SPACE RESEARCH IN SLOVAKIA

2006 - 2007

SLOVAK ACADEMY OF SCIENCES

COSPAR

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Contents.

1. EXPERIMENTS ON THE SATELLITES. INSTRUMENTS UNDER DEVELOPMENT.

NUADU AT DOUBLE STAR (TC-2).

The Energetic Neutral Atom (ENA) imager NUADU (NeUtral Atom Detection Unit, PI Susan McKenna-Lawlor) installed onboard of TC-2 provided panoramatic imaging of the ENA-emitting magnetospheric regions, particularly the ring current from July 2004.
The Department of Space Physics of IEP SAS has participated on NUADU development and construction in the frame of scientific-technical cooperation between IEP-SAS and STIL-NUIM, Maynooth, Ireland.
NUADU was developed specifically for operation on board of the TC-2 in the frame of European - Chinese cooperation agreed among Laboratory of Space Technology at National University of Ireland STIL-NUIM in Maynooth, Swedish Institute of Space Physics IRF in Kiruna and Center for Space Science and Applied Research CSSAR in Beijing. The project also cooperates with Johns Hopkins University - Applied Physics Laboratory JHU-APL, Maryland, USA, aiming for parallel two-point (stereo) ENA-imaging in cooperation with the NASA-IMAGE satellite.

PEEL FOR ROCKET EXPERIMENT HOTPAY-2.

The HotPay-2 atmospheric and ionospheric sounding rocket project is conducted by Andoya Rocket Range (ARR) and Arctic Lidar Observatory for Mid-Atmospheric Reserach (ALOMAR), Norway in the frame of 6th EU framework. The project has wide international (EU) background and involves launch of variety of scientific instruments for atmospheric and ionospheric research on board of the sounding rocket upto altitude 350 km from ARR (69° 16’ 42“ North, 16° 00’ 31“ East), located on Norwegian island Andoya. The rocket launch and operation is supported by variety of ground-based scientific facilities (LIDAR, riometers, etc). The Hot Pay-2 was launched on January 31, 2008.
The Department od Space Physics of IEP SAS is participating in this project with development, manufacture and operation of a detector of precipitating elec-

trons PEEL (acronym from „detector of Precipitating Energetic Electrons at high Latitude“), which is a joint scientific project of IEP SAS and Democritus University of Thrace, Greece.

Fig. 1. The PEEL experiment (Precipitation of Energetic Electrons at high Latitude) has been developed at DSP-IEP-SAS in cooperation with Democritus University in Xanthi, Greece and Andoya Rocket Range for sounding rocket HotPay-2 [31].

MEP-2 FOR PROJECT RADIOASTRON.

The RadioAstron space exploration mission is conducted by Space Research Institute (IKI) of Russian Academy of Sciences. In parallel with the essential radioastronomical scientific objectives, interesting space physics projects are conducted on board of the spacecraft using its favourable orbit crossing the Earth's magnetosphere and regions outside the magnetosphere of Earth.
The MEP-2 (Monitor of Energetic Particles) is a scientific space device under development at Department of Space Physics IEP SAS, dedicated for charged energetic particles temporal and energy sampling on board of RadioAstron

spacecraft. A significant feature of the MEP-2 is its programmability, allowing definition of plenty of various operating modes either during pre-launch operation, or during a flight on the Earth‘s orbit. MEP-2 is a joint international scientific space project of IEP-SAS, Democritus University of Thrace, Greece and Space Research Institute, Russian Academy of Sciences, Moscow.

Fig.2. Programmable particle spectrometer MEP-2 (Monitor of Energetic Particles), has been developed and manufactured at Department od Space Physics in cooperation with Democritus University in Xanthi, Greece and Space Research Institute, Moscow. The instrument will provide energy spectra and time variations of energetic particle flux at middle energies on board of the Russian satellite RadioAstron. The instrument will continue the studies of medium energy protons and electrons on the orbit which is for relatively long time periods outside the magnetosphere. Specifics are large geometrical factors allowing to study fine structure of low level fluxes of particles [32,58].

2. SPACE PHYSICS, GEOPHYSICS AND ASTRONOMY.

Space research activities in the directions of space solar physics and X-ray astronomy, interplanetary matter and explorations of the comets, solar wind and its interactions with the Earth's magnetosphere, energetic particles in the magnetosphere and in interplanetary space, atmosphere and ionosphere of the Earth, are continuing in various institutes in Slovakia. The following short survey presents selected activities of the abovementioned directions and the obtained results.

The ***Institute of Experimental Physics, SAS, Košice*** (IEP SAS, its Department of Space Physics, http://space.saske.sk) in the co-operation with the laboratories in abroad and with P.J. Šafárik University as well as Technical University Košice is studying the dynamics of cosmic particles with the energies well below those of cosmic rays and well above those of solar wind (from few tens of keV up to several MeV). In addition, the measurements of secondary cosmic rays observed by ground based methods have been analyzed. The methodological works were conducted jointly with the team of magnetic field measurements on Venus-Express. The analysis of the data obtained both from the low altitude and high apogee satellites, as well as development and construction of new instruments for the future studies continued in the period of years 2006 and 2007.

One of the experiments on the Russian solar observatory CORONAS-F, launched into a circular orbit on July 31, 2001 and operated until December 12, 2005, was the instrument with acronym SONG (SOlar Neutrons and Gamma quanta), a joint experiment of Skobeltsyn Institute of Moscow University and IEP SAS. This instrument observed in 2001-2003 more than 40 flares of hard X ray and gamma ray emission, identified with a particular active region that produced each event. The solar corona structure and dynamics above the active regions was studied on the basis of the microwave observations with two Russian radio telescopes RATAN-600 and Siberian Solar Radio Telescope (SSRT). Paper [1] analyzed in details the flare of September 5, 2001 (1430 UT) which is interesting because of emission of gammas $E > 1$ MeV, while its power was only M6.0 in soft X rays. The response of hard X and gamma rays of the scintillator used in SONG experiment has been estimated [38].

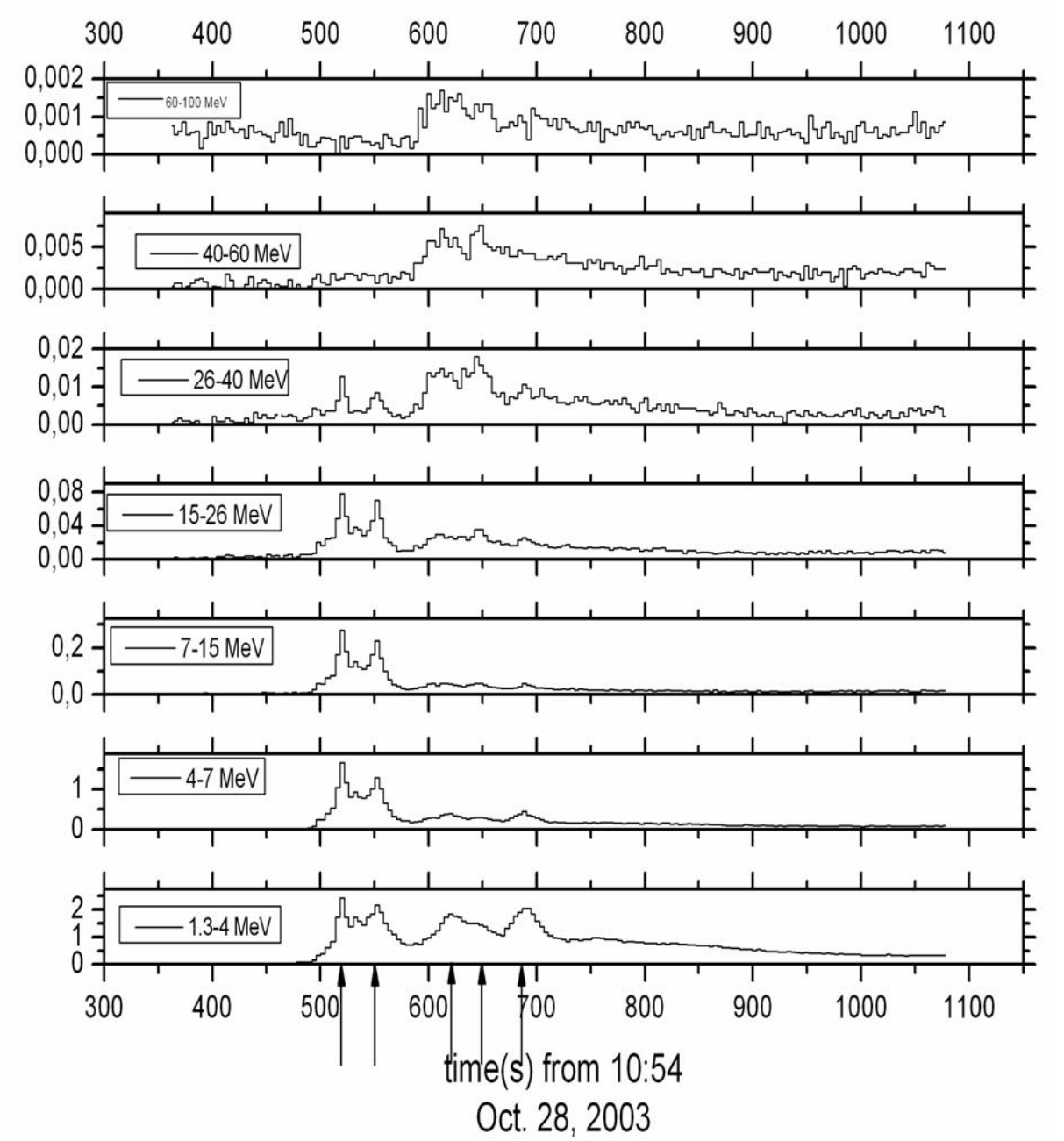

Fig.3. Gamma rays have been observed up to high energies during one of strongest solar flares on October 28, 2003 on CORONAS-F satellite. Counting rates in various energy channels of SONG experiment during that flare show strong variability of γ ray spectra. The arrows depict time intervals with different energy spectra.

Study of gamma rays from the solar flare of October 29, 2003 according to the data of the SONG and AVS-F instruments onboard the CORONAS-F satellite was done in [10,19]. The maximum energy release of this flare according to the SONG data was detected in the channel 4-7 MeV, which corresponds to

the nuclear gamma-lines in the flare energy spectrum. Nuclear lines and the 2.23 MeV line were observed during that flare by AVS-F experiment and comparison with the measurements by GOES-12 and GOES-10 was discussed. The time profiles according to the AVS-F data were considered for energy ranges corresponding to the continuum in the energy 0.3-0.6 MeV, several nuclear deexcitation lines and 2.23-MeV line corresponding of neutron capture.

The acceleration of protons to unusually high energies during the solar flare on January 20, 2005 was studied with using hard X ray and gamma ray observations by SONG [14]. During that event the γ emission with energy 0.05 - 300 MeV was observed. Measured spectra show the peculiar excess in the 26 - 200 MeV energy range produced by neutral pion decay. The presence of pions proofs that protons were accelerated up to energies > 200 MeV during that flare. Comparison of temporal profiles of high-energy gamma emission with GLE onset time observed by neutron monitors network leads to conclusion that these protons escaped from the Sun immediately after their acceleration. The strong anisotropy of high energy protons observed as GLE was discussed and an estimate of the pitch angle distribution of protons was obtained.

SONG data were used also for the estimate of the energy spectra of accelerated protons in the solar flare on October 28, 2003. The satellite is crossing high latitudes four times per orbit and the position of the latitudinal boundary of high energy proton penetration to the magnetosphere is compared with the computations of transmissivity by Tsyganenko-89 model. Thus with relatively good time resolution the evolution of the energy spectra in the range of 0.5 – 4 GeV was obtained and compared with the spectra deduced from the ground based neutron monitor network [18].

For several events with high-energy solar proton emissions and different geomagnetic disturbances in 2003 and 2004, the shifts of the penetration latitude boundary of protons 50-90 MeV at CORONAS-F satellite were analyzed and compared with neutron monitor profiles [16]. In paper [15] the variations of the radiation belt particle fluxes in 0.3-6 and 1-50 MeV, as observed on CORONAS-F during several strong magnetic storms from August 2001 through November 2003, were reported. The electron flux is decreasing abruptly in the outer radiation belt during the main phase of the magnetic storms. During the recovery phase, the outer radiation belt is recovering much closer to Earth, near the boundary of the penetration of solar electrons observed during the main phase of the storm. The electron flux decrease is suggested to be associated with the abrupt decrease of the size of the magnetosphere during the main phase of the storm. In all cases studied, the radiation belts exhibited rather long time

variations of several days. In the cases when solar cosmic rays were observed during the storm, protons E=1-5 MeV could be trapped to form an additional maximum at L >2. For the intervals November 2001 and October-November 2003 the dynamics of the boundary of the penetration of solar energetic electrons and protons was analyzed using CORONAS-F data [17]. The correlation coefficient between the invariant latitude of the penetration boundary and the Kp and Dst indices for electrons 0.3-0.6 MeV in the dayside sector is higher than that that in the nightside sector. The correlation coefficient for protons 1-5 MeV is higher in the nightside sector as compared to the dayside one. For high energy protons (50-90 MeV), the correlation is relatively high in all sectors of magnetic local time.

The measurements of SONG instrument were used also for atmospheric studies. Preliminary examination of data from October until December 2002 has revealed many X-ray enhanced emissions (30-500 keV) in the slot region (L = 2-3) between the Earth's radiation belts. In one case, CORONAS-F data were analyzed when the intense hard X-ray emissions were seen westward of the South Atlantic Anomaly in a rather wide L shell range from 1.7 to 2.6. Enhanced fluxes observed on 12 November were most likely associated with a Major Severe Weather Outbreak in Eastern USA, producing extensive lightning flashes, as was documented by simultaneous optical observations from space . It was proposed that the whistler mode signals from these lightning discharges cause precipitation of energetic electrons from terrestrial trapped radiation belts, which, in turn, produce atmospheric X-rays in the Southern Hemisphere[4]. The electron precipitation in January 2005 producing hard X ray emissions was discussed [37]. Other results based on SONG observations and related to atmospheric effects have been presented in [39,40].

Relativistic electrons of the outer radiation belt are important for the malfunction of the microcircuits on the spacecraft. Significant enhancements of relativistic electron flux in the outer radiation belt, as observed on CORONAS-F, were found not only during the strong magnetic storms near solar activity maximum, but also after the weak storms caused by the high speed solar wind streams [22]. The earthward shift of the position of maximum flux of relativistic (0.6-1.5 MeV) outer belt electrons into the slot region, as observed by CORONAS-F during 22 strong magnetic storms in the period 2001-2004, was analyzed [26].

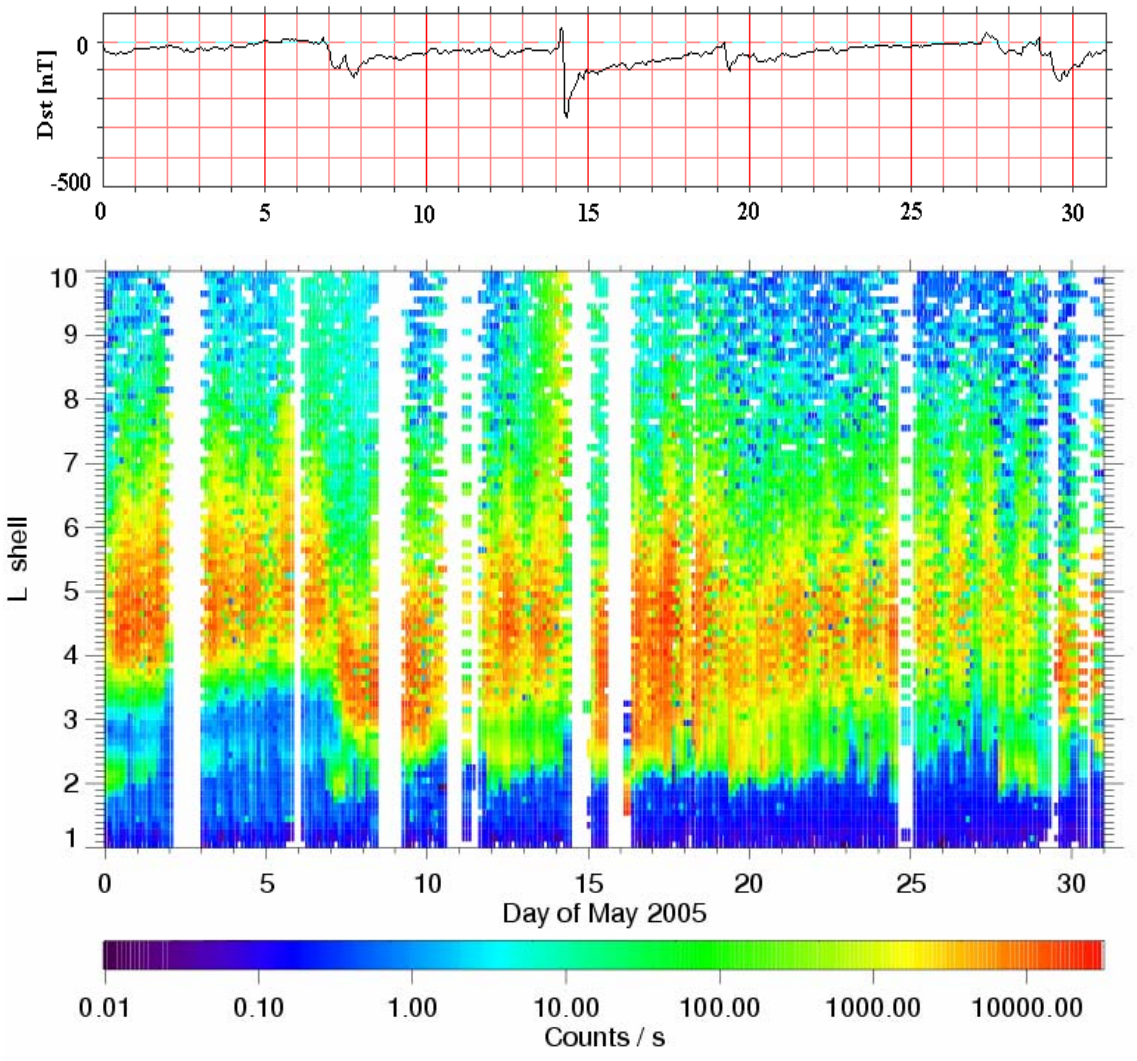

Fig.4. The dynamic of relativistic 0.3-0.6 MeV electrons measured by MKL device (PI S.N. Kuznetsov, SINP MSU Moscow) onboard the CORONAS-F satellite during May 2005 in L-t diagram of 3 hour-averaged electron fluxes. Dst is in the top panel. Significant redistribution of outer belt electron fluxes is apparent not only in connection with rather large depression of Dst after May 15, but also during and after weaker disturbances.

The instrument with acronym NUADU (NeUtral Atom Detector Unit) measured continuously on the satellite TC-2. In paper [20] its measurements during a geomagnetic storm on August 24, 2005 with Dst=-219 nT in the near Earth plasma sheet were analyzed. Energetic ion beam events characterized by symmetrical, ring-like angular distributions around the ambient magnetic field lines were observed during a 34-minute traversal of the plasma sheet by the spacecraft. At the same time the multiple crossings of the plasma sheet were observed by another instrument aboard the same spacecraft, namely the magnetometer FGM. The low frequency electromagnetic wave detector LFEW/TC-2

observed at each crossing a whistler-mode chorus enhancement at a frequency just above that of the local lower hybrid wave. The whistler-mode chorus may have been produced due to ion gyro-resonance during particle pitch angle diffusion after the plasma sheet compression. The pitch angle distribution showed that an enhancement in the field aligned energetic ion flux was accompanied by tailward stretching of the magnetic field lines in the plasma sheet. The perpendicular ion flux enhancement was accompanied by a signature indicating the corresponding shrinkage of the magnetic field lines in the plasma sheet. Since both parallel and perpendicular ion-flux enhancements occurred intermittently, the data were interpreted to imply a dynamical, oscillatory process of the magnetic field line (stretching and shrinking) in the near-Earth plasma sheet.

An algorithm for error detection in measurements of the magnetometer composed of two sensors of the instrument MAG-VEX (PI Tielong Zhang, IfWF OeAW, Graz, Austria) situated at two different distances from the satellite body of Venus-Express was prepared in IEP SAS. The algorithm is identifying the time intervals with additional internal magnetic field of the probe and providing correction of the data. Computer code based on the algorithms described in [42,52-55] is utilized in the preprocessing of unique measurements of magnetic field near Venus by the ESA probe Venus-Express. Expected new results of the measurements were listed in [29]. The algorithm and preprocessing code developed contributed to the first finding of the detailed structure of magnetic field in the vicinity of Venus [30, 59].

Energetic particle measurements by DOK-2 instruments on Interball satellites were analyzed both in the case as well as in statistical type of studies. Radio bursts in the frequency range 100-1500 kHz and fluxes of energetic electrons with energies of 20-450 keV recorded onboard the Interball-1 satellite during prominent chromospheric flares on the Sun were studied in relation to electron observations at $E > 20$ keV [13]. The time of propagation of the electrons to the Earth was estimated using the method of comparison of the onset of radio emission generation during the explosive phase of the flare and the arrival of the accelerated electrons to the vicinity of Earth. A statistical study of solar wind plasma fluctuations in the Earth's foreshock and their relationship to measurements of energetic ions (~25, 50, 110 keV energy channels) under different solar wind and interplanetary magnetic field conditions, based on the Interball-1 data during 1995-2000, was done in [23]. The spatial and temporal characteristics of the energetic particle interaction with the foreshock plasma was discussed.

Based on 2 min averages of energetic ion measurements, the results on the flux distribution at various energies within the magnetosheath and in the region upstream from the bow shock were presented in [44,46]. Energetic particle data from Interball-1 were analyzed also in [33].

The analysis of data from the earlier experiments on low altitude satellites with the participation of IEP SAS was continuing. One of the results is using the data from energetic particle measurements on IK-25 satellite and Magion-3 daughter satellite (APEX), in addition to plasma and wave measurements. A specific feature of that experiment was that both the ion and electron beams were injected upward, in the same direction along the magnetic field. The excitation of HF and VLF-LF waves and the generation of fast charged particle flows, recorded on both satellites, is indicated from the analysis [2]. Another result, to which the energetic gamma ray measurements by the instrument on low altitude CORONAS-I satellite working in 1994 contributed, has been published in [23]. The wave measurements detected by the SORS instrument in the 0.1-15 MHz frequency range, as well as the gamma ray fluxes in the energy range 0.12-0.32 and 3.0-8.3 MeV, detected by the SONG instrument, located on CORONAS-I were used to describe the ionospheric plasma response to the strong seismic activity on 31.03.1994 during quiet geomagnetic conditions and on 6.04.1994 during the geomagnetic storm period. The electron fluxes of 30-500 keV obtained from the Active satellite experiment (IK-24 in 1989-1990, altitude from 500 km up to 2500 km) and ones with energies 0.3-1.0 MeV obtained onboard the MIR station (SPRUT-VI experiment in 1999, altitude from 350 km up to 400 km) were analyzed in [8]. The distribution of electron fluxes at low and middle latitudes and the influence of charged particles on surface layers of materials and film coverings were described. The comparison with results of other satellite experiments revealed the time and spatial stability of electron flux enhancements at L = 1.2-1.8.

Space weather study and predictions are using also energetic particle and cosmic ray data. A short overview of some tools for space weather issues, derived from middle/low latitude cosmic ray measurements in the past was presented in [12]. Both statistical and case studies performed to understand the observed relationship between the cosmic ray variability and the enhanced geomagnetic activity levels are discussed in that paper. In [5] the empirical relations between space weather effects and psycho-physiological, physiological and biochemical parameters measured in aviation personnel, were decsribed. In

paper [21] the arrival times at Earth of 166 flare-related shocks identified exiting the Sun (using metric radio drift data) during the maximum phase of solar cycle 23, were forecast in near-real time using three models. The predictions are compared with the arrival at L1 of shocks recorded in plasma and magnetic data aboard the ACE spacecraft.

Paper [25] presents results of cosmic ray modulation using neutron monitor data over long time period 1953-2001. Cosmic ray intensity is better correlated ($r = 0.93$) to the solar coronal hole area than to solar activity represented by the sunspot number R. In papers [6,7] the propagation of energetic particles in the interplanetary space is considered on the basis of kinetic equation describing the scattering of charged particles by magnetic irregularities and the particle focusing by regular magnetic field. Some results obtained from the study of reentrant heliospheric particles were presented [34,35].

The computations of the magnetospheric transmissivity for the application on AMS-01 observations have been discussed [3]. The possibility to deduce the fraction of secondary particles at different geomagnetic latitudes is discussed. Access of low energy cosmic rays to any position on the Earth depends on the state of the magnetosphere. In [11] it is illustrated that computations of magnetospheric transmissivity based on different available models of geomagnetic field for the selected strong geomagnetic disturbances in 2003 and 2004 imply different profiles of cut-off rigidities in time, different transmissivity functions and different asymptotic directions. Using of cosmic ray records by neutron monitors at middle and low latitudes during geomagnetically active periods, in addition to cosmic ray anisotropy in interplanetary space deduced from high and low energy cosmic ray ground based measurements, may be used for checking validity of geomagnetic field models. Magnetospheric transmissivity was discussed also in [36,47].

The continual high mountain neutron measurements at Lomnický Štít (2634 m above sea) with high statistical accurracy allowed to observe fine profiles of the two GLEs (January 20, 2005 and December 13, 2006) which indicate the acceleration of primaries to energies corresponding to rigidities at least 4 GV during those events. Analysis of October 28, 2003 with 1 min measurements at Lomnický Štít in comparison with Tsumeb neutron monitor data helped in identification of the arrival of solar neutrons to the Earth during that event (Fig. 3 in [27]). Radiation environment at Lomnický Štít was studied in paper [26].

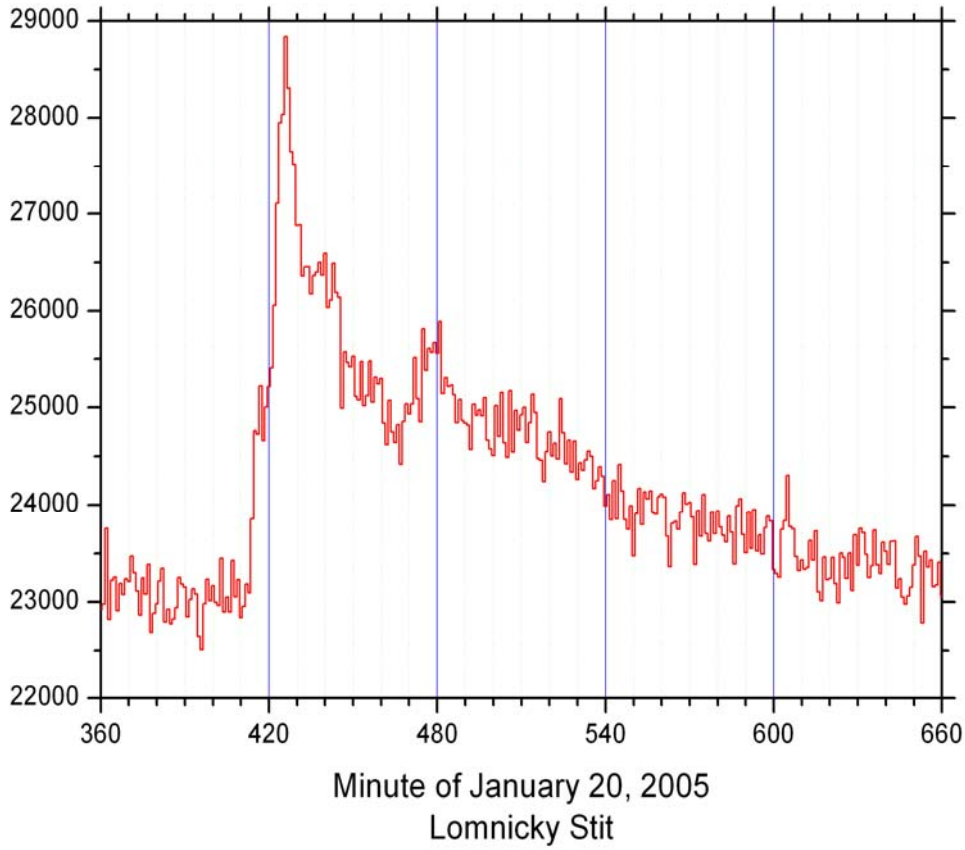

Fig.5. Ground level event observed at Lomnický Štít neutron monitor on January 20, 2005 [43]. Particle with the energy above that corresponding to the vertical cut-off rigidity (~4 GV) are indicated to be accelerated at the Sun and/or in interplanetary space with maximum at ~0707 UT. The effect was strongly anisotropic. The increase of high energy gamma rays (up to 100 MeV) was observed during that flare on CORONAS-F satellite.

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Last year the activities of ***Faculty of Mathematics, Physics and Informatics, Comenius University, Bratislava*** *in the field of interaction of cosmic rays with material objects were oriented on the study of four major problems:*

- Study of chemical elemental composition of Mars.
- Study of irradiation histories of iron meteorites
- Study of geomagnetic field intensity variations using in situ produced cosmogenic nuclides
- Study of possible link between cosmic ray intensity and some environmental factors.

Result of these studies were punished in 4 reviewed papers, 4 were submitted and accepted for publications and in about 8 contributions to conferences from which were published abstracts in current journals.

Last year, were obtained more experimental data from martian missions. We participated in this data analysis. Using the measured fluxes of gamma rays and our model calculations we were able to convert obtained fluxes in elemental maps of Mars surface.

During the last few years a lot of meteorites belonging to iron meteorites were analyzed at University Bern. In collaboration with group of professor Ingo Leya we studied the irradiation history of these meteorites, influence of granular structure on the production rates, and also the estimates on long term variations of galactic cosmic rays were established [6,7]. One of the basic questions related to history of these objects is the size of the parent body. Ratios of various cosmogenic nuclides can be used as shielding depth and preatmospheric size indicators. We analyzed a few meteorites and used our model for simulation of production rates. Based on this work we were able to put some limits on the sizes of investigated parent bodies, their exposure and terrestrial age. Further we concluded that production rates obtained from model simulations with present intensity of cosmic ray fluxes are consistent with measured and they do not indicate increase in their intensity in the past at time scale of hundred millions of years. This is due to inclusion of contribution from S and P into production rates of neon isotopes and ^{26}Al. Similar studies aimed on determination of exposure histories and sizes of parent bodies were carried out also for diogenites [4]. Fur-

ther improvements were achieved also in our study of Hf/W systematics and its application to dating of accretion processes in the Solar system [8].

A few years ago there was suggested idea that there exists inverse correlation between cosmic ray flux and cloud coverage. Using the codes developed for simulation of cosmic ray interactions with matter we were able to simulate the number of secondary particles produced in these interactions. There is proportional relation between these secondaries and condensation nuclei. Having calculated their density we concluded that cosmic rays couldn't be main trigger of cloudiness formation. In the following this model we extended our simulation about the simulation of muon fluxes. Muons were suggested as one of main contributors to this effect. Our simulations showed not significant effect.

One of the main results of our Department in the field of cosmic rays physics is the model for simulation of particle fluxes and production of cosmogenic nuclides in the Earth atmosphere and in the Earth surface [5]. This model was benchmarked last year with the data obtained from irradiation experiment carried out in collaboration with institutions from Denmark, Germany and England [1]. The production rates of in situ produced cosmogenic nuclides depends on primary cosmic ray particle flux, they modulation because the solar activity and geomagnetic field intensity. As most of cosmic ray particles are charged the interaction of geomagnetic field with them leads to their deflection. This leads to the dependence of cosmogenic nuclide production rates on geomagnetic field intensities [2,3]

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In the ***Geophysical Institute of the Slovak Academy of Sciences, Bratislava***, a number of issues important within the frame of the space weather studies were investigated using both the satellite (e.g. ACE, POLAR, DMSP) and ground-based data.

High-latitude geomagnetic field daily variations were studied from the view-point of the time-space distribution of auroral electrojets. If polar coordinates CGL-LMT (corrected geomagnetic latitude – local magnetic time) are used, the westward and eastward electrojets are located along three truncated spirals: the morning and night spirals nearby the auroral oval (for WE), the postnoon-evening spiral in the region of diffuse auroral precipitation (for EE). The night and morning spirals do not construct the closed oval. Between prenoon and postnoon hours, there is a gap between spirals at latitudes of the daytime cusp. In this time sector the polar electrojet is located just at these latitudes. In addition, the spiral distribution of most intense magnetic disturbances in daily variations of geomagnetic activity are in accord with that of high-latitude electrojets [1].

Variations of the location and intensity of the auroral electrojets during magnetic storms and substorms were studied using a numerical method for estimation the equivalent ionospheric currents based on data from meridian chains of magnetic observatories (IMAGE, GWC, and CANOPUS). The interrelation of electrojets with diffuse and discrete particle precipitation as well as with field-aligned currents was considered. Based on the international co-operation, such an approach made it possibly to modify the 3D system of electric currents in the magnetosphere during a magnetic storm [2].

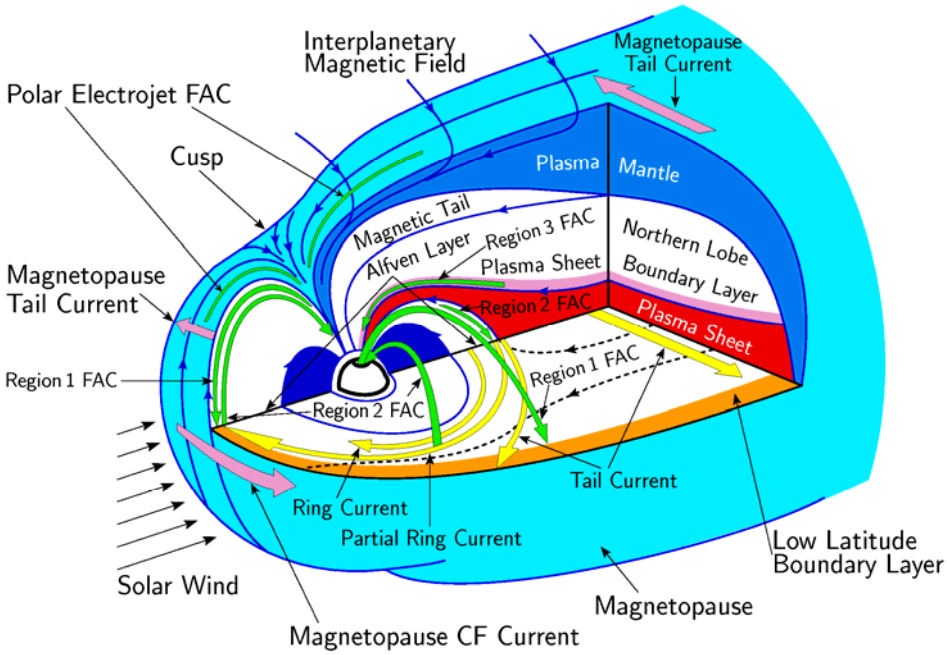

Fig. 6. The 3D system of electric currents in the magnetosphere during a magnetic storm.

The dynamics of auroral electrojets and field-aligned currents was analysed in detail during magnetic disturbances using a numerical method for estimating the equivalent ionospheric currents based on data from meridian chains of magnetic observatories. As shown, the westward electrojet adjoins to the polar electrojet located at cusp latitudes in the dayside sector. The association of electrojets with the field-aligned currents (FACs), namely Region 1 FAC and Region 2 FAC was considered. During intense disturbances a Region 3 FAC (accompanied by diffuse electron precipitation from the plasma sheet boundary layer) with the downward current was identified. The analysis of observational data is summarized in terms of 2D time-latitude distribution of electrojets at ionospheric altitudes. The magnetic field sawtooth variations generated during the storm main and early recovery phases were also discussed [3].

The analysis of magnetospheric and ionospheric plasma domains, typical regions of auroral luminosity and regions of auroral energy particle precipitation into the upper atmosphere under substorm conditions were analysed in relation to the auroral electrojets and their location. It was shown that there are more arguments for the two-vortex ionospheric current system at high latitudes, the most important being the independence of the eastward and westward electro-

jets. In fact those are associated with different types of both the auroral luminosity and auroral particle precipitation [4].

High quality and availability of digital measurements along a dense chain of IMAGE magnetic stations make them the unique and valuable tool for investigation of magnetic field variations at high latitudes. Together with data from Canada and Greenland chains this database was used to compare existing models of 2-D equivalent ionospheric currents. Locations of westward, eastward and polar electrojets are compared with characteristic regions of auroral luminosity and precipitating energetic electrons and ions observed by DMSP satellites at polar orbits. The natural tracers method was used to improve our understanding of links among various geophysical phenomena at ionospheric altitudes and in magnetospheric plasma domains [5].

The investigations from International Geophysical Year (IGY–1957) to International Heliophysical Year (IHY–2007) show that the space geophysics problems can be successfully solved when global interactions are taken into account using global databases. That intends the tight scientific co-operation within the frame of international programs and projects in order to promote the adequate nowcasting and forecasting of space weather [6].

On the basis of the initial neural network (NN) model a modified model for the Kp index prediction using not only solar wind data but also ground-based observations of the geomagnetic field was proposed. The horizontal component H variations of the geomagnetic field from the Hurbanovo Geomagnetic Observatory were used to predict storm profiles. The modeled geomagnetic activity level within the stormy intervals obtained by means of the modified NN model was compared with previous results to judge how the additional input information on a current state of the magnetosphere improves the accuracy of modeling. The results reveal that the November 2004 superstorm with a more complicated development is replicated better when the information on H component variations is taken into account [7, 8, 9].

Data concerning solar energetic events, published in 1996-2004 by the USA/NOAA in the form of daily reports, have been collected. The analysis of the particular event types indicates that the degree of their geoeffectiveness depends on their size and on their solar disc location. The mere information that a solar X-flare (XRA) event or a Long Duration XRA Event (LDE) has occurred on the solar disc is insufficient to produce a relevant forecast of geomagnetic

disturbances. The probability increases if the XRA is of class X which has occurred on the solar disk in central region (30°E, 30°W, 30°S, 30°N). XRAs associated with metric type II and IV radio bursts (RSP II and RSP IV), which occurred on the solar disc in this region will very probably cause a geomagnetic disturbance not only if X class, but also M class and B-C class are involved. The Disappearance of Solar Filament (DSF) data cannot be used in forecasting geomagnetic disturbances. The geoeffective and nongeoeffective DSFs are too disproportional [10, 12].

A forecasting scheme of geomagnetic activity is presented, based on the analysis of the geoeffectiveness of X-ray flares, accompanied by Type II and/or Type IV radio bursts (RSP) observed on the solar disc in the years 1996-2004. The neural network was used to construct this scheme enabling us to determine the probability, with which flares will be followed by a geomagnetic response of a particular intensity. The successfulness of forecasts produced after the fact depended on the flare class and on the combination of radio-burst types. In the case of RSP IV, 58 % of the geomagnetic responses of X-ray flares of at least B class were successful. If only RSP II was observed, the forecast was successful only for flares of the X class (67 % of successful forecasts). In the second step, a strong geomagnetic response was correctly forecast after geoeffective flares in 58 % of the cases. The results are in a good agreement with recent results based on physical modeling [11, 12].

An analytical model of a rotating annulus has been set up in order to study the formation of MHD instabilities. Preliminary findings indicate that multiple wave instabilities possessing different spatial and temporal scales can be excited due to the applied magnetic field. This sort of modelling can provide more insight into understanding of MHD processes in the near-Earth space influenced by solar variability [13, 14].

In the ***Department of Astronomy, Physics of the Earth, and Meteorology, Faculty of Mathematics, Physics and Informatics, Comenius University, Bratislava,*** the study of the upper atmosphere response to solar proton events (SPE) was continued.

The mesosphere and the lower ionosphere response to the SPE on 14 July 2000 was modeled over both South and North Poles. The general circulation model and 3D global transport-photochemical middle atmosphere model are used for simulations of neutral composition, wind and temperature response. Our simulations show that electron concentrations over both poles increase by more than 3 orders of magnitude. In the northern polar region (in polar summer) this enhancement lasts longer than in the southern polar region (in polar night). Riometric measurements in Finland and the Antarctic are in agreement with the model presented. Significant temperature changes in the northern polar mesosphere during the SPE found earlier contribute to the electron concentration changes by 10% at altitudes of 88–98 km with a delay of 5–8 days after the SPE onset [15].

Simulations presented show the greater SPE response of negative ions over the sun-lit northern polar cap then in the dark southern polar ionosphere. The response of the positive clusters is found to be similar in the both hemispheres. The cluster ion to molecular ion ratio is found to decrease by 2 orders of magnitude over the both poles, which is in agreement with measurements performed for the November 1969 SPE [16].

In the ***Department of Astronomy, Physics of the Earth and Meteorology (solar physics division), Faculty of Mathematics, Physics and Informatics, Comenius University, Bratislava,*** some problems of the solar corona physics were studied.

The changes in the excitation equilibrium of ions Fe VIII – Fe XV in the solar corona due to the electron non-thermal κ-distribution were studied. The shape of the distribution affected the electron excitation rate and together with the changes in ionization equilibrium they influenced the final intensities of spectral lines. The suitable intensity ratios of spectral lines have been used to propose

and discuss the diagnostics of the non-thermal parameters of coronal plasma [17].

High spectral and temporal resolution data from SUMER/SOHO plus high resolution images from TRACE were used to study the nature of high-velocity flow events in the solar transition region. In the transient feature discussed, we have seen a factor of two enhancement in N V 1238, coupled with a factor of two decrease in O V 629 visible over 3"-4" along the slit. Furthermore, the O V line shows a secondary component with a down-flow of ≈75 km s^{-1}, while the N V line showed only a small additional broadening of the line. This feature can be explained via a highly focused jet at the O V/O VI formation temperature resulting from reconnection [18].

Using the linear force free extrapolations of photospheric magnetic field of an active region and the scaling laws the electron density, temperature and pressure were computed along the magnetic loops in solar corona. Computed emissivity was convolved with SOHO/EIT response functions and compared with EUV observations of that active region [19].

The software and database package CHIANTI was modified. The modification includes the procedures which allow the computation of synthetic spectra for two kinds of non-thermal electron distributions: kappa-distribution and n-distribution (power distribution). The database now involves the non-thermal ionization equilibrium data sets for several ions and uses the collision strengths (Omega-s) which were acquired by the inverse technique from the collision strengths averaged over the Maxwell distribution (Y-s) or from the TIPbase atomic database [20].

The synthetic intensities of the spectral lines observable by SPIRIT were computed using the modified CHIANTI codes. The diagnostics, which could be used for the determination of the parameters such a distribution function shape, mean energy and electron density in different regions in the solar corona was suggested [21].

The positions of vertical current kernels obtained from MSFC vector magnetograms were compared with positions of the observed EUV flare kernels and with the maps of vorticity and kinetic helicity at several depths below the photosphere. The vorticity maxima were situated within the active region and were

located at depth of 3.0 Mm below the photosphere. The maxima of kinetic helicity were dominant within the active region in depth range 1.8–4.5 Mm and they were not located directly below the vertical current kernels but they were still located in their vicinity [22].

The solar flare spectra in X-ray region within 5-6 Å obtained by RESIK spectrograph were analysed in order to detect the time changes of the energy distribution function of the free electrons. The CHIANTI modification for n-distribution was used for calculating the synthetic spectra under the assumption of non-thermal distribution. Although there were large relative errors, the observed line ratios clearly show that during the flare the parameter n of the distribution and pseudo-temperature τ move to higher values and then thermalize during the decay phase of the flare [23].

The non-thermal electron distributions with a rather mono-energetic shape and a higher peak than the Maxwellian distribution can be observed in flaring plasmas. The influence of this kind of electron energy distribution on the excitation equilibrium of Fe VIII-Fe XVI in the solar corona was studied. The possibilities of finding the shape of the electron energy distribution from the Fe line ratios was suggested and the diagnostics can be used e.g. for EUV spectra form EIS aboard Hinode (Solar-B) [24].

Both the Hα solar telescope of the Astronomical and Geophysical Observatory (AGO) in Modra-Piesok in Slovakia and system of observations were described [25].

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The activities of ***the Astronomical Institute of the Slovak Academy of Sciences (AISAS)***, Tatranská Lomnica (http://www.astro.sk), related to COSPAR, were devoted to the research in solar and stellar physics using different satellite observations, mainly in the UV, XUV and X-ray spectral regions. Usually data of the current SOHO mission, the TRACE and the RHESSI satellites and previous satellites of the NOAA and GOES series were used for solar research. Some other studies were focused on the solar activity, solar coronal emission and the cosmic rays with respect to the solar cycle and its influence on the heliosphere using the ground-based data. Stellar data of the IUE satellite and the HST were used for research of various variable stars.

New results on dynamics and energy transfer in the outer layers of the solar atmosphere were presented in papers devoted to quiet solar network and dynamic fibrils with help of data acquired in frame of the SOHO/TRACE joint operation program JOP078 using CDS, MDI, EIT instruments on-board SOHO as well as the TRACE satellite. In particular, mutual relations of the upper layers of the quiet solar atmosphere in/above chromospheric network were studied (Fig.7) in order to identify physical mechanisms which control energy transfer to the corona [4,5]. Dynamics of fibrils was investigated statistically to confirm/regret the theoretically proposed mechanisms causing highly dynamic nature of the solar chromosphere. Data were acquired thanks to EU 6thFP funds of the OPTICON Trans-national Access Program [6].

The space-time distribution of the solar corona brightness was investigated over more than five solar cycles using the data sets compiled and the institute. A pronounced north/south asymmetry of the solar corona was studied including the quasi-biennial oscillations and rotation of the solar corona [2,3,13].

By analyzing a time-latitudinal evolution of the intensities of the green corona in the period of 1939-2006 we found out that the splitting of their poleward-migrating branch at middle-latitudes and its disappearance around the poles can be used to forecast the minima and maxima of solar activity. We showed, for the first time, that the localization of the intensities of the green corona in this high-

latitude branch of the corona is intricately related with the migration of magnetic fields from middle latitudes towards the poles, which is also traced by large prominences [8].

After comparing the coronal index with similar indices of solar activity like the Wolf number, radio flux 10.7m (2800 MHz), MgII index and Total Solar Irradiance (TSI) one, we found that the coronal index is completely on par with all the other indices, correlating with TSI even better in some phases of a cycle [9,10]. Periodicities of the Total Solar Irradiance (TSI) as well as other solar indices was investigated [1].

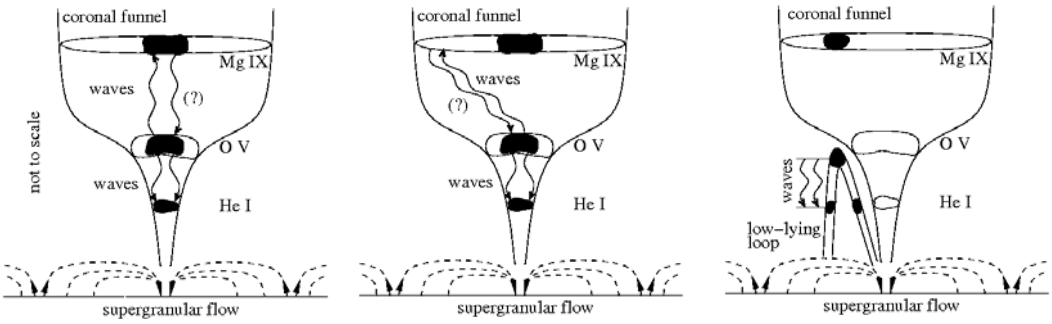

Fig. 7. *Sketches of the different possible scenarios of the dynamics and energy transport between the corona and the undelying layers/structures of the solar atmosphere in/above the network. Our observational findings do not conflict with predictions derived for the reconnection (nanoflare) heating mechanism of the outer solar atmosphere although the original source of the energy release was impossible to recognize.*

An analysis of the eclipse observations from 2005 and 2006 has revealed that the inner part of this corona is structurally almost identical with the X-ray and EUV coronas, what means that these two layers of the corona can be used to model the former. This is a very important fact in light of our recent findings, employing a qualitatively new method of data processing, that the hyper-fine structure of the white-light corona differs much from what we thought of it so far [11].

Ground-based radio data and the UV imaging of the solar corona, obtained by the space-born instruments, were analyzed together in order to reveal mechanisms causing the solar radio burst with the long emission periods [7].

A new extremely extended solar activity index covering independently from the northern and the southern atmospheres of the Sun was prepared and published

[14,15]. It consists of the daily and monthly data of the hemispheric relative sunspot numbers. Data of two observatories – Kanzelhoehe Solar Observatory (Austria) and Skalnate Pleso Observatory (Slovakia) were used reaching the 84% data coverage over the whole time epoch between 1945 and 2004. The data set is now the best possible tool to investigate the N-S asymmetry of the solar magnetic flux over the epoch of the last 5 solar cycles (Fig.8).

The far ultraviolet spectroscopy taken by the FUSE satellite (Far Ultraviolet Spectroscopic Explorer) was used to study the outburst stage of the symbiotic prototype Z And during its major 2000-03 outburst. The UV spectra, complemented with other ground-based observations, revealed an expansion of the hot object and an enhanced mass loss from the system (Fig. 9). Evolution of the two-temperature type of the spectrum at the initial stages of the outburst suggested that the active object consisted of optically thick, slowly expanding disk-like structured material encompassing the white dwarf at the orbital plane and of a fast optically thin wind escaping the star at higher latitudes. A striking similarity between [FeVII] 608.7 nm and the Raman scattered OVI 103.2 nm line profiles at/after the dilution of the disk suggested their origin within the interaction zone, where the winds from both stars collide. This can help to study streaming along the zone of interaction between the two winds [12].

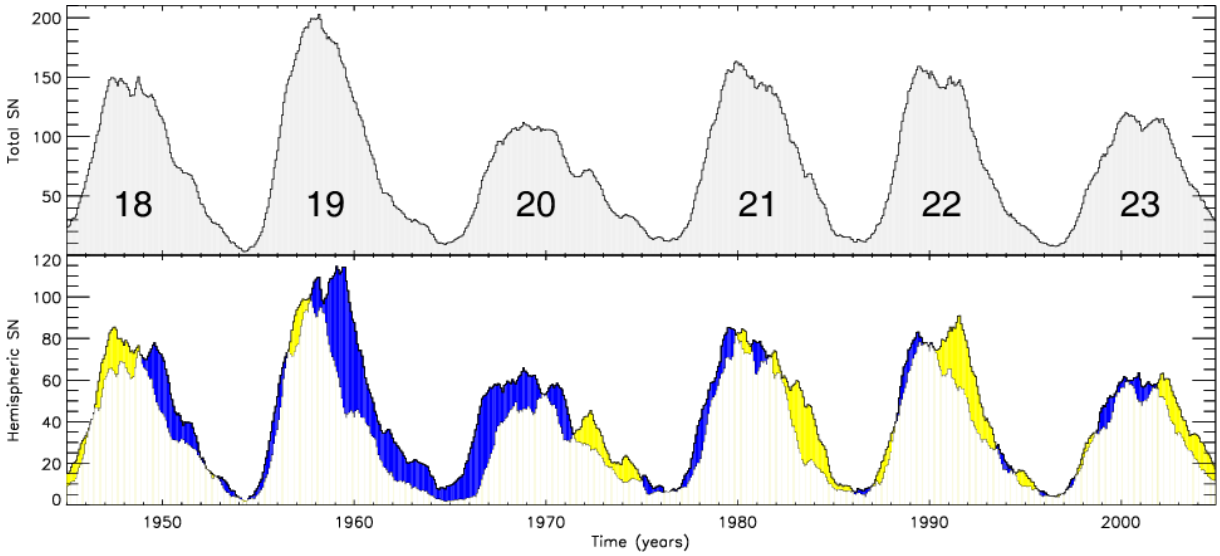

Fig. 8. *Smoothed monthly relative sunspot numbers for the entire disk (upper panel) and excesses of one hemisphere over the other (bottom panel) based on smoothed-monthly hemispheric sunspot number. Excess of the southern/northern hemisphere is shaded yellow/blue. The time span covers the years from 1945 until 2004 which corresponds to solar cycles 18−23.*

In the period Jun 28 – July 12, 2006 the new run of the SOHO joint observing program JOP 171 (SOHO, TRACE, RHESSI) was performed together with support of the ground-based observations of the Dutch Open Telescope and the Kanzelhoehe and Hvar Solar Observatories. Details are given at the dedicated web page of the campaign http://www.astro.sk/~choc/open/06_dot/06_dot.html. The first results have been already presented at different conferences on the topic of the onset of the flare/CME events. New SOHO joint observing program JOP 189 for instruments on-board the SOHO, thew HINODE, the TRACE and the RHESSI satellites was performed (August 3-31, 2007) supported by the ground-based observing campaign of the Dutch Open Telescope and the Kanzelhoehe and Hvar Solar Observatories (http://www.astro.sk/~choc/open/07_dot/07_dot.html). The best data of these campaign will be utilized in the near future. Additionally, a special observing program was prepared and run in frame of the first SOHO-HINODE observing campaign in April 2007 upon invitation of the campaign leader Dr. W. Curdt (MPS, Lindau, Germany).

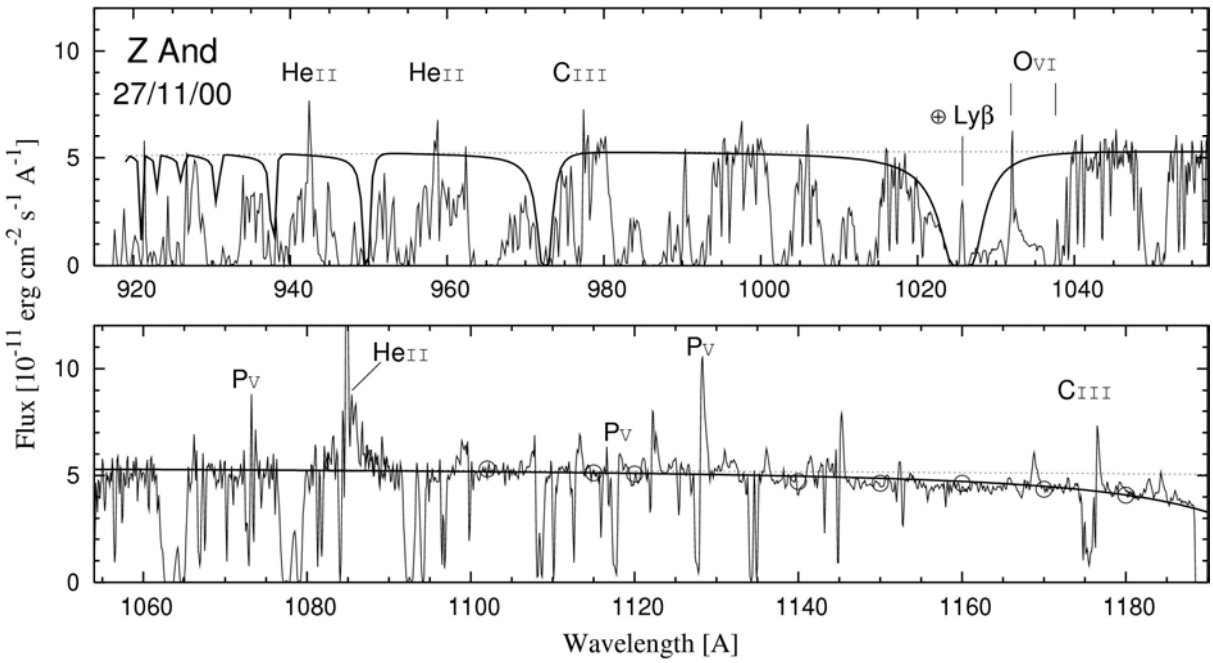

Fig. 9. *De-reddened FUSE spectra of Z And from the maximum of the optical brightness. The solid line represents the Rayleigh attenuated (N_H = 7E+21 cm-2) blackbody radiation from the hot stellar source at 28000 K, while the dotted line is not attenuated. Most of the absorption features are due to H_2 in the interstellar medium. The P-Cygni type of profiles for C III and P V lines and the broad emission in the He II 1084 A profile indicate the mass outflow from the star.*

The Astronomical Institute organised in cooperation with the US-SK Joint Research Project on Space Weather led by prof. S.T. Wu (CSPAR, UAH, Huntsville, AL, USA) a closed (upon invitation) workshop on the topic of the solar flares and their relation to initialisation of the coronal mass ejections (Tatranska Lomnica, 13-15 Sept, 2006*, web page: http://www.astro.sk/~choc/open/06_wrkshp/06_wrkshp.html*). Colleagues working in this branch of solar physics from the Central Europe region (Austria, Croatia, Czech republic, Hungary, Poland) and Slovakia (Bratislava, Rimavska Sobota, and Tatranska Lomnica) have taken part at the workshop. Oral presentations of almost all participants about their research and latest achievements in the field of solar flares and CMEs.

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3. LIFE SCIENCES.

The project „*Investigation of neuroendocrine system activity in rats exposed to hypergravity using telemetrically controled collection of blood* „ was performed with participation of ***Institute of Experimental Endocrinology, Institute of Animal Biochemistry and Genetics and Institute of Measurement Sciences , all in the Slovak Academy of Sciences.***

The response of neuroendocrine system to hypergravity was investigated by using a special equipment (developed at the Institute of Measurement Sciences), which serves for programmable blood collection from experimental animals located in special cages on a centrifuge during the exposure to hypergravity.
Rats subjected to various accelerations (+G) exhibited increased levels of plasma epinephrine (EPI), norepinephrine (NE) and corticosterone (C). However, in previou observations, the collection of blood was performed after a centrifugation finished and therefore the levels could be affected by the process of deceleration.

The aim of this study was to evaluate plasma EPI, NE and C levels in blood collected directly during the centrifugation after reaching different G (2-6) using newly developed remote controlled equipment. Animals placed into the centrifuge cabins had inserted plyethylen tubing in the tail artery, which was connected with preprogrammed device for blood withdrawals. Plasma EPI, NE and C were measured at different time intervals of hypergravity of 2-6 G. Plasma EPI showed a huge hypergravity level dependent increase. After the last blood collection was completed during hypergravity, the centrifuge was turned off and another blood sampling was performed immediately after the centrifuge stopped (10 min) In these samples plasma EPI showed significantly lower levels compared to centrifugation intervals. Plasma NE levels were increase only after 6G. The increase of plasma C was dependent on level of G, however after centrifuge stopped, C levels stayed elevated.

Thus our data show that hypegravity activates the adrenomedullary and hypothalamo-pituitary-adrenal systems, whereas the sympathoneural system is activated only at high G. Immediately after the centrifugation is over, the EPI levels very quickly return to control values. Our technique of blood collection during centrifugation allows to reach the real hormonal levels at the particular hypergravity value.

In further experiment the effect of short and long-term exposure of rats to hypergravity of 2G on gene expression of catecholamine biosynthetic enzymes in adrenal medulla was studied. Significant increase of mRNA of tyrosine hydroxylase (TH), dopamine-beta-hydroxylase (DBH) and phenylethanomamine-N-tranferase (PNMT) was noted after 6, 24 and 72 hours exposure to hypergravity. After 144 hours levels of TH and PNMT mRNA in adrenal medulla had fallen significantly as compared to those observed at 72 hours and were not longer increased as related to absolute control. DBH mRNA levels were elevated after 24 and 72 hours in hypergravity, and after 144 hours were similar as in controls. These results showed that short term hypegravity is an intensive stressor that activate TH, DBH and PNMT enzyme gene expression in adrenal medulla. After longer term exposure to 2G (for 144 hours), the gene expression of these enzyme was decreased suggesting an adaptation mechanism probably involving adrenergic feedback.

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The project „*Activity of neuroendocrine system in the conditions simulating microgravity effects"* was performed on collaboration of ***Institute of Experimental Endocrinology, Slovak Academy of Sciences, Bratislava,*** and ***Department of Applied Physiology, Medical Research Centre, Polish Academy of Sciences, Warsaw.***

The aim of present study was to observe if the prior improvement of physical fitness by endurance training (ET) may decrease a negative effect of subsequent bed rest (simulating some conditions of microgravity) on glucose metabolism. The effect of endurance training (ET) and subsequent head down bed rest (HDBR) on glucose and insulin responses to oral glucose load and to physical exercise was investigated in 14 physically fit males. The trial consisted of 6 weeks of ET followed by 6 days of –6° strict HDBR with a minimum of physical activity. A standard oral glucose tolerance test (OGTT) and treadmill exercise at 80% of pre-training VO_{2max} were performed before and after ET as well as after HDBR. It was noted that fasting as well as OGTT plasma glucose levels were significantly lowered after the training. After three days of HDBR plasma glucose levels during the second hour of OGTT tended to be higher, however, without statistical significance. Average plasma levels of insulin and C-peptide during OGTT were not significantly changed after the ET, but they were significantly altered during HDBR, with increased response predominantly in the second hour of OGTT. Insulin resistance (HOMA-IR) tended to decrease after ET and to increase after HDBR, however without statistical significance (1.62±0.20, 1.25±0.23, and 1.33±0.15; control, ET and HDBR, respectively). Peripheral insulin sensitivity represented by ISI Cederholm was significantly elevated after the training (76.2±5.4 vs. 61.3±3.2) and decreased slightly after HDBR but did not reached statistical significance (64.8±4.3). ISI Matsuda exhibits similar pattern like ISI Cederholm, however without statistical significance (6.8±0.8, 8.9±0.8 and 7.4±0.6; control, ET and HDBR, respectively). Plasma glucose, insulin and C-peptide response to exercise before and after ET were similar, whereas all three parameters were significantly elevated in response to exercise after HDBR. 6 weeks of ET were followed by increase in maximal oxygen uptake by about 11%. Neither absolute nor relative changes in VO_2max induced by ET were associated with glucose, insulin and C-peptide responses to OGTT and

exercise or with the indices of insulin sensitivity and resistance after ET and after HDBR.

These results showed that the endurance training decreased, whereas three days of subsequent bed rest increased glucose, insulin and C-peptide responses to oral glucose load in physically fit male subjects. Endurance training did not change glucose, insulin and C-peptide responses to physical exercise. After bed rest glucose, insulin and C-peptide responses to exercise were significantly enhanced. As expected, insulin sensitivity mainly peripheral (muscle) increased after endurance training and tended to decrease after HDBR. In conclusion, the results of present study showed that antecedent physical training could ameliorate the negative effect of short lasting physical inactivity on insulin-mediated glucose metabolism.

It was reported that microgravity during space flight resulted in redistribution of body fluid including higher cerebral blood. These changes in blood flow could affect the glucose supply to brain and also the neuroendocrine response to hypoglycemia. The total body immersion in isotermic water has the similar effect on blood redistribution. Therefore the effects of immersion into isotermic water on neuroendocrine response to insulin induced hypoglycemia were investigated in adult healthy subjects. Significantly higher increase of epinephrine during hypoglycemia was noted in human subjects during water immersion as compared to response in laboratory conditions. Rapid increases of growth hormone and prolactin plasma concentrations were observed during immersion, the maximal levels of prolactin were higher in immersion as compared to laboratory conditions. These results showed differences in the neuroendocrine responses during exposure of human subject to water immersion in comparison to head down bed rest or to microgravity during space flights.

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The project *„Accumulation and persistence of cytogenetic damage induced by radiation and other factors of space flight"* was performed at ***Institute of Biological and Ecological Sciences, Faculty of Sciences, P. J. Šafárik University, Košice.***

The effects of a whole body gamma irradiation with the sublethal dose (3 Gy) on the brain of adult male rats and late consequences in the form of induced genomic instability in their progeny were studied. In the brain of irradiated rats, some transient quantitative changes in DNA and RNA, an increase in H1° subfraction in the histone H1 (Bálentová et al. 2007d), and especially profound changes in the proliferative activity in the rostral migratory stream (RMS) were found. More specific computer image analysis of proliferative activity in the forebrain RMS allowed quantifying the numbers of dividing $BrdU^+$ cells. Alteration of adult cell proliferation following irradiation showed a biphasic course, which was characterized by initial decrease in number of proliferating cells in the whole extent of the RMS in course of the first days after irradiation and subsequent transient increase, mainly in its initial parts (Bálentová et al. 2006a, 2006b, 2007a, 2007c). The observed increases in $BrdU^+$ cells within the RMS suggested the possibility of post-radiation reparative neurogenesis. Initial decrease in the number of BrdU positive cells in the RMS of irradiated rats was accompanied by increased occurrence of apoptotic cells (Račeková et al. 2006).
In the progeny of male rats irradiated 25 or 80 days before mating, significant changes of BrdU positive (proliferating) cells in the individual parts of the RMS of progeny was found in course of the first month after birth (Bálentová et al. 2006c, 2007b, 2007e). It is presumed that increase in the $BrdU^+$ cells in the progeny of irradiated male rats is due to radiation-induced genome instability and it may reflect an enhanced cell proliferation for compensation of the damaged cell loss, or may result from the decelerated migration of proliferating $BrdU^+$ cells along the rostral migratory pathway. Results of these investigations could be useful in human medicine to estimate the late effects and genetic risk of ionizing radiation or other genotoxic factors.

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4. REMOTE SENSING

Activities in the field of remote sensing carried out at the ***Institute of Geography, Slovak Academy of Sciences*** in Bratislava in the period 2006-2007 were connected with:

A/ Landscape changes assessment for the period of 1990-2000 at the regional and all-European levels based on the Corine Land Cover (CLC) data derived by interpretation of satellite images also available at the web site – http://www.eea.europa.eu of the European Environment Agency (EEA).
Landscape change assessment at the regional level was realized in the context of the joint research project *„Changes of the rural landscape in Slovakia and Bulgaria in 1990-2000 identified by application of the CLC data on example of areas Trnava and Tatry in Slovakia and Plovdiv and Burgas in Bulgaria"* between the Slovak Academy of Sciences and the Bulgarian Academy of Sciences. Land cover changes characterizing urbanisation processes were identified only in areas Trnava and the Tatras. Intensification of agriculture was also higher in these two areas. Land cover changes characterizing the process of extensification of agriculture were dominant in areas of Plovdiv and Trnava. Deforestation and afforestation were identified in all areas (Trnava, the Tatras, Plovdiv and Burgas).

Landscape change assessment at the European level was carried out in the cooperation of the Institute of Geography, SAS, IGN France International, GISAT, and Alterra. Results suggest that urbanisation was most conspicuous in the Netherlands (2.1 % of total country's area; see Fig. 10), intensification of agriculture was highest in Ireland (3.3 %), extensification of agriculture was highest in the Czech Republic (over 3.5 %), afforestation and deforestation dominated in Portugal (over 3.5 % and over 4 % respectively) and construction of water bodies was highest in the Netherlands and Slovakia (over 0.1 %).

B/ Work on the all-European CORINE Land Cover 2006 (CLC2006) Project, aim of which is identify land cover changes in Europe for the period of 2000-2006, by application of SPOT and IRS satellite data. Derivation of land cover changes data for Slovakia in the quoted period in case of the CLC2006 Project is coordinated by the Slovak Environmental Agency in Banská Bystrica. The Institute of Geography SAS is the subcontractor of this Project. The work on the CLC2006 Project in Slovakia will be completed in 2008.

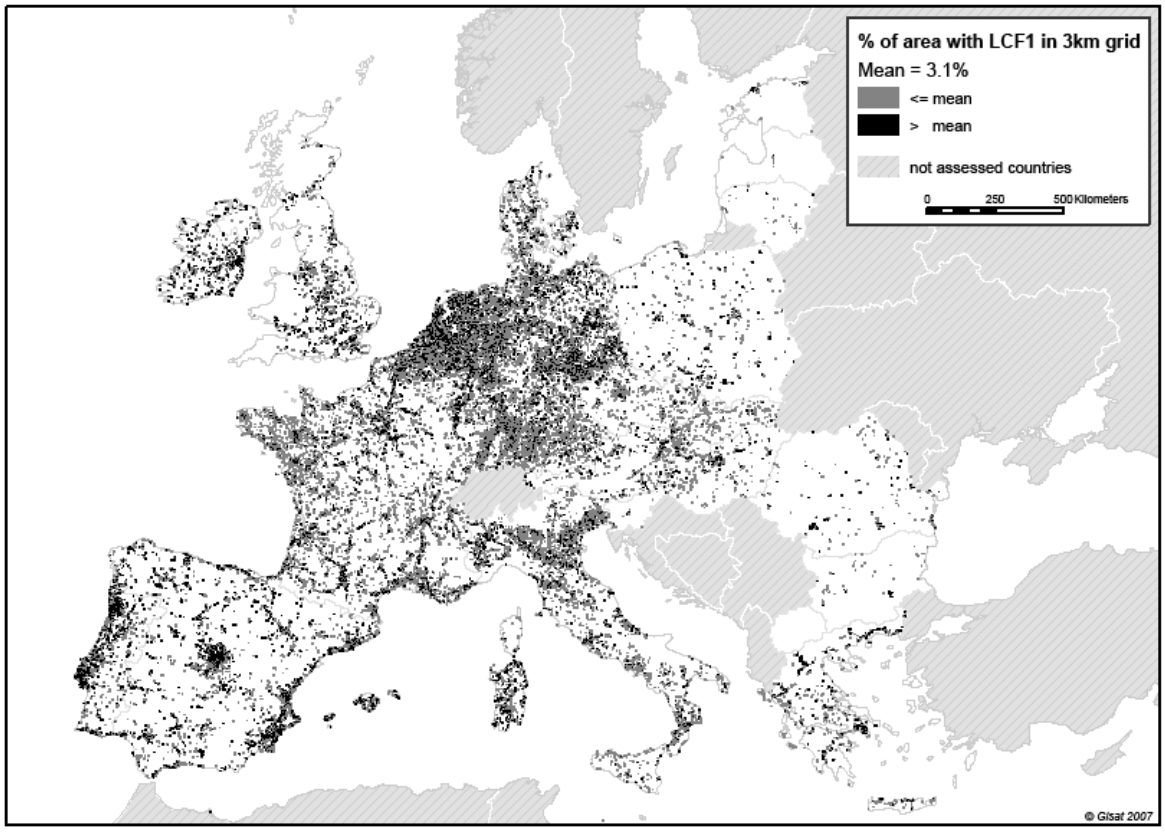


Fig. 10. Spatial distribution of urbanisation (LCF1) in 24 European countries.

Slovak Environment Agency was active in the following remote sensing projects/tasks in period 2006-2007 land cover mapping and changes analyses along with verification, spatial modelling of zoones, real time GPS service and participation in GMES initiative.
Remote Sensing Dept. at Slovak Environment Agency is located in Banska Bystrica, it has 4 persons, using ESRI products Unix ArcInfo, Win ArcGIS, ArcView, ArcIMS, PCI product Geomatica and many open source SW supported by Debian and Solaris, futher info is accessible at URL http://www.sazp.sk/DPZ email dpz@sazp.sk

GMES FTS CLC 2006 and CORINE products verification
This project is financed by European Environment Agency and Slovak Ministry of Environment. Institute of Geography, Slovak Academy of Sciences in Bratislava, as subcontractor of this project, was partly responsible of visual interpretation. Remote Sensing Dept. at Slovak Environment Agency completed these tasks: image preprocessing of georeferenced scenes from satellites SPOT and IRS over the whole Slovak territory, enhancement for visual interpretation, mosaicing of cloud areas, preprocessing of relevant aerosurvey datasets, GIS processing of coverages and changes, topology building, statistic analyses, collection of metainformation, verification of landcover, forest and soil sealing products for GMES FTS. Project should be completed in 2008. Old results and standard CORINE products from All results along with reports are publicly available via Internet:

http://www.sazp.sk/corine Project CORINE landcover in Slovakia
http://atlas.sazp.sk Public Map services SAŽP (OGC WMS)
http://enviroportal.sk/sektor Core Set Indicator Reports from Slovakia
http://www.sazp.sk/slovak/struktura/ceev/DPZ/CLC2000/corine/verifikacia-01-clc-sk.pdf Verification of Slovak CORINE products IMA2000. CLC1990, CLC2000, CLC2000scale50 (PDF format from Impress presentation)

Spatial modelling of zoones

Project is based on cooperation with Parasitological Institute, Slovak Academy of Sciences in Kosice. Multitemporal analyses along with GIS processing help to find spatial relations and develop risc map of potential occurences of tick born diseases. Time sequence analyses for Lyme borreliosis (1996-2004) and Tick-borne encephalitis (1971-2004) was done and published at CEECHE 2006 conference (Central and Eastern European Conference on Health and the Environment). More info is available at URL:

http://www.ceeche.org
http://www.sazp.sk/parazity
http://www.sazp.sk/slovak/struktura/ceev/DPZ/PARAZITY/lbke/multivar04notebook.pdf (PDF format from Impress presentation)

Real time DGPS service

Slovak Environment Agency Banska Bystrica in cooperation with GEOTECH Bratislava has ensured real time DGPS permanent service since 2003. It is accessible by users via GPRS. NAVSTAR satellites are used LEICA reference station which has accuracy suitable for GIS applications. Permanent measurements (24h 365d) with interval 1s are archived in raw and RINEX format.

Activities during years 2006 – 2007 in the field of remote sensing on the ***Soil Science and Conservation Research Institute*** in Bratislava were focused on the Control of area-based subsidies, Crop yield forecasting (regional inventory, monitoring of crop conditions and crop growth development, crop yield forecasting) and Precision farming.

Remote sensing control of area-based subsidies in agriculture (2006-2007)

The subsidies play a key role in agricultural sector and contribute to the prosperity of agricultural subjects. The subsidies to agriculture sector represent a major part of European budget and that is why supervision is emphasized.

The controlled schemes by remote sensing are the following:

- SAPS – Single area payment scheme
- CNDPs – Complementary National Direct Payment scheme (crops)

On the following figure, the distribution of the control sites can be seen. The Slovak Administration has chosen 4 sites per year which are usually defined by 20x20km (Fig. 11). They cover approximately 5 % of applications.

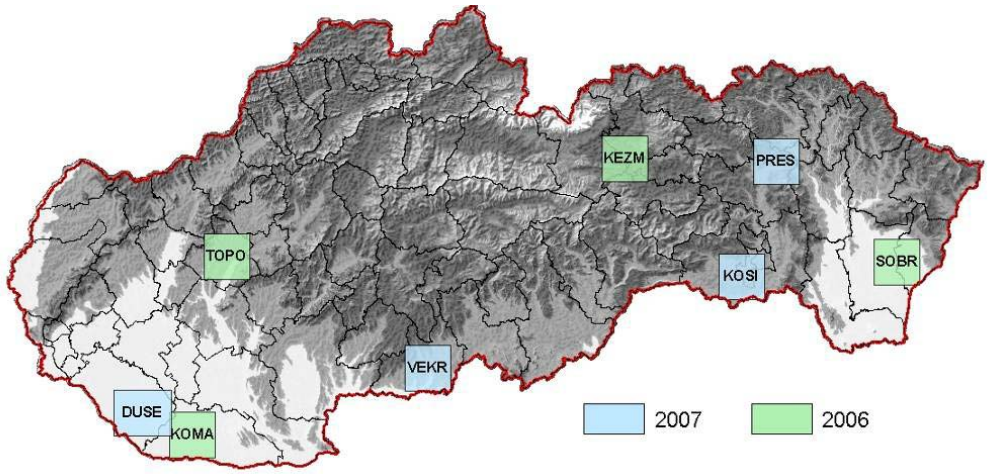


Fig. 11. Location of the controlled sites in 2006 and 2007 campaigns.

In control procedure, a set of high resolution (HR) multispectral images as SPOT, Landsat and IRS (mainly 3 or 4 per site) were used for precise identification of the grown crop. To control the cultivated area and its use, Very High Resolution (VHR) images from IKONOS2, QuickBird-2 and SPOT 5 Supermode as back-up images were applied per each site (Fig. 12). Features which have to be excluded from the parcels like field path, straw stacks, midden, etc. are well recognisable on these images.

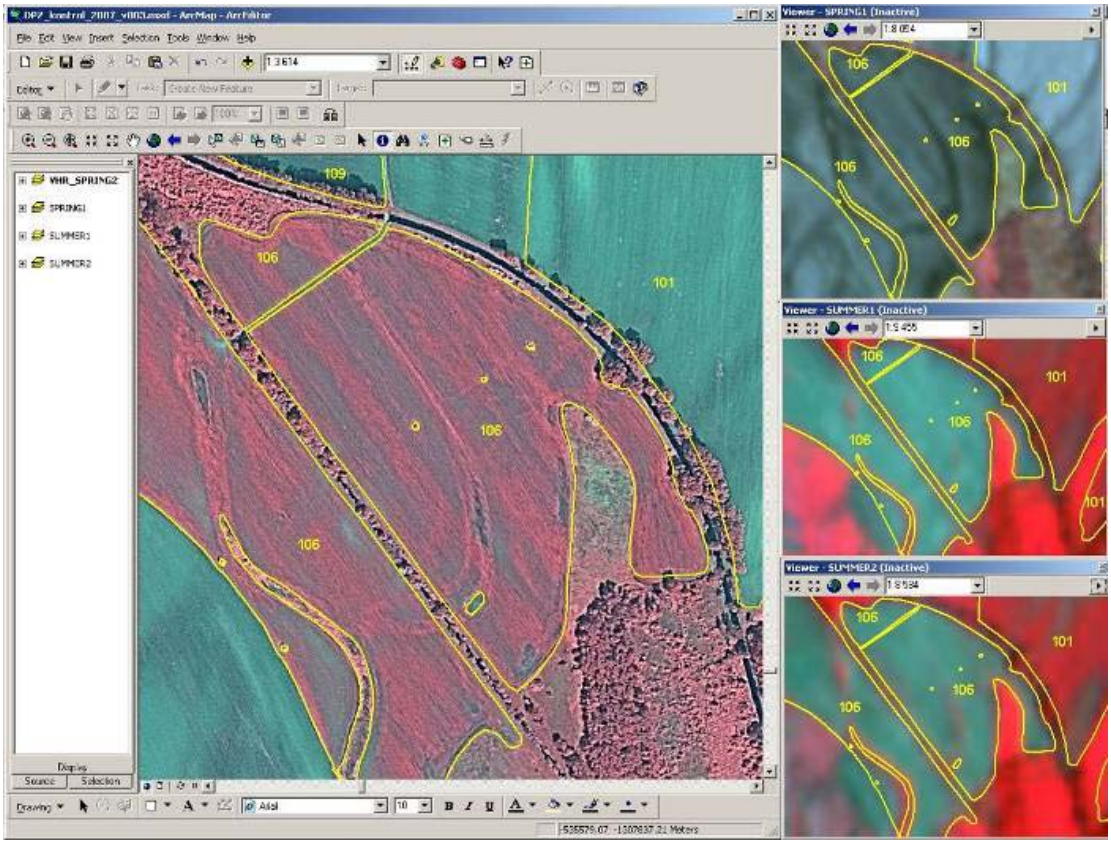


Fig. 12. Land use check with multi-temporal HR images.

The results of the controls for the 2006 and 2007 campaigns can be seen in tables 1 and 2. Usually only 50% of the applications are accepted for SAPS while 35% are accepted for CNDPs.

Table 1. Controlled applications

Year	Sites	Applications	Deklared parcels	Declared area [ha]	Retained area [ha]
2006	4	725	8 596	113 142.7	105 852.07
2007	4	615	6 376	32 458.6	31 224.72

Table 2. Status of the applications

Year	Scheme	Accepted		Rejected		Sum
2006	SAPS	403	56%	322	**2006**	SAPS
	CNDP	239	34%	463		CNDP
2007	SAPS	340	55%	275	**2007**	SAPS
	CNDP	270	46%	319		CNDP

The reasons of rejections are different (Fig. 13); they can be a result of:

- wrong parcel identification on the graphical annex (orthophotomap 1: 10 000),
- imprecise declared area due to change of cultivation,
- unused area on the parcel,
- expansion of built-up area on the arable land.

Fig. 13. Discrepancies found during the control.

Remote sensing applied to crop yield and crop production forecasting (2006-2007)

Regional crop inventory

High resolution images like IRS or Landsat are appropriate inputs for quick area estimation of major crops. Methodology of estimates is based on digital classification of satellite images. Crop inventory is carried out three times per year. Monitored crops are the following: winter wheat, oilseed rape, spring barley, maize, sunflower, sugar beet (Fig. 14).

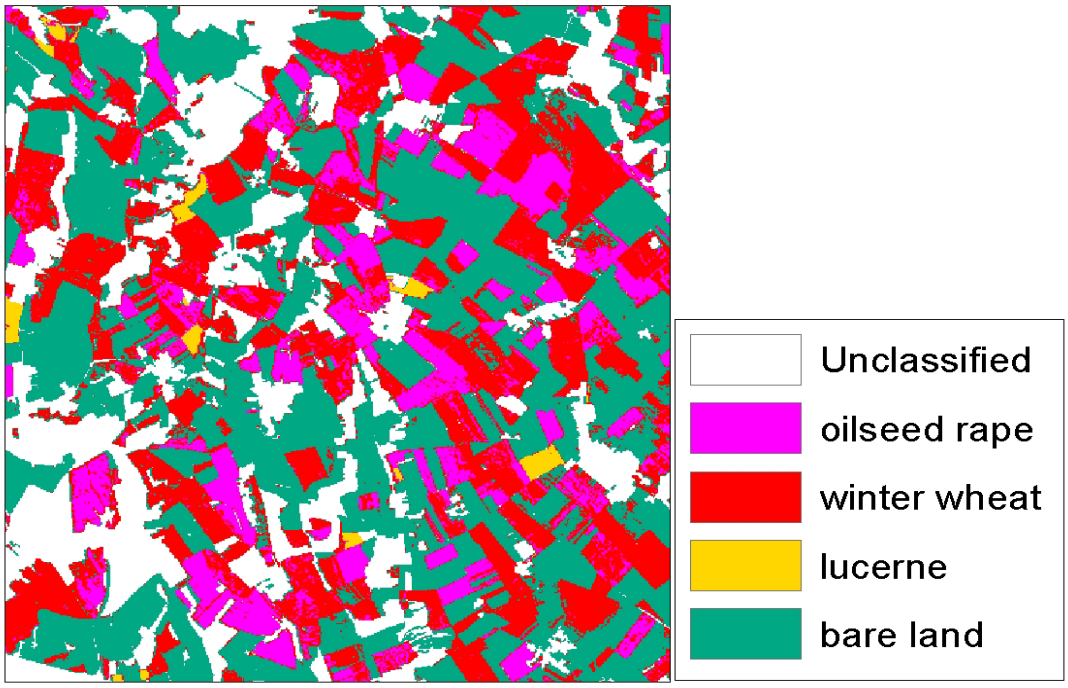


Fig. 14. Sample from regional crop inventory – winter season.

The aggregated results of the early planted area estimation for winter wheat in 2007 campaign can be seen in the Table 3.

Table 3. Comparison between planted area estimates (SSCRI) and real planted area (Statistical Office SR; SO SR) of winter wheat in 2007.

Region	**Real planted area**	**Planted area estimates in 2007**	**Differences between planted areas**	**Differences between planted areas**
(NUTS3)	**in 2007**	**(RS)**	**in 2007**	**in 2007**
	SO SR	**SSCRI**	**SO SR - SSCRI**	**SSCRI/ SO SR**
	(ha)	(ha)	(ha)	(%)
Bratislava	4 791	3 980	811	-16,93
Trnava	19 143	20 084	-941	4,92
Trenčín	9 358	9 145	213	-2,28
Nitra	49 953	51 493	-1540	3,08
Žilina	3 208	3 832	-624	19,45
B. Bystrica	19 293	18 625	668	-3,46
Prešov	10 048	8 402	1646	-16,38
Košice	31403	32 331	-928	2,95
SR	**147197**	**147 891**	**- 694**	**0,47**

Monitoring of Crop Conditions and Crop Monitoring

Regional monitoring of natural crop conditions aims to study effects of weather (coupled with soil) on crop growth and crop development during current vegetation season.

Day and night land surface temperature, land surface moisture and also NDVI (Normalized Difference Vegetation Index) are derived from NOAA's AVHRR sensor (Figs. 15a, 15b, 16a, 16b, 17a, 17b).

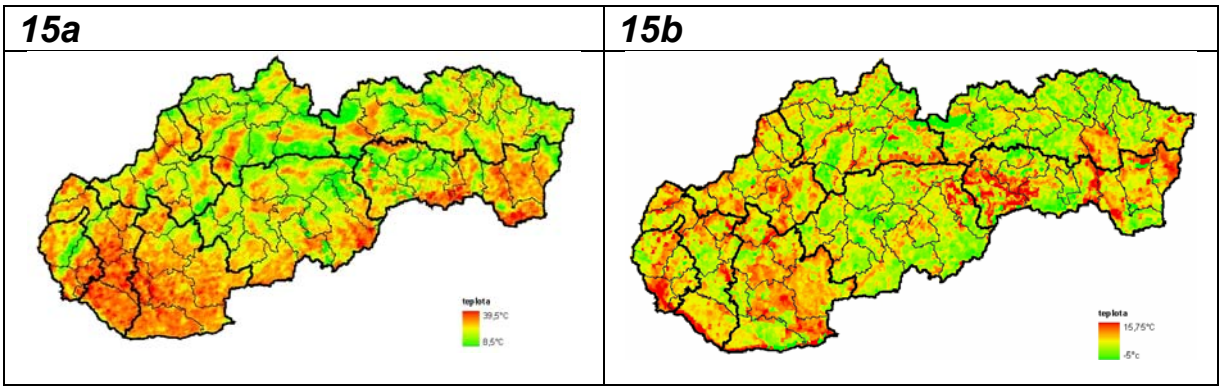


Fig. 15. Day (15a) and night land surface temperature average (15b) in the first decade of May 2007.

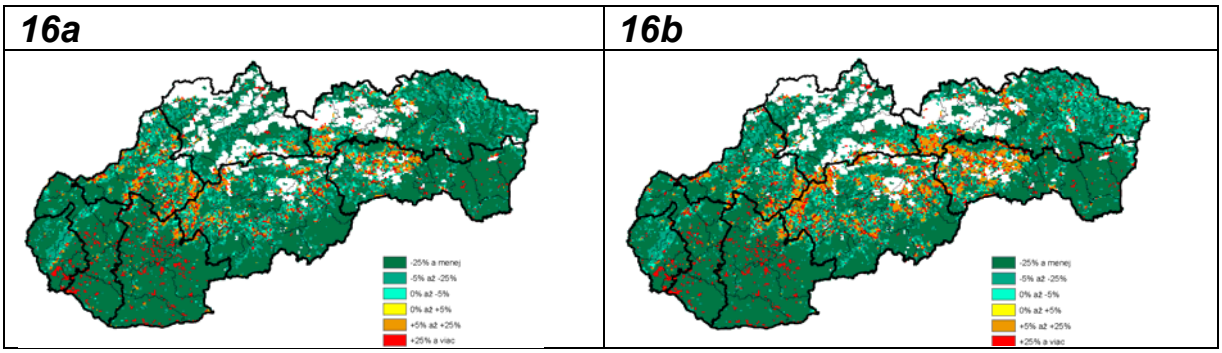


Fig. 16. Comparison of land surface moisture average in second decade of July in 2007 and in 2006 (16a); difference in land surface moisture average in second decade of July 2007 and long term average for the same period (16b).

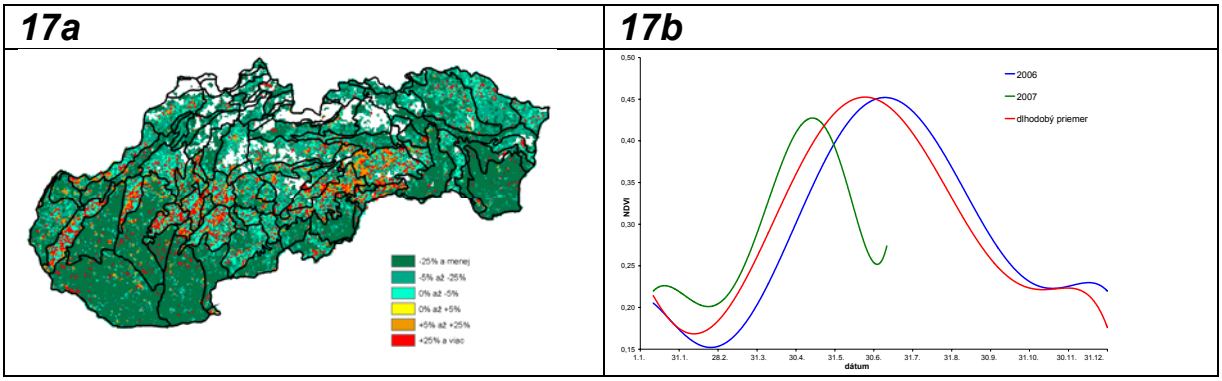


Fig. 17. Difference in NDVI in first decade of July in 2007 and NDVI long term average for the same period (17a); the figure with the comparison of NDVI development in 2007, 2006 and NDVI long term average (17b).

Crop yield forecasting

The aim of the crop yield and crop production forecasting is to provide the most likely, scientific, as precise as possible and independent forecast for main agricultural crop yields for the Ministry of Agriculture of the Slovak Republic and for the public.

The National Crop Yield and Crop Production Forecasting System has been created on SSCRI and is based on two different principles which are applied to specify vegetation indexes as the biomass stage and biomass development:

- Remote Sensing methods – interpretation of vegetation indicators (as NDVI or DMP- Dry matter development) from satellite images (mainly from low resolution satellite sensors as NOAA AVHRR and SPOT Vegetation satellite system;
- Bio-physical modeling (WOFOST model) and simulation of vegetation indexes (mainly TWSO - Total Dry Weight of Storage Organs and TAGP - Total Above Ground Production). In WOFOST, weather and phenological data, soil hydro-physical data and crop physiological data are utilized as the model key inputs.

The crop yield and crop production forecasting is carried out for the main agricultural crops – winter wheat, spring barley, oil seed rape, grain maize, sugar beet, sunflower and potatoes. The forecasts are reported six times per year – in half of May, June and July for "winter and spring crops" and in the end of July, August and September for "summer crops". The forecast results are interpreted at national level as well as at NUTS 3 and NUTS4 level and they are published at SSCRI website (www.podnemapy.sk). The example of web-application on "crop yield forecasting with remote sensing" – namely figures of NDVI a DMP development in 2006 can be seen in the Fig. 18.

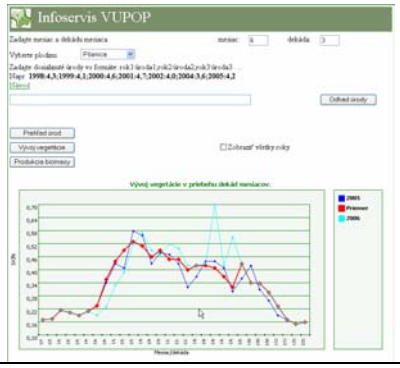
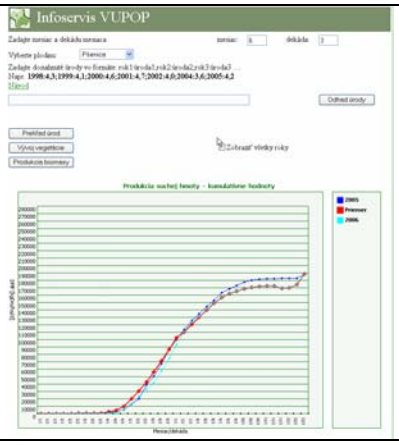
18a	18b
	

Fig. 18. Example of NDVI a DMP development in 2006.

Application of Precision Farming (2006-2007)

Precision Farming represents the "response" on demand of new, more effective methods and technologies for utilization in agriculture. The aim of Precision Farming is to enhance the agriculture production efficiency by decreasing the costs (inputs) with considerable environmental aspect.

As agricultural activities are conditioned markedly by local (site specific) soil properties and local (site specific) soil variability, the requirement on detail georeferenced soil and landscape data as the essential input for precise agriculture management has to be solved. The field soil sampling and laboratory measurements related to soil properties determination represent traditional methods in soil research. Their utilization is supplemented with methods based on remote sensing techniques (vegetation indexes) or based on non-destructive determining of soil and crop properties using electro-magnetic waves (soil electrical conductivity, chlorophyll contents) together with parallel GPS utilization. On the other hand, precision farming as scientific and practical field, includes amount of problems related to agriculture production (plant production, animal production and their management), to information technologies (technologies for data collection, interpolation and visualization of data, etc.) as well as to statistical and geo-statistical assessment (spatial variability, spatial analysis, etc.).

Following data were collected and processed (see Fig. 19):

- vegetation indexes that express the amount and vitality of vegetation,
- soil mechanical resistance (coupled with soil moisture) used to detect the compacted layers in soils,
- soil analyzes (soil texture, pH, nutrients, Cox),
- yield maps (from combine harvesters).

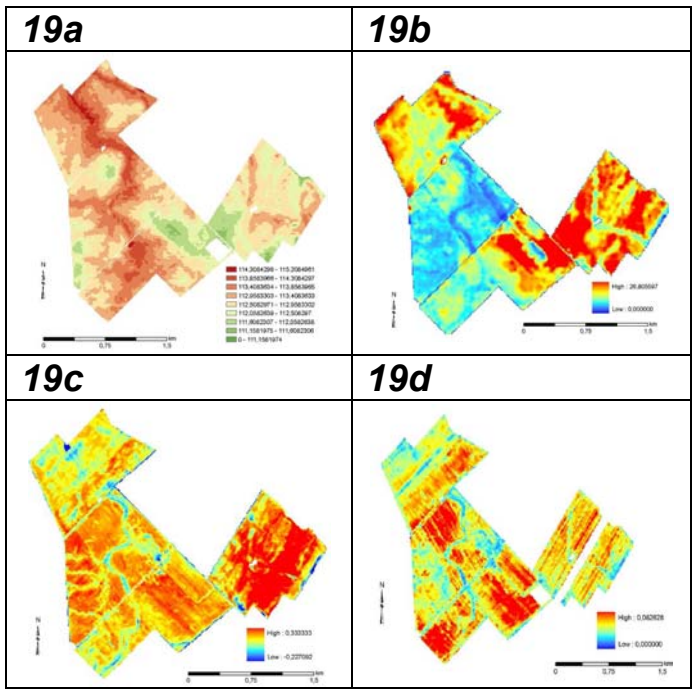


Fig. 19. Map DEM (19a), soil electrical conductivity in depth of 30 cm (19b) (AGRO-Divízia Selice), of NDVI from 17.06.2005 (19c) and spatial variability of the wheat and barley yield (19d)

Based on the above mentioned analysis, it is possible to consider and to summarize (especially on Selice locality) that:

- the weather condition during the year has dominant influence (especially amount of rainfalls and their distribution during the vegetation period) on the character and intensity of relations in the system of atmosphere–soil–crop and on the character of spatial variability of crop yield,
- soil texture as well as individual texture categories (fractions) have high influence on yield and its variability with assistance of terrain configuration (micro-relief),
- there is high likelihood of mapping (prediction) of the crop yield and its spatial variability based on the vegetation indexes (from satellite images) as well as based on electromagnetic conductivity.

National Forest Centre (NFC) – Forest Research Institute[1] in Zvolen applied remote sensing methods in following projects:

A) Evaluation of spruce forests damage using satellite imagery SPOT
Spruce forests decline is actual and the most important problem of forestry in Slovakia. It is effect of complex factor influence – climatic changes, windstorms breakage, gradation of bark beetles, fungi disease and air pollution. This task was solved as contract for the largest forest management enterprise – Forests of Slovak Republic (FSR), state enterprise. Six satellite images from SPOT 4 and 5 were purchased by NFC in 2007. These images cover the territory of Slovakia, where the majority of spruce forests occurred (see Fig. 20) Coniferous forests were classified in first step. The damage of forests was represented by foliage loss and discoloration, these symptoms were classified using two phased sampling with regression. Outputs belonging to FSR managed territory were delivered to FSR for purposes of planning and operational measures realization.

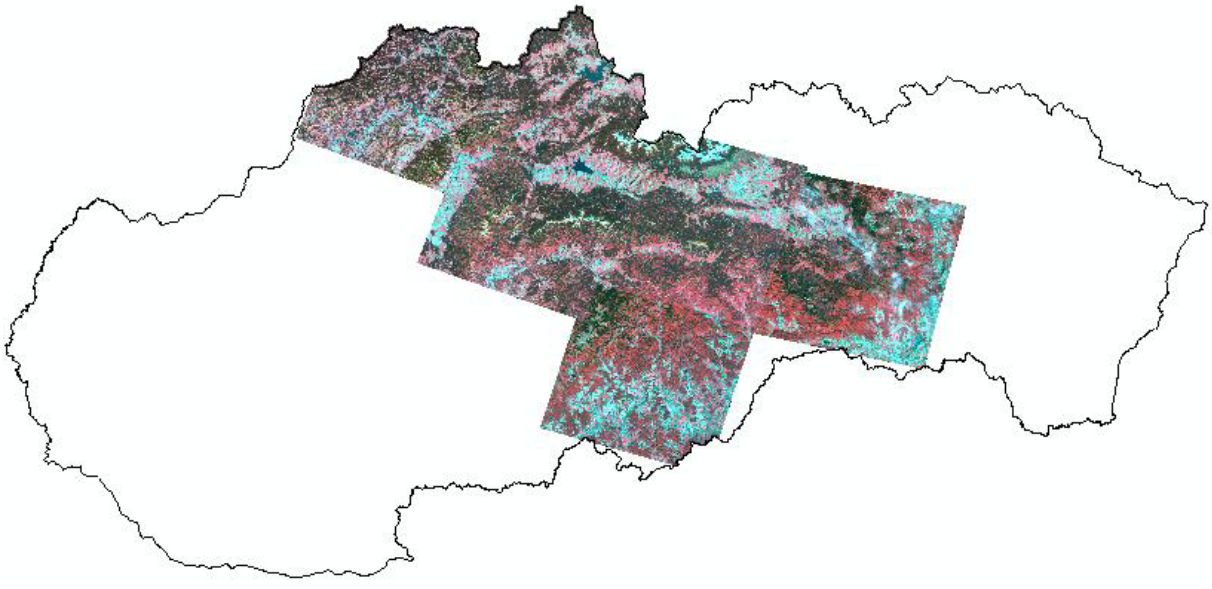


Fig. 20. SPOT 4 and 5 images for coniferous forests health classification.

Monitoring of forests health condition in Slovakia

Satellite imagery Landsat 5 was purchased covering central Slovakia territory in the year 2005. The classification of forest stands distribution and evaluation of forest health condition was realized. Satellite images SPOT from 2007 were used to classify spruce forests health condition of all covered territory.
Standard errors (SE) of applied regression models are in the range of 7.4% to 13.3% (totally approx. 11 %). It means that foliage loss assigned to individual pixels is in the range of ± mentioned standard error with probability of 68 % and in the range of ± 2SE with probability of 95 %. Resulting values of foliage loss were re-classified into common foliage loss classes: 0 (0-10%), 1 (10-25%), 2 (25-60%), 3 (60-95%), 4 (95-100%). The portion of evaluated territory belonging into foliage loss classes and corresponding area are given in Table 4 and graphically demonstrated in Fig. 21 below (Pavlenda et al. 2008).

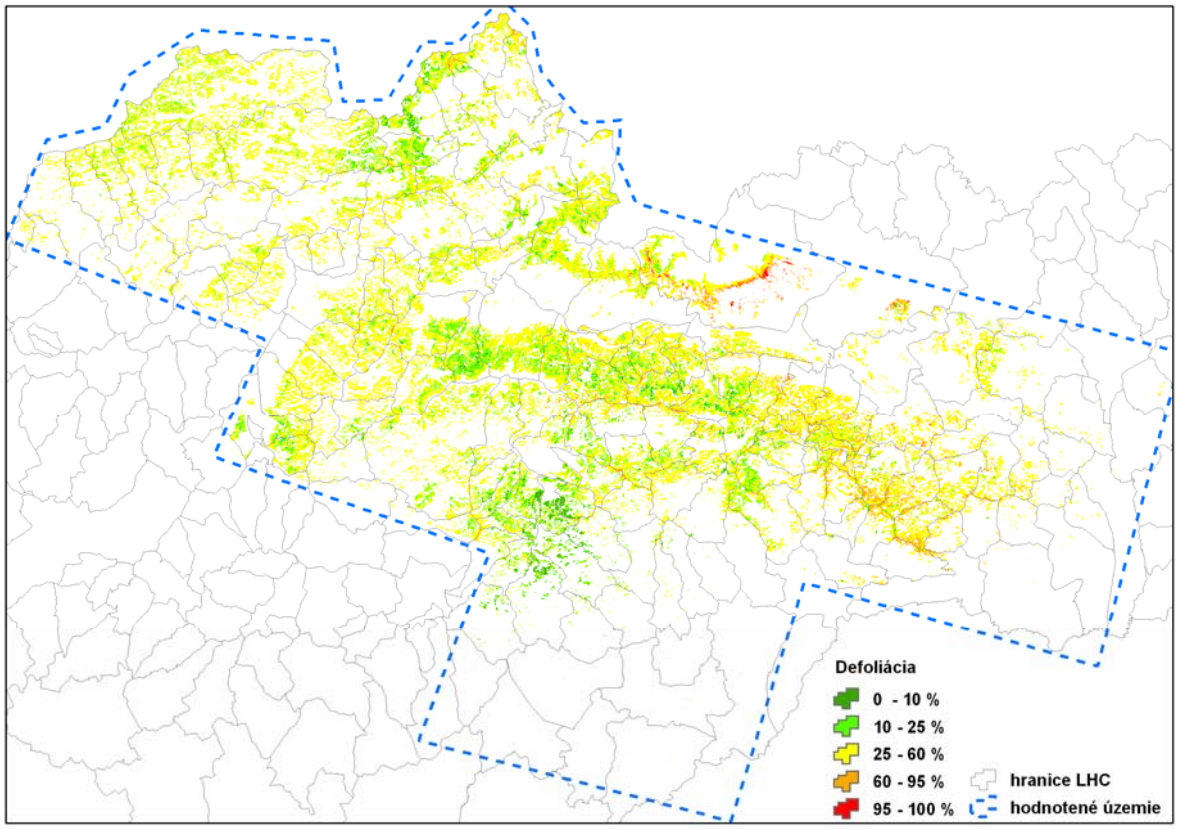


Fig. 21. Results of coniferous forests health classification.

Table 4. Frequency and area of coniferous forests defoliation classes in 2007

Defoliation class	Number of pixels	Frequency (%)	Area in hectares
0 (0-10%)	1 517 507	4.11	15 175
1 (10-25%)	5 610 408	15.18	56 104
2 (25-60%)	26 679 635	72.18	266 796
3 (60-95%)	2 998 364	8.11	29 984
4 (95-100%)	155 395	0.42	1 554
Total	36 961 309	100.00	369 613

B) National inventory and monitoring of forests in Slovakia

National inventory and monitoring of forests in Slovakia (NIMFS) was realized by means of representative methods in Slovakia for the first time. Realization was divided into two levels. Field evaluation was realized on monitoring plots each of 500 m^2, systematically distributed in 4×4 km grid. The evaluation was realized only on plots covered by forests. The second level of evaluation was realized by means of aerial photo interpretation of plots each of 2500 m^2, systematically distributed in 2×2 km grid. The evaluation was realized on all plots belonging to Slovakia territory. Orthorectified colour aerial photos offered from Slovak ministry of agriculture were used.

Reconstructions of altered forests

Project solves problems of management of forests with altered tree species composition with regard to primary tree species composition. Available satellite images were used for evaluation of forest status and its change dynamics. These data were combined with data sources from forestry and other databases and causal effects of actual status were analyzed.

Research, classification and application of forest functions in landscape

Satellite images SPOT from year 2007 were used for actualization of land cover – actual distribution of forests in model territory Kysuce, where influence of forests on precipitation water runoff is modelled. Data on actual forest distribution are necessary for used model SWIM (Soil Water Integrated Model) calibration.

The influence of global climatic changes on forests in Slovakia

The evaluation of spatial distribution, structure and forest health status from satellite imagery were used as indicators of forests status under influence of

climatic changes. Detection of mentioned indicators is fully applicable and time effective regarding character of Slovakia.

Project of forest protection after windstorm calamity in Tatras
Satellite images SPOT and colour infrared aerial photos were used for identification of new damage by bark beetles and critical areas identification. Derived data were used as background for protective measures proposal (Vakula et al. 2007).

Reaction of forest plant associations on edaphic and climatic changes in Slovakia
Orthorectified colour aerial photos offered by Ministry of agriculture were used for identification of forest typology representative plots, where repetitive investigation was realized after approx. 50 years.

Research of basic aspects of spontaneous auto-vegetative regeneration of spruce on upper forest limit
Orthorectified colour aerial photos offered by Ministry of agriculture were used for identification of territories covered by spruce forests with potential of auto-vegetative regeneration on upper forest limit.

National Forest Centre (NFC) – Institute of Forest Resources and Informatics in Zvolen has used methods of aerial remote sensing for primary material acquisition for forest thematic maps actualization, which yearly realizes at 1/10 of Slovakia territory by means of photogrammetric methods. Aerial metric photos were bought and photogrammetric processing was realized for this purpose.

International cooperation was realized through seconded national expert from NFC – FRI Zvolen in EC DG JRC Ispra, where he cooperated in project of Global Land Cover mapping by means of satellite imagery. Respecting previous results (Raši and Bucha 2001), the mutual methodical project was prepared with ERTI Budapest for monitoring of floodplain forests surrounding water scheme Gabčíkovo.

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5. SPACE METEOROLOGY.

In the years 2006-2007 **Slovak Hydrometeorological Institute** (SHMÚ) continued in international cooperation in the frame of EUMETSAT project H-SAF (Satellite Application Facility in support to Operational Hydrology).

Project H-SAF covered by Eumetsat member states (Slovakia became full member state of Eumetsat in the beginning of 2006) proceed by activities of development phase. Slovakia participates in the following tasks:

1. Methodology and the procedures development for the calibration/validation of the satellite derived precipitation fields using radar precipitation data and raingauge network.

Calibration and validation activities of precipitation H-SAF products were based mainly on precipitation fields estimated by Slovak radar network consisting of two Doppler weather radars working in C-band. Due to the strong affects of radar signal by terain beamblockage, signal attenuation on distance and in the heavy precipitating clouds it is important to use properly adjusted radar precipitation fields. Adjustment will be done by ground truth obtained from raingauge measurements.
The processing chain for inter comparison of satellite precipitation and radar based precipitation fields was developed in the SHMÚ. Full automation of this processing chain enable us to perform inter comparison of full data sets repeatedly with slightly changed parameters and/or input data as a result of different algorithm's versions.

2. Calibration and validation case studies.

Two case studies were selected and performed to evaluate feasibility of proposed calibration/validation methodology:

- Case 7-8 September 2007 with mainly stratiform long duration very intensive precipitation field connected with low pressure over central Europe.
- Case 11 May 2007 with precipitation produced by convective stormy clouds in central and western part of Slovakia.

Early results based on the case studies and continuous statistics showed that understanding of limitations of remote sensing precipitation estimation techniques is crucial for successful application of new precipitation products for hydrological simulation and forecasting. The combination of statistical long-term and online automatic adjustments of radar measurements by gauge data are necessary assumptions for future calibration/validation activities in Slovakia.

3. Hydrological validation of precipitation, snow and soil moisture satellite products using hydrological runoff models. The SHMI model (Model Hron of HBV-type) was used for these purposes. Validation results of the satellite soil moisture data were done by Austrian partner Technical University of Vienna on the base of in situ measurements. In-situ measurements were provided by SHMÚ for the period 2005-2006.

Data from meteorological satellites are processed and used also for nowcasting and very short range weather forecasting in SHMÚ. Product Convective Rainfall Rate as operational output of the Nowcasting Satellite Facility was adopted into INCA system. This system is designed for integration of observational data together with numerical weather prediction model outputs to receive more accurate forecasts for nearest 2-6 hours.

6. Institutions involved in Space Research relevant to COSPAR.

Members of the National Committee of COSPAR with their e-mail addresses are listed too. The website of NC is http://nccospar.saske.sk.

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Space Research in Slovakia 2006 – 2007
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