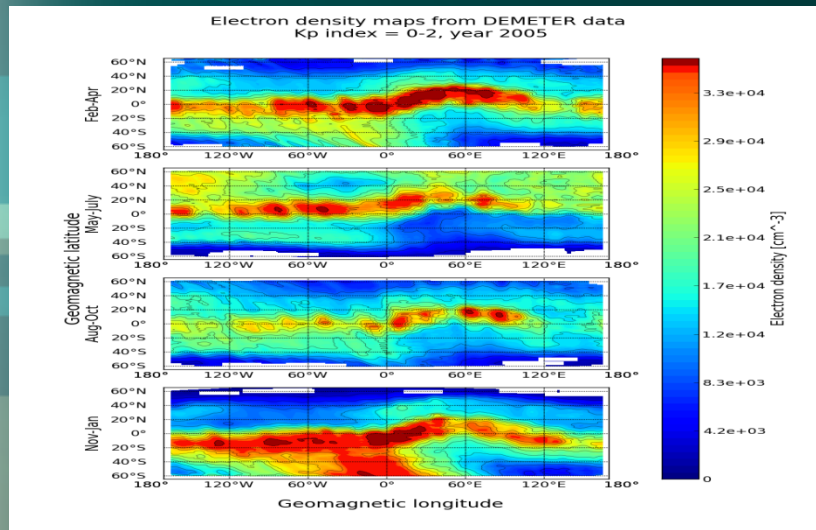


Comparison of COSMIC electron density profiles and ionosonde measurements over Pruhonice for quiet (left panel) and disturbed (right panel) days about 16 UT. The stars indicate the minimum of the main trough ionospheric trough position determined by wave and particle measurements registered on board of DEMETER satellite.



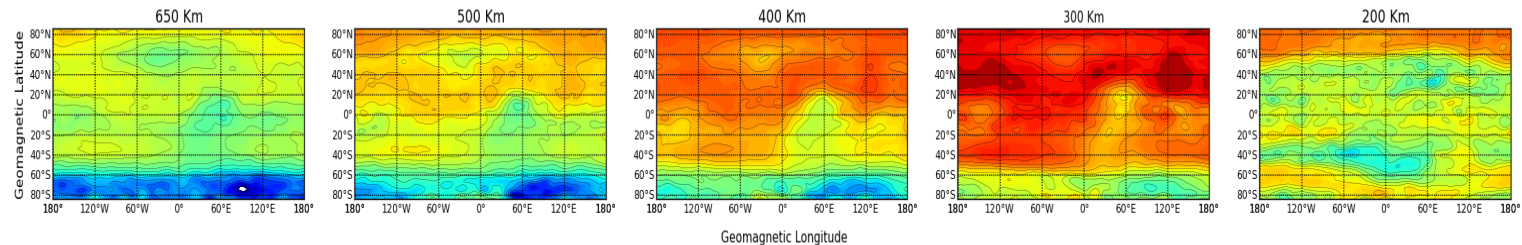
TEC maps with 1-hour time resolution over Europe for October 11, 2008. The stars indicate the minimum of the main trough ionospheric trough position determined by wave and particle measurements registered on board of DEMETER satellite.

Global changed during last solar long minimum of electron densities at 600 km

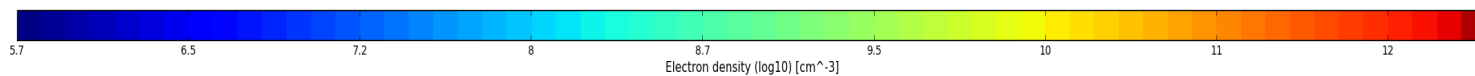
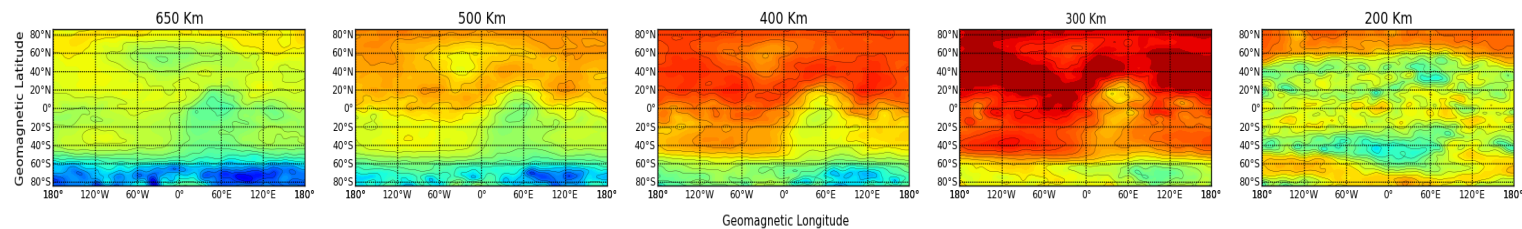


Global high profiles of electron densities during last long solar minimum

Electron density maps from COSMIC data
Kp index = 0-2, May-July 2007

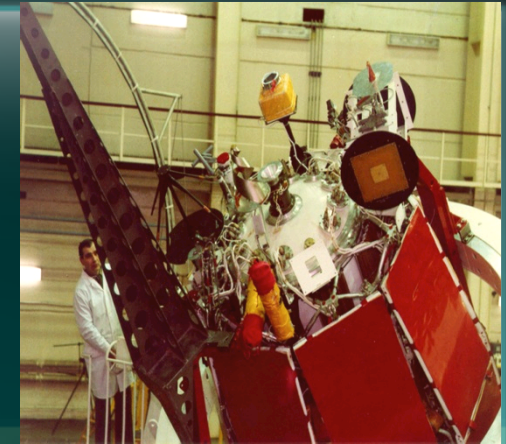


Electron density maps from COSMIC data
Kp index = 0-2, May-July 2010

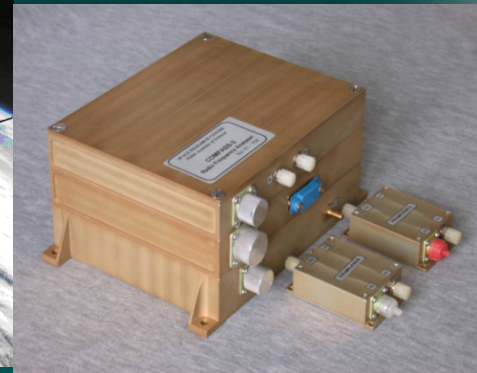


SRC PAS experience

past experiment -RF diagnostics



IK-19 1978-1981	500-980 Km inc. 74 deg	0.1-6. MHz SRC
IK-24 Activn 1989-1990	500-2500 Km inc. 82.5 deg	0.1- 10. MHz SRC
IK-25 Apex Magion-3 1991-1992	430-3100 Km inc. 82.5 deg	0.1-10. MHz SRC
Coronas-I 1994	500 Km inc. 82.5 deg	0.1-30. MHz SRC
Compass-2	600km, inc 79 deg	0.1-15 MHz SRC+IRF-u



OBSTANOVKA on ISS

The complex of OBSTANOVKA instrument was transported on ISS on 12 February 2013. The successful installation and deployment of the antenna system was conducted by cosmonauts of 35 Expedition on the Russian Zvezda service module on 19 February 2013. First scientifically data has been registered on 3th September 2013.



- Geophysical studies of the plasma-wave processes, connected with the manifestation in the ionosphere it is solar – magneto-sphere - ionosphere - atmosphere - litospere connections;
- Ecological monitoring of the low-frequency electromagnetic radiations anthropogenic and global catastrophes origin.
- Coordinated ground observations on the influence of electro-magnetic disturbances on the technogenic structures and the living organisms
- Study of the influence of the factors of space weather on the state of the middle-latitude and equatorial ionosphere



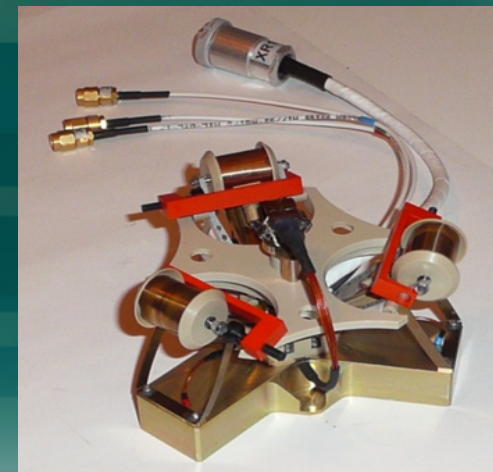
RELEC (Relativistic ELECTrons)

July 2014 satellite will be launched into a sun-synchronous orbit to height of about 750 km.

The aim of the RELEC mission is to study precipitation of magnetosphere relativistic electrons and their impact on the Earth atmosphere and ionosphere including the observations of fast transient phenomena in the upper atmosphere. It will provide combined observations of UV, X and gamma radiation and charge particle fluxes, as well as electromagnetic fields.

Radio Frequency Analyser (RFA) has been developed by SRC PAS. The Radio Frequency Analyzer (RFA), with three electric field component of antenna system, is devoted to diagnose temporal and spatial electric field fluctuation in the frequency range from **20 kHz to 15.0 MHz**.

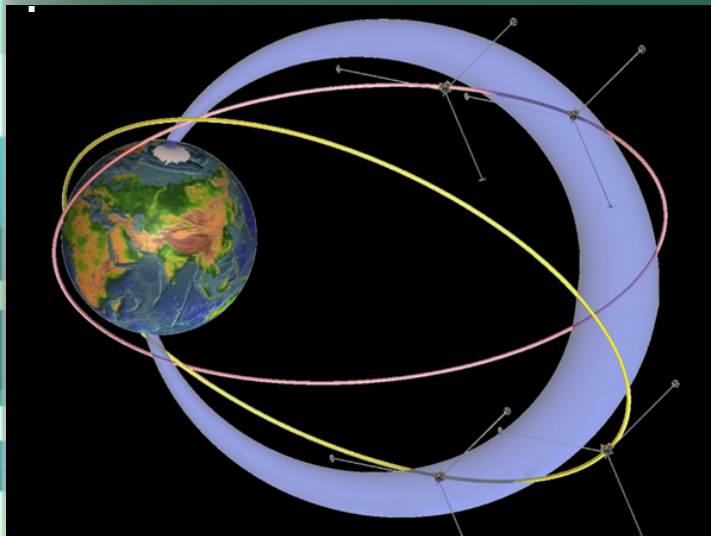
In order to observe the effects related to the thunderstorm activity, the instrument will have possibility of **very fast(25 ns) wave form registrations**. The instrument can be also used for monitoring the electromagnetic ecosystem for space weather purpose.



RESONANS 2016

The HF radio analyzer designed and build by the polish team is an electronic module devoted to measure electrical and magnetic components of radio frequency emissions in the frequency range from 10 kHz up to 1.0 MHz

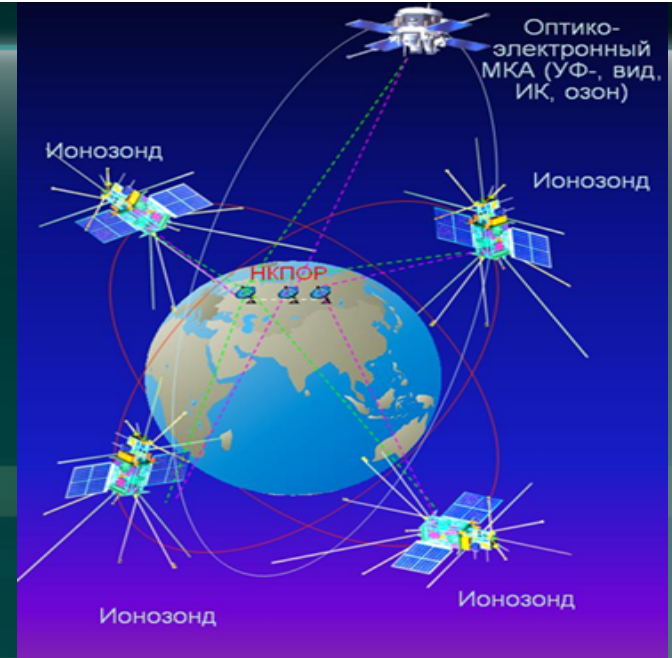
and phase difference measurement of two monochromatic signal on frequency 5.0 MHz and 15.0 MHz transmitted from “RIC” instrument.



The instrument is composed of main units that includes two Digital Vector Receivers and Data Processing Unit with Control Module. Signals to be analysed by HFA came from following sources:

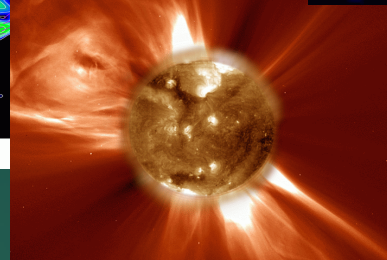
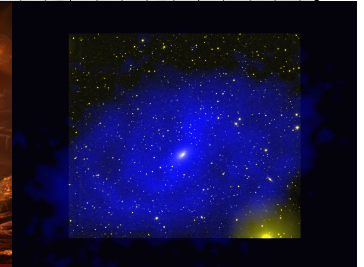
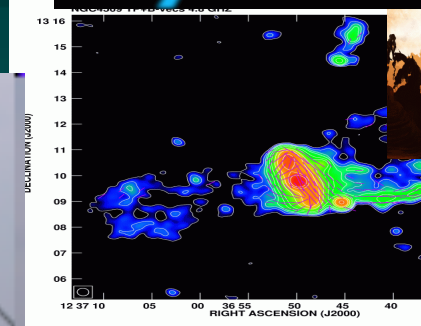
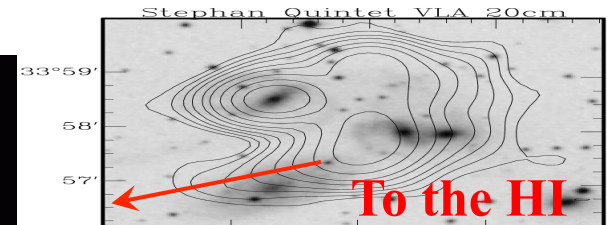
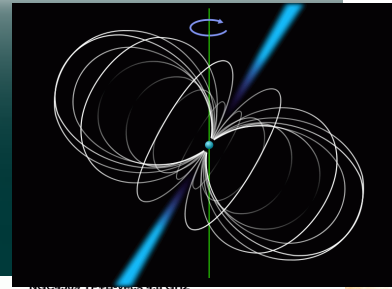
- three dimensional low frequency electric field antenna set (AMEF-WB),
- three dimensional magnetic field antenna set,
- narrow band 5MHz and 15 MHz antenna sets

In order to diagnose top-side ionosphere, spacecraft mission **JONOSOND** leading by Russian Space Agency was proposed



The four identical spacecrafts will be located at the polar circular orbit at the altitude 600 km and 800 km. In the frame of contract with Russian side the **four ionosonds LAERT**, dedicated for top-side in situ active diagnostics were designed in SRC PAS.

LOFAR Low Frequency ARray for radio astronomy



With LOFAR, astronomers can look back billions of years to a time before the first stars and galaxies were formed (the so-called 'Dark Ages'), they can survey vast areas of the low-frequency radio sky, and they can be constantly on the lookout for some of the most energetic and burst-like events in the universe.

Science interests in Poland range from neutral hydrogen distribution in the distant early universe, to the timing of pulsars, and to studies of magnetic fields in various intergalactic, interstellar, **planetary, and solar environments**.

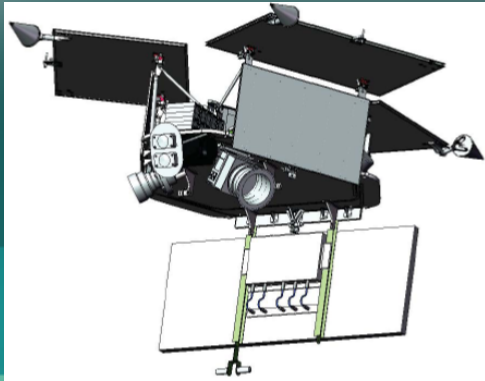
3 LOFAR station In POLAND



ASTRON and the Polish LOFAR consortium POLFAR signed a contract



LOFAR is the Low-Frequency Array, exploring yet poorly studied range between 30-240 MHz frequencies. It constitutes a European array of thousands of antennas - a challenge for data transfer and processing techniques. The project is based on an interferometry array of radio telescopes using about 25,000 small antennas concentrated in at least 48 larger stations. 40 of these stations are distributed across the Netherlands, five stations in Germany, and one each in Great Britain, France and Sweden. The data processing is performed by a Blue Gene/P supercomputer situated in the Netherlands at the University of Groningen.



LOFAR and topside satellite radio frequency diagnostics Solar science and space weather

- Ionospheric and magnetospheric environmental diagnostics
- Sun diagnostics
- Service of ionospheric modeling and corrections

