Space weather monitoring in Russia: nowadays and in the future

SPACE WEATHER IMPACTS

X-Rays, EUV, radiobursts

- SATCOM - disturbances
- Radar - errors
- Geolocation - errors
- Satellites - orbit trim

Ionosphere inhomogeneity, scintillations.

SATCOM disturbances
HF comunication - disruptions
GPS - position, time and course errors

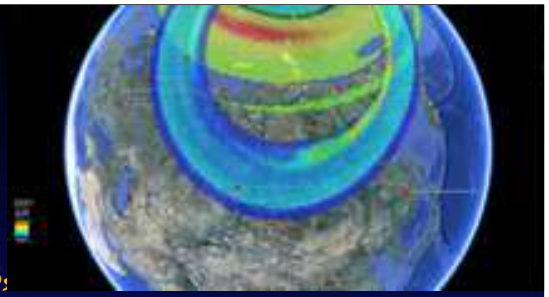
Proton events

- Radiation effect on high latitudes and altitudes
- Satellite damages
- Disorientation
- Errors during the space vehicle starts
- Errors in sensors data
- Loss of HF communication

Magnetic storms

- Onboard static-charge accumulation, drag
- Position errors
- Errors while tracking the orbits
- Radar errors
- Errors during the space vehicle starts
- Radio waves propagation anomalies
- Abnormalities at the electric power transition

OBJECTIVE:

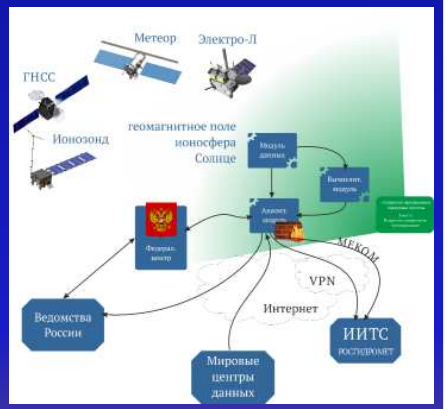


In case of geophysical disturbances, to provide for safety of satellite constellation on various orbits, safety of aircraft, communication channels, industrial and energy facilities as well as forecast of adverse geophysical conditions to minimize potential damage to human health.

ISSUES:

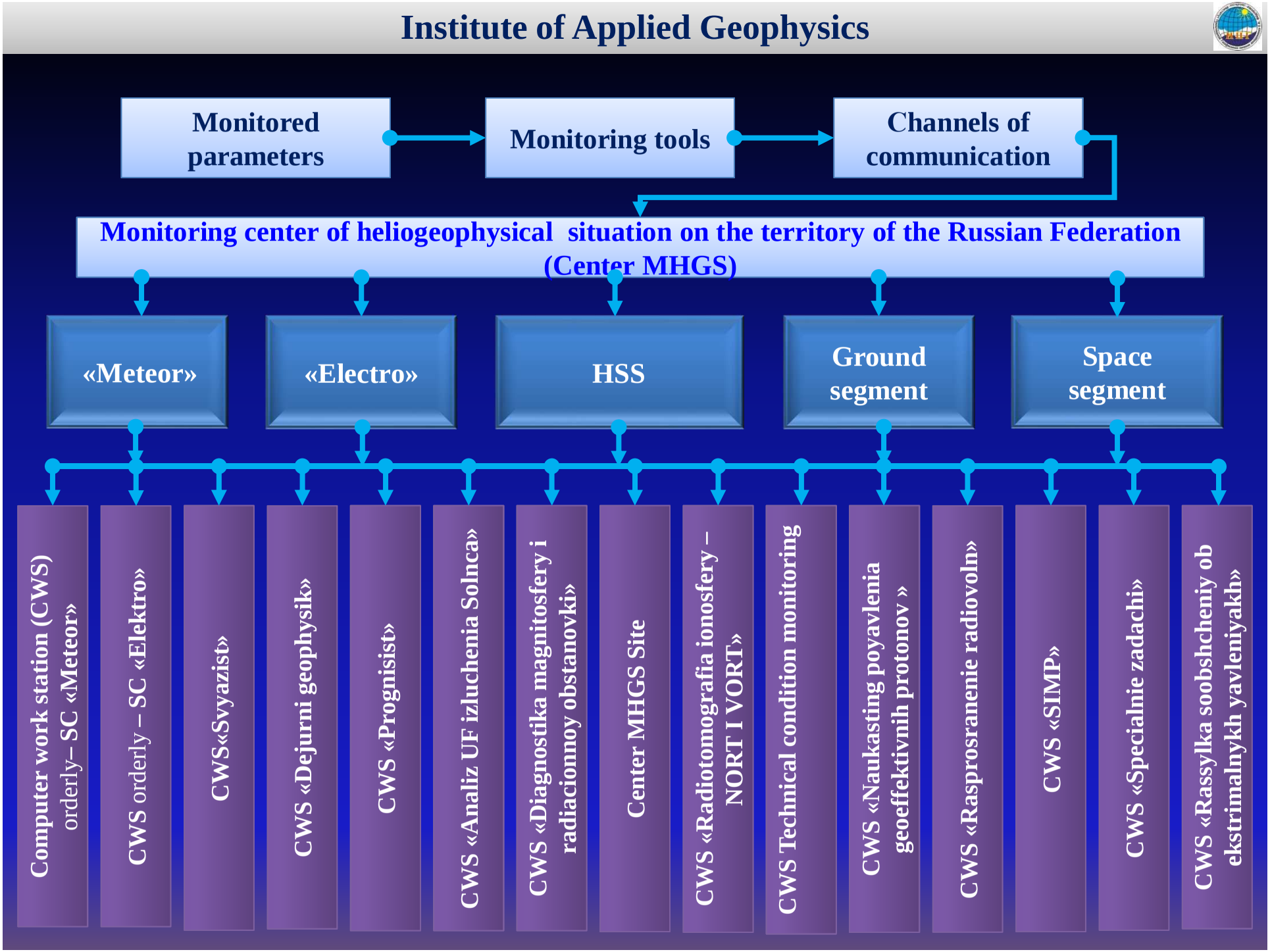
Lack of observation means, communication channels, data collection and analysis centers, and methodologies for diagnosing and forecasting space weather disturbances.

SOLUTION:



To create new and refurbish existing observation platforms; organize a telecommunication network connecting observation platforms with data collection and processing centers; establish data analysis centers and software/hardware facilities for data processing; and develop techniques for diagnosing and forecasting space weather disturbances.

Institute of Applied Geophysics



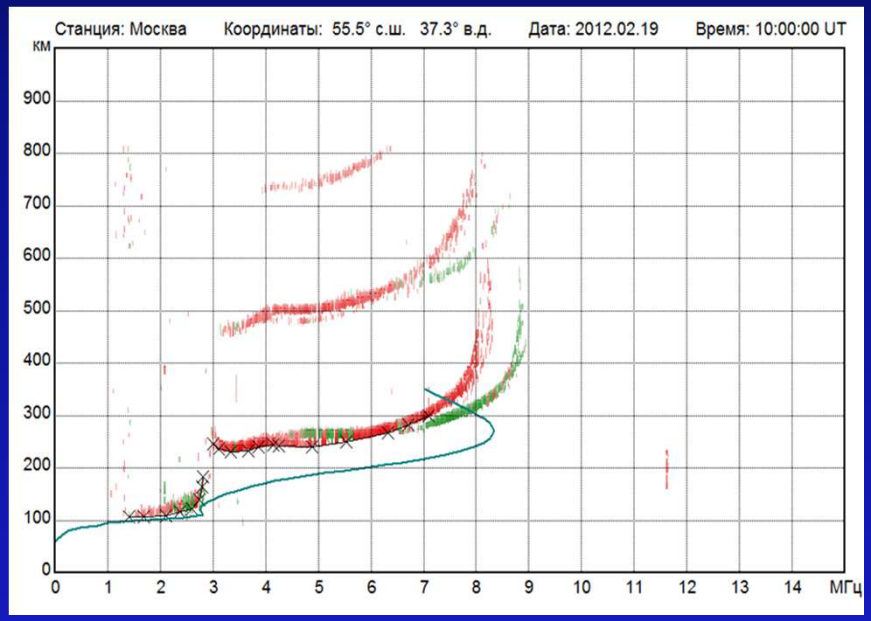
Monitored parameters

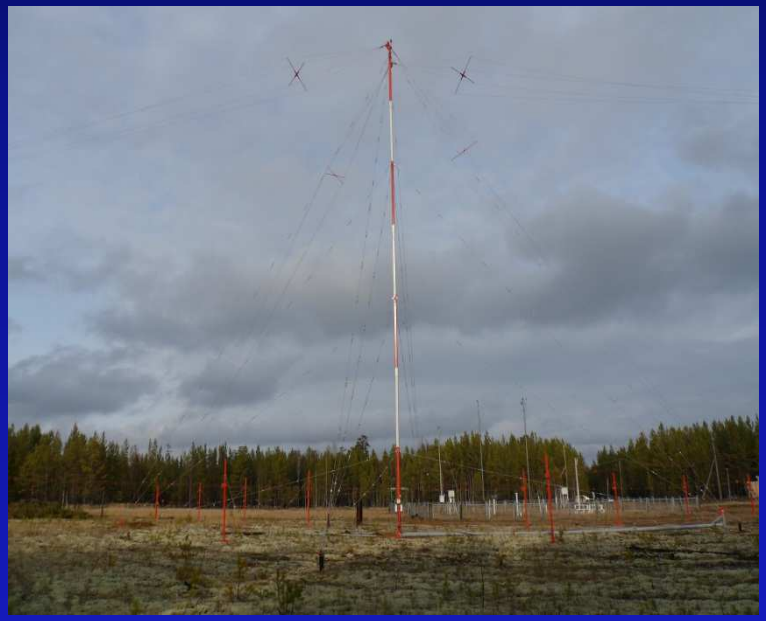
- solar radiation in the optical, ultraviolet, x-ray and radio wavelength bands.
- particles fluxes in the interplanetary medium and near-earth space;
- magnetic field, speed, temperature and density of the plasma in the interplanetary medium and near-earth space;
- magnetic field on the surface of the Earth;
- distribution of the electrons, ion concentration and neutral component in the ionosphere and in the upper atmosphere;
- the degree of the absorption of radio waves in the ionosphere;
- time delays from the GLONASS/GPS satellites' radio signals.

Monitoring tools

- low-orbital satellites (including «Meteor»);
- high-orbital satellites (including “Electro”);
- radiotomography net;
- network of the GPS/GLONASS receiving stations;
- network of the ground ionospheric stations;
- onboard ionosondes;
- network of magnetic observatories;
- network of riometers;
- network of solar observatories;
- world data resources;
- space system «Ionosond» (for the future)

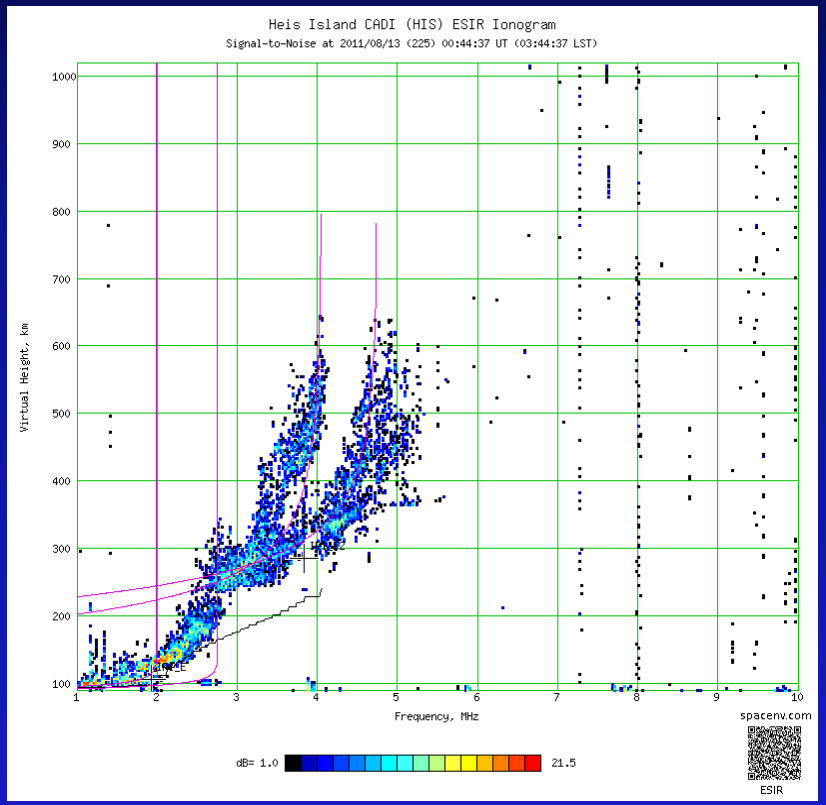
THE STATION OF IONOSPHERE VERTICAL SOUNDING. ANTENNA-FEEDER COMPLEX PODKAMENNAYA TUNGUSKA





Ionogram of ionosonde «Parus-A».
«Parus-A» is registered in the State Register of measuring instruments (MI)

STATION OF IONOSPHERE VERTICAL SOUNDING AND ANTENNA-FEEDER COMPLEX



Installation of antenna and feeder complex vertical radio sounding of ionosphere situated on Kheysa island, Franz Josef Land

POLAR BEAR IS DESTROYING ANTENNA-FEEDER BLOCK OF THE IONZOND IN KHEYSA ISLAND

SPACE WEATHER MONITORING IN ARCTIC AND ANTARCTIC REGIONS

ФЕДЕРАЛЬНАЯ СЛУЖБА ПО ГИДРОМЕТЕОРОЛОГИИ И МОНИТОРИНГУ ОКРУЖАЮЩЕЙ СРЕДЫ
Арктический и Антарктический Научно-Исследовательский Институт

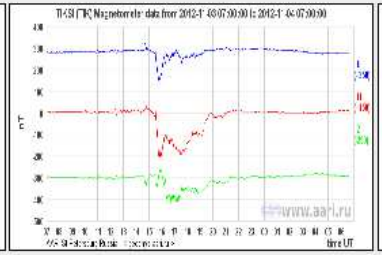
Отдел Геофизики

Мониторинг геофизической обстановки

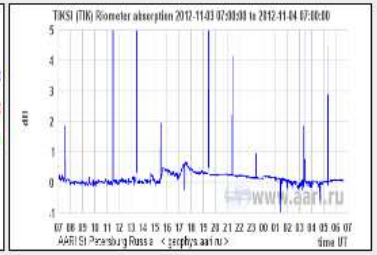
по данным станций Арктики и Антарктики

Данные

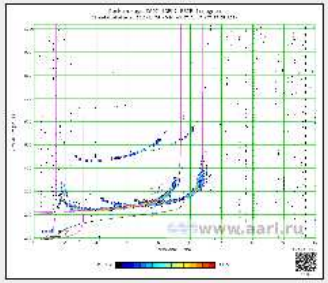
PC-индекс



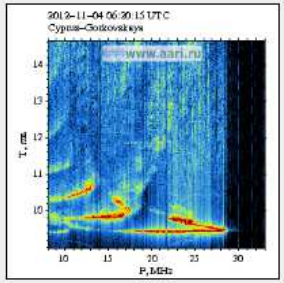
Магнитометр



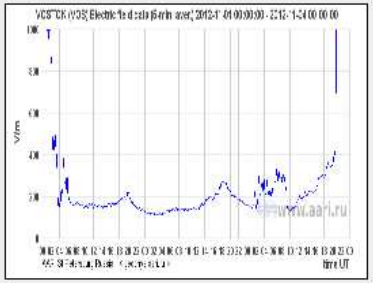
Риометр



Ионозонд вертикального зондирования

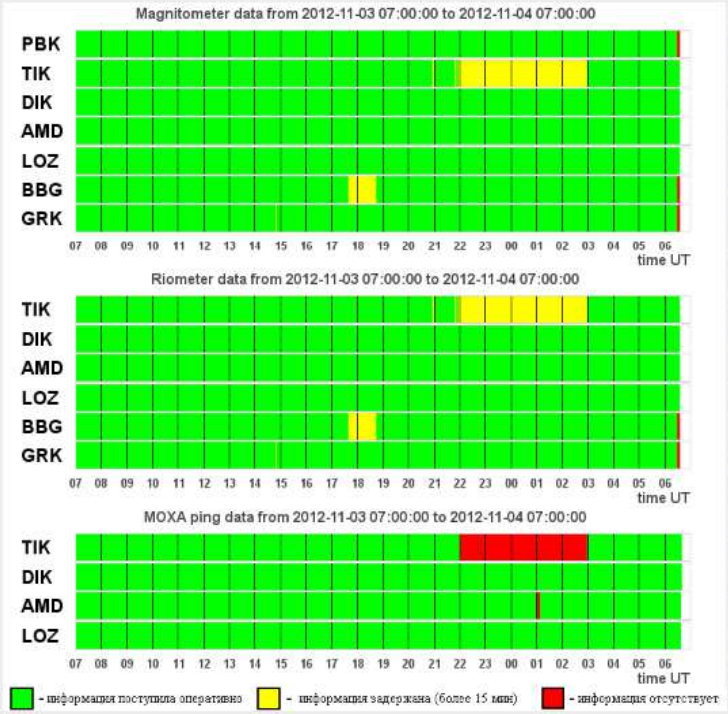


Ионозонд наклонного зондирования



Атмосферное эл.поле

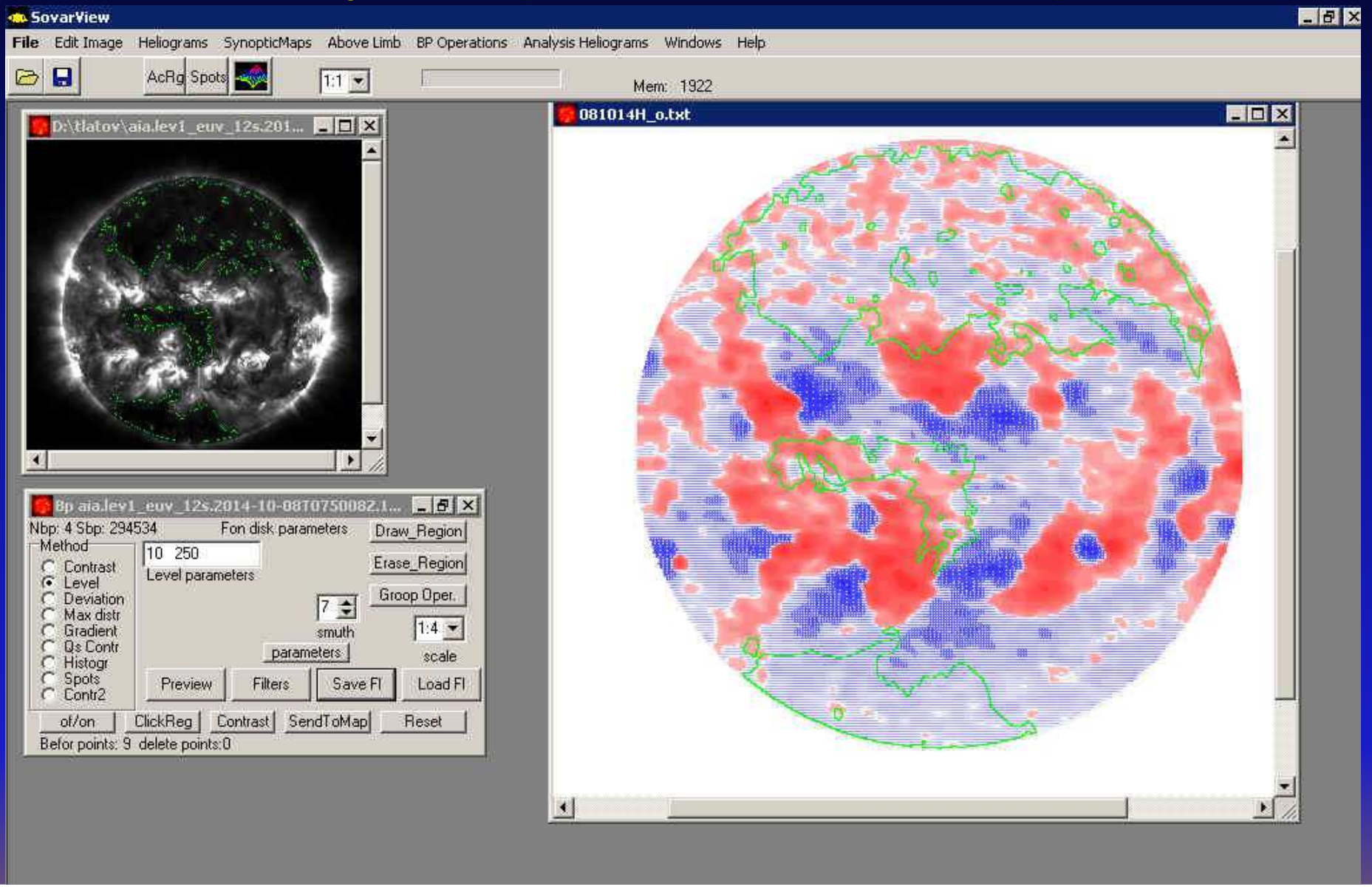
Оперативное поступление информации



07:38:25 Воскресенье 04.11.2012

SIBERIAN RADIOHELIOGRAPH

Illustration of the «SolarView» program with separate images: coronal holes according to space apparatus SOHO, magnetic field by STOP (Kislovodsk –the Caucasus)



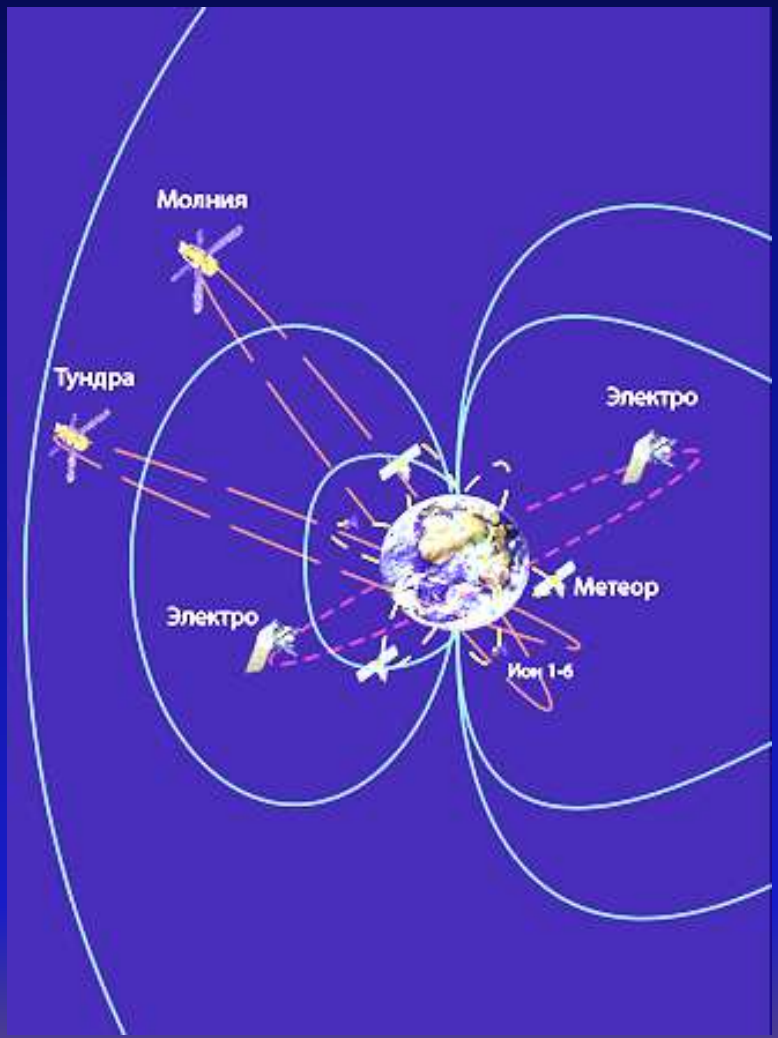
HELIOGEOPHYSICAL OBSERVATIONS

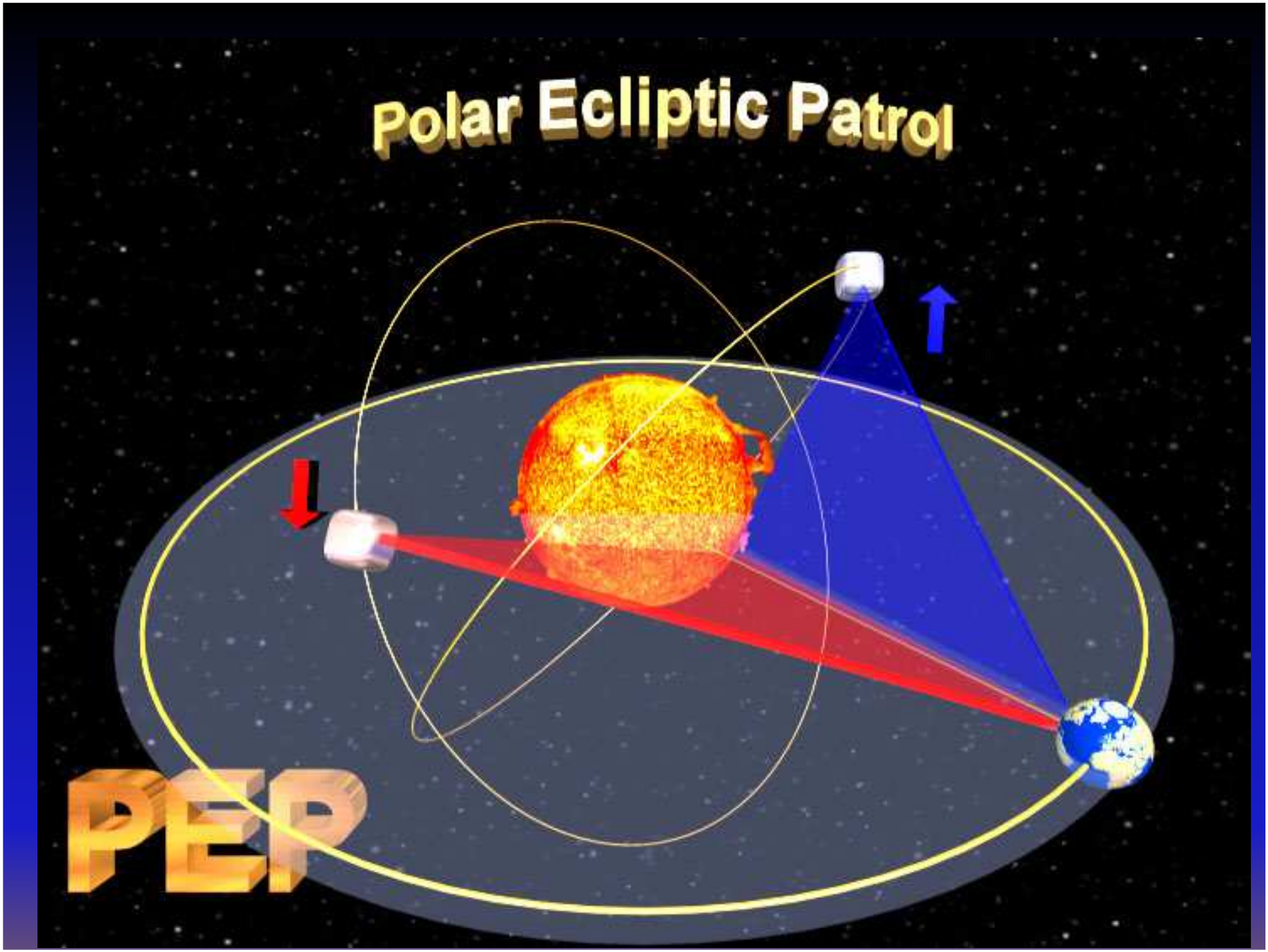
Ground based segment

Heliophysical	Magnetic
Ionosphere	Radio-tomography
Meteorological radar	Atmospheric electricity
Aerologic	Ozonometry
Sounding atmosphere by meteorological rocket and lidar	Thunderstorm detection

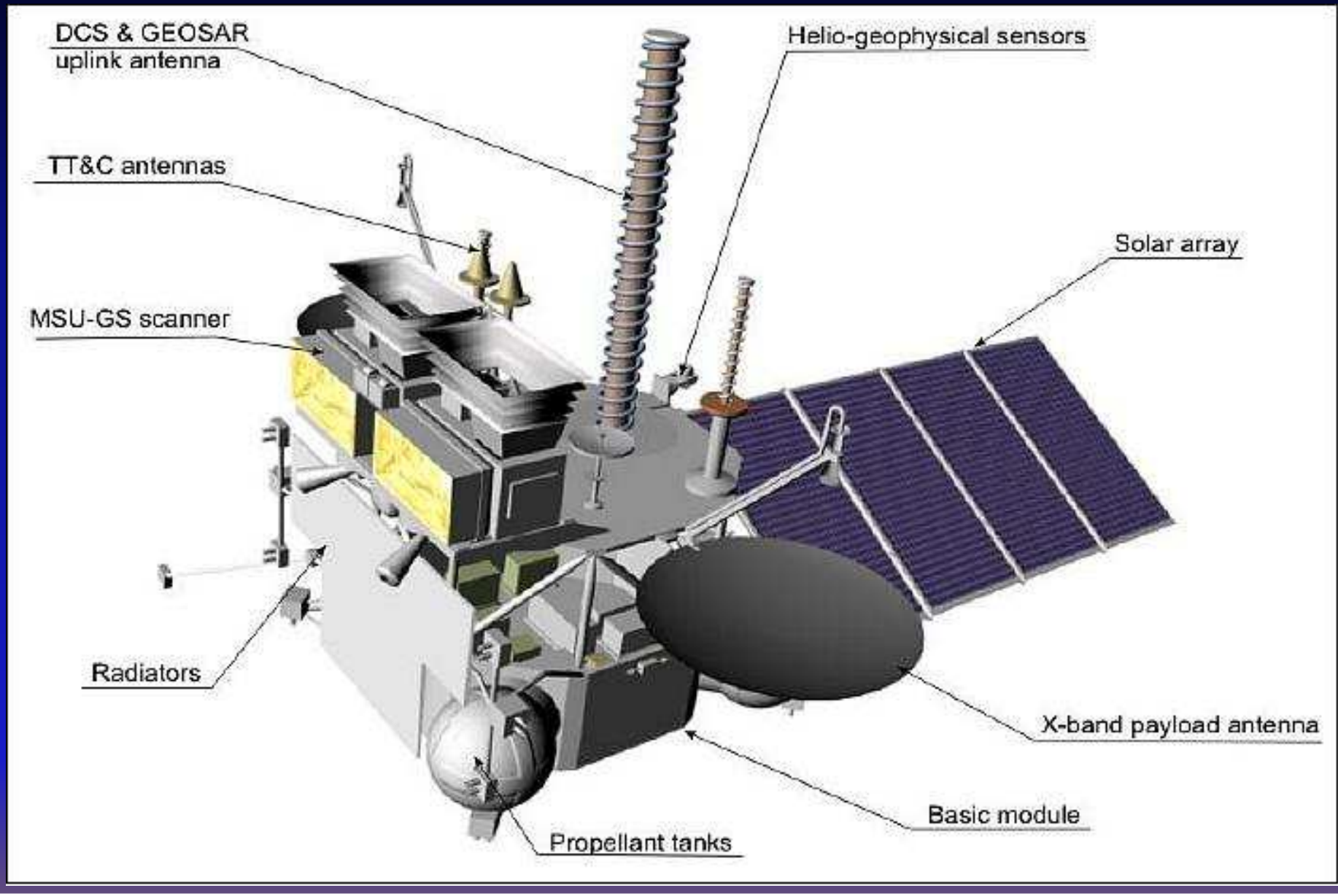
Space based segment

Heliophysical, Ionosphere, Magnetic, Radiation




Polar Ecliptic Patrol
PEP

ONBOARD COMPLEX GGAK on GEO «ELECTRO»



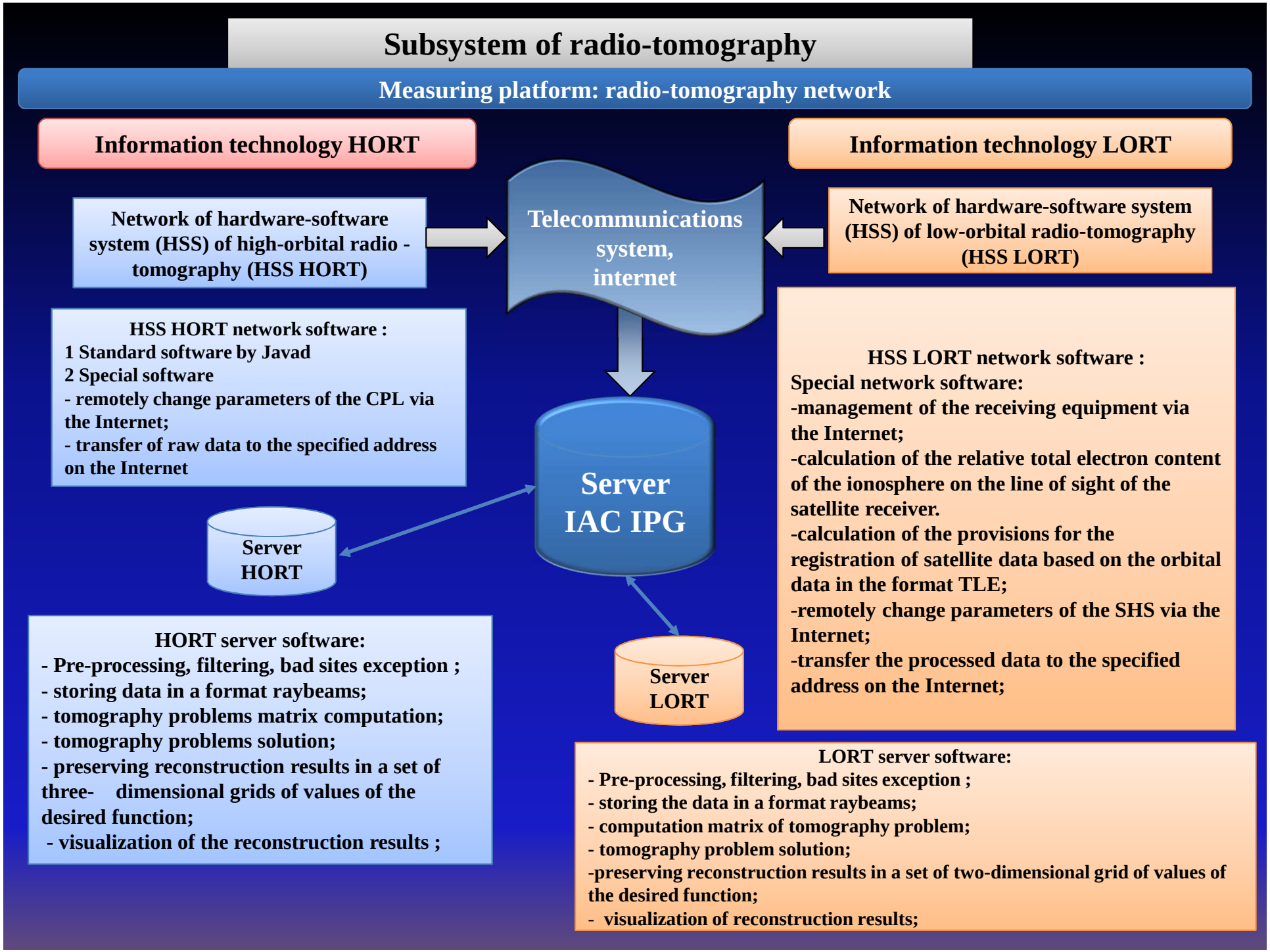
Space Complex “Ionozond”

Space complex "Ionozond":

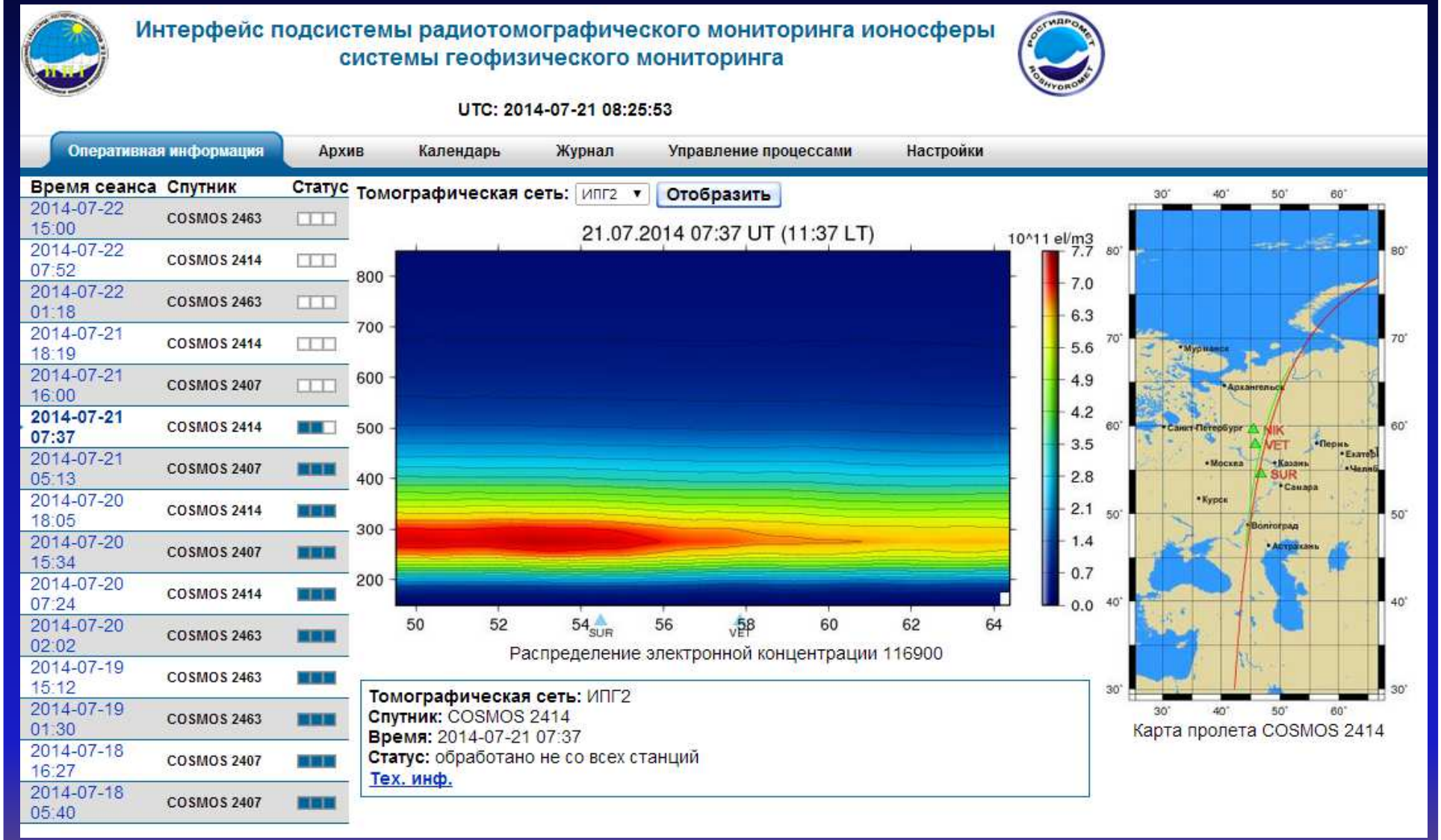
Subsystem “Ionosfera": four spacecraft in two orbit planes - “Ionosfera -T" and “Ionosfera-M") on a circular sun-synchronous low orbit (600-900 km altitude);

Subsystem "Zond": one spacecraft "Zond" on near-circular sun-synchronous near-terminator low orbit; 600-650 km altitude, orbital period 98 minutes, inclination 97°.

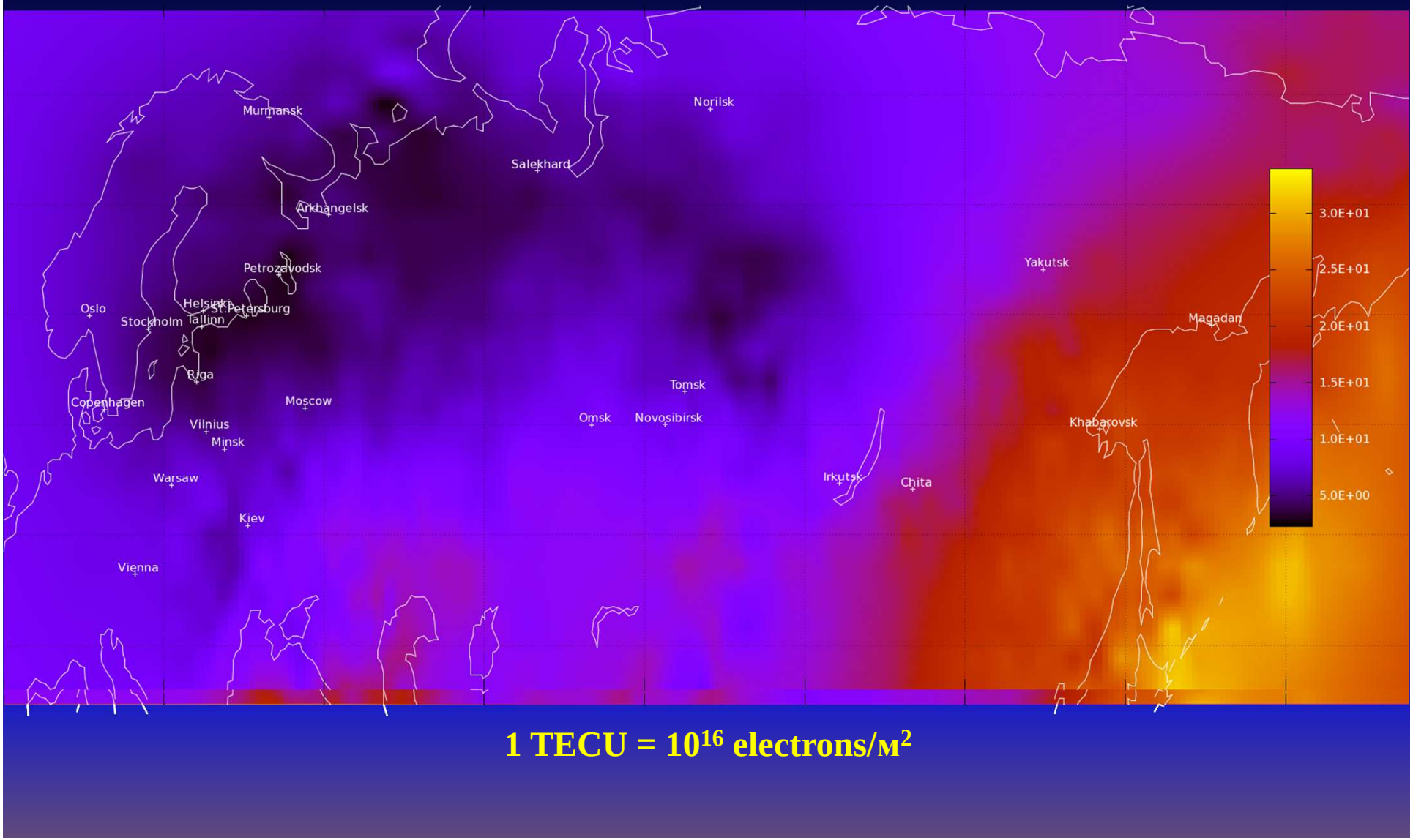
The scheme of the orbital structure of Space complex «Ionosond» (equatorial plane)


Subsystem of radio-tomography
Measuring platform: radio-tomography network
Information technology HORT
Information technology LORT
Network of hardware-software system (HSS) of high-orbital radio - tomography (HSS HORT)
Telecommunications system, internet
Network of hardware-software system (HSS) of low-orbital radio-tomography (HSS LORT)
HSS HORT network software :
1 Standard software by Javad
2 Special software
- remotely change parameters of the CPL via the Internet;
- transfer of raw data to the specified address on the Internet
Server IAC IPG
Server HORT
HSS LORT network software :
Special network software:
-management of the receiving equipment via the Internet;
-calculation of the relative total electron content of the ionosphere on the line of sight of the satellite receiver.
-calculation of the provisions for the registration of satellite data based on the orbital data in the format TLE;
-remotely change parameters of the SHS via the Internet;
-transfer the processed data to the specified address on the Internet;
HORT server software:
- Pre-processing, filtering, bad sites exception ;
- storing data in a format raybeams;
- tomography problems matrix computation;
- tomography problems solution;
- preserving reconstruction results in a set of three- dimensional grids of values of the desired function;
- visualization of the reconstruction results ;
Server LORT
LORT server software:
- Pre-processing, filtering, bad sites exception ;
- storing the data in a format raybeams;
- computation matrix of tomography problem;
- tomography problem solution;
-preserving reconstruction results in a set of two-dimensional grid of values of the desired function;
- visualization of reconstruction results;

Network of the hardware-software systems of high and low-orbital radio tomography (Here - for low orbital tomography)



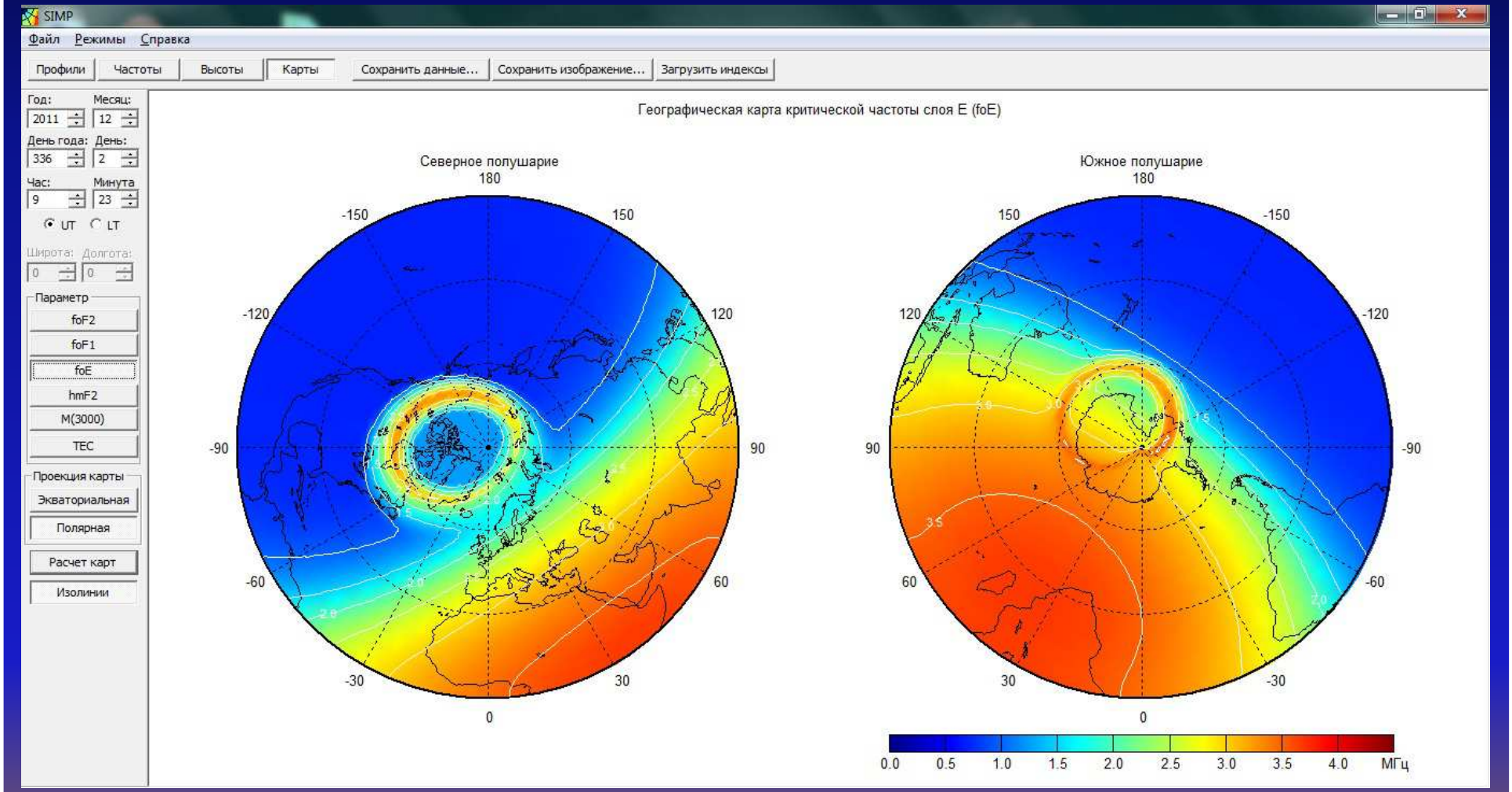
Variations of the total electron content over Russia on December 1st, 2014, (00:00 UT - 23:00 UT) by the Roshydromet's radiotomography net data



1 TECU = 10^{16} electrons/м^2

SIMP-2 (System of Ionosphere Monitoring and Prediction)

The program has been designed for evaluating ionosphere's current status and short-term forecasts of the ionosphere and radio waves's propagation. This technique is based on the ground and space board data and the correcting ionosphere models.



Nowcast appearance of the geoeffective proton fluxes in near-Earth space

The physical basis of nowcast:
1. Statistical relationship between the characteristics and the coordinates x-ray burst on the Sun and the flow of protons in the NES.
2.Information about the X-ray burst arrives after 8 minutes after the fact of the burst, and the appearance of proton fluxes near the Earth are usually recorded a few hours later

SWPC every minute X-ray text data (Goes 15)

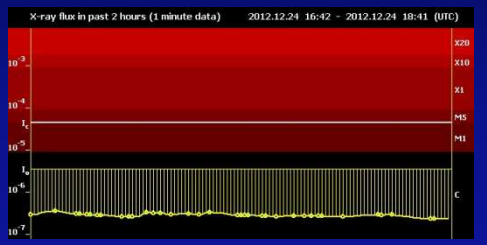
Pictures of the active regions of the Sun. where bursts usually occur (data from SDO, updated after 30 minutes).

SWPC data concerning the structure of the active regions

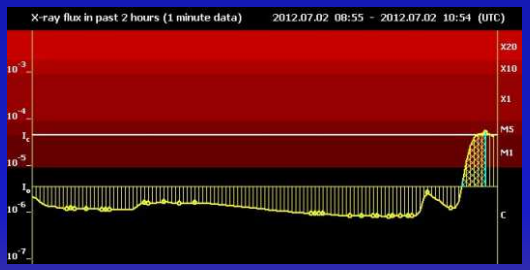
processing and data analysis

The level of X-ray radiation on NOAA's scale on our site(www.space-weather.ru)

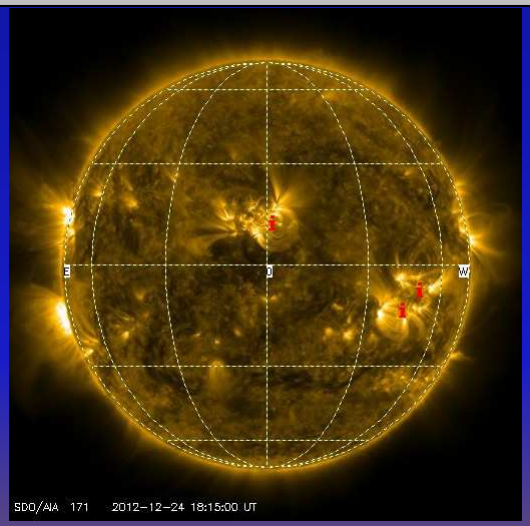
Selection and calculation of the X-ray characteristics



The proton danger warning on the IAG site



Linking the current picture of the Sun with the data on the active regions



COMPARISON OF THE RISKS OF THE RADIATION EXPLORATION

RADIATION INTENSITY DURING "VIENNA-QUEBEC" AIR FLIGHTS AT QUIET SUN

400 mcR /h

RADIATION INTENSITY AROUND FUKUSHIMA

100 mcR /h

RADIATION INTENSITY IN CHERNOBYL

60 mcR /h

Выбор параметров полета | Расчет полета | Мощность ГКЛ | Жесткость обрезания ГКЛ | ГКЛ без магнитного поля | Дополнительные сведения | Т

Выбор параметров полета по кратчайшему (геодезическому) маршруту

Выбор высоты полета (7.0 <= H <= 14) [км]:

12.0

Выбор средней скорости полета [км/час]:

900.0

Выбор даты полета:

04.09.2014

Выбранный месяц: 9

Выбор коэффициента модуляции:

- K = 0.3
- K = 1.5
- K = 0.7
- K = 2.0
- K = 1.0
- K = 2.5

Выбор точек вылета и прилета:

Вылет: Москва

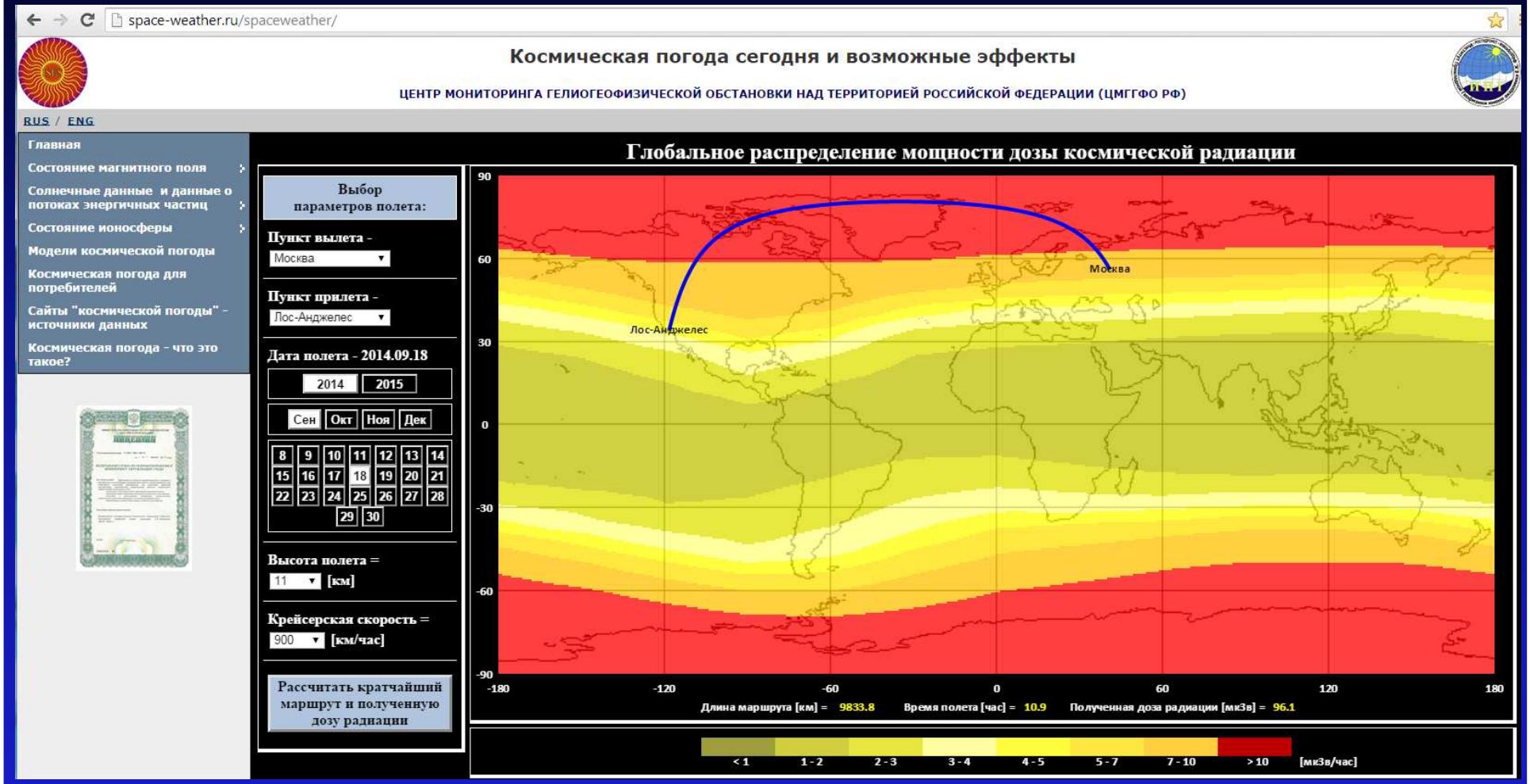
Прилет: Нью-Йорк

Москва
Анкоридж
Астана
Асунсьон
Берлин
Ванкувер
Веллингтон
Гавана
Джакарта
Дубай
Каир
Касабланка
Кейптаун
Лондон
Лос-Анджелес
Магадан
Майами
Мыс Горн
Нью-Йорк
Нью-Дели
Париж
Пекин
Рио-де-Жанейро
Сантьяго
Сидней
Сиэтл
Тайбей
Токио
Хабаровск
Ханой

Выбор то

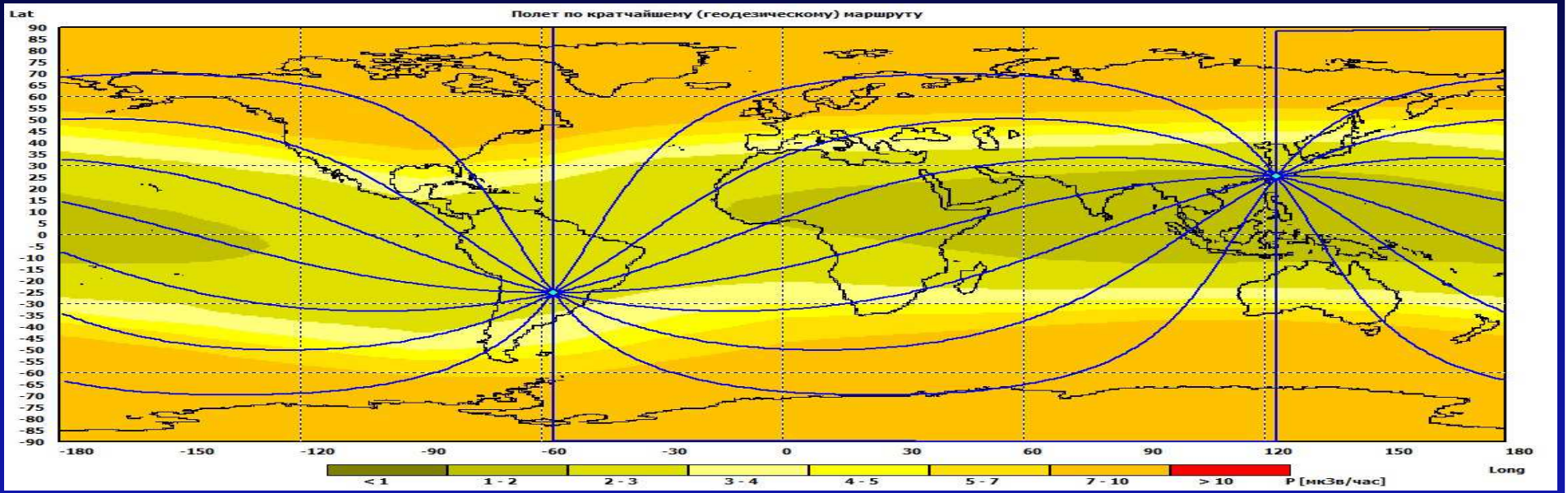
Рассчитать маршрут и полученную дозу

User interface for calculating the cosmic radiation during air transportations



www.space-weather.ru

Here you can see an interesting example of our calculations for antipodes points (Beijing – Asuncion)



- There is an unlimited number of the least-time tracks between Beijing and Asuncion with the equal distance. In this case the route choice may comply with the requirements of the minimal radiation dose.
- Height 10,8 km. Distance - 20049 km. Flight duration - 22, 3 h.
  - **Dose from 40 micZv up to 135 micZv.**

GROUND SEGMENT OF IONOSPHERE MONITORING SYSTEM

Methods and tools for terrestrial ionosphere observations

The network structure of the ionosphere observations

Methods of vertical radio sounding of the ionosphere

Vertical sounding ionosondes «Parus-A»

→ Moscow center of ionosphere monitoring
IPG Elektrougli
Central Siberian UGMS
Podkamennaya Tunguska
Far East UGMS Khabarovsk
North Caucasus UGMS Rostov-on-Don
West Siberian UGMS Novosibirsk
Kamchatka UGMS
Petropavlovsk-Kamchatski UGMS
Kolyma UGMS Magadan

Vertical sounding ionosondes«CADI»

→ Northern UGMS Dikson
Northern UGMS Amderma
Northern UGMS Heiss Island
Ob-Irtysh UGMS Salekhard
Murmansk UGMS Lovozero
GU AANII Gorkovskaya

The methods of oblique radio-sounding ionosphere

Oblique sounding ionosondes

→ Northern UGMS Dikson
Northern UGMS Amderma
Northern UGMS Heiss Island
Ob-Irtysh UGMS Salekhard
Murmansk UGMS Lovozero
GU AANII Gorkovskaya

THE SPACE SEGMENT OF IONOSPHERE MONITORING.

Methods and tools for space observations of ionosphere	The network structure of the ionosphere observations
Methods with satellite radio sounding of the ionosphere on the basis of ionosphere sensor «Laert»	
Vertical radiosounding	**Satellite system «Ionozond»** **Telemetry receiving stations: Moscow, Novosibirsk, Khabarovsk**
Trans-ionosphere radiosounding	**Satellite system «Ionozond» in a complex with ground-based ionosphere stations equipped with ionosonde «Parus-A»**
Methods of ionosphere radio tomography	Network of receivers GLONASS/GPS/Galileo
High-orbital complex radio tomographic studies of the ionosphere	**Moscow, Anapa, Kursk, Murmansk, Syktyvkar, Arkhangelsk, Bugulma, Vologda, Cheboksary, Magadan, Orenburg, Saratov, Anadyr, Zimovniki, Nizhni Novgorod, Petropavlovsk**
Low-orbiting complex radio tomographic studies of the ionosphere	**Moscow, Rostov, Kem, Babayevo Lipetsk, Verkhnetoluomsk**

OBSERVATION NET IN 2013

OBSERVATION NET BY 2016

USER IMPACT SUMMARY

We issue the short-term forecasts for parameters of ionosphere, for radio wave propagation, for characteristics of the magnetic activities, and we produce the information concerning the time of the beginning and the end of the space weather disturbances. Totally, there have been issued over 20 000 daily informative materials per year, for more than one hundred organizations.

HIGHEST PRIORITY PRODUCT GOALS

Particles fluxes in the near-earth space, distribution of the electrons in the ionosphere, magnetic field’s disturbance on the surface of the Earth.

FORECAST VERIFICATION RESULTS

We can’t forecast the time of the solar flare and CME appearance. At quite intervals our forecasts are excellent. In the terms of forecast success rate, it’s over 90%.
But, as I said many times, using the forecast success rate is incorrect. However, we haven’t yet agreed about other criteria for forecast verification.

HIGHEST PRIORITY DATA NEEDS

Particles fluxes in the near-earth space, distribution of the electrons in the ionosphere, variation of the magnetic field on the surface of the Earth, CME, solar radiation in the optical, ultraviolet, x-ray and radio wavelength bands, particles fluxes in the interplanetary medium; magnetic field, speed, temperature and density of the plasma in the interplanetary medium and near-earth space;

SPACE WEATHER SECTION FROM THE INSTITUTE OF APPLIED GEOPHYSICS IN THE NATIONAL CRISIS MANAGEMENT CENTER OF THE RUSSIAN EMERGENCIES MINISTRY

The “Space Weather Today” service has been created to provide the information about the current space weather situation and its probable negative sequences.

Space Weather Today and Related Phenomena

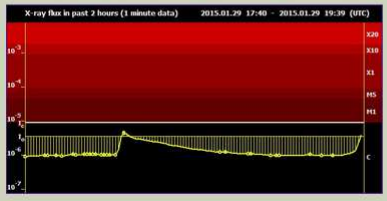
RUSSIAN HELIOGEOPHYSICAL MONITORING CENTER (RHMC)

RUS / ENG

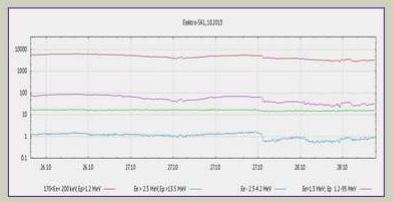
- Main Page
- Magnetic fields
- Flare Activity and Energetic Particle Fluxes
- Ionosphere
- Space Weather Models
- Space Weather Services
- Space Weather Related Links - Data Sources
- Space Weather - what is it?

Space Weather disturbances at the current time

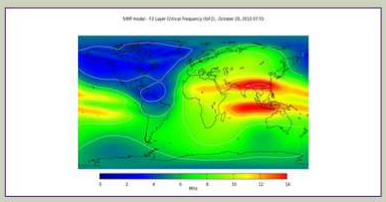
Geomagnetic Storms	Solar Radiation Storms	Radio Blackouts	Space Weather disturbances in the past 24 hours:
G5 G4 G3 G2 G1 Quiet	S5 S4 S3 S2 S1 Quiet	R5 R4 R3 R2 R1 Quiet	G: Quiet S: Quiet R: R1
Related phenomena	Related phenomena	Related phenomena	Kp-index (24 hours) Proton flux (24 hours) XRay flux (24*3 hours)



Solar Proton Flux Nowcasting

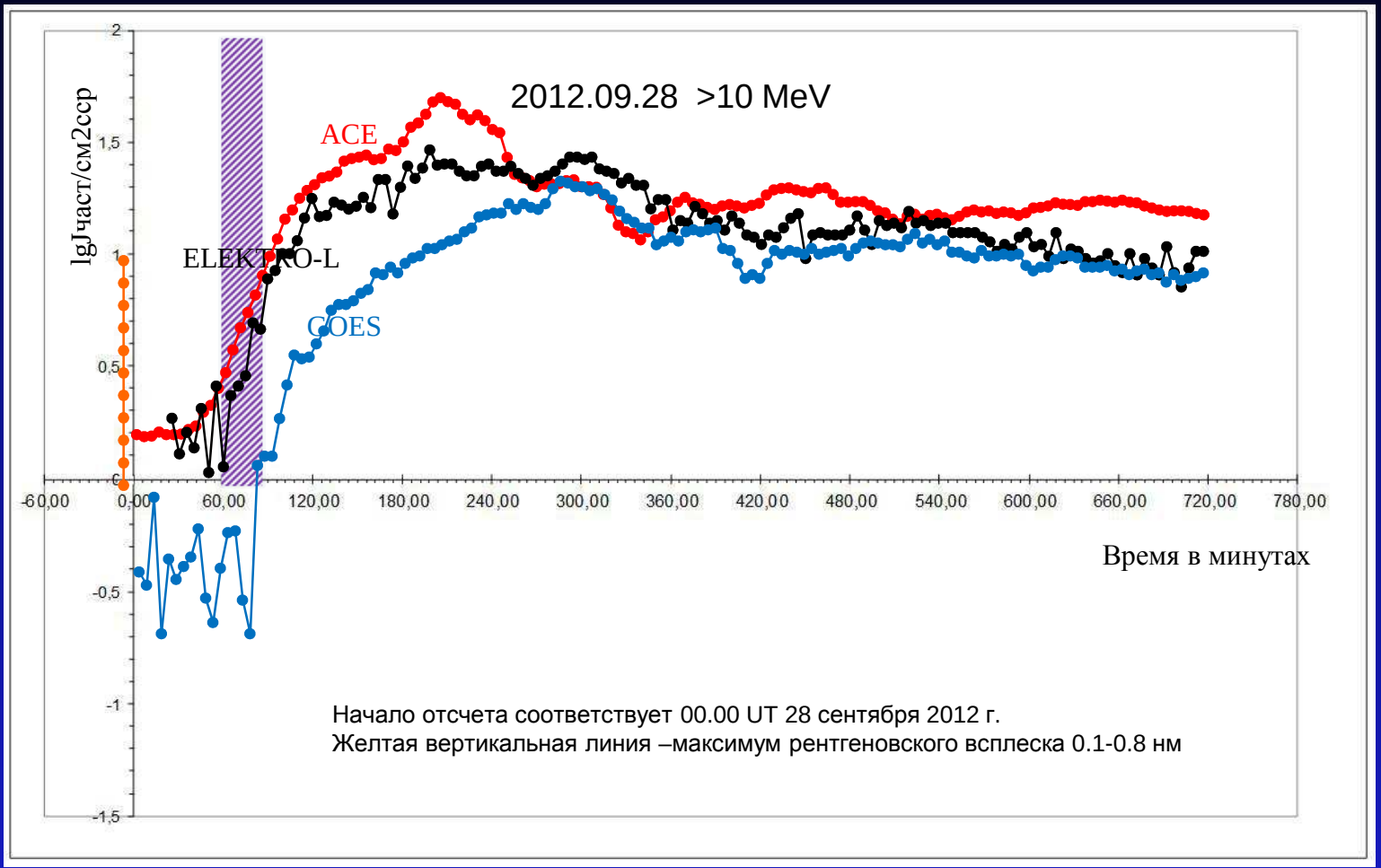


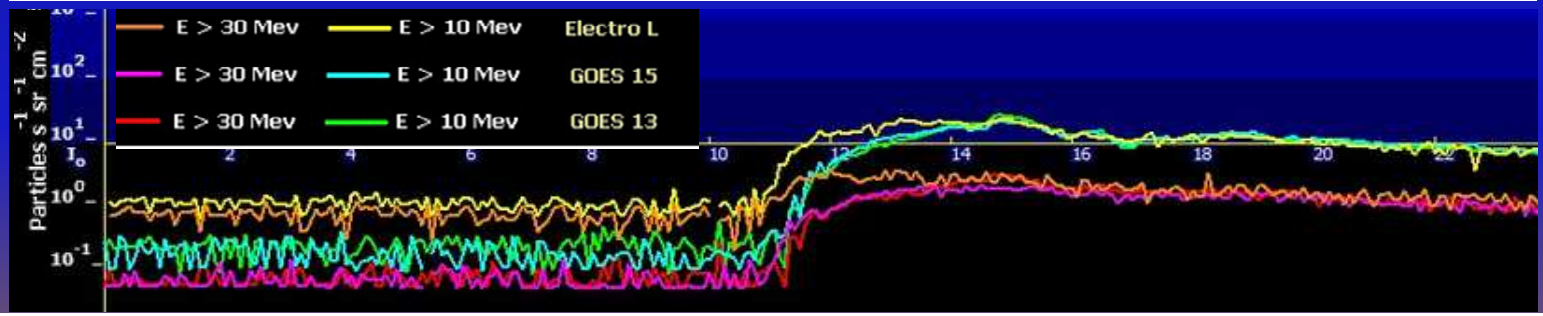
Particles Flux according to Elektro-L sattelite data



Ionosperic activity based on SIMP Model

SOLAR PROTON EVENT 28.09.2012





Thank you!