RUSSIAN SPACE WEATHER INITIATIVES

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ABSTRACT

Russian Space Weather initiatives cover practically completely the wide sphere of solar terrestrial physics field: from the solar activity via interplanetary and magnetospheric perturbations to the ionosphere-atmosphere coupling. Many scientific groups study different aspects of Space Weather during more than two last decades. The wide network of ground based stations (practically 170° in longitudes and 60° in latitudes) has been created in Russia. This network permits to perform the measurements of Earth's magnetic field (magnetometers), radio waves (radio-telescopes) and fluxes of high energy particles (neutron monitors). Highly developed program of near Earth satellite experiments permits to obtain in-situ information about magnetosphere and interplanetary medium including radiation environment, plasma characteristics, solar wind and interplanetary magnetic field properties and so on. This information is ultimately important for diagnostics of the interplanetary medium and Earth's magnetosphere conditions. Many theoretical and empirical models developed by Russian scientists are used successfully for description and prediction of practically any phenomena in the solar-terrestrial linking. At present time the important problem is to join different Russian scientific group activities to present the experimental data and model results to different groups of users that have an interest and requirements in Space Weather. The Russian Initiative Space Weather Task Group activity will be co-ordinated by Dr. A. Dmitriev (dalex@srdlan.npi.msu.su). He will develop and support corresponding Web-site of the Task Group for the information exchange and dissemination http://alpha.npi.msu.su/RSWI/rswi.html

INSTITUTE OF APPLIED GEOPHYSICS (IAG) RUSSIAN FEDERAL SERVICE FOR HYDROMETEOROLOGY AND ENVIRONMENTAL MONITORING

Director Prof. S. Avdyushin (tel., fax 7-095-1878186, e-mail geophys@wmc.rssi.ru). *Heliogeophysical Center* (the head Dr. S. Frolov) in the Institute works for more than two decades as a National Space Weather forecast center as well as the European Regional Center (RWC Moscow) of the International Space Environment Service (ISES). It is responsible for gathering and processing of real time solar-geophysical data from the network, providing solar, geomagnetic, ionospheric and space radiation predictions with different advance, and distributing the information to the users as well as exchanging these data with other RWCs. The operational data network includes ground-based solar, ionospheric and geomagnetic observatories as well as a space segment, that consists of “Meteor” series satellites (polar orbit at 900 km altitude) and geostationary “Electro” satellites (85 deg. E). Being accumulated, the current network data form an observational base which is used for making short-term and medium-term forecasts. There also exists a rocket and lidar (satellite and ground-based) observation database of the principal parameters of the upper and middle atmosphere.
The Center is supported by Scientific and Technological Divisions which develop (in cooperation with corresponding Institutes of the Russian Academy of Sciences, Universities and Agencies) new facilities for regular observations and methods of diagnostics and forecasting of space weather parameters: solar and geomagnetic activity, energetic particle fluxes in the near-Earth space, and the state of the upper atmosphere

and ionosphere. The Divisions also facilitate transition of research results into operations. In particular, an ionospheric radio-sounding experiment at the MIR Space Station has currently begun. The equipment (ionospheric sounder) is located on board the MIR Station. The sounder can store ionospheric information during MIR passes over various regions, and can also immediately transmit ionospheric information about zones over which it flies in the designated channel (137.85 MHz). The ionospheric operating parameters are determined from one or several ionograms. The global model of the ionosphere is then corrected using these parameters before making estimates of radio communication conditions. The information about IAG Forecasting Center activity in more detail is regularly published in the Proceedings of Workshops on Solar-Terrestrial Predictions and can be found in each issue of the Proceedings.

Everyone interested in space weather information is invited to co-operate with us using our monitoring systems. All data and forecasts can be reached via e-mail hciag@ssunny.aha.ru or Gelionet network (60:5020/0@gelionet, tel. 7-095-1877302).

INSTITUTE OF TERRESTRIAL MAGNETISM, IONOSPHERE AND RADIOWAVE PROPAGATION (IZMIRAN) http://www.izmiran.rssi.ru

Solar Radio Laboratory (contact person Dr. I. Chertok ichertok@izmiran.troitsk.ru) CMEs and associated phenomena as drivers of nonrecurrent interplanetary and geophysical disturbances are studied in the following points of view (*Chertok*, 1996):

- CME manifestations in various ranges from gamma-rays to radio emission (*Chertok*, 1997),
- Large-scale chains on the solar disk and their relations to CMEs (http://helios.izmiran.troitsk.ru/lars/Chertok).

Post-CME energy release and prolonged particle acceleration in the corona (*Akimov, et al.*, 1996),

-Large-scale variations of noise storms at metric wavelengths as a result of CME interaction with pre-existing coronal structures (*Chertok, et al.*, 1996).

A methods of the quantitative diagnostics of proton flares by radio bursts has been elaborated (*Chertok and Fomichev*, 1990). Regular spectral (45-270 MHz) and fixed-frequencies (169, 204, 3000MHz) observations of the solar radio emission are being carried out with a digital registration. The data are accessible via http://helios.izmiran.troitsk.ru/lars/LARS.html.

Cosmic Ray Department (contact person Dr. A. Belov abelov@izmiran.troitsk.ru) Cosmic Ray Department of IZMIRAN is supervising groundlevel monitoring of the cosmic ray variations in Russia and in former USSR. The cosmic ray station Moscow was the first with the real time cosmic ray variation data in Internet http://helios.izmiran.rssi.ru/cosray/main.htm (*Belov, et al.*, 1998a). Now the data of two Russian cosmic ray stations are accessible in real time http://pgi.kolasc.net.ru/CosmiRay/Monitor.htm (Moscow and Apatity). Data from the world wide cosmic ray station network (> 40 stations) are processed by the special methods (*Belov, et al.*, 1997) to obtain hourly means of density, spectral index of density variations and of the 3D anisotropy parameters of cosmic rays near the Earth. CME manifestations in cosmic rays (Forbush-effects) are investigated and catalogs of cosmic ray storms are composed. In addition to the retrospective catalogue the list of recent Forbush-effects is maintained in near real time (http://helios.izmiran.rssi.ru/cosray/events.htm). The special method (*Belov, et al.*, 1995) is applied to analyse the behaviour of cosmic rays during Forbush-effects and to search for some predictors of the approaching disturbed regions. The indices on the level of cosmic ray activity, which could characterise some peculiarities of the space weather, are proposed (*Belov, et al.*, 1998b). The possibility of a single station indices is realised in real time http://helios.izmiran.rssi.ru/cosray/indices.htm.

Space Electrodynamics Department, Lab. of Active Space Experiments (contact person Dr. V. Larkina vlarkina@izmiran.troitsk.ru) It was detected that ionosphere, as a whole, and the phenomenon occuring in it are an indicator of processes in lithosphere. The investigations of electromagnetic effects related to earthquakes at ionosphere altitudes with the use of satellite measurements were initiated. For example, electromagnetic noise in the low frequency range (0.1-20 kHz) were discovered for the first time from "Intercosmos" satellites over the earthquake centres. As a result of observations on board the "OGO 6", Aureol 3 and other satellites many associations with earthquakes were collaborated. In IZMIRAN it was worked out the method of treat, choise and analysis of satellite data for possible prediction of the earthquakes (*Migulin, et al.*, 1983). In the last time it was established, that electromagnetic processes in ionosphere are connected not only with catastrophic manifestations of seismic activity, but also with current processes occurring in the low-frequency emission field, registered on board Intercosmos satellites at its flight above deep lithospheric faults (*Migulin, et al.*, 1997, *Larkina, et al.*, 1998).

Laboratory of Geomagnetic Variations A. Reznikov - director of the Department of Electrodynamic Processes in Earth Environment of IZMIRAN (lgromova@izmiran.troitsk.ru) The model of electromagnetic parameters (electric and magnetic field, ionospheric and field-aligned electric currents) at high-latitude ionosphere is constructed. Input parameters for this model are solar wind parameters. New satellite will be launched at the distance 10-15 million km in 2001. Using the satellite measurements we are going to realize diagnosis and prediction of the electromagnetic weather in near Earth space (*Papitashvili, et al.*, 1998).

InterHelios Mission (contact person Dr. V. Kuznetsov kvd@izmiran.rssi.ru) The InterHelios mission will orbit the Sun at close distances (30-100 solar radii) at a speed three times as fast as the Earth and will occupy an ideal position near the transient sources in the solar atmosphere. This will allow us to detect the occurrence and to determine the boundary conditions in the solar environment of such events as CMEs and global interplanetary shock waves, that exist all over the heliosphere and influence all planets. InterHelios can be an important element in the future program of orbital studies of solar-terrestrial coupling at the libration point, providing real-time information for the space weather forecast. From its unique position on the orbit, the mission will be able to provide images of the solar atmosphere, to measure the photospheric fields at the base of coronal loops, and thus, to follow the field evolution in solar ejections. The related interplanetary effects will be studied without a significant time delay. The spacecraft "hanging" over the active region at about 60 solar radii will measure the fields and particles without distortions due to the transport.

CORONAS-F mission (contact person Dr. V. Kuznetsov kvd@izmiran.rssi.ru) CORONAS-F is a mission designed to study the events of solar activity and to directly measure the flare-associated solar energetic particles, penetrating the Earth magnetisphere and reaching the altitudes of SC orbit (about 500 km). These observations supported by ground-basedionospheric and magnetospheric measurements will allow the spaceweather control in the Earth environment and, in cooperation withother solar-heliospheric missions, its forecast on the Earth orbit.

ROUTINE OBSERVATIONS at IZMIRAN (contact person Dr. V. Obridko solter@izmiran.troitsk.ru) with a solar vector-magnetograph and a high-sensitivity tachometer with 2" resolution enable the flare and CME forecast with a lead time of 1-3 days, as well as the forecast of the related interplanetary disturbances. Simultaneously, the full-disk and high-resolution observations of solar activity are carried out with an H-alpha filter. The new methods for predicting solar and geophysical activity with different lead time have beed developed on the basis of original and literature data. By the next solar maximum (2000-2001), it is supposed to design an updated version of the solar magnetograph and magnetograph-tachometer for infrared observations on board the orbital station.

Solar electrodynamic and prognostic support of space missions laboratory V. Ishkov (ishkov@izmiran.rssi.ru). The forecast of the large solar flare and the forecast of the solar geo-effective events (large flare, filament ejection and coronal holes) impact on magnetic and radiation condition in environment have been developed. Short-term large flare event forecasting is presently based on observation by the process of new magnetic flux emergencies, its evolution: the magnitude and rate of emergence, its localization and interaction with already existing magnetic fields of the active region or outside of it. Taking into account physical and geometrical parameters of the own flare and the flare active region makes possible to predict the parameters of solar proton events, the characteristics of geomagnetic activity and other, collectively called space weather. The method of the large solar flare prediction has been put to successful test on Russian scientific satellites such as GRANAT, GAMMA, CORONAS-I. Computer version this forecast techniques has been developed on the base of real-time solar data. The forecasts are accessible via http:\\izmiran.rssi.ru\space\solar\forecast.html.

SKOBELTSYN INSTITUTE OF NUCLEAR PHYSICS MOSCOW STATE UNIVERSITY (SINP MSU) http://www.npi.msu.su

Space Physics Department Prof. M. Panasyuk (panasyuk@srdlan.npi.msu.su). *Data Base of Low Altitude Space Radiation Environment* (DB LASRE) (http://dec1.npi.msu.su/english/data/lasre/index.html) maintained by A. Dmitriev (dalex@srdlan.npi.msu.su) contains experimental data about energetic electrons (E>40 keV) and energetic protons (E>0.5 MeV) observed on five near Earth's satellites at altitudes 300-1000 Km during the period since 1979. The real time fluxes of penetrated particles observed on MIR piloted station are presented on http://dec1.npi.msu.su/~rtmir/.
Empirical models developed by means of Artificial Neural Networks (ANNs) are presented on http://dec1.npi.msu.su/~alla/ by A. Suvorova. There are 3D model of the dayside magnetopause, dynamical model of the slot region of Earth's electron radiation belt, long time forecasting of months averaged means of the solar activity, solar wind and interplanetary magnetic field parameters. The solar wind and interplanetary magnetic field models (Veselovsky I. veselov@dec1.npi.msu.su) are developed based on the real experimental data obtained during three solar cycles (*Veselovsky*, 1998; *Dmitriev, et al.*, 1998). *Empirical semi-dynamical model of 100keV-2MeV electrons at low altitudes* (300-500 km) has been developed on the base of interpolation of electron fluxes in geography's coordinate system in solar minimum under geomagnetic activity conditions varied from severe magnetic storm (Dst<-300 nT) to quite condition. Input parameters of the model: altitude and geography's coordinates of the modelling point and Dst-variation in the moment of modelling. *Model of Galactic Cosmic Rays* (http://www.npi.msu.su/gcrf/form.html) is developed by R. Nymmik (nymmik@srdlan.npi.msu.su). The Model establishes the fluxes of GCR particles (protons and Z = 2-92 nuclei in the 10.0 - 105 MeV/nucleon range) in the near-earth space beyond the Earth's magnetosphere. The input parameters are the predicted sunspot numbers for

the expedition period. *Probabilistic model for fluences and peak fluxes of solar energetic particles* (http://www.npi.msu.su/scrf/form.html) is developed by R. Nymmik (nymmik@srdlan.npi.msu.su). The Model is intended for predicting the sizes of fluences and peak fluxes of 10 MeV/nucleon Z = 1- 28 solar cosmic ray (SEP) particles in the Earth orbit beyond the Earth's magnetosphere. The Model establishes the SEP particle fluxes within a given period (from 3 months to 11 years) under a given solar activity level (annual mean sunspot numbers) to within a given probability (from 50% to 1%), whose sizes exceed the values defined in the Model as energy spectra. *Space Environment and Radiation Effects Information System* (SEREIS) (http://alpha.npi.msu.su/~vfb/SEREIS) developed by V. Bashkirov (volod@srdlan.npi.msu.su) provides access to the models of near Earth's Space Environment and Radiation Effects on satellites. The modern dynamical models of the Earth's magnetic and electric field, thermosphere, ionsphere and plasmasphere, radiation belts, Galactic and Solar cosmic rays, neutron albedo are implemented in the SEREIS. The models of radiation effects: Solar cell degradation, energetic particles and LET spectra, radiation dose behind of simple and complex geometry shields, SEU (single event upsets) rate and reliability of electronics are implemented in the SEREIS. The SEREIS can analyze a single location, profile, grid, orbit for given time moment and Space Weather parameters.

Theoretical and Applied Space Physics Department Dr. E. Sosnovets (sosnov@taspd.npi.msu.su) Creation of a dynamical model of energetic electrons (>1 MeV) of the outer Earth's radiation belt at high altitudes. *Tverskaya L.V.* (tverskaya@taspd.npi.msu.su) For prediction of storm-time position of several magnetospheric plasma domains (maximum of storm-time injected radiation belt of relativistic electrons, ring current maximum, trapped radiation boundary, auroral electrojet center, boundary of solar cosmic rays penetration into the magnetosphere) the empirical relationships connecting their position with Dst-amplitude are investigated. *Solar Cycle prediction* N. Kontor (kontor@taspd.npi.msu.su) We use a special mathematical function to describe the sunspot cycle. Via analysis the parameters of fitting function for the last 27 solar cycles we got a method for prediction of the new solar cycle (23rd solar cycle will be lower than 21st and 22nd ones). *Nowcasting & short term forecasting of Solar-Heliospheric Events* (N. Kontor kontor@taspd.npi.msu.su) An objective of our initiative is the most "influential" solar activity phenomena. We describe them as Solar-Heliospheric Events (SHEs) including active region evolution (ARE) in the solar atmosphere; development of CMEs and solar flares (SFs); generation, propagation and acceleration of solar cosmic rays (SCR) in the solar corona and heliosphere. We use INTERNET near real data to predict ARE and periods of dangerous solar activity, to evaluate SCR fluxes near the Earth and compare our current forecast with spacecraft data to adjust our model. *Empirical model for the propagation and trapping of solar cosmic rays in the corona and heliosphere* (Lyubimov G.P. kontor@taspd.npi.msu.su). A model uses the large-scale magnetic loops in the corona and heliosphere as channels for SCR propagation and trapping. The large-scale distant magnetic loops exist in the heliosphere and can reach the orbits of inner planets.

Department of Nuclear and Space Researches Prof. L. Novikov (novikov@nsrd.npi.msu.su), V. Mileev (mileev@npi.msu.su). We propose *a set of computer models and methods for research of effects of influence of the factors of space environment on space crafts* (SC). On the base of space plasma fluxes data on various orbits of SC (geostationary, high elliptic and low polar orbits) for typical configuration and materials of SC it is proposed to carry out the operative analysis and prediction spacecraft charging (*Krupnikov, et al.*, 1996), and also to give estimations of influence SC charging on the scientific devices and serviceability of onboard systems. Using static and dynamic models of space radiation on various orbits, including the low orbits, operative data on fluxes of the charged particles and dosimetric data, it is proposed using computer engineering model RDOSE (*Makletsov, et al.*, 1997) to calculate the absorbed doze of space radiation inside SC to determine a shielding in various radiating conditions and to predict radiating conditions onboard SC. Under condition of reception flux data of microparticles and small dispersion fraction of artificial particles are proposed to be executed estimations of influence of these particles on external elements of SC and to predict an opportunity of their damage (*Novikov, et al.*, 1996, 1997).

Department of Radiation and Computational Methods. Cosmic Electrodynamics Laboratory Prof. A. Kropotkin (apk@dec1.npi.msu.su). A new concept of *substorm dynamics* (*Kropotkin and Sitnov*, 1997) (http://alpha.npi.msu.su) results in a model of abrupt explosion-like breakdowns of metastable plasma equilibrium in the geomagnetic tail. Substorm hot plasma injections provide a hazardous environment for spacecraft. A model of acceleration mechanism due to the action of strong Alfvenic resonant disturbances excited by substorm activations, is being developed, for relativistic electrons that are an important factor of space weather. Nonlinear analysis techniques for observational data processing are being created; they serve to identify self-organisation features in the magnetospheric system dynamics, and thus form a tool for space weather forecasting. *Laboratory of Computational Mathematics* I. Alexeev (alexeev@dec1.npi.msu.su). The differences between magnetic storms during Solar Maximum and Solar Minimum periods will be investigated using paraboloid model of the magnetosphere and satellite and ground based measurements. Relative contribution from different magnetospheric current systems will be calculated for selected magnetic storms. The role of the field-aligned and its ionospheric closure currents and especially tail current systems during magnetic storms and magnetospheric substorms will be carefully investigated. As a result of investigation a new dynamic model of the magnetospheric magnetic field for disturbed magnetosphere will be developed (*Alexeev, et al.*, 1998; *Belenkaya*, 1998; *Kalegaev, et al.*, 1988).

SPACE RESEARCH INSTITUTE (IKI) (http://www.iki.rssi.ru)

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As the leading organisation of the Russian Academy of Sciences in the field of investigations of Outer Space, Solar System planets and other objects of the Universe, IKI is primary in charge of long-range planning and elaboration of space research programs of which a considerable part is performed within the framework of international space research cooperation. IKI is the contractor of the Russian Space Agency. Space Plasma Physics is one of the main lines of theoretical and experimental investigations performed at IKI. All stars, including the Sun, the interstellar and interplanetary medium, planetary upper atmosphere (ionosphere) - in a word, roughly 99% of matter in the Galaxy is in the plasma state. The processes of the transformation of some types of energy into other, which constitute the essence of active phenomena on the Sun and in the close vicinity (magnetospheres) of the planets, including the Earth, are of plasma nature. The tasks of some theoretical and experimental laboratories at the Institute is to construct models of the Earth and other planetary magnetosperes and to study individual physical phenomena specific for such complex and inter-linked systems as solar wind - magnetosphere - ionosphere system, including magnetic storms and substorms.

Department Space Plasma Physics includes the following laboratories: Theory of space plasma processes (Prof. L. Zelenyi lzelenyi@iki.rssi.ru), Acceleration processes in space plasma and radiation problems during space flights (Prof. N. Pissarenko mira@ares.iki.rssi.ru), Near-planetary and interplanetary plasma (Dr. M. Verigin verigin@iki.rssi.ru), Study of electromagnetic measurements (Dr. S. Klimov sklimov@mx.iki.rssi.ru), Study of solar wind (Prof. O. Vaisberg oleg@iki.rssi.ru), Physics of magnetosphere processes (Prof. Yu. Galperin ygalperin@iki.rssi.ru).

Performed Missions: INTERBALL (Tail and Auroral Probes), PROGNOZ 1 - PROGNOZ12, PHOBOS, ARCAD, ACTIVE, APEX, Intercosmos Bulgaria-1300, RELICT.

Experimental data resource contains data archive (http://www.iki.rssi.ru/da.html) and Data Retrieval Service (http://www.iki.rssi.ru/lsarc.html) for space experiments Prognoz-7, Prognoz-8, Prognoz-9 (Relict), Prognoz-10 (missions) and Interball.

Active partners of IKI: Goddard Space Flight Center, Inter-Agency Consultative Group, European Space Agency (ESA), Institute of Space and Astronautical Science (Japan), CNES (France), MPI fur Extraterrestrische Physik (Germany).

POLAR GEOPHYSICAL INSTITUTE OF KOLA SCIENCE CENTER OF RAS http://pgi.kolasc.net.ru

Deputy Director Dr V. Ivanov (yahnin@pgi.kolasc.net.ru). Institute carries out different routine observations of ionosphere and atmosphere on Kola Peninsula. The observations are:

1) Magnetic field variations in different frequency ranges including geomagnetic pulsations up to 40 Hz and VLF waves;
2) Optical observations including all-sky TV monitoring of auroras, upper atmosphere optical emissions, observation of neutral wind by Fabry-Perot interferometer, etc.
3) Ozone observations in the atmosphere.

During campaigns the radiotomography measurements of ionosphere from low latitudes up to polar cap are perfomed. Cosmic ray station Apatity is in operation for many years. The neutron monitor data are available in real time via Internet. PGI participates in the international balloon campaigns. Besides of observations a lot of theoretical work and modelling have been done related to the Space Weather problem. In particular:

1) Model of magnetospheric field depending on geomagnetic activity and solar wind parameters;
2) Model of thermosphere-ionosphere-magnetosphere interaction;
3) Model of auroral particle transport in the atmosphere;
4) Model of geomagnetic field disturbance during geomagnetic storm.

STERNBERG ASTRONOMICAL INSTITUTE MOSCOW STATE UNIVERSITY

Working group on "solar activity display in earth weather and climate changes E. Kononovich, R. Smirnov (konon@sai.msu.su). The crucial point in the Sun-troposphere problem development is accepting of the necessity of international co-operation between astro- and geophysicists. A lot of important points still are not clear in spite of definite achievements in the problem solving. For example the question is which solar activity agent plays the prime role in connection to weather and climatic changes. What are physical grounds of the solar-atmospheric relationship mechanism? What can be suggested about weather and climatic succession in respect to solar-atmospheric relationship? The spatial-temperature relationship structure is poor known up to now and the results of physical and statistical treatments are badly consistent. In the same time the theoretical treatments of the problem do not take into account the real solar-atmospheric relationship nature.

The main difficulty of the Sun-Troposphere problem is in the power full troposphere processes as a background of the solar-atmospheric events display. The energy of these processes is by several orders of magnitude higher then that of particle streamers. As a result the pattern and intensity of the solar-atmospherical effects must depend upon synoptically initial values and several other conditions, such as: seasons, zones of high recurrence of cyclogenesys, condition of global high altitude frontal zone, energetically active regions. Also it depends upon middle atmosphere conditions, including low atmosphere and transmission channel for solar disturbances. And that is one side of the solar-atmospheric relationship instability. On the other hand, a simultaneous influence of different often poorly known factors of the solar activity is also possible. The geophysical efficiency of these factors is not adequately treated as yet. A good example is the discovery the interplanetary magnetic field sector structure influence upon the tropospheric circulation.

The pattern of display of different solar factors is modulated by the solar cycles phases of different duration. And that is the other side of the solar-atmospheric relationship instability. Here are the main points to be treated during the outlined problem solving.

1.Multiparametric analysis of causes of the solar-atmospheric relationship instability. The aim of this analysis is to take into account the corresponding results during the treating of factors of solar activity as possible predictors of weather and climatic changes.

2. The display of various solar cycles in the lower atmosphere, especially their phase properties and the modulation of the well known atmospheric oscillation by the 11-year solar cycle.

3. The causes of different intensity of the solar-atmospheric effects over the Earth surface. The importance of exchange instability in the atmosphere for a realisation of the solar influences.

4. Changes of tropospheric characteristics of circulation in connection with the parameters of the solar activity. Transformation of circulation forms caused by solar effects. Detecting of systems of atmospheric circulation, connected with the solar activity. Also changes of net energy (potential and kinetic) of the atmosphere.

5. The mechanisms of the solar-atmospheric relationship, corresponding to the real regional pattern of spatial solar- atmospheric effects distribution. Development of 3-D models, incorporating the existent models of atmospheric instability.

LEBEDEV PHYSICAL INSTITUTE

Plasma Astrophysics Department A. Podgorny (podgorny@fiand.msk.su) and I. Podgorny (Institute for Astronomy RAN) *Investigations of energy accumulation above an active region for solar flare prediction*. It was shown that photospheric disturbances produce current sheet creation in the vicinity of a singular magnetic field line above the active region. The 3D MHD calculations show that magnetic energy is accumulated in the magnetic field of the current sheet. This energy is released in forms of fast particles, visible and x-rays radiation, and plasma jet eruption from the Sun. The results of calculations permit to build the solar flare electrodynamical model, which explains the main solar flare phenomena. The PERESVET code is used for solving resistive MHD equations for compressible plasma. The magnetic field in an active region is approximated by sets of dipoles under the photosphere. Their values and positions correspond to observed Sun spots in an preflare active region. The aim of these investigations is prediction of solar flares development using the photospheric magnetic field. Recent results are published in the papers (*Podgorny*, 1998a; 1998b).

Solar Physics and Cosmic Ray Department Yu. Stozhkov (stozhkov@fiand.msk.su) and N. Svirzhevsky (svirzhev@fiand.msk.su) Daily radiosonde measurements of the ionising radiation in the atmosphere made with Geiger counters are carried on in Moscow and Murmansk and at station Mirny, Antarctica for more than 40 years. In the measurements *in situ* data sets on the total and vertical fluxes of secondary cosmic rays in the troposphere and stratosphere were obtained. The data sets may be used for the atmospheric processes models taking into account the ionisation effects of cosmic rays. Now in correlations between the electric dependent parameters of the atmosphere and solar activity variations are usually used the sunspot numbers or neutron intensities. But the cosmic ray fluxes variations in the troposphere are substantially different from the solar spot or neutron intensity variations. In the lower atmosphere short scale (2-3 months duration) cosmic ray variations are often equal to the total 11-year variation, and the 11-year variations themselves are special.

At present the data sets on the cosmic ray fluxes in the atmosphere from ground level up to altitudes 30-35 km are available for four basic stratospheric stations - Murmask (1957-1998), Moscow (1957-1998), Alma-Ata (1962-1992) and Mirny, Antarctica (1963-1998). Monthly mean data sets were computed in the pressure intervals 4-20 g/cm^2 wide and can be used as a function of atmospheric pressure from 1033 g/cm^2 to approximately 3-4 g/cm^2. ASCII files exist for a) Geiger counter and counter telescope count rates, b) total fluxes (in 1/(m^2 s)) and c) vertical fluxes (in 1/m^2 s sr).

Pushchino Radioastronomy Observatory (PRAO), Astro Space Center V. Vlasov (vlasov@prao.psn.ru) Detection of the large scale perturbations (of the shock wave type) in the Solar Wind using the interplanetary scintillation index mapping and observations of the scattering angles of radio-sources. Analysis of the active phenomena in the interplanetary plasma with the solar and geophysical perturbations. The experimental equipment is the radiotelescope at the frequency 111 MGz of 30000 m^2 effective area and the radiotelescope at 151 MGz of 7000 m^2 effective area.

RADIOPHYSICAL RESEARCH INSTITUTE, NIZHNY NOVGOROD (NIRFI)

S. Polyakov (spol@nirfi.nnov.su) During more than 40 years the Radiophysical Research Institute (NIRFI, Nizhny Novgorod) has been carrying out the investigations in the field of space and solar physics, radio wave propagation, physics of the ionosphere and earth's atmosphere. NIRFI is one of the leading organizations in the field of Space Weather. This is conditioned by the complex character of investigations permitting to follow the dynamics of phenomena from the solar atmospere through the solar wind up to the earth magnetosphere, ionosphere and atmospere. NIRFI has its own experimaental base including two Unique Research Facilities: "NIRFI, Staraya Pustyn Radio Astronomical Observatory" (reg.N 06-29) and "Multi-purpose Facility SURA"(reg.N 06-30). The 10-m radiotelescope and phase-stable radio interferometers of 14- and 7-m radiotelescopes of Staraya Pustyn Radio Astronomical Observatory are used to study solar-terrestrial relations and to control ionospheric conditions. The SURA facility consists of three 250 kW short-wave broadcasting transmitters PKW-250 (the frequency band of transmitters is 4-25 MHz) and three-section 4.3-9.5 MHz transmitting-and-receiving antenna of 300x300 m^2 with a gain of 26dB at a frequency of 6.6 MHz. There is a corresponding diagnostic equipment as well. There is an experimental diagnostic complex at the test station "Novaya Zhisn". *T. Podstrigach* (sunpts@nirfi.sci-nnov.ru) NIRFI has a complex of radiotelescopes in Laboratory Zimenki for monitoring and patrol observations of solar radio emission and activity as well as solar-terrestrial relations. The technical characteristics of the complex are the following:

- wavelength (cm) 3.3, 10.2, 32, 46, 150, 300;
- diameter of antenna (m) 1, 2, 4, 4, 15, 15 respectively;
- antenna beam (deg) 2.5, 3.5, 5.5, 6, 7, 15 respectively;
- time constant 1 s;
- sensitivity, part of quiet Sun flux 0.01, 0.01, 0.007, 0.01, 0.004, 0.01 respectively;
- maximal recorded intensity, part of quiet Sun flux 100, 100, 100, 100, 10000, 10000 respectively.

V. Melnikov (meln@nirfi.sci-nnov.ru), *T. Podstrigach* (sunpts@nirfi.sci-nnov.ru) On the basis of regular observations of the intensity, effective duration, and the frequency of spectral maximum of solar microwave bursts it has been shown the possibility to estimate the intensity and shape of solar particles (p+ and e) spectra. *V. Fridman* (fridman@nirfi.sci-nnov.ru), *O. Sheiner* (rfj@nirfi.sci-nnov.ru) The statistical studies based on the special observations in the microwave region (wavelength about 3cm) made it possible to create a short-term prediction procedure for geoeffective flares (*Kobrin, et al.*, 1997) An algorithm of the forecast procedure has been proposed. It consists of the comparison of the mean long-period (t>20min) pulsation amplitude in the current series of observations and that one in a calm (nonflare) period taking into accout the specific features of the equipment and observation procedure. *V. Fridman* (fridman@nirfi.sci-nnov.ru), *O. Sheiner* (rfj@nirfi.sci-nnov.ru) The investigations are under way to create procedures for short-term forecasting of Coronal Mass Ejection onset on the basis of registration the nonstationary processes in the lower layers of the solar atmosphere at a stage of the coronal mass ejection formation using the patrol observations of solar radio emission. *Yu. Tokarev* (yt@nirfi.sci-nnov.ru) Successful experiments on plasma environment detection by back scattering technique have been done with evidence of a detectable reflected signal from the magnetosphere (*Gurevich, et al.*, 1995). Also it has been shown that when the space-borne receiver is located out the Earth's magnetosphere the observations of SURA signals would permits to recognise plasma inhomogeneties, which are near of the upper boundary of inertial interval of the solar wind turbulence (*Tokarev, et al.*, 1998). Because the powerful sounding HF waves can interact with the earth's ionosphere, it is necessary to understand ionospheric effects on wave propagation (wave refraction, scattering, etc). The programme explore NIRFI experience in studying of such phenomena. The HF radar observations may be a new, very cost-effective method of diagnosing global solar wind - Earth plasma environment dynamics. An early warning procedure of radial moving Coronal Mass Ejection has been developed using Sura radar in decametric radiowave band. *V. Razin* (razin@nirfi.sci-nnov.ru), *A. Teplykh* (tepl@nirfi.sci-nnov.ru) A regular control of ionospheric conditions has been carrying out since 1978 at the Radio Astronomical Observatory "Staraya Pustyn" by the measurements of the ionosphere total electron content (TEC) and its variations using a polarimeter on the basis of 10-m steerable radiotelescope at operating frequency 290 MHz. The measurements are carried out for the sky regions which polarization characteristics have been thoroughly studied at NIRFI. These observations make it possible to measure the Faraday rotation angle of the polarization plane of the linearly polarized Galactic radio emission in the ionosphere and by its value to determine TEC. There have been gathered large statistical data to make conclusions both on regular TEC variations and on the nature of different ionospheric disturbances. The accuracy of TEC determination is about 5% that is not worse than that attained with geostationary satellites. The performance of the polarimeter with a receiver tuned to coherent frequency signals (type NNSSA) of satellites with circular polar orbits allows one to obtain a time-space TEC pattern within geographic latitudes 15-20 deg. along the satellite trajectory. NIRFI has similar stations in polar and equatorial regions. Joint cooperation of these three stations makes it possible to study the dynamics of ionospheric disturbances from equatorial to polar regions (*Razin, et al.*, 1988). *V. Razin* (razin@nirfi.sci-nnov.ru), *N. Dugin* (tepl@nirfi.sci-nnov.ru) To make a continuous and operative control of the irregular component of ionospheric horizontal inhomogeneities (caused, for example, by heliophysical factors, earthquakes or internal gravitational waves of anthropogenic origin) it is suggested to use phase-stable radio interferometers for high-accuracy measurements of signal phase differences and amplituses in real time. The measurement procedure based on continuous observations of extra-terrestrial sources with known characteristics makes it possible to register the passage of TEC horizontal gradient fronts in the given sector of the ionosphere. This procedure has been approved on small-based radio interferometerts of the Radio Astronomical Observatory "Staraya Pustyn" (*Dugin*, 1997). *V. Uryadov* (ur@nirfi.sci-nnov.ru) The nonregular structure of the ionosphere is studied by standard methods of vertical and oblique sounding with the help of up-to-date chirp sounders. *E. Myasnikov* (me@nirfi.sci-nnov.ru) The methods have been developed to determine 3D spectra of ionospheric turbulence based on the analysis of amplitude and phase fluctuations of satellite signals. *A. Rakhlin* (avr@nirfi.sci-nnov.ru) The analysis of long-term homogeneous (more than 30 years) sequence of data on the ionospheric sounding according to a specially developed methodics has revealed time-related parameters of F-spread type ionospheric disturbances. It has been found, in particular: long-term trend of the disturbances, quasi-periodic character of their occurrences. The revealed temporal characteristics can be explained both the natural processes and the impact of anthropogenic factors (*Vybornov, et al.*, 1997). *P. Belyaev* (belyaev@nirfi.sci-nnov.ru) Since 1985, over the last Solar Cycle and up to the present, NIRFI has been carrying out groundbased broadband ULF-ELF-VLF (0.01Hz-100kHz) monitoring of natural electromagnetic environment (receiving site near N.Novgorod). Temporal variations of electromagnetic emission activity in different frequency ranges as well as variations of near-earth's waveguide and resonator geometrical and electromagnetic parameters (magnetospoheric magnetic shell resonators, ionospheric Alfven Resonator, MHD-waveguide in ionospheric F2 region, Schumann resonator in the cavity earth-ionosphere, ELF-VLF waveguide earth-ionosphere) exhibit a strong dependence on solar radiations of different nature and solar wind or, in other words, they are high-sensitive indicators of Space Weather. The coordination of European geophysical stations with sensitive broadband receiving equipment allow us to develop models for prediction of near-earth's space response and electromagnetic environment with respect to the Sun's activity having the greatest influence on human life. *I. Kozhevatov* (kozh@nirfi.sci-nnov.ru) The institute has developed the spectral and optical apparatus, methodics and observational programmes to determine main thermodynamic parameters of the atmosphere at heights 20-50 km (temperature, pressure, flow velocities) on the basis of observations of solar telluric lines (*Kozhevatov, et al.*, 1996). *A. Naumov* (nau@nirfi.nnov.su) *It* has been developed and now is under way a multichannel radiometric system including 4 channels in the molecular oxygen emission band (5 mm), 2 channels in the water vapour spectral line (1.35 cm) and 2 channels in mm band radio windows. By the measurement of the atmosphere thermal radio emission this system can monitor height profiles (0-10 km) of the temperature, pressure, water vapour content as well as its total mass and cloud water content (*Gaikovich, et al.*, 1983). *V. Uryadov* (ur@nirfi.sci-nnov.ru) Russia has built a network of oblique sounding stations on the basis of the national low-power chirp ionosonde by cooperative efforts of NIRFI, Mari State Technical University, the Institute of Solar-Terrestrial Physics of the Siberian Branch of the RAS, IKIR of the Far Eastern Branch of the RAS. The network is used at present to conduct a large-scale investigations of the ionosphere and natural and modified conditions, NIRFI is a leading organisation in complex studies of short radio wave ionospheric and magnetospheric propagation. The transmitting-and-receiving complexes are equipped with PCs to control chirp sounder operation, to register and process ionograms, to create ionospheric channel parameters data base for its further dissemination via the Internet web. The software package has been developed for short-term forecast of current ionospheric parameters and ionospheric model operative corrections. It has been shown on the basis of the experimental data obtained on the chirp sounder traces that the ionospheric model adaptation to current ionospheric conditions makes it possible to forecast MOF in real time scale and to have the forecast error 3-5 times less than that of the long-term forecast method. The experience of joint work with the Australian chirp sounder located in Alis Springs has shown that the network can be used for the ionosphere monitoring in a global scale together with analogous systems located in different places of the globe.

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Geomagnetic activity variations controlled by "space weather" geoeffective parameters as the solar wind and interplanetary magnetic field originate from sources near the Sun. We have developed technique to predict few days ahead a sector structure of the interplanetary magnetic field and solar wind streams by using daily magnetic field observations at the solar photosphere.

The solar wind and interplanetary magnetic field observed near the Earth's orbit differ significantly from those originating just near the solar surface. Taking into account distortions of the solar wind streams while their propagation to the Earth a fully 3D MHD model of the solar corona and the solar wind was developed.

Solar wind and interplanetary magnetic field coupling mechanisms with the Earth's magnetosphere based on the MHD reconnection theory were developed. Prediction of intense geomagnetic storms (superstorms) seems to be necessary to potential users. The history of superstorm occurrence rate during a course of solar activity cycle was reconstructed and a forecasting technique of catastrophic "space weather" events was proposed.

Monitoring the dynamics of magnetospheric magnetic configuration based on data from low-altitude spacecraft (method, software and testing results).

Mechanisms of solar impact on weather and climate were investigated and the history of climatic change in the Northern Hemisphere was studied. A neural network forecasting technique of the air surface temperature in St.Petersburg was proposed.

The results of studies are presented in (*Ponyavin,* 1997a; b; *Pudovkin, et al.*, 1997a; b; *Sergeev, et al.*, 1998a; b; *Usmanov,* 1998a; b)

INSTITUTE OF SOLAR-TERRESTRIAL PHYSICS, IRKUTSK STATE ACADEMY OF ECONOMICS

G. Popov (popov@irk.isea.ru) *Input indices for dynamical models of radiation and for neural networks*

The use of dynamical models and neural networks for Space Weather forecasts should include development of new and auditing of old input indices, which should describe the state of the magnetosphere and of processes, which control the dynamics of particles. Values of indices should be determined from results of ground-based observations or/and from results of solar wind and solar activity measurements and should be accessible to users both in retro -spective and in real time. Such work is performed in ISTP for more then 20 years in cooperation with many Russian and foreign scientifical and industrial institutes. Due to development of new models of radiations this field of research became extreme actuality. Future investigations of indices should pay special attention to following questions:

a) The time resolution of indices (for example, Kp has resolution of 3 hour only, and Dst or AE - 1 minute and even smaller). So, the question must be answered - what resolution in time is necessary to users and what resolution should be optimum one?

b) The spatial resolution of indices includes two questions:

- Whether “point” indices can control flows of particles on some predetermined orbit?

For example, the local K is a “point” index in contrast with Kp which is obtained after processing data from network of ground based stations (this procedure requires some time and includes averaging). Solar wind parameters give “point “ indices too.

- What space domaines describe indices? For example, Dst describes the processes in the inner radiation belt, but AE describes processes in the outer magnetosphere.

c) Special question must be answered in relation with indices, constructed from solar activity observations: What manifestations of the solar activity are the most geoeffective?

V. Senatorov (uzel@iszf.irk.ru) Within the context of the "Space Weather" problem, the following issues of academic and economic relevance are, in my view, important and interesting:

1. Study of the dynamics of the gas and plasma clouds produced due to collisions of dust particles with man-made space objects; simulation of the possibilities of he appearance and development of electric charges in them.
2. Investigation of the dynamics of dust and plasma-dust clouds in the Earth's immediate interplanetary environment.
3. Analysis of the regularities of charged-particle emission, light flashes and shock waves produced due to collisions of micrometeorites with spacecraft.

ST-PETERSBURG ARCTIC AND ANTARCTIC RESEARCH INSTITUTE http://aari.nw.ru

O. Troshichev (olegtro@geophys.spb.su), Member of the S-RAMP WG on Space Weather

1. Observations of magnetic variations at the high-latitude stations Amderma, Dixon, Heiss Island, Vise Isl., Izvestii Isl., C.Chelyuskin, Tixie in the Northern Hemisphere, and Vostok and Mirny in the Southern Hemisphere. All stations are equipped by digital magnetometers.
2. 1-min magnetic data from Vostok station (Antarctica) are transmitted in quasi-real time (with 12-min delay). These data are used to calculate the PC index characterising current state of the magnetosphere (http://aari.nw.ru).

3. Invasion of the solar and galactic cosmic rays into the polar caps is controlled by absorption of the cosmic radioemission at stations Vostok, Mirny, Dixon, Heiss Isl., and C. Chelyuskin.

SHIRSHOV INSTITUTE OF OCEANOLOGY, RUSSIAN ACADEMY OF SCIENCE

Space weather effects on the pipelines corrosion L. Vanyan and I. Yegorov (yegorov@geo.sio.rssi.ru) Natural telluric currents are induced in the Earth by the geomagnetic disturbances. Normally the induced electric field on the Earth surface is about 1 mkV/m in middle latitudes and increases at one order of magnitude towards the projection of the ionospheric electrojet. There is even stronger increase of telluric currents during geomagnetic storms. Normal electric current density is quite weak (about 0.1 mkA/m/m) and can not strongly influence the corrosin processes. However the current distribution changes dramatically due to extremely high electrical conductivity of the steel pipeline: hundreds of million times more conducting than soil. Main physical process is concentration of the telluric currents in the well-conducting pipeline. We developed a new algorithm and computer program for the mathematical modelling of the telluric current concentration in pipelines. The program allows to take into account as follows: geographical distribution of the telluric currents, real shape of the pipeline, geographical distribution of the Earth electric conductivity (analysis shows significant effect of deep conductivity (down to depth of 10-20 km) that is a result of the great pipeline length) and real parameters of the pipeline protection including the places where protection is broken. The aim of the mathematical modelling is to predict the most dangerous localities of the pipeline. First calculations showed that due to concentration the current strength in the pipeline may reach a few Amperes. If there are small holes in protection, electric current will flow through the holes into the surrounding soil. This process leads to fast dissolution of the steel, especially during geomagnetic storms.

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