First International Symposium on Space Climate
"Direct and Indirect Observations of Long-Term Solar Activity"

Abstract and participant booklet

June 20-23, 2004, Oulu, Finland

CONTENT

SYMPOSIUM PROGRAM

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1000-1030 Makarov, V.: Long-term changes of polar activity of the Sun (*Invited*)

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Session: Solar dynamo

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Session: Solar Proxies: 14C

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1530-1600 Miyahara, H.: The 11-year solar cycle during the Spörer and the Maunder minima (*Invited*)

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1230-1300 Kudela, K.: Long-term variations of geomagnetic rigidity cutoffs (*Invited*)

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P4 Usoskin, I.G.: Sunspot activity during the Maunder minimum: The upper limit

P5 Kozlovsky, A.: A model equation for the sunspot activity

P6 Nagovitsyn, Yu.A.: ESAI database and some properties of solar activity in the past

P7 Vanlommel, P.: The 'Solar Influences Data analysis Center' as 'World Data Center' for the Sunspot Index

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P14 Tlatov, A.G.: Oscillations in the polarized solar radio emission at 1.76 cm wavelength during 1992-2002

P15 Tlatov, A.G.: Properties of the magnetic fields in the coronal holes in the period of the 22nd-23rd activity cycles

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P22 Raspopov, O.: October-November, 2003 solar events as manifestation of the long-term solar activity

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P32 Karinen, A.: Dst index since 1932

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INVITED REVIEWS

Cosmogenic Be-10 as a long-term solar proxy

J. Beer (1), M. Vonmoos (1), W. Mende (2), R. Muscheler (3)

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Cosmogenic radionuclides such as 10Be, 36Cl, and 14C are produced by the interaction of galactic cosmic rays with the atmosphere. Since the propagation of cosmic rays through the heliosphere is modulated by the solar wind the production rate of radionuclides can be used as a measure of the intensity of the solar activity. Unlike a neutron monitor which continuously records the neutron flux at a specific site the production rate of cosmogenic radionuclides cannot be recorded on-line. Instead the number of produced nuclides is determined and used to derive the cosmic ray intensity. The solar activity is then calculated making use of the known relationship between cosmic ray intensity and solar activity. This procedure has the great advantage that the production rate can be reconstructed over thousands of years provided the half-life of the radionuclide is long enough and the produced nuclides are stored sequentially in an appropriate archive. Such archives are for example ice sheets in the case of 10Be and 36Cl and tree rings in the case of 14C. The disadvantage of this method, however, is that fluctuations in the transport from the atmosphere into the archive cannot easily be distinguished from production changes. In addition, when reconstructing the solar activity over many millennia one has to take into account the fact that the varying geomagnetic dipole field causes a long-term change in the production rate which has to be corrected for.

Using detailed 10Be records from polar ice cores the solar activity of the past 9000 years is reconstructed. The potential as well as the limitations of this approach is discussed.

Presenting author: J. Beer, e-mail: *beer@eawag.ch*

Large-scale non-axisymmetric magnetic fields on the Sun and cool stars

Svetlana Berdyugina

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The magnetic activity of the Sun is known to be asymmetric in both North–South (N–S) and East–West (E–W) directions. While the existence of the N–S asymmetry was largely accepted and confirmed by numerous studies of various features of solar activity, the E–W asymmetry was not so obvious on longer time scales. The modulation of the activity with nearly the solar rotation period suggests however for the existence of long-lived complexes of activity at preferred longitudes. For instance, two preferred active longitudes in both Southern and Northern hemispheres were found to be persistent at the century time scale. The pattern and behaviour of the active longitudes on the Sun was found to be similar to that on cool, rapidly rotating stars with outer convective envelopes. This suggests that the magnetic dynamo processes are similar in such stars. Also, this allows us to overview the phenomenon of stellar magnetic activity and to study it in detail on the Sun.

Presenting author: S. Berdyugina, e-mail: *sveta@astro.phys.ethz.ch*

The 1859 Solar-Terrestrial Event: Space Weather's "100-yr Flood"

E. Cliver

Air Force Research Laboratory, Hanscom AFB, MA, 01731-3010 USA

Extreme events are a key aspect of space weather climatology. What is the space weather equivalent of the "100-yr flood"? By a remarkable coincidence, the first flare ever reported, by R.C. Carrington and R. Hodgson on September 1, 1859, was followed by a severe geomagnetic storm that has not been equaled since. In this talk, I compare various measures of the 1859 solar-terrestrial event (size of: flare, sudden ionospheric disturbance, solar energetic particle event, geomagnetic storm; inferred CME transit time) with those of other major events occurring during the past 150 years. The 1859 event stands at or near the top of the list in each of these categories. While the 1859 solar eruption originated in a sunspot group that was large and complex, the active region was not nearly as extreme as the event it produced.

Presenting author: E. Cliver, e-mail: *edward.cliver@hanscom.af.mil*

Long term solar irradiance measurements (1978-2004): results and uncertainties

S. Dewitte

Royal Meteorological Institute of Belgium

A possible long term trend of the total solar irradiance could be a natural cause for climate variations on earth. Measurement of total solar irradiance with space radiometers have started in 1978. With the progress of instrument metrology, the accuracy of the instruments has increased gradually in time.

We present the results of the total solar irradiance measurements made up to the present. The uncertainty of this time seris is derived by an objective comparison of the time series of the individual instruments that contribute to it.

Presenting author: Steven Dewitte, e-mail: *Steven.Dewitte@oma.be*

Nitrate as a proxy of extreme solar energetic particle events in the past

G.A.M. Dreschhoff(1), K.G. McCracken(2), M. A. Shea (3) and D.F. Smart(3)

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Nitrate (NO_3-) are unique among trace compounds in the snow of the polar ice sheets, because their variation in concentration reflects, in part, the ionization history of the polar atmosphere. It has been shown that major solar proton events produce strong nitrate anomalies that are traceable in the north and south polar ice sheets. The nitrate anomalies are of a characteristic impulsive (<6 weeks) nature, and are superimposed on a background of seasonal variations. The impulsive anomalies remain unchanged in a medium that undergoes various stages of compaction and metamorphism, and are detected by ultrahigh resolution measurements of nitrate and simultaneous electrical conductivity with a flow-through system. While signal verification has been a major goal, the evaluation of the nitrate signal (a) in relation to the longer-term geophysical records of mid-latitude magnetic and auroral activity, and (b) in terms of particle flux of major solar proton events have been companion endeavors.

As reported previously, we have identified 125 impulsive nitrate events with a >30 MeV fluence >1.0x10^9 cm^{-2} in a Greenland ice core corresponding to the period 1561-1950. The largest corresponds to the "white light" flare observed by Carrington in 1859, and we estimate that it had a fluence four times greater than those observed since 1950. The frequency of occurrence of the impulsive events varies strongly with time, ranging from 0 to 6 per solar cycle. We report here a comparison of the event frequency, and the strength of the interplanetary field, based upon an inversion of cosmogenic ^{10}Be results using the cosmic ray transport equation. A strong association is apparent, the greatest frequencies of impulsive events being associated with the lowest interplanetary field strength. The implications regarding the connection between the closed and open solar fields will be discussed. In general, the frequency distribution of the impulsive nitrate events follows the short-term (11-yr) and longer-term 80-yr periodicities of the Gleissberg cycle, indicating that the occurrence of the nitrate events is determined by a production term (roughly proportional to sunspot number) and a transmission term (inversely proportional to the strength of the open field). We propose that these impulsive nitrate anomalies, together with the properties of the open field inferred from cosmogenic ^{10}Be data, provide the ability to investigate the properties of the heliosphere into the past.

Presenting author: Gisela A.M. Dreschhoff, e-mail: *giselad@ku.edu*

Models of the solar dynamo

Antonio Ferriz-Mas (1,2)

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An outstanding feature in the history of surface solar activity is a prolonged minimum between 1645 and 1715, known as the Maunder Minimum. Tracing back solar activity by means of proxy data (abundances of cosmogenic isotopes ^{10}Be and ^{14}C) has shown that grand minima in magnetic activity are a recurrent feature. The mean solar magnetic field behaves irregularly in time. Grand minima are the most prominent manifestation of this irregularity, albeit not the only one: it is also apparent in the length and amplitude variations of the 11-year sunspot cycle.

Although the statistical and spectral properties of solar activity –as measured by the sunspot number– are still not well known, there is evidence for various modulations of the solar cycle. The question whether the observations and the historical sunspot record allow to distinguish between a stochastic or a deterministic origin of the irregularity in the solar cycle seems to be as yet unresolved.

Most of the computations aiming at describing intermittent activity are based on low-order systems of ordinary differential equations (ODE) which can be considered as truncated expansions of the partial differential dynamo equations (PDE), but also models based on full PDE may lead to intermittent behaviour. Although all theoretical models of the solar dynamo rely on mean-field dynamo theory, in which the small-scale turbulent motion is parametrized in order to compute large-scale effects, there are significant differences in the physical assumptions considered by different groups.

Various alternative scenarios for the long-term magnetic activity will be critically reviewed.

Presenting author: Antonio Ferriz-Mas, e-mail: *antonio.ferriz@oulu.fi*

Helioseismic probing of the solar cycle

Laurent Gizon

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Observations of global solar oscillations, available since the rise of cycle 22, have revealed solar-cycle variations in the structure and dynamics of the Sun. These changes, which are detectable in the upper convection zone, have now been mapped as a function of latitude for cycle 23 (MDI/SOHO and GONG data). I will review these observations. To complement techniques of global helioseismology that have no resolution in longitude and cannot distinguish the northern from the southern hemisphere, new techniques of local helioseismology are being developed. I will present new results that show connections between magnetic activity and local flows (from meridional circulation to supergranulation).

Presenting author: Laurent Gizon, e-mail: *lgizon@solar.stanford.edu*

What the long-term sunspot record tells us about space climate?

David H. Hathaway

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Direct observations of sunspots span the nearly 400 years since the time of Galileo. Dedicated observing programs at several observatories over the last 150 years have provided detailed information not only on the number of sunspots but on their sizes and positions as well. The data acquired by those original observers, and by those who have more recently brought those observations to light, provide important clues about the nature of the solar cycle and its contribution to space climate. The period of the cycle, the equator-ward drift of the active latitudes, the asymmetry between the rise to maximum and the fall to minimum, shifting asymmetries between northern and southern hemisphere activity, the tilt of active regions, and the increasing amplitude of the cycles since the Maunder Minimum are all well established. Other, less well established characteristics such as multi-cycle and short-term periodicities, often depend upon the method of data analysis. The strong correlation between sunspot statistics and other measures of solar activity, coupled with the length of the sunspot record, make these observations extremely valuable for characterizing and understanding space climate.

Presenting author: David H. Hathaway, e-mail: *david.hathaway@nasa.gov*

Review of long-term solar activity inferred from tree-ring based C-14 measurements

Bernd Kromer (1) and Michael Friedrich (2)

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(2) Michael Friedrich, Institute of Botany, University of Hohenheim, Stuttgart, Germany

The production of cosmogenic isotopes, such as 14C and 10Be, reflects changes in heliomagnetic activity, due to magnetic shielding of cosmic rays. Tree-ring chronologies are ideal archives of past 14C activity, as they can be dated absolutely to annual accuracy, and they provide reliable carbon samples for high-precision 14C analyses. We present time series of atmospheric 14C activity back to 12.440 BP and discuss the mechanisms that caused decadal to millennial fluctuations in the 14C signal. In the Holocene the solar signal is considered to dominate, but reservoir changes (through ocean ventilation changes) may play a secondary role. We recently extended the tree-ring based 14C record into the Late Glacial, where ocean dynamics potentially could have been more significant. We discuss solar versus oceanic contributions in the 14C signal by comparing the atmospheric and ocean mixed-layer 14C level.

Presenting author: Bernd Kromer, e-mail: *bernd.kromer@iup.uni-heidelberg.de*

Long term variations of geomagnetic rigidity cutoffs

Karel Kudela and Pavol Bobik

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Using the results published earlier (e.g. Smart and Shea, 28th ICRC, 7, 4201, 2003; Shea and Smart, 28th ICRC, 7, 4205, 2003; 27th ICRC, 10, 4063, 2001) and the trajectory calculations of cosmic ray in the geomagnetic field, the changes of vertical cutoff rigidities in the past and their consequences for cosmic ray access to the Earth are discussed. The computations of vertical cutoff rigidities are done for selected positions at the Earth's surface using the IGRF model data for the period 1900 - 2000. In addition, the disturbed field is approximated by Tsyganenko'89 model. The differences in variability of cutoff in different positions on the Earth's surface are described. The estimates of cutoff rigidities using the first three Gauss coefficients for the period of years between 0 and 2000 are computed according to magnetic field described in papers (Hongre et al., Phys. Earth Planet. Inter., 106, 311, 1998; Bloxham and Jackson, J. Geophys. Res., 97 (B13), 19537, 1992).

Presenting author: Karel Kudela, e-mail: *kkudela@kosice.upjs.sk*

Long-term changes in the open solar magnetic flux, the total photospheric flux and the total solar irradiance

M.Lockwood (1, 2)

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Century-scale changes in the open solar flux have been deduced from geomagnetic and auroral activity and from the abundance of cosmogenic isotopes. In the past, the aa geomagnetic activity has been used, but it is shown that the results are very similar for other geomagnetic indices, provided that they do not introduce spurious sampling effects nor systematic calibration errors. The several numerical simulations which have reproduced this long-term change in the open solar flux do not need to introduce emergence of small magnetic flux tubes outside of active regions: however, this does not mean that such flux is not present and that it has not varied over the past century. The correlation between open solar flux and Total Solar Irradiance, implicitly or explicitly assumed in many paleoclimate studies, is discussed and its implications assessed for facular brightening and the photospheric magnetic fields outside of active regions. Using careful inter-calibration of a composite sunspot group data series from Greenwich, Pulkovo and Mt Wilson, both the brightening and darkening effect of active regions can be quantified. Using the contrasts of small flux tubes derived for red continuum emission by the MDI instrument on the SoHO spacecraft, limits are placed on the solar irradiance variation over the past 150 years, an important component in terrestrial climate change between about 1900 and 1955. Three new reconstructions of the TSI are presented which establish the range of potential behaviour, based on three assumptions about magnetic flux emergence during the Maunder minimum.

Presenting author: M.Lockwood, e-mail: *m.lockwood@rl.ac.uk*

Long-term changes of polar activity of the sun

V.I. Makarov, A.G. Tlatov

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The analysis of the polar activity of the Sun was carried out using the observations in the optical, x-ray and radio ranges. The peculiarities of the magnetic activity on the high latitudes are discussed:
- an increase of the area of polar caps, occupied by unipolar magnetic field at the minimum activity during 1878-2000,
- a decrease of coronal temperature at the high-latitude zones during the last 50 years,
- the temperature deficit during the Maunder Minimum relative to the present,
- the connection between the polar activity and sunspot activity,
The comparison of various activities was carried out using the different tracers. It was shown that the bright features in the white light and in the x-ray ranges on the high latitudes had as a rule the bi-polar magnetic field structures.

The work was supported by Russian Foundation for Basic Research, grants 02-02-16035, 03-02-16091.

Presenting author: V. Makarov, e-mail: *makarov@gao.spb.ru*

The 11-year solar cycle during the Spörer and the Maunder minima

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(1) Nagoya University, Solar-Terrestrial Environment Laboratory, Japan
(2) Nagoya University, Graduate School of Earth and Environmental Sciences, Japan
(3) Nagoya University, Center for Chronological Research, Japan

We have measured the radiocarbon concentration of annual tree-rings for the period around the Spoerer (1415–1534 AD) and the Maunder (1645–1715 AD) minima in order to investigate the characteristics of solar activity during the grand solar minima. We are mainly interested in the 11-year and the 22-year cycle, which are clearly seen in the recent solar activity but suggested that they might have been different due to the extraordinary calming down of the sun as can be seen in the sunspot records for the Maunder Minimum.
We used two Japanese cedar trees of 714 and 382 years old obtained at 30N 130E and 34N 136E respectively, and have conducted the measurement for 1409–1551AD and 1630–1730 AD. The $^{14}C/^{12}C$ ratio in each tree ring was measured by using the Accelerator Mass Spectrometer of Nagoya University in Japan. This machine achieves the accuracy of about three per mill of Delta ^{14}C.
We have completed the annual measurement for 1409–1551 AD and biannual measurement for 1630–1730 AD. Both of the time series showed the Delta ^{14}C level consistent with the decadal radiocarbon data previously derived by Stuiver et al. Then, the time series were analyzed for the periodicities. The power spectrum for the Spoerer Minimum showed the peaks around 7, 11 and 22 years. The 11-year periodicity was most dominant, however, the time profile showed that it was weakened around 1460–1510 AD. During this period, the amplitude of the 11-year cycle in radiocarbon concentration (Delta ^{14}C) kept less than 1 per mill. The 11-year cycle for the Maunder Minimum also showed the similar trend as was seen in the Spoerer Minimum, although its amplitude kept less than 1 per mill in most of the period during 1630–1730 AD. Peristykh and Damon have also pointed out that there is a weakening trend of the 11-year cycle during the Maunder Minimum. These results might be suggesting the consistency of weakening of the 11-year cycle during the grand solar minima and its close relation to the intensity of solar activity.

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Solar hemispherical and longitudinal asymmetry in the heliosphere

K. Mursula

Department of Physical Sciences, University of Oulu, Finland

Several studies during many decennia have tried to find possible longitudinal and hemispherical asymmetries in various forms of solar activity. E.g., sunspots have been found to occur preferably in two roughly back-to-back longitude sectors, the so called active longitudes. Also, there are well known periods when one of the solar hemispheres has dominated the other in sunspot numbers, flare occurrence or some other form of solar activity. However, the significance of these solar asymmetries has so far remained rather modest since they have not been found to be very conclusive or to form any clear systematical patterns (e.g., relation to solar cycle). On the contrary, recent studies of similar solar longitudinal and hemispherical asymmetries in various heliospheric parameters have shown a very clear and systematic behaviour. E.g., it was found recently that the dominance of the two IMF sectors experiences an oscillation with a period of about 3.2 years. This new flip-flop periodicity in the open solar magnetic field is quite systematic and most likely related to a similar periodicity in solar surface magnetic fields and sunspots. Also, it has been found that the IMF sector of the northern solar hemisphere dominates at 1AU during solar minimum times. This leads to a persistent southward shift or coning of the heliospheric current sheet that can be picturesquely described by saying that the Sun is a bashful ballerina who is repeatedly trying to push her excessively high flaring skirt downward. This result also implies that the Sun has a large-scale quadrupole magnetic moment. Even the properties of the solar wind depict clearly solar cycle related hemispheric asymmetries. In this paper we review these recent developments concerning the longitudinal and hemispherical asymmetries detected in the heliopshere.

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Compilation and analysis of space climate data: Geomagnetic and auroral observations

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We have compiled archived geomagnetic observations from the Helsinki magnetic observatory as well as visual sightings of auroral occurrence in Finland. The magnetic database comprises of about 2,000,000 observations of H- and D-components measured during 1844-1909 with the time resolution of 10 min to 1 h (1). In addition, magnetic observations carried out in the First and Second Polar Years in Finland have been recompiled. Magnetic activity indices (three-hour K- and daily Ak-figures) have been derived from the magnetic observations. Comparisons between the Finnish indices and simultaneous global aa-index (starting in 1868) show a good mutual correlation. The Helsinki activity index series can be used as an (pseudo) extension of the aa-index series for about two solar cycles 1844-1868. In the annual level the correlation coefficient is about 0.9 during the overlapped time interval 1868-1897. The auroral database consists of about 20,000 single observations observed in Finland since the year 1750. The database of visual auroras has been completed by auroral occurrence (AO) index data derived from the Finnish all-sky camera recordings during 1973-1997 at several sites in Lapland (2). The AO-index reveals both spatial and temporal variations of auroras from diurnal to solar cycle time scales in different space weather conditions. In the long-term data series there can be clearly seen signatures of Schwabe-, Hale- and Gleissberg-cycles. In the shorter part of the solar periodicities, the terrestrial data series show well defined signals of 13.5 d, 27 d as well as semiannual variations. A local activity peak can be seen in mid-July in magnetic and mid-latitude auroral data. The long-term auroral occurrence frequency shows an increasing trend since about 1900 similarly with the trend in the aa-index indicating a corresponding increase in the solar activity. The current annual level of the aa-index is higher than ever since 1868, which may predict that the high activity level of the long-term solar activity will be continued although the last sunspot maximum (in 2000) remained lower than predicted.

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Statistical Properties of Long-Term Activity and Variability Among Sunlike Stars

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The behavior of stars similar to the Sun offers a powerful approach for constraining the range of possible long-term solar activity and variability. Contemporary astrophysics has accumulated considerable evidence indicating that magnetic activity, governed primarily by stellar rotation and mass and following a predictable evolution, is a normal feature of lower main-sequence stars, including the Sun.

Samples of sunlike stars have been monitored in chromospheric Ca II HK emission since 1966 from Mount Wilson Observatory, and in Stromgren b and y photometry between 1984-2000 from Lowell Observatory and since 1993 from Fairborn Observatory. One bone fide "solar twin" (HD146233 = 18 Sco) has been observed for about a decade. We believe that the full range of variability on activity-cycle timescales has probably now been observed for many of the stars in these samples. The observations suggest that the present-day Sun is fairly typical for a star of its age. If anything, the Sun's current behavior may be somewhat unusually regular and sedate - it is not uncommon to encounter stars that vary more strongly and erratically than the Sun.

Stellar brightness and chromospheric variations follow fairly tight power law relations with respect to mean chromospheric activity. Both diminish with decreasing mean chromospheric activity (or increasing stellar age). The Sun's chromospheric variability lies slightly above the stellar power law, but its brightness variations (about 0.1the 11-year solar cycle) appear somewhat low compared with stars of similar activity levels. Restricting the analysis to the larger sample to stars observed only at Fairborn (but for a shorter length of time) reduces the discrepancy, but the Sun still lies below the best-fit trend line.

This work was supported by the Air Force Office of Scientific Research, the National Science Foundation, and the National Aeronautics and Space Administration.

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Long-term variations in the Sun's shape

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The Sun is a variable star which undergoes changes over a wide range of temporal scales, from seconds to decades, from centuries to millennium. Among the different proxies aiming to study the Sun variability, spots are the most well-known, but different others are also popular, such as the total solar irradiance (TSI), the MgII index, the radio flux, etc. Since now about ten years, it has been advanced that the solar diameter may also varies with time. Such a change in the solar shape rises several questions. In this review, we will first indicate how historical measurements can be used, then we will show that the modern diameter measurements lead to a solar distorted shape. We will indicate some physical mechanisms that could be at the basis of such asphericities and then, we will show why accurate measurements (of astrometric precision) are needed in the future. We will conclude by mentioning some new space missions devoted to such observations, which are also important to detect the signature of a solar activity variability in the climate of our planet.

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Effects of Cosmic rays serving as tracers for the past

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Galactic Cosmic rays are produced outside the solar system and their interstellar spectral flux is generally assumed to be constant on short time periods and, as an average, also on very large time periods. Nevertheless, as is well known, the flux of galactic cosmic rays (GCR's) inside the solar system is known to be modulated due to the GCR interaction with the solar wind turbulence and with the heliospheric magnetic field (HMF), both of which are highly variable over the solar cycle. There exist clear observational hints, that, depending on the polarity of the HMF during the 22-year magnetic solar cycle, different physical mechanisms are important for the GCR modulation, like particle diffusion and particle drift effects. A thorough understanding of these transport processes is necessary to extrapolate the tracer-indicated cosmic ray fluxes into the extended past, especially, to interpret observations of cosmogenic isotopes, which have been produced by the comsic ray bombardment of specific elements (C,N,O,Be) in the Earth's atmosphere. As an example, the cosmic ray fluxes needed to explain the required production rates of cosmogenic elements during the Maunder Minimum are discussed. In conclusion, it will be shown, that over time scales of 100 million years the bombarding cosmic ray fluxes at Earth have to be taken as fairly variable due to the long-periodic changes in the galactic GCR environment around the solar system.

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Maunder minimum in context of solar dynamo theory

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Maunder minimum is a great minimum of solar activity which occurred recent enough to be observed by astronomers directly by telescopes rather to be isolated in isotopic data. Analysis of archive data main bulk of which was obtained by French astronomical school allows to describe a scenario for solar activity during Maunder minimum. In particular, we can believe that the solar dynamo system tried to move into a Great minimum episode a dozen years before the beginning of Maunder minimum however the solar activity recovered prompt. During the recovery times the solar activity was substantially asymmetric. The very transition into the Maunder minimum seems to be abrupt however the recovery at the end of Maunder minimum occupied quite a long time. The sunspot distribution during the last years of Maunder minimum demonstrated strong North-South asymmetry. We discuss to what extent these features can be reproduced by solar dynamo models. In particular, we discuss to what extent the Maunder minimum can be considered as an intrinsic episode of solar magnetic field evolution rather to include features connected with something occurred with solar hydrodynamics. The role of Dalton minimum as well as Maunder minima type events in activity of solar type stars in understanding of great minima is discussed.

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Long-term solar irradiance variations: From current measurements to long-term estimates

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Measurements of solar irradiance are now available for around 2.5 solar cycles and show that the solar irradiance changes on time scales ranging from minutes to the solar cycle. These cycles, although not identical, have been reasonably similar, so that the direct measurements do not provide a good guide to possible longterm variations of solar irradiance. Models combined with proxy data are therefore needed to help answer questions such as the total amount of irradiance change since the Maunder minimum. Models aim to obtain an understanding of the causes of the observed irradiance variations to build on these in order to extrapolate into the past.

In the talk I introduce and critically discuss results of irradiance measurements and the main modelling approaches, whereby I distinguish between the shortterm (solar cycle) and the usually far less sophisticated models for longer term solar irradiance variations.

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The Value of Old Geomagnetic Records

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That there is a relationship between solar and geomagnetic activity has been recognized since about 1850. After the initial excitement wore off and since progress in understanding the complex relationship was slow, interest waned and the regular measurements of geomagnetic variations were often discontinued or curtailed. The IGY and the ensuing space age provided new impetus to geomagnetic research. Today, our understanding of the complex relations is rapidly improving. We are now in the position of being able to disentangle many of the simultaneously occurring causes and effects. This new knowledge makes it possible to view the older observations in a new light and to extract real physical meaning and parameters from the old records. This talk will demonstrate how to determine the solar wind speed (since 1890), the strength of the interplanetary magnetic field (since 1872), and the EUV-flux (since 1843) from geomagnetic observations. Using the Wolf relationship between sunspot number and daily range of the declination one can reconstruct the sunspot number for periods where it is poorly known. We discuss measurements by Canton (1759–60) and by Gilpin (1786-1805) that allow us to reconstruct and cross- check the yearly sunspot number during these intervals. Other old data exists (e.g. Hjorter 1740s, Arago 1820s, and data from early observatories [Oslo, Helsinki, Prague,...]) and we should collect these early observations, evaluate, and (possibly) calibrate them in light of our modern understanding. There are good prospects for extending the inferred solar wind properties back to about 1840 and possibly beyond. The various time series that can be (and have been) constructed can be intercompared and checked against each other. This includes a re-calibration of the aa-index. We are moving towards a "climatology of solar wind (and thus solar) properties".

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Regularities, cyclicities and asymmetries in the solar corona over more than fifty years

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Solar corona represents a highly rarefied and fully ionized plasma. That is why, its temporal and spatial organizations are extremely sensitive a to the topology and strength of the solar magnetic field. Unfortunately, nowadays,the coronal magnetic field is still not reliably measured on regular basis. On the other hand, all the activities, regularities, cyclicities and asymmetries observed in the solar corona are, undoubtedly, reflected in structuralization and properties of the interplanetary medium, modulating physical processes in the heliosphere and creating space weather. All the findings about solar corona may be helpful for a better understanding of both the above-mentioned topics. A number of the large-scale and long-term distributions of the coronal Fe XIV 530.3 nm emission line brightness are demonstrated and discussed on the data covering 1943-2001 period. Among them, fine structure of the butterfly diagram, existence of "active longitudes", presence of the double maxima in the solar cycles, N/S asymmetry and relevance of solar N and S middle-latitude zones in displaying coronal variability, are concerned. Very regular evolution of coronal activity during five solar cycles is demonstrated by a 2-minute movie.

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Long-term solar cycle evolution: New facts and old myths

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The long-term solar activity cyclic evolution is studied over centuries, using the longest astronomical data series - number of sunspots observed since the invention of telescope. During the long period of investigation, the results on long-term solar cycle evolution became surrounded with some settled myths, which are, as all myths, based on really observed facts but deviating sometimes far from it.

The most generic myth is that the Wolf sunspot series is precisely defined and all cycles are absolutely known. A new look at the sunspot historical record is possible now thanks to the tremendous work of Hoyt & Schatten (1998) who made available all the auxiliary information. As a clear example of big uncertainties related to the cycle evolution in the past, a possible lost cycle in 1790s is discussed. Other myths are also discussed as related, e.g., to cycle length definition, relation between cycle's length and amplitude, increase of sunspot activity after 1900, interpretation of the so-called Gnevyshev-Ohl rule, etc.

Here I make an attempt to review both newly discovered facts and old myths about the long-term solar cycle evolution.

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The Sun's Large-Scale Field and its Long-Term Evolution

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I discuss the evolution of the Sun's large-scale magnetic field, emphasizing the role of flux transport processes and the differing behaviors of the open flux and the total photospheric flux. After reviewing the evolution of the large-scale field during the last 30 years, I go on to speculate about what happened during the Maunder Minimum.

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CONTRIBUTED TALKS

Long-term dynamics of the large-scale magnetic structures

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Large-scale magnetic field regions are evolving on time scale of many weeks and months and also are modified during solar activity cycle. Changes of the position and spatial distribution as well as temporal variations of the field strength closely relates with occurrence and variations of another forms of the solar activity as sunspots, filaments and prominences and coronal structures. Besides of the axially symmetric zonal and meridional drifts relating with differential rotation and meridional circulation also the non-axially symmetric velocity structures were observed during three last solar activity cycles. Processes connected with such kind of flows relates with fluctuating distribution of the magnetic flux in solar photosphere. In combination with 11 year cyclic changes of the large-scale velocity field a new global dynamic regime of the convection zone is described.

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Starspots, activity cycles and differential rotation on solar-type stars

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We present the first results in searching for stellar cycles by the analysis of the stellar spottedness with the algorithme developed in CrAO. From about 30 red spotted stars we find 8 targets which demonstrate cyclical variations of middle latitudes and total areas of starspots. Activity cycles detected by this method have a typical cycle length about 4 - 15 years similarly 11-year Schwabe cycle. A most of program stars demonstrate a rough analogue of the butterfly diagram. They show a tendency of an average starspots latitude reduction with the total spot area growth. A number of stars (for example young solar analogue $LQ\ Hya$ or $RS\ CVn$-type variable $V711\ Tau$) demonstrates cyclical switches of the dominant activity between two active longitudes (so-called flip-flop phenomenon). These switches are synchronized with spottedness cycles and occuring near epoches of the maximum starspots latitudes. At the same time we can see a tendency for decreasing of stellar photometric period (which is tracing by starspots) with the starspots drift toward the stellar equator analogously to the solar differential rotation effect. Unlike the solar case the spottedness cycles do not show clear correlations with the slellar activity observed by chromospherical emission in $CaII\ HK$ lines ($BE\ Cet$, $EK\ Dra$, $DX\ Leo$), in H_α line ($LQ\ Hya$) or by cyclical flare activity ($EV\ Lac$). For some stars (for example $V833\ Tau$, $BY\ Dra$) the Schwabe cycles co-exist with long cycles which are similar to the solar Gleissberg cycle.

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Long-Term Variation of the Solar Coronal Temperature

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Observations of the forbidden coronal lines Fe XIV 530.3 nm and Fe X 637.4 nm obtained at the National Solar Observatory at Sacramento Peak are used to determine the variation of coronal temperature at latitudes above 30 degrees during solar activity cycles 21, 22 and 23. Latitudes below 30 degrees are not studied, because the technique used to determine the coronal temperature is not applicable in active regions. The polar temperature varies cyclically from approximately 1.3 to 1.7 MK. The temperatures are similar in both hemispheres. The temperature near solar minimum decreases strongly from mid-latitudes to the poles. The temperature of the corona above 80 degrees latitude generally follows the sunspot cycle, with minima in 1985 and 1995 - 1996 (cf. 1986 and 1996 for Rz) and maxima in 1989 and 2000 (cf. 1989 and 2000 for Rz). The temperature of the corona above 30 degrees latitude at solar maximum is nearly uniform; i.e., there is little latitude-dependence. The maximum temperature was higher in solar cycle 23 than in solar cycle 22. The difference in annual N+S averages was 56 kK near the poles and 64 kK for all latitudes above 30 degrees. The minimum temperature following solar cycle 22 was cooler than that preceding solar cycle 22. The difference in annual N+S averages was -32 kK near the poles and -23 kK for all latitudes above 30 degrees. If the maximum temperatures of cycles 22 and 23 are aligned in time (superposed epochs), the annual N+S average temperature in cycle 23 is hotter than that in cycle 22 at all times above 80 degrees latitude and for all except the early rise time above 30 degrees latitude.

The author was supported by the Air Force Office of Scientific Research.

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Evolution of the large-scale magnetic field on the solar surface: a parameter study

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Magnetic flux emerging on the Sun's surface in the form of bipolar magnetic regions is redistributed by supergranular diffusion, a meridional poleward flow and differential rotation. In this talk I present the main results of a systematic and extensive parameter study of the influence of various parameters on the large-scale field, in particular the total unsigned surface flux and the flux in the polar caps, using a flux transport model. Both, model parameters and source term properties are discussed. The average tilt angle of the emerging bipolar regions, the diffusion coefficient (below a critical value), the total emergent flux and, for the polar field, the meridional flow velocity and the cycle length are identified as parameters with a particularly large effect. Of special interest is the influence of the overlap between succesive cycles. With increasing overlap, an increasing background field (minimum flux at cycle minimum) is built up, which is of potential relevance for secular trends of solar activity and total irradiance.

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Time-latitudial development of the white-light coronal structures over a solar cycle

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Large-scale coronal structures (helmet streamers) represent global magnetic field of the Sun. They are located above the solar equator in cycle minima and nearly around the whole solar limb in cycle maxima. Their time-latitudinal distribution and development during the solar cycle is less known yet. On the other hand, local maxima intensities of the green corona (530.3 nm) and prominences show both the poleward and equatoreal migrations, beginning in cycle minimum from heliographic latitudes of about 40 degrees. We are trying to compare distribution of the helmet streamers, as observed during solar eclipses and/or with a white light coronagraph with the distribution of the location of the green corona local maxima of intensities and prominences during solar cycle.

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Sources of $^{18}O/^{16}O$ Concentration variability in Greenland ice cores: Temperature, North Atlantic Oscillation and solar activity

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To study a possible connection between variations of $^{18}O/^{16}O$, temperature, precipitation, NAO and solar activity (SA) there were analyzed variations of the relative concentration of ^{18}O isotope in Greenland ice. To reduce a noise component and to increase a reliability of our results the original data were averaged over 10-year intervals. The averaged data of $^{18}O/^{16}O$ were compared with averaged meteorological data (temperature and precipitation) in Greenland during 1873-2000 [Laursen et al., 1999; Box, 2002]. The values of diurnal precipitates were used as weighting coefficients in the procedure of temperature averaging to take into account variations in precipitation amount. Then the relationships between 10-years averaged values of $^{18}O/^{16}O$ and monthly temperatures were derived making use of regression analysis methods. When the internal relation between $^{18}O/^{16}O$ and temperature was investigated it was discovered that February temperature yields the main contribution in variability of $^{18}O/^{16}O$. The correlation coefficient between weighted night temperature of February and $^{18}O/^{16}O$ equals to 0.85 ± 0.01. Besides the local source of $^{18}O/^{16}O$ changes, defined by the amount of precipitation and temperature, an additional source correlated with the level of SA has been revealed. The relative contribution of this source in the $^{18}O/^{16}O$ variance is about 0.1. By the maximum entropy method spectral peaks of $\approx$30 years in the spectrum of $^{18}O/^{16}O$ power was obtained. The dynamics of spectral characteristics is demonstrated on the frequency-time diagram. It has been shown that there are two areas of high amplitude variations with the period of $\approx$30 years centered on time scale in 13th and 20th centuries. To examine the connection between $^{18}O/^{16}O$, NAO and yearly averaged Wolf numbers the values of monthly averaged NAO indices were averaged over 10-year intervals. Using the regression analysis, it has been shown that the multiple correlation coefficient between $^{18}O/^{16}O$ and NAO indexes is equal to 0.85. Therefore NAO yield more than 2/3 variances of climatic changes in Greenland region. The multiple correlation coefficient between $^{18}O/^{16}O$, NAO and SA is equal to 0.99, i.e. an independent contribution of SA in climatic changes is about 1/3. Thus, reliable statistical connection between the relative concentration of ^{18}O isotope in Greenland ice cores and SA has been established making use of regression analysis. A relative contribution of solar activity into the 18O/16 variance varies from 0.1 up to 0.3, depending on a choice of variables (series of averaged temperatures or NAO indexes).

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Why do astrophysical dynamos saturate below equipartition?

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We illustrate how a flow with zero mean helicity can drive a fast dynamo, and study the dynamo's mode of operation during the non-linear saturation regime. We use a flow without cosine terms and it turns out that apart from the high growth rate in the linear regime, the dynamo saturates at a level significantly higher that the intermittent turbulent dynamos, namely at exact energy equipartition in case of fluid Reynolds number Re below ≈ 200. During the linear regime, several kinematic modes can be present depending on the initial condition e.g. a sheet/vortex-mode and a mode that is similar to the normal ABC "double cigar" mode. In the non-linear regime, the magnetic topology is not symmetric, but the initial structure of the velocity field is retained through-out if $\mathrm{Re} > 200$. We show by an analysis of the flows and the magnetic field, how the non-linear dynamo mode is altered when the flows become turbulent at high Re and we explain why saturation at equipartition does not occur.

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Some changes in the structure of the polar magnetic field during the solar cycle and their association with the global field characteristics

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is a very hard subject of investigation because the direct measurements on the basis of the Zeeman effect are practically impossible as the line of sight is close to the tangent to the surface. Thats why indirect methods of obtaining information on polar magnetic field characteristics are very valuable. We compare the shape and position of some plasma formations visible in the polar corona with the expected evolution of the global magnetic field during the cycle. The first type of objects is polar crown prominences. The double decrease of the height of polar crown prominences was found during their poleward migration from the middle latitudes to the poles before a polar magnetic field reversal. The effect could be assigned to the decrease of the scale the magnetic field, the polarity inversion lines of which filaments outline. In the global magnetic field it manifests itself in the growth of the weight of high-order multipoles in the field expansion into the spherical functions. The second type of objects is polar plumes, ray like structures that follow magnetic field lines. Geometry of the polar magnetic field is changing during the activity cycle. Tangents to polar ray structures are usually crossed near some point below the surface. This point can be named as a magnetic focus. The distance q between the focus and the center of the solar disk changes from the maximum value about 0.7 R at solar minimum activity to the minimum value about 0.5 R at solar maximum. This behavior was not been understood till now. Really, all tangents to field lines near the pole of the axially symmetric potential magnetic field described by zonal spherical harmonics cross at the same point. However, the greater is the number of a harmonic, the closer to the surface is the crossing point. As far as at activity maximum high harmonics dominate, the behavior of the focuses seems to be in contradiction with the results of the harmonic analysis. We have found that the focus depth changes could be explained by complicated relationship between the harmonics of new and old cycle. General features of the process are seen in a pattern of a polar magnetic field reversal.

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Interpretation of stellar activity in terms of dipole and quadrupole dynamo modes

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Cool, rapidly rotating stars exhibit enhanced magnetic activity with cyclic behavior on various time scales. In particular, the longitude of the dominant activity region switches quasi-periodically by 180 degrees, which is known as the 'flip-flop' phenomenon. In solar-type stars the 'flip-flops' coexist with a cyclic variation of the overall activity level. In the present paper we introduce a new approach for the interpretation of stellar cycles based on a decomposition of the activity into a series of dipole and quadrupole dynamo modes. We analyze long-term photometric data of different stars and discuss the time evolution of the involved dynamo modes.

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Distribution and rotation velocity of sunspot formation zones

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The data from the Greenwich Observatory for 1879-2002 (cycles 12-23) have been used to plot a time (years) vs. Carrington longitude diagram of distribution of the rotation-summed daily areas for each sunspot group. Besides, the distribution of the rotation-summed areas of sunspot groups over the heliolatitude and Carrington longitude has been studied for each cycle under consideration. It has been revealed that most of the sunspots appear as clusters having common sources (Sunspot Formation Zones) that lie on a surface rigidly rotating with a period close to the Carrington rotation period. The behaviour of the active longitudes (their location, shift, and intensity variations) identified on these diagrams has been analysed over the entire time interval under consideration.

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Reconstruction of open solar magnetic flux and interplanetary magnetic field in 20th century

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We use coefficients of the global solar magnetic field multipole expansion, which were obtained from synoptic H-alpha charts and are available since 1915, to reconstruct the solar open magnetic flux (SOMF) from this time. Using these values, we reconstruct the interplanetary magnetic field (IMF) magnitude for this epoch. We also made an independent estimation of IMF, which is based on geomagnetic indices and proved to be in satisfactory agreement with the results of the first reconstruction. The obtain indices confirm the conclusion that a positive trend of SOMF and IMF magnitudes took place during the first half of the past century.

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Solar cycles in Arctic tree-ring climatic records

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Analysis of tree-ring records from various parts of Finnish Lapland and Kola Peninsula (northwestern Russia) is presented. The tree-ring samples at the regions were selected close to the northern timberline (the more sensitive forest area to climatic influence). The series collected contain the longest one (448 years long) got up to date in Khibiny mountain region. Results of spectral analysis of more than 20 chronologies allowed us to select the main periods of solar variability: 11-year, 22-year, 30-33-year, and 80-90-year cycles. Note that 22-year (Hale) cycle was found in practically all climatic records at many Earth regions. The appearance of 11-year (Schwabe) solar cycle was occurred apparent everywhere and as well did not exhibit high amplitude in climatic records compared with 22-year cycle. As for 30-33-year (Bruckner) cycle, which physical nature is not known up to date, then it was discovered only in some regional climatic records (Northern Finland, Tasmania, Chile, Mexico, North America). Some features of Bruckner cycle manifestations in solar and geophysical parameters and as well in climatic records are discussed. It was demonstrated that manifestations of solar signal in climatic records are spatially inhomogeneous and seemed to be more pronounced along the so-called nod-lines of standing thermobaric waves induced in the atmosphere. In the North Atlantic/European sector this nod-line spreads from Northern Finland and Kola Peninsula to Pyrenees. Our results may be helpful in using tree-ring chronologies as a proxy of solar activity.

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North-south asymmetries in the evolution and rotation of the Sun's large-scale photospheric magnetic fields

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Several solar activity indices such as relative sunspot numbers, sunspot areas, flares, filaments and magnetic flux are known to exhibit some form of asymmetry between the northern and the southern hemisphere. Using Kitt Peak synoptic Carrington rotation maps (1975-2003), we have investigated the long-term evolution and the rotation of the photospheric magnetic field separately for each hemisphere and compared our results with the longer data set of sunspot areas (1876-2003). We have revealed a regular pattern of pronounced oscillations with periods of 1.5 yr, 1.8 yr and 3.6 yr in the magnetic flux asymmetry. The former two periods are related to a process which leads to a gradual shift in the excess magnetic flux from north to south or vice versa. Additional periods of 44 yr and 320-330 days were detected in the sunspot asymmetry. Moreover, large-scale magnetic fields have been found to rotate rigidly. The rotational power is concentrated at only a few discrete latitudes and frequencies. The rotation velocities of these large-scale magnetic fields differ substantially not only between the hemispheres but also from cycle to cycle, thus providing a possible cause for the different hemispheric activity levels and the long-term variations seen in the asymmetry.

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Long-term correlation between the Northern Atlantic Oscillation and solar activity

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The aa index of geomagnetic activity provides the longest (since 1868) geomagnetic data set. We extend the correlation analysis of solar signal and the Northern Atlantic Oscillation (NAO) back in time by using the aa index as a proxy of the interplanetary electric field imparted the magnetosphere. Previous to 1940s the records of the NAO and the aa index are almost anticorrelated, while after 1940s their rhythm match. The same regularity is observed in the interconnection of aa and Arctic winter temperature. High correlation coefficients are obtained for the relationship between the NAO and high-latitude geomagnetic indices, AE and PC. We compare the two distinctive periods of the NAO and solar signal correlation with recent results on the long scale reconstruction of solar activity. The shift in the NAO and aa interconnection can obtain the explanation in a significant increase in solar activity after 1940s.

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The NorthSouth asymmetry of sunspot and solar flares

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The existence of the North-South (N-S) asymmetry in solar activity is generally accepted but this phenomenon has not yet been fully interpreted. We analyse the N-S asymmetry of sunspot and solar flares registered in H alpha and soft X-ray (SXR) during the 11-year solar cycles (SCs) 20-23. The analysis is done using two types of indices: frequency indices (Wolf numbers, numbers of flares by H alpha importance or by spectral class in soft X-ray) and importance indices (sunspot area, Q index for H alpha flares and Qx index for SXR flares). The monthly and annual N-S asymmetry values computed by us, for the mentioned period, are in agreement with the results from the literature and a general trend can be inferred for the N-S asymmetry curve during a SC. At the beginning of a cycle, there is a preference for one of the hemispheres, while during, or immediately after the maximum epoch, the N-S asymmetry drops sharply towards zero and remains very low until the polarity reversal of the polar solar magnetic field is finished. After this moment, in which a new dipole with inverse polarity is installed, the N-S asymmetry increases again, either in favour of the opposite hemisphere, or in favour of the same one. Some differences between the two types of used indices are also revealed. In order to explain them we analyse the fine structure of each 11-year SC with a special account of the maximum and descendant phases. The differences between the pairs of SCs 20-21 and 22-23 (Hale Cycles nos. 11 and 12) could explain partially the forecasts of high activity in SC 23, which proved to be unreal. Finally, we consider that the detailed study of the descendant and minimum phases of the SCs, at the stage when magnetic phenomena from both the old and the new cycle interact in the solar atmosphere, would be useful for inferring information about the activity level of the next cycle.

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Reconstruction of magnetic activity of the Sun and changes in its irradiance on a millennium timescale using neurocomputing

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To reconstruct magnetic activity of the Sun and changes in its luminosity on a millennium timescale empirical models have been constructed. These models were developed using the Neural Network (NN) technique. The models adequately describe temporal changes in both direct and indirect data on magnetic activity of the Sun. The obtained models are free of model restrictions and physical uncertainties. These provide an independent approach to verify previous reconstructions of the global solar indices. Non-linear regression relations derived with NNs from the sunspot indices, cosmogenic isotopes and solar irradiance data give a possibility to reconstruct basic physical parameters of the Sun on a millennium timescale. Taken the sunspot indices and the cosmogenic isotope data as the input and output of the NNs, we model, reconstruct and extrapolate these datasets. Given sunspot indices as the input of the NNs with cosmogenic isotope time series being the output, we model the behavior of solar-activity-related cosmogenic isotope abundances as if these would occur during the epoch of modern observations without the influence of the anthropogenic contamination. Taken sunspot indices and the cosmogenic isotope time series as the input of the NN, we obtain the empirical model for changes in Total Solar Irradiance (TSI) through the training the NN to approximate the composite TSI dataset. The TSI trend on a secular timescale is derived using both sunspot indices and indirect data about magnetic activity of the Sun from natural archives of cosmogenic isotopes. This work was supported by the INTAS project 2001-0550.

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Exploring Magnetic Activity From the Sun to the Stars

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Sun-like stars are known to display a wide variety of magnetic activity, which is believed to be the signatures of a hydromagnetic dynamo mechanism working in stellar interiors. The dynamo mechanism has been studied extensively in the context of the Sun. Here we take the ideas and experience gained from solar dynamo modeling and build upon it to study various well-known and observed scaling laws involving stellar parameters. We also discuss how such a synthesis of theoretical dynamo modeling of Sun-like stars and stellar cycle observations may help us understand the long-term variability of the Sun.

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On the possibility of the Sun's activity forecast using radiocarbon solar proxy

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Sunspot numbers are reconstructed for the time interval 8005 B.C. - 1945 A.D from the long decadal radiocarbon series. The reconstruction was made using a five-reservoir carbon exchange model. Rescaled analyses shows apparent persistency in the reconstructed Wolf number series that indicates the existence of long-term memory in the Sun's activity and makes it possible a long-term prognosis of the mean solar activity level. The horizon of solar activity forecast is estimated as more than 500 years. Nonlinear prognosis of the mean value of Wolf number is made for the next 40 years using the obtained solar proxy. Comparison of the result with the other long -term solar forecasts is performed.

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Solar cycle signal in geomagnetic activity and climate

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Historical geomagnetic and climate records were analyzed to study long-term trends and relationships with the solar activity. Wavelet technique and recurrence plot analysis are applied to the data to find their coherence and similarities at different time and time-scale. It is shown that recurrent geomagnetic plots display 'secular' trend of the solar wind variability near ecliptic plane resulting from change of magnetic field topology in the solar corona. Solar cycle signal is more pronounced in climatic data during the last 60 years. Unusual solar impact on terrestrial climate is discussed.

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Discovery of the "Space Weather"-"Earth Weather"-"Prices Level" Causality for Medieval England

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The database of Professor Rogers (1887/1963), which includes wheat prices in England in the Middle Ages (1249-1703) and data of Brown and Hopkins (1956) of prices on consumables was used to search for possible manifestations of solar activity and cosmic ray intensity variations in market dynamics. The main object of the statistical analysis presented is investigation of bursts of prices. Our study shows that, as a result of the nonlinear causal links between space weather, earth weather, agriculture production and market reaction, bursts and troughs of wheat prices and prices of consumables can take place at extreme states (maximums or minimums) of solar activity cycles. We present a conceptual model of possible modes for sensitivity of wheat prices to weather conditions, caused by solar cycle variations, and compare the expected price fluctuations with wheat price variations recorded in the Medieval England.

For test of the proposed model we create a sample of price bursts from database of Prof. Roger for wheat price with clear criteria for amplitude discrimination. A new sample of time intervals between price bursts was obtained from this initial sample. We compared statistical properties of the intervals between price bursts with statistical properties of the intervals between extremes (minimums) of solar cycles during the years 1700-2000. We show that statistical properties of these three samples are similar. The average interval between price bursts is 11.14 years, while for solar activity the average minimum-minimum interval is 11.02 years (difference 1%). The medians of both samples have the values of 11.00 and 10.7 years (difference 3%); standard deviations are 1.44 and 1.53 years for prices and for solar activity, respectively. The hypothesis that the frequency distributions are the same for both of the samples was not rejected with ?2-test (significance level >95%). We repeat this investigation for prices on consumables from database of Brown and Hopkins (1956) in the period 1271-1730, constructed from independent sources. We show that price bursts statistics on consumables is like to the statistics for wheat price with mean interval between bursts - 10.85 years and median of distribution of intervals - 11.00 years, standard deviation is 1.27 years

In the next step we analyzed direct links between wheat prices and solar activity in the 17th Century, for which both wheat prices and solar activity data as well as cosmic ray intensity (derived from 10Be isotope) are available. We show that for all solar activity minimums (cosmic ray intensity maximums) the observed prices were systematically higher than prices for the intervals of maximal solar activity preceded to the minimums (100% sign correlation, at a level of significance <1%). This evident asymmetry of prices in Min/Max sunspot number states, combined with the conclusion of similarity of statistical properties of the price and solar activity/cosmic ray intensity extremes we consider

as direct evidence of a causal connection between prices bursts and solar activity/cosmic ray intensity extremes. In additional we analyse possible Min/Max asymmetry effects in modern wheat market and show that some effects of this type has place in 20-th century, too.

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The uses of geophysical data in studies of the historical solar-terrestrial environment

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Recent studies of the solar-terrestrial environment for the past 500 years have necessitated the use of a variety of historical databases: nitrates in ice cores, knowledge of large volcanic eruptions, sunspot numbers, mid-latitude aurora and the geomagnetic record. The nitrate data have been used to identify large solar proton fluence events. The volcanic record helps with time markers for the ice core. The record of major geomagnetic storms and mid-latitude aurora have been used for additional identification. We also know that the earths magnetic field is evolving with a present steady decrease in magnitude. In addition the wandering magnetic pole must be considered in ascertaining what was "mid latitude" in 1600 vs. "mid latitude" in 2000. We illustrate how these databases are being used in recent studies of historic solar proton events and the possibility that the galactic cosmic radiation may contribute to mid-latitude cloud cover and hence climate.

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Hale cyclicity of solar activity and its relation to climate variability

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Periodicity of climatic processes along the Russian Arctic Ocean coast during several hundred years has been studied by analyzing the tree-ring chronologies for the regions close to the northern timberline. The wavelet analysis of annual series of conifer tree-rings generalized for 10 regions along the northern timberline, from the Kola Peninsula to Chukotka, for the period 1458 1975 has revealed climatic oscillations with periods of 20-25 years. The analysis has also shown that information about the quasi- bidecadal climatic oscillations is contained in different Earth archives such as ice, lake and sea sediments, variations in ground and sea surface temperatures (SST), etc. The amplitudes and periods of climatic oscillations in the region of Russian Arctic Ocean proved to exhibit appreciable changes. In order to understand solar variability and its impact on climate is need to analyze records of solar variability and climate over the historical periods substantially distinct from each other such as the Maunder minimum and the last few decades. Especially strong climatic variations in comparison with the recent were found to occur during the Maunder minimum epoch when the period of oscillations increased from 22-23 years to 24-29 years and oscillations with a period of 15-17 years appeared. After the Maunder minimum, the periods of oscillations and their amplitudes again decreased, and the 15-17-year maximum disappeared. Analysis of radiocarbon (14C) concentration in annual tree rings has revealed a similar pattern in changes of periodicity before, during, and after the Maunder minimum. This suggests that quasi-bidecadal climatic oscillations and variations in solar activity can be connected with each other. A possible solar forcing of periodic climatic processes and its nonlinear influence on the atmosphere-ocean-continental system are discussed. The intense quasi- bidecadal climatic oscillations can be, in all probability, interpreted as resulting from amplification of a weak solar signal in the atmosphere-ocean system that has its own noises whose frequencies are close to the 22-23-year solar cycles. This work was supported by RFBR (projects 03-04-48769 and 03-05-65063), NorFA Grant "Network for Dendroecological and Dendrochronological Research in Northern Europe", and General Physics Department of RAS (program No. 16)

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Solar cycle length variations: Their physical interpretation in connection to global temperature changes

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As it was shown by Friis-Christensen and Lassen in 1991 solar cycle length (SCL) variations display a very good anti-correlation with Northern hemisphere temperature changes in XX century. The physical interpretation of the connection given later by Shumilov showed that during more intensive cycles one can observe solar radiation increase and decrease of galactic cosmic ray influence on cloud formation. Both effects are additive and lead to temperature enhancement. So, the shorter cycles are the warmer ones. It is demonstrated on tree-ring data of Taymir Peninsula and Lapland that the connections between SCL and temperature anomalies (dT) are different for the periods of 1705-1810 and 1900-1990, and equal 0.03 deg./yr and 0.4 deg./yr correspondingly, and practically absent for the period of 1810-1890. Therefore, a good correlation between SCL and dT found by Friis-Christensen and Lassen (1991) seemed to be occasional one, and SCL parameter could hardly be used for numerical estimetes of solar influence on the climate in linear approximation. It is surprising a good anti-correlation between SCL and dT is observed during a time interval of increased human-induced effects on the climate, so-called global warming caused by green-house effect. Some comments on changes of climate response on solar and geophysical parameter variations around 1970 year is as well discussed.

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Anharmonicity of stellar cycles: wavelet analysis of observations and dynamo models

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The origin of stellar activity cycles is believed to be connected with a dynamo action occurring somewhere in the stellar convective zone. Currently, stellar dynamo theory can explain some basic properties of stellar activity cycles; however at the moment the confrontation between dynamo theory and observational data only includes a quite limited number features. We feel that the choice of cycle properties suitable for such a critical comparison needs to be enlarged and suggest the anharmonisity of stellar cycles as a stellar cycle characteristic suitable for this extended confrontation. We propose a quantitative measure of anharmonicity which can be extracted both from available observations as well as from dynamo models. Then we show that choosing different sets of parameters governing the dynamo model results in cycles with different degree of anharmonisity. In this sense, the anharmonicity of stellar cycles extracted from observations has the possibility to provide some understanding of governing parameters of stellar dynamos.

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Two modes in rotation of the solar corona

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Comprehensive investigation of the solar rotation seems to be crucial for understanding of the magnetic field generation within the Sun's convective zone and for explanation of the cyclic evolution of solar activity. Our own database of the Fe XIV 530.3 nm coronal green line brightness, covering more than five solar cycles (1943-2001), has been subjected to the Spectral Variation Analysis (SVAN) and the following principal results were obtained: (a) The period of rotation increases from 27.0 days at the equator to about 29.2 days at the latitudes of +/-40 degrees, displaying much slower differentiality than that for majority of the solar photospheric phenomena (sunspots, etc.); (b) The differential rotation diminishes at +/-40 latitudinal degrees and displays practically rigid character (a little more than 29-day period) up to the polar regions; (c) A more detailed analysis revealed that two quasi-rigid modes of coronal rotation probably exist, the faster one with period of 27 days (slightly increasing towards the higher latitudes), and the slow one displaying the rotational period of about 30.5 days. The observed dependence of coronal rotation on the solar latitude results from a combination of them; (d) It seems that the temporal variations of the faster mode could indicate a presence of the torsional oscillations in the corona.

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Long-term variations in cosmic ray fluctuations

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It has been shown recently that the level of cosmic ray fluctuations varies over a solar cycle due to the corresponding changes of the in interplanetary turbulence spectrum. In earlier studies, fragmentary high-resolution data from polar neutron monitors (Tixie Bay and Oulu) were used. Here we present the results of an analysis of 5-min resolution cosmic ray data series from six neutron monitors with geomagnetic cutoff rigidities from polar to 6 GV (Calgary, Kiel, Lomnicky Stit, Oulu, Rome and Tixie) as well as from space-borne IMP-8. The longest time series of 5-min data is from Oulu NM since 1968. As the index of cosmic ray fluctuations we use the mean power of the cosmic ray power spectrum in the frequency range $10^{-4} \div 1.67 \cdot 10^{-3}$ Hz. The dominant 11-year periodicity is found in all series, confirming earlier results but in a wide range of cutoff rigidities. We report also new persistent periodicities in cosmic ray fluctuations. A strong $1.5 - 1.8$-year periodicity related the corresponding cyclicities in IMF is apparent in all data series. Another strong peak is found at nearly 1 year period, which is related to the relative position of the Earth in the heliosphere. These results provide a new basis for testing the cosmic ray modulation theory.

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22-year variations in solar rotation

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Rotation of an atmosphere of the Sun is investigated according to synoptic the α-alpha of maps during 1887-2003. Latitude-time diagrams of variation of the periods in a range of latitude band $\pm 45^\circ$ are constructed. For this purpose the method of definition of the periods in "windows" in width 8-12 years, with the subsequent shift of a window along row data is used. Thus, it was possible to reveal long-term variations of rotation. It is shown, that in a range of latitude band $\pm 20^\circ$ degrees the basic mode of rotation are 22-years modulation. And, speed of rotation during an epoch of odd cycles of activity is slowed down, and during even cycles' fast rotation is observed. At increase in "window" of sample till $\approx$17 years the mode of rotation of the Sun is allocated $\approx$60 years. In this case the maximum of rotation speed falls at an epoch $\approx$1930 and 1990. The opportunity of generation of a solar cycle torsional waves with the period of the 22-year, cooperating with a relic magnetic field under convective a zone is discussed.

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Titanium-44 activity in meteorites: Witness of the GCR flux decline in the interplanetary space since 1700 AD

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Cosmic ray produced ^{44}Ti activity measured in 20 stone meteorites that fell between 1760 and 2001 AD, when corrected for the abundances of target elements and shielding effects, show a decreasing concentration in time during the past 250 years. Superimposed on this declining trend is a 100 year periodicity with an amplitude of about 17% consistent in phase with the Gleissberg cycle in the sunspot numbers, although the amplitude is larger than expected. The variations in ^{44}Ti activity are related to the cosmic ray intensity and its modulations due to the heliospheric magnetic field in the interplanetary space between 1 and 2.5 AU, estimated by Solanki et al (2000).

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Solar activity from 14C: Use of new observations for detrending procedure and generalized multi-scale box model

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It has been shown that centennial scale fluctuations in atmospheric radiocarbon concentrations are caused mostly by variations in the solar activity (SA). We have analyzed the global tree ring radiocarbon concentration (Δ14C) and supplementary data in order to extend the solar activity record over the Holocene (past 11000 years). Long-term changes of the initial Δ14C curve are corrected by using recent compilation of the archaeomagnetic data and the combined atmospheric CO2 record of three Antarctic ice cores. We show that CO2 change is significant for the Δ14C long-term trend. The presented results do not support the hypothesis that smoothed Δ14C can be directly rescaled for the magnetic moment change. A generalized multi-scale box model was constructed and used for the reservoir effect correction. The corrected curve has no global trend and correctly shows the temporal positions of SA global extremums as estimated by Schove for the last 5000 years. The 1000-yr-average curve shows a Mid-Holocene optimum that is traced in a number of climatic series, e.g. 18O, D and melting ice percent measured in ice cores. The same procedure was applied to annual Δ14C series (1510-1950) and high correlation of the corrected curve with the sunspot numbers was achieved (r=0.9) for the period 1700-1950. The fine structure of Maunder minimum epoch shows that none of 11-yr-cycles was lost.

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POSTERS

The Nile flooding as indirect indicator of the long solar cycles.

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In the present paper, data of the Nile River flooding during the years 622 - 1915 have been used to investigate the cycles of its variability. This study has identified groups of different cycles, which reflect some correlations with the solar cycles. Such as 667-323, 158-116, and 88-79 years. The last one is defined as Gleissberg solar cycle. These figures show that the Solar variability influences the climate on decadal as well as centennial time scales.

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Cosmic ray variations during two greatest bursts of solar activity in the 23-rd solar cycle

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During two extreme bursts of solar activity in March-April 2001 and October-November 2003 ground based neutron monitor network recorded series of outstanding events distinguished by their magnitude and unusual peculiarities. Solar activity flash in the end of March-beginning of April 2001 put the end of "Gnevyshev minimum" (so-called Gnevyshev gap) lasted from December 2000 to March 2001. In a few days more than ten active regions appeared to be originated simultaneously on the visible and on the opposite sides of the Sun. The important changes lead to the great activity flash, evident to be started not with the spot generation, but with the large scaled reconstruction of the solar magnetic field. The beginning of this flash turns out to be easier observed at Earth than on the Sun. The series of strong and moderate magnetic storms, and two powerful proton events (with GLEs) were registered during this period. Then, after four months of the quite Sun in 2003, during 10 days the second unexpected burst of activity was observed in October-November. The biggest and most productive in 23-rd solar cycle active region 486 generated significant series of solar flares among of which the flare (X28/3B on 4 November) was the mostly powerful over the history of X-ray solar observations. The fastest (after August 1972) arrival of the interplanetary disturbance from the Sun and the highest solar wind velocity and IMF intensity were recorded during these events. Within one week three ground level enhancements of solar cosmic ray were registered by the neutron monitor network (28, 29 October and 2 November 2003). Maximum proton energy in these events seems to be ranged from 5 to 10 GeV. Joint analysis of the data from ground level (neutron monitors) and satellite measurements allowed an estimation of some characteristics of proton flux. In this work a tentative analysis of the mostly interesting effects in cosmic rays during these two periods is performed by the neutron monitor network and other relevant data.

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The 155-day periodicity in the solar cycle 16 as an alias

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The short-term periodicities of the daily sunspot area fluctuations from August 1923 to October 1933 are discussed. For these data the correlative analysis indicates negative correlation for the periodicity of about 155 days, but the power spectrum analysis indicates a statistically significant peak in this time interval. A new method of the diagnosis of an echo-effect in spectrum is proposed and it is stated that the 155-day periodicity is a harmonics of the periodicities from the interval of [400,500] days.

The autocorrelation functions for the daily sunspot area fluctuations and for the fluctuations of the one rotation time interval in the northern hemisphere, separately for the whole solar cycle 16 and for the maximum activity period of this cycle do not show differences, especially in the interval of [57, 173] days. It proves against the thesis of the existence of strong positive fluctuations of the about 155-day interval in the maximum activity period of the solar cycle 16 in the northern hemisphere. However, a similar analysis for data from the southern hemisphere indicates that there is the periodicity of about 155 days in sunspot area data in the maximum activity period of the cycle 16 only.

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Large activity complexes as a cause of the existence of strong positive monthly Wolf number fluctuations

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A new method of the evaluation of strong positive monthly Wolf number fluctuations is presented. The only input it requires is the periodical or quasi-cyclical time series. To evaluate very strong activity complexes within different phases of the 11-year cycle a percentage index of a participation of an activity complex in the monthly Wolf number is introduced. I find fair agreement between strong positive monthly Wolf number fluctuations and development curves of large activity complexes.

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The 11-month quasi-cycle of the mean monthly Wolf number fluctuations

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I apply the spectral and the autocorrelation analyses to find the mean time interval among the monthly Wolf number fluctuations for each of 22 solar cycle and I state an existence of a 11-month quasi-cycle in these data. Its strength correlates very well (the correlation is 0.9) with the variance of fluctuations. Moreover, I divide a stationary version Xi of fluctuations time series Fi into two parts: periods of low and high solar activity and find statistically significant quasi-cycles (9 months) for these. I also find the quasi-cycle about 15 months for high activity periods.

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Forecasting of galactic cosmic rays variations based on solar magnetic field data

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Using the model of cosmic rays (CR) modulation in the heliosphere proposed previously, which considers a relation between long-term CR variations with parameters of the solar magnetic field, the observed CR variations in the near Earth space were estimated with accuracy allowing their predictions. It is shown that there are two possibilities: 1) to predict CR intensity for 1-6 months by using a delay of CR variations relatively to effects of the solar activity (SA) and 2) to predict CR intensity for the next solar cycle. For the second case predictions of global solar magnetic field characteristics are crucial. In both reliable longterm CR and SA data are necessary. CR variations for the next solar cycle are predicted by solar magnetic field data of two magnetographs (Stanford and Kitt Peak) using the statistical method.

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Solar activity in the past: from different proxies to combined reconstruction

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On the base of time series of proxies that includes ancient naked-eye observations of sunspots and auroras, the concentration of cosmogenic C-14 isotope in tree rings and Be-10 isotope in ice cores from Greenland and Antarctica we have reconstructed the average sunspot activity level for the period from 683 BC to present. For this purpose a set of linear and nonlinear independent inductive models has been constructed by so called self-organizing methods. The reconstructions of solar activity variations, independently obtained by different proxies, are in a good agreement with each other (despite of some differences in details) and with the well known global solar activity extremums. The reconstructed activity level also agrees with results obtained by multi-scale regression method and with a reconstruction that was presented earlier by one of the authors (Nagovitsyn, 1997). The obtained results demonstrate that over the last two thousand years some long periods with high solar activity level existed, and the global maximum in 20-th century is not much higher, if at all, then others.

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Dst index since 1932

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The Dst index is calculated from the horizontal component of the magnetic field measured at the following four magnetometer stations: San Juan (SJG), Honolulu (HON), Kakioka (KAK) and Hermanus (HER). Although the magnetic measurements at these stations started already earlier, the Dst index has so far been calculated only since the international geophysical year 1957. Using the earlier measurements at the four original Dst stations (SJG since 1926, HON since 1902, KAK since 1913 and HER since 1941) we now calculate the Dst index from 1941 onwards following the original derivation of the Dst index as closely as possible. Moreover, since the HER station was preceded by the nearby Cape Town station during 1932-1940, we can further extend the Dst index for the time interval after 1932 so that the geographical distribution of the used stations remains nearly the same. We compare the new and the original Dst indices during the overlapping years 1957-2000 and study their mutual consistency and statistical properties. The new Dst index also corrects some known problems in the original Dst index, e.g., in 1971. We also discuss the long-term development of the ring current in terms of the obtained extended Dst index. Presenting author: A. Karinen, e-mail: *arto.karinen@oulu.fi*

Global Upper Atmospheric Heating During the last 30 Years

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We use a trio of empirical models to estimate the relative contributions of solar extreme ultraviolet (EUV) heating, Joule heating and particle heating to the global energy budget of the earth's upper atmosphere. Our preliminary estimate of Joule power input to the upper atmosphere, based on a quadratic fit to the PC and DST indices, places the late October 2003 event in the top 15 heating events of the last 28 years. Daily power values are derived from models of three heat sources. The SOLAR2000 solar irradiance specification model provides estimates of the daily extreme EUV solar power input. Geomagnetic power comes from a combination of satellite-derived particle precipitation power and an empirical model of Joule power derived from hemispherically-integrated estimates of high-latitude heating, which we discuss in this paper. Joule and particle heating combine to provide more than 15% of the total global upper atmospheric heating and approximately one third of the variability in the heating. For the top ten percent and top one percent of heating events, contributions rise to about 20% and 25% respectively. In the top 15 heating events geomagnetic power contributed more than 50% of the total power budget. During three events the Joule power alone exceeded solar power. I will briefly discuss our methods of heating estimates and then compare the total upper atmospheric heating for the events of late 2003 with the events solar cycles 21-23. By our estimates the Oct 30 event was the 5th most powerful event of the last 28 years and Oct 29 was the 9th most heated day. November 20, 2003 ranks in the top 20.

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On the possible mechanism of influence of cosmic ray variations on clouds anomalies in the Earth's atmosphere

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The possible mechanism of cosmic rays influence on the clouds formation at low altitudes in the Earth's atmosphere is considered. This mechanism takes into account an opportunity of the influence of cosmic rays on transparency of the Earth's atmosphere. Variations of the atmosphere transparency in turn result in variations of its thermodynamic parameters (temperature and pressure) and finally change the growth rate of the in the Earth's atmosphere at low altitudes . Possible variations of the growth rate of drops in the atmosphere are calculated for various altitudes. It is shown, that the amplitudes of variations of the drops growth may reach few percents. This research was done in the frame of an exchange between the Russian and Finnish Academies (project No16).

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A model equation for the sunspot activity

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Due to the alternating magnetic field polarities of the bipolar sunspot groups in the neighbouring 11-year cycles (Hale rule), alternating signs were attributed to the sunspot numbers in the odd/even 11-year cycles, to construct an alternating-sign sunspot series. A-priori, the alternating-sign series was considered as an output of the autonomous oscillating system described by a second-order non-linear differential equation of a general form, given by a bivariate polynomial. After that, a linear inversion was applied to obtain the equation that fits to the observed sunspot time series. It has been shown that the solar activity can be well modelled by a Van der Pol equation, which implies a limit cycle. Solutions of the equation are presented and analysed in terms of phase-plane diagrams (i.e., phase portraits). The diagrams are discussed in the light of known peculiarities of the solar activity (like e.g. Hale rule, Maunder minimum, etc.). Finally, the problem of stability of the limit cycle is considered.

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Cosmic ray and solar coronal emissions: Crosscorrelations of the time series

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Cosmic ray time series of daily means from the Climax neutron monitor and from green 530.3 nm coronal emission line intensity over years 1951 - 2002 are compared. There is a clear asymmetry in the crosscorrelation function between cosmic rays and green emission corona in the even and odd solar cycles with the time lag ranging between 0 and 380 days. While for the periods 1954-1964 and 1978-1985 the optimum time lag is above 200 days, in the periods 1965-1976 and 1986-1995 the time lag is below 130 days. The comparison with the crosscorrelations between the cosmic rays and Wolf number in the period 1951 - 2002 is also presented. The causes of the different behaviour of crosscorrelation functions for different periods is discussed.

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Long-Term Solar Activity Cycle Observed in Historical Data of Sunspots and Aurorae

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The historical records of sunspots and aurorae are very important data to understand for the variations of solar activity and the terrestrial climate. We have collected the historical records in ancient Korea(from 11th century to 18th century). Through the power spectrum analysis using these records, we have investigated the long-term and short-term solar activity cycle and cross-correlations between sunspots and aurorae.

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On the Polar Coronal Holes and Cosmic Rays

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The daily values of the green limb intensity were used for calculation of coronal hole areas. There have been studied relation among polar coronal hole areas and the cosmic ray fluxies observed at Lomicky Stit for period 1986 - 2003. It was found, the coronal hole areas precede the cosmic rays of 100 - 270 days. The lag depends from the criterion used for the coronal hole definition.

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Absolute accuracy and repeatability of the RMIB radiometers for TSI measurements

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Radiometers for the measurement of the Solar Irradiance are built at the Royal Meteorological Institute of Belgium since 1982, these radiometers have successively flown on SPACELAB1, ATLAS1, EURECA, ATLAS2, ATLAS3, SOHO and several shuttle flights, among them the SOLCON III radiometer on the last STS107 flight.

Other radiometers are under construction or integration for the upcoming missions: one as part of the SOVIM experiment on the ISS and SOVAP on the PICARD micro satellite. One of the particularities of these radiometers is their symmetrical design and operation.¡BR¿In order to construct a long time series and to detect any variation between two cycles, it is important to know all the instrument parameters and make a clear distinction between what will lead to uncertainty on an absolute level and what guarantee the repeatability of the measurements.¡BR¿The purpose of this paper is to review these parameters; after a description of the instrument principle, the instrumental equation will be established. The electrical parameters and the determination of remaining instrumental parameters are done during the characterisation phase at the RMIB. As a consequence, the results from the DIARAD/VIRGO radiometer on board of SOHO are presented. The repeatability of the measurements is found to be of the order of 100 ppm after correction from the aging effect, the accuracy on an absolute level is of the order of 0.9 W/m for DIARAD left cavity. This accuracy is limited by the characterisation accuracy with a dominant role of the precision aperture determination. The understanding of the behaviour of the DIARAD instrument allows improving the design of the new radiometers on the upcoming missions.

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Changes in space weather and the heliospheric oscillations due to rotation and rearrangement of solar magnetic field

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Based on analyzing the fine structure of timeseries of solar and heliospheric parameters, a universal numerical technique is developed to study large-scale patterns of solar activity and the heliospheric structure. It is shown that the behaviour of the large-scale magnetic field and its multi-periodic rotation determine the heliospheric structure and changes in space weather. In particular, the solar proton events, flares and coronal mass ejections follow the rearrangements of global magnetic structures. Long-lived patterns of increased flaring activity reveal persistent sources of solar cosmic rays. A comparative time-longitude analysis comprehensively describes both solar activity and changes in space weather in their causal relation to rearrangements of large-scale magnetic field of the Sun for 1975–2003. Study of the rotational modulation of solar and heliospheric parameters reveals cyclic changes in their rotation. Modes of slow rotation dominate at the phase of activity rise, whereas the fast modes dominate at the phase of descending activity. These cyclic changes are interpreted as the result of solar torsional oscillations. These features of solar rotation appear also in the heliosphere. Time-longitude analysis of direct measurements of Interplanetary Magnetic Field (IMF) near the Earth complemented by earlier data by L. Svalgaard reveals the 11-yr modulation of the heliospheric parameters due to the torsional oscillations for 1926–2003. Alternating rotational modes appear also in the IMF time-longitude diagram on a secular timescale. Numerical models describe both the 11-yr and secular changes in solar rotation due to magnetic modulation of the angular momentum transport in the convection zone. This work was supported by the INTAS project 2001-0550.

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Bashful ballerina: Southward shifted heliospheric current sheet

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It is known since long [Rosenberg and Coleman, 1969] that one of the two sectors of the interplanetary magnetic field (IMF) observed at the Earth's orbit dominates at high heliographic latitudes during solar minimum times, reflecting the poloidal structure of the global solar magnetic field at these times. Here we find that while this latitudinal variation of the dominant IMF sector around the solar equator is valid for both solar hemispheres during the last four solar minima covered by direct observations, it is systematically more strongly developed in the northern heliographic hemisphere. This implies that the average heliospheric current sheet is shifted or coned southward during solar minimum times, suggesting that the temporary southward shift of the heliosheet found earlier by Ulysses observations in 1995 is a persistent pattern. This also implies that the open solar magnetic field is north-south asymmetric at these times, suggesting that the solar dynamo has an asymmetric component. Accordingly, the Sun with the heliosheet is like a bashful ballerina who is repeatedly trying to push her excessively high flaring skirt downward. However, the effective shift at 1 AU is only a few degrees, allowing the Rosenberg-Coleman rule to be valid, on an average, in both hemispheres during solar minima.

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Did open solar magnetic field increase during the last 100 years: A re-analysis of geomagnetic activity

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One of the most interesting and important questions in solar-terrestrial physics is whether the magnetic activity of the Sun has greatly increased during the last 100 years. A significant increase in solar magnetic activity is indicated by the well known fact that the average amplitude of sunspot cycles during the latter part of the 20th century is higher than in the beginning. The increasing sunspot activity leads, in a model presented by Solanki et al. (2000), to a corresponding centennial increase of the total and open (heliospheric) solar magnetic fields. The heliospheric magnetic field is a major driver of cosmic ray modulation and geomagnetic activity. Lockwood et al. (1999) used the geomagnetic aa index to show that the interplanetary magnetic field has more than doubled during the last 100 years. Also, Usoskin et al. (2003) used long-term measurements of cosmogenic isotopes produced by cosmic rays to show that the average sunspot activity since 1940s is higher than during the last 1000 years. Despite the versatility and reasonable uniformity of these results, serious concern has recently been raised on the long-term consistency of the aa index and, thereby, on the centennial rise of solar magnetic activity. As an alternative to the aa index, Svalgaard et al. (2003) introduced a new IHV index as a more reliable and more homogeneous measure of long-term geomagnetic ac-tivity, finding no significant increase during the last 100 years. Here we reanalyse the longest series of geomagnetic observations from a number of stations in order to find out whether or not there is reliable evidence for a centennial increase of geomagnetic activity and, thereby, of solar magnetic field.

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ESAI database and some properties of solar activity in the past

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The database hereinafter referred to as ESAI (Extended time series of Solar Activity Indices) is a new information resource located at http://www.gao.spb.ru/database/esai . ESAI includes observational, synthetic and simulated sets to study solar magnetic field variations and their influence on the Earth. ESAI extend ordinary lengths of some traditional indices of solar activity: sunspot areas, Wolf numbers (i.e. equatorial component of the solar global magnetic field), polar faculae numbers (polar component of the field), sunspot mean latitudes and north-south asymmetry of hemispheres (N-S location of activity). The monthly sunspot areas (1821-1989), the yearly sunspot areas (1821-1994) and the yearly mean latitudes of sunspots (1854-1985) were created by compilation of pre-Greenwich observational data sets (by Schwabe, Carrington, De La Rue, Sporer) and post-Greenwich observations (by Gnevysheva) to the Greenwich general system. The yearly polar faculae numbers were constructed by synthesis of different data series: Mt.Wilson, Greenwich, Lyon, Kodaykanal, Tokyo, Zurich, Kislovodsk observations of polar faculae and observations of polar coronal structures during solar eclipses. The series of yearly Wolf numbers for 1090-2003 were reconstructed using the Krylov-Bogolyubov approach to description of weakly nonlinear oscillatory processes, on the one hand, and the well-known Schove data on the epochs of extrema of 11-yr solar cycles in the past, on the other. The yearly polar faculae numbers for 1705-1999 were created by analogous procedure (in assumption that 11-yr cycles of polar faculae develop in exact antiphase to sunspot cycles). Through the use of wavelet transform some properties of solar activity over extended time scale are demonstrated. In particular, it is shown that non-stationary dynamics of 11-yr cycle for the different components of solar activity has identical properties. The work was supported by grants INTAS 2000-0752 "Key parameters for Space Weather", INTAS 2001-0550 "The Solar-terrestrial climate link in the past millennia and its influence on future climate", Federal Scientific and Technical Program "Astronomy-1105", Program of Presidium of Russian Academy of Sciences "Non-stationary phenomena in astronomy".

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Relation of polar cap sporadic-E and interplanetary magnetic field

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In this paper the relation of the interplanetary magnetic field (IMF) and sporadic-E within the polar cap is investigated. The sporadic-E data are collected from the Svalbard (78°N, 16°E) and Thule (76°N, 68°W) ionosondes and the IMF data from the WIND satellite. The polar cap electric field for each IMF observation is calculated from the APL statistical convection model. It turns out that the modeled electric field almost exclusively points in some direction between local geomagnetic north and west or between west and south. This is true especially on Svalbard. The diurnal distributions of sporadic-E are also investigated separately for the IMF directions (By>0, Bz>0), (By>0, Bz<0), (By<0, Bz>0) and (By<0, Bz<0). The distributions show clear MLT dependencies which persist from year to year but are different for Svalbard and Thule. The APL model indicates that, within time sectors where the occurrence probability of sporadic-E is high, the ionospheric electric field is in each case likely to point either in the (local geomagnetic) north-west quadrant or in the west-south quadrant. All these observations are in agreement with the theory which predicts that thin sporadic-E layers can be produced by the ionospheric electric field if the field direction lies within the north-west quadrant, and thicker layers if the direction lies within the west-south quadrant. Hence these observations indicate that the IMF, which controls the polar cap convection pattern and electric field, also controls the occurrence of sporadic-E within the polar cap. This is a direct space weather mechanism causing deviation of radio waves at high latitudes and thus affecting human activities within this region.

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Cosmogenic radiocarbon as a tool for investigation of solar activity in the past

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Analysis of radiocarbon records measured at A.F. Ioffe Physico-Technical institute, Tbilisi State University, the University of Washington and the University of Arizona is performed. It is shown that different radiocarbon series agree reasonably over long (multi-decadal and centennial) time scales. Variations in the atmospheric 14C level on timescales of tens and hundreds of years correlate well with the corresponding variations of the GCR intensity and solar activity. Thus, radiocarbon can be considered as a reliable source of information on long-timescale variations of solar activity in the past. Short-timescale (<30 years) fluctuations of 14C measured in different laboratories diverge appreciably. That makes use of radiocarbon for reconstruction of short-term solar variability problematic. Possible causes of short-timescale dissimilarity between different Delta14C series is discussed.

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Century-scale variability in terrestrial climate and its possible connection with the long-term change of solar activity

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Various proxy temperature records give evidence for a roughly regular centennial rhythm in climate over large regions during the last millennium. Both the Fourier and wavelet approaches are applied in analyses and it is shown that this variability most likely consists of two oscillation modes (55-80 and 100-130 years periodicities). It is shown that the most probable origin of this climatic rhythm is a modulation of terrestrial climate by secular variation of solar activity. Possible mechanisms of the influence of solar activity on climate are discussed. The obtained results provide new evidence of the reality of the solar-climate link over long time-scales and show that a combined use of both paleoclimatological and paleoastrophysicalapproaches give perspective to the exploration of climatic changes

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Daily variation of magnetospherically propagated power line harmonic radiation (PLHR) detected in northern Finland

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Many human activities causes changes in the VLF radio frequencies. The most significant are the VLF waves radiated by electric power systems at the harmonic frequencies of 50 or 60 Hz. This is called Power Line Harmonic Radiation (PLHR). The most dominat feature of these are the harmonics (especially odd) of these fundamental signals. These waves are supposed to amplify and trigger many emissions and thus participate in the precipitation of electrons. PLHR-lines were recorded already in the 1960s but first they were positively recognized as human generated signals by Helliwell et al. in 1975. Simple model of PLHR assumes that these are due to magnetic interaction from unbalanced harmonic currents flowing in the power lines with ground return.

In our VLF recordings we have seen direct radiation from nearby power lines. We have also seen signals which could have propagated in the ionospheric waveguide in a way analogous to VLF heating signals. Also we have found phenomena which PLHR signals have been propagated magnetospherically and either amplified or triggered VLF waves.

Park and Miller have identified in 1979 a significant decrease in the occurance of VLF emissions between 2-4 kHz recorded on Sundays in Antarctica. They concluded that this was due to changes in the daily power consumption. Also the power distribution at the surface of the Earth is different at weekends.

Duplets are very interesting PLHR phenomenon. They are generated when alternate currents are transformed to direct current in industrial scale. These produces two nearby PLHR signals. Frequencies of these duplets can be calculated by following equation when fundamental frequency is 50 Hz ($f = 50(n \cdot 12 \pm 1)$ Hz). We have detected duplet lines in Northern Finland near Kilpisjrvi. We can assume that the sources of these signals are in Finland because magnetospheric conjugate point is in southern Indian Ocean near Antarctica. One possible canditate is Tornio steel factory. These signals are definitely ionospherically propagated and some cases we can assume that they are magnetospherically propagated too. We have found events where hiss has been triggered between duplet lines. These are the strongest PLHR signals we have detected when not counting near field direct signals.

In this paper we study if there is any weekday dependence in duplet occurrence.

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Temporal variability of the north-south asymmetry in the solar flare index between activity cycles 17-23

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This paper reports the results of a study of the N-S asymmetry in the flare index for the solar cycles 17 to the current cycle 23. During the period 1934 - 2002 the periodicities have been searched and the dominant hemisphere of the solar activity has been clarified by calculating the actual probability of the hemispheric distribution of the flare index. By comparing the temporal variation of the asymmetry curve with the solar activity variation of the 11-year cycle, we have found that the flare index asymmetry curve is not in phase with the solar cycle and that the asymmetry peaks during solar minimum. A periodic behaviour in the N-S asymmetry appears: the activity in one hemisphere is more important during the ascending part of the cycle whereas during the descending part the activity becomes more important in the other hemisphere.

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Changes in the Earth's albedo over the past two decades

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We correlate an overlapping period of earthshine measurements of the earth's reflectance (1999 through mid-2001) with satellite observations of global cloud properties to construct from the latter a proxy measure of the earth's global shortwave reflectance. This proxy shows a steady decrease in the earth's reflectance from 1984 to 2000, with a strong drop during the 1990's. During 2001-2003 only earthshine data are available, and they indicate a complete reversal of the decline. The radiative forcing implied by either of these decadal changes in reflectance is climatologically significant. Understanding how these changes are apportioned between natural variability, direct forcing, and feedbacks, is fundamental to confidently assessing and predicting climate change.

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Geology and climate changes on Mars

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Knowledge of atmospheres can be connected to Martian geological evidence [1]. We highlight Martian geology and climate, and encourage space climate community to assess potential significance of the Martian record over the last 10 Myr in respect of solar activity. Changes in Mars' climate were connected to the obliquity [2,3,4; typically 45°, extreme 83°]. The obliquity increase at 5 Myr ago provides a constraint for Martian paleoclimatology [3]. It relates to Milankovitch cycles [5], although more dramatic. Average insolation of 82.3% onset was reached in the southern hemisphere 5.3 Ma ago [2,3]. Nine northern insolation peaks exsisted from 7.8 to 8.1 Ma ago and from 9.12 to 9.57 Ma ago. The best insolation was 9000 summers long [6]. Eccentricity changed from 0.0 to 0.13 (7). Geologic evidence support climate changes. Mostly, Mars was an arid polar desert with water ice in polar caps and regolith only. Orbit variations redistributed water, ice and dust making layered polar deposits, mid-latitude sediments, channels, glacial features, and jarosites and hematites. Obliquity extremes and igneous activity resulted in cryosphere melting, springs and hydrology [5]. The first billion years were "warm and wet" with a vertical hydrologic cycle [5,8]. Noachian valley networks support a warm, wet era [6] but cold and dry ideas are also postulated [9,10]. Mars may have had snow, ice, groundwater, water circulation, and cryosphere melting [5]. Hesperian channels prove violent water bursts which produced oceans in lowlands [11,12]. Fast freezing was followed by a long sublimation. Permafrost and cryosphere dominated over occasional liquid water and conditions were cold and dry in general [5]. Amazonian polar deposits record climate changes [13]. Its 350 m thick layers correlate to variations in insolation [13] and volatile transport [6]. The repeated 30 m wavelength in the 350 m ice package indicates repeated climatic processes. Accumulation changed and underneath there are 100 m deposits without layers. If the discontinuity relates to the end of 5.3 Ma ice age the deposition rate was 0.067 mm/year [13,14]. We do not know how the polar deposits form and if they disappear or reform or accumulate at obliquity extremes. What volatile sources were present? How did the active Sun effect the climate on Mars?

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October-November, 2003 solar events as manifestation of the long-term solar activity

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Analysis of direct measurements of cosmic ray fluxes for the last 60 years performed by balloon-borne and ground-based facilities has revealed a long-term trend towards decrease in the cosmic ray intensity caused by solar activity. Based on analysis of data on changes in concentrations of cosmogenic 10 and 14 isotopes in samples of known age, it is shown that the observed trend towards decrease in the cosmic ray intensity is associated with the 210-year cycle of solar activity whose rising face onset occurred around 1900 and whose maximum takes place at present. The physical nature of the 210-year cycle is still unclear. Development of extreme solar events and particular, October-November events of 2003, under the condition of decreasing number of sunspots during the last 11-year cycles in the late 20th and early 21st century can be regarded as manifestation of the long-term solar cyclicity or, to be more exact, of the 210-year solar cycle. Palaeoclimatic data show that 210-year solar cyclicity plays important role in long-term climatic changes. This work was supported by General Physics Department of RAS (program N 16), by RFBR (projects 03-05-65063 and 03-04-48769), and NorFA Grant "Network for Dendroecological and Dendrochronological Research in Northern Europe".

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Solar and volcanic activity signals as inferred from the acidity ice core records

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The influence of cosmic rays modulated by solar variability and volcanic activity on climate is analyzed. For analysis the Crete (Greenland) acidity ice core records have been used. It has been shown that the sunspot number (Wolf numbers) correlates with the background value of acidity in Greenland ice, characterizing the variation in the atmospheric aerosol component. It has been also demonstrated that large volcanic eruptions (Laki, 1783; Tambora, 1815; Krakatau, 1883; Pinatubo, 1991) and as well powerful solar proton events result in sulfate anomalies in polar ice. This supports the mechanism of the influence of solar and galactic cosmic rays on the concentration of aerosols in the atmosphere previously suggested by the authors. The results of the analysis have indicated that the acidity ice core records can be used as a proxy of solar activity in the past.

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Do Be-10 and C-14 tell us about cosmic ray fluxes in the past?

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In the period from 1957 till 1986 there are two overlapped sets of data: the Be-10 concentration data obtained from polar ice and the data on cosmic ray fluxes obtained in the polar atmosphere. As cosmic rays in nuclear interactions with atoms of the atmosphere produce Be-10 atoms the strong relationship is expected to exist between cosmic ray fluxes and radionuclide concentrations. But the correlation coefficient of these two sets of experimental data in the period under consideration is very low. The conclusion is made that the meteorological processes give the main contribution to the time changes of Be-10 concentrations.

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About cosmic ray fluxes in the past

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Cosmic rays play a key role in the climate changes. So, it is important to know the cosmic ray fluxes in the past. We found the relationship between cosmic ray fluxes observed and solar activity (number of sunspot groups). Then this relationship was used to calculate the cosmic ray fluxes in past (from 1700). In the calculations the negative trend of cosmic ray flux observed was taken into account.

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160-min Pulsation in the ground pressure

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By 5-min data of two far separated stations (Moscow and Yakutsk) the oscillations of the ground pressure with a period of 160 min from January 1 to March 1, 2000 are studied. It is shown that these oscillations are themselves in Moscow and Yakutsk synchronously, mainly in the form of "packets" containing 2-5 of 160-min oscillations. Phases inside "packets" are mainly preserved. The average amplitude of synchronous variations for Moscow and Yakutsk is equal to 0.011 ± 0.0006 mb. Their mean phase coincides with a phase of 160-min oscillations of the Sun's brightness. The onset of phase is at 0000 UT of January 1, 2000. The assumption that 160-min changes of ground pressure is caused not by the Sun but some other external source is argued.

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Changes in the Cosmic Ray Distribution under the effect of the Jupiter

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The possibility of the Jupiter to affect the change of physical conditions in interplanetary medium, spatial-temporal cosmic ray characteristics and reconstruction of mechanical movements (circulations) of air masses in the Earth's atmosphere is studied. Taking into account a large amount of observation data at the Oulu station (1964-2002) the effects of such an influence were estimated according to the change of sign of a general solar magnetic field. The effect of the Jupiter on cosmic rays is manifested in the form of the increase of their intensity. On the Earth this effect correlates with the change of the ground pressure as its decrease with a delay of 120 days relative to the change of cosmic rays. During the change of general solar magnetic field from (-) to (+) (positive change) the effects in cosmic rays and ground pressure are 0.36% and 0.33%, respectively, during the periods from (+) to (-) (negative change) it is 0.99% and 0.42% relative to the mean value of the instrument counting. Effects of the Jupiter's influence on cosmic rays and ground pressure during the periods of negative changes are greater by factor of 2.8 and 1.3 than during the periods of positive changes.

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Polar magnetic field reversal of the sun in polarization of radioemission 17GHz

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We investigated the distribution of polarization of the radioemission of the Solar disk according to the Nobeyama radioheliogrph observations. The data for each day of observations obtained at 10-minute interval and 1-second average. Latitude-time distributions of the circular polarization of the radio emissions during 1992-2003 were constructed. The latitudinal drifts of the polarization both in area of the sunspots appearance and at the high latitude were identified. Further analysis of the distribution of the polarization in the bright (Tbr>11000K) and dark (Tbr<11000K) areas showed the following. The distribution of the polarization of the bright areas on the whole corresponds to the distribution of the polarity of the magnetic field at the low and high latitudes. The distribution of the polarization of the dark areas is mainly connected with filaments drift during the reversal towards the poles. Thus the process of the reversal of the large-scale magnetic field in the polarization of the solar radio emissions during 22-23 cycle was found.

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Oscillations in the polarized solar radio emission at 1.76 cm wavelength during 1992-2002

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We examine some variations in the radio emission of the whole Sun at 1.76 cm wavelength, obtained with the Nobeyama radio heliograph during 1992-2003. For this purpose the daily data for the intensity and for the right/ left circular polarization of the radio emission with one-second average were processed. It was found that 3 minute oscillations are present at the different phases of the solar activity, including the minimum activity. These oscillations are especially conspicuous in the difference between the right and the left circular polarization. The intensity of the oscillations changes with the level of the solar activity. A power spectrum analysis shows that there exist modulations with periods of 27 and 157 days. During the minimum activity these main periods of the 3 minute oscillations are slightly shorter than during the maximum activity.

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Sunspot activity during the Maunder minimum: The upper limit

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Using the detailed information [Hoyt & Schatten 1998] on individual daily observations of sunspot groups which include also generic statements of long spotless periods, we analyze sunspot activity during the Maunder minimum (1645-1710). By means of a statistical probabilistic approach applied for periods with sparse observations and generic statements by observers, we estimate the upper limit (at 95% confidence level) of sunspot activity that can be derived from the available observations. This result does not modify earlier conclusions on the dominant 22-year periodicity during the Maunder minimum but makes it more robust.

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The 'Solar Influences Data analysis Center' as 'World Data Center' for the Sunspot Index

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Since January1981, the Royal Observatory of Belgium has operated the Sunspot Index Data Center, the World Data Centre for the Sunspot index. The SIDC continued the work of the Zurich Observatory, when this institution decided to stop publishing the sunspot number. From 2000, the SIDC obtained the status of Regional Warning Centre (RWC) of the International Space Environment Service (ISES) and became the 'Solar Influences Data analysis Center'. The sunspot number is the oldest solar index measuring the solar activity and its main interest results from its long-term behaviour and the length of its series. For a long time, it was the only index representative of the solar cycle, and many studies on the cyclical behaviour of the Sun make use of the Sunspot Number. The SIDC collects monthly observations from worldwide stations (typically 70) in order to calculate the International Sunspot Number. The center broadcasts the daily, monthly, yearly international sunspot numbers, with middle range predictions (up to 12 months). Since August 1992, the hemispheric Sunspot Numbers are also provided. In the accompanying poster, the way of processing the data to obtain the provisional and definitive (hemispheric) sunspot numbers will be one of the raised items.

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Chromospheric structure and activity in solar analogues

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We compute chromospheric models of the Sun as a star and of ten solar analogues. The atmospheric models were constructed to obtain the best possible match with the Ca II H and K and Hβ lines, including the assimetry of the lines due to macroscopy velocity fields. To do this we used the Pandora computer program, which solves the transfer and statistical equilibrium equations. We obtained the observations with the 2.15 m telescope of the CASLEO Observatory located in San Juan, Argentina. To test our models, we compare other chromospheric lines (Balmer series, b Mg I lines and d Na I lines) with observations obtaining good agreement. To constrain the position of the transition region, we calculate the electronic density distribution of the transition region. We compared this results with IUE and Hubble observatios in the UV range.

The stars were chossen with $0.62 <$ B-V < 0.68 (the solar B-V=0.65).Those stars are (in ascending activity levels order) HD187923, HD172051, HD146233 (the best solar twin to date), HD19467, HD197076, HD189567, HD20766, HD30495, HD1835 and HD202917, where the latest four stars conform the most active stars group. These stars have a wide variety of magnetic activity levels, so we study differences among their atmospheric structures and we compare these with the Sun. We found for the less active stars that the changes with activity are in the region of the temperature minimum, while the most active stars show changes all along their atmospheric structures, mainly in the upper chromosphere. Regarding the macroscopy velocity fields, we can distinguish between the two groups. The most active group have a velocity field in the minimum-temperature region, and the other group in the chromospheric plateau. From these models we can estimate the amount of energy to support these atmospheric structures, to constrain the physical processes responsible for the chromospheric heating.

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Solar activity record from archaeomagnetic data

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Each of available solar activity (SA) proxy data (historical notes, radio nuclides 14C and 10Be concentration) is contaminated by additional factors and composite data should be used for precise historical SA restoration. Here we show that archaeomagnetic measurements 95% confidence interval (a95) may serve as new proxy for the SA estimation. This proxy is in good correspondence with sunspot numbers over 1700-2000yr. The three independent SA estimations (based on aurora borealis historical notes, 10Be and a95) show remarkable similarities over 1500-1700yr. It is supposed here that quick perturbations of the geomagnetic field caused by SA can destruct magnetic multi-domain structures of the overheated sample near the Curie point and decrease the a95 value. Because no dependence of a95 on the geomagnetic field secular variations and climatic parameters was found, a95 may be more perspective then 10Be - and 14C proxies for SA estimations in the geological time scales.

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Semiannual variation in solar-climate links

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It has been shown that semiannual variation is typical for geomagnetic activity. The aurora borealis frequency, riometer and other data show an equinoctial maximum that can be explained by orbital and solar wind magnetic geometry (Russel-McPherron effect). Here we show that the global earth monthly temperature data (1880 - 2000yrs) have better correlation with solar activity level for equinoctial months than for other months within a year. This fact can be interpreted as stronger influence of solar activity on climate during the equinox period due to amplifying chain "solar activity - cosmic rays - cloudiness".

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Neutron monitor network as a basis tool for providing long term observations of the solar activity manifestation in cosmic ray intensity

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World wide neutron monitor network today consists of more than 45 neutron monitors. To provide long time observation of solar activity revealed in cosmic rays the first importance has a stable operating of the neutron monitor network. The method of this long time stability estimation is considered in presented work. The quantitative ratios of stable operation, and causes of the long time drifts in the neutron monitor data are presented for each station. Now days the new scientific and applying problem stand before the network, so, this network is essentially modernized at present. The main task now is to provide the network operating as a single multidirectional device with sufficiently stable long time accuracy.

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