# SPACE RESEARCH IN SLOVAKIA

## 2008 - 2009

**SLOVAK ACADEMY OF SCIENCES**

**COSPAR**

SLOVAK NATIONAL COMMITTEE

JUNE 2010

ISBN 978-80-968060-7-2
EAN 9788096806072

Contents.

# 1. EXPERIMENTS FOR MEASUREMENTS IN SPACE

The experiment NUADU (NeUtral Atom Detection Unit) installed onboard of Double Star TC-2 provided panoramatic imaging of the energetic neutral atoms - emitting magnetospheric regions, particularly the ring current since July 2004 (more details in previous NK COSPAR Slovakia report 2006-2007). The Department of Space Physics of Institute of Experimental Physics, Slovak Academy of Science, Košice (IEP SAS) has participated on NUADU development and construction in the frame of scientific-technical cooperation between IEP-SAS and STIL-NUIM, Maynooth, Ireland. Contact with TC-2 which was lost early August 2007, was succesfully reestablished in November and NUADU was switched on succesfully.

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 $6^{th}$ 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. IEP SAS participated in this project with development, manufacture and operation of a detector of precipitating electrons 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 (photo from launch in Fig. 5).

The instrument MEP (Monitor of Energetic Particles) designed for middle energy particle measurements on RadioAstron mission in the near interplanetary mission, went through the tests and it is ready for launch which is scheduled for 2010 in Russia. The plasma package for that mission is conducted by Space Research Institute (IKI) of Russian Academy of Sciences. The MEP was developed at IEP SAS in cooperation with Democritus University of Thrace, Greece and Space Research Institute, Russian Academy of Sciences, Moscow.

Parts of another scientific devices dedicated for studies in the frame of ESA missions are either under the development (Fig.1) or measuring already in space (Fig.2). In addition, the supporting works for the project JEM-EUSO (Japanese Experiment Module (JEM) on the International Space Station) for the study of the extreme energetic cosmic rays using the earth's atmosphere as a detector, have started in IEP SAS during 2009. Also the infrastructure needed for the tests of experimental devices measuring in space was improved (Fig.4).

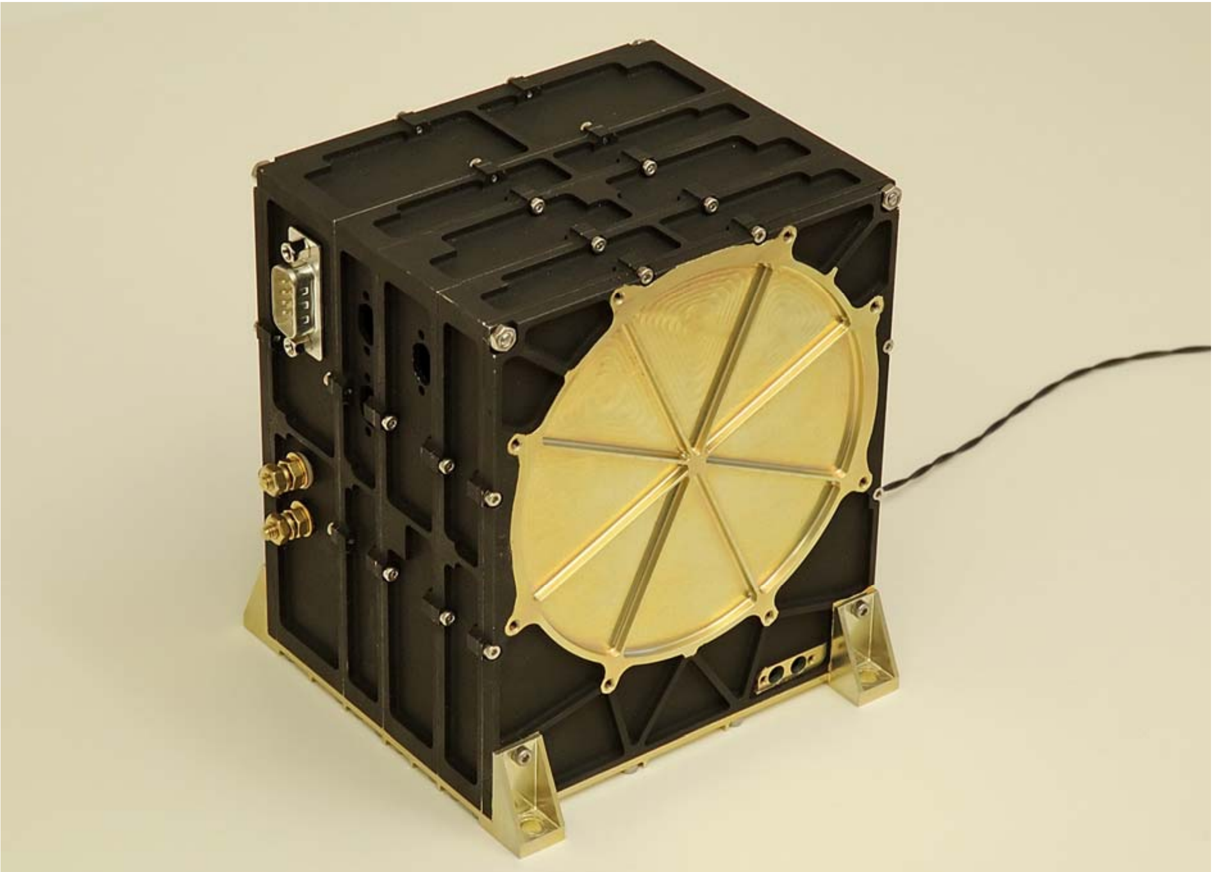


*Fig.1. Electronic box of the PICAM (Planetary Ion CAMera) instrument. The PICAM is an ion mass spectrometer to study the processes in the environment of planet Mercury for the mission ESA-BEPICOLOMBO. Institute of Experimental Physics participates in development and manufacture of the PICAM electronic box in the frame of collaboration with Space Technology Ireland (STIL) and Austrian Space Research Institute (IWF).*

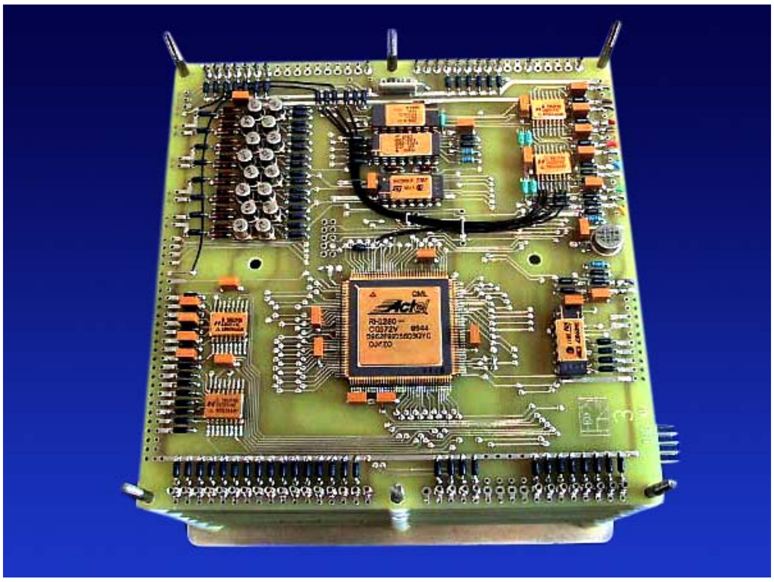


*Fig.2. Electronic Service System ESS of the ESA-Rosetta spacecraft. The ESS is an important part (flight critical hardware) of the ESA-ROSETTA mission that provides communication between the main spacecraft (Orbiter) and landing module Philae. During the cruise phase to the comet 67P/Churyumov-Gerasimenko (2004-2014) the ESS provides the communication via umbilical link, but in November 2014 the ESS will participate on separation and landing of the Philae on the comet surface. After landing, the ESS will manage the communication with Philae by radio link. Institute of Experimental Physics has participated in development and manufacture of the ESS unit in the frame of collaboration with Space Technology Ireland (STIL).*

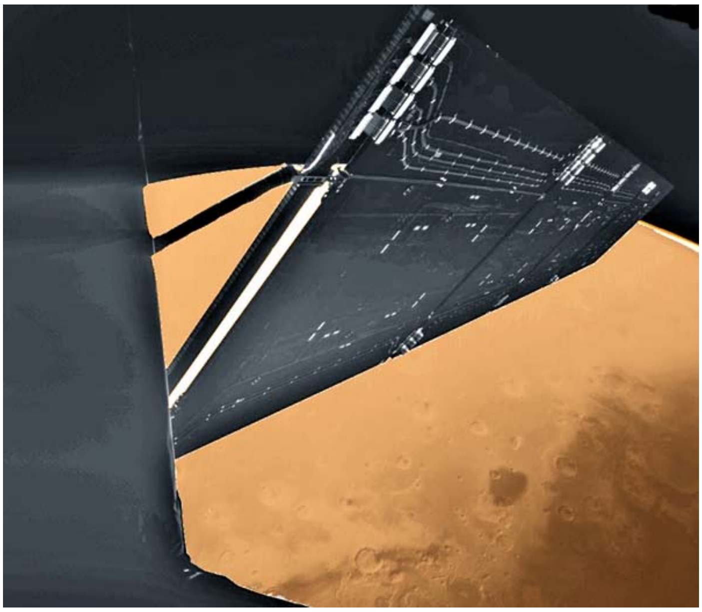


*Fig.3. Flyby of the ROSETTA spacecraft around planet Mars in February 2007. The image of the Mars surface was provided by CIVA camera on board of Lander Philae and transferred to Orbiter via umbilical link under ESS data management (Credit: ESA)*


*Fig.4. The space environment simulator SPACEVAC has been developed and manufactured in cooperation with Vacuum Praha company for environmental testing and qualification of spaceborn instrumentation that are under development at Institute of Experimental Physics. The SPACEVAC consists of a bell vacuum chamber equipped with dry pumping system (scroll pump + turbomolecular pump), temperature-controlled mounting platform and temperature-controlled background radiation shroud. Support by APVV grant agency, project 00538 is acknowledged.*

*Fig.5. The launch of the rocket HotPay-2 in northern Norway on January 31, 2008. One of the devices, PEEL, developed at IEP SAS Kosice, measured very low flux of precipitating electrons >30 keV which is probably related to low geomagnetic activity and to the period of solar activity minimum (http://ecrs2008.saske.sk/dvd/s2.19.pdf).*

## 2. SPACE PHYSICS, GEOPHYSICS AND ASTRONOMY

Selected 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 collaboration with the laboratories in abroad continued studies of the dynamics of cosmic rays and 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). 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 2008-2009.

Based on earlier measurements (Active satellite, SPE 1 experiment) the dynamics of energetic electrons below the trapping region in the magnetosphere was described at low L values [8].

The electron dynamics during 31 geomagnetic storms based on low altitude measurements (CORONAS-F) was analyzed. The summary of the hard photon emission (solar gamma rays and X rays) obtained by the experiment SONG on the same satellite during its whole mission was published [14] and single solar flares have been analyzed.

The long wave radio bursts from solar flares observed by Interball measurements along with energetic electron emissions (DOK-2 in particular) and their connection was analyzed with the indication of its use for strong geomagnetic storms alert [15]. Long period Pc5 magnetic field pulsations near field-aligned current (FAC) regions in the high-latitude magnetosphere, observed by INTERBALL-Auroral satellite during selected periods have shown that the corresponding magnetosphere regions and sub regions is provided by electrons and protons in the energy-range of 0.01-100 keV measured simultaneously onboard the spacecraft. A fairly good correlation is demonstrated between these ULF Pc5 waves and the consecutive injection of magnetosheath low energy protons. The ULF Pc5 wave occurrence is observed in both upward and downward FACs [3].

The method of iterative inversion of the NUADU measurements on TC2 satellite was demonstrated to be one of the possibilities of obtaining information about the redistribution of ENA during geomagnetically disturbed periods [12,13].

The contribution of the re-entrant particles (entering repeatedly the heliosphere from outside) on the distribution of cosmic rays observed in the inner heliosphere was examined in [1].

Magnetospheric transmissivity for cosmic rays during strong geomagnetic storms assuming different geomagnetic field models has shown rather large differences [10]. Comparison of geomagnetic field models for cosmic ray propagation through magnetosphere is in [4]. At 1 AU and outside the Earth's magnetosphere, the relative abundances to protons for He (He/p), C (C/p) and Fe (Fe/p) nuclei were calculated using the observation data of AMS-01 (for p and He) and HEAO-3 (for C and Fe) above 0.8 GeV/nucleon [2]. Figure 1 illustrates the result.

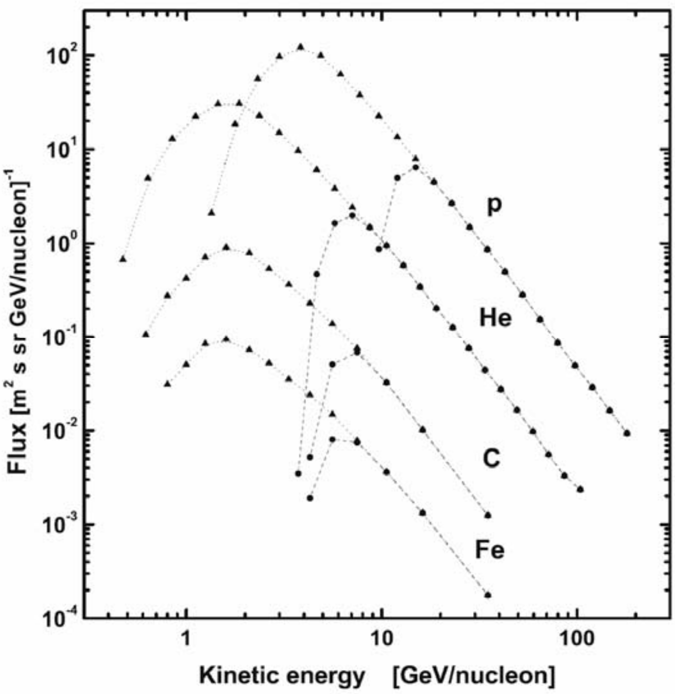



*Fig.1 (adapted from [2]). Flux of primaries p, He, C and Fe, in the geomagnetic regions M1 (low latitudes, circles), and M7 (high latitudes, triangles).*

Although the significant correlation between cosmic ray (CR) variations and global cloud cover (CC) has been found, discussions about causal relations are continuing. Paper [7] did not prove clear connections between other local ionizing agents and low cloud coverage (LCC). Power spectra of CR and LCC are different. In paper [6] there are analyzed various aspects of the connection between CC and CR. The anticorrelation between LCC and MCC (cloud coverage at medium altitudes) is shown. The scenario of the parallel influence of the solar activity on global temperature and CC from one side and CR from another side, which can lead to the observed correlations, is discussed and advocated.

Prediction of interplanetary shock arrival to different planets was studied in detail for the time interval during December 2006 characterized by solar flares and consecutive interplanetary disturbances [14]. The space weather events in January 2005 especially Forbush decreases were analyzed in [5]. Peculiarities of cosmic ray variability obtained from continuous measurements at high mountain neutron monitor for past decades were summarized in [9].

A review on energetic particles in space with a rather long list of references is in [11]. Dynamics of energetic particles in the near Earth environment is reviewed in [17].

IEP SAS contributed to the methodical works related to the corrections of the measurements by magnetometer on Venus-Express (IWF Graz, leading team of the experiment, T.L. Zhang PI). This was partially utilized in the papers describing the magnetic field characteristics in the surroundings of that planet [18-22].

References. Publications in refereed journals.

*1. BOBÍK, P. - KUDELA, K. - BOSCHINI, M.J. - GRANDI, D. - GERVASI, M. - RANCOITA, Pier Giorgio. Solar modulation model with reentrant particles. In Advances in Space Research, 2008, vol. 41, no. 2, p. 339-342*

*2. BOBÍK, P - BOELLA, G. - BOSCHINI, M.J. - GERVASI, M. - GRANDI, D. - KUDELA, K - PENSOTTI, S. - RANCOITA, Pier Giorgio. Fluxes and nuclear abundances of cosmic rays inside the magnetosphere using a transmission function approach. In Advances in Space Research, 2009, vol. 43, no. 3, p. 385-393*

*3. BOCHEV, AZ - KUDELA, K - DIMITROVA, IA. - NENOVSKI, P - SINHA, A - SLIVKA, M. Observations of Pc5 pulsations near field-aligned current regions. In Studia Geophysica et Geodaetica, 2009, vol. 53, no. 4, p. 537-556*

*4. DESORGHER, L. - KUDELA, K - FLÜCKIGER, EO. - BÜTIKOFER, R - STORINI, M. - KALEGAEV, V. Comparison of Earth´s Magnetospheric Magnetic Field Models in the Context of Cosmic Ray Physics. In Acta Geophysica, 2009, vol. 57, no. 1, p. 75-87*

*5. DOROTOVIČ, I. - KUDELA, K. - LORENC, M. - RYBANSKÝ, M. On 17 - 22 January 2005 Events in Space Weather. In Solar Physics, 2008, vol. 250, no. 2, p. 339-346*

*6. ERLYKIN AD, GYALAI G, KUDELA K, SLOAN T, WOLFENDALE AW. On the correlation between cosmic ray intensity and cloud cover. J Atmos Solar Terr Phys, 2009, 71:1794-1806*

*7. ERLYKIN, A.D. - GYALAI, G. - KUDELA, K. - SLOAN, T. - WOLFENDALE, A.W. Some aspects of ionization and the cloud cover, cosmic ray correlation problem. In Journal of Atmospheric and Solar - Terrestrial Physics, 2009, vol. 71, no. 8-9, p. 823-829*

*8. GRIGORYAN, O.R. - KUDELA, K - ROTHKAEHL, H. - SHEVELEVA, V.N. The electron formations under the radiation belts at L-shell 1.2-1.9. In Advances in Space Research, 2008, vol. 41, no. 1, p. 81-85*

*9. KUDELA, K. - LANGER, R. Cosmic ray measurements in High Tatra mountains: 1957-2007. In Advances in Space Research.Cosmic Rays from Past to Present, 2009, vol. 44, no. 10, p. 1166-1172*

*10. KUDELA, K - BUČÍK, R - BOBÍK, P. On transmissivity of low energy cosmic rays in disturbed magnetosphere. In Advances in Space Research, 2008, vol. 42, no. 7, p. 1300-1306*

*11. KUDELA, K.. On energetic particles in space. In Acta Physica Slovaca, 2009, vol. 59, no. 5, p. 537-652*

*12. LU, L. - MCKENNA-LAWLOR, S - BARABASH, S - KUDELA, K - BALÁŽ, J - STRHÁRSKY, I - LIU, Z.X. - SHEN, C. - CAO, J.B. - BRANDT, P.C. - TANG, C.L. - DANDOURAS, I. Iterative inversion of global magnetospheric ion distributions using energetic netral atom (ENA) images recorded by the*

*NUADU/TC2 instrument. In Annales Geophysicae, 2008, vol. 26, no. 6, p. 1641-1652*

*13. LU, Li - MCKENNA-LAWLOR, Susan - BARABASH, Stas - BALÁŽ, Ján - LIU, Zhen Xing - SHEN, Chao - CAO, JinBin - TANG, C.L. Iterative inversion of global magnetospheric information from energy neutral atom (ENA) images recorded by the TC-2/NUADU instrument. In Science in China Series E : Technological Sciences, 2008, vol. 51, no. 10, p. 1731-1744*

*14. MCKENNA-LAWLOR, S - DRYER, M. - FRY, C.D. - SMITH, Z. - INTRILIGATOR, D.S. - COURTNEY, W.R. - DEEHR, C.S. - SUN, W. - KECSKEMÉTY, K. - KUDELA, K - BALÁŽ, J - BARABASH, S - FUTAANA, Y. - YAMAUCHI, M. - LUNDIN, R. Predicting interplanetary shock arrivals at Earth, Mars, and Venus: A real-time modeling experiment following the solar flares of 5-14 December 2006. In Journal of Geophysical Research : space Physics, 2008, vol. 113, no. A6, art. no A06101*

*15. MYAGKOVA, I.N. - KUZNETSOV, S.N. - KURT, V.G. - YUSHKOV, B.Yu. - GALKIN, V.I. - MURAVJEVA, E.A. - KUDELA, K. X-ray, gamma emission and energetic particles in near-Earth space as measured by CORONAS-F satellite: From maximum to minimum of the last solar cycle. In Advances in Space Research, 2007, vol. 40, no. 12, p. 1929-1934*

*16. PROKUDINA, V.S. - KURIĽCHIK, V.N. - YERMOLAEV, Yu.I. - KUDELA, K - SLIVKA, M. Peculiarities of Long-Wave Radio Bursts from Solar Flares Preceding Strong Geomagnetic Storms. In Cosmic Research, 2009, vol. 47, no. 1, p. 14-21*

*17. VAINIO, R. - DESORGHER, L. - HEYNDERICKX, D. - STORINI, M. - FLÜCKIGER, E.O. - HORNE, R.B. - KOVALTSOV, G.A. - KUDELA, K. - LAURENZA, M. - MCKENNA-LAWLOR, S. - ROTHKAEHL, H. - USOSKIN, I. Dynamics of the Earth´s Particle Radiation Environment. In Space Science Reviews, 2009, vol. 147, no. 3-4, p. 187-231*

*18. VÖRÖS, Z. - ZHANG, T.L. - LEUBNER, M.P. - VOLWERK, M. - DELVA, M. - BAUMJOHANN, W. - KUDELA, K. Magnetic fluctuations and turbulence int the Venus. In Geophysical Research Letters, 2008, vol. 35, no. 11, p. L11102-1-5*

*19. ZHANG, T.L. - DELVA, M. - BAUMJOHANN, W. - VOLWERK, M. - RUSELL, C.T. - WEI, H.Y. - WANG, C. - BALIKHIN, M. - BARABASH, Stas - AUSTER, H.U. - KUDELA, K. Induced magnetosphere and its outer boundary at Venus. In Journal of Geophysical Research, 2008, vol. 113, no. E, art. no. E00B20*

*20. ZHANG, T.L. - DELVA, M. - BAUMJOHANN, W. - VOLWERK, M. - RUSSELL, C.T. - BARABASH, S - BALIKHIN, M. - POPE, S.A. - GLASSMEIER, K.H. - KUDELA, K - WANG, C. - VÖRÖS, Z. - ZAMBELLI, W. Initial Venus Express magnetic field observations of the Venus bow shock location at solar minimum. In Planetary and Space Science, 2008, vol. 56, no. 6, p. 785-789*

*21. ZHANG, T.L. - DELVA, M. - BAUMJOHANN, W. - VOLWERK, M. - RUSSELL, C.T. - BARABASH, Stas - BALIKHIN, M. - POPE, S.A. - GLASSMEIER, K.H. - WANG, C. - KUDELA, K. Initial Venus Express magnetic field observations of the magnetic barrier at solar minimum. In Planetary and Space Science, 2008, vol. 56, no. 6, p. 790-795*

*22. ZHANG, T.L. - POPE, S.A. - BALIKHIN, M. - RUSSELL, C.T. - JIAN, L.K. - VOLWERK, M. - DELVA, M. - BAUMJOHANN, W. - WANG, C. - CAO, J.B. - GEDALIN, M. - GLASSMEIER, K.H. - KUDELA, K. Venus Express observations of an atypically distant bow shock during the passage of an interplanetary coronal mass ejection. In Journal of Geophysical Research, 2008, vol. 113, no. E, art. no. E00B12*

Last 2 years the activities of ***Faculty of Mathematics, Physics and Informatics, Comenius University, Bratislava*** have been oriented mainly in the field of interaction of cosmic rays with material objects.

Since the publication of our first paper by Masarik and Beer in 1999 devoted to particle fluxes and cosmogenic nuclide production rates in the Earth atmosphere we have extended our model, using new cosmic ray and nuclear data. Therefore, we revised particle fluxes in the atmosphere and used them, in concert with experimental or evaluated cross sections to calculate the production rates of 3H, 7Be, 10Be, 14C, and 36Cl. The dependencies of these production rates on solar activity and geomagnetic field intensity were investigated in detail. Our simulations cover whole range of these two parameters observed in the past. Comparison of the production rates calculated from two of the most frequently used primary galactic cosmic ray spectra showed weak dependence on the shape of the spectra. Alpha particles were for the first time included in the simulations and we showed that the previously used scheme for estimation of alpha particle contributionto the total production rates is more complicated and latitude dependent. The obtained production rates agree well with most published experimental values.

We developed new model calculations for depth and size dependent cosmogenic production rates in ordinary and carbonaceous chondrites by galactic cosmic rays. This model, folds together particle spectra and cross sections for the relevant nuclear reactions, but has been significantly improved due to major improvements in the neutron cross section database and better Monte Carlo modeling of the primary and the secondary particle spectra. The data obtained by this model replace (and extend) the results of our earlier model predictions. Now we give for ordinary and carbonaceous chondrites elemental production rates for the cosmogenic radionuclides $^{10}$Be, $^{14}$C, $^{26}$Al, $^{36}$Cl, $^{41}$Ca, $^{53}$Mn, $^{60}$Fe, and 129I as well as for the noble gas isotopes $^{3}$He, $^{4}$He, $^{20}$Ne, $^{21}$Ne, $^{22}$Ne, $^{36}$Ar, and $^{38}$Ar. Using the new data and expressing size and depth scales to the unit [g/cm2], we are able to demonstrate that the matrix effect for both chondrite types is negligible for alltarget product combinations, except for those which are dominated by thermal or very low energy neutron reactions. Based on the new model predictions, we present a variety of elemental and isotopic production rate ratios allowing for a reliable determination of preatmospheric sizes, shielding depths, cosmic-ray exposure ages, and diffusive losses.

We developed also the first purely physical model for cosmogenic production rates in iron meteorites with radii from 5 cm to 120 cm and for the outermost 1.3 m of an object having a radius of 10 m. The calculations are based on our current best knowledge of the particle spectra and the cross sections for the relevant nuclear reactions. The model usually describes the production rates for cosmogenic radionuclides within their uncertainties; exceptions are $^{53}$Mn and $^{60}$Fe, possibly due to normalization problems. When an average S content of about 1 ± 0.5% is assumed for Grant and Carbo samples, which is consistent with our earlier study, the model predictions for $^{3}$He, $^{21}$Ne, and $^{38}$Ar are in agreement. For 4He the model has to be adjusted by 24%, possibly a result of our rather crude approximation for the primary galactic α particles. For reasons not yet understood the modeled $^{36}$Ar/$^{38}$Ar ratio is about 30–40% higher than the ratio typically measured in iron meteorites. Currently, the only reasonable explanation for this discrepancy is the lack of experimentally determined neutron induced cross sections and therefore the uncertainties of the model itself. However, the new model predictions, though not yet perfect, enable determining the radius of the meteoroid, the exposure age, the sulphur content of the studied sample as well as the terrestrial residence time. The determination of exposure ages is of special interest because of the still open question whether the GCR was constant over long time scales. Therefore we discuss in detail the differences between exposure ages determined with different cosmogenic nuclides. With the new model we can calculate exposure ages that are based on the production rates (cm3 STP/(gMa)) of noble gases only. These exposure ages, referred to as noble gas exposure ages or simply $^{3,4}$He , $^{21}$Ne , or $^{36,38}$Ar ages, are calculated assuming the current GCR flux. Besides calculating noble gas ages we were also able to improve the $^{41}$K-$^{40}$Kand the $^{36}$Cl-36Ar dating methods with the new model. Note that we distinguish between $^{36}$Ar ages (calculated via $^{36}$Ar production rates only) and 36Cl-$^{36}$Ar ages. Exposure ages for Grant and Carbo, calculated with the revised $^{41}$K-$^{40}$K method, are 628 ± 30 Ma and 841 ± 19 Ma, respectively. For Grant this is equal to the ages obtained using $^{3}$He, $^{21}$Ne, and $^{38}$Ar but higher than the $^{36}$Ar- and $^{36}$Cl- 36Ar ages by □30%. For Carbo the $^{41}$K-$^{40}$K age is □40% lower than the ages obtained using $^{3}$He, $^{21}$Ne, and $^{38}$Ar but equal to the $^{36}$Ar age. These differences can either be explained by our still insufficient knowledge of the neutron-induced cross sections or by a long-term variation of the GCR.

Cosmic ray produced $^{10}$Be (half-life = 1.36 x $10^{6}$ yr), $^{26}$Al (7.05 x $10^{5}$ yr), and $^{36}$Cl (3.01 x $10^{5}$ yr) were measured in a depth profile of 19 carefully-ground samples from the glass-coated lunar surface rock 64455. The solar cosmic ray (SCR) produced $^{26}$Al and $^{36}$Cl in this rock are present in high concentrations, which in combination with the low observed erosion rate, <0.5 mm/Myr, provide well defined depth profiles characterizing the SCR component of the cosmic rays. In conjunction with new experimentally determined excitation functions, the $^{36}$Cl concentrations suggest a softer solar proton spectral shape than that derived from most previous measurements. The fact that no SCR produced $^{10}$Be activity could be detected in 64455 is in good agreement with observations in 68815 and also indicates a softer SCR spectrum. Comparison of observed SCR profiles in 64455 with theoretical calculations indicates that the average solar-proton spectrum over the past 2 Myr (based on $^{26}$Al) has an exponential rigidity parameter ($R_0$) of about 90 MV with a proton flux (J) of 73 protons/cm$^2$/s·4π above 10 MeV. Over the last ~0.5 Myr (based on $^{36}$Cl) $R_0$ is about 70 MV with a flux of ~196 protons/cm$^2$/s·4π above 10 MeV. These SCR fluxes are consistent with most previous work.

References:

*1. LEYA, I. – MASARIK, J. Cosmogenic nuclides in stony meteorites revisited. In Meteorritics & Planetary Science, 2009, vol. 44, Issue 7, p. 1061-1086*

*2. AMMON, K. – MASARIK, J. – LEYA, I. New model calculations for the production rates of cosmogenic nuclides in iron meteorites. In Meteorritics & Planetary Science, 2009, vol. 44, Issue 4, p. 485-503*

*3. MASARIK, J. – BEER, J. An updated simulation of particle fluxes and cosmogenic nuclide production in the Earth's atmosphere. In Journal of Geophysical Research – Atmospheres, 2009, Volume: 114 Article Number: D11103*

*4. NISHIIZUMI, K. - ARNOLD, J. R. - Kohl, C. P. - Caffee, M. W. -Masarik, J. - Reedy, R. C. Solar cosmic ray records in lunar rock 64455. In Geochimica et Cosmochimica Acta, 2009, vol. 73, Issue 7, p. 2163-2176*

*5. WELTEN, K.C. – NISHIIZUMI, K. –LAVIELLE, B. – CAFFEE, M.W. – HILLEGONDS, D.J. – FINKEL, R.C. – KOLLAR, D. – MASARIK, J. The complex exposure histories of the Pitts and Horse Creek iron meteorites: Implications for meteorite delivery models. In Meteorritics & Planetary Science, 2008, vol. 43, Issue 8, p. 1321-1332*

*6. AMMON, K. – MASARIK, J. – LEYA, I. Noble gases in Grant and Carbo and the influence of S- and P-rich mineral inclusions on the K-41-K-40 dating system. In Meteorritics & Planetary Science, 2009, vol. 43, Issue 4, p. 685-699*

*7.QIN, L. – DAUPHAS, N. – WADHWA, M. – MASARIK, J. – JANNEY, P.E. Rapid accretion and differentiation of iron meteorite parent bodies inferred from Hf-182-W-182 chronometry and thermal modeling. In Earth and Planetary Science Letters, 2008, Vol. 273, Iss. 1-2, p. 94-104*

*8. WELTEN, K.C. – CAFFEE, M.W. – MASARIK, J. Cosmogenic radionuclides in paired diogenites from Lapaz Icefield, Antarctica. Workshop on Antarctic Meteorites - Search, Recovery, and Classification, Date: JUL 26-27, 2008 Inst Polar Res, Antarctic Meteorite Res Ctr Matsue JAPAN. In Meteorritics & Planetary Science, Vol. 43, Iss. 7, p. A168-A168*

*9. MASARIK, J. Calculation of cosmogenic nuclide production rates in the Earth atmosphere and in terrestrial surface. 8th Annual V M Goldschmidt Conference, Date: JUL, 2008 Vancouver CANADA, In Geochimica et Cosmochimica Acta, Vol. 72, Iss. 12, p. A600-A600*

In the ***Geophysical Institute of the Slovak Academy of Sciences, Bratislava and Hurbanovo***, a number of issues important within the frame of the space weather studies were investigated.

In particular, coronal mass ejections (CMEs) were considered as significant causes of changes in space weather. A prediction scheme was set up using the method of artificial neural networks. The question was answered whether successfulness of the prediction based solely on the solar disk observations (XRA and RSP) can be improved by additional information concerning the solar energetic particle (SEP) flux. The new forecasting model is an extension of the previous scheme of Valach, Bochníček and Hejda proposed in 2007.

The SEP events possessing significant enhancement in the 10-h window, commencing 12 h after the generation of XRAs were chosen for the analysis. A chi-square test was used to demonstrate that supplying such extra input data improves the prediction.  Data on the occurrence of XRA events and integral values of high energy proton flux (HEPF) with energies in excess of 10 MeV (hourly averages) were taken from daily reports published by the Space Environment Center, NOAA, Boulder, Colorado. Events observed on the solar disk were characterized by heliographic coordinates of the location on the solar disk where the X-ray flare occurred, the flare class, and information on whether the flare was accompanied by a RSP of type II and/or IV. The SEP flux was characterized comparing the maximum of the integrated density of HEPF for energies more than 10 MeV during the 12 h after XRA occurrence with the minimum value of the SEP flux during the 6 h before XRA occurrence. Alternatively the HEPF enhancement the minimum value of the SEP flux during the 6 h before XRA occurrence was compared with the SEP flux during the 10 h following the 12 h after the XRA occurrence. This modified version of the measure of HEPF enhancement was introduced in order to eliminate from our deliberations the impulsive SEP events, which, as opposed to gradual SEP events, are not produced by CME-driven shocks.

Geomagnetic response was studied using planetary Kp index, which is the most suitable geomagnetic response parameter for practical use in midlatitude regions. A four-grade scale was used to evaluate the geomagnetic response of the separately studied impulsive events according to the series of geomagnetic indices Kp (The geomagnetic response to be severe, medium, weak, or insignificant). The catalogs used were based on daily forecasts of the geomagnetic activity performed at the Regional Warning Center Prague (http://www.ig.cas.cz/cz/struktura/observatore/geomagneticka-observator-budkov/predpoved-geomagneticke-aktivity/)

In order to quantify the geomagnetic response of particular solar events, a three-layer feed forward artificial neural network posessing one output neuron to compute the geomagnetic response was used. The number of neurons in the hidden layer was determined separately for each case of studied combinations of the input parameters of solar events. The standard backward propagation algorithm was employed to train the neural network. A new method for dealing with outputs of the neural network was proposed. The new procedure was introduced in order to distinguish between 0/1 (No/Yes) from continuous outputs of the neural network model.

Several combinations of input parameters for the neural network were tested and three different versions of the output quantity were considered. The neural network was trained to discriminate between cases in which at least a weak geomagnetic response occurred. Besides of that, the aim was to distinguish between a weak response or no response on the one hand, and a medium or severe geomagnetic response on the other hand. And finally, the task was to discriminate between a severe geomagnetic response and all other cases (medium,weak, or no response). The model with the choice of input parameters as shown in Figure 1 can be considered the most appropriate. Of the 23 geomagnetic responses observed (independent test, years 2005 and 2006), 11 cases were forecasted successfully, i.e., 48%. Only one false alarm occured. The forecast for the joint set of the training and validation specimens (years 1996 – 2004) was successful in 55% of the cases. It was shown that the worst results were obtained for the models in which the information about SEP was not considered.

The analysis revealed which parameters are the most important ones for foreacesting space weather. The heliographic position of the flare on the sun is an essential parameter. This input replaces, to some extent, the information whether the CME is a full halo or only partial halo CME. Thus, it provides evidence of the geometry of the event and its consequences. Other important information concerns the type of radio burst since enhanced geomagnetic activity is mostly associated with RSPs of type II and/or IV. Information about the XRA class and information on how HEPF >10 MeV increased in the 10-h time window commencing 12 h after the beginning of the XRA are also useful. It was found that the latter has a higher information value in forecasting geomagnetic activity than if we were to observe the increase in HEPF >10 MeV in the time window immediately subsequent to the XRA onset. Therefore, we concentrated only on gradual events which we assumed were directly associated with enhancements of geomagnetic activity [1,2,3,4 and 6].

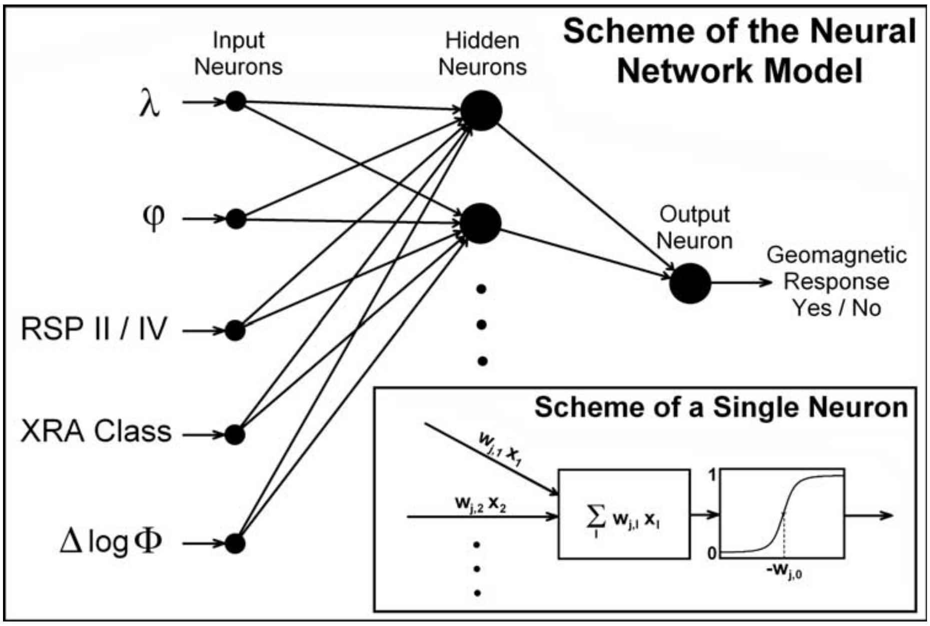



*Fig. 1. The scheme of the neural network model for the purpose of geomagnetic activity forecasting (according to [1]). The input parameters are the heliographic coordinates of the flare on the solar disk, λ and φ, the data on the type of radio burst (RSP II and/or IV), class of XRA and quantity characterizing the enhancement of the energetic proton flux after 12 h following the occurrence of the XRA.*

Hurbanovo Geomagnetic observatory performs continuous monitoring and registration of the geomagnetic field components (1-minute mean values of all components of the geomagnetic field are available together with records made by 1-second sampling interval). The observatory is a member of the international network of world first order magnetic observatories (INTERMAGNET). K-indexes characterising the geomagnetic activity in the middle latitudes are computed regularly. The data are sent to World Data Centers in Edinburgh and Paris, from where they are available for the whole geomagnetic and space weather community. Information about the geomagnetic activity is also published on the web site of the geomagnetic observatory (www.geomag.sk) and it is also submitted to public media (TV).

Old geomagnetic registrations of Hurbanovo Geomagnetic Observatory of GPI SAS (previous names of the observatory: Ógyalla, Stará Ďala) were studied and some indications of the influence of the cometary tail on the earth's geomagnetic field were found in the data of the first half of the 20$^{th}$ century [5].

References:

*1. VALACH, Fridrich – REVALLO, Miloš – BOCHNÍČEK, Josef – HEJDA, Pavel. Solar energetic particle flux enhancement as a predictor o geomagnetic activity. In Space Weather, Vol. 7, 2009, S04004, doi: 10.1029/2008SW000421.*

*2. REVALLO, Miloš – VALACH, Fridrich – BOCHNÍČEK, Josef – HEJDA, Pavel. Enhanced flux of SEP as a measure of CME geoeffectivness in relations to the SEP event onset time. In Fifth European Space Weather Week : abstract book and final programme, november 17-21, 2008. Brussels, p. 60.*

*3. VALACH, Fridrich - REVALLO, Miloš - BOCHNÍČEK, Josef - HEJDA, Pavel. Vysokoenergetické slnečné protóny ako indikátor geomagnetickej aktivity. (In Slovak: High energetic solar protons as an indicator o tme geomagnetic activity.) In DOROTOVIČ, I. Zborník referátov z 19. celoštátneho slnečného seminára, Papradno 2008 [CD-ROM]. - Hurbanovo : Slovenská útredná hvezdáreň, 2008. ISBN 978-80-85221-60-2, s. 136-138. Elektronický zborník na CD-ROM.*

*4. VALACH, Fridrich - REVALLO, Miloš - BOCHNÍČEK, Josef - HEJDA, Pavel. Geomagnetic activity forecast based on solar energetic events. In Slovenská geofyzikálna konferencia : Konferencia konaná pri príležitosti 40. výročia založenia Katedry aplikovanej a environmentálnej geofyziky PRIF UK v Bratislave. VIII. [CD-ROM]. - Bratislava : Geofyzikálny ústav Slovenskej akadémie vied : Katedra aplikovanej a environmentálnej geofyziky Prírodovedeckej fakulty Univerzita Komenského : Katedra astronómie, fyziky Zeme a meteorológie, Fakulta matematiky, fyziky a informatiky, Univerzita Komenského : Katedra geodetických základov, Stavebná fakulta, Slovenská Technická Univerzita, 2009, p. 57. Názov z CD-ROM.*

*5. VÁCZYOVÁ, Magdaléna – DOLINSKÝ, Peter – VALACH, Fridrich. Historical data records at Hurbanovo Geomagnetic Observatory. Abstract Book of the IAGA 11th Scientific Assembly, Sopron, Hungary, 24-29 August 2009.*

*6. HEJDA, Pavel - BOCHNÍČEK, Josef - VALACH, Fridrich - REVALLO, Miloš. On the solar energetic events, neural networks and forecasts of geomagnetic activity. In SGEM 2009: 9th International Multidisciplinary Scientific Geoconference: vol 1, conference proceeding, June 14-19, 2009. Albena Bulgaria, pp. 685-692.*

*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. Influence of SPE on Schumann resonances was studied, too.

Response of the mesosphere and the lower ionosphere to the 14 July 2000 Solar proton event (SPE) was modelled 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 nothern 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 this finding. Significant temperature changes in northern polar mesosphere during the SPE found by Krivolutsky et al. (2006) contribute to the electron concentration changes by 10 % at 88-98 km on day 5 to 8 after the SPE onset.

Changes of the first Schumann resonance frequency as measured at the Astronomical and Geophysical Observatory (AGO) during the December 2006 SPE show an increase due to increased X-rays fluxes. Significant decrease of SR frequency follows after the major enhancement of the particle flux.

References.

*1. ONDRÁŠKOVÁ, A. - KRIVOLUTSKY, A.A. - KUKOLEVA, A., et al.: Response of the lower ionosphere to solar proton event on July 14 2000. Model simulations over both poles. In Journal of atmospheric and solar-terrestrial physics, 2008, Vol 70, No 2-4, p. 539-545*

*2. ONDRÁŠKOVÁ, A. - ŠEVČÍK, S. - TÓTH, J. - KYSEL, R. - SÁTORI, G. - BÓR, J. TLE's observed at AGO and their ELF Counterparts & Influence of SPE on SR parameters, 3rd VERSIM Workshop, 15-20 Sept. 2008, Tihany, Hungary. (oral presentation)*

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. Mainly 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. Stellar data of several satellites like e.g. IUE or HST were used for research of various variable stars.

The most important management event in the reported period is creation of the Center of excellence named "Center of space studies: effects of space weather" approved by the Ministry of Education of Slovakia and funded by the Structural funds of the EU for support of science in Slovakia. This center is led by the AISAS but the following partners are members of the center as well: Institute of Experimental Physics, SAS, Košice (IEP SAS, http://space.saske.sk) and Faculty of Science, Pavol Jozef Safarik University, Košice.

Results on particular manifestations of the solar activity (spicules, flares) and their consequences in the heliosphere (coronal mass ejections) and on nature of symbiotic star AG Draconis, consisting of a cool giant and a compact star, were selected hereafter as examples of solar/stellar research performed recently at AISAS.

We used high-resolution images of the Sun taken by the Very high Angular resolution ULtraviolet Telescope (VAULT) in the spectral line of neutral hydrogen Lyα at 121.6 nm for analysis of dynamic fibrils in the solar atmosphere. The rocket with the VAULT on board was launched from White Sands Missile Range in New Mexico (USA) on June 14, 2002. The VAULT was flown as a payload of sounding rocket Black Brant with a parabolic trajectory reaching maximum altitude of about 294 km. We analyzed the VAULT Lyα images to find whether Hα dynamic fibrils widespread in the solar chromosphere are also observed in the spectral line Lyα mapping the upper chromosphere and transition region. We found many extending and retracting Lyα jets measuring top trajectories of the best-defined ones. The similarities between dynamic Lyα jets and Hα fibrils suggest that the magnetoacoustic shocks causing dynamic Hα fibrils also affect dynamic Lyα jets. [2]

Using a variety of solar telescopes at different satellites we studied two well-observed, fast halo CMEs, allowing to cover the full CME kinematics including the initiation and impulsive acceleration phase, and their associated flares. We found a close synchronization between the CME acceleration profile and the flare energy release as indicated by the RHESSI hard X-ray flux onsets, as well as peaks occur simultaneously within 5 minutes. These findings indicate a close physical connection between both phenomena and are interpreted in terms of a feedback relationship between the CME dynamics and the reconnection process in the current sheet beneath the CME. [4]

We studied the multi-wavelength characteristics at high spatial resolution, as well as chromospheric evaporation signatures of solar microflares. To this end, we analyzed the fine structure and mass flow dynamics in the chromosphere, transition region and corona of three homologous microflares (GOES class 3 keV) using several different types of the satellites in EUV and X-rays and ground based observations. We found the flow dynamics associated with the events to be very complex. For all three microflares, multi-component fitting is needed for several profiles of He i, O v, and Ne vi lines observed at the flare peaks, which indicate spatially unresolved, oppositely directed flows of < 180 km/s.We interpreted these flows as twisting motions of the flare loops. RHESSI X-ray spectra showed evidence of non-thermal bremsstrahlung for two of the three microflares. The electron beam flux density deposited in the chromosphere for these events is estimated to straddle the threshold heating flux between gentle and explosive evaporation. Data were acquired thanks to EU 6thFP funds of the OPTICON Trans-national Access Program. [1]

Star AG Draconis produces a strong supersoft X-ray emission. The X-ray and optical-UV fluxes are in a strict anticorrelation throughout the active and quiescent phases. To understand this relationship we modeled the X-ray/near-IR energy distribution at different levels of the star's brightness, and provided a profile-fitting analysis of the broad wings of OVI 1032,1038 A and HeII 1640 A emission lines by Thomson scattering. By this way we confirmed the observed flux anticorrelation quantitatively, and showed that the optical bursts are associated to an increase in the nebular component of radiation. These results led us to a conclusion that the supersoft X-ray/optical-UV flux anticorrelation is caused by the variable wind from the hot star. The enhanced hot star wind gives rise to the optical bursts by reprocessing high-energy photons from the Lyman continuum to the optical-UV. Understanding the inverse relationship between optical and X-ray fluxes represents an important ingredient in the investigation of the Z And-type outbursts. [3]

In the period Oct 6–20, 2008 the new run of the SOHO joint observing program JOP171 (SOHO, TRACE, RHESSI) was perfomed and supported by the ground-based observations of the Dutch Open Telescope (Observatorio del Roque de los Muchachos, La Palma) and the Kanzelhoehe (Austria) and Hvar (Croatia) Solar Observatories. Details are given at the dedicated web page of the campaign http://www.astro.sk/~choc/open/08_dot/08_dot.html. The best data of this campaign will be utilized in the near future. Additionally, a special observing program was prepared and run at the CORONAS-PHOTON satellite using the TESIS/FET instrument.

References.


*1. BERKEBILE-STOISER, S. - GÖMÖRY, P. - VERONIG, A. - RYBÁK, J. - SÜTTERLIN, P. Multi-wavelength fine structure and mass flows in solar microflares. In: Astronomy and Astrophysics Vol. 505, 2009, p.811-823.*

*2. KOZA, J. - RUTTEN, R.J. - VOURLIDAS, A. Dynamic Ly alpha jets. In: Astronomy and Astrophysics Vol. 499, 2009, p.917-921.*

*3. SKOPAL, A. - SEKERÁŠ, M. - GONZALES-RIESTRA, R. - VIOTTI, R. The origin of the supersoft X-ray-optical-UV flux anticorrelation in the symbiotic binary AG Draconis. In: Astronomy and Astrophysics Vol. 50, 2009, p. 1531-1539.*

*4. TEMMER, M. - VERONIG, A. - VRŠNAK, B. - RYBÁK, J. - GÖMÖRY, P. - STOISER, S. - MARIČIČ, D. Acceleration in fast halo CMEs and synchronized flare HXR bursts. In: The Astrophysical Journal, Vol. 673, 2008, p.L95-L98.*

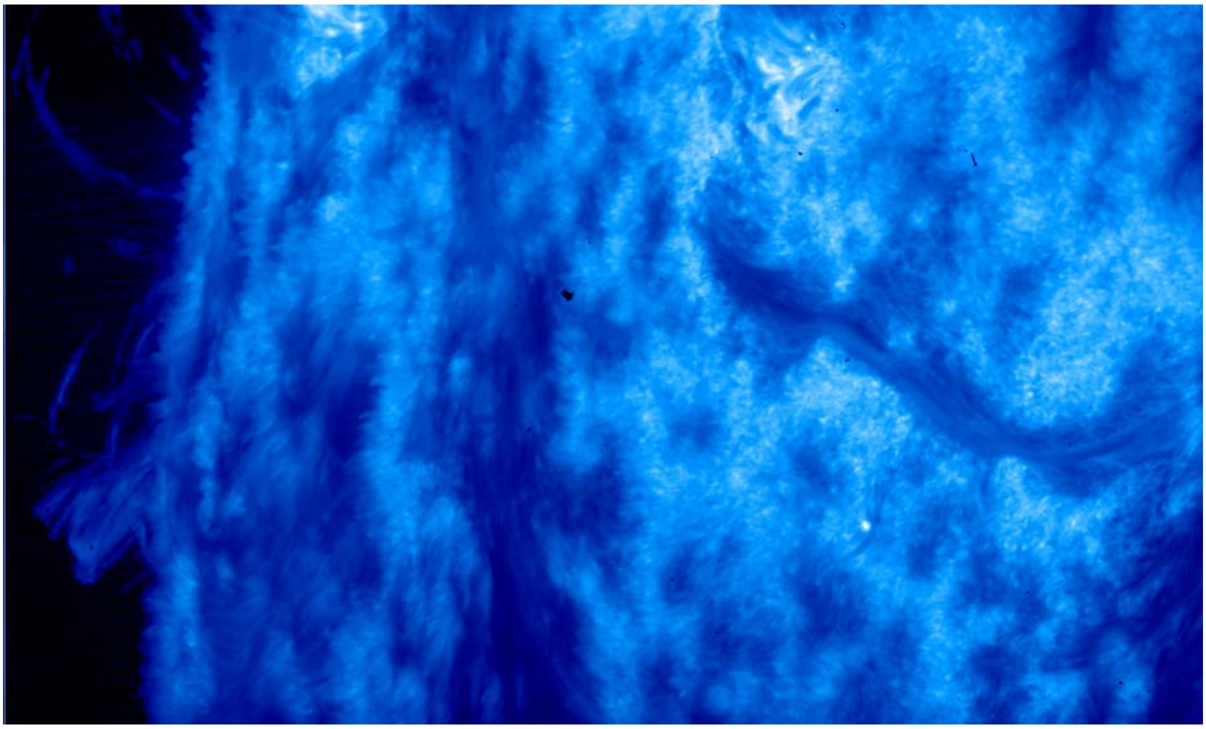


*Fig.1. Lyα image taken by the VAULT telescope showing thick hedgerows of elongated Lyα jets and a prominence at the east solar limb.*

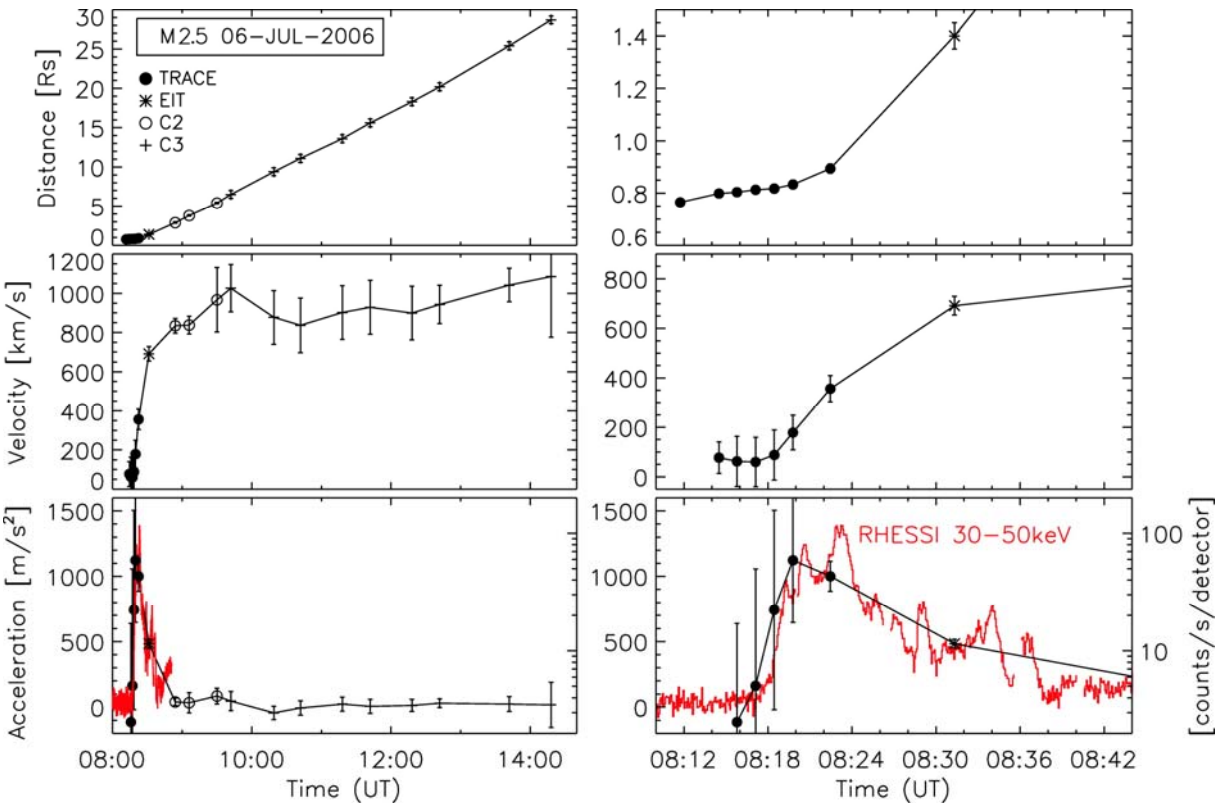



*Fig.2. CME/flare event of 2006 July 6. From top to bottom, distance-time profile, velocity, and acceleration of the CME as observed by different instruments (different plot symbols specified in the legend). In the bottom panel, we plot also the RHESSI 50-100 keV HXR flux of the associated flare. The left panels show the full CME height range covered by the LASCO FOV. The right panels zoom into the early acceleration phase of the CME as observed by TRACE and EIT. The solid curves connects the black features measured in the SXI running ratio images and subsequent LASCO measurements, the dashed curves refer to the white features.*

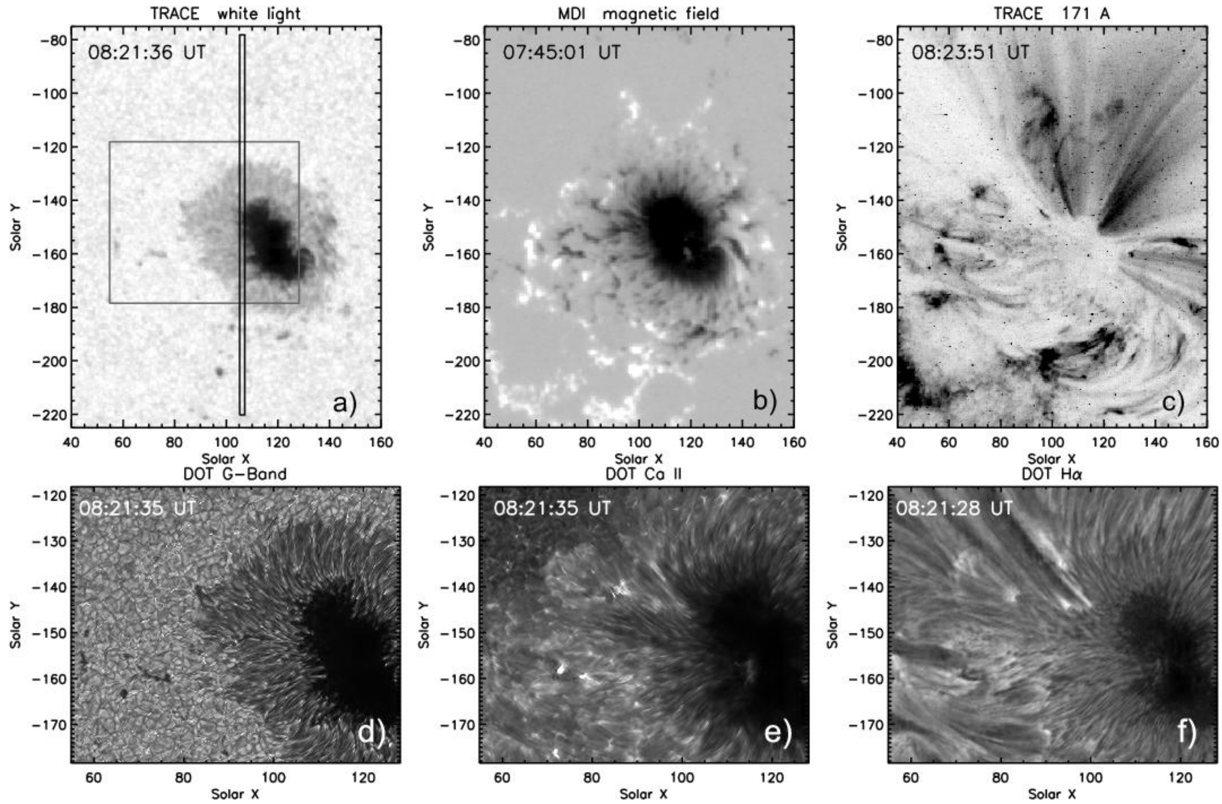



*Fig.3. The solar active region AR 10898 as observed by TRACE, MDI instruments and DOT telescope before the 08:26 UT microflare occurred. Panel a): TRACE white light image with the position of the CDS slit and the DOT FoV indicated by a black and grey frame, respectively. Panel b) shows an MDI high resolution longitudinal magnetogram recorded 45 min before the other images and rotated to 08:21:36 UT. In Panel c), a TRACE 17.1 nm image (inverse grey scale) with the same FoV as the white light map is shown. Panels d) to f) show the DOT G Band, Ca II H and H alpha images nearest in time to the TRACE white light map. In each panel, the image recording time is indicated in the top left corner.*

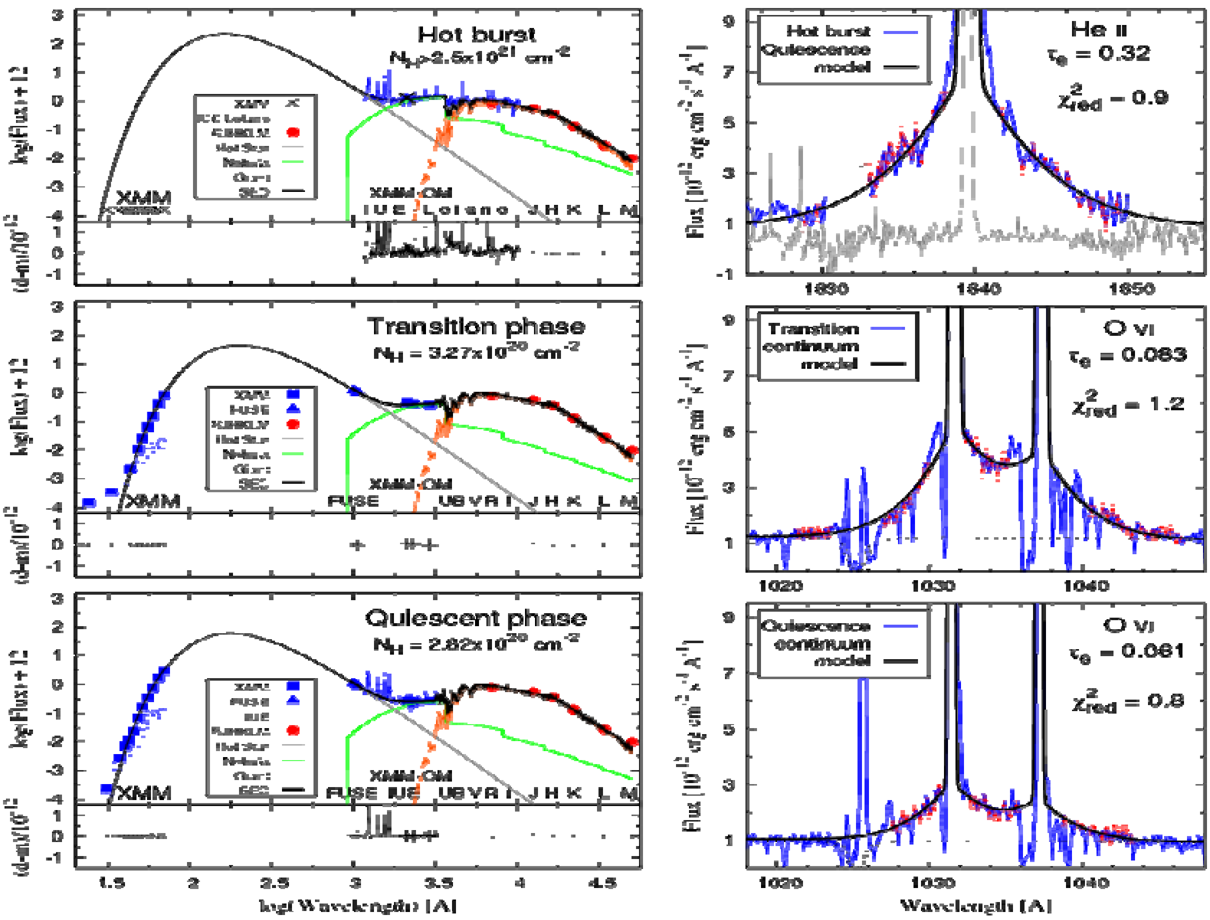



*Fig.4. AG Dra in different phases of its activity. Left panels show a comparison of the observed and modeled SEDs of AG Dra during the hot burst (top), transition phase (middle), and quiescent phase (bottom). Fluxes are in units of erg/s/cm$^2$/A. Right panels compare the observed and modeled broad wings of the OVI 1032, 1038 A doublet and the HeII 1640 A line at these stages of activity.*

# 3. LIFE SCIENCES

The project „*Activity of catecholaminergic system in hypergravity. Is gene expression of enzymes and receptors of this system changed?* „ 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 activity of sympathoadrenal system in rats 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. In previous observations, the collection of blood was performed after a centrifugation finished and therefore the levels could be affected by the process of deceleration. In the present experiment, however, the plasma epinephrine (EPI), norepinephrine (NE) were estimated in samples collected during the centrifugation, and at the end the expression of genes of enzymes involved in the biosynthesis of these nerotransmitters in adrenal medulla and ganglion stellatum were determined.

Rats were subjected to short term or 8 - times repeated hypergravity (+ 4 G). The results showed increased levels of plasma epinephrine (EPI), however, plasma levels of norepinephrine (NE) were not significantly changed. Repeated exposure to hypergravity 4 G demonstrated that increase of plasma epinephrine levels was eliminated. These results demonstrated the activation of adrenomedullar system yet during the exposure to hypergravity.

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 exposure to hypergravity. However , the gene expression of these enzymes in ganglion stellatum was not affected by exposure to hypergravity, suggesting that the activity of sympathoneural system is not influenced by hypergravity.

Publications.

*1. PETRÁK, J. – MRAVEC, B. – JURÁNI, M. – BARANOVSKÁ, M. – HAPALA, I. - FROLLO, I. – KVETNANSKÝ, R. Hypergravity-induced increases in plasma catecholamine and corticosterone levels in telemetrically collected blood of rats during centrifugation. Ann NY Acad Sci 2008, 1148, p 201- 208.*

*2. PETRÁK, J. – JURÁNI, M. – BARANOVSKÁ, M. – HAPALA, I. – FROLLO, I. – KVETŇANSKÝ, R. Plasma catecholamines and gene expression of catecholamine biosynthetic enzymes in adrenal medulla and sympathetic ganglia of rats exposed to single and repeated hypergravity. J. Gravit. Physiol. 2008, 15, p 143-144*

*3. KVETNANSKÝ, R.: Molecular genetics of sympathoadrenal system in stress. In.: Program and Abstracts from Joint Conference of the Czech and Slovak Neuroscience Societies , Prague, November 1-4, 2009, p. 23*

*4. MACHO, L. – KVETŇANSKÝ, R. -, VIGAŠ, M. – FROLLO, I. Effects of space flights on living organisms. History of technical and natural sciences. National Technical Museums. Prague vol. 19. 50 yeares of space flights. 2008, p. 1-16. (in slovak).*

*5. MACHO, L. – KVETNANSKY, R. – KOSKA, J. – KSINANTOVA, L. – NOSKOV, V.B. – GRIGORIEV, A.I. – VIGAS, M. Effects of real and simulated microgravity on endocrine system functions. Book of Abstracts. Trilateral Symposium of Physiology. Graz, (19.9.2008.) s. 37. 2008.*

# 4. REMOTE SENSING.

Remote sensing activities carried out at the ***Institute of Geography, Slovak Academy of Sciences (IG SAS) in Bratislava*** and ***Slovak Environmental Agency (SEA) in Banska Bystrica*** in the period 2008-2009 were focused on the project CORINE Land Cover 2006 (CLC2006). The SEA was the national coordinator and major technical contributor of this project in Slovakia.

The European Environment Agency (EEA) approved update of the CLC2000 thematic map to the time horizon 2006 in June 2005. Identification of land cover changes in Europe in the period 2000-2006 was the main target of the project CLC2006. This project became part of the European Global Monitoring for Environment and Security (GMES) Programme, particularly its servicing section of Fast Track Service Precursor Land Monitoring (FTSP Land Monitoring). The data obtained in this Programme should satisfy the requests of users on the European and national levels for preparation of various environmental strategies, evaluation of management in the network of the NATURA 2000 protected areas, evaluation of commitments adopted under agreements concerning climate change, evaluation of the common European agricultural policy and development of the rural area, in the development of the INSPIRE infrastructure (Infrastructure for Spatial Information in Europe) etc. Slovakia joined the European CLC2006/GMES FTSP Land Monitoring Project in 2007.

The introductory step of the CLC2006 project applied methodology was the revision of the CLC2000 map layer according to the Landsat 7 ETM satellite imagery from 2000 (+/- one year) carried out by visual interpretation in computer environment of ArcView 3.2. For the national activities (scale 1:50 000), the existing thematic errors were removed in the CLC2000 map layer and areas with surface of 5-24 ha, for example those of arable land (211), pastures (231) or forest enclaves were identified above all in heterogeneous agricultural areas (243). The corrected CLC2000 map layer represented the basic dataset for derivation of the new thematic CLC2006 layer. Applied hierarchic English/Slovak nomenclature is available at http://www.sazp.sk/slovak/struktura/ceev/DPZ/CLC2000/corine/english.html

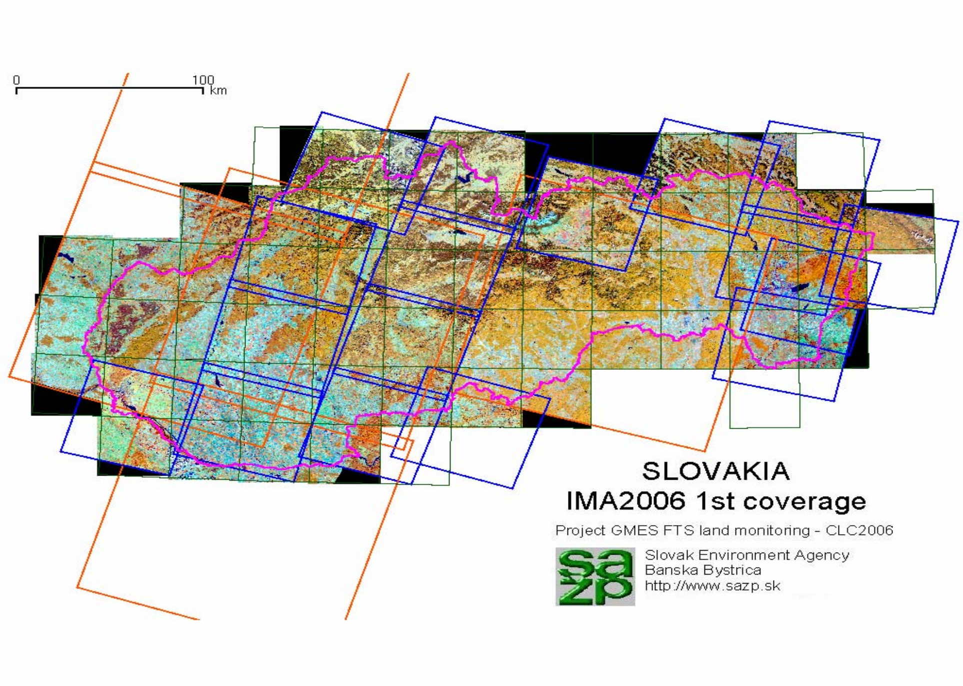



*Fig. 1. Georeferenced mosaic IMA2006-1 from satellites IRS and SPOT.*

The new CLC2006 map layer is based on georeferenced IMAGE 2006 (IMA2006) derived from satellite scenes of IRS and SPOT from two time horizons: IMA2006-1 images from June to September (Fig. 1) and IMA2006-2 images from spring or autumn months. Two time horizons made possible to distinguish pastures from arable land, annual from permanent crops, etc. LC changes in Slovakia in the period of 2000-2006 were identified by GIS overlay of CLC2000 – CLC2006 map layers.

The first result of the CLC2006/GMES FTSP Land Monitoring Slovakia Project was the CLC2006 status map layer. Its statistical characteristics are in Tab. 1. This vector GIS layer is accessible as a map service of the SEA http://atlas.sazp.sk and EEA http://www.eea.europa.eu/data-and-maps

**Tab. 1. Statistical characteristics of the CLC2006 map layer of Slovakia**

| CLC class | No of areas | Total area (in ha) | % from the country area |
|---|---|---|---|
| 111 | 11 | 765.64 | 0.02 |
| 112 | 2659 | 222,501.49 | 4.40 |
| 121 | 361 | 29,051.15 | 0.57 |
| 122 | 47 | 2955.28 | 0.06 |
| 123 | 3 | 187.75 | 0.00 |
| 124 | 21 | 2433.75 | 0.05 |
| 131 | 73 | 3228.27 | 0.06 |
| 132 | 30 | 1593.22 | 0.03 |
| 133 | 21 | 1279.36 | 0.03 |
| 141 | 23 | 1244.65 | 0.02 |
| 142 | 145 | 8697.40 | 0.17 |
| 211 | 1750 | 1,701,234.84 | 33.66 |
| 221 | 283 | 23,883.00 | 0.47 |
| 222 | 181 | 11,115.97 | 0.22 |
| 231 | 3082 | 284,107.12 | 5.62 |
| 242 | 869 | 69,176.50 | 1.37 |
| 243 | 3994 | 331,324.96 | 6.56 |
| 311 | 2070 | 1,115,793.56 | 22.08 |
| 312 | 1213 | 520,469.20 | 10.30 |
| 313 | 2456 | 410,817.70 | 8.13 |
| 321 | 135 | 30,262.87 | 0.60 |
| 322 | 84 | 14,978.88 | 0.30 |
| 324 | 2754 | 215,255.60 | 4.26 |
| 332 | 7 | 6784.96 | 0.13 |
| 333 | 60 | 5373.01 | 0.11 |
| 411 | 61 | 3003.89 | 0.06 |
| 412 | 3 | 238.88 | 0.00 |
| 511 | 107 | 14,843.56 | 0.29 |
| 512 | 134 | 21,430.55 | 0.42 |
| **Total** | **22,637** | **5,054,033.00** | **100** |

The second result informs about land cover changes in Slovakia in the period of 2000-2006. Size of these changes is quoted in Tab. 2 and Fig. 2 respectively. Spatial distribution of identified changes and their thematic grouping in urbanized, agricultural and forest landscape is represented in Fig. 3.

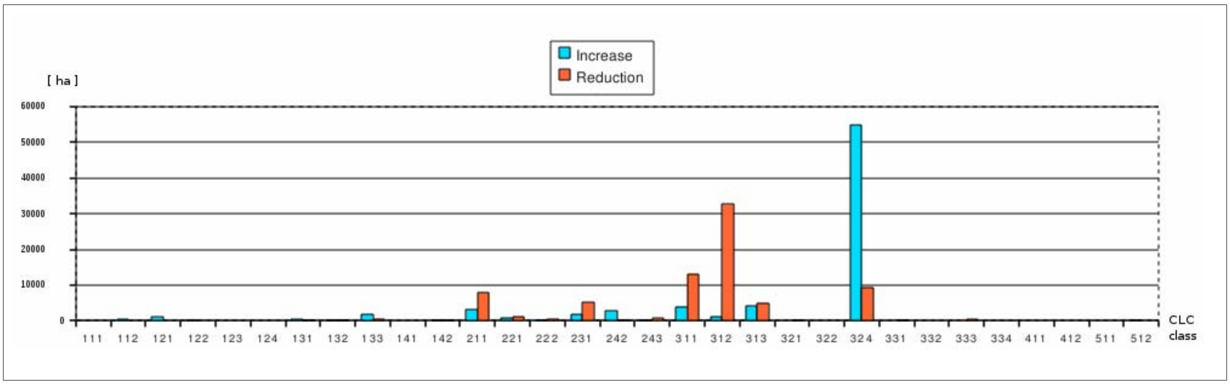



*Fig. 2. Land cover changes of Slovakia in 2000-2006.*

Obtained results reveal that in Slovakia in the period of 2000-2006, totally 76,925 ha of land cover changed. The figure includes above all the change of 54,842 ha of forest into transitional wood/scrub, followed by the change of 9348 ha of transitional wood/scrub into forest, but also changes of 2731 ha of arable land into complex cultivation pattern or change of 1373 ha of arable land into construction areas and 1336 ha of arable land into pastures and other changes (see. Tab. 2 and Fig. 2).

Main land cover changes are linked to:

- restitution or land ownership changed after 1989, majority of changes is visible in period 1990-2000 (mostly in NW area),
- natural disasters (wind storms and forest fires) the crucial damage was caused by wind storm over the High Tatras territory in 2004 (central North area),
- urban sprawl and transport development is mostly linked to urban development in the surroundings of large cities, construction of highways and so called industrial parks 1990-2009,
- activities linked with flood prevention and energy production Gabcikovo barrage system and power plant completed in 1992-1996 (mostly in SW area).

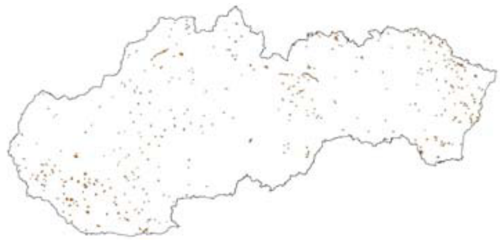
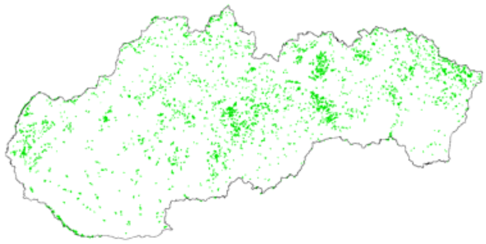
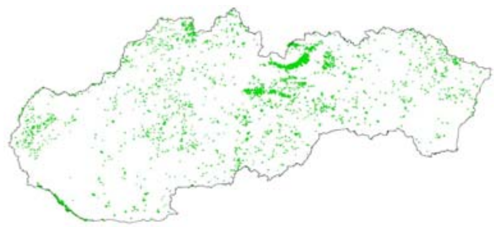
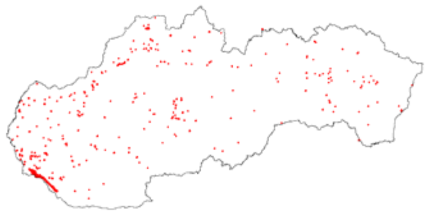
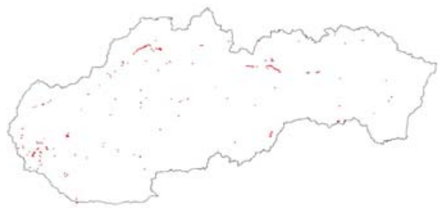
| | Spatial change in period 1990-2000 | Spatial change in period 2000-2006 |
|---|---|---|
| AGRO land |  |  |
| FOREST land |  |  |
| URBAN land |  |  |
| Source: Slovak Environmental Agency http://www.sazp.sk/corine | | |

*Fig. 3. Spatial distribution of land cover changes in Slovakia and their thematic aggregation into urbanized landscape, agricultural landscape and forest landscape.*

Tab. 2. Land cover changes of Slovakia in 2000-2006 (in ha)

| Area in ha | CLC 2000 | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CLC 2006** | 131 | 132 | 133 | 142 | 211 | 221 | 222 | 231 | 242 | 243 | 311 | 312 | 313 | 321 | 324 | 331 | 333 | **Total area** |
| 112 | | | 195 | 7 | 92 | | | | | 17 | | 15 | | | | | | **327** |
| 121 | | | 8 | | 917 | | | | 16 | 20 | | 21 | | | 15 | | | **997** |
| 122 | | | 214 | | | | | | | | | | | | | | | **214** |
| 131 | | | | | 280 | | | | 6 | 17 | 16 | 12 | 10 | | | | | **342** |
| 132 | | | 26 | | | | | | | | | | | | 8 | | | **34** |
| 133 | | | | | 1,373 | 65 | | 158 | 15 | 147 | 22 | 10 | 58 | | 6 | | | **1,854** |
| 142 | | | | | 75 | | | | 33 | | | | 6 | | | | | **114** |
| 211 | | | 95 | | | 1,066 | 495 | 1,262 | 96 | 116 | | | | | | | | **3,130** |
| 221 | | | | | 843 | | | | | | | | | | | | | **843** |
| 222 | | | | | 130 | | | | | | | | | | | | | **130** |
| 231 | | 27 | | | 1,336 | 100 | 16 | | | 348 | | | | | | | | **1,827** |
| 242 | | | | | 2,731 | | | | | | | | | | | | | **2,731** |
| 243 | | | 32 | | | | | | | | | | | | | | | **32** |
| 311 | | | | | | | | | | | | | | | 4,021 | | | **4,021** |
| 312 | | | | | | | | | | | | | | | 1,193 | | | **1,193** |
| 313 | | | | | | | | | | | | | | | 4,134 | | | **4,134** |
| 324 | 38 | | | | | | 10 | 3,714 | | | 13,106 | 32,556 | 4,970 | 51 | | 66 | 333 | **54,842** |
| 512 | | | | | 110 | | | 7 | | 20 | 6 | | | | 15 | | | **158** |
| **Total area** | **38** | **27** | **571** | **7** | **7,887** | **1,232** | **521** | **5,141** | **167** | **685** | **13,151** | **32,614** | **5,044** | **51** | **9,391** | **66** | **333** | **76,925** |

Activities during years 2008-2009 in the field of remote sensing in the ***Soil Science and Conservation Research Institute 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 another images interpretations.

Remote sensing control of area-based subsidies in agriculture (2008-2009)

The subsidies play a key role in agriculture sector and contribute to the prosperity of agricultural subjects. The subsidies to agriculture sector represent major part of European budget and that's why there is taken an emphasis to the control.

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 in 2008 and 5 sites (see Fig. 1) in 2009 which were usually defined by 20×20km. They cover approximately 5% of the applications.

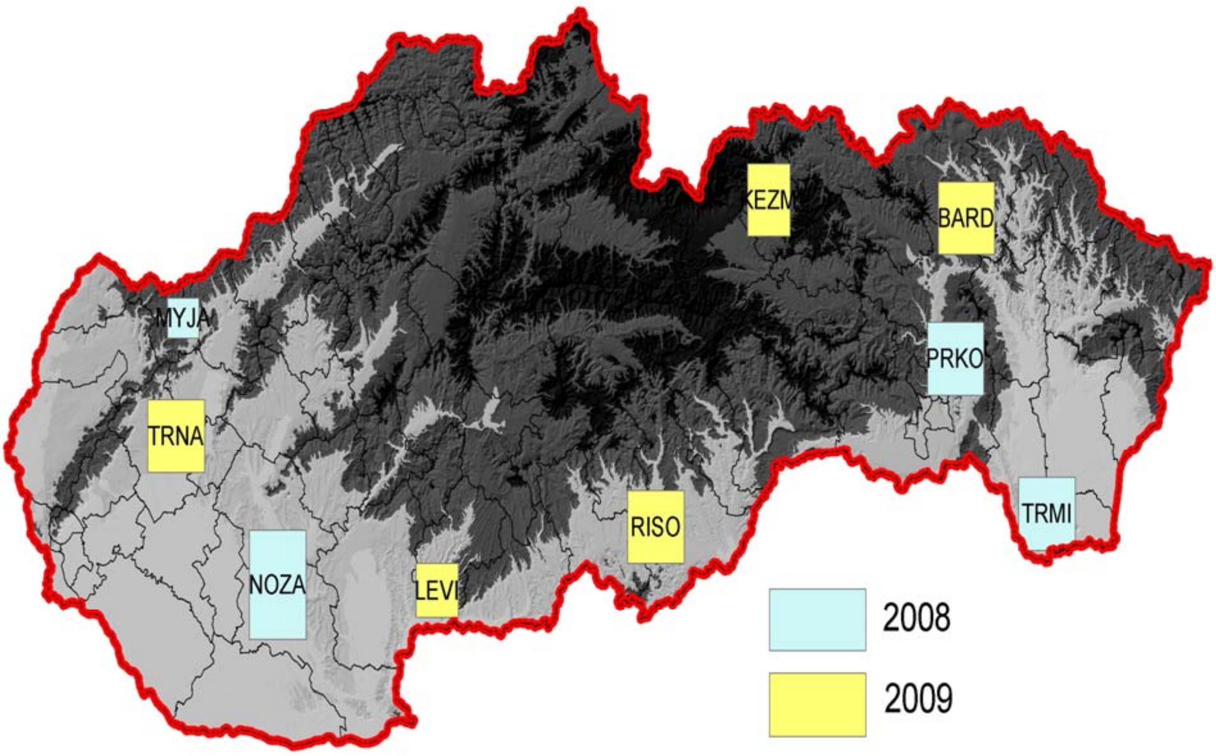



*Fig.1. Localization of the controlled sites in campaigns 2008 and 2009.*

In control procedure a set of high resolution (HR) multispectral images as SPOT, Landsat and IRS (mainly 2 or 3 per site) were used for precise identification of grown crop. To control the cultivated area and the usage Very High Resolution (VHR) images from IKONOS2, GeoEye1 and EROS-B and FORMOSAT2 as back-up images were used per each site (Fig. 2). Features which have to be excluded from the parcels like field path, straw stacks, midden, etc. are well recognisable on these images.

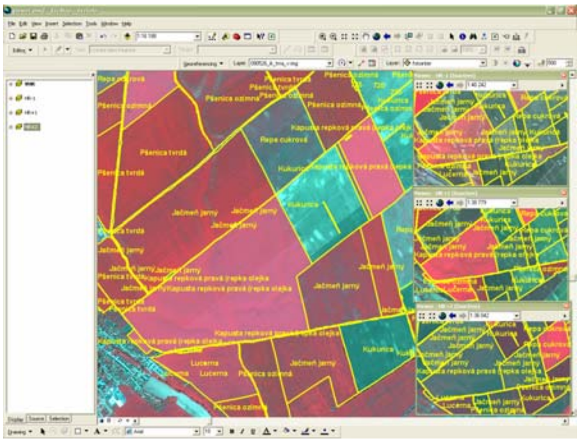


*Fig. 2. Land use check with multi-temporal HR images.*

The results of the controls for the 2008 and 2009 campaigns can be seen in the Tabs. 1 and 2 below. Usually only 50% of the applications are accepted for SAPS and 35% for CNDPs.

Tab. 1. Controlled applications

| **Year** | **Sites** | **Applications** | **Deklared parcels** | **Declared area [ha]** | **Retained area [ha]** |
|---|---|---|---|---|---|
| 2008 | 4 | 629 | 7 390 | 55643.27 | 52830.61 |
| 2009 | 5 | 711 | 8 066 | 149791.01 | 145835.97 |

Tab. 2. Status of the applications

| **Year** | **Scheme** | **Accepted** | | **Rejected** | | **Sum** |
|---|---|---|---|---|---|---|
| 2008 | SAPS | 366 | 58% | 263 | 42% | 629 |
| | CNDP | 291 | 50% | 292 | 50% | 583 |
| 2009 | SAPS | 351 | 49% | 360 | 51% | 711 |
| | CNDP | 311 | 44% | 400 | 56% | 711 |

The reasons of the rejections are different; they can be a result of (see Fig. 3):

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


*Fig. 3. Discrepancies found during the control.*

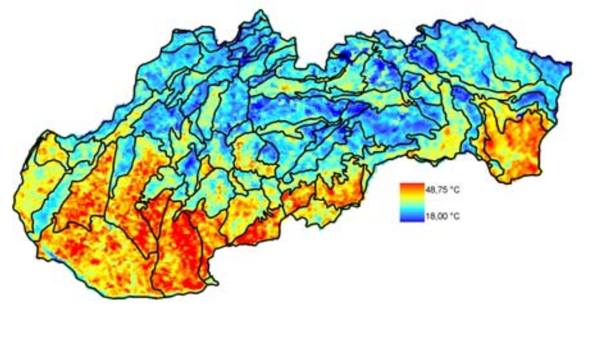
<u>Remote sensing within crop yield and crop production forecasting (2008-2009)</u>

*Monitoring of Crop Conditions and Crop Monitoring*

Regional monitoring of natural crop conditions aims to study the influence 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 (see Figs. 4a,b, 5a,b and 6a,b).

**4a**




**4b**

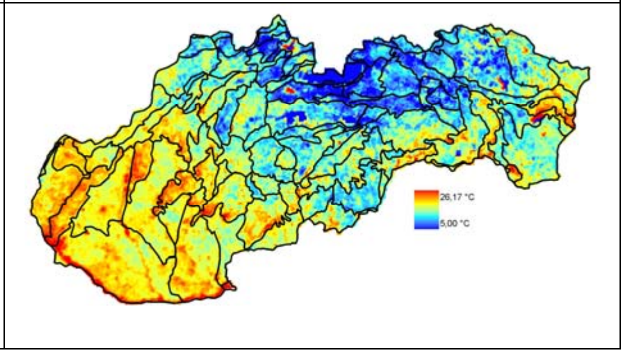
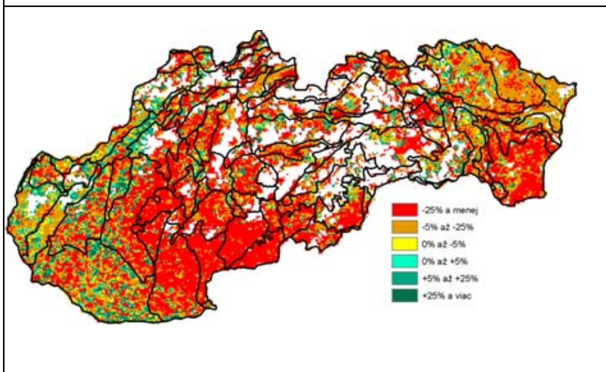



*Fig. 4. Day (4a) and night land surface temperature average (4b) in the third decade of July 2009.*

**5a**




**5b**

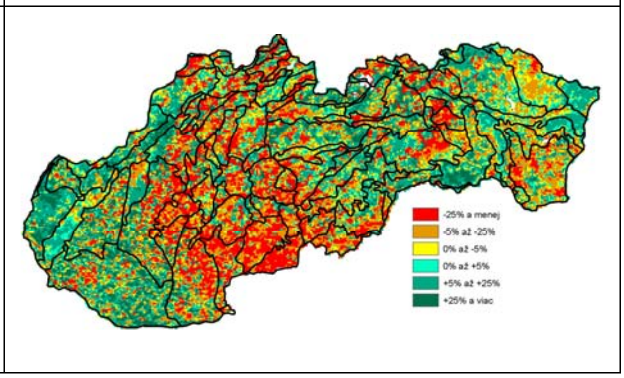
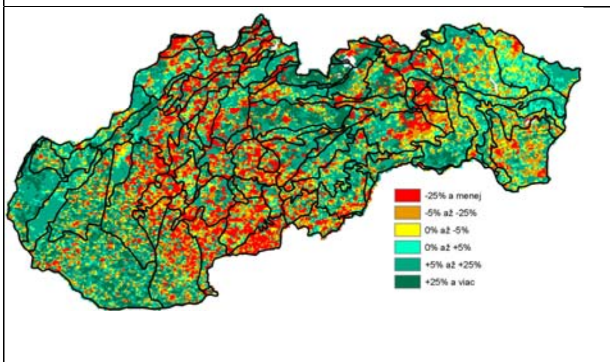



*Fig. 5. Comparison of land surface moisture average in third decade of July in 2009 and in 2008 (5a); difference in land surface moisture average in third decade of July 2009 and long term average for the same period (5b).*

**6a**




**6b**

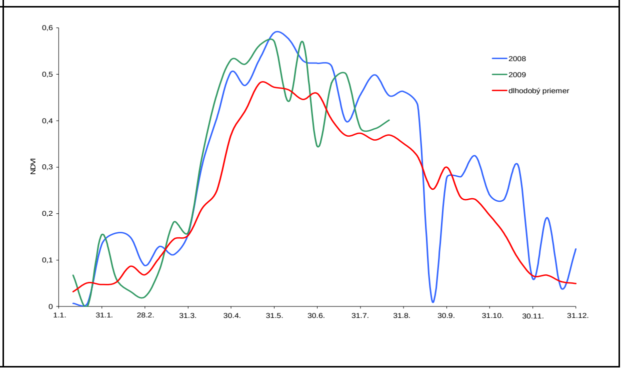



*Fig. 6. Difference in NDVI in third decade of July in 2009 and NDVI long term average for the same period (6a); the figure with the comparison of NDVI development in 2009, 2008 and NDVI long term average (6b).*

*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 Ministry of Agriculture of Slovak Republic and for the public.

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 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 model key inputs;
- Integrated assessment method, which means the implementation of specific meteorological and vegetation indicators in the statistical analysis, assesses the impact of weather on the projected harvest. Integrated estimate summarizes a wider range of disparate indicators and indices that are currently for the purposes of forecasting yields and consequently the production of crops used.

The crop yield and crop production forecasting is carried out for 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 the 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 (see Fig. 7) (www.podnemapy.sk). The example of web-application on crop yield forecasting in 2009 can be seen in the figure below.

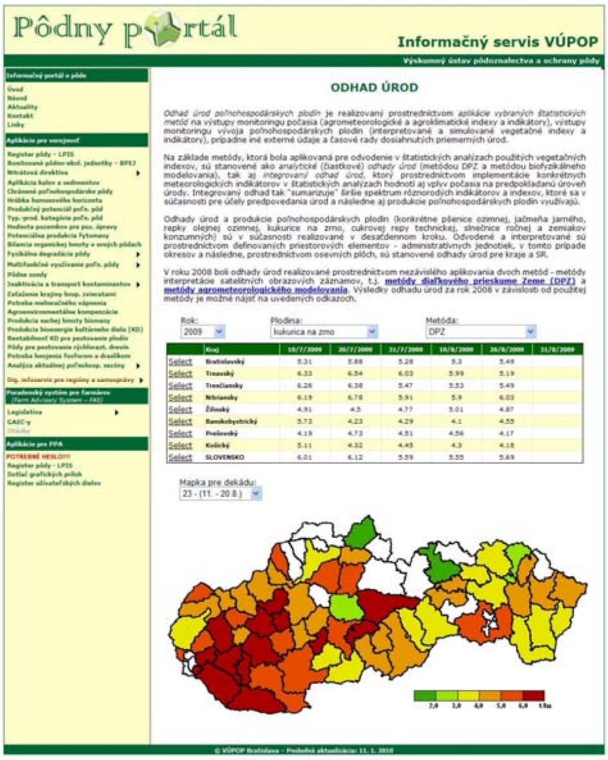



*Fig. 7. Example of crop yield forecasting with remote sensing in 2009.*

<u>Identification of stubblesses and vegetation remains burning by remote sensing methods (2007-2009)</u>

Often occurrence of fires damages forest and non-forest ecosystems. There are two main seasons of fire occurrence in Slovakia. One peak is in March and April, when abandoned grassland is burnt out. The second peak occurs from July to September during the harvest-time. The remote sensing allows fast identification of fires, eventually documentation of burned areas. Medium spatial resolution satellite images Landsat and IRS and the orthophotomap 2008 were used in the course of identification of burned areas. Burned areas distinguished by visual interpretation were digitized in GIS ArcMap (see Figs. 8, 9 and 10).

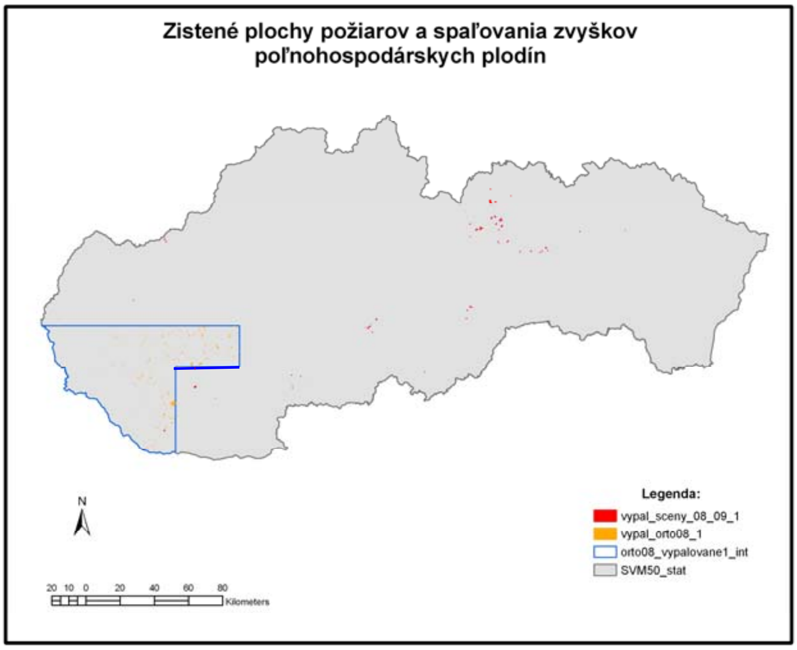



*Fig. 8. Burned areas identified by satellite images (red areas), burned areas identified by orthophotomap from the 2008 year (yellow areas) and area of interpreted orthophotomap (blue line).*

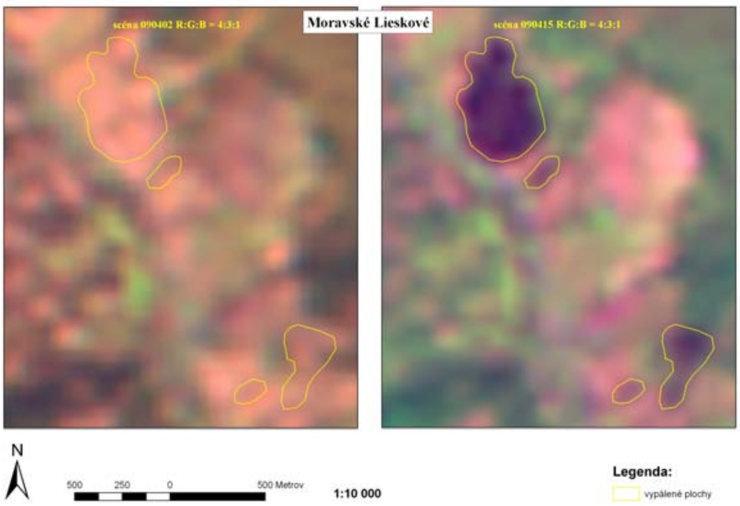



*Fig. 9. Burned areas identified by satellite images from 2nd April and 15th April 2009. (grass burning).*


*Fig. 10. Burned areas identified by the orthophotomap 2008.*
*(stubblesses burning).*

The results of the visual identification for satellite images and orthophotomap can be seen in Tab. 3. Different areas were controlled.

Tab. 3: Results from burned areas mapping

| **Background** | **Number of burned areas** | **Summary of burned area [ha]** | **Maximum size of single area [ha]** | **Minimum size of single area [ha]** | **Median area of single area [ha]** |
|---|---|---|---|---|---|
| Satellite images | 67 | 785.2494 | 139.5773 | 0.3708 | 11.7201 |
| Orthophotomap 2008 | 525 | 351.3007 | 32.2625 | 0.004183 | 0.6691 |

## THE FRAME OF REMOTE SENSING AND GROUND SURVEY IN SSCRI

<u>Collections of reference materials – ground survey</u>

The collection of reference data in ground survey covers:

a) Terrestrial data collection of ground truth data representing different crops (signatures – Fig. 11). In the case of the use of remote sensing methods in the purpose of regional crop inventory is the crop identification oriented on following strategic crops: winter wheat (Triticum aestivum L.), barley (Hordeum vulgare L.), oilseed rape (Brassica napus L.), maize (Zea mays L.), sunflower (Helianthus annuus L.) and sugar beet (Beta vulgaris L.). The digital records are collected according to the following criteria: the area of determined crop must be minimum 50m wide and must be recognized on satellite images with high resolution; ground position is determined by GPS/GNSS equipment with appropriate accuracy; digital photo documentation is done by detail and overall view.

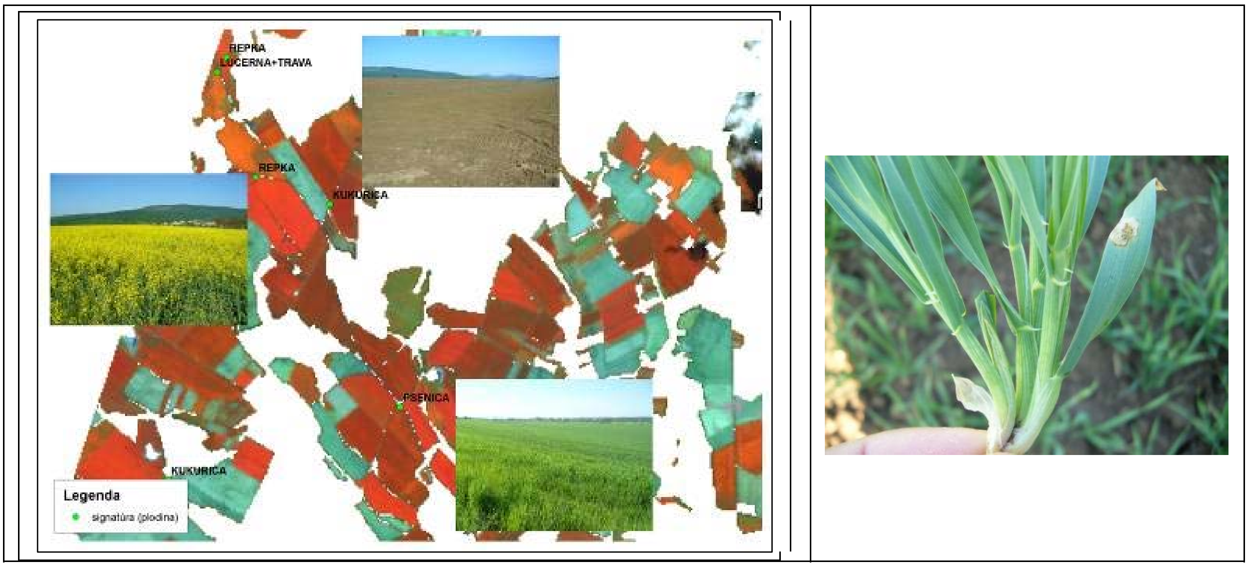



*Fig. 11. Collection of ground reference truth data in the purpose of regional crop inventory.*

b) The collection of very high accurate ground position information for the purposes of control with remote sensing by utilization of very high resolution satellite images is performed by measurement with geodetic GPS/GNSS equipment (Fig. 12) in real time mode, utilizing SKPOS service (Slovak permanent service for the exploitation of global navigation satellite systems). Selection of suitable ground control points (GCP) and independent check points (ICP) requires good practice and selection. They are considered as "well defined" in the context of resolution of the images. Well defined points are represented by features easily visible and exactly identifiable on the ground and on satellite images as well. The following accuracy for Real Time Kinematics (RTK) is available: SKPOS/cm – correction for carrier phase measurement for precise position determination in real time with accuracy better then 0,02 m.

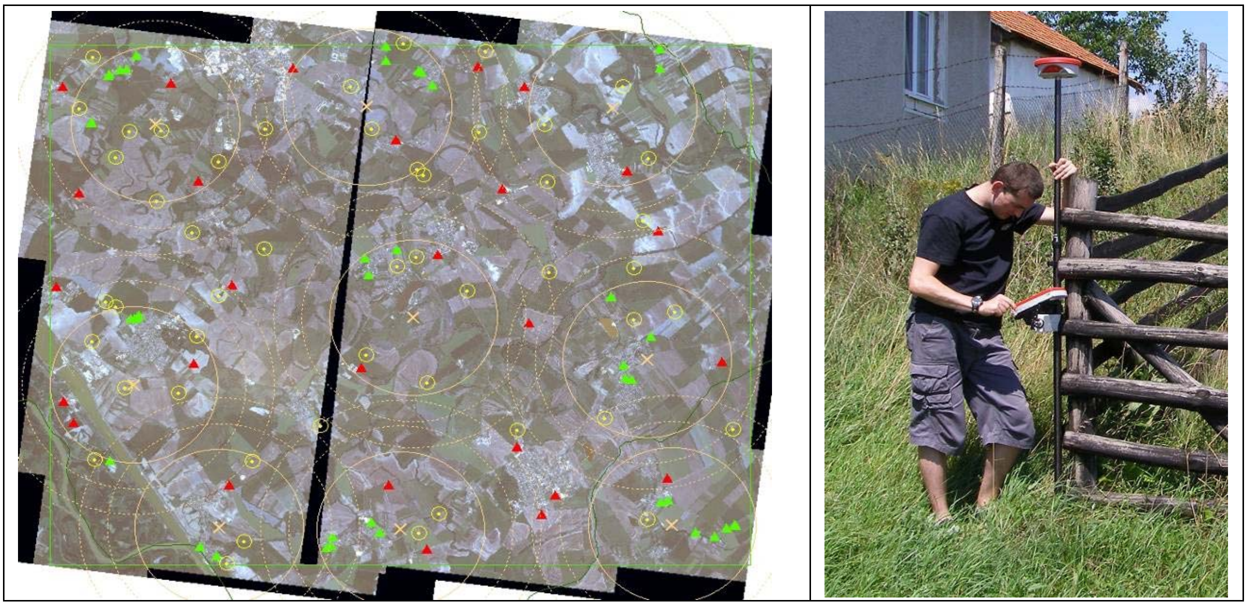


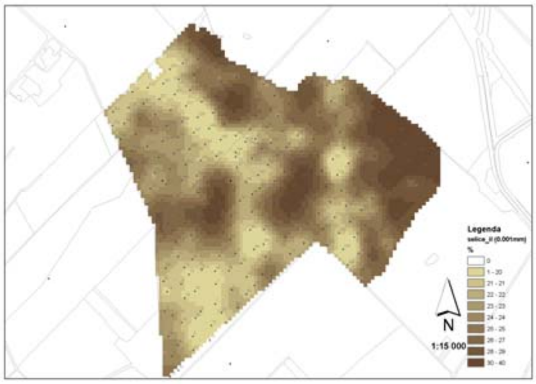
*Fig. 12. Example of existing satellite data processing in the frame of ortorectification, collection of ground data information (GCP, ICP) with very high accuracy precision GNSS equipment.*

c) Reference measurements important for selected property: soil evaluation should be represented by clay content measurement (evaluation of clay content index). The ratio TM5/TM7 (middle infrared 1.55-1.75 μm Landsat satellite spectra TM5) and (middle infrared spectra 2.08-2.35 μm Landsat satellite spectra TM7) is commonly used to measure the concentration of clay minerals. The value of clay index is derived from absorption spectra of different materials like clay minerals, silt loam absorption etc. Using the sensor with large number of approximately 10nm wide bands and selection of the proper selections of band rations allows identification and determination of and spatial distribution of selected mineral more precise.

<u>Soil indexes used in the indication of soil spatial variability</u>

The aim of the soil property measurement was i) to analyze clay content (TM 5/7) index, TM Landsat image from 08.04.2007 period was compared with the texture analytical data from 270 soil samples (A horizon). The weak correlation (r=0,15) between index of clay content and real clay content was observed on sample of 270 soil samples (Fig. 13a,b). The appropriate distribution of ground soil samples, time series satellite images with no loss of spectral integrity and influence of antropic activity is necessary to harmonize and standardize the utilisation of vegetation/soil property indexes.


a)




b)

*Fig. 13a) Clay content detection as the ratio TM5/TM7 of Landsat TM multispectral scanning system b) Spatial interpolation (ordinary kriging) of ground reference measurement (analytical laboratory measurement of 0,001 mm particle size fraction of the fine earth fraction.*

The Remote Sensing research activities of the ***National Forest Centre in Zvolen*** were aimed at observation of forest ecosystem's response to global environmental changes. A forest response was evaluated by biophysical characteristics derived from satellite data from spectroradiometer MODIS, namely: Normalised vegetation index (NDVI), Leaf area index (LAI), Photosynthetic active radiation absorbed by vegetation (FPAR) and Gross and Net primary production (GPP, NPP).

At first MODIS products were analysed and MOD09 Surface reflectance product was selected as optimal for NDVI calculation. The quality layer of the MOD09 product is utilized for quality assessment. The values for the pixels that did not pass through the quality criteria were interpolated using NDVI values from days before and after the day with unsuitable value. A problem of derivation of annual dynamic of NDVI was solved by using sigmoid curve. The curve was then analysed in relation to the observed phenological phases. The software product Phenological profile (© Milan Koreň) was developed for interpolation, modelling and interpretation of course of phenological curves (Fig. 1).

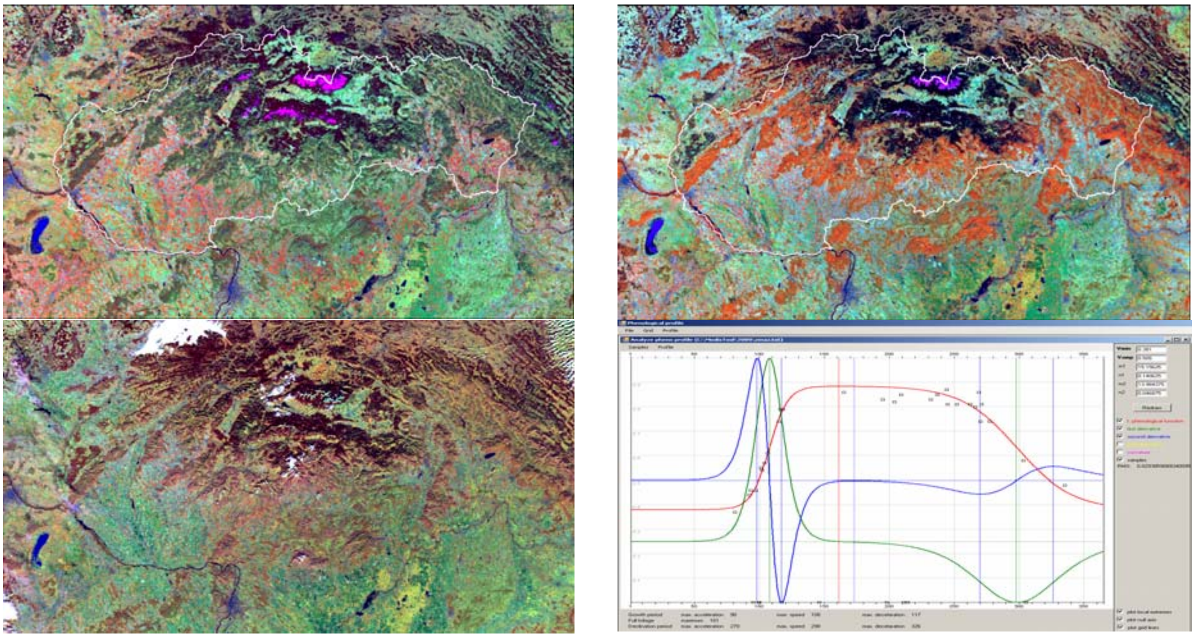


*Fig. 1. Satellite images MODIS from April, 12, September 20 and October 27. Left down: Modelling of phenological curve based on NDVI values for oak forest in Čifare region in 2007.*

All available data of product MOD15A2 LAI/FPAR at 8-day basis and 1 km resolution were collected and basic procession was done. The ground measurements of LAI were done in 2009 within selected study areas for validation of satellite derived data. The first results showed overestimation of

LAI retrieved from MODIS in comparison to ground measurements. It influences the quality of NPP derivation. Therefore a procedure for LAI correction was proposed based on relation between NDVI and LAI.
We analysed the algorithm of the product MOD17 appointed for GPP and NPP evaluation of the terrestrial vegetation on global level. Model will be refined to spatial resolution to 250 × 250 m by input of NDVI 250 m data. Further refinement will be ensured by input of climate data from national meteorological stations and by applying photosynthetic active radiation data (PAR) formed from radiometer AVHRR data (Advanced Very High Resolution Radiometer) in 15 minutes interval rescaled to 250 m resolution.

A concept of a regional information system (RIS) of forest condition was proposed based on satellite data. The RIS is proposed to inform forest owners and forest state administration about the actual state of forest stands, its changes and productive characteristics derived from remote sensing data. The RIS contains tools for collection and pre-processing of input data, their storage, analyses and presentation of output data via internet map application. Geographically it covers Western Carpathians and adjacent parts of surrounding units, especially the Pannonia basin. Remote sensing data from satellites MODIS, Landsat, SPOT and Aster are the main inputs data for RIS. The evaluation of state and changes of forest within the RIS is focused in actual decline of spruce forest. This decline overspread in all territory of spruce occurrence in Slovakia (Fig. 2).

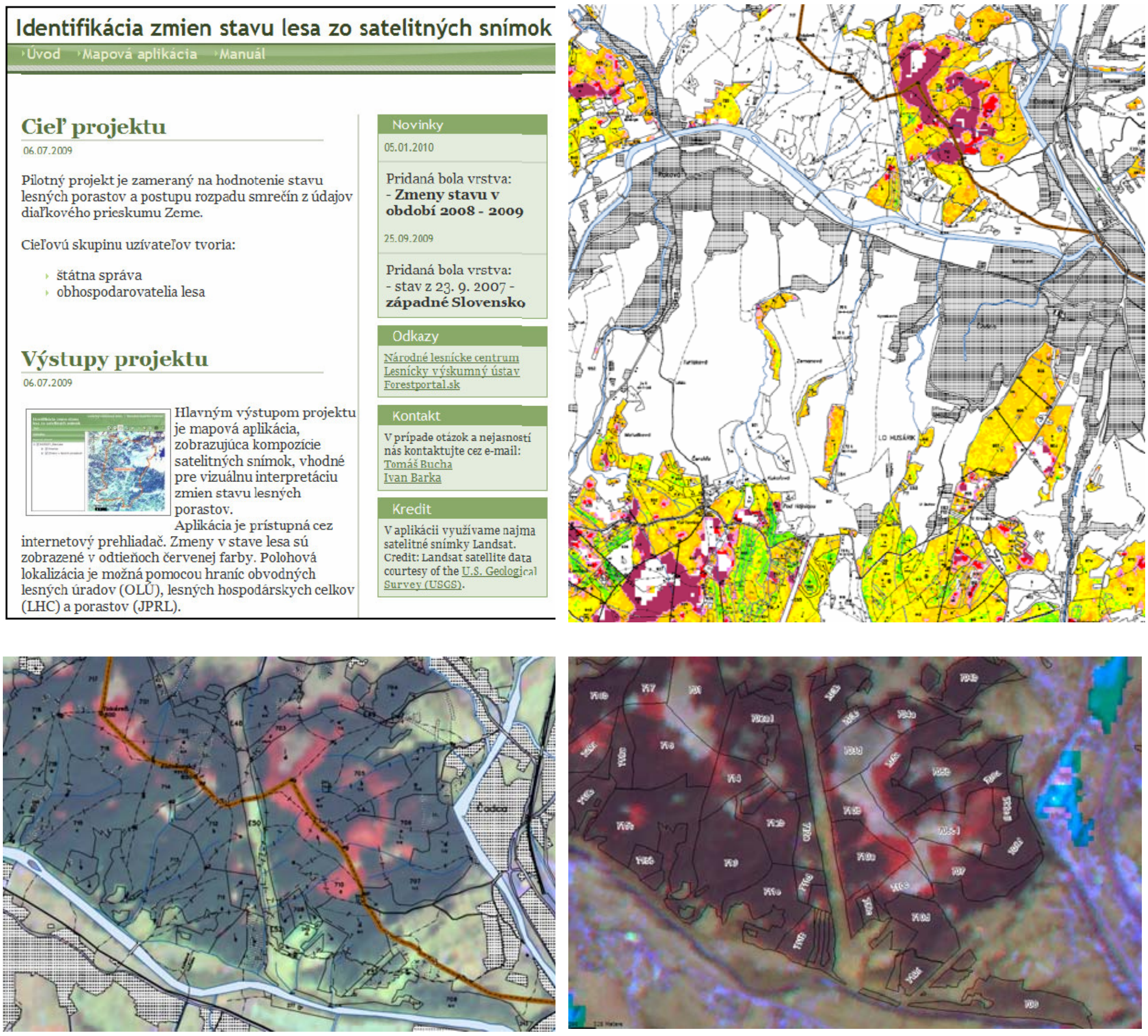



*Fig. 2. Top left: An introduction page of the web application (http://www.nlcsk.org/stales/) focused on state and changes of forest stands.*
*Top right: An example of classification of forest health condition in 2008 in form of map which was submitted to forest owners. Bottom left and right: Composite of SPOT images from 2007–2008 and 2008–2009. Red colour indicates an augment of heavily damaged and dead forest stands or clear-cuts realised between given periods. © CNES 2004 – 2007/Spot Image*

## 5. SPACE METEOROLOGY.

Main activities in the last two years were oriented to operational receiving and processing meteorological satellite data. Baseline system supported by EUMETSAT and WMO – EUMETCast distribution system is permanently fed by increasing number of products which raise requirements on standard reception stations. In October 2008 distribution of satellite signal for Europe was switched from Hotbird-6 to Eurobird-9 broadcasting satellite. This was the reason also in Slovakia to modify and partially upgrade the satellite receiving system. To increase the reliability of the satellite data receiving station and to decrease data losses we decided to duplicate almost all components of receiving equipment. At first we have double the computer with DVB-card and later the whole receiving system including the antenna. From the end of 2009 we have operated parallel both receiving systems in synchronized regime. The received data are reciprocally complemented and processed to the best user disposal.

In 2008 Slovakia supported Ukrainian Hydrometeorological Institute with the software package "Processing and visualization MSG satellite high rate image data -MSGPROC". This package has been developed in Slovak Hydrometeorological Institute as non-commercial tools and it is dedicated to scientific and operational weather forecasting purposes in the agreed scope. Both institutes agreed on bilateral cooperation concerning possible further development of relevant algorithms and methods. Image products are visualized by ViewMSG software tool for MS Windows platform. Image products are generated in compliance with EUMETSAT recommendations.

In October 2009 Slovak Hydrometeorological Institute hosted EUMETSAT representatives from the Development and Training Department. It was the opportunity to spread the information what EUMETSAT has been doing and what provides for wide user and research community. EUMETSAT presented current and future programmes, operating satellites and satellites under development. Specialists from SHMÚ and from other invited institutions received comprehensive information about all EUMETSAT data services and products.

EUMETSAT training activities involve not only education of users from member and cooperating states but they are spread practically in all regions covered by EUMETSAT satellites field of view. In May 2009 EUMETSAT organized international training workshop on usage of meteorological satellite data in cooperation with UHMI in Kiev. Participants came from all eastern

European countries and lectures were provided not only by EUMETSAT training officers but also by specialists from other member and cooperating states. Slovakia was also invited and provided lesson on standard EUMETCast receiving station, processing of MSG satellite data and usage of image products with emphases on cloud classification and severe weather detection.

From 2007 Slovakia participates in EUMETSAT Convection working group, which is initiative of EUMETSAT training department and EUMETCAL project leaded by ZAMG Austria. This working group collects tools, ideas, algorithms and methods for the best utilization of satellite data for detection of convection connected with severe weather like thunderstorms, heavy precipitation, wind gusts, hail and lightning. In the frame of this group Slovakia obtained in 2008 EUMETSAT software GII. This software serves for computation of global instability indices for localization of areas where convection can start. We have adopted this software in SHMÚ for ingestion of numerical weather prediction model Aladin outputs. Model data are used as first guess for vertical temperature and humidity profiles which are consequently retrieved from brightness temperatures measured by 6 infrared MSG channels. Adopted GII software was implemented into operation for purposes of weather forecasting office in September 2008. Generated data – K-index, Lifted index and Total precipitable water content were tested in operation during summer season 2009. Additionally we reprocessed and evaluated about 25 selected convective cases from 2008 and 2009 summer period. Evaluation was partially done in cooperation with Faculty of Mathematics, Physics and Informatics of Comenius University in Bratislava. Results were presented on annual EUMETSAT Meteorological Satellite Conference held in Bath, UK in September 2009.

During 2008-2009 Slovak Hydrometeorological Institute continued in international cooperation in the frame of EUMETSAT project H-SAF (Satellite Application Facility in support to Operational Hydrology).
Calibration and validation of precipitation products and hydrological validation is crucial for development of algorithms. SHMÚ validation activities were based on precipitation fields estimated by Slovak radar network and raingauge precipitation measurements. Experiments have been done also using INCA system for integration of various precipitation sources. The HSAF project is currently in development and operational phase and all the essential products are available in near real time for operational validation and testing purposes.

In second half of 2009 we started the development of processing and visualization software for AVHRR (Advanced Very High Resolution

Radiometer) polar satellite data level 1B. Software supports data from EPS satellites (currently MetOp-A) and NOAA-19. This software enables us to use high resolution imagery including RGB products in near real time. User can define various regions of interest (ROI) and to set up several attributes of resulting RGB products. Software was implemented in SHMÚ on EUMETCast receiving station and currently is in testing operation (see Figs. 1 and 2).

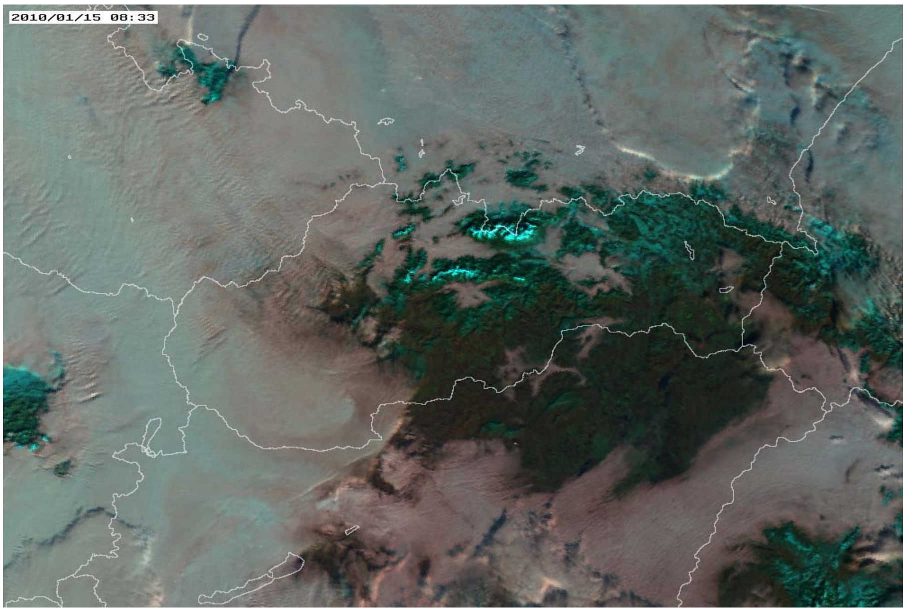



*Fig. 1. EPS MetOp-A satellite 2010/01/15 08:33UTC: RGB combination of channels 3,2,1 in resolution of 1.1 km showing snow cover, fog and low clouds over Slovakia and surrounding countries. Copyright 2010 EUMETSAT. Data received and processed in SHMÚ.*

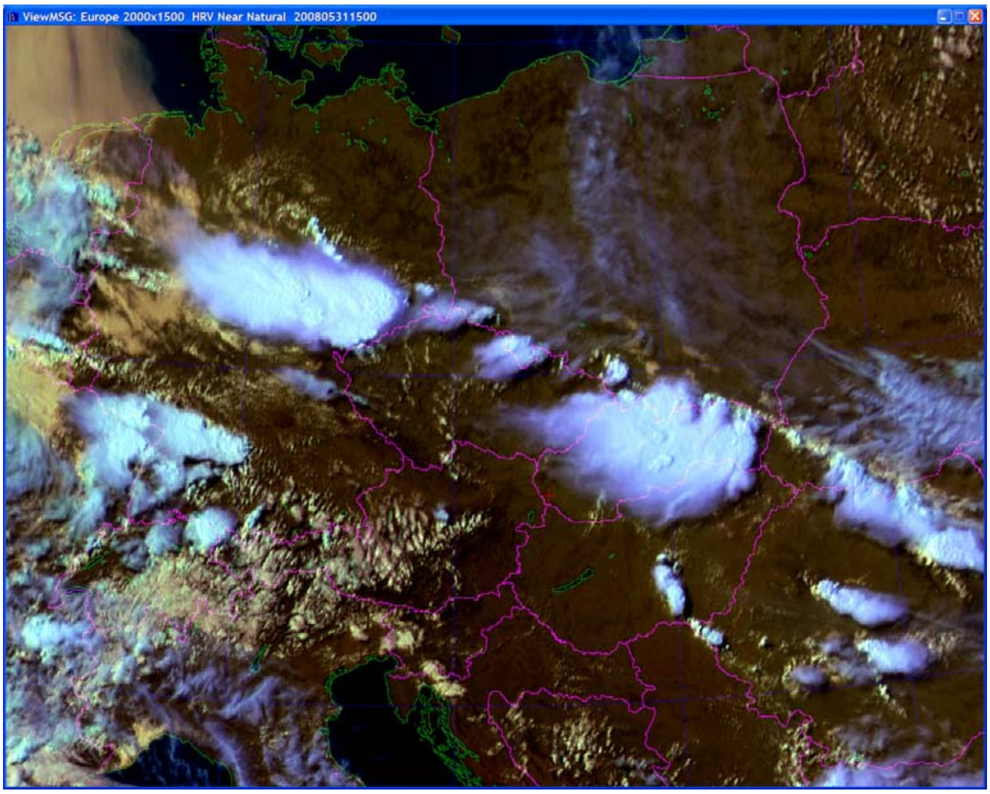



*Fig. 2. MSG-2 satellite 2008/05/31 15:00UTC: RGB combination of channels 3,12,9 in resolution 3 km showing severe storms with overshooting tops which hit especially northern and eastern part of Slovakia. Copyright 2008 EUMETSAT. Data received and processed in SHMÚ.*

References (1-4, 12-18, 25 in Slovak).


*1. BARKA, I. 2009: Návrh regionálneho informačného systému ekologického a produkčného stavu lesa na báze údajov DPZ. In. Bucha, T., Pavlendová, H., eds. Diaľkový prieskum Zeme – lesy v meniacich sa prírodných podmienkach. Zvolen (NLC), pp. 123–142*

*2. BUCHA, T. Využitie satelitných snímok pri vyhodnotení stavu a vývoja smrekových porastov na Slovensku. Životné prostredie, 2009, 43, 4, pp. 230–234.*

*3. BUCHA, T.- PAJTÍK, J. - PRIWITZER, T. - KOREŇ, M. Satelitne založené sledovania odozvy lesných ekosystémov na globálne sa meniace podmienky prírodného prostredia. In. Klikušovská, Z., Sviček, M., eds. Environmentálne indexy a indikátory analýzy a hodnotenia krajiny 2009 (terénny prieskum, modelovanie a diaľkový prieskum Zeme ako alternatívne zdroje údajov). Zborník príspevkov z vedeckého seminára, Bratislava, 5.11.2009. Bratislava (VÚPOP), pp. 8–18.*

*4. FERANEC, J. Krajinná pokrývka a využitie krajiny Slovenska v kontexte národnej štatistiky a dát CORINE Land Cover (Land cover and land use of Slovakia in the context of national statistics and the CORINE land cover data). Acta Geographica Universitatis Comenianae, 2008, 50, pp. 135-144.*

*5. FERANEC, J. -, OŤAHEĽ, J. Land Cover Changes in Slovakia in the Period 1970-2000. Geografický časopis, 2008, 60, 2, pp. 113-128.*

*6. FERANEC, J. - NOVÁČEK, J. - OŤAHEĽ, J. - KOPECKÁ, M. Identification and Assessment of Change Concerning Pastures by the 1990-2000 CORINE Land Cover Data in Slovakia. In Man in the Landscape across frontiers: Landscape and land use change in Central European border regions: CD Proceedings of the IGU/LUCC Central Europe Conference. Editori Jan Kabrda, Ivan Bičík. - Prague: Charles University, Faculty of Science, 2008, pp. 60-68.*

*7. FERANEC, J. - JAFFRAIN, G.- SOUKUP, T. - HAZEU, G. Determining changes and flows in European landscapes 1990-2000 using CORINE land cover data. Applied Geography, 19 August 2009, vol. 30, online first, p. 1-17*

*8. FERANEC, J. - NOVÁČEK, J. The CORINE Land Cover database of Slovakia and its changes in the period 2000-2006. Moravian Geographical Reports, 2009, 17, 3, pp. 2-9.*

*9. FERANEC, J. - KOPECKÁ, M.  VATSEVA, R. - STOIMENOV, A. - OŤAHEĽ, J. - BETÁK, J. - HUSÁR, K. Landscape change analysis and assessment (case studies in Slovakia and Bulgaria). Central European Journal of Geosciences, 2009, vol. 1, no. 1, pp. 106-119.*
*http://versita.metapress.com/content/d382j7t8030852t1/fulltext.pdf*

*10. FERANEC, J. - ČIŽMÁR, J. - KONTRA, P. Developments in Cartography and Geoinformatics in Slovakia after 1989. In ICA Symposium on Cartography for Central and Eastern Europe: Vienna, 16-17 February 2009: proceedings [CD ROM]. Editor Georg Gartner, Felix Ortag. - Vienna: Research Group Cartography: Vienna University of Technology, 2009, pp. 295-312.*

*11. FERANEC, J. - PRAVDA, J. Aesthetics of the CORINE Land Cover Maps. In Cartwright, W., Gartner, G., Lehn, A., eds. Cartography and Art. Berlin (Springer), 2009, pp. 69-79.*

*12. FERANEC, J. - MACHKOVÁ, N. Využitie informácií satelitného monitorovania Zeme pri mapovaní krajinnej pokrývky (Use of information obtained by satellite monitoring of Earth for land cover mapping). Životné prostredie, 2009, 43, 4, pp. 195-202.*

*13. HAMLÍKOVÁ, Ľ. - HUTÁR, V. Využitie nových družicových snímačov na kontrolu priamych podpôr metódou Diaľkového prieskumu zeme. In Bujnovský, R., ed.: Vedecké práce Výskumného ústavu pôdoznalectva a ochrany pôdy, 31, 2009. Bratislava (VÚPOP), pp. 54-59*

*14. HUTÁR, V. - HALAS J., 2008: Detekcia vybraných parametrov pôdy na základe interpretácie údajov diaľkového prieskumu Zeme. In Nováková, M., Sviček, M., eds. Environmentálne aspekty analýzy a hodnotenia krajiny: Identifikácia a stanovenie indikátorov (a indexov) na báze prieskumov krajiny a údajov DPZ. Zborník z vedeckého seminára konaného v Bratislave 5.11.2009. Bratislava (VÚPOP), pp. 29-32.*

*15. JANEČKA, P. Identifikácia vypálených území interpretáciou satelitných obrazových záznamov. In: Klikušovská, Z., Sviček, M., eds. Environmentálne indexy a indikátory analýzy a hodnotenia krajiny 2009 (terénny prieskum, modelovanie a diaľkový prieskum Zeme ako alternatívne zdroje údajov). Zborník z vedeckého seminára konaného v Bratislave 5.11.2009. Bratislava (VUPOP), 2009, pp. 41-48.*

*16. JURAŠEK, M. - KAŇÁK, J. - KOTLÁRIKOVÁ, D. História družicových meteorologických pozorovaní v Slovenskom hydrometeorologickom ústave. Životné prostredie, 43, 4, pp.208-211, 2009*

*17. KAŇÁK, J. - HABROVSKÝ, R. Možnosti včasnej detekcie silných búrok s využitím meteorologickej družice MSG. Životné prostredie, 2009, 43, 4, pp.227-229.*

*18. MACHKOVÁ, N. Využitie satelitov v katastrofických situáciách (Satellite usage in case of natural or industrial hazards). Životné prostredie, 2009, 43, 4, pp. 238-242.*

*19. KAŇÁK, J. - HABROVSKÝ, R. - CSAPLÁR, J. - SOKOL, A. Implementation of EUMETSAT GII/RII software to SHMÚ ALADIN operational suite and first validation results. 2009 EUMETSAT Meteorological Satellite Conference, Bath, United Kingdom 21 – 25 September 2009. EUMETSAT P.55, ISBN 978-92-9110-086-6, ISSN 1011-3932.*

*20. NOVÁKOVÁ, M. - SVIČEK, M. Implementation of European system for estimating yields and crop production (CGMS and MCYFS) in Slovakia (in Slovak). Final report. Bratislava (SSCRI), 2008, 62 pp.*

*21. NOVÁKOVÁ, M. - KLIKUŠOVSKÁ, Z. - SVIČEK, M. Completing an application and a national system for estimating yields and production of agricultural crops (SK_CGMS) (in Slovak). Final report. SSCRI Bratislava, 2009, 52pp.*

*22. OŤAHEĽ, J. - FERANEC, J. - KOPECKÁ, M. - BETÁK, J. - HUSÁR, K. Landscape development (long-term changes) assessment: case study of the Tatra region. In Man in the Landscape across frontiers: Landscape and land use change in Central European border regions: CD Proceedings of the IGU/LUCC Central Europe Conference. Editori Jan Kabrda, Ivan Bičík. - Prague: Charles University, Faculty of Science, 2008, pp. 31-33.*

*23. SVIČEK, M. - SZŐCSOVÁ, I. - SCHOLTZ, P. - FENDEKOVÁ M. - HAMLÍKOVÁ Ľ. - KOVÁČIKOVÁ, I. The 2008 campaign of remote-sensing control of area-based subsidies. Final report. Bratislava (SSCRI), 2008, 19 pp.*

*24. SVIČEK, M. - HAMLÍKOVÁ, Ľ. - KOVÁČIKOVÁ, I. The 2009 campaign of remote-sensing control of area-based subsidies. Final report. Bratislava (SSCRI), 2009, 20 pp.*

*25. SZÖCSOVÁ, I. - HAMLÍKOVÁ, Ľ. - HUTÁR, V. - SVIČEK, M. Využitie metód diaľkového prieskumu Zeme pre účely regionálnej inventarizácie plodín. In Feranec, J., Fencík, R., eds. Aktivity v kartografii 2008. Bratislava (Kartografická spoločnosť Slovenskej republiky a Geografický ústav Slovenskej akadémie vied), 2008, pp. 164-172.*

## 6. Institutions involved in Space Research relevant to COSPAR.

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

Astronomical Institute (AI)
Slovak Academy of Sciences (SAS)
Stará Lesná
059 60 Tatranská Lomnica
J. Rybák ( choc@astro.ta3.sk, NC member)

Faculty of Mathematics, Physics and Informatics (FMPI)
Comenius University
Mlýnska dolina
842 15 Bratislava
J. Masarik (Jozef.Masarik@fmph.uniba.sk, NC member)

Faculty of Science (FS)
P.J. Šafárik's University
Moyzesova 11
041 67 Košice
E. Ahlersová (iahlers@kosice.upjs.sk, NC member)

National Forest Centre
T.G. Masaryka 22
960 92 Zvolen
T. Bucha (bucha@nlcsk.org)

Geophysical Institute (GI)
Slovak Academy of Sciences (SAS)
Dúbravská cesta
842 28 Bratislava
A. Prigancová (geofpria@savba.savba.sk, Secretary of NC )

Institute of Biochemistry and Genetics of Animals (IBGA)
Slovak Academy of Sciences (SAS)
900 28 Ivanka pri Dunaji
M. Juráni (jurani@ubgz.savba.sk, NC member)

Institute of Experimental Endocrinology (IEE)
Slovak Academy of Sciences (SAS)
Vlárska 3
833 06 Bratislava
R. Kvetňanský (ueenkvet@savba.sk, Vice- chair of NC)
L. Macho (ueenlaco@savba.sk, NC member)

Institute of Experimental Physics (IEP)
Slovak Academy of Sciences (SAS)
Watsonova 47
043 53 Košice
K. Kudela (kkudela@kosice.upjs.sk, Chair of NC, Representative of Slovak NC to COSPAR)

Institute of Geography (IGG)
Slovak Academy of Sciences (SAS)
Štefánikova 49
814 73 Bratislava
J. Feranec (feranec@savba.sk, NC member)

Institute of Measurement Science (IMS)
Slovak Academy of Sciences (SAS)
Dúbravská 9
842 19 Bratislava
contact: I. Frollo (frollo@savba.sk)

Institute of Normal and Pathological Physiology (INPP)
Slovak Academy of Sciences (SAS)
Vlárska 1
884 23 Bratislava

Slovak Environmental Agency
Remote Sensing Department
Tajovského 28
975 90 Banská Bystrica
contact: N. Machková (machkova@sazp.sk)

Slovak Hydrometeorological Institute
Maly Javornik Observatory
827 13 Bratislava
D. Kotláriková (dagmar.kotlarikova@shm.sk, NC member)

Soil Science and Conservation Research Institute
Gagarinova 10
827 13 Bratislava
contact: M. Sviček (svicek@vupu.sk)

Space Research in Slovakia 2008 – 2009
National Committee of COSPAR in Slovak Republic
Slovak Academy of Sciences
Institute of Experimental Physics, SAS, Košice

Editors: Karel Kudela, Ján Feranec and Ladislav Macho
Technical editor: Jana Štetiarová

Printed by CopyCenter Košice, June 2010
ISBN 978-80-968060-7-2