Institute of Atmospheric Physics

Academy of Sciences of the Czech Republic

Biennial Report 2007–2008

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Institute Management (as of May 2009)

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Board (as of May 2009)

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Dr. **Radan Huth**

Dr. **Dagmar Novotná**

Assoc. Prof. **Ondřej Santolík**

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Dr. **Aleš Špičák**, Institute of Geophysics AS CR

Dr. **Radim Tolasz**, Czech Hydrometeorological Institute

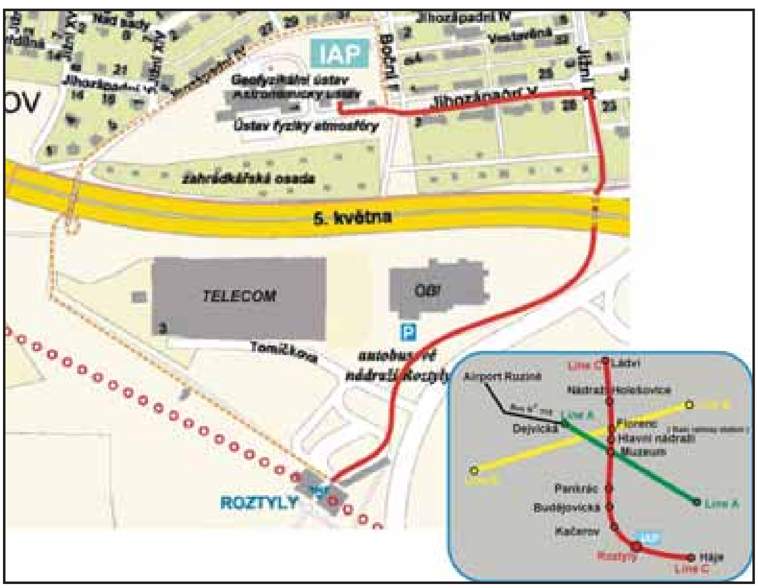
Prof. **Bedřich Velický**, Scientific Council of AS CR

How to get to us when you arrive in Prague

By car: Take highway D1 (Prague–Brno). If you go south from downtown in direction Brno, take exit Spořilov (marked in red colour in the upper figure) and immediately another exit Spořilov; coming from Brno, take exit Spořilov (marked in blue in the upper figure). Then follow the dashed red and blue line to the Institute.

By train or bus: From the Hlavní nádraží main railway station, the Holešovice railway station, and the Florenc main coach station, take underground line C, direction Háje; from the Masarykovo nádraží railway station, take underground line B to station Florenc and change for line C, direction Háje. Get off at station Roztyly. When you get to the surface, you will already see buildings of the Institute behind the highway. The walk takes about 10 minutes and leads right of the OBI supermarket through a highway underpass. The path is depicted by red line on the map of the neighbourhood of the Institute.

By plane: From the Prague-Ruzyně airport you can take taxi or go by public transport. The journey takes about 60 min in both cases, in the former case depending on the traffic density. If you decide to go by public transport, take bus No. 119 to the bus terminal Dejvická. Then take underground line A to station Muzeum and change for line C, direction Háje. Get off at station Roztyly. When you get to the surface, you will already see buildings of the Institute behind the highway. The walk takes about 10 minutes and leads right of the OBI supermarket through a highway underpass. The path is depicted by red line on the map of the neighbourhood of the Institute.



1. General Information

The Institute of Atmospheric Physics (IAP) is a part of the Academy of Sciences of the Czech Republic (AS CR), which joins research institutions, covering the whole field of science and humanities.

History

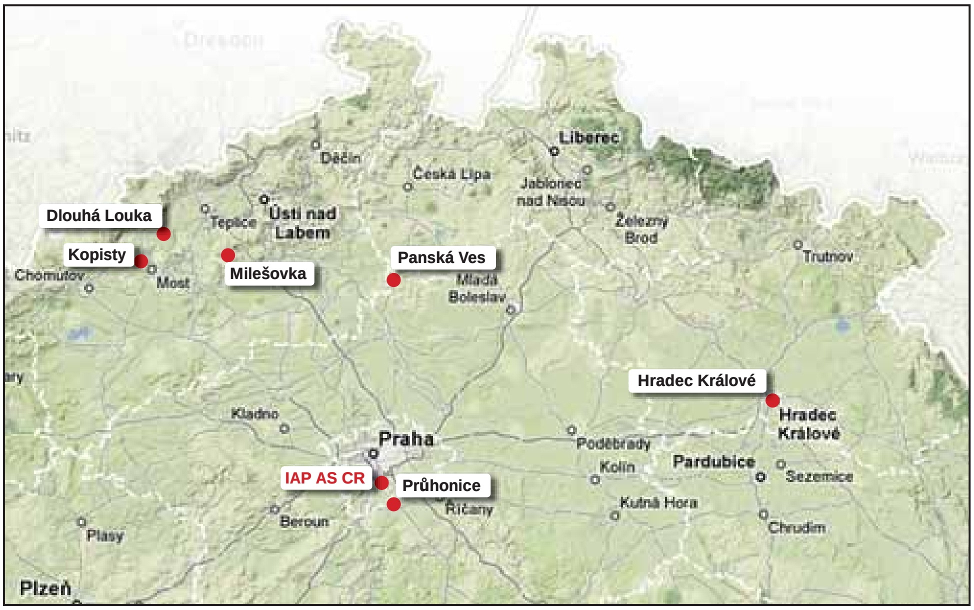
The Institute of Atmospheric Physics was established in 1964 as a continuation of the former Laboratory for Meteorology of the Geophysical Institute. The main research focus was on the processes taking place in the troposphere. In 1994, the former Ionospheric Dept. of the Geophysical Institute joined the IAP, thereby expanding the research domain, which now covers the whole atmosphere from the boundary layer up to interplanetary space.

Main research topics

The IAP deals with scientific investigations of the atmosphere in its whole vertical extent, thus studying the boundary layer, troposphere, middle atmosphere, ionosphere, and magnetosphere of the Earth by applying experimental and theoretical methods and numerical simulations. The activities include also monitoring and special measurements, data evaluation and their transfer into worldwide data networks, and expertises.

The research is now conducted in the following main streams:

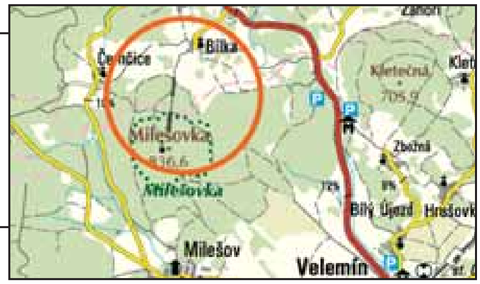
- atmospheric boundary layer processes
- mesoscale meteorological processes, precipitation physics
- atmospheric effects on radiowave propagation
- climate variability and climate change
- ozone research
- ionosphere and magnetosphere, including our own satellite experiments
- space plasma physics
- solar-terrestrial relations

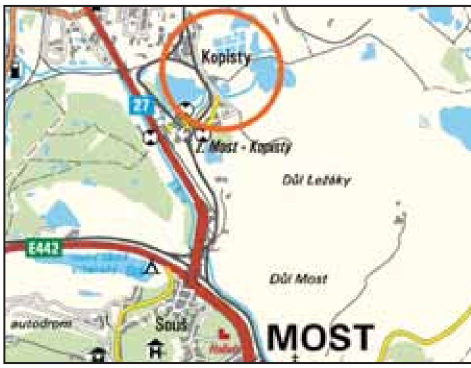


Observatories, detached units

In addition to central facilities in Prague, the IAP manages six detached units. Their locations are displayed on the maps below. The detached units are:

Meteorological observatory Milešovka:
the oldest mountain observatory in the Czech Republic operating since 1905; in addition to standard synoptic and climatic observations, fog and low cloud water sampling for studies on atmospheric chemistry has been performed there since 1998





Meteorological observatory Kopisty:
being located in a valley in the most polluted region of the Czech Republic, the observatory is dedicated mostly to measurements for the boundary layer studies; since 1998, precipitation chemistry measurements have been performed there

Experimental meteorological site Dlouhá Louka:
serves mainly for routine mast measurements of wind

Ionospheric observatory Průhonice:
performs ionospheric vertical soundings and Doppler type measurements

Satellite telemetric station and ionospheric observatory Panská Ves:
consists of the telemetry and telecommand station for scientific satellites and the ionospheric observatory, monitoring sudden ionospheric disturbances

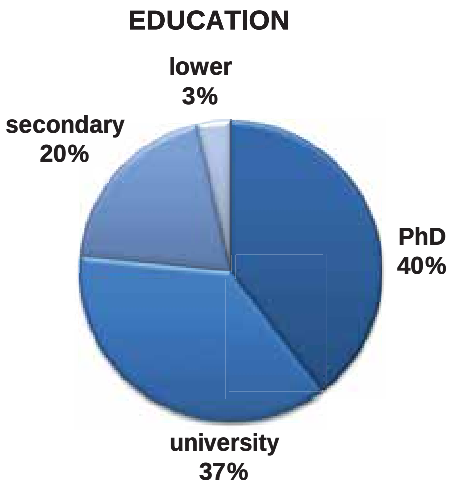
Detached unit at Hradec Králové:

a minor part of Dept. of Climatology is located in Hradec Králové; the experimental site serves for rain rate measurements

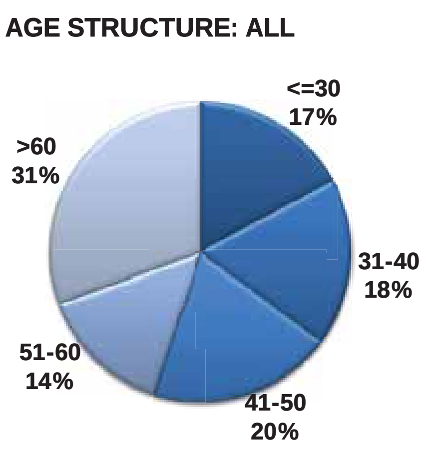
More details on the observatories can be found in the text related to the individual departments.

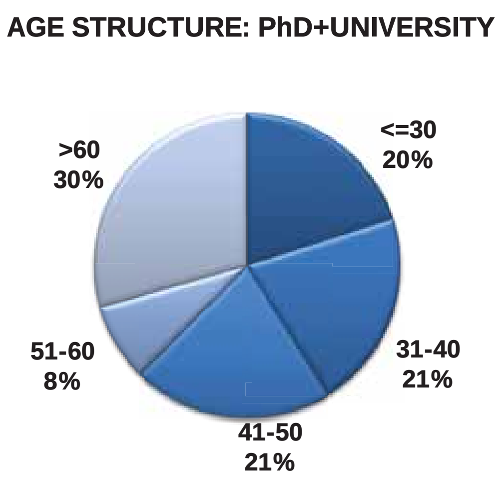
Professional and age structure

The staff of the Institute amounts to 111 persons (or 80.9 if recalculated to the number of full-time jobs; state at the end of 2008), 40 % of which hold the PhD degree or its equivalent. The professional and educational structure is shown on the diagram below.



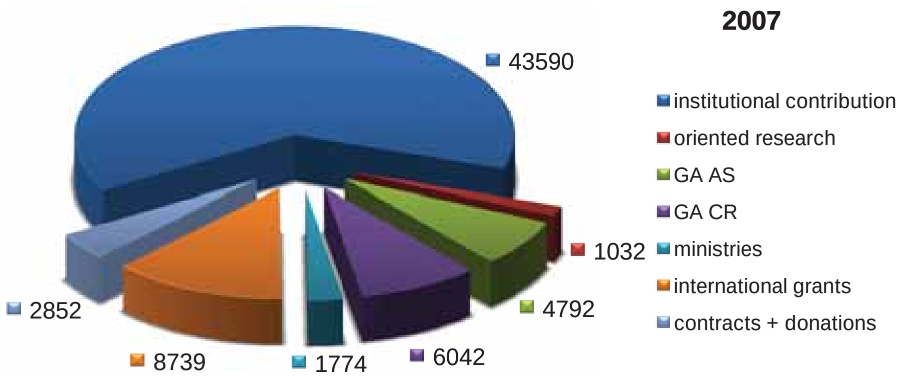
The other two diagrams display the age structure of the staff, both for all staff and for scientists only. Favourable features are an rather even distribution of the staff among all age categories, and in particular, a relatively high share of the young (both postgraduates and undergraduates).

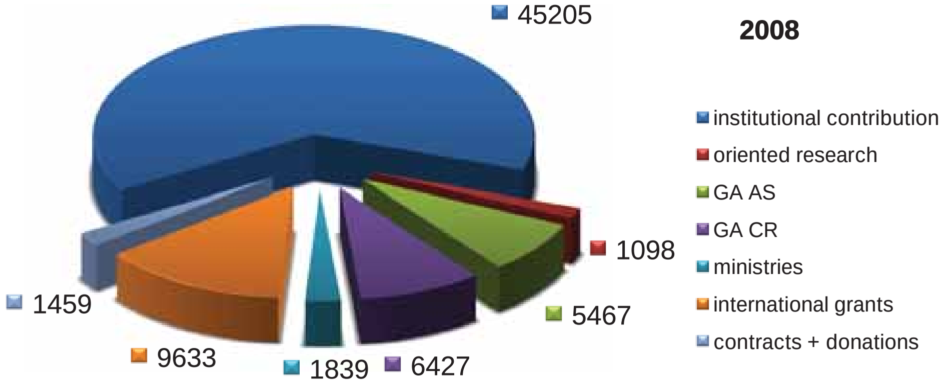




Budget

The total budget of the IAP amounted to 68.8 millions Czech crowns (CZK; exchange rate is approx. 27 CZK = 1 EUR) in 2007 and 71.1 millions CZK in 2008. Several sources contribute to the budget. The largest one, the institutional contribution, comes directly from the budget of the Academy of Sciences and is directed at basic salaries and overhead costs. The Academy of Sciences covers also the oriented research, intended to support specific projects with expected application outcomes. The international funding includes among others ESA, NASA, and the 6th and 7th Framework Programmes of EU; it is the second largest contribution to the budget of the IAP. Other sources of funding include national grant agencies viz the Grant Agency of the Academy of Sciences (GA AS) and the Czech Science Foundation (GA CR); and ministries of the Czech government, most importantly the Ministry of Education, Youth and Sports, which provides contributions to the participation in international programmes (e.g. COST, KONTAKT). Around 2 million CZK come annually from contracts with industrial and other companies. The composition of the budget (in thousands of CZK) is displayed in the diagrams below.





2. Department of Space Physics

Web site: http://www.ufa.cas.cz/html/okf/

The main scientific subject is the investigation of linear and non-linear processes in space plasmas related to the solar-terrestrial interactions. The investigation methods include processing and interpretation of experimental and simulation data using sophisticated mathematical methods and software tools.

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Main research topics

Magnetosheath mirror structures

Magnetosheath is a transition region between the bow shock and the magnetopause filled with turbulent subsonic plasma of solar wind origin. Wave phenomenon characteristics for this region are so called mirror modes: large amplitude enhancements or depressions in the magnetic field accompanied by anti-correlated perturbation in plasma density. These structures are believed to be created by a plasma process that keeps the magnetosheath plasma in a marginally stable state by dissipating excessive free energy of plasma ions when temperature anisotropy exceeds a certain limit. This property makes mirror structures important for the global magnetospheric dynamics.

In our study (Souček et al., 2008) we used data from Cluster satellites to perform a statistical investigation of the occurrence of mirror modes within the magnetosheath, their shape and its correlation with local plasma parameters. Main focus of the study was on the distinction between two basic types on mirror modes: magnetic 'peaks' and magnetic 'dips'. An ad-hoc statistical technique based on a wavelet transform was developed to distinguish these two types of structures by automatic computer processing of magnetic field data. Two months of Cluster data were then processed with this method to crate a large database of mirror events.

A subsequent analysis of the resulting database revealed interesting properties of mirror structures which could be compared with recent theories and numerical simulations. Most importantly it was shown that the degree instability of the plasma with respect to mirror instability (or a distance to instability threshold) is a determining parameter for the shape of mirror structures. As shown in Fig. 2-1, peaks are found almost exclusively above the instability threshold, but dips can exist both in stable and unstable plasma. A phenomenological model of creation and evolution of mirror structures in the magnetosheath was constructed based on the results. This model proposes that mirror modes are created close to the bow shock and after a brief period of growth, the instability saturates to form trains of magnetic peaks. As the mirror structures are convected downstream towards the magnetopause, changes in plasma parameters drive the plasma to a stable state and mirror modes often turn into dips. Our results were shown to be consistent with recent theoretical studies, including works co-authored by researchers from the IAP (CALIFANO ET AL., 2008; TRÁVNÍČEK ET AL., 2007B).

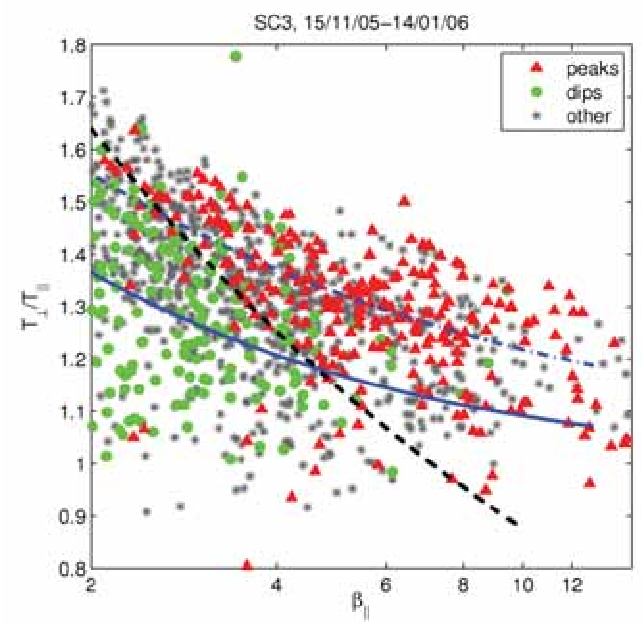

Fig. 2-1. Different types of mirror structures plotted in ion anisotropy-ion beta plane. Each symbol represents a 5 minute interval of Cluster data: red triangles mark intervals dominated by peaks and green circles intervals with dips. Solid blue line is the classical threshold of mirror instability, the black dashed line is an empirical fit of the boundary between peaks and dips.

Systematic study of magnetospheric line radiation using the DEMETER spacecraft

Electromagnetic waves observed by a low-orbiting satellite represented in the form of the frequency-time spectrogram sometimes consist of several nearly horizontal and almost equidistant intense lines. These are called Magnetospheric Line Radiation (MLR). They have been reported also in the ground-based data and the evidence for their propagation through the magnetosphere has been given. In some cases, mutual frequency separation of the lines is 50/100 or 60/120 Hz. These are usually called Power Line Harmonic Radiation (PLHR) and are believed to be caused by an electromagnetic radiation from electric power systems on the ground. In collaboration with our colleagues from LPCE/CNRS laboratory (Orléans, France) we analysed a large amount of data from DEMETER spacecraft (launched in June, 2004, altitude of orbit approximately 700 km).

We have used an automatic identification procedure in order to look for the events, obtaining a unique dataset of several tens of events. We have shown that there are two principally different classes of events: (1) events with frequency spacing of 50/100 or 60/120 Hz (PLHR) and (2) events with a different frequency spacing (NĚMEC ET AL., 2007A). The first class of events is generated by power systems on the Earth's surface, with frequency spacing well corresponding to the fundamental frequency of the radiating power system (NĚMEC ET AL., 2007B). On the other hand, the second class is most probably generated in a completely natural way. All the detected events were thoroughly analyzed, and different properties of the two classes were statistically demonstrated. We have found that PLHR events occur both during low and high geomagnetic activity, with none of them significantly preferred. However, MLR events occur more frequently under disturbed conditions. Most of the PLHR events are observed at frequencies of 2 to 3 kHz. On the other hand, MLR events most frequently occur at frequencies below 2 kHz and seem to be more intense than PLHR. Additionally,

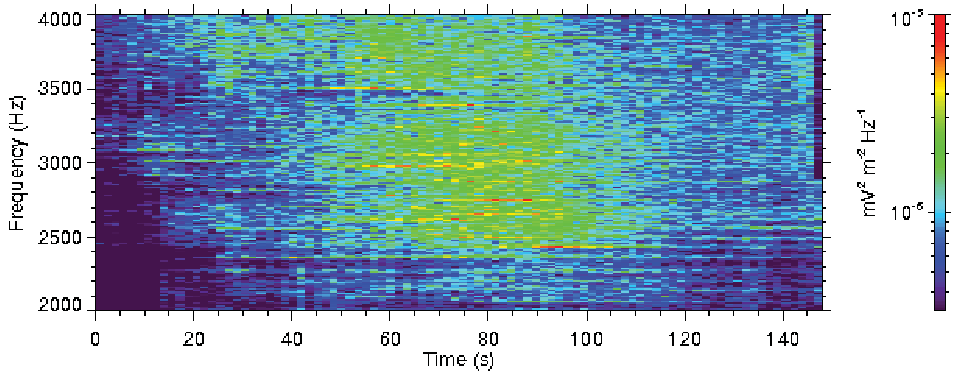

Fig. 2-2. An example of frequency-time spectrogram of magnetospheric line radiation.

PLHR events are more intense during the night than during the day (which can be probably explained by different penetration characteristics of the ionosphere, see Němec et al., 2008b), and there is about the same number of PLHR events observed during the day and during the night. On the contrary, no dependence of MLR peak intensities on magnetic local time was found, and more MLR events were observed during the day than during the night, although this difference is not statistically significant. Finally, there is a group of MLR events with characteristics corresponding to the previous spacecraft observations of equatorial noise emissions at larger radial distances.

Electron temperature anisotropy constraints in the solar wind

Solar wind is an ionized plasma flow streaming away from the solar corona. The solar wind is relatively tenuous (~5 particles/cm^3) while fast (~500 km/s) and pretty hot (~100 000 K) at the same time. It consists largely of protons and electrons with a small admixture of heavier ions. The solar wind fills up the whole solar system and interacts with its solid bodies (e.g. strongly influences the Earth's magnetosphere). Even though the solar wind was intensively studied during the last several decades, many of its properties are still not fully understood. One of these is the regulation of the temperature anisotropy. We have focused on controlling mechanisms of temperature anisotropy of electrons.

The expansion of the electron gas in the solar wind along the magnetic field lines should, based on classical theoretical approaches, produce large temperature anisotropies, i.e. different effective temperatures in the parallel ($T_\parallel$) and perpendicular ($T_\perp$) direction with respect to the orientation of the local magnetic field. Though the core of electron distribution functions observed in the solar wind is typically almost isotropic. The main mechanisms representing possible constraints on the rising anisotropy are the kinetic plasma instabilities and Coulomb collisions. Extreme temperature anisotropies become unstable and generate waves that bring again the temperatures closer to each other; these instabilities thus constitute constraints on the anisotropy. For electrons, the theoretically dominant instabilities are the electron whistler instability (for $T_\perp/T_\parallel > 1$) and oblique propagating electron fire hose instability ($T_\perp/T_\parallel < 1$). Next to the instabilities, the temperature anisotropy is naturally controlled by the effect of collisions which can transfer the energy from one 'direction' to the other directly by relative particle interactions. Štverák et al. (2008) analyzed in detail a large set of electron distributions from three spacecraft – Helios I, Cluster II and Ulysses. The core temperature anisotropy of these distributions was obtained by fitting the measured data with an analytical model. We then examined the results in terms of the temperature anisotropy versus parallel electron plasma beta, relating the measurements to the growth rates of unstable modes, and the effect of Coulomb collisions was expressed by the electron collisional age (Ae) defined as the number of collisions suffered by an electron during the expansion of the solar wind. We show that both instabilities and collisions are strongly related to the isotropisation process of the electron core population. The results also indicate that the bulk of the solar wind electrons are constrained by Coulomb collisions, while the large departures from isotropy are constrained by instabilities.

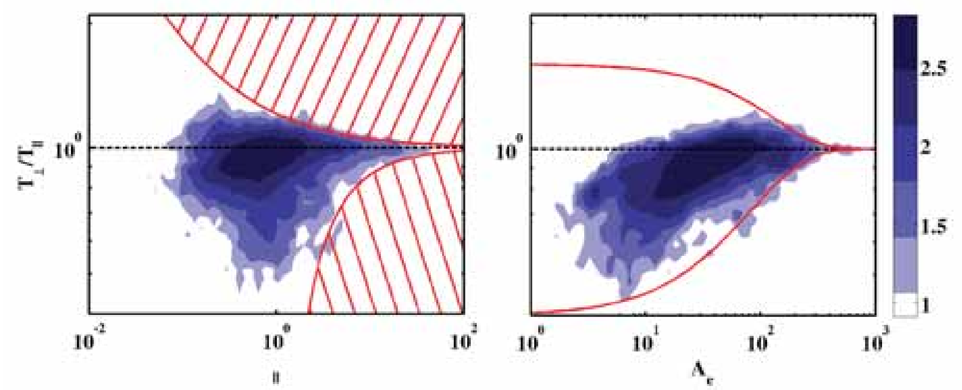

Fig. 2-3. Observations of electron temperature anisotropy, expressed with the ratio $T_\perp/T_\parallel$, measured on board Helios I, II and Ulysses. The left panel shows the frequency of measurements in the frame of $T_\perp/T_\parallel$ vs. electron parallel plasma beta. The red hatched regions represent the unstable configurations in which the plasma can last out only for a very short time. Observations of such configurations should be therefore nearly vanishing, as it is proved by our results. The right panel then compares the temperature anisotropy with respect to the effect of Coulomb collisions (expressed with the electron collisional age Ae). The red curves show a simplified model for the relaxation of an initial anisotropy related to number of suffered collisions needed to reach the isotropic state.

Research projects

International

Data processing and simulation facility, numerical modelling, and interpretation of wave observations. PI **P. Trávníček**, funded by ESA/PRODEX and ESA/PECS contracts (2000–2010).

Dual segmented Langmuir Probe. PI **P. Trávníček**; funded by ESA/PRODEX contract (2003–2009).

Investigation of waves and turbulence in space plasma. PI **O. Santolík**, funded by ESA/PECS contract (2005–2010).

Propagation of electromagnetic waves observed on the DEMETER spacecraft. PI **O. Santolík**, funded by KONTAKT-Barrande program (2006–2007).

Lunar-Based Soft X-ray Science. NASA award: Concept Studies for Lunar Sortie Science Opportunities (2006–2008, **P. Trávníček**, Co-I; M. R. Collier, Goddard Space Flight Center, PI).

Le vent solaire et son interaction avec la magnetosphere terrestre: Analyse des donnees. CNRS-PICS award (2006–2008, P. Trávníček, Co-I; M. Maksimovic, PI).

Formation of nonlinear coherent structures in space plasmas. PI **P. Hellinger**, funded by KONTAKT-Barrande program (2007–2008).

Etude statistique des donnees du satellite demeter. PICS award, Co-I **O. Santolík** (2007–2009, M. Parrot, PI).

Understanding Mercury's Magnetosphere using MESSENGER Data and Global Kinetic Simulations. NASA award: MESSENGER (2007–2013, **P. Trávníček**, Co-I; D. Schriver, UCLA, PI).

A Study of the Moon's Plasma Environment and Mini-Magnetospheres. NASA award: Geospace Science (2007–2010, **P. Trávníček**, Co-I; D. Schriver, UCLA, PI).

Interactions of the Icy Satellites of Saturn with Its Magnetosphere. NASA award: CDAP (2008–2010, **P. Trávníček**, Co-I; K. Khurana, UCLA, PI).

Studies of the Interaction between Jovian Plasma and Io Using Hybrid Simulations. NASA award: Outer Planets (2008–2012, **P. Trávníček**, Co-I; R. Walker, UCLA, PI).

National

Global-scale and meso-scale numerical modeling of space plasmas. PI **P. Trávníček**, funded by GA CR (2005–2007).

Solar wind plasmas: Numerical simulations and in situ observations. PI **P. Trávníček**, funded by GA AS (2006–2010).

Low-frequency wave coupling of the atmosphere, ionosphere, and inner magnetosphere of the Earth. PI **O. Santolík**, funded by GA CR (2006–2008).

Investigation of plasma waves in the magnetosphere and in the solar wind. PI **O. Santolík**, funded by GA AS (2006–2010).

Kinetic processes in the solar wind. PI **P. Hellinger**; funded by GA AS (2007–2011).

Analysis of high frequency plasma waves observed in the solar wind. PI **J. Souček**, funded by GA CR (2008–2010).

3. Department of the Upper Atmosphere

Web site: http://www.ufa.cas.cz/html/upperatm/

The scientific and technical activity of the department is focused mainly on theoretical and experimental studies of the Earth's plasma environment, plasma waves in the inner magnetosphere, mass and energy transport from the solar wind to the magnetosphere and ionosphere, including work on International Reference Ionosphere (IRI), and scientific instrumentation and micro-satellite systems.

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Main research topics

Modelling and studying of thermal plasma parameters

We have advanced in development of a new global model of electron temperature (Te) with the inclusion of its variability with solar cycle. Using a database comprising all available satellite Te data and incoherent scatter measurements, and with assistance of the mathematical FLIP model, we have proposed a new global Te model that consists of sub-models for altitudes 350, 550, 850, 1400 and 2000 km for equinox and solstices. The model is described by spherical harmonics up to the 8th order. Variability of Te with solar cycle is modelled in additive terms to the specific sub-models (Bilitza et al., 2007).

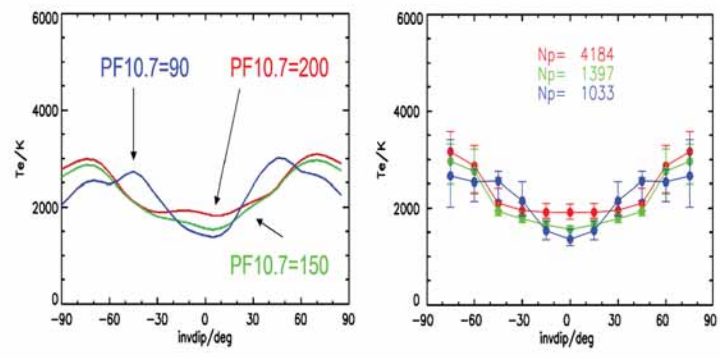


Fig. 3-1. Electron temperature in 550 km height at equinox: first version of empirical Te model (left plot) in comparison with our database (right plot).

Mass and energy transport from the solar wind to the magnetosphere and ionosphere

The geomagnetic activity is strongly coupled with the solar wind variability. Solar wind mass and energy penetrate by a variety of processes into the magnetosphere, they are stored there, and then released causing geomagnetic storms and sub-storms. The change of the geomagnetic field during these sudden events can be so large and sharp that the induced electric field and/or enhanced fluxes of energetic particles can destroy industrial and communication systems. It is desirable to predict such events but our knowledge of processes involved is still insufficient for this task. We used the experimental data obtained from the missions that have investigated magnetospheric boundaries (Interball, Cluster II and Themis projects) and studied the penetration of the solar wind through the magnetopause. The interpretation of data obtained from the Interball project was carried out in collaboration with the Dept. of Surface and Plasma Science of the Faculty of Mathematics and Physics. We dealt with observations of the high altitude cusp and boundary layers. Focus was on investigation of a response of boundary layers to the solar wind conditions (Šafránková et al., 2007) and plasma propagation in the cusp region. In the future work we plan to use data from current missions (Cluster II, Themis) and compare our model of plasma propagation in cusp region with experimental data.

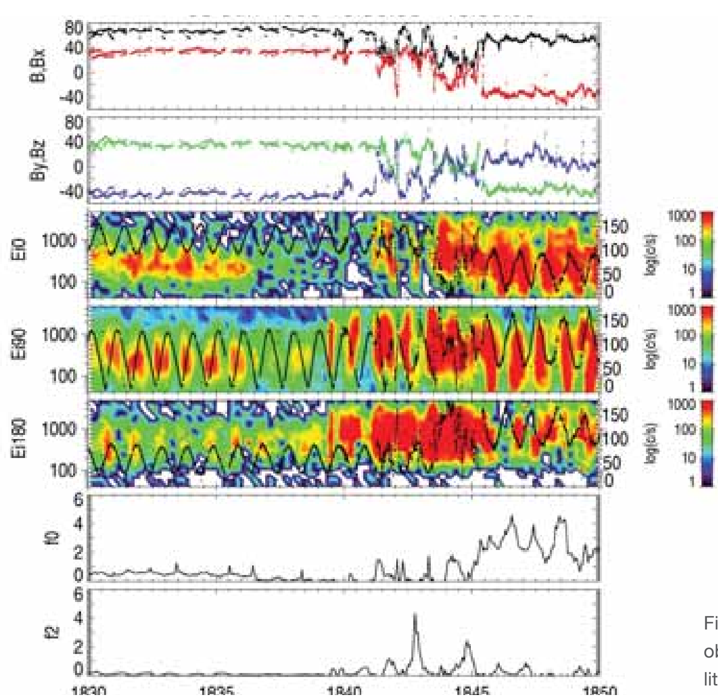


Fig. 3-2. Vortex like structure observed by Magion-4 satellite above magnetopause.

The influence of solar wind turbulence on geomagnetic activity

The proper description of fluctuations in the solar wind can elucidate important aspects of the geoeffectivity of upstream turbulence and contribute to our understanding of space weather. In our investigation we concentrate on whether fluctuations play any role in geoeffective processes besides all well-defined geoeffective parameters and conditions studied earlier. We examined the multiscale evolution of higher-order statistical properties of probability distribution function in the solar wind plasma parameters, interplanetary magnetic field and magnetospheric fluctuations. We concentrated on the changes in the higher-order statistical properties, namely the 3rd (skewness, S) and 4th (kurtosis, K) orders. We worked with simultaneous data sets of the interplanetary magnetic field IMF GSM components B_z and SYM-H index, as a proper measure of the ring current intensity. Our results (Jankovičová et al., 2008a, 2008b; Bruno et al., 2008) indicate that

(i) The fluctuations of the solar wind cannot be always described as stationary random processes, because the fast and slow solar winds have different sources on the Sun. Therefore, different physical processes drive the fluctuations. From the point of view of consistent time series analysis and straightforward identifications of specific processes in the solar wind, quasi-stationary intervals must always be selected for statistical estimations.

(ii) The asymmetry of the probability density functions described in terms of the skewness does not seem to be important as a geoeffective parameter.

(iii) The increase of kurtosis (K; Fig. 3-3 Ab,d and Bb,d) towards small scales is representative in the interplanetary magnetic field B_z component and SYM-H index time series, and differs for quiet and more active periods. Thus, we can assume that the kurtosis estimated from solar wind magnetic fluctuations appears to be a representative geoeffective parameter, which can influence reconnection processes at the Earth's magnetopause and the efficiency of the solar wind – magnetosphere coupling.

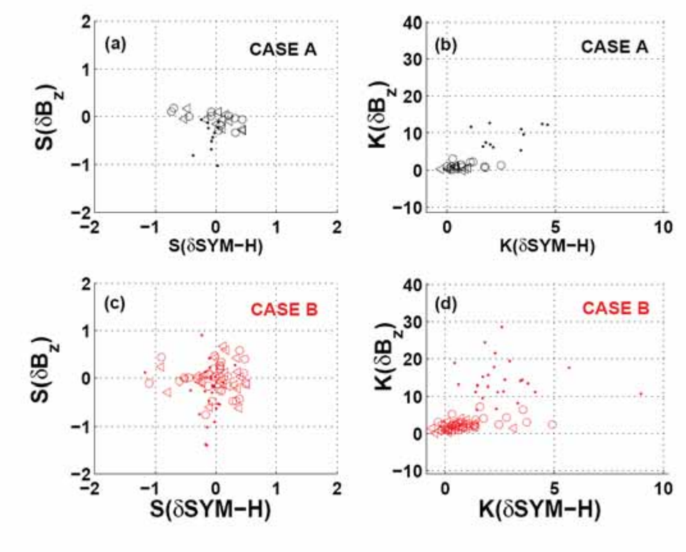


Fig. 3-3. (A-left plot) The time scale τ dependence of (a,c) S and K of the IMF B_z for time scales between τ ϵ <16s, 60min> in moving window W=45min for CASE A (black – quiet periods) and CASE B (red – active periods); (b,d) S and K of the magnetospheric SYM-H index. (B-right plot) Scatter plots of S of the magnetospheric SYM-H index vs S of IMF B_z for (a) CASE -quiet periods and (c) CASE B-active periods; and the scatter plots of K of the magnetospheric SYM-H index vs K of the IMF B_z for (b) CASE A and (d) CASE B for different time scales τ_1 =1min (•), τ_2 = 0min (o) and τ_3 = 20min (Δ) (Jankovičová et al., 2008a).

Waves in the inner magnetosphere and ionosphere

We investigated three different wave phenomena:

(1) Chorus emissions. We focused on the multipoint observations of chorus by CLUSTER spacecraft, and showed that a source location of individual chorus element can be estimated using a ray tracing technique if we observe the same chorus element on separated spacecraft (Breneman et al., 2007). We also found that frequency differences observed between corresponding elements on different spacecraft can be explained by oblique propagation of chorus waves (Chum et al., 2007).

(2) Lightning induced whistlers and their propagation in the ionosphere and magnetosphere. We showed that the whistler mode waves can penetrate the ionosphere up to ~1000 km away from the causative lightning. Using the plane wave analysis based on multi-component measurements by DEMETER (SANTOLÍK ET AL., 2008B) and 3D ray tracing technique, we studied the penetration and propagation of whistlers in the ionosphere. We proved that upgoing 0+ whistlers have vertical wave vectors in the F2 layer peak, which is consistent with the condition for free space to whistler mode conversion (SANTOLÍK ET AL., 2009).

We also investigated so-called subprotonospheric (SP) whistlers (Fig. 3-4). These are whistlers undergoing multiple reflections in a waveguide formed by a profile of the increasing lower hybrid resonance frequency in the upper ionosphere (~1000 km) and the lower boundary of the ionosphere. Using the ray tracing technique with initial conditions obtained by DEMETER measurements, we conclude that the individual components of the SP whistler propagate along different raypaths, often across magnetic meridian planes. The reflected components enter the ionosphere at relatively large distances from the magnetic satellite footprint and experience a spread of wave-normal angles during this entry. Depending on the initial wave-normal angle, these waves undergo a different number of reflections before reaching the satellite, thus arriving with different time delays (CHUM ET AL., 2009). The first component observed of a SP whistler is formed by waves entering the ionosphere at relatively small distances from the satellite footprint and at relatively small wave-normal angles. These waves do not reflect above the satellite but propagate to the opposite hemisphere.

(3) Observation of acoustic gravity and infrasonic waves in the ionosphere by means of continuous Doppler sounding. We focused on short-time phenomena (CHUM ET AL., 2008) that cannot be observed by ionosondes, on the comparison of Doppler sounding measurements with digisonde data (BUREŠOVÁ ET AL., 2007), analysis of ionospheric response to solar eclipse (JAKOWSKI ET AL., 2008), relationship between severe weather in the lower atmosphere and occurrence of infrasonic waves in the ionosphere, and on the ionospheric oscillation caused by geomagnetic pulsations.

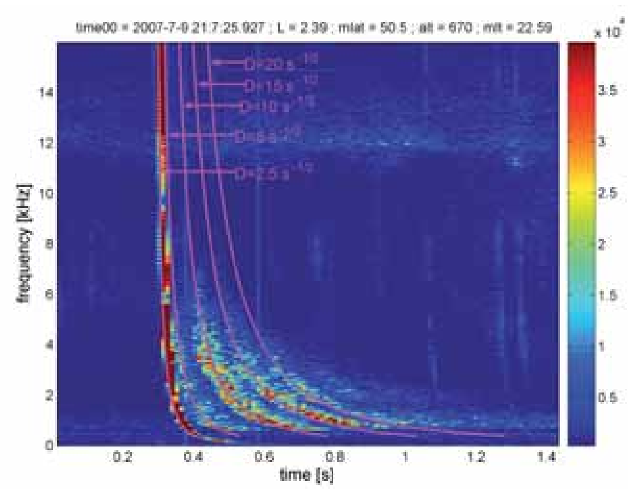
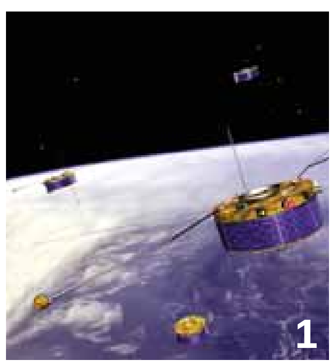


Fig. 3-4. A detailed amplitude spectrogram of the SP whistler analyzed and curves corresponding to the dispersions D = 2.5, 5, 10, 15, and 20 $s^{1/2}$.

Scientific instrumentation, micro-satellite systems

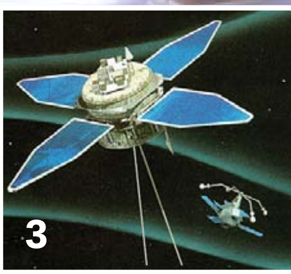
We finished development of the Thermal Plasma Measurement Unit (TPMU) for the ESA micro-satellite PROBA II (2). The goal of our PROBA II experiment is the study of the electrodynamics of the ionosphere and its application to ionosphere-magnetosphere interactions. The TPMU objectives are to provide a measure of the electron temperature, floating potential and the ion temperature, concentration and composition. The flight model of the instrument passed all specified tests and was intergrated to the satellite. The launch is expected in November 2009.

We kept regular sessions with the CLUSTER mission satellites (1). Data from WBD instrument were processed and sent to Iowa University. Reconstruction and upgrade of the telemetry station Panská Ves continued, and installation of the new 6.2m antenna system has started.



Cluster sattelites in constellation

TPMU box during testing in ESTEC 2



3 Pair satellite-subsatellite of Interball mission

4 Digital Sun sensor developed at IAP

5 Satellite Magion 1

We have continued with retrieving and archiving data from previous MAGION and INTERCOSMOS missions (3). All the analogue data, beginning from 1972, are continuously digitized and written to CD and DVD media.

Other activities:

Construction of flight model of ***digital sun sensors*** for Russian satellite project RADIOASTRON (launch planned for year 2009) (4)

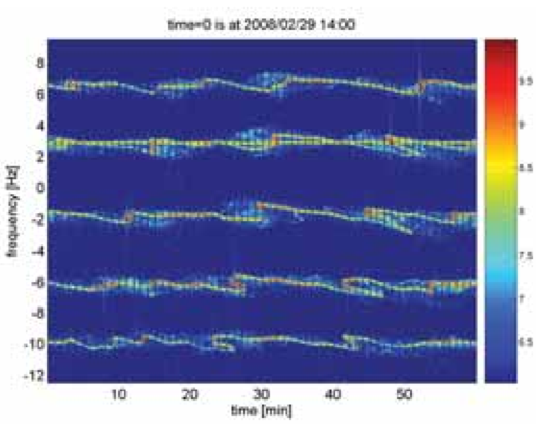
Manufacturing of ice-meters (the ice-meters are installed at several places in the Czech Republic and abroad)

Deployment of a ***Doppler type multipoint*** (5 points) measurement system, non-stop data acquiring and retrieving

Design of electronics for microbarograph sensor type ISGM03 and installation of 3 sensors on observatories, infrasound data acquiring and retrieving

Cooperation with the Seismic Dept. of the Institute of Geophysics AS CR during seismic events in October 2008 in West Bohemia; we provided complex measurements comprising infrasound measurement, ionospheric Doppler measurement, ULF (ultra low frequency) measurement and electric field measurement

The 30-year anniversary since the ***MAGION 1*** launch in October 1978 was celebrated by an exhibition in Planetarium Prague (5)



Multipoint spectrogram of S-shape effects recordet by Doppler sounding system

Observatory at Panská Ves

The Panská Ves ionospheric observatory and satellite telemetry station is situated 60 km north of Prague. It comprises

- **telemetry and telecommand station** for reception of radio signals from satellites in VHF, UHF, SHF and X band including primary data processing;
- **ionospheric observatory** monitoring Sudden Ionospheric Disturbances (a) using the ionospheric radio absorption A3-method, (b) measuring the atmospheric noise level and the phase anomalies in the LF band;
- **technical support of scientific projects** (e.g. seismological measurements, Doppler measurements, environmental measurements).

Ten-metre antena for S-band operation at Panska Ves observatory

Additional references (all other references are included in the list at the end of the report):

Bruno, R., Carbone, V., **Vörös, Z.**, D'Amicis, R., Bavassano, B., Cattaneo, M.B., Mura, A., Milillo, A., Orsini, S., Veltri, P., Sorrisso-Valvo, L., Zhang, T., Biernat, H., Rucker, H., Baumjohann, W., **Jankovičová, D.**, Kovács, P. (2008) Coordinated study on solar wind turbulence during the Venus-Express, ACE and Ulysses Alignment of August 2007. Earth, Moon and Planets, DOI: 10.1007/s11038-008-9272-9.

Chum, J., **Santolík, O.**, Parrot, M. (2009) Analysis of subprotonospheric whistlers observed by DEMETER: A case study. Journal of Geophysical Research, 114, A02307, DOI: 10.1029/2008JA013585.

Santolík, O., Parrot, M., Inan, U.S., **Burešová, D.**, Gurnett, D.A., **Chum, J.** (2009) Propagation of unducted whistlers from their source lightning: a case study. Journal of Geophysical Research, DOI: 10.1029/2008JA013776.

Research projects

International

Thermal Plasma Measurement Unit (TPMU). PI **V. Truhlík,** ESA/PECS contract funded by the Ministry of Education, Youth and Sports (2003–2008).

Discrete and noise-like ELF/VLF emissions in the Earth's magnetosphere. PI D. Nunn, Southampton University, UK, co-I **F. Jiříček**, INTAS project (2003–2007).

National

On the role of fluctuations in the solar wind-magnetosphere-outer ionosphere system. PI **D. Jankovičová**, funded by GA AS (2005–2007).

Solar wind events as predictors of geomagnetic response. PI Z. Němeček, Charles University, Prague; co-I **J. Šimůnek**; funded by GA CR (2006–2008).

Modelling of the cold plasma in the Earth upper atmosphere and magnetosphere. PI **V. Truhlík**, funded by GA AS (2006–2008).

Adjustment of the DSS sensors and its preparation for launch on board RADIOASTRON satellite. PI **J. Vojta**, funded by the Ministry of Education, Youth and Sports (2007–2008).

4. Department of Aeronomy

Web site: http://www.ufa.cas.cz/html/climaero/index_aero.html

The research activities of the department concern the ionosphere, particularly its response to space weather phenomena and to forcing by atmospheric waves, long-term global change in the ionosphere-upper atmosphere system, and stratospheric ozone. Measurements taken at the Průhonice observatory contribute to the research.

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Main research topics

Aeronomic investigations cover a very broad range of partly overlapping topics from the middle and upper atmosphere, and the lower and upper ionosphere. In 2007–2008, investigations were run predominantly in four basic directions: (i) effects of atmospheric waves in the ionosphere, (ii) impacts of space weather on the ionosphere-atmosphere system, including improvements of the International Reference Ionosphere (IRI) model, (iii) long-term trends in the ionosphere and atmosphere, including ozone, and (iv) ionospheric drifts.

Effects of atmospheric waves in the ionosphere

A method of the acoustic-gravity wave (AGW) detection has been further developed (Šauli et al, 2007b). The 2-D AGW detection toolbox is available on the webpage http://www.ufa.cas.cz/html/climaero/sauli.html, the 3-D toolbox developed for the GEO-6 project requires data of quality and spatial density/frequency provided by the coming Galileo GNSS constellation.

Height and critical frequency of sporadic E layer variations have been analysed over a wide period range of hours to several days, covering tidal and planetary oscillation domain. Besides periodicities in the tidal and planetary range that are known to occur within time series of critical frequencies (foEs) of sporadic-E layer, we evidence the existence of the 4-day planetary wave well developed in the height of sporadic E time series (hEs), as shown in Fig. 4-1. Central period of the diurnal tidal component of hEs is not exactly 24 h but varies between 22 and 26 h (Fig. 4-2) at the planetary wave period. Our interpretation is based on the perturbation of the height of the Es layer imposed by the planetary wave. In this mechanism the Es layer is moved up and down by the planetary wave producing a Doppler effect and resulting in a shift of the central period around 24 h. With this interpretation, the excursion of the central period is related to the vertical velocity perturbation of the Es layer due to the planetary wave. For a central period varying between 22 and 26 h, the perturbation velocities are 0.026 and -0.022 m/s, respectively (Šauli and Bourdillon, 2008).

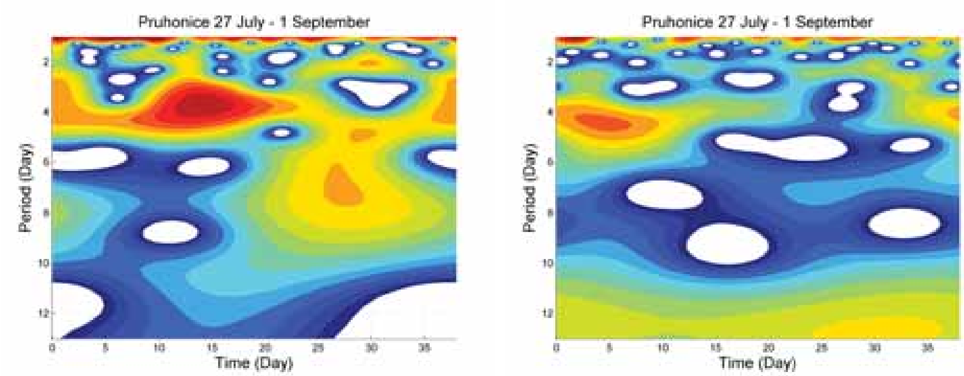

Fig. 4-1. Wavelet power spectrum of foEs (panel a) and hEs (panel b) display significant 4-day oscillations in the first half of the campaign.

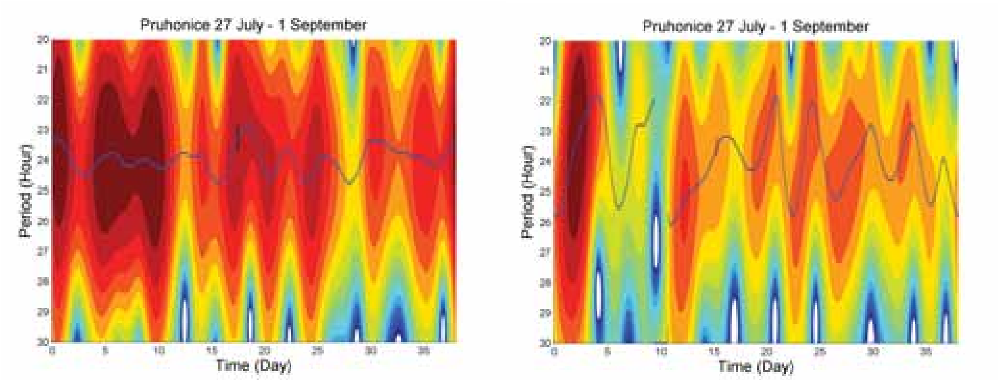

Fig. 4-2. Wavelet power spectrum of foEs (panel a) and hEs (panel b) with positions of maxima marked.

When waves of periods of about 1–5 min are observed simultaneously on all five measuring paths of the Czech Doppler system, they are caused by geomagnetic micropulsations as one of space weather phenomena (CHUM ET AL., 2008). If these waves are observed with an evident time shift in the network of the five measuring paths, they are caused by infrasound.

Infrasound of meteorological origin is not typically observed at ionospheric heights in the Czech Republic. Infrasonic waves occurred in few cases of exceptionally severe weather conditions in Central Europe (ŠINDELÁŘOVÁ ET AL., 2009). The results significantly differ from those obtained in the central part of the US, where observations of infrasonic waves were frequently reported, particularly during convective storms. However, that part of the US has different climatic conditions – environment suitable for the development of intense convective storms, which are an efficient tropospheric source of infrasonic waves.

The important impact of atmospheric waves on the lower ionosphere, together with the impact of space weather, has been summarized by LAŠTOVIČKA (2009).

Impacts of space weather on the ionosphere-atmosphere system

The extensive evaluation of the Storm-Time Ionospheric Correction Model (STORM) outputs has been performed for selected locations at Northern and Southern Hemisphere middle latitudes. The created database incorporated 65 strong-to-severe geomagnetic storms, which occurred in 1995–2006. Data from ionospheric stations (e.g., Průhonice, El Arenosillo) that were not included in the development or the former validations of the model were used for the validation purposes. Hourly values of the F2 layer critical frequency, foF2, measured for 5–7 days during the main and recovery phases of each selected storm, were compared with the predicted IRI 2007 foF2 with the STORM model option activated. To perform a detailed comparison between observed values, medians and predicted foF2 values the correlation coefficient, the root-mean-square error (RMSE), and the percentage improvement were calculated. Overall summary of the evaluation results of the STORM model storm-time corrections for Northern Hemisphere is presented in Fig. 4-3. The prime observation from the figure for NH is the decreasing ability of the model to simulate storm effects with decreasing latitude. An efficiency of the model corrections seems to be considerably lower for SH and decreases with increasing latitude, though we need here to involve more ionospheric stations in the analysis. An improvement of a recovery phase representation is significantly lower. As for seasonal dependence of the quality of the storm-time corrections (right panel of Fig. 4-3), the model gives best results for summer storms.

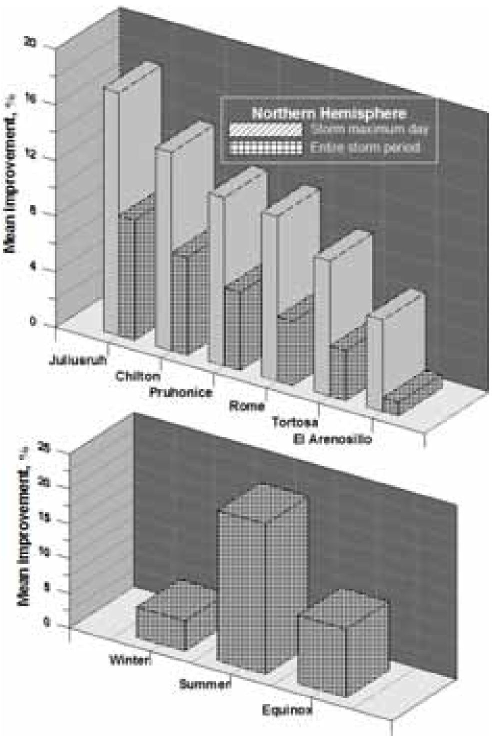

Fig. 4-3. Overall summary of the STORM model evaluation results for Northern Hemisphere. Left side panel represents the mean improvement calculated for all analysed storm culmination days (forward slashed bars) and for the entire stormy periods (crosshatched bars). Right side panel is for seasonal dependence of the quality of the model predictions.

The sufficiently strong (ΔfoF2 > 20%) pre-storm enhancements of electron density in the ionosphere have been further studied, mainly for the European region (Burešová and Laštovička, 2008). They occur before 20–25% of strong geomagnetic storms. They were observed both day and night, more often in summer than in winter half-year, they do not display a systematic dependence on latitude in Europe and are not accompanied by respective changes in hmF2. They have not been observed in the E and F1 regions; the pre-storm enhancements are confined to the F2 region. Comparison of European, Japanese and US measurements revealed a typical longitudinal size of this phenomenon to be 120–240°. We established several constraints for the mechanism of the pre-storm enhancements, several potential sources of the pre-storm enhancements were excluded, but their mechanism remains to be uncovered.

Long-term trends in the ionosphere and upper atmosphere

J. Laštovička chaired the IAGA/ICMA WG 'Long-Term Trends in the Mesosphere, Thermosphere and Ionosphere' and co-organized a couple of symposia/workshops to this topic including the 5th IAGA/ICMA/CAWSES Workshop 'Long-Term Changes and Trends in the Atmosphere', St. Petersburg, September 2008 (chairman of Program Committee).

The first global scenario of long-term changes and trends in the upper atmosphere-ionosphere system has been developed in more detail (Laštovička et al., 2008a). Mesospheric temperature, thermospheric density, electron density in the lower ionosphere and the E- and F1-region ionosphere, and ion temperatures in the upper F region behave at least qualitatively as expected from model simulations of the increasing greenhouse gas concentrations in the atmosphere. Three areas were identified where the trends have not been undoubtedly established; they are characterized by key words middle atmospheric dynamics, middle atmosphere water vapour, and the F2 region ionosphere. As for trends in foF2, Laštovička et al. (2008b) showed that neural network based methods provide essentially the same trend results as linear regression methods.

A review of current knowledge and understanding of long-term changes and trends in the upper atmosphere and ionosphere (Laštovička, 2009) showed that the role of increasing greenhouse gas concentrations is principal, but some other agents also play a significant role, namely stratospheric ozone depletion in the mesosphere, lower ionosphere and E-region ionosphere, long-term changes of geomagnetic activity and of the Earth's magnetic field in the upper thermosphere and F2 region ionosphere. Moreover, the role of individual agents is changing in time.

Ozone research

We contributed to an overview of ozone trend results in European area and over the Northern Hemisphere, based on project CANDIDOZ (HARRIS ET AL., 2008).

LAŠTOVIČKA AND KRIŽAN (2009) showed that strong geomagnetic storms and Forbush decreases of cosmic rays do not affect total ozone at higher middle latitudes of the Southern Hemisphere contrary to the Northern Hemisphere, where an effect is observed under specific conditions.

Variability of the ionospheric plasma drift

Our Digisonde DPS-4 can be used for sounding drifts in the E and F layers of the ionosphere (KOUBA ET AL., 2008). Digisonde records E and F drift measurement routinely every 15 minutes. For F region, sounding frequencies are variable and are set up automatically according to critical frequency foF2 obtained from preceding ionogram. For the E region we use fixed sounding frequency window between 2.0 and 2.6 MHz. During summer a special campaign of monitoring drifts in the Es layer was performed. Drift-measurement on a higher sounding-frequency window 3.2–4.7 MHz was run every 15 minutes in addition to the standard E-region drift measurement.

All components of the ionospheric F region drift velocity, measured during medium and strong geomagnetic events, are strongly disturbed by storm conditions. Observed horizontal drift velocity components reach 100–150 m/s during medium storms and 250-350 m/s during strong storms. Vertical drift velocity component reach 60–75 m/s during medium storms and ~100 m/s during strong storms (with Dst between -100 and -300). Variations in the E and F region drift velocity components are caused by large number of factors like gravity waves, particle events, TIDs etc.

In the daytime interval there is a chance to observe drift height dependence in the E region when the sporadic E layer occurs. It is possible to study drifts in Es and rest of the E layer independently under the situation when there are measurements in a lower frequency window realized below foE and simultaneously there are reflections from Es layer registered in the higher frequency window. Our results show differences of the plasma motion in the Es layer and the rest of the E region, as illustrated by Fig. 4-4.

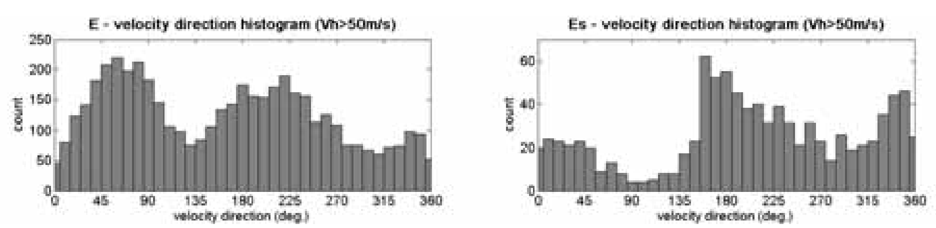

Fig. 4-4. Velocity direction histograms for (a) E region drift measurements, (b) drift measurements in Es layer. In both cases only measurements where velocity exceeds 50 m/s are presented.

Observatory Průhonice, development of observational methods, and ionospheric service

Two types of measurements have been made at the observatory (49°59'N, 14°33'E):

1. Ionospheric vertical sounding by the digisonde DPS-4. Routine repetition (15 min) soundings and a few campaigns of more frequent measurements. The evaluation software of the digisonde has been updated.
2. Ionospheric plasma drift measurements by the digisonde, performed in two different modes: F region autodrift mode and E region mode (at height interval 90–150 km).

In collaboration with the Dept. of the Upper Atmosphere we run an ionospheric Doppler system consisting of five well separated transmitters over the western part of Bohemia and two receivers, completed by three ground-based microbarographs with the main goal to detect infrasonic and gravity waves.

We run the Regional Warning Center Prague (head: D. Burešová) of the International Solar and Environmental Service. Our users are supplied with near-real time ionospheric observations. Ionograms and results of their automatic scaling are transferred in real time to European ionospheric server DIAS since late 2005. Automatically scaled data are also transferred to the international data exchange servers and the world data centers. Manually scaled data are archived and supplied on request. Monthly ionospheric predictions have regularly been issued and distributed.

Additional references (all other references are included in the list at the end of the report):

Laštovička, J. (2009) Lower ionosphere response to external forcing: A brief review. Advances in Space Research, 43, 1–14.

Laštovička, J., **Križan, P.** (2009) Impact of strong geomagnetic storms on total ozone at southern higher middle latitudes. Studia geophysica et geodaetica, 53, 151–156.

Šindelářová, T., **Burešová, D.**, **Chum, J.**, **Hruška, F.** (2009) Doppler observations of infrasonic waves of meteorological origin at ionospheric heights. Advances in Space Research 43,1944–1651.

Research Projects

International

ALOMAR – enhanced Approach to Research Infrastructure (ALOMAR-eARI). PI M.Gaussa, ALOMAR, Norway; Czech participant **P. Križan**; the 6th Framework Programme of the EU (2005–2008).

Galileo for Scientific User Community (GEO-6). PI M.-J. Sedo, AtosOrigin, Barcelona, Spain, 6 other participating institutions; co-I **J. Laštovička**; funded by the 6th Framework Programme of the EU (2006–2008).

Lapland Atmosphere-Biosphere Facility (LAPBIAT-2) – approach to European research facilities. PI T. Turunen, Sodankylä Geophysical Observatory, Finland; Czech participants: **J. Laštovička**, **Z. Mošna**; funded by the 7th Framework Programme of the EU (2007–2009).

COST 724 (Developing the Scientific Basis for Monitoring, Modelling and Predicting Space Weather). Chair J. Lilensten, University of Grenoble, Grenoble, France, 46 more institutions from 26 countries participating; co-I **J. Laštovička** (2005–2007).

COST 296 (Mitigation of Ionospheric Effects on Radio Systems). Chair A. Bourdillon, University of Rennes, Rennes, France, 33 other institutions from 22 countries participating; co-I **J. Laštovička** (2006–2009).

COST ES 0803 (Developing Space Weather Products and Services in Europe). Chair A. Belehaki, National Observatory of Athens, Athens, Greece; 27 institutions from 18 countries; co-I **J. Laštovička** (2008–2012).

Changes of long-term trends in the dynamics of the upper atmosphere. PIs **J. Laštovička**, and Ch. Jacobi, Institute for Meteorology, University of Leipzig; joint project funded by Deutsche Forschungsgemeinschaft (DFG) and GA CR (2007–2010).

Ionospheric modelling for the purpose of HF communication prediction. PI **D. Burešová**, National Research Foundation (NRF) Key International Science Capacity (KISC) Initiative, South Africa (2007–2010).

National

Development of methods for space weather forecasts and impacts of space weather on the ionosphere atmosphere system. PI P. Hejda, Institute of Geophysics AS CR, co-I **D. Burešová**; funded by AS CR (2005–2009).

Dynamic structures in the ionosphere. PI **J. Boška**; funded by GA AS (2005–2007).

Wave processes, structures and scaling phenomena within the ionospheric plasma. PI **P. Šauli**; funded by GA CR (2006–2008).

Infrasonic waves in the iononosphere and thermosphere. PI **J. Laštovička**; funded by GA CR (2007–2011).

Sporadic E layer variability. PI **P. Šauli**; funded by GA AS (2007–2011).

Patterns of the ionospheric lower F region variability over European middle latitudes. PI **D. Burešová**, funded by GA CR (2008–2010).

Contracts

Ionospheric predictions and information. The Ministry of Defence; person in charge **J. Laštovička** (terminated 2007/4).

5. Department of Climatology

Web site: http://www.ufa.cas.cz/html/climaero/

Research of the department covers three basic areas: **climate change**, including its detection, assessment of future climate development, and impacts; recent **climate variability**; and **statistical climatology**, that is, development and implementation of statistical methods in climate research.

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Main research topics

Climate change

Long-term **changes in persistence of atmospheric circulation** were examined for a large number of classifications of daily circulation patterns, both objective and subjective, collected within the COST 733 action. Long-term changes in the lifetime of circulation types are mostly insignificant, the numbers of types with positive and negative trends are approximately the same for most classifications. One of the few exceptions is the subjective catalogue of Hess and Brezowsky, in which the lifetime gets abruptly longer in the mid-1980s (Fig. 5-1). This feature of the Hess-Brezowsky catalogue, discussed recently in several papers, thus appears to be an artifact of the catalogue, likely resulting from its subjective nature (Cahynová and Huth, 2009a).

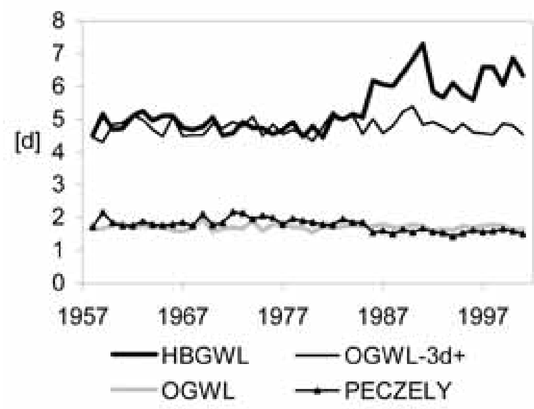


Fig. 5-1. Changes in the mean annual persistence (residence time) over all circulation types in selected subjective and objective circulation classifications. HBGWL – German subjective Hess-Brezowsky catalogue, PECZELY – Hungarian subjective catalogue, OGWL – 'objectivized' Hess-Brezowsky, OGWL-3d+ – 'objectivized' Hess-Brezowsky with a constraint of at least 3-day duration of synoptic situations. Years start in December in order to encompass the whole winter season.

The influence of long-term circulation changes on trends in surface climate elements was examined using multiple catalogues of circulation types for 11 climate elements in the Czech Republic. Two independent methods revealed that the circulation changes affect surface climatic trends in a considerable manner only for temperature in winter and autumn when the observed temperature trends can be explained by circulation changes from 20 % in autumn and 30–50 % in winter. Trends in other seasons and in other climate elements (e.g., precipitation, cloudiness, sunshine duration, wind components) are thus caused by changing climatic properties of individual circulation types (Cahynová and Huth, 2009b).

Relative drought indices (Standardized Precipitation Index [SPI], Palmer Drought Severity Index [PDSI]) were used to assess the **present and future drought conditions** in the Czech Republic (Dubrovský et al., 2009; Trnka et al., 2009). In the climate-change impact experiments, the future climate at 45 Czech stations is represented by modifying the station specific observed series according to climate change scenarios based on 5 Global Climate Models from the IPCC-TAR database. Changes in the SPI-based drought risk closely follow the modelled changes in precipitation, which is predicted to decrease in summer and increase in both winter and spring. Changes in the PDSI (which is considered to be superior to SPI in climate change impact studies as it accounts for the effects of both temperature and precipitation) indicate an increased drought risk at all stations under all climate-change scenarios (Fig. 5-2).

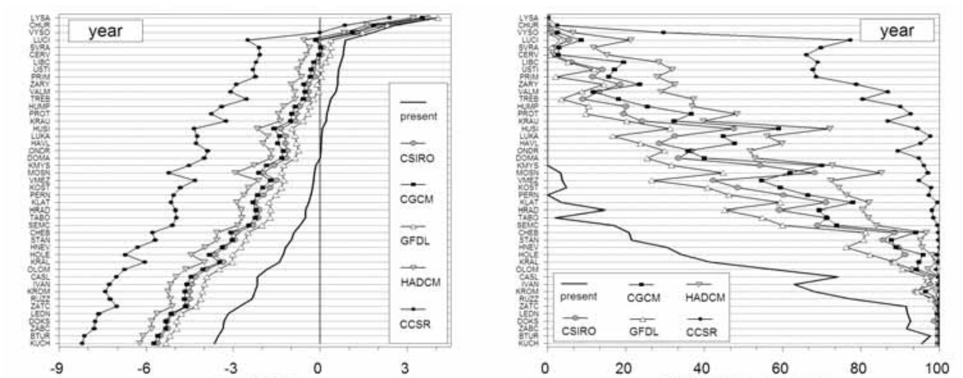
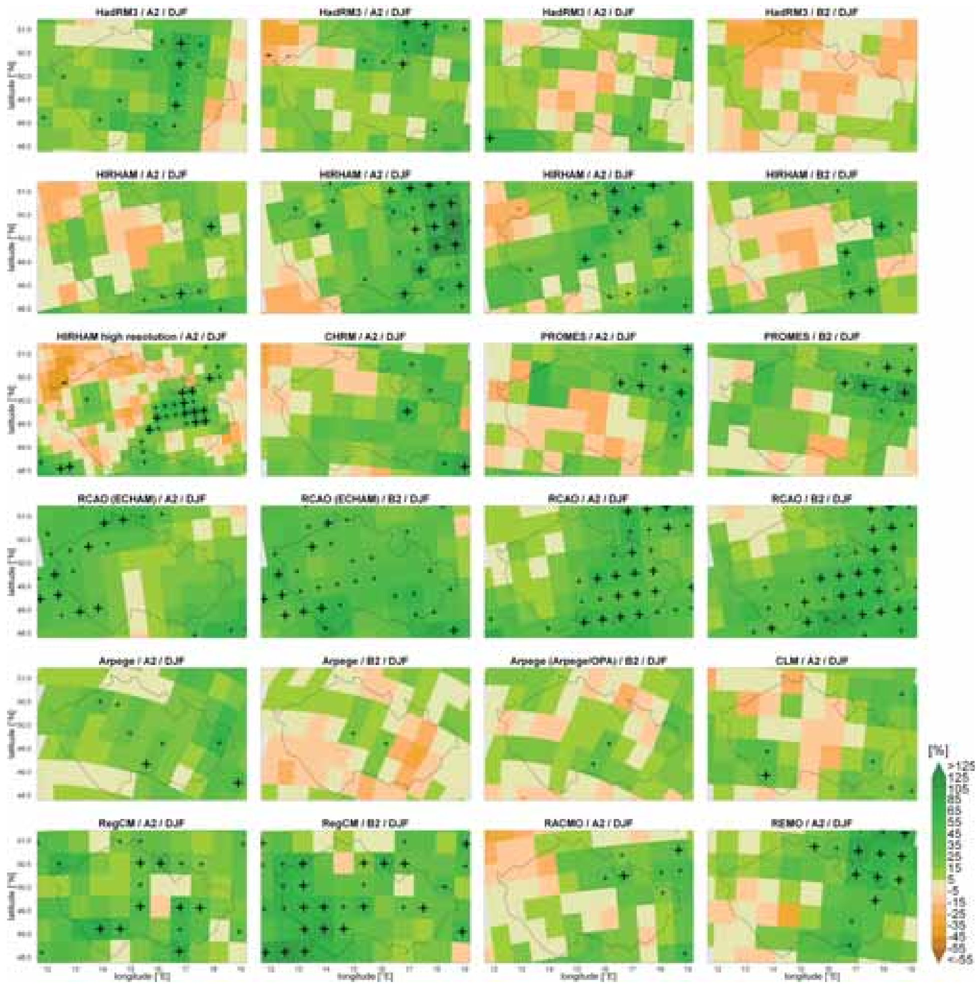


Fig. 5-2. Relative PDSI (Palmer drought severity index calibrated with weather data pooled from 45 Czech stations and the 1961–2000 period) in the present and future climates. The future climate projection is based on 5 GCMs (CSIRO-Mk2, CGCM2, GFDL-R30, HadCM3, CCSR/NIES) and relates to 2060–99 period assuming SRES-A2 emission scenario. The left panel shows the spectrum of drought conditions in the set of 45 stations in terms of average values of rPDSI (the negative values of PDSI indicate drier conditions than the present-climate all-station average). The right panel shows a percentage of rPDSI-based drought months in the 40-year series (Dubrovský et al., 2009).

Scenarios of **changes in extreme precipitation** were examined in 24 future climate runs of 10 regional climate models, focusing on the area of the Czech Republic (KYSELÝ AND BERANOVÁ, 2009). The peaks-over-threshold analysis with increasing threshold censoring was applied to estimate multi-year return levels of daily rainfall amounts. The results showed that heavy precipitation events are likely to increase in severity in winter (Fig. 5-3) and (with less agreement among models) also in summer. The inter-model and intra-model variability and related uncertainties in the pattern and magnitude of the change are large, but the scenarios tend to agree with precipitation trends recently observed in the area, which may strengthen their credibility. In most scenario runs, the projected change in extreme precipitation in summer is of the opposite sign than a change in mean seasonal totals, the latter pointing towards generally drier conditions. A combination of enhanced heavy precipitation amounts and reduced water infiltration capabilities of a dry soil may severely increase peak river discharges and flood-related risks.

Fig. 5-3. Relative changes (in %) of 50-yr return values of daily precipitation amounts between the late 21st century scenarios and control climate (1961–1990) in winter (DJF) in 10 regional climate models. A2/B2 denotes the SRES emission scenarios; a driving global model is given in the heading of panels if different from the HadAM/HadCM model. Larger (smaller) crosses indicate gridboxes in which the estimated 90 % (80 %) confidence intervals of the 50-yr return values do not overlap, i.e. the change is statistically significant approximately at the 0.01 (0.07) level.



Climate variability

Possible **influence of solar/geomagnetic activity on climate variability** has been a subject of many recent studies, due to a substantial increase of solar/geomagnetic activity during the last century. There is no generally accepted mechanism for tropospheric responses to the variability in solar/geomagnetic activity up to now. Long-term records of the near surface air temperature from several midlatitude European locations, the North Atlantic Oscillation (NAO) index, as well as the geomagnetic activity aa-index and the sunspot numbers have been analyzed to detect possible common oscillatory modes. The statistically significant oscillatory modes with a period of approximately 8 years have been detected in the geomagnetic activity index as well as in the NAO index and surface air temperature records. The existence of the common oscillatory mode gives us a solid basis for further research of relations between the geomagnetic activity and climate variability (Paluš and Novotná, 2007).

The research into **solar effects on tropospheric circulation** has been extended to the effects of the 11-year solar cycle on the frequency, duration, and position of blocking highs; the frequency of synoptic types; and the Arctic Oscillation. Statistically significant differences between solar maxima and minima appear for all the circulation characteristics. The general effect is that under high solar activity, the circulation tends to zonalize. High solar activity is also accompanied by a larger geographical extent of blocks and more positive and more variable Arctic Oscillation. One of the most striking solar effects is the different frequency of westerly and easterly Hess-Brezowsky synoptic types: whereas under low solar activity, the westerly types are about twice as frequent as the easterly types, under high solar activity the westerly types occur four times more frequently than the easterly ones (Huth et al., 2007, 2008c; Barriopedro et al., 2008).

In research on **modes of atmospheric circulation variability**, we contributed to a hot scientific debate on whether Arctic Oscillation (AO) or North Atlantic Oscillation (NAO) should be considered as the leading mode of the low-frequency variability in the Northern Hemisphere, that is, whether the hemispheric or sectorial view of the variability should be preferred. We used mainly statistical arguments and demonstrated that the AO is likely a statistical artifact and that its Pacific centre is a result of a high local variability rather than of its relationships with the Arctic and Atlantic centres; therefore, we suggest that it is the NAO that should be viewed as the primary mode of variability (Huth, 2007). We also examined, in terms of correlation coefficients, the effects the variability modes have on surface climate elements (including temperature, cloudiness, sunshine duration, wind components, and precipitation amount and probability) in the Czech Republic and on temperature and precipitation over Europe. We took into account the major modes in the Euro-Atlantic sector, viz., the NAO, the East Atlantic mode, and two Eurasian modes (Pokorná et al., 2007). The correlations between the circulation variability modes and surface climate elements vary considerably in time; a major contributor to the variations are geographical shifts in the action centres of the modes (Beranová and Huth, 2007, 2008; Pokorná et al., 2007).

Relationships between **persistent circulation patterns and surface air temperature anomalies** were studied over the 20th century using the Hess-Brezowsky catalogue of circulation types and long-term temperature series over the European continent. Types significantly conducive to heat and cold waves were identified, and temperature anomalies were linked to their persistence. More persistent circulation tends to enhance the severity of both warm and cold temperature extremes; the effects depend on the circulation type and the roles of radiative/advective mechanisms of local temperature changes (Kyselý, 2007, 2008b).

Statistical climatology

Estimates of **confidence intervals in extreme value models by parametric and nonparametric bootstrap** were compared in terms of simulation experiments, with several combinations of 'true' and fitted probability distributions. For small to moderate sample sizes ($n \leq 60$), the nonparametric bootstrap (i.e. *resampling with replacement* from the given sample and calculating the required statistic from a large number of repeated samples) should be interpreted with caution since it leads to confidence intervals that are too narrow and underestimate the real uncertainties involved in frequency models. Although the parametric bootstrap (based on *randomly generated samples from a parametric model* fitted to the data) yields confidence intervals that are slightly too liberal as well, it improves uncertainty estimates in most examined cases, even under conditions when an incorrect parametric model is adopted for the data. We recommend that the parametric bootstrap should be preferred whenever inferences are based on small to moderate sample sizes and a suitable model for the data is known or can be assumed, including applications to confidence intervals related to extremes in global and regional climate model projections (Kyselý, 2008a).

Regional frequency analysis was applied to improve estimates of probabilities **of extreme precipitation** in the Czech Republic. The delimitation of homogeneous regions was based on cluster analysis of site characteristics and subsequent tests for regional homogeneity; however, the regions reflect also synoptic patterns causing heavy precipitation. The regional approach lessens the between-site variation of estimates of the shape parameter of the distribution of extremes compared to at-site procedures, and estimates of high quantiles (e.g. 50-yr return values) are more reliable and climatologically consistent. Noteworthy is the heavy tail of distributions of multi-day events, reflected also in the inapplicability of the L-moment estimators for the general 4-parameter kappa distribution utilized in Monte Carlo simulations in regional homogeneity and goodness-of-fit tests. We overcome this issue by using the maximum likelihood estimation (Kyselý and Picek, 2007a, 2007b).

Methods of **nonlinear time series analysis** were used to **detect oscillations hidden in the noise**. Time series of climatic, geomagnetic, and solar data were analysed using the extension of Monte Carlo Singular System Analysis (MCSSA). The so-called enhanced MCSSA is based on evaluating and testing regularity of dynamics of the SSA modes against the coloured noise null hypothesis. Several statistically significant oscillatory modes with the period in the range from 2 to 11 years were detected in the tested time series (Paluš and Novotná, 2008).

In **statistical downscaling**, which consists in identifying statistical relationships between large-scale upper-air variables with the local surface ones, and applying them to coarse-scale outputs from GCMs, we proceeded by comparing the performance of two families of downscaling methods, the linear and nonlinear ones, for daily temperature. The linear methods include multiple linear regression and canonical correlation analysis, the nonlinear approaches include neural networks and linear models conditioned by a stratification by circulation types. The linear methods, and multiple regression in particular, perform better in most aspects, including the variance explained, and temporal and spatial structure of the downscaled series. On the other hand, neural networks are better at reproducing the properties of statistical distributions (Huth et al., 2008b).

In the examination of **classifications of circulation patterns**, we contributed to the inventory of classifications and their applications that have been available in Europe. For two subjective catalogues of circulation types, Brádka's and Hess-Brezowsky, which have been widely used in both synoptic and climatological studies in the Czech Republic, we studied their possible inhomogeneities. Both catalogues suffer from unrealistic changes in the lifetime of the types, resulting in a sharp shortening of events in Brádka's catalogue in the mid-1970s and a lengthening of events in the mid-1980s for Hess-Brezowsky. In the Hess-Brezowsky catalogue, changes of types are signifantly more frequent at the edge of months and years than elsewhere, which is also apparently an undesirable and unrealistic feature. This suggests that these two catalogues must be used in climate change studies very carefully (Huth et al., 2008a; Cahynová and Huth, 2007a, 2007b).

Additional references (all other references are included in the list at the end of the report):

Cahynová, M., Huth, R. (2009a) Enhanced lifetime of atmospheric circulation types over Europe: fact or fiction? Tellus, 61A, 407–416.

Cahynová, M., Huth, R. (2009b) Changes of atmospheric circulation in central Europe and their influence on climatic trends in the Czech Republic. Theoretical and Applied Climatology, 96, 57–68.

Dubrovský, M., Svoboda, M.D., Trnka, M., Hayes, M.J., Wilhite, D.A., Žalud, Z., Hlavinka, P. (2009) Application of relative drought indices in assessing climate change impacts on drought conditions in Czechia. Theoretical and Applied Climatology, 96, 155–171.

Kyselý, J., **Beranová, R.** (2009) Climate change effects on extreme precipitation in central Europe: uncertainties of scenarios based on regional climate models. Theoretical and Applied Climatology, 95, 361–374.

Trnka, M., **Dubrovský, M.**, Svoboda, M.D., Semerádová, D, Hayes, M.J., Žalud, Z., Wilhite, D.A. (2009) Developing a regional drought climatology for the Czech Republic for 1961–2000. International Journal of Climatology, DOI: 10.1002/joc.1745.

Research projects

International

ENSEMBLE-based predictions of climate change and its impacts (ENSEMBLES). PI J. Mitchell, Meteorological Office, Exeter, UK; 70 cooperating institutions, co-I **R. Huth**; integrated project funded by the 6th Framework Programme of the EU (2004–2009).

Central and Eastern Europe Climate Change Impacts and Vulnerability Assessment (CECILIA). PI T. Halenka, Charles University, Prague, Czech Republic; 17 cooperating institutions, co-I **R. Huth**; specific targeted research project (STREP) funded by the 6th Framework Programme of the EU (2006–2009).

COST 733 (Harmonization and Applications of Weather Types Classifications for European Regions). Chair O. E. Tveito, Meteorological Institute, Oslo, Norway; 23 participating countries, co-I **R. Huth**; Czech participation funded by Ministry of Education, Youth and Sports (2005–2010).

Meteorological causes and human mortality impacts of extreme hot weather in summer: a comparative study. Bilateral project funded by GA CR and Korea Research Foundation; PIs **J. Kyselý**, and J. Kim, Korea Meteorological Administration, Seoul (2007–2009).

National

Solar and geomagnetic effects on the Northern Hemisphere tropospheric circulation. PI **R. Huth**; co-Is J. Bochníček, Institute of Geophysics AS CR, and M.Paluš, Institute of Computer Science AS CR; funded by GA AS (2004–2007).

Are persistence and time-scales of atmospheric circulation in European mid-latitudes changing? PI **R. Huth**; funded by GA AS (2005–2008).

Atmospheric teleconnections over the Euro-atlantic sector. PI **R. Huth**, co-Is L. Metelka, Czech Hydrometeorological Institute, Hradec Králové, and T. Halenka, Charles University, Prague; funded by GA CR (2005–2007).

Calibration of weather generator for sites without or with incomplete meteorological observations. PI **M. Dubrovský**; co-Is M. Trnka, Mendel University of Agriculture and Forestry, Brno, L. Metelka, Czech Hydrometeorological Institute, Hradec Králové, and M. Růžička, Institute of Hydrodynamics, Prague; funded by GA CR (2005–2007).

Impact of climate change on potential incidence of selected pathogens and pests. PI Z. Žalud, Mendel University of Agriculture and Forestry, Brno; co-I **M. Dubrovský**; funded by GA CR (2005–2007).

Extreme value models with time dependent parameters and their application in climate change studies. PI **J. Kyselý**, co-I J. Picek, Technical University, Liberec; funded by GA CR (2006–2008).

Frequency analysis of precipitation extremes by the region-of-influence approach and non-stationary extreme value distributions. PI **J. Kyselý**, co-Is L. Gaál, Czech Hydrometeorological Institute, Prague, and J. Picek, Technical University, Liberec; funded by GA AS (2006–2008).

Climate change impacts on the crop growth and development of selected crops. PI Z. Žalud, Mendel University of Agriculture and Forestry, Brno; co-Is **M. Dubrovský**, and M. Možný, Czech Hydrometeorological Institute, Prague; funded by the National Agency for Agricultural Research (2006–2009).

Growth rhythms, sclerochronology, Earth rotation, and weather in Devonian. PI A. Galle, Institute of Geology, Prague; co-Is C. Ron, Institute of Astronomy, Prague, **D. Novotná**, and L. Strnad, Faculty of Science, Charles University, Prague; funded by GA AS (2007–2010).

Effects of short-term and long-term variability of weather on mortality. PI **J. Kyselý**, co-I B. Kříž, National Institute of Public Health, Prague; funded by GA CR (2007–2010).

Probabilistic climate scenarios for the Czech Republic. PI **M. Dubrovský**; co-I L. Metelka, Czech Hydrometeorological Institute; funded by GA AS (2008–2011).

Effect of climate variability and meteorological extremes on the production of selected crops between 1801 and 2007. PI M. Trnka, Mendel University of Agriculture and Forestry, Brno; co-Is R. Brázdil, Masaryk University, Brno, **M. Dubrovský**, and M. Možný, Czech Hydrometeorological Institute; funded by GA CR (2008–2010).

Regional and grid-box extreme value models in high-resolution climate model outputs. PI **J. Kyselý**, funded by GA AS (2008–2010).

Extraterrestrial effects on atmospheric circulation in mid and high latitudes. PI **R. Huth**; co-Is J. Bochníček, Institute of Geophysics, Prague, and M. Paluš, Institute of Computer Science, Prague; funded by GA AS (2008–2011).

Impact-targeted validation of statistical and dynamical downscaling models. PI **R. Huth**; co-Is J. Mikšovský, Charles University, Prague, and P. Štěpánek, Czech Hydrometeorological Institute, Brno; funded by GA CR (2008–2010).

6. Department of Meteorology

Web site: http://www.ufa.cas.cz/html/meteo/

The research activities involve mesoscale meteorology (with focus on quantitative forecasting of convective precipitation), boundary layer meteorology (fog and turbulence research), hydrometeorology (heavy precipitation events and their relationship to synoptic-scale anomalies), and applied meteorology (effects of meteorological conditions on microwave propagation). Meteorological measurements at the Milešovka and Kopisty observatories contribute to our research.

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Main research topics

Mesoscale meteorology

a. Convective precipitation forecasting by a numerical weather prediction (NWP) model

Local flash flood storms with a rapid hydrological response are difficult to forecast and investigations in this topic have been carried out throughout the world. We used the COSMO (Local Model of the Consortium on Small-scale Modelling) NWP model with a horizontal resolution of 2.8 km and focused on assimilation of radar reflectivity and satellite data into the model. We used radar data from the Czech radar network and satellite measurements (radiances) from Meteosat Second Generation (MSG). We developed a new assimilation method based on the water vapour correction (WVC) of the model mixing ratio (SOKOL AND ŘEZÁČOVÁ, 2009). This method can use either radar reflectivity data or combination of both radar reflectivity and satellite data. The assimilation of satellite data utilizes two channels (10.8 and 6.2 μm) in order to find precipitating clouds, and rain rates are assigned to observed clouds (SOKOL, 2009; SOKOL AND PEŠICE, 2009). Two types of corrections were examined with respect to locations at which the correction was applied. The first approach performed the correction at the same grid point where the difference was calculated. The second one, which is a new approach, applied the correction at a grid point advected upwind from the point where the difference was calculated.

The results showed that the WVC assimilation method applied to radar reflectivity data is a good alternative to the latent heat nudging method, which is the standard option of the COSMO model. Futhermore, the results showed that the assimilation of radar information or combined radar and MSG data significantly improves precipitation forecasts for at least three forecast hours. Despite uncertainties in the relationship between MSG data and precipitation, the assimilation method that combines radar and MSG data showed comparable or better precipitation forecasts than the one in which only radar reflectivity was used. The advantage of the approach transforming MSG measurements into precipitation is that the same assimilation technique can be applied to both radar reflectivity and satellite data. Both assimilation methods apparently improved the original non-assimilation forecast, and the results show that the COSMO model is able to simulate storms if they are triggered by assimilated data (Fig. 6-1).

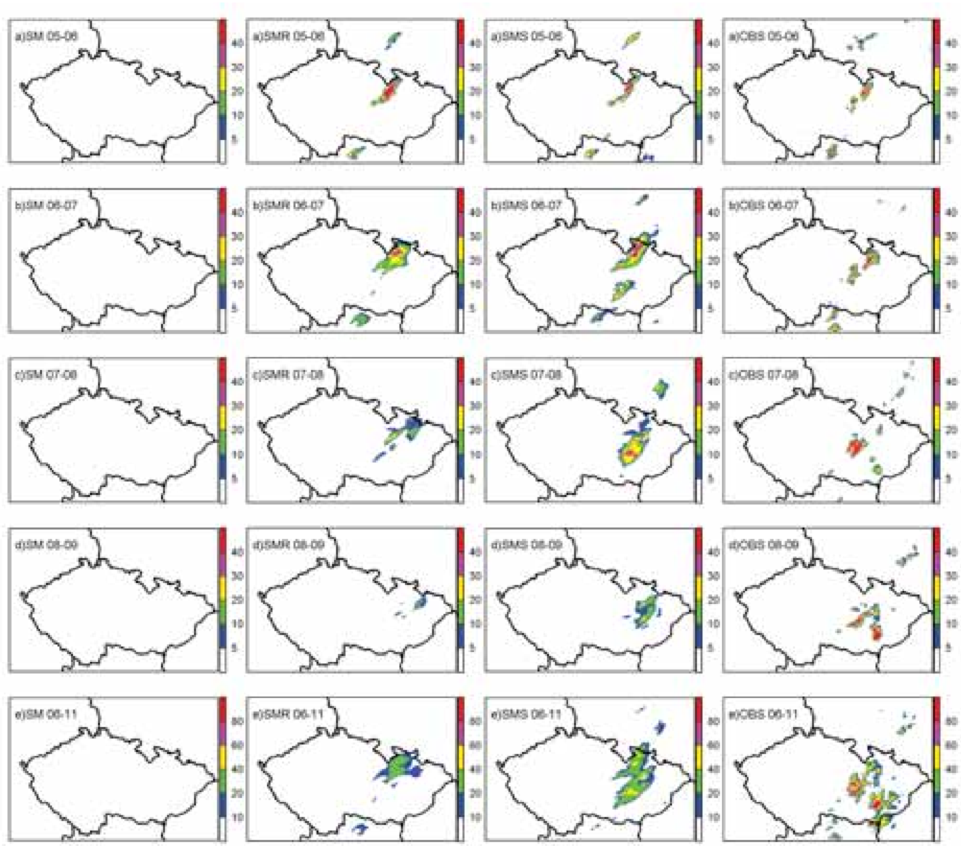


Fig. 6-1. Precipitation forecasts on 26 June 2006 by the COSMO model (i) without assimilation (SM), (ii) with the assimilation of radar reflectivity (SMR), (iii) with the assimilation of combined radar reflectivity and satellite data (SMS), and (iv) observed precipitation derived from radar and gauge data (OBS).

b. Convective precipitation forecasting, estimation of QPF uncertainty

Current operational NWP models are capable of generating high-resolution prognostic precipitation fields with a mesh size on the order of 100 km. In principle, NWP models have achieved a stage at which quantitative precipitation forecast (QPF) is a useful tool in hydro-meteorological forecasting and/or warning if we can determine a suitable QPF form (target area size, precipitation threshold or interval, etc.) and estimate a forecast uncertainty. In order to find a suitable QPF form, it is necessary to verify prognostic fields of precipitation-related variables. When assessing forecast uncertainty, it is useful to employ an ensemble approach.

In ensemble forecast regime, we analyzed several events with heavy convective precipitation in the Czech Republic (Fig. 6-2). We used the NWP model COSMO to obtain a high resolution very short-range forecast of summer convective precipitation with a horizontal resolution of 2.8 km. Large variability of both forecast and observed convective precipitation is a major difficulty in assessing the QPF performance. At present, a quantitative precipitation estimate (QPE) obtained by merging radar-based precipitation with gauge information enabled us to acquire reliable verification-related values (Zacharov and Řezáčová, 2008). We created an ensemble of 13 forecasts by modifying initial and boundary conditions. Uncertainty in the area-related QPF was evaluated with the help of Fractions Skill Score (FSS) that was used to quantify the ensemble spread and skill. The FSS-spread represents the differences between the control forecast and the forecasts provided by ensemble members, and the FSS-skill evaluates the difference between the precipitation forecast and radar-based rainfall. Ensemble skill and ensemble spread were computed as the mean values over the ensemble members. The analyses show how the forecast lead time and spatial scale influence the spread and skill values. The results show a positive scale influence on the spread and skill in general. The increase in elementary area causes a decrease in the ensemble spread and an increase in the forecast skill. The scale effect is event dependent. Given the elementary area size, we can obtain different spread and skill values for different events. This means that there is not a fixed scale that can give a threshold FSS value. As expected, the increasing precipitation threshold deteriorates the forecast spread and skill. Moreover, the spread-skill relationship changes with integration time (Fig. 6-3).

Despite the different areal structures of precipitation fields, the relationships between spread and skill appear to be similar. The corresponding mean curves tend to be positioned in a belt in the skill and spread coordinates, which is encouraging for the effort to find a suitable projection of spread into skill. The results are summarized in Řezáčová et al. (2009).

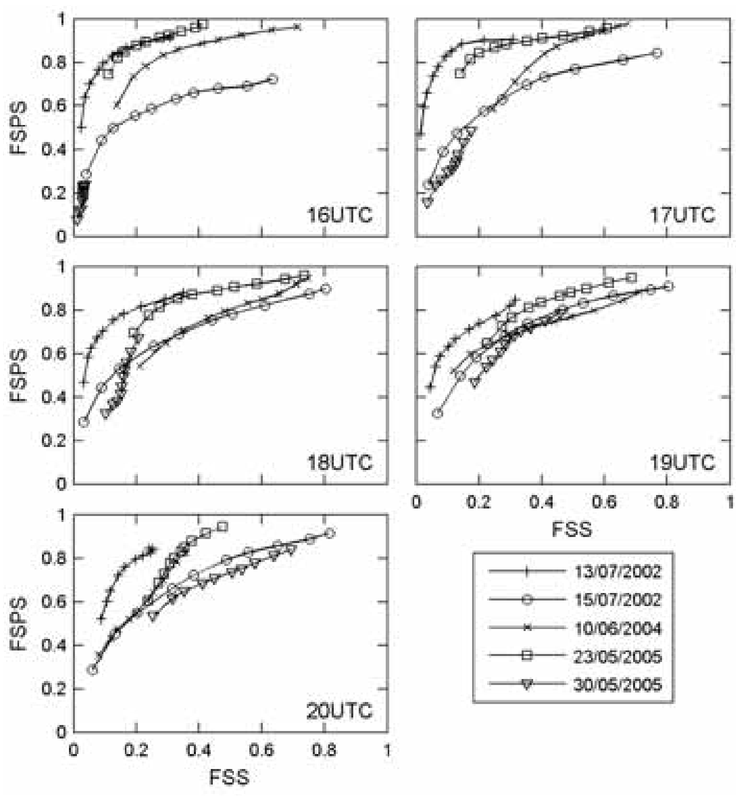
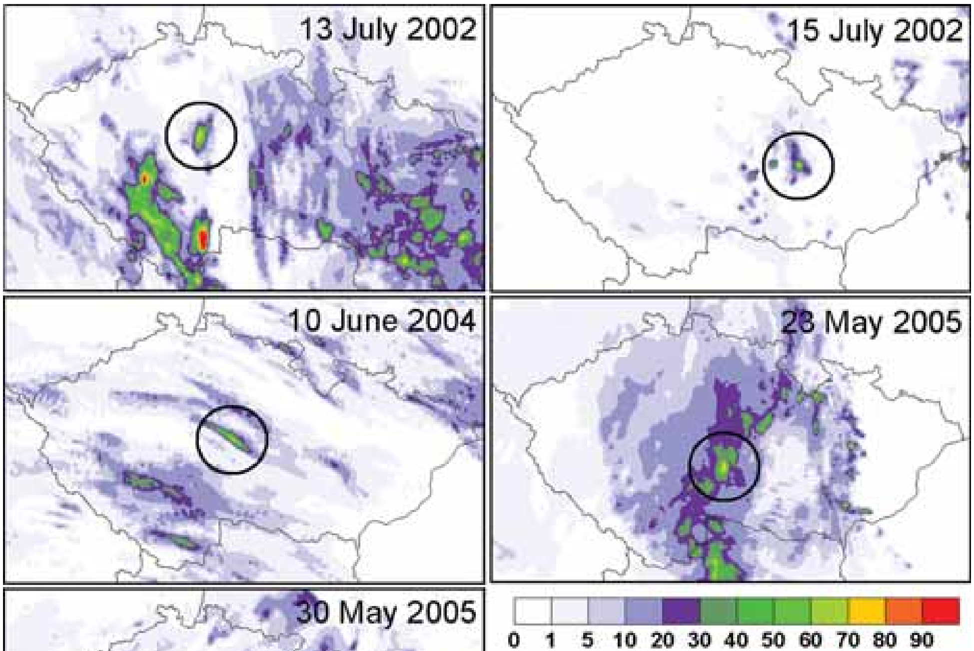


Fig. 6-2. Radar-based 12 h (10 UTC – 22 UTC) rainfall for five events. The date is marked in each panel. The circles indicate the positions of local floods. The rainfall values in mm/12h are indicated in the legend.



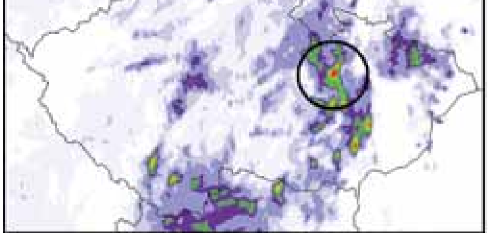


Fig. 6-3. Mean FSPS-FSS relationship for 1h rainfalls and various sizes of elementary squares, where FSPS stands for fraction spread score. The single panels refer to the time in UTC marked in each panel. The event dates are shown in the legend. The symbols indicate the elementary squares with sides of 5, 11, 15, 21, 25, 31, 35, 41, 51, and 61 grid points, respectively.

c. Nowcasting of precipitation

A method of nowcasting of precipitation based on statistical advective approach was developed for the territory of the Czech Republic and the warm part of the year (Novák and Sokol, 2008; Sokol et al., 2009; Sokol and Pešice, 2009). Radar, lightning, satellite and NWP model prognostic data were used as an input into a logistic regression model, which forecasts probabilities that area precipitation accumulated over 1, 2 and 3 hours will reach or exceed given thresholds in defined boxes of 9×9 km. Then the probabilistic forecasts are transformed into quantitative precipitation (Sokol, 2009). The resulting forecasting model, called SAM, was semi-operationally tested in the Czech Hydrometeorological Institute in 2008. The first results confirmed that SAM is able to forecast development and decay of convective storms (Fig. 6-4).

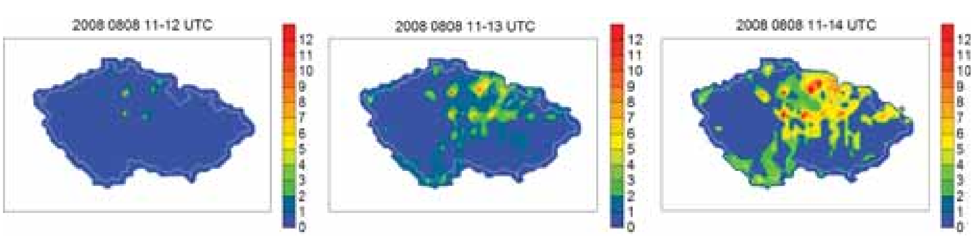


Fig. 6-4. An example of 1-h, 2-h and 3-h forecasts of precipitation.

Hydrometeorological research

a. Selection of historic precipitation events in the Czech Republic

We proposed a criterion for the selection of the most significant events in terms of heavy, widespread and steady rains in the warm half-year from 1951 to 2006. The criterion is based on daily areal precipitation amounts in river basins and on time concentration of the amounts in 3-day periods. We identified several groups of events with similar spatial distribution of precipitation, which is most likely related to similar thermodynamic conditions at the synoptic scale. The most exceptional events were concentrated in high summer, particularly in orographically exposed river basins. The analysis of interannual variability revealed two periods with a rather low frequency of events: 1965–1974 and 1986–1995 (Fig. 6-5; Kašpar and Müller, 2008).

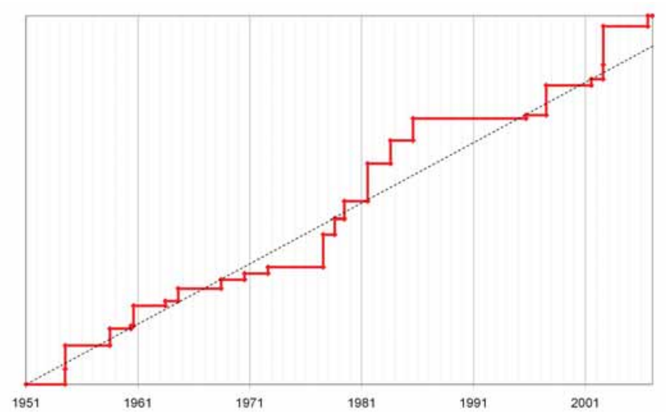


Fig. 6-5. Interannual distribution of xtreme precipitation events during the warm half-years (MJJASO) in 1951–2006. Vertical segments of he cumulative curves represent the events. The height of the segment corresponds to the extremeness of the event within the entire Czech Republic. Adapted from Kašpar and Müller (2008).

b. Extremeness of meteorological variables as an indicator of heavy, widespread and steady rainfalls in the Czech Republic

Using the ERA40 re-analyses from 1958 to 2002, we detected the same synoptic-scale anomalies of meteorological variables during the episodes with heavy, widespread and steady rainfalls as during the events in July 1997 and August 2002. Consequently, we defined the combined index EM expressing the total extremeness of selected variables. The values of the index EM up to 0.07 correspond to the occurrence of exceptionally heavy precipitation when rain floods are highly probable in the Czech Republic (Müller et al., 2009). It is evident from the case study of torrential rains in July 1984 that even this kind of precipitation may be accompanied by significant anomalies of meteorological variables in synoptic scale, however entirely different from the anomalies typical of widespread and steady rainfalls. Unusual accurate re-forecast of torrential rains from 12–13 July 1984 can be explained by the exceptionality of weather conditions (Kašpar et al., 2009). The evaluation of extremeness of appropriate thermodynamic variables could be therefore used to improve the assessment of the uncertainty of quantitative forecast of steady and torrential precipitation as well (Fig. 6-6).

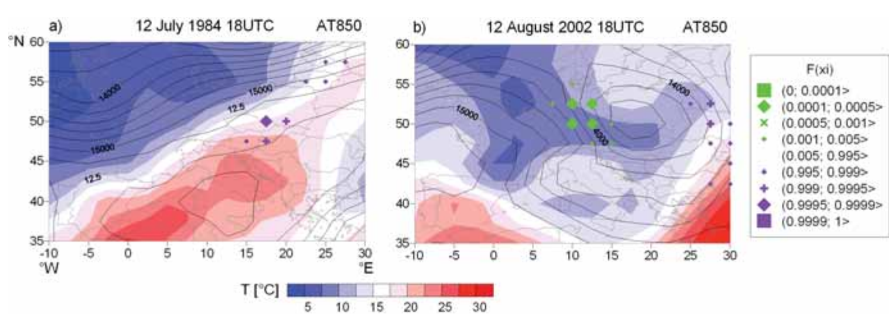


Fig. 6-6. Percentile levels F of specific humidity at 850 hPa on 12 July 1984 at 18 UTC (flash flood) and F of meridional flux of moisture at 850 hPa on 12 August 2002 at 18 UTC (large-scale flood). The background of both maps shows the geopotential height of 850 hPa [gpdam] and temperature fields.

Ground and boundary layer studies

a. Pollutants in deposited precipitation

Deposited precipitation can contribute significantly to the local increase in the load with pollutants. That is why several topics related to the pollution detected in deposited precipitation were investigated using data from fog and rime sampling at the Milešovka and Kopisty observatories. In 2007–2008, the research continued in comparing pollutant concentrations in differently polluted regions, between fog water and rime water, and in studying the dependence of pollutant concentrations on the direction of air mass transfer. In addition, we studied the dependence of fog liquid water content on visibility (FIŠÁK ET AL., 2008B), and published first results from sampling soluble and insoluble pollution particles (FIŠÁK ET AL., 2007). The insoluble particles were analysed in the Institute of Physical Chemistry of Bulgarian Academy of Sciences.

b. Flow and turbulence over a forested ridge

In collaboration with the Institute of Systems Biology and Ecology AS CR, the investigations focused on the Experimental Ecological Study Site Bílý Kříž in the Beskydy Mts.

Large-scale turbulence structures contribute significantly to the forest–atmosphere exchange of mass and energy. The recent study (POTUŽNÍKOVÁ ET AL., 2008) aimed at detecting and describing the low-frequency oscillations and coherent structures in the time series of temperature and wind velocity components sampled at one level above the canopy with a 3D sonic anemometer. The wavelet-based methodology for detection of periods of the structures, their persistence and their contribution to the mean turbulent heat flux was extended and tested. Orographic forcing induced by the mountain ridge was revealed: The flow on the downwind (leeward) side of the ridge generates shorter periods of lower frequency than the periods generated by the upslope flow. Also, the contribution of the periods to the mean turbulent heat flux is smaller in the downwind cases. The length of the periods decreases with increasing wind speed above the canopy. The linkage between the length of the periods and the temperature stability within the surface layer was not found.

We participated in a site evaluation approach combining Lagrangian stochastic footprint modelling with a quality assessment approach for eddy-covariance data. The approach was applied to 25 forested sites of the CarboEurope-IP network, including Bílý Kříž (GÖCKEDE ET AL., 2008). The analysis addressed the spatial representativeness of the flux measurements, instrumental effects on data quality, spatial patterns in the data quality, and the performance of the coordinate rotation method.

Applied meteorology

Wireless optical links are broadly used as additional short-range communication means; however, the optical signal passes the atmosphere and is randomly attenuated mainly by fog and rain. On the other hand, radio links use higher frequencies and the studies of atmospheric propagation are of a great importance. Our research activities related to the atmospheric influence on propagating radiowaves and wireless optical signal included special measurements and their analysis:

- Rain data sampling and analysis. Rain measurements were performed at 6 sites in the Czech Republic and analysed using a novel method (FIŠER AND WILFERT, 2009; FIŠER AND FIŠER, 2009).
- Visibility and LWC measurements. Observed data were used to compute atmospheric attenuation and the aim of our research was a design of link parameters at a given reliability level.
- Atmospheric attenuation measurements were studied using two experimental optical links (in Prague – link length 800 m, wavelength 850 nm, and at the Milešovka observatory – link length 70 m, wavelengths 850 nm and 1550 nm). Attenuation was also studied in dependence on wind turbulence measurements and visibility observations at the Milešovka observatory (KOLKA ET AL., 2007).
- A generator of rain rate time course was developed. It serves as a data base for testing of rain data processing methodologies. A procedure focused on the design of system parameters (link availability, transmitter power, antenna gain, transmission rate, bandwidth, noise figure etc.) has been developed using above mentioned results. The procedure is used in several research institutions in Europe.

Meteorological Observatories

Deptartment of Meteorology manages two meteorological observatories, both located in North Bohemia: Milešovka and Kopisty.

Mountain meteorological observatory Milešovka

The Milešovka observatory is situated at the summit of an isolated, conically shaped mountain (837 m a.s.l.), overtopping the surrounding terrain by about 400 meters. The observatory has been operating continually (with minor exceptions in 1917 and during the World War II) since 1905. Additionally to standard climatological and synoptic observations, special measurements and field experiments have been performed there. One of the new measurements concerning fog and low cloud water sampling has started in 1998. In 2006, the Milešovka observatory was equipped with a device for the objective measurement of fog/cloud drop size spectrum (EPCS – RTSizer MALVERN). The uniqueness of the Milešovka observatory is due to its position; atmospheric conditions are close to free atmosphere. More information about the observatory can be found at http://www.ufa.cas.cz/html/milesovka.

Meteorological observatory Kopisty

The Kopisty observatory is located at the bottom of an industrial basin (240 m a.s.l.). Standard climatological observations have been performed there since 1969. The observatory is equipped with a meteorological mast (80 m); measurements of vertical profiles of wind, temperature and humidity are utilized in boundary layer studies. The sampling of fog water started in 1998. In 2008, a new observatory building was completed. Its construction started in 2006 and was financially supported by the AS CR. More information about the observatory can be found at http://www.ufa.cas.cz/html/kopisty.

Fig. 6-7. Meteorological observatory at the Milešovka Mt.

Fig. 6-8. Meteorological observatory at Kopisty.

Additional references (all other references are included in the list at the end of the report):

Fišák, J., Stoyanova, **V. Chaloupecký, P.**, **Řezáčová, D.**, Tsacheva, Ts., Kupenova, T., Marinov, M. (2007) Soluble and insoluble pollutants in fog and rime water. In Biggs A. and Cereceda P. (eds): Proceedings of the 4th International Conference on Fog, Fog Collection and Dew. Pontificia Universitad Católica de Chile, La Serena, Chile, 141–144.

Fišer, O. and **Fišer, O.** jr (2009) New Czech rain data and methods applied to radiowave propagation. EuCAP 2009 – 3rd European Conference on Antennas and Propagation, Berlin, VDE, 5 pp.

Fišer, O. and Wilfert, O. (2009) Novel Processing of Tipping-bucket rain gauge records. Atmospheric Research. DOI: 10.1016/j. atmosres.2009.01.008.

Kašpar, M., **Müller, M.**, **Kakos, V.**, **Řezáčová, D.**, **Sokol, Z.** (2009) Severe Storm in Bavaria, the Czech Republic and Poland on 12–13 July 1984 – a statistic- and model-based analysis. Atmospheric Research, DOI: 10.1016/j.atmosres.2008.10.004.

Müller, M., **Kašpar, M.**, **Řezáčová, D.**, **Sokol, Z.** (2009) Extremeness of meteorological variables as an indicator of extreme precipitation events. Atmospheric Research, DOI: 10.1016/j.atmosres.2009.01.010.

Novák, P., **Sokol, Z.** (2008) Use of Czech Weather Radar Network Data for Precipitation Estimating and Nowcasting. World Environmental and Water Resources Congress 2008 Ahupua'a, ASCE, Honolulu, CD. Published by American Society of Civil Engineers, 10 pp.

Řezáčová, D., **Zacharov, P.**, **Sokol, Z.** (2009) Uncertainty in the area-related QPF for heavy convective precipitation. Atmospheric Research, DOI: 10.1016/j.atmosres.2008.12.005.

Sokol, Z., **Řezáčová, D.** (2009) Assimilation of the radar-derived water vapour mixing ratio into the LM COSMO model with a high horizontal resolution. Atmospheric Research, DOI: 10.1016/j.atmosres.2009.01.012.

Sokol, Z. (2009) Effects of an assimilation of radar and satellite data on a very-short range forecast of heavy convective rainfalls. Atmospheric Research, DOI: 10.1016/j.atmosres.2008.11.001.

Sokol, Z., **Pešice, P.** (2009) Comparing nowcastings of three severe convective events by statistical and NWP models. Atmospheric Research, DOI: 10.1016/j.atmosres.2008.09.016.

Sokol, Z., Kitzmiller, D., **Pešice, P.**, Guan, S. (2009) Operational 0–3h probabilistic quantitative precipitation forecasts: Recent performance and potential enhancements. Atmospheric Research, DOI: 10.1016/j.atmosres.2009.01.011.

Zacharov, P., **Řezáčová, D.** (2008) The effect of radar-based QPE on the verification of QPF for convective rainfalls. ERAD 2008 – The Fifth European Conference on Radar in Meteorology and Hydrology, CD-ROM, Finnish Meteorological Institute, Helsinki, 5 pp.

Projects

International

COST 731 (Propagation of uncertainty in advanced meteo-hydrological forecast systems). Chair A. Rossa (Italy), about 25 institutions from 20 countries participating; co-I **D. Řezáčová**; supported by the Ministry of Education, Youth and Sports and EU (2006–2010).

Development of short-range precipitation prediction systems for hydrologic and flood prediction. PI **Z. Sokol**, co-Is D. Kitzmiller (NOAA NWS, US) and P. Novák (Czech Hydrometeorological Institute, Prague); supported by the Ministry of Education, Youth and Sports and NOAA National Weather Service (US) (2005–2008).

National

Physics and chemistry of deposited (occult) precipitation in heavy polluted subregion of the Czech Republic. PI **J. Fišák**, co-Is M. Tesař, Institute of Hydrodynamics AS CR, and D. Fottová, Czech Geological Service; funded by GA AS (2003–2007).

Methods for availability improvement of free space optics communications. PI O. Wilfert, Technical University Brno, co-Is **O. Fišer**, and V. Kvičera, TESTCOM, Prague; funded by GA CR (2005–2007).

Study of turbulent structures at the atmosphere-forest interface over complex terrain. PI **K. Potužníková**; funded by GA CR (2005–2007).

The amount of deposited precipitation measurement and assessment of wet deposition of pollutants. PI **J. Fišák**; funded by AS CR (2005–2009).

Extremeness of meteorological quantities as a predictor of heavy rainfall and rain floods. PI **M. Müller**; funded by GA AS (2007–2009).

Advanced communication techniques for atmospheric transmission channel. PI Z. Kolka, Technical University Brno, co-Is **O. Fišer**, and V. Kvičera, TESTCOM, Prague; funded by GA CR (2007–2009).

A comparative study of significant rain floods in the Czech Republic considering their synoptic-dynamic and hydrometeorological cause. PI **M. Kašpar**; funded by GA AS (2008–2010).

Evaluation of QPF uncertainty. PI **D. Řezáčová**, co-I R. Brožková, Czech Hydrometeorological Institute; funded by GA AS (2008–2010).

Missing CO_2 flux in night-time eddy covariance measurements. PI **P. Sedlák**, co-I D. Janouš, Institute of Systems Biology and Ecology AS CR; funded by GA AS (2008–2011).

7. Department for Wind Energy

Web site: http://www.ufa.cas.cz/html/dllouka/

The department is involved in meteorological research and its practical applications for wind energy purposes in the Czech Republic. The research focuses on wind modelling, sodar measurements and atmospheric icing on structures. The applications include wind resource assessments and mast measurements.

Staff of the department

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Technicians

Eva Lhotková (lhotka@ufa.cas.cz)

Chief observer at the Dlouhá Louka observatory

Josef Pazdera

Main research topics

Assessment of wind energy potential over the area of the Czech Republic

Technical potential of wind energy over the area of the Czech Republic was assessed (Hanslian and Pop, 2008). The calculation was based on wind turbines of state-of-the-art technology in the mean wind field that was produced at horizontal resolution 100 × 100 m at 100 m above ground. The final wind climatology was obtained by weighted averaging of outputs from the hybrid model VAS/WAsP and the flow model PIAP. The meteorological inputs included standard meteorological measurements as well as meteorological mast data and wind measurements from air quality monitoring stations. All available measurements were subjected to critical evaluation from the point of influences by neighbouring obstacles and orography.

To estimate the technical potential of wind energy, areas where wind installations are possible were specified. Among others, the areas of low wind potential, residential areas with surroundings of 500 m, military areas, and areas of high level of nature protection were excluded. The forested areas were only considered as acceptable if they met an increased limit of necessary wind potential. The resulting areas were covered by hypothetical wind installations with respect to the minimum distance limits. The number of installations was then reduced using simulated wake effects and decreased to 13 374, which can be considered as technical potential of wind energy in the Czech Republic.

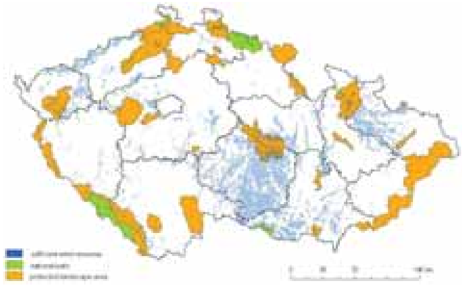

Fig. 7-1. Areas with sufficient wind resource versus large-scale nature protected areas.

The analysis continued with the estimation of realizable potential. Under present technical and legislative conditions, the realizable potential of wind energy in the Czech Republic was evaluated at 2500 MW of installed capacity and 5.6 GWh of energy production. This can cover about 8% of present energy consumption of the Czech Republic. The areas of highest potential are the Českomoravská vrchovina highlads, the Nízký Jeseník highlands and the Krušné hory (Ore) Mts.

The main application of the results is the analysis of the wind energy related load of electric power distribution network. The results also show the limits for development of wind energy and its portion in the energy policy of the country.

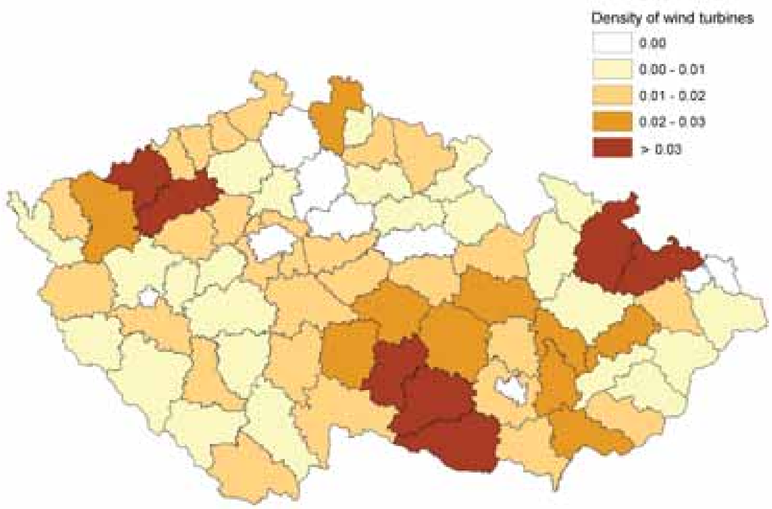

Fig. 7-2. Realizable potential of wind energy – number of wind turbines (2–3 MW) per square km by district.

Atmospheric icing on structures – icing climatology

The icing climatology was studied in the framework of project COST 727. The icing represents a serious hazard to structures like TV towers, high voltage power line towers or wind turbines. In the case of wind turbines, the icing causes two major problems: power production loss and falling ice. Since the region most suitable for wind energy production in the country – the Krušné hory Mts. – belongs to the areas where severe icing occurs, the application of the study in the wind energy is straightforward.

In 2007–2008, icing measurements continued on the top of the Milešovka Mt. and at Dlouhá Louka. The icing measurements were compared to the simulations based on reanalysis and MM5 forecasts (Hošek, 2007). The global data are not detailed enough for icing estimation in mountainous terrain due to the rough spatial and time resolution. The mesoscale forecasts depend much on the microphysics settings. With full microphysics scheme, the model is able to predict icing events to some extent. Most differences in predicted ice mass are obviously caused by errors in temperature prediction during periods with temperatures around zero. The other effect that causes the model to behave differently from reality is the decrease of ice mass when temperatures are negative. Since the mesoscale simulations were performed in a domain with horizontal resolution of 9 km, the station altitude was several hundred meters above the grid surface and the inputs were taken from that model layer. The model temperature would be influenced by radiation much less than it should be, so there is a possible future improvement for the icing forecast.

The icing measurements were compared to routine synoptic measurements. The results showed that the synoptic measurements are applicable for the icing studies. The spatial distribution of mean number of icing hours was calculated using residual kriging, while the independent variables in the deterministic part of interpolation included wind speed and elevation. The resulting values ranged from 30 hours/year in lowlands to more than 2000 hours/year in the mountainous regions.

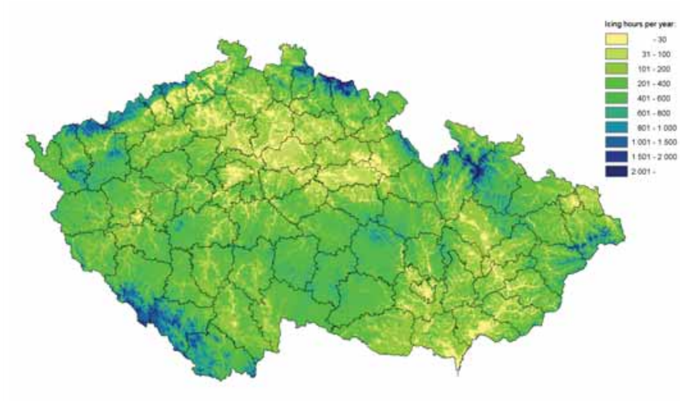

Fig. 7-3. Mean number of icing hours per year.

Wind resource assessment and mast measurements

The applied research consists of mast measurements and wind resource assessments at sites requested by developers in wind energy. The wind resource assessments are based either solely on models or on wind measurements combined with model WAsP. The measurements were performed on the wind masts with the highest level at 35 m in Malý Háj (2006–2007) and Přísečnice (2006–2007), and on the telecommunication masts at 50 m in Kozlov (since 2008) and Skuhrov (since 2008). The observations of wind speed up to 50 m above ground were carried out at the Dlouhá Louka observatory. During the second half of 2008, we also organized wind measurements for the 2009 World Championship in skiing in Liberec. A special attention was paid to the measure-correlate-predict analysis applied to complete the missing data and/or to extend the series up to the climatologically relevant period. Several methods were developed to optimize the simulation of the wind speed and direction distributions, not only the average wind speed.

Additional references:

Hanslian, D., **Pop, L.** (2008) The technical potential of wind energy and a new wind atlas of the Czech Republic. In: Proceeding of european Wind Energy Conference, Brussels, European Wind Energy Association, 10 pp.

Hošek, J. (2007) Icing measurements at Milešovka and their comparison with reanalysis and mesoscale model outputs. In: Proceedings of the 12th International Workshop on Atmospheric Icing of Structures, Yokohama, 5 pp.

Research projects

International

COST 727 (Measuring and forecasting atmospheric icing on structures). Chair B. Tammelin, Finnish Meteorological Institute, 16 more institutions from 12 countries; co-I **J. Hošek** (2004–2008).

National

Modelling of vertical wind profile in mountainous terrain. PI **J. Hošek**, funded by GA AS (2005–2007).

Contracts

Assessment of wind energy potential over the area of the Czech Republic. Contractor: ČEPS, a.s., person in charge: **J. Štekl** (2006–2007).

Temporal and spatial variability of wind speed related to energy production by wind turbines. Contractor: ČEPS, a.s., persons in charge: **Z. Sokol**, **J. Štekl** (2007).

8. International Activities

Coordination and organization of scientific events

Several international workshops and meetings were organized and/or hosted by the IAP in 2007–2008:

A joint **IRI/COST296 workshop 'Ionosphere – Modelling, Forcing and Telecommunications'** was organized by the IAP (chairman of LOC J. Laštovička) in Prague on July 10–14, 2007, with participation of 103 scientists and doctoral students from five continents. Altogether 66 oral and 53 poster papers were presented. Selected papers from the workshop are in press in two special issues of Advances in Space Research (J. Laštovička was one of guest editors).

IAP was co-organizer of the **General Assembly of the ENSEMBLES** ('ENSEMBLE-based predictions of climate change and its impacts') **project**, November 2007 (150 participants, 135 from abroad); the main organizer was the Charles University, Prague.

INTAS ELF/VLF workshop on wave phenomena in the plasmasphere of the Earth took place at the IAP in January 2007 (18 participants, of which 11 from abroad).

COST 727 Core Group Meeting was hosted by the IAP in May 2007 (10 participants, of which 9 from abroad), and **COST 727 Management Committee** and **Working Groups Meeting** was hosted in May 2008 (25 participants, of which 23 from abroad).

The staff of the IAP participated also in **programme and scientific committees of international conferences**, e.g. the 5th IAGA/ICMA/CAWSES Workshop 'Long Term Changes and Trends in the Atmosphere', St. Petersburg, Russia (2008; J. Laštovička chaired the program committee), the COST 733 mid-term conference 'Advances in Circulation and Weather Type Classifications and Applications', Kraków, Poland (2008; R. Huth chaired the scientific committee), Cluster – THEMIS science workshop, New Hampshire, Durham, US (2008; O. Santolík), and the 3rd VERSIM Workshop, Tihany, Hungary (2008, O. Santolík); and **organized and convened/co-convened symposia** at the Scientific Assembly of IUGG, Perugia, Italy (2007), the EGU General Assemblies, Vienna, Austria (2007, 2008), STAMMS – Cluster input to critical issues in magnetospheric physics, Orléans, France (2007), the 7th European Conference on Applied Climatology / 8th Annual Meeting of European Meteorological Society, Amsterdam, the Netherlands (2008), and the 29th General Assembly of URSI, Chicago, Illinois, US (2008).

Participation in international research programs

CAWSES (Climate and Weather of the Sun-Earth System)

IRI (International Reference Ionosphere)

Participation in international research projects

The international projects are listed in the sections related to individual departments of the IAP; herein they are summarized and ordered by the programme and funding institution.

6th Framework Programme of the European Union:

- ENSEMBLE-based predictions of climate change and its impacts (ENSEMBLES)
- Central and eastern Europe Climate change Impact and vulnerabiLIty Assessment (CECILIA)
- GEO-6 (Galileo for Scientific User Community)
- ALOMAR-eARI (ALOMAR – enhanced Approach to Research Infrastructure)

7th Framework Programme of the European Union:

- Lapland Atmosphere-Biosphere Facility (LAPBIAT-2)

ESA / Prodex and PECS contracts:

- Dual segmented Langmuir Probe
- Data processing and simulation facility, numerical modelling, and interpretation of wave observations
- Investigation of waves and turbulence in space plasma
- Thermal Plasma Measurement Unit (TPMU)

NASA awards:

- Understanding Mercury's Magnetosphere using MESSENGER Data and Global Kinetic Simulations
- A Study of the Moon's Plasma Environment and Mini-Magnetospheres
- Interactions of the Icy Satellites of Saturn with Its Magnetosphere
- Studies of the Interaction between Jovian Plasma and Io Using Hybrid Simulations
- Lunar-Based Soft X-ray Science

CNRS-PICS:

- The solar wind and its interaction with the Earth's magnetosphere: Data analysis
- Statistical study of the Demeter spacecraft data

KONTAKT/Barrande:

- Propagation of electromagnetic waves observed on the DEMETER spacecraft
- Formation of nonlinear coherent structures in space plasmas

INTAS:

- Discrete and noise-like ELF/VLF emissions in the Earth's magnetosphere

COST projects – the participation of Czech institutions is funded by the Ministry of Education, Youth and Sports, and partly EU:

- COST 296 (Mitigation of ionospheric effects on radio systems)
- COST 724 (Developing the scientific basis for monitoring, modelling and predicting space weather)
- COST 727 (Measuring and forecasting atmospheric icing on structures)
- COST 731 (Propagation of uncertainty in advanced meteo-hydrological forecast systems)
- COST 733 (Harmonization and applications of weather types classifications for European regions)
- COST ES 0803 (Developing space weather products and services in Europe)

Bilateral collaboration in research and development:

- Development of short-range precipitation prediction systems for hydrologic and flood prediction (with NOAA National Weather Service, US)
- Meteorological causes and human mortality impacts of extreme hot weather in summer: a comparative study (with Korea Meteorological Administration, Korea)
- Changes of long-term trends in the dynamics of the upper atmosphere (with Institute for Meteorology, University of Leipzig, Germany)
- Ionospheric modelling for the purpose of HF communication prediction, with Hermanus Observatory, South Africa
- Study and modelling of space weather impact on ionospheric variability, with Compleo Astronomico El Leoncito (CONICET)-CASLEO, Argentina
- Geomagnetic, meteorological and solar influences on the ionosphere, with Observatorio del Ebro, Spain
- Effects of solar activity in the upper atmosphere, with Solar-Terrestrial Influences Laboratory, Bulgarien Academy of Sciences, Bulgaria

International education activities

P.Šauli teaches a recurrent course on Physics of the Ionosphere at Universite de Rennes, France.

The staff of the IAP have served as supervisors and consultants of PhD theses of students of Universite de Paris 6, France; University of Alberta, Canada; and Ebro Observatory, Roquetes/Tortosa, Spain.

Cooperating institutions

The IAP collaborates with various institutions in Europe, North and South America, Africa and Asia. The important collaboration proceeds especially with the following institutions (under joint projects and/or with joint publications; arranged alphabetically by country):

University of Tucuman, Argentina
Astronomical observatory of San Juan, CASLEO-CONICET, Argentina
Space Research Institute, Department of Extraterrestrial Physics, Graz, Austria
Institute of Meteorology and Physics, University of Agricultural Sciences (BOKU), Vienna, Austria

Terrestrial Influences Laboratory, Bulgarian Academy of Science, Sofia, Bulgaria
Institute of Physical Chemistry, Bulgarian Academy of Science, Sofia, Bulgaria
Department of Physics, University of Alberta, Canada
Geophysical Observatory, Sodankylä, Finland
University of Rennes 1, France
Ecole Normale Superieure de Lyon, France
Centre d'Etudes des Environnements Terrestre et Planétaires (CETP), Vélizy, France
Laboratoire de Physique et de Chimie de l'Environnement, LPCE, CNRS, Orléans, France
Laboratoire d'Etudes Spatiales et d'Instrumentation en Astrophysique, LESIA, Observatoire de Paris-Meudon, France
Centre d'Etude Spatiale des Rayonnements, CNRS, Toulouse, France
Observatoire de Cote d'Azur, Nice, France
Department of Geography, University of Augsburg, Augsburg, Germany
Leibnitz Institute of Atmospheric Physics, University of Rostock, Kühlungsborn, Germany
Institute for Meteorology, Leipzig University, Germany
Technical University of Freiberg, Germany
Department of Astronomy and Space Science, University of Florence, Italy
Institute of the Ionosphere, Almaty, Kazakhstan
Korea Meteorological Administration, Seoul, Korea
Space Science Department, European Space Agency, ESA, Noordwijk, the Netherlands
Center for Space Research, Polish Academy of Sciences, Warsaw, Poland
Centre of Geophysics, University of Lisbon, Lisbon, Portugal
Institute of Applied Physics, Nizhny Novgorod, Russia
Slovak University of Technology, Bratislava, Slovakia
Hermanus Magnetic Observatory, Hermanus, South Africa
Rhodes University, Grahamstown, South Africa
Ebro Observatory, Roquetes, Spain
Rutherford-Appleton Laboratory, Didcot, United Kingdom
Mullard Space Science Laboratory, Dorking, United Kingdom
Department of Physics, Imperial College, London, United Kingdom
Astronomy Unit, Queen Mary University of London, United Kingdom
Institute of Geophysics and Planetary Physics, University of California at Los Angeles, US
Department of Physics, University of Nevada, Reno, US
National Drought Mitigation Center, University of Nebraska, Lincoln, Nebraska, US
Department of Physics and Astronomy, University of Iowa, Iowa City, US
MIT Kavli Institute for Astrophysics and Space Research, Cambridge, US
Jet Propulsion Laboratory, Caltech, Pasadena, US
Space Science Laboratory, University of California, Berkeley, US
University of Massachusetts, Center for Atmospheric Research, Lowell, US
Office of Hydrologic Development, NOAA National Weather Service, Silver Spring, MD, US

Long-term stays abroad

University of Iowa, US
O. Santolík, 3 months in 2007 and 3 months in 2008; visiting research scientist
Observatoire de Cote d'Azur, Nice, France
P. Hellinger, 1 month in 2008; visiting research scientist
Observatory Paris-Meudon, France
Š. Štverák, 3 months in 2007; doctoral fellowship
Imperial College, London, UK
J. Souček, 7 months in 2007, post-doctoral research associate

UCLA, US

P. Trávníček, 4 months in 2007, 3 months in 2008, visiting researcher

CESR, Toulouse, France

P. Trávníček, 3 months in 2007-2008, post rouge award CNRS

Jet Propulsion Laboratory, US

P. Trávníček, 6 months in 2008, visiting researcher

University of Orléans- LPCE Orléans, France

O. Santolík, 2 months in 2007, visiting professor

LPCE Orléans, France

F. Němec, 6 months in 2007, 6 months in 2008; doctoral fellowships

NASA Goddard Space Flight Center, Greenbelt, Maryland, USA

V. Truhlík, 2 months in 2007 and 3 months in 2008; visiting research scientist

Participation in international conferences and meetings, invited presentations

The staff of the IAP presented about 350 lectures and posters at international conferences and meetings in 2007 and 2008. 40 lectures were invited; see the list below.

Solicited/invited presentation at international scientific conferences:

Altadill, **D., Boška, J.**, Cander, L.R., Gulyaeva, T., Reinisch, B.W., Romano, V., Krankowski, A., Bremer, J., Belehaki, A., Stanislawska, I., Jakowski, N.: Near Earth space plasma monitoring under COST 296. 5th Workshop COST 296, Rome, 2008.

Bremer, J., **Laštovička, J.**, Mikhailov, A.V., Altadil, D., Bencze, P., **Burešová, D.**, De Francesschi, G., Jacobi, Ch., Kouris, S., Perrone, L., Turunen, E.: Climate of the upper atmosphere. 5th Workshop COST 296, Rome, 2008.

Burešová, D., McKinnell, L.-A., **Šindelářová, T.**, Blanco Alegre, I., De la Morena, B.: Evaluation of the STORM model storm-time corrections for middle latitudes. 37th COSPAR Scientific Assembly, Montreal, 2008.

Burešová, D., Nava, B., Galkin, I., Coisson, P., Angling, M., Stankov, S.M.: Data ingestion and assimilation in ionospheric models, 5th Workshop COST 296, Rome, 2008.

Fiala, V., Chugunov, Yu. V., James, H. G.: Effective length of a dipole in plasma at resonance frequencies. International Symposium on Radio Systems and Space Plasma, URSI, Sofia, Bulgaria, 2007.

Fišer, O., **Řezáčová, D.**: Rain Measurement for Improved Propagation Modelling in Czech Republic. 2nd European Conference on Antennas and Propagation, Edinburgh, 2007.

Génot, V., **Hellinger, P.**, Passot, T., Belmont, G.: Mirror instability and structures in the magnetosheath: Cluster observations, simulation and theory. AOGS, Bangkok, Thailand, 2007.

Hellinger, P., **Trávníček, P.**, Lembege, B., Savoini, P.: Reformation of perpendicular shocks: 1-D vs 2-D simulations. Joint Spring AGU Assembly, Acapulco, Mexico, 2007.

Hellinger, P., **Trávníček, P.**, Lembege, B., Savoini, P.: Nonstationarity of perpendicular shock front: Hybrid versus PIC simulations. AOGS, Bangkok, Thailand, 2007.

Hellinger, P., **Trávníček, P.**, Passot, T., Sulem, P. L., Kuznetsov, E., Califano, F.: Nonlinear Mirror Instability: Hybrid Simulations and Modelling. AOGS, Busan, Korea, 2008.

Hellinger, P., Louarn, P., Nakamura, R., Owen, C. J., Pincon, J. L., Schwartz, S., Sorriso-Valvo, L., Vaivads, A., Wimmer-Schweingruber, R., Fujimoto, M., Saito, Y., Bale, S., Kessel, M., Escoubet, C. P., Falkner, P., Opgenoorth, H., Taylor, M. G. G. T., Wielders, A.: Cross-Scale: A Cosmic Vision Mission to Study Multi-scale Coupling in Plasmas. AOGS, Busan, Korea, 2008.

Jacobi, Ch., Hoffmann, P., **Križan, P.**, **Laštovička, J.**, **Kozubek, M.**, Merzlyakov, E.G., Portnyagin, Yu.I.: Midlatitude mesopause region winds and waves and comparison with stratospheric variability. 5th IAGA/ICMA/CAWSES workshop 'Long Term Changes and Trends in the Atmosphere', St. Petersburg, 2008.

Kyselý, J., Kříž, B.: Effects of hot summer periods on human mortality in the Czech Republic. 18th Annual Meeting of the International Environmetrics Society, Mikulov, 2007.

Kyselý, J., **Huth, R.**, Kim, J.: Application of objective classifications of 'air masses' in evaluating heat-related mortality. Advances in Weather and Circulation Type Classifications & Applications, Krakow, Poland, 2008.

Laštovička, J.: Solar activity effects on long-term trends in the upper atmosphere. Joint Spring AGU Assembly, Acapulco, Mexico, 2007.

Laštovička, J.: Progress and problems in the global change pattern in the upper atmosphere and ionosphere. 24th IUGG General Assembly, Perugia, Italy, 2007.

Laštovička, J.: Meteorological impacts on space weather. 4th European Space Weather Week, Brussels, Belgium, 2007.

Laštovička, J., Akmaev, R.A., Beig, G., Bremer, J., Emmert, J., Jacobi, C., Jarvis, M., Nedoluha, G., Portnyagin, Yu.I., Ulich, T.: The emergence of a pattern of global change in the upper atmosphere and ionosphere. Joint Spring AGU Assembly, Acapulco, Mexico, 2007.

Laštovička, J.: Long-term trends and changes in the thermosphere-ionosphere system. 37th COSPAR Scientific Assembly, Montreal, 2008.

Laštovička, J.: Lower ionosphere response to external forcing: A review. 37th COSPAR Scientific Assembly, Montreal, 2008.

Laštovička, J.: Global pattern of trends in the upper atmosphere and ionosphere. 5th IAGA/ICMA/CAWSES workshop 'Long Term Changes and Trends in the Atmosphere', St. Petersburg, 2008.

Parrot, M., **Němec, F.**, **Santolík, O.**, Manninen, J.: Observations of magnetospheric kline radiation in the ionosphere. International Symposium on Radio Systems and Space Plasma, Sofia, Bulgaria, 2007.

Radicella, S.M., **Šauli, P.**, Jakowski, N., **Kouba, D.**, Portillo, A., Herraiz, M., Strangeways, H.J., Žernov, N., Gherm, V.: Space plasma effects. 5th Workshop COST 296, Rome, 2008.

Santolík, O., Gurnett, D.A., Pickett, J.S., **Macúšová, E.**, Cornilleau-Wehrlin, N., de Conchy, Y., Yearby, K.H.: Waves and Wave-Particle Interactions in the Inner Magnetosphere: Whistler-Mode Chorus Measured by the Cluster and Double Star Spacecraft. 8th International School/Symposium for Space Simulations, Kauai, Hawaii, US, 2007.

Santolík, O., Gurnett, D.A., Pickett, J.S., Trakhtengerts, V.Y., Demekhov, A.G., Cornilleau-Wehrlin, N., Daly, P.W., Fazakerley, A.: Hiss and chorus emissions: loss and source mechanisms for energetic particles. EGU General Assembly, Vienna, Austria, 2007.

Santolík, O.: AC field measurements and wave analysis tools. 6th COSPAR Capacity Building Workshop, Regional Workshop for Space Physicists from Central and Eastern Europe, Sinaia, Romania, 2007.

Santolík, O., Gurnett, D.A., Pickett, J.S., Parrot, M., Cornilleau-Wehrlin, N., Daly, P.W.: Storm-time dynamics of whistler-mode chorus at different scales. 24th IUGG General Assembly, Perugia, Italy, 2007.

Santolík, O., Gurnett, D.A., Pickett, J.S., Meredith, N., Winningham, D., Cornilleau-Wehrlin, N., Fazakerley, A.: Morphology of whistler mode chorus and its interactions with energetic electrons. 24th IUGG General Assembly, Perugia, Italy, 2007.

Santolík, O., Parrot, M.: Observations of chorus emissions in the inner magnetosphere, International Symposium on Radio Systems and Space Plasma. Sofia, Bulgaria, 2007.

Santolík, O., Gurnett, D.A., Pickett, J.S., **Macúšová, E.**, **Němec, F.**, Cornilleau-Wehrlin, N.: Characteristics of whistler-mode chorus and equatorial noise. USNC/CNC/URSI North American Radio Science Meeting, Ottawa, Canada, 2007.

Santolík, O., Gurnett, D.A., Pickett, J.S.: Structure of Wave Packets of Whistler-Mode Chorus. WISER Alfvén 2007 Workshop on Space Environment Turbulence, Warsaw, Poland, 2007.

Santolík, O.: Observations of chorus, hiss and equatorial noise emissions. 15th CLUSTER Workshop, Puerto Santiago, Tenerife, Spain, 2008.

Santolík, O., Gurnett, D.A., Pickett, J.S., Cornilleau-Wehrlin, N.: Observations of whistler-mode chorus and equatorial noise in the radiation belts. 37th COSPAR Scientific Assembly, Montreal, Canada, 2008.

Santolík, O.: Overview of recent results on whistler-mode chorus. Dynamical Processes in Space Plasmas, Ein Bokek, Israel, 2008.

Santolík, O.: Nonlinear properties of whistler-mode chorus. The 7th International Workshop on Nonlinear Waves and Turbulence in Space Plasmas (NLW-7), Beaulieu, France, 2008.

Santolík, O., Gurnett, D.A., Picket, J.S., Laakso, H., Masson, A., Cornilleau-Wehrlin, N.: Multi-point observations of chorus and hiss emissions. 29th General Assembly of URSI, Chicago, Illinois, US, 2008.

Schwartz, S., **Hellinger, P.**, Louarn, P., Nakamura, R., Owen, C. J., Pincon, J. L., Sorriso-Valvo, L., Vaivads, A., Wimmer-Schweingruber, R., Fujimoto, M., Saito, Y., Bale, S., Kessel, M., Escoubet, C. P., Falkner, P., Opgenoorth, H., Taylor, M. G. G. T., Wielders, A.: Cross-Scale: multi-scale coupling in space plasmas. EGU General Assembly, Vienna, Austria, 2008.

Šindelářová, T., **Laštovička, J.**, **Burešová, D.**, **Chum, J.**: Investigations of ionospheric infrasound in the Czech Republic. EGU General Assembly, Vienna, Austria, 2008.

Truhlík, V., Bilitza, D., Richards, P.G., **Třísková, L.**: Towards an empirical representation of solar activity variation of electron temperature for IRI. 37th COSPAR Scientific Assembly, Montreal, Canada, 2008.

Zacharov, P., **Řezáčová, D.**: The use of fraction skill score to assess the relationship between ensemble QPF spread and skill. EGU General Assembly, Vienna, Austria, 2008.

Other international activities

- Coordination of international scientific collaboration within IAGA by J. Laštovička as a member of the Executive Committee of IAGA and chairman of the IAGA/ICMA WG 'Long-term trends in the mesosphere, thermosphere and ionosphere', and P. Šauli as co-chair of working group II.C of IAGA; within COSPAR by J. Laštovička as a member of the COSPAR Council and chair of the Czech National Committee; within EGU by J. Laštovička as EGU secretary for the ionosphere.
- Operating the Regional Warning Center (RWC Prague), which is one of the 11 centres of the worldwide network ISES (head D. Burešová).
- Coordination of international scientific collaboration within URSI by V. Fiala as a member of the URSI Council, O. Santolík as elected vice-chair of international commission H of URSI.
- Memberships in national commitees of URSI (V. Fiala – chairman of the Czech national committee of URSI; O. Santolík – member of commission H, Waves in Plasmas; J. Boška – member of commission G, Ionospheric Radio; O. Fišer – secretary of the Czech national committee of URSI) and COSPAR (O. Santolík – member of the committee).
- J. Laštovička is a member of panel evaluating projects in the ERC program Ideas.
- P. Hellinger is a member of the Cross-scale Science Study team within the ESA Cosmic vision program.
- P. Trávníček is a member of Atmosphere Magnetosphere Data Group (AMDG) of the NASA project MESSENGER.

- J. Laštovička is co-chairman of WG-1 of COST 296, D. Burešová is co-chair of WP1.2 of COST 296, P. Šauli is co-chair of WP3.1 of COST 296.
- D. Řezáčová and Z. Sokol are members of the Management Committee of COST 731.
- R. Huth is a vice-chair of the Management Committee of COST 733, Czech national representative there, and chair of its WG-1.
- J. Hošek is a vice-chair of WG-1 of COST 727.

- Editorial activities
- Co-editor of *Advances in Space Research* (J. Laštovička)
- Memberships in editorial boards/advisory boards of *International Journal of Climatology* (R. Huth), *Meteorologische Zeitschrift* (R. Huth), *Studia geophysica et geodaetica* (J. Laštovička and R. Huth)
- Guest-editors of special issues of *Journal of Atmospheric and Solar-Terrestrial Physics, Advances in Space Research* (J. Laštovička) and *Theoretical and Applied Climatology* (R. Huth)

9. Awards

International Awards

The contribution of **I. Nemešová** to the efforts of the Intergovernmental Panel for Climate Change (IPCC), for which the **Nobel Peace Prize** was awarded in 2007, was acknowledged by the IPCC.

D. Kouba and **F. Němec** received the URSI Young Scientist Award for publication activity in 2008.

National Awards

D. Řezáčová and **M. Kašpar** received **the Josef Hlávka award** of the Hlávka foundation and the Czech Literary Foundation for the best Czech monograph in natural sciences in 2007; the award was given for book 'Cloud and precipitation physics' by D. Řezáčová, P. Novák, M. Kašpar and M. Setvák.

J. Horák received **the award of the chancellor of the Charles University in Prague** for the best Czech monograph in mathematics and physics in 2008; the award was given for book 'Deterministic chaos and curious kinetics'.

F. Němec was awarded the 3rd place in the competition for **the Milan Odehnal award** by the Czech physical society in 2008.

The Otto Wichterle prize was awarded to **P. Šauli** in 2007; the prize is given by the Council of the Academy of Sciences of the Czech Republic 'to outstanding young scientists under 35 years in the Academy of Sciences'.

J. Kyselý received **the Josef Hlávka award** for best graduates and young scientists under 33 years of age in 2007.

For their life-time work, **V. Lahovský** and **V. Veselý** received **the Certificate of Recognition** from the president of the Academy of Sciences of the Czech Republic in 2007.

10. Educational Activities

Teaching in undergraduate and postgraduate courses

Undergraduate courses

- Ionospheric physics (P. Šauli; Universite de Rennes, France)
- Physical climatology (J. Kyselý; Faculty of Mathematics and Physics, Charles University, Prague)
- Mathematical modelling of cloud and precipitation processes (D. Řezáčová; Faculty of Mathematics and Physics, Charles University, Prague)
- Weather chart analysis II (Z. Sokol; Faculty of Mathematics and Physics, Charles University, Prague)
- Selected topics in hydrometeorology (M. Müller, Faculty of Science, Charles University, Prague)
- Physical processes in the atmosphere (D. Řezáčová; Faculty of Science, Charles University, Prague)
- Geographical information systems in meteorology and climatology (J. Hošek; Faculty of Science, Charles University, Prague)
- Numerical modelling of plasmas (P. Trávníček; Faculty of Nuclear Science and Physical Engineering, Czech Technical University, Prague)
- Current topics in meteorology, climatology and air protection (R. Beranová, V. Bližňák, M. Cahynová, D. Hanslian, J. Hošek, P. Chaloupecký, Z. Chládová, J. Moliba, T. Šindelářová, P. Zacharov; Faculty of Science, Charles University, Prague)
- Electrical engineering and measurements (O. Fišer; Jan Perner Transport Faculty of the University of Pardubice)
- Electromagnetic compatibility (O. Fišer; Faculty of Electrical Engineering and Informatics of the University of Pardubice)
- High frequency technology for communications (O. Fišer; Faculty of Electrical Engineering and Informatics of the University of Pardubice)

Postgraduate courses

All postgraduate courses are taught at the Faculty of Mathematics and Physics, Charles University, Prague:

- Predictability of atmospheric processes (J. Horák)
- Applications of multivariate statistical methods in meteorology and climatology (R. Huth)
- Topical issues in synoptic climatology (R. Huth)
- Stratosphere and mesosphere (J. Laštovička)
- Applied cloud and precipitation physics (D. Řezáčová)
- Expert systems in meteorology (D. Řezáčová)

Supervising diploma and PhD theses

The staff of the IAP have served as supervisors and consultants of diploma and PhD theses of students of the Faculty of Mathematics and Physics and the Faculty of Science, Charles University, Prague; University of Pardubice; Czech Technical University; Universite de Paris 6, France; University of Alberta, Canada; and Ebro Observatory, Roquetes/Tortosa, Spain.

Defended ***diploma theses*** (in parantheses are given the names of the MSc student and his supervisor/consultant from the IAP):

- ***Analysis of short term precipitation and its relationship to the orography of the Czech Republic*** (**V. Bližňák**, Faculty of Science, Charles University, Prague, 2007; supervisor **Z. Sokol**)
- ***Effects of sudden air temperature and pressure changes on mortality*** (**E. Plavcová**, Faculty of Mathematics and Physics, Charles University, Prague, 2008; supervisor **J. Kyselý**)
- ***Verification of normality of statistical distributions for selected climate elements*** (P. Jelínek, Faculty of Mathematics and Physics, Charles University, Prague; supervisor **R. Huth**)

Defended ***PhD theses*** both supervised and conducted by the staff of the IAP (in parantheses are given the names of the PhD student and his supervisor/consultant, the staff of the IAP is in bold):

- ***Specifics of climate of Prague and its relation to the air pollution*** (**J. Hošek**, Faculty of Science, Charles University, Prague; supervisor I. Sládek, Charles University, Prague)
- ***Hydrometeorological conditions of the origin of significant rain floods in the Czech territory*** (**M. Müller**, Faculty of Science, Charles University, Prague; supervisor I. Sládek, Charles University, Prague)
- ***Long-term variability of relationships between atmospheric circulation and surface climate elements*** (**R. Beranová**, Faculty of Mathematics and Physics, Charles University, Prague; supervisor **R. Huth**)

Habilitation thesis (for title 'Associate Professor') defended in 2007–2008:

- ***Very short-range precipitation forecast*** (**Z. Sokol**, Faculty of Mathematics and Physics, Charles University, Prague, 2007)

Memberships in university bodies

The cooperation of the IAP with universities is also realized through numerous memberships of the staff members in various university bodies. Of them, the most important are:

Scientific councils:

- Faculty of Mathematics and Physics, Charles University, Prague (J. Laštovička)
- Dept. of Geography, Faculty of Science, Charles University, Prague (D. Řezáčová)
- Faculty of Electrical Engineering and Informatics, University of Pardubice (O. Fišer)

Board for graduate state exams:

- Faculty of Mathematics and Physics, Charles University, Prague: Meteorology and climatology (J. Laštovička, D. Řezáčová)
- Faculty of Science, Charles University, Prague: Physical geography (D. Řezáčová, J. Štekl)
- Faculty of Electrical Engineering, Czech Technical University (O. Fišer)
- Jan Perner Transport Faculty, University of Pardubice (O. Fišer)
- Faculty of Electrical Engineering and Informatics, University of Pardubice (O. Fišer)

Boards for doctoral studies:

- Faculty of Mathematics and Physics, Charles University, Prague: Meteorology and climatology (R. Huth, J. Laštovička, D. Řezáčová, Z. Sokol), Physics of plasma and ionized media (J. Laštovička), Physics (R. Huth, D. Řezáčová)
- Faculty of Science, Charles University, Prague: Physical geography (D. Řezáčová, J. Štekl)
- Faculty of Science, Masaryk University, Brno: Climatology and hydrology (J. Štekl)
- Faculty of Electrical Engineering and Informatics, University of Pardubice: Electrical Engineering and Informatics (O. Fišer)

11. Cooperation with Other Institutions in the Czech Republic

In 2007–2008, the IAP had 10 joint research projects with **national universities**. The subjects include plasma and space physics, climate variability and modelling, climate change impacts, extreme value analysis, theory of dynamical systems, and telecommunication systems. The cooperating departments are:

- Dept. of Surface and Plasma Science (former Dept. of Electronics and Vacuum Physics), Charles University, Prague,
- Dept. of Meteorology and Environment Protection, Charles University, Prague,
- Institute of Agrosystems and Bioclimatology, Mendel University of Agriculture and Forestry, Brno,
- Dept. of Electromagnetic Field, Czech Technical University, Prague,
- Dept. of Applied Mathematics, Technical University, Liberec,
- Faculty of Electrical Engineering and Communication, Technical University, Brno.

Within the **Academy of Sciences of the Czech Republic**, the IAP collaborates through joint grant projects mainly with the Institute of Geophysics, Astronomical Institute, Institute of Computer Science, Hydrobiological Institute, Institute of Hydrodynamics, Institute of Geology, and Institute of Systems Biology and Ecology.

The IAP participates in the **National Climate Programme**, which joins institutions in the Czech Republic dealing with climate, climate change, and its impacts.

A continual cooperation with the **Czech Hydrometeorological Institute** concerns mainly research on severe meteorological phenomena, radar meteorology and climatology.

The cooperation with the **Czech Metrological Institute** (formerly **TESTCOM**) is focused on the research on radiowave propagation through the atmosphere, by establishing a joint 800 m long experimental link at the frequency of 58 GHz, to obtain a continuous record of atmospheric attenuation.

Other important activities of the staff include the membership in the following bodies:

- Board of the Institute of Geophysics, AS CR (J. Laštovička)
- Supervisory Board of the Astronomical Institute, AS CR (J. Laštovička)
- Specialized commissions of the Grant Agency of the Czech Republic, sub-commission 205 Earth and Space Sciences: D. Řezáčová – chair of the sub-comission, D. Burešová (till 2007/4), J. Laštovička (since 2007/5).
- Grant Agency of the Academy of Sciences of the Czech Republic, sub-commission 3 Earth and Space Sciences: P. Šauli (till 2007/4), D. Burešová (since 2007/5), I. Nemešová (till 2008/10).
- Committee for International Collaboration of the Academy of Sciences (D. Burešová)
- Committee for Environment of the Academy of Sciences (I. Nemešová, till 2008/10)
- Examinatory board of the Ministry of Transport (section of shipping) to test the qualification of examinators in meteorology (V. Kakos)
- Editorial board of Meteorological bulletin (D. Řezáčová)
- Board of the Czech Meteorological Society (D. Řezáčová) and its Prague division (V. Kakos, P. Sedlák)

12. Popularization activities

The important popularization activities of the staff of the IAP and of the Institute as a whole were as follows:

Days of Science are organized annually with the aim of opening the research institutions to the public. Majority of the institutes of the Academy of Sciences, as well as many other research institutions take part in them. The IAP organizes exhibitions in its main building in Prague and at the Milešovka and Panská Ves observatories. The exhibitions are attended by several hundreds of interested people annually, mainly by secondary school students. Every year on the **World Day of Meteorology** (March 23), the Milešovka observatory is open to the public.

The results of the Institute's research were presented at various **exhibitions and lectures** for a broad community of meteorologists/physicists, general audience, and secondary school students.

The staff of the IAP participated in activities (lectures, student competitions) related to the **International Heliospheric Year** in 2007. In October to December 2008, the IAP organized an **exhibition to celebrate the 30th anniversary of the launch of satellite MAGION 1** in Planetarium Prague.

The experts from the IAP were invited to the **TV and radio** news and other programmes, mainly to inform on topical aspects of climate change, floods, severe storms, renewable energy resources, development of the ozone layer, trends in the middle and upper atmosphere, space science, Amálka supercomputing facility, etc. A press conference was held on November 28, 2007, to announce recent scientific achievements having utilized the Amálka supercomputing facility.

The staff of the IAP were also interviewed for **newspapers** and collaborated on preparation of many newspaper and magazine articles. Experts from the IAP on environmental aspects of meteorology and climatology were co-authors or reviewers of several **popular-scientific books**.

13. Publications in 2007 and 2008

A. Publications in international peer-reviewed journals with impact factor

Altadill, D., Arrazola, D., Blanch, E., **Burešová, D.** (2008) Solar activity variations of ionosonde measurements and modeling results. Advances in Space Research, 42, 610–616.

Baranets, N. V., Sobolev, Ya. P., Ciobanu, M., **Vojta, J.**, **Šmilauer, J.**, Klos, Z., Rothkaehl, H., Kiraga, A., Kudela, K., Matišin, J., Afonin, V. V., Ryabov, B. S., Isaev, N. V. (2007) Development of beam-plasma instability during the injection a low-energy electron beam into the ionospheric plasma. Plasma Physics Reports, 33, 995–1013.

Barriopedro, D., García-Herrera, R., **Huth, R.** (2008) Solar modulation of Northern Hemisphere winter blocking. Journal of Geophysical Research, 113, D14118, DOI: 10.1029/2008JD009789.

Beranová, R., **Huth, R.** (2007) Time variations of the relationships between the North Atlantic Oscillation and European winter temperature and precipitation. Studia geophysica et geodaetica, 51, 575–590.

Beranová, R., **Huth, R.** (2008) Time variations of the effects of circulation variability modes on European temperature and precipitation in winter. International Journal of Climatology, 28, 139–158.

Bilitza, D., **Truhlík, V.**, Richards, P., Abe, T., **Třísková, L.** (2007) Solar cycle variations of mid-latitude electron density and temperature: Satellite measurements and model calculations. Advances in Space Research, 39, 779–789.

Blanch, E., Arrazola, D., Altadill, D., **Burešová, D.**, Mosert, M. (2007) Improvement of IRI B0, B1 and D1 at mid-latitude using MARP. Advances in Space Research, 39, 701–710.

Bortnik, J., Thorne, R. M., Meredith, N. P., **Santolík, O.** (2007) Ray tracing of penetrating chorus and its implications for the radiation belts. Geophysical Research Letters, 34, L15109, DOI: 10.1029/2007GL030040.

Bougeret, J. L., Goetz, K., Kaiser, M. L., Bale, S. D., Kellogg, P. J., Maksimovic, M., Monge, N., Monson, S. J., Astier, P. L., Davy, S., Dekkali, M., Hinze, J. J., Manning, R. E., Aguilar-Rodriguez, E., Bonnin, X., Briand, C., Cairns, I. H., Cattell, C. A., Cecconi, B., Eastwood, J., Ergun, R. E., Fainberg, J., Hoang, S., Huttunen, K. E. J., Krucker, S., Lecacheux, A., MacDowall, R. J., Macher, W., Mangeney, A., Meetre, C. A., Moussas, X., Nguyen, Q. N., Oswald, T. H., Pulupa, M., Reiner, M. J., Robinson, P. A., Rucker, H., Salem, C., **Santolík, O.**, Silvis, J. M., Ullrich, R., Zarka, P., Zouganelis, I. (2008) S/WAVES: The Radio and Plasma Wave Investigation on the STEREO Mission. Space Science Reviews, 136, 487–528.

Breneman, A., Kletzing, C. A., **Chum, J.**, **Santolík, O.**, Gurnett, D., Pickett, J. (2007) Multispacecraft observations of chorus dispersion and source location. Journal of Geophysical Research, 112, A05221, DOI: 10.1029/2006JA012058.

Burešová, D., **Krasnov, V. M.**, **Drobzheva, Y. V.**, **Laštovička, J.**, **Chum, J.**, **Hruška, F.** (2007) Assessing the quality of ionogram interpretation using the HF Doppler technique. Annales Geophysicae, 25, 895–904.

Burešová, D., **Laštovička, J.** (2007) Pre-storm enhancements of foF2 above Europe. Advances in Space Research, 39, 1298–1303.

Burešová, D., **Laštovička, J.** (2008) Pre-storm electron density enhancements at middle latitudes. Journal of Atmospheric and Solar-Terrestrial Physics, 70, 1848–1855.

Califano, F., **Hellinger, P.**, Kuznetsov, E., Passot, T., Sulem, P. L., **Trávníček, P.** (2008) Nonlinear mirror mode dynamics: Simulations and modeling. Journal of Geophysical Research, 113, A08219, DOI: 10.1029/2007JA012898.

Chum, J., **Laštovička, J.**, **Šindelářová, T.**, **Burešová, D.**, **Hruška, F.** (2008) Peculiar transient phenomena observed by HF Doppler sounding on infrasound time scales. Journal of Atmospheric and Solar-Terrestrial Physics, 70, 866–878.

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Explanation of acronyms used in the text

AGU – American Geophysical Society
AS CR – Academy of Sciences of the Czech Republic
a.s.l. – above sea level
co-I – co-investigator
COSPAR – Committee for Space Research
COST – European Cooperation in Scientific and Technical Research
EGU – European Geosciences Union
ERC – European Research Council
ESA – European Space Agency
EU – European Union
GA AS – Grant Agency of the Academy of Sciences of the Czech Republic
GA CR – Czech Science Foundation / Grant Agency of the Czech Republic
IAGA – International Association of Geomagnetism and Aeronomy
IAP – Institute of Atmospheric Physics
IRI – International Reference Ionosphere
ISES – International Space Environment Service
IUGG – International Union of Geodesy and Geophysics
NASA – National Aeronautics and Space Administration
PI – principal investigator
URSI – International Union of Radio Sciences
WG – Working Group