

MSU/Russia-NASA Space Weather Center Collaboration



V. Kalegaev

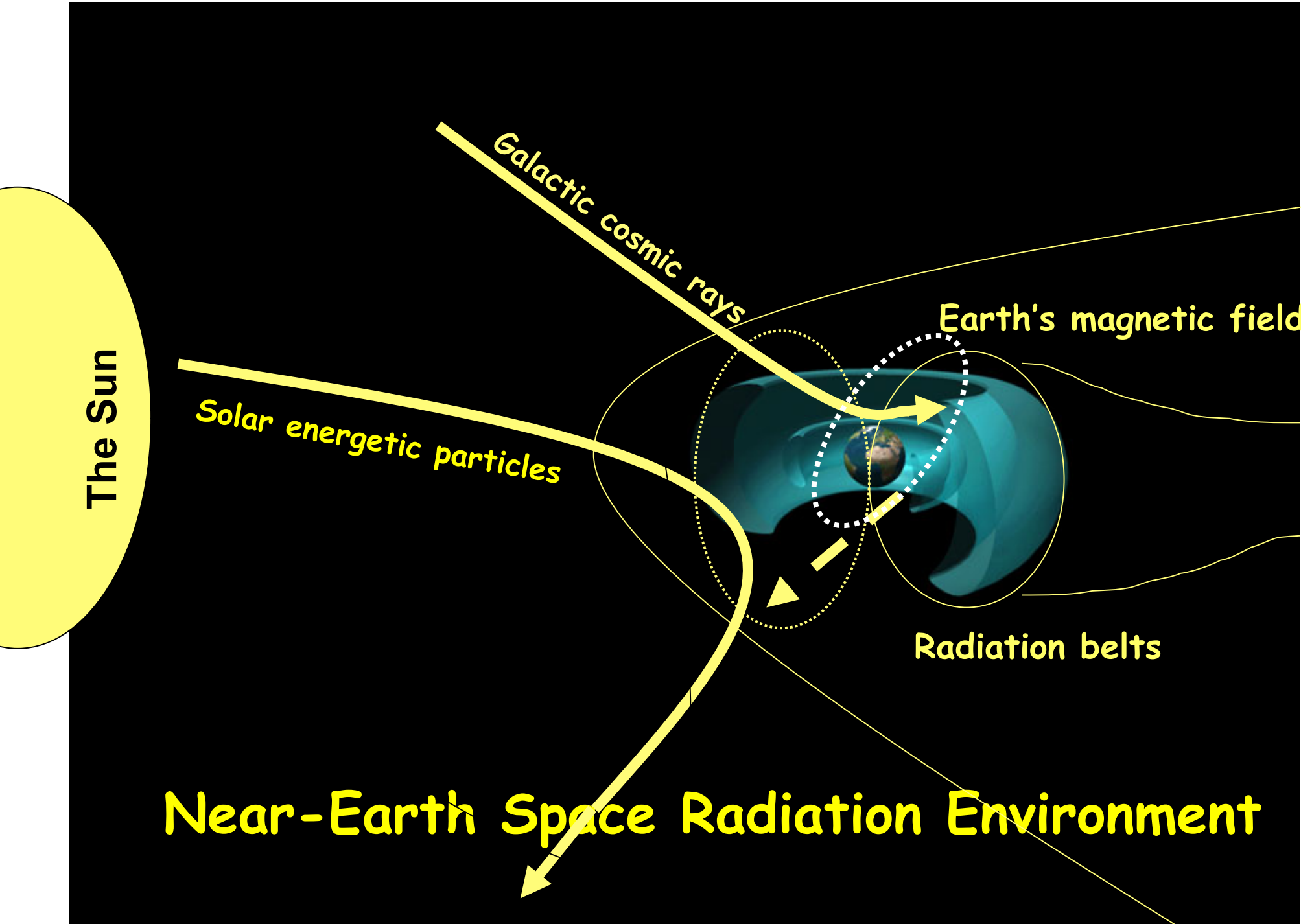
*Skobeltsyn Institute of
Nuclear Physics,
Moscow State University*





SINP/MSU Activities

- Space physics and astrophysics
- High energy physics
- Nuclear physics
- Informational technologies and telecommunications
- Investigation of nanostructures





Recent missions

- Coronas-F
- Meteor-3M
- Glonass
- Mir orbital station
- Coronas-Photon

- Tatyana 1
- Tatyana 2

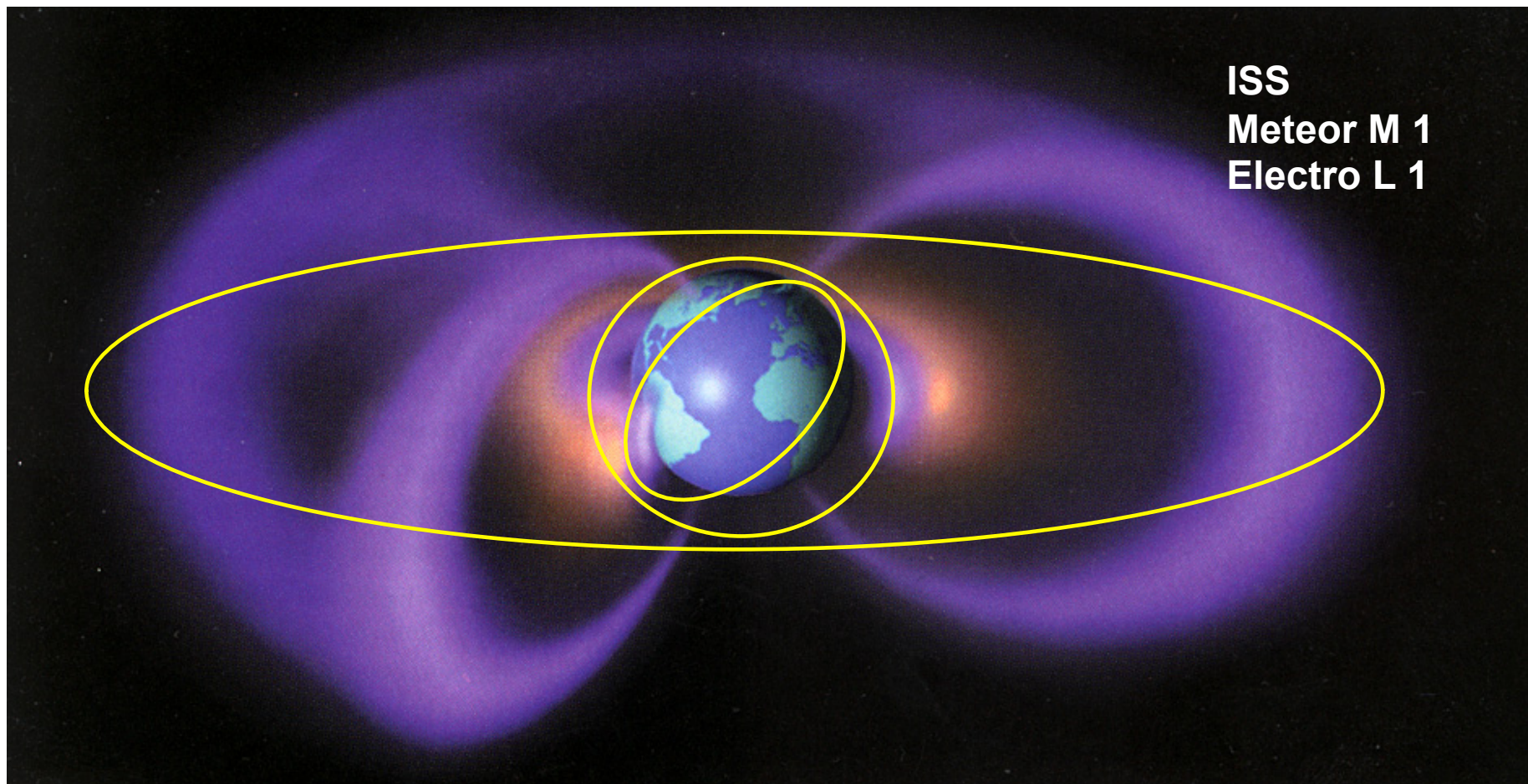
Energetic particle fluxes measurements

Main tasks:

- Solar protons and electrons dynamics in polar caps
- Penetration of solar particles in the Earth's magnetosphere during magnetic storms
- Electron fluxes variations in outer radiation belts

- Lomonosov
- Intergeliozond
- Relec

Current and future missions





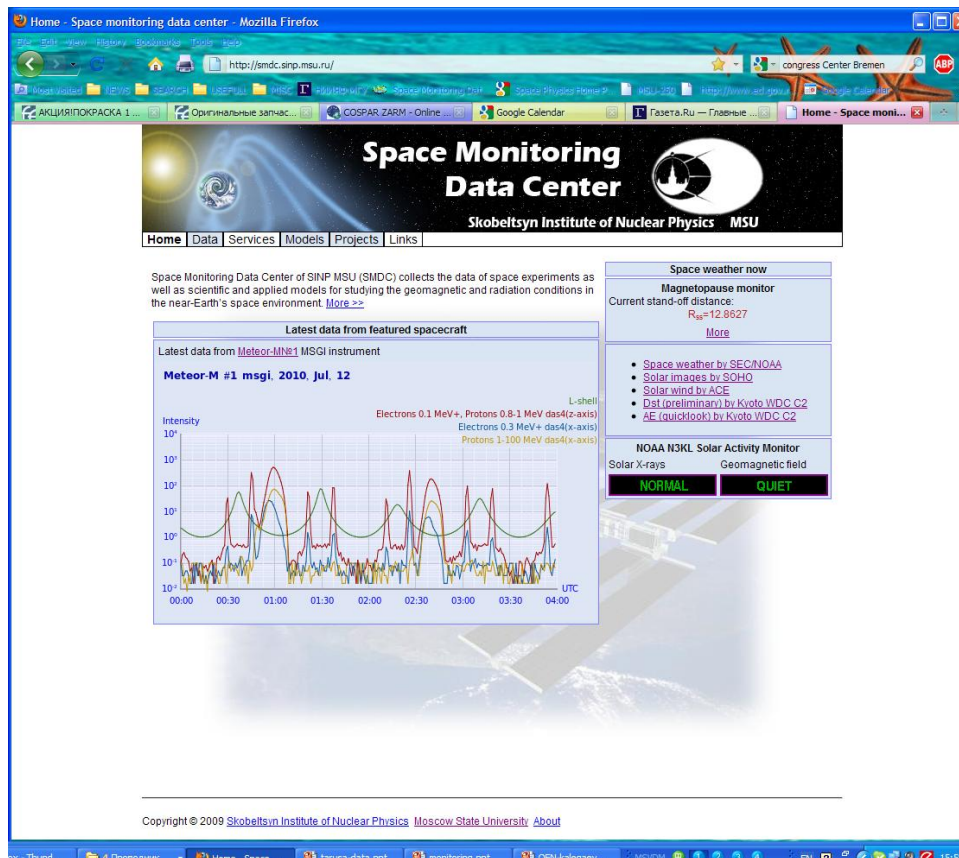
Space Monitoring Data Center of SINP MSU

- Established in 2005
- Main objective: provide engineering and scientific communities with reliable analysis of current space radiation conditions
 - Data collection and distribution;
 - Model's interfaces in the Web;
 - Real-time analysis of near-Earth's conditions.



Internet Portal of Space Monitoring Data Center

<http://smdc.sinp.msu.ru>



1. Data bases (Oracle)
2. Models
3. Real-time systems

Coronas-I
Coronas-F
Meteor-3M
Mir orbital station
Coronas-Photon
Tatyana 1
Tatyana 2

Integrated data bases...



Data access

Table

Figure

File

The screenshot shows the Space Monitoring Data Center website. The browser address bar displays <http://smdc.sinp.msu.ru/index.py?nav=photon>. The page title is "Space Monitoring Data Center" and the subtitle is "Skobeltsyn Institute of Nuclear Physics MSU". The navigation menu includes "Home", "Data", "Services", "Models", "Projects", "Experiments", "Links", and "Sign in". The main content area is titled "Coronas-Photon" and includes a link for "Overview [Particle fluxes]". Below this, it states "Data available from 2009-03-04 and arriving in quasi real time." The "Time interval" section has two rows of dropdown menus: the first row is set to "4", "March", "2009", "19", "0"; the second row is set to "4", "March", "2009", "23", "0". The "Output type" section has three radio buttons: "Table" (selected), "Graphic", and "File". The "Data channels" section lists several energy ranges and parameters with checkboxes: E_e 0.2 - 1.0MeV, E_e 1 - 4MeV, $E_e > 4$ MeV, E_p 4 - 16MeV, E_p 41 - 55MeV, $E_p > 80$ MeV, E_e 5-16MeV/nucleon, E_e 16 - 24MeV/nucleon, CNO 6 - 15MeV/nucleon, X [km], Y [km], Z [km], and Latitude [deg]. At the bottom, there is a copyright notice: "Copyright © 2007 Skobeltsyn Institute of Nuclear Physics Moscow State University About" with flags for the UK and Russia.



Data processing

Telemetry and TLE

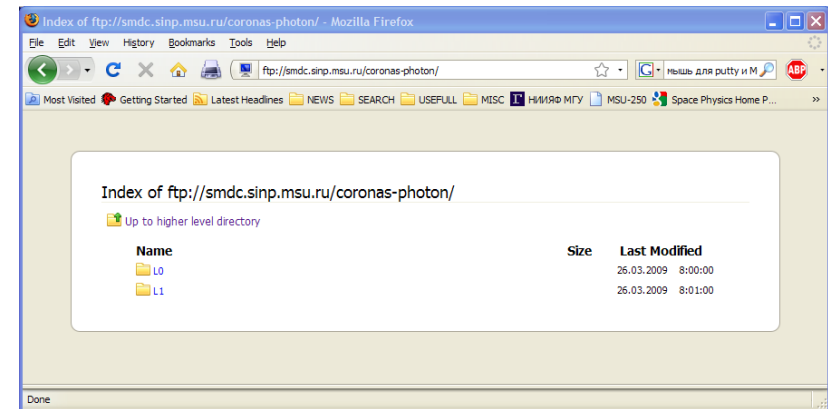
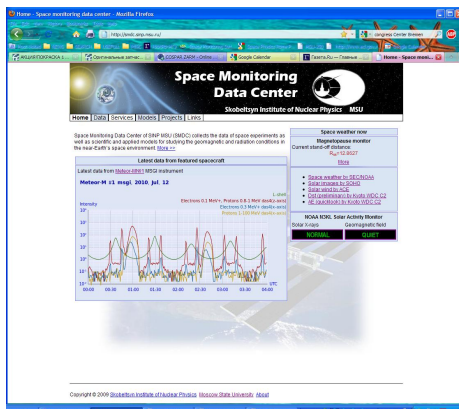
Processing

Coordinates, data_1, data_2, ..., data_n

Web-site

FTP-server
<ftp://smdc.sinp.msu.ru>

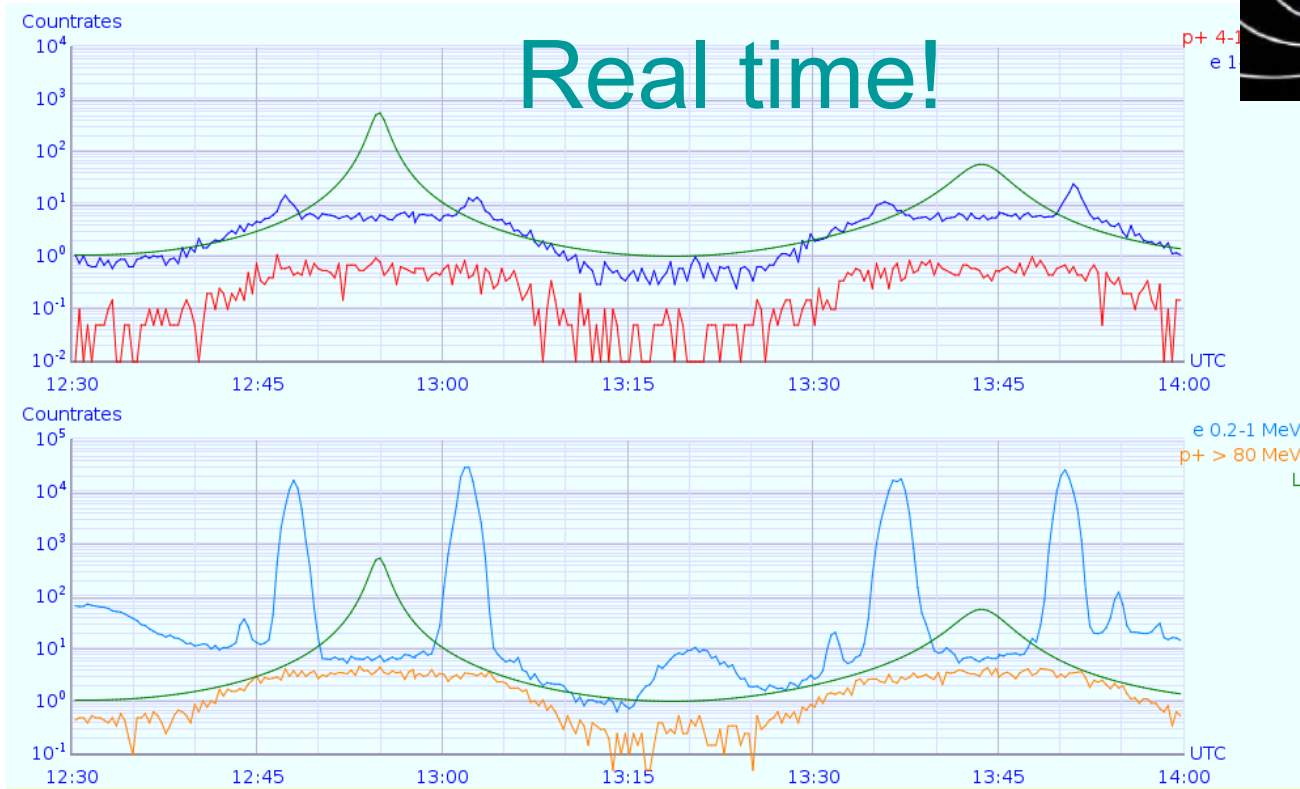
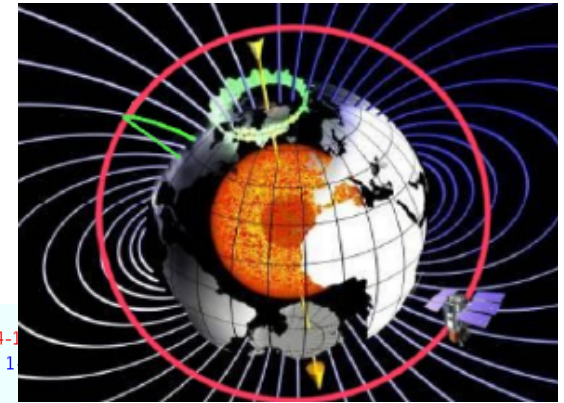
ORACLE RDB





Radiation conditions monitoring by low-altitude spacecrafts

Registration of ERB particle fluxes

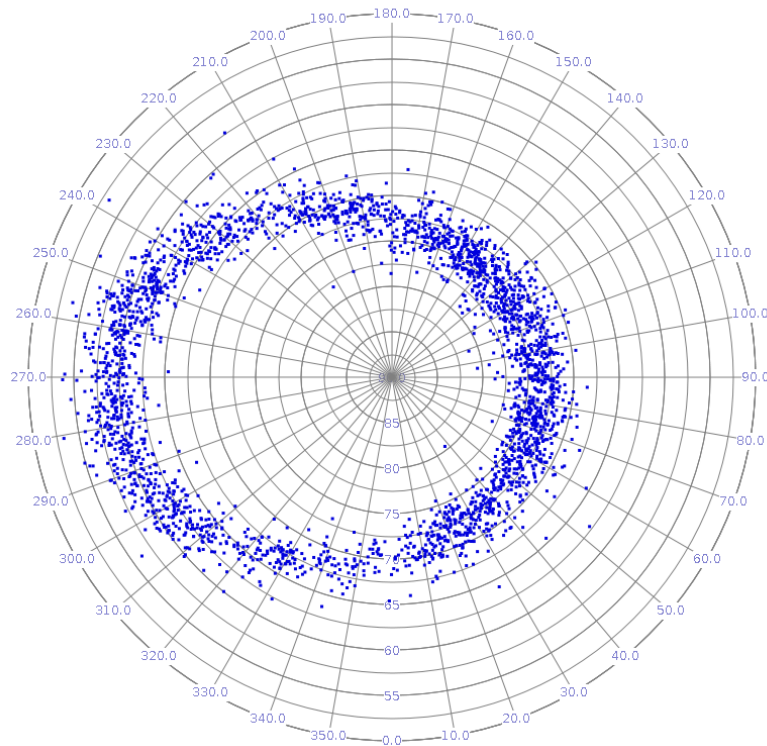


**Meteor-M 1
Coronas-Photon
Tatyana-1 and 2**



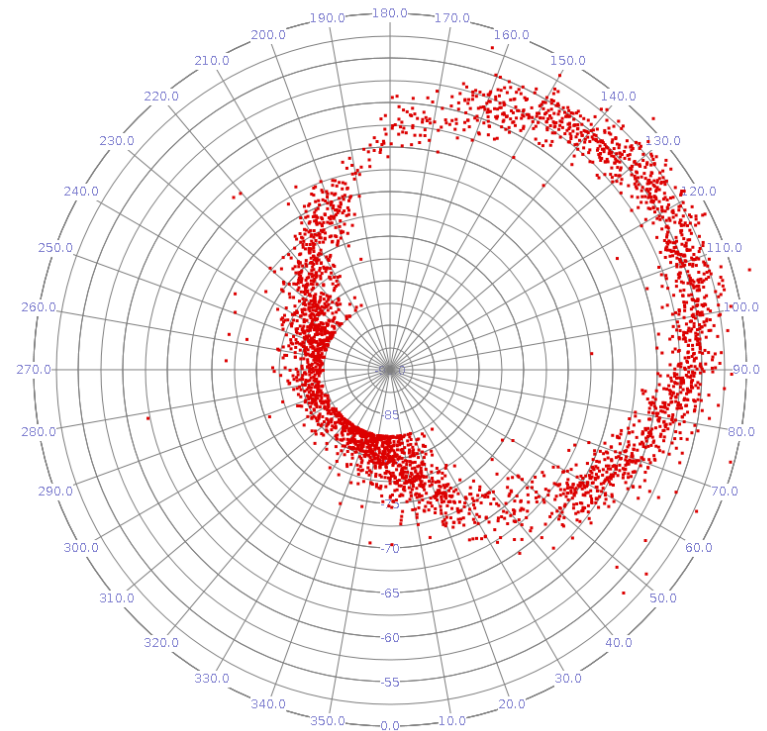
Outer ERB high-latitude boundary location (geographical coordinates)

Northern oval (0-24 hours UT) + |lat|,lon|



North

Southern oval (0-24 hours UT) + |lat|,lon|

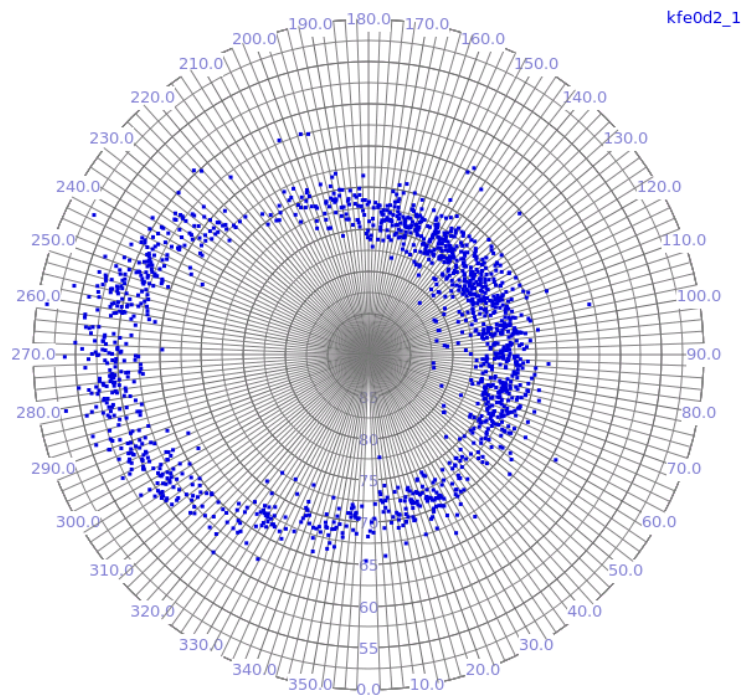


South

IGRF and magnetospheric currents influence

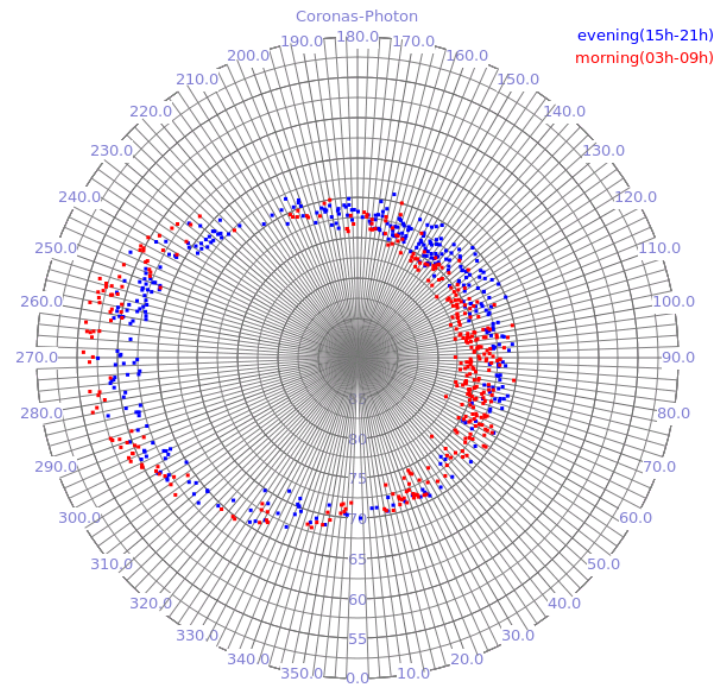


Outer ERB high-latitude boundary location: UT effect in measured data



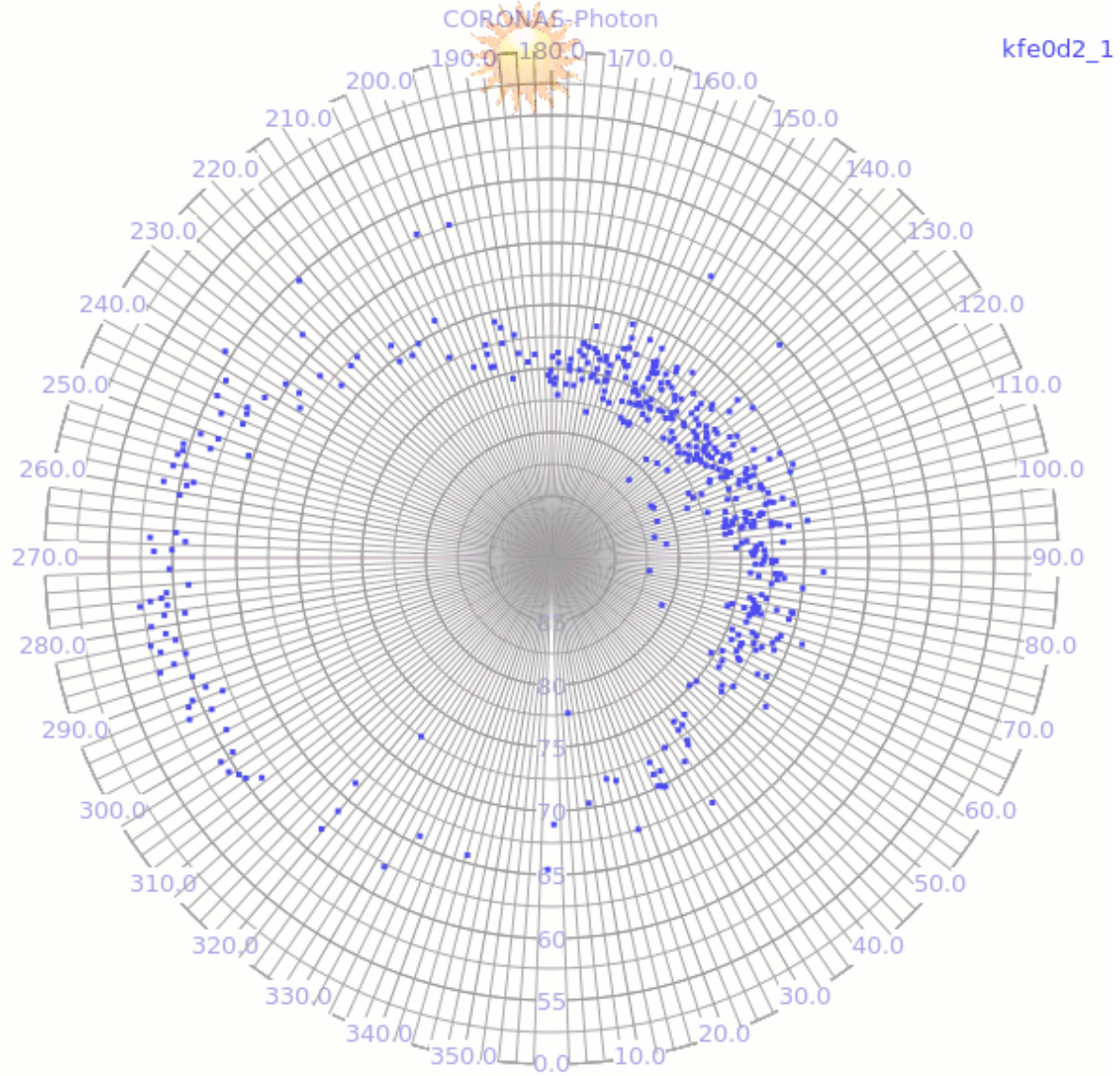
Full data set

Sun



Sun

Data around UT=5,55h and UT=17,55h





Theoretical research

- Sun
- Heliosphere
- Earth's magnetosphere
- Magnetospheres of the planets in Solar system
- Cosmic rays
- Radiation belts



Paraboloid model of the magnetospheric magnetic field (by I. Alexeev et al.)

experimental data

⇓ - submodels

**parameters of the magnetospheric
current systems**

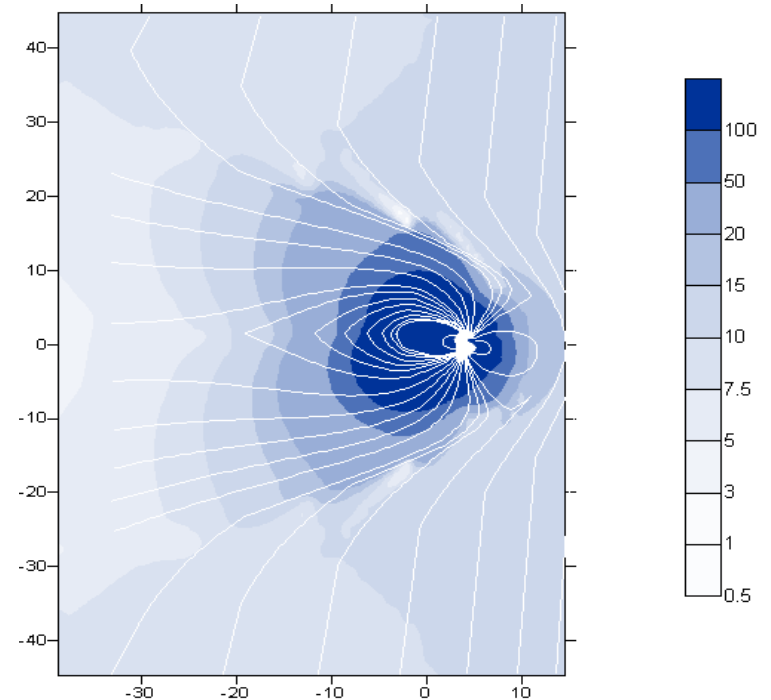
⇓ -A2000

magnetospheric magnetic field

Applications to magnetospheres of

- Jupiter
- Saturn
- Mercury

<http://smdc.sinp.msu.ru/index.py?nav=model-para>

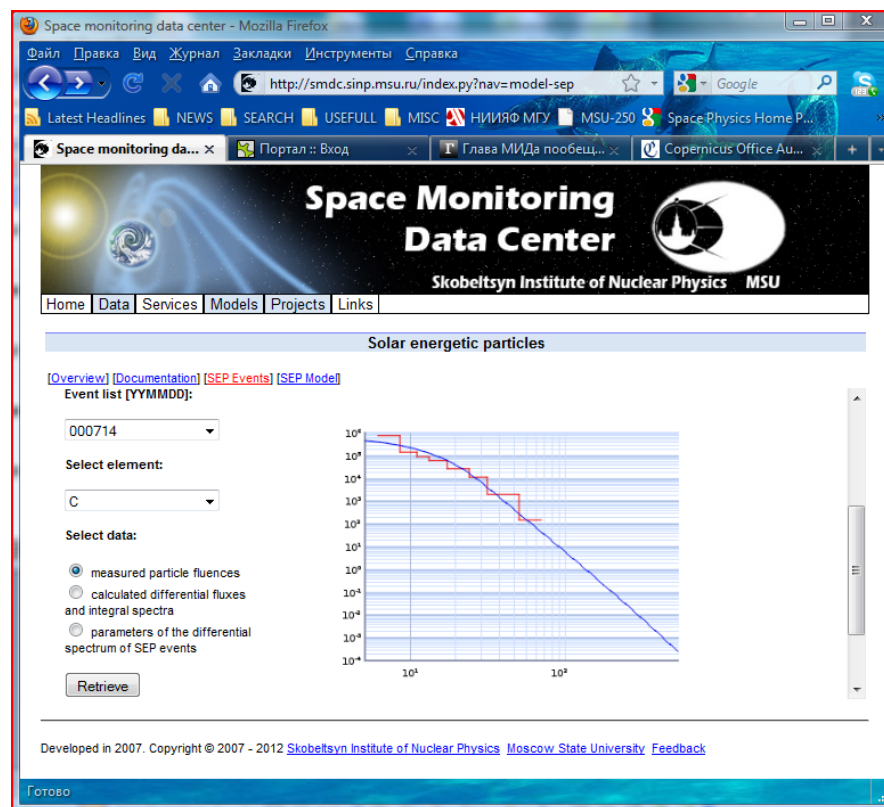


ISO CD No 22009 "Space Environment (Natural and Artificial). Model of the Earth's Magnetic Field."



Semi-empirical probabilistic model of SEP fluxes (by R. Nymmik)

- describes solar energetic particle fluxes depending on solar activity level

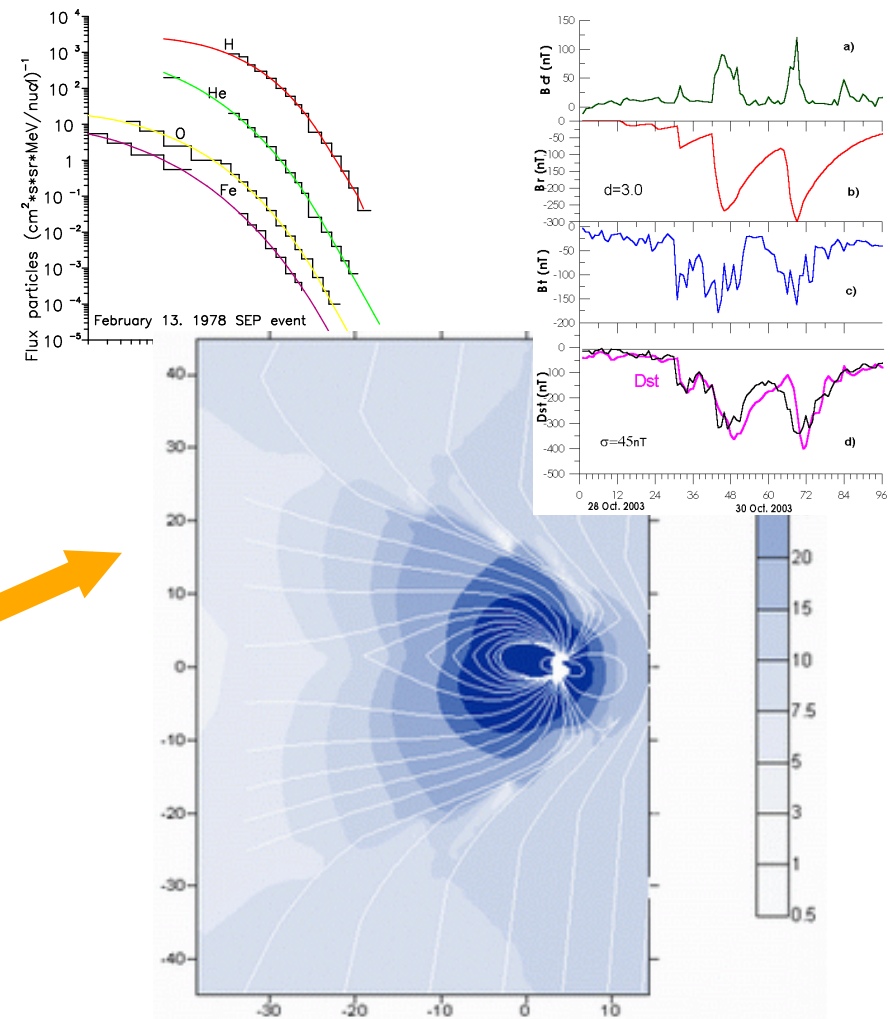
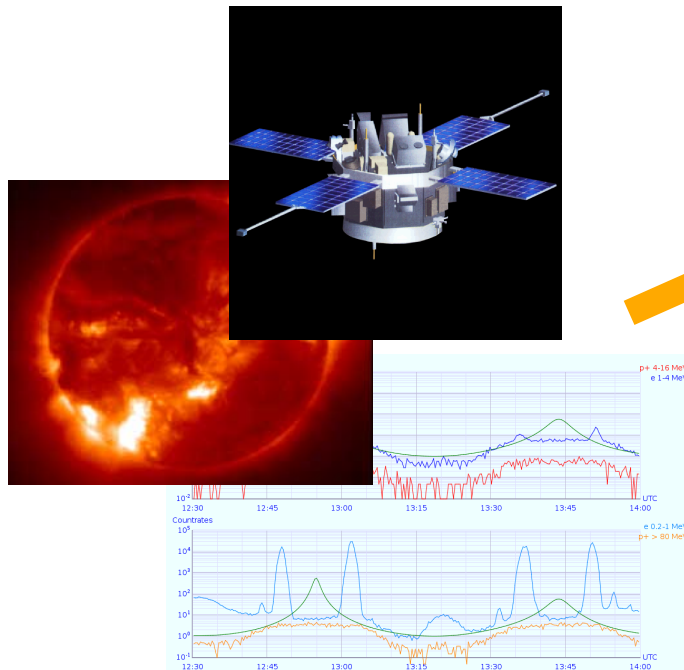


<http://smdc.sinp.msu.ru/index.py?nav=model-sep>



Real-time services

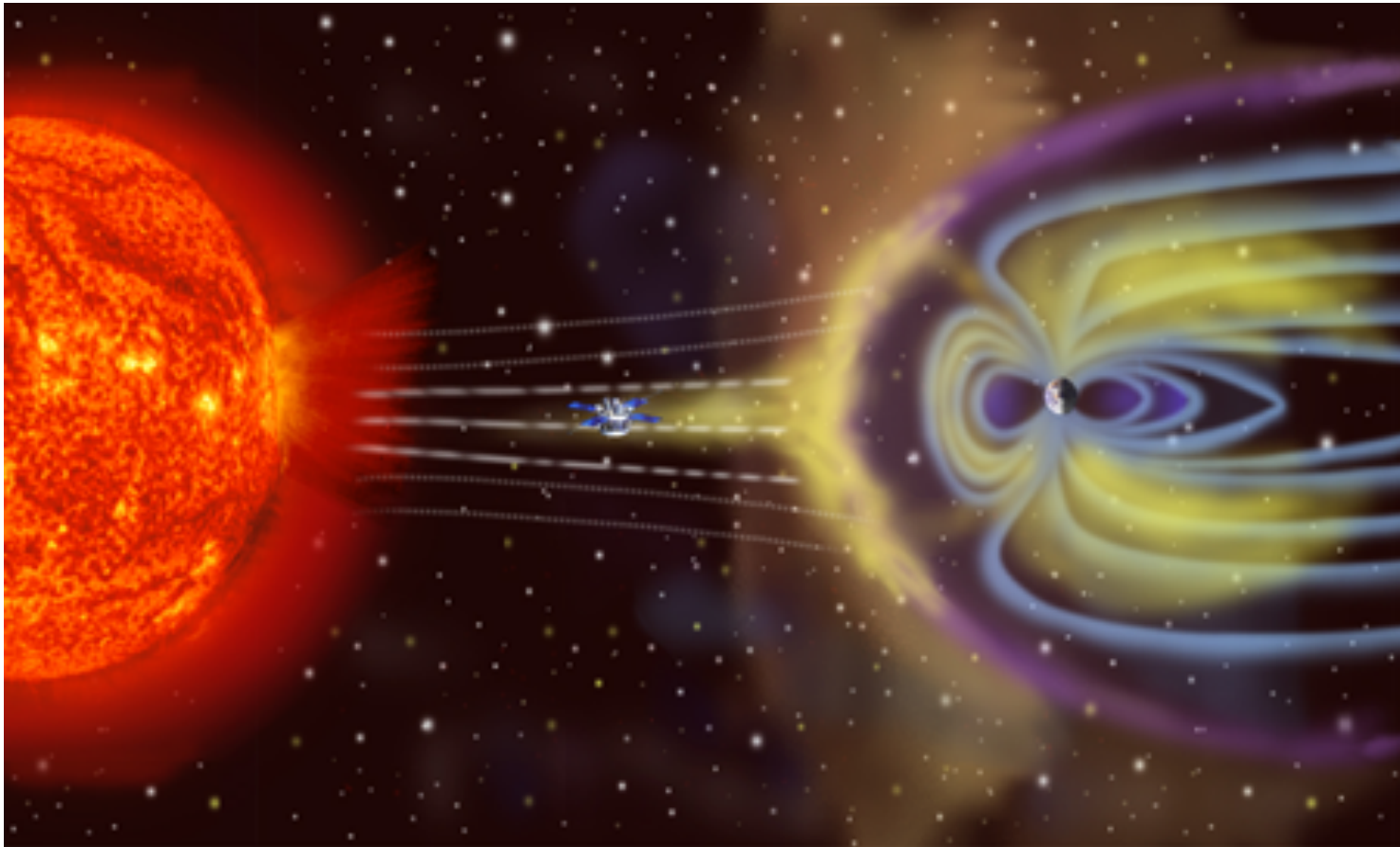
- Data from Space
- Modeling
- Scientific applications
- Space weather prediction





Magnetopause monitor

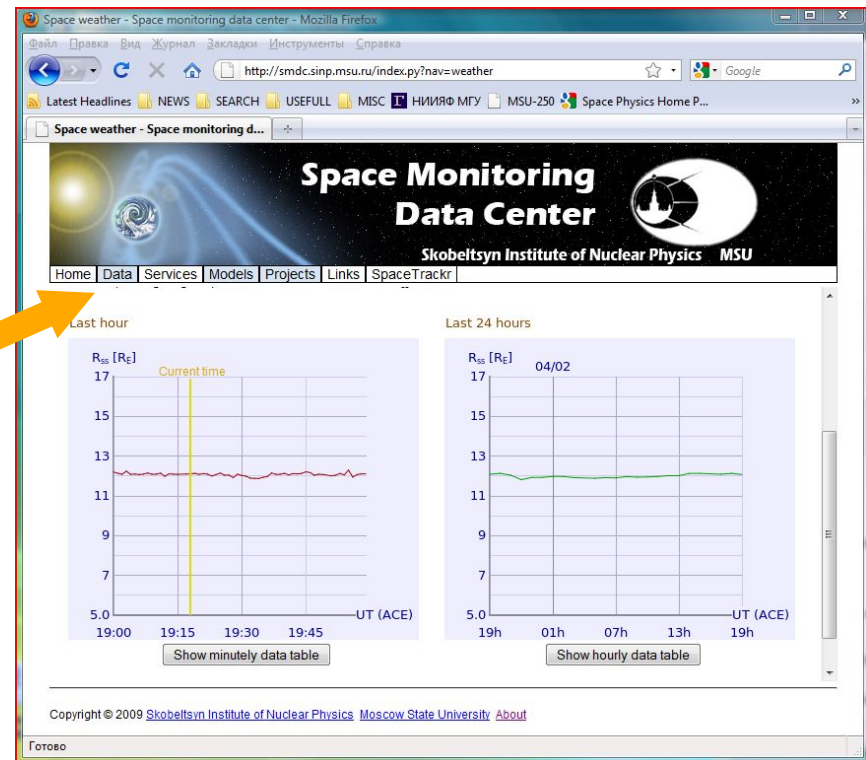
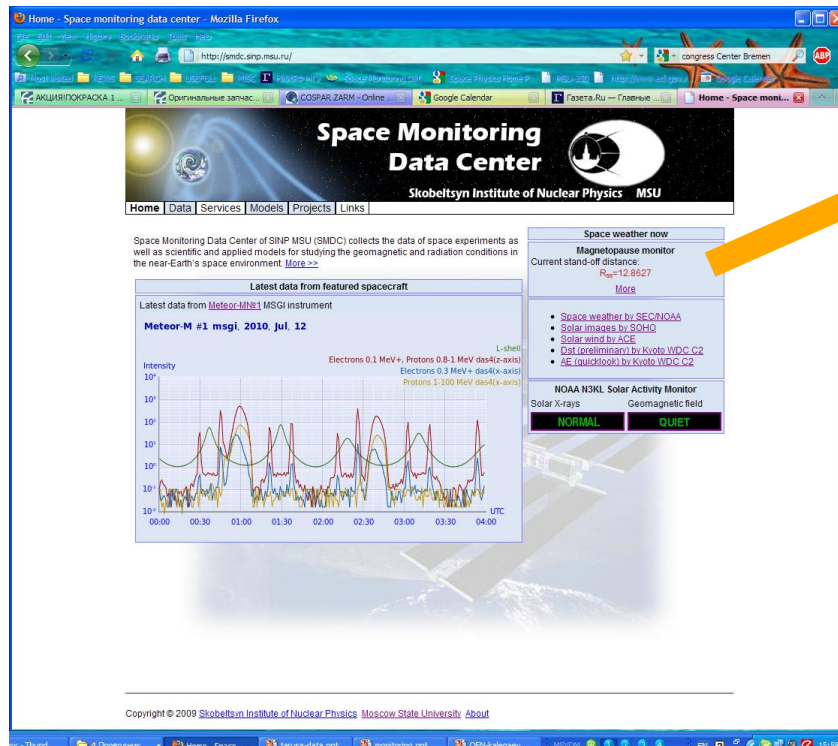
Solar wind monitoring by ACE





Magnetopause stand-off-distance

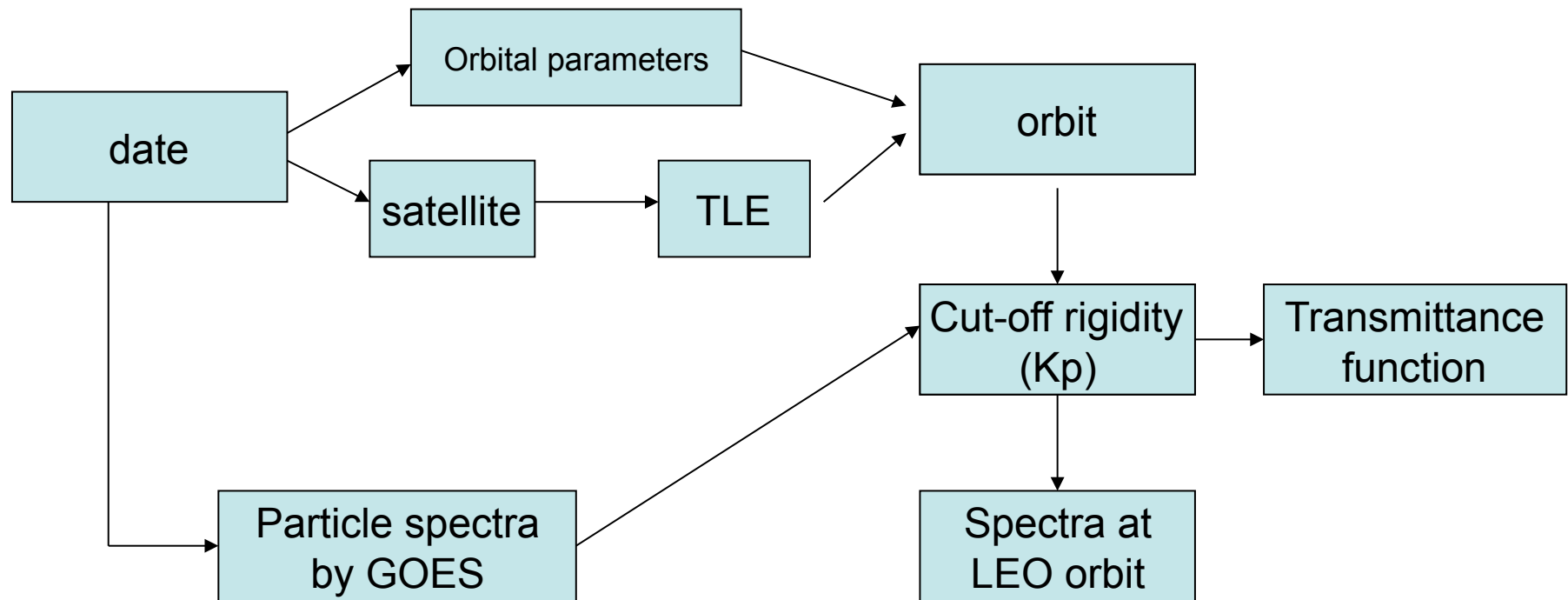
$$R_{SS} = 8.6 * (1 + 0.407 * \exp(-(|Bz| - Bz)^2 / (200 * p^{0.15}))) * p^{-0.19} - \text{by S.N. Kuznetsov}$$



Input from ACE



Particle spectra at LEO orbits



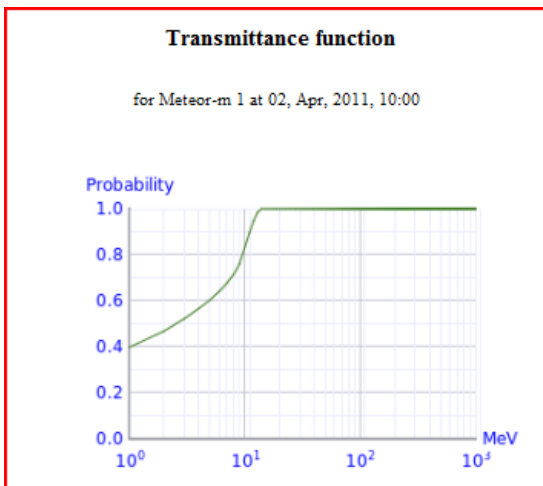
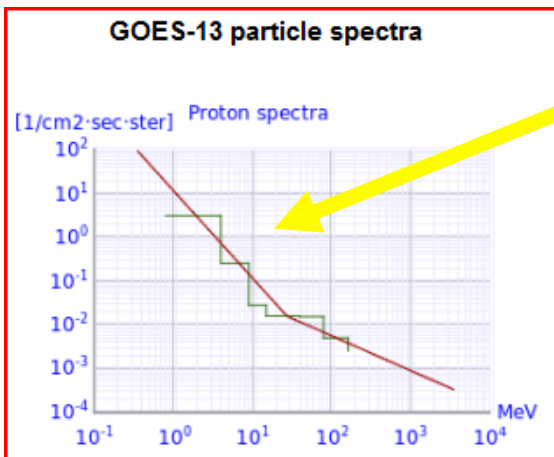
Input from NORAD, NOAA/GOES, Potsdam (Kp), Meteor-m 1



Particle spectra at LEO orbits

SEP spectra from GOES

SEP spectra at LEO
Cut-off model by R. Nymmik



Space monitoring data center - Mozilla Firefox

http://smdc.sinp.msu.ru/index.py?nav=dosepredict

Space Monitoring Data Center

Skobeltsyn Institute of Nuclear Physics MSU

Home | Data | Services | Models | Projects | Links

Education
 All types (except debris)

Filter by name or ID:

Matching objects

- ELEKTRO-L1
- METEOR-M

[Submit]

Meteor-m 1 particle spectra

Position: lat/lon=-72.4/202.19, h=825.39km. [More](#)

Cutoff rigidity: 0.08 GeV/c

[1/cm²·sec·ster] Proton spectra

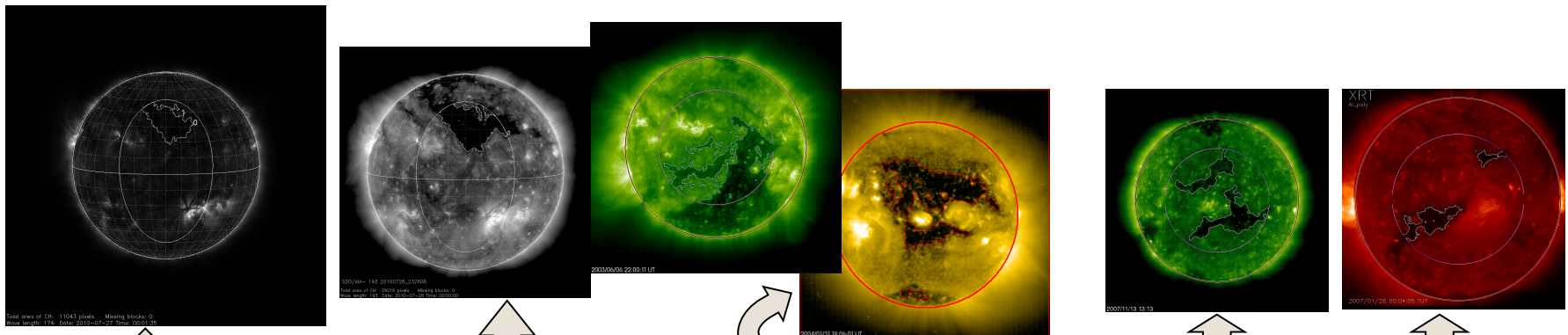
MeV

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Готово



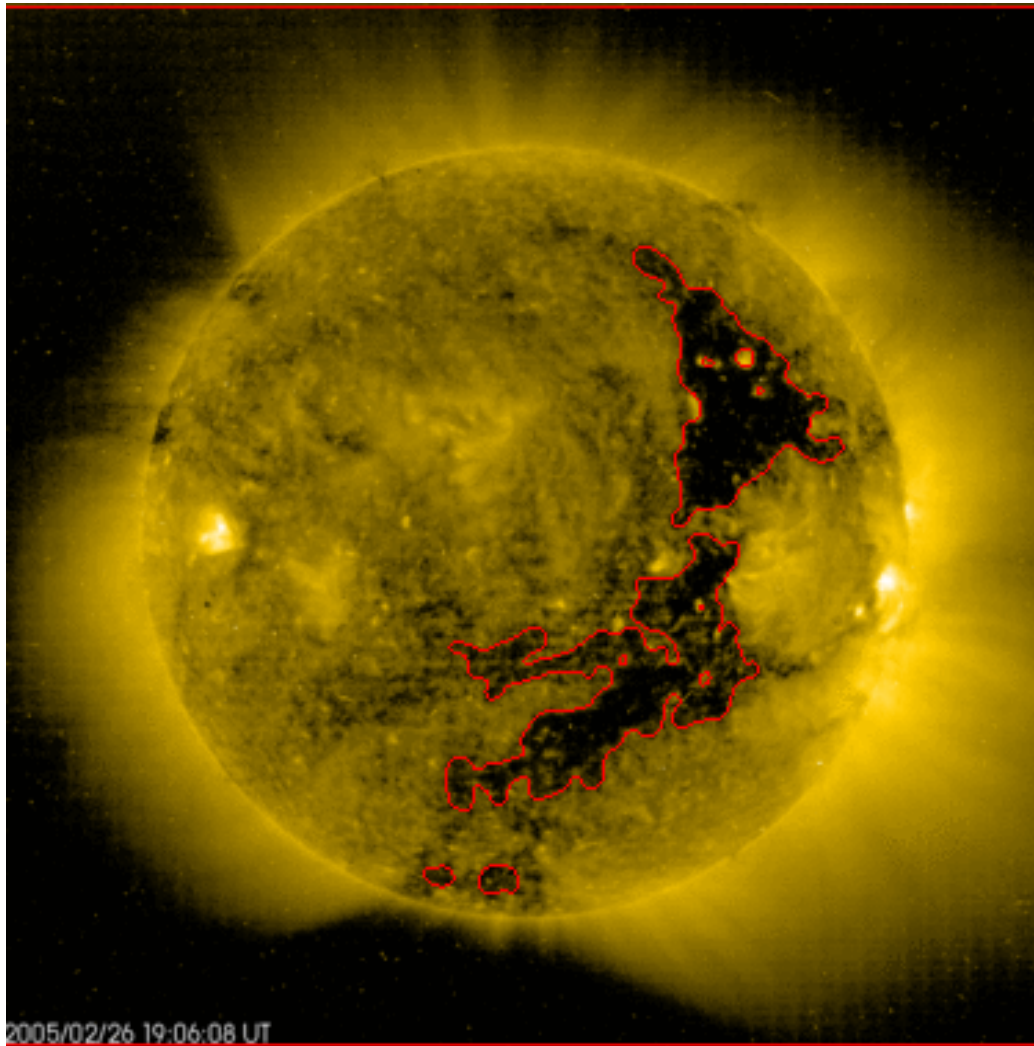
Solar wind velocity forecast by coronal holes area



•Coronal holes – dark regions on SOHO/EIT, STEREO/SECCHI, Hinode/XRT, PROBA2/SWAP and SDO/AIA images (UV and X-ray images)



Determination of coronal holes area



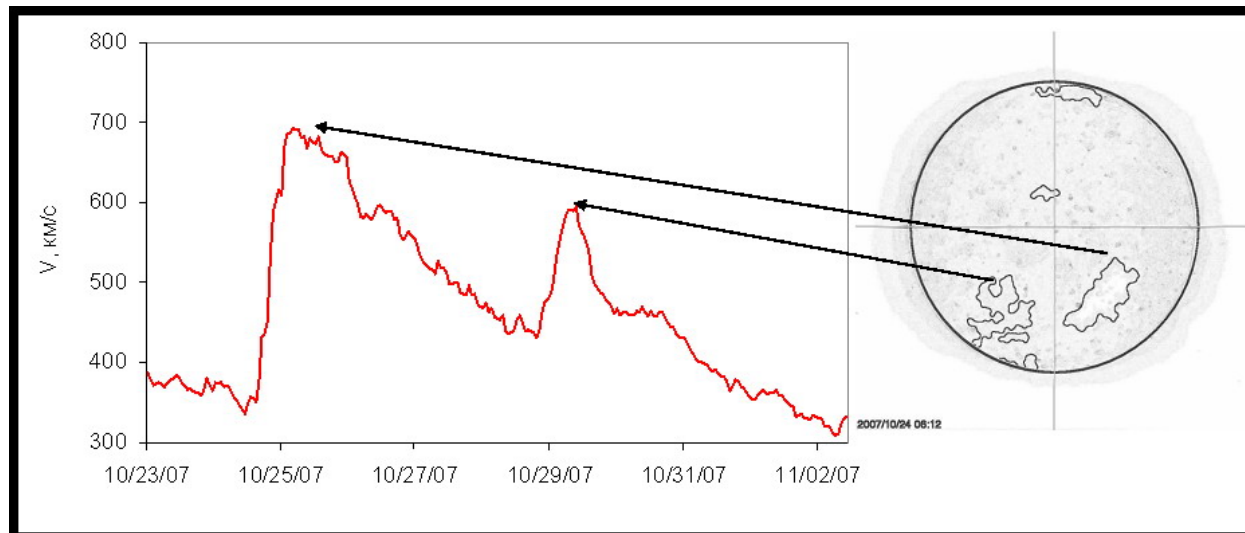
Index	Area	Intensity
1	0.0020	33.7032
2	0.0522	25.8788
3	0.0036	32.9647
4	0.0413	16.5017



Prediction of SW parameters

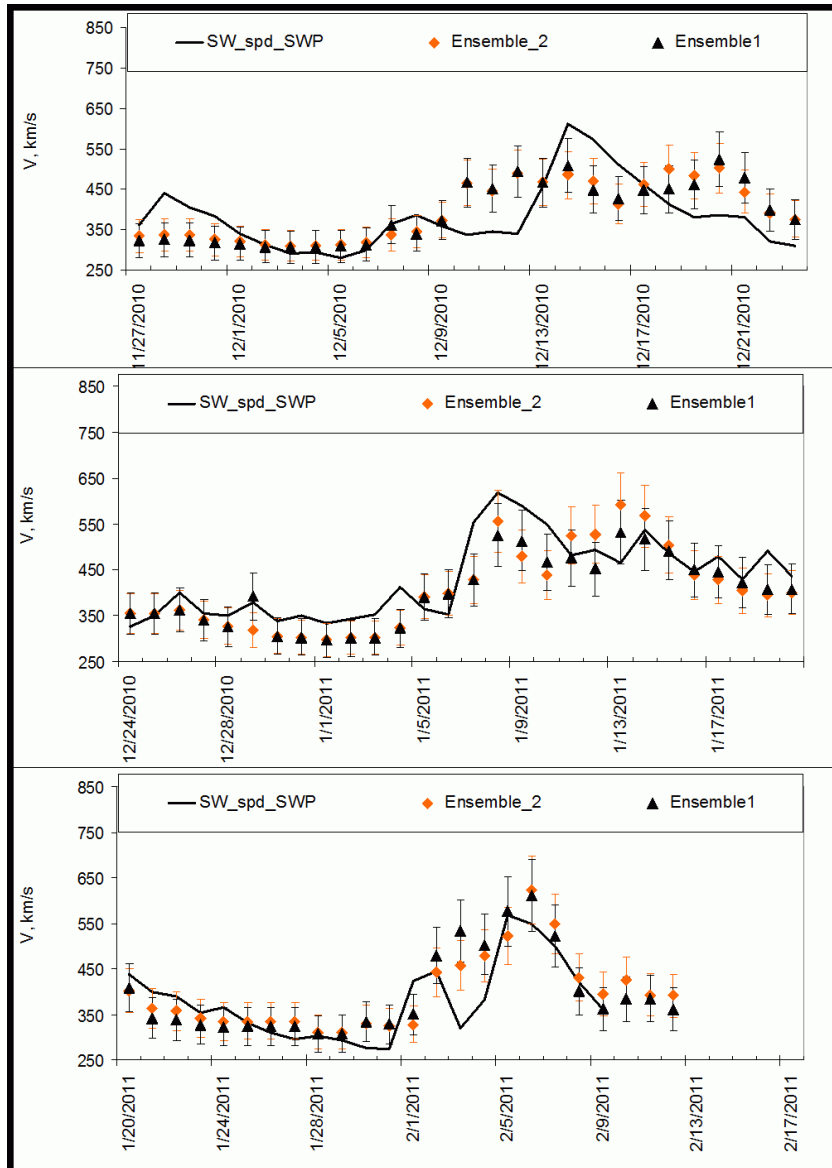
Artificial neural network

- Does not require a strict mathematical model
- Can trace non-linear relationships
- Automatically determines the time delay between observation on Sun and values measuring near/on Earth





Recurrent solar wind velocity streams forecast



- **Black curve** - observed daily SW velocity values
- **Orange diamonds and Black triangles** - 3 days advanced predictions by ensembles of experts on examination data set

- **Orange diamonds** - Ensemble#2
- $r = 0.67$, RMSE = 67 km/s
- **Black triangles** – Ensemble#1
- $r = 0.64$, RMSE = 70 km/s

– Input data

- Daily images obtained by **PROBA2/SWAP** at 174 Å (level 1) and by **SDO/AIA** at 193Å (synoptic level 1.5, 1024x1024)
- SW velocity values from two previous rotations



Conclusions

- **Space monitoring data center of MSU gives access to satellite data and to space models via Web-site <http://smdc.sinp.msu.ru>**
- **Main aim is to provide real-time analysis of physical conditions in the near-Earth space based on data and models – the same as at NASA Space Weather Center**
- **NASA Space Weather Center and MSU Space monitoring data center began first contacts in 2011 and intend to work in close collaboration**