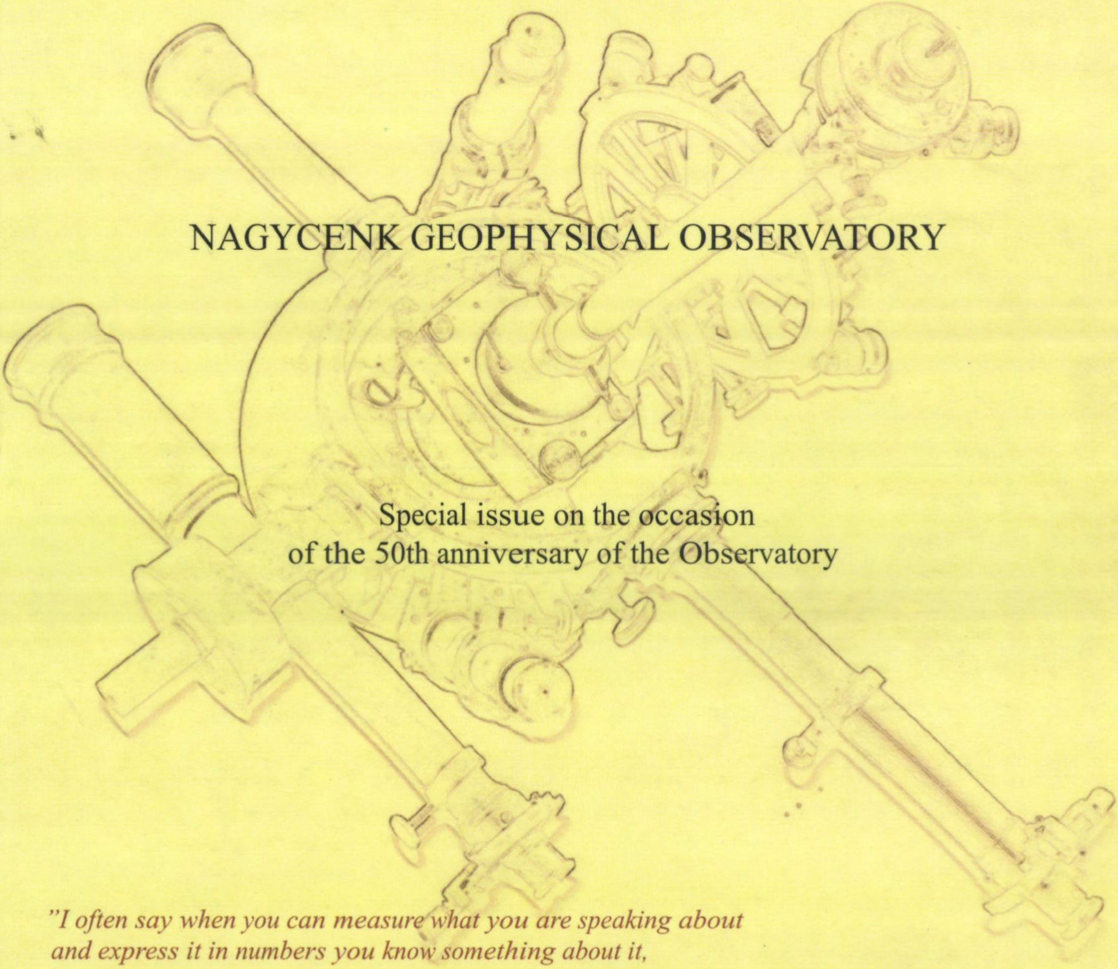
GEOPHYSICAL OBSERVATORY REPORTS

2005/2006

OF THE GEODETIC AND GEOPHYSICAL RESEARCH INSTITUTE OF THE HUNGARIAN ACADEMY OF SCIENCES

YEAR
2005–2006



NAGYCENK GEOPHYSICAL OBSERVATORY

Special issue on the occasion
of the 50th anniversary of the Observatory

*"I often say when you can measure what you are speaking about
and express it in numbers you know something about it,
but when you cannot measure it, when you cannot express it in numbers,
your knowledge of it is of meagre and unsatisfactory kind"*

Lord Kelvin

Sopron
2007

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NAGYCENK GEOPHYSICAL OBSERVATORY

IAGA CODE: NCK

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SOPRON

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Cover illustration:
Contours of a fine old magnetometer, manufactured by Nándor Süss in Kolozsvár. It served in Ógyalla, than in the Nagycenk Observatory until 1986. Altogether nearly 100 years!

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Preface

The Széchenyi István Geophysical Observatory of the Hungarian Academy of Sciences is pleased to present the 2005–2006 reports in the Geophysical Observatory Report series.

In 2007 the Geophysical Observatory celebrates the 50th anniversary of its founding.

The anniversary is an opportunity to look back, to evaluate results and also to consider future possibilities. In this special anniversary issue historical papers and photos, a selection of notes from the guestbook and scientific results are also included.

The observatory was founded by the Hungarian Academy of Sciences, as perhaps the first Hungarian establishment dedicated to upper atmosphere and near-Earth space research. The observatory became operational on the beginning of the International Geophysical Year (IGY, between July 1957 and December 1958).

Present-day activity of the observatory is rooted in 240 years history of geophysical observations in Hungary. Measurements of the Earth's magnetic fields started at Nagyszombat University in 1768 and moved to Buda soon with the university. Buda Observatory was put into operation in 1777. It had to be replaced at the end of the 19th century due to industrial development and electrification of the capital. Konkoly Thege Miklós, director of the Central Institute of the Hungarian Kingdom for Meteorology and Earth Magnetism (*Meteorológiai és Földdelejességi Magyar Királyi Központi Intézet*) established the new geomagnetic observatory at Ógyalla in 1893. With the Treaty of Trianon the territory became a part of Czechoslovakia. After a chaotic period a temporary station was set up at Budakeszi and the final replacement of Ógyalla became fully operational in Tihany in 1955. By that time the importance of solar terrestrial interactions and diagnostics of the ionosphere and magnetosphere had been recognized and the growing interest inspired the Geophysical Research Laboratory of the Sopron University, headed by professor Károly Kántás, to establish a purpose built observatory near Nagycenk. That is why the Széchenyi István Geophysical Observatory became known as Nagycenk Observatory (IAGA code: NCK) worldwide. Foundation of the observatory set in motion the permanent development of instrumentation, continuous international data services and scientific research especially in geomagnetism and aeronomy.

Nagycenk Geophysical Observatory has been supplying data since 1957. Geophysical Observatory Reports comprise earth current data from 1957 on, geomagnetic data from 1961 on and atmospheric electricity data from 1962 on.

Observatory is networked through the institute (Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences), data are available in near real time. The institute doesn't charge academic users for data products.

Further information and data including archived data are available by special arrangement at the institute:

Geodetic and Geophysical Research Institute
Hungarian Academy of Sciences
H-9401 Sopron, P.O.Box 5
Phone: +36–99–508340, e-mail: wv@ggki.hu

Foundations upon which we stand today were laid by the staff of the Geophysical Research Laboratory. Antal Ádám, Pál Bencze, Ferenc Märcz, József Verő and Ákos Wallner are still with us. We would like to express our admiration and gratefulness for everything that they have done during the 50 years. The patient guidance, scientific accuracy and precision.

On this occasion we acknowledge the assistance and the impact of the international and Hungarian geoscience societies and especially the generous support of the Hungarian Academy of Sciences, and the Hungarian Scientific Research Fund (OTKA, project numbers TS 408048 and NI 61013).

We would like to express our gratitude also to the COST 724 Action "Developing the Scientific Basis for Monitoring, Modelling and Predicting Space Weather" for coordination and outreach efforts.

In addition to our core activity commercial applications are searched for. We thank the collaboration and the revenue received for our space weather related studies to the MAVIR and AB AEGON companies.

Sopron, August 2007

V. Wesztergom

THE 50TH BIRTHDAY OF THE NAGYCENK OBSERVATORY AND THE INTERNATIONAL GEOPHYSICAL YEARS

L. SZARKA

The whole activity of the 50 years old Nagycenk Geophysical Observatory (in its full name: Széchenyi István Geophysical Observatory of Hungarian Academy of Sciences) is closely related to international geophysical co-operations, and its history is milestoned by such events as the International Geophysical Year 1957–1958 (the starting date), and the IGY+50 anniversary years, especially the Electronic Geophysical Year.

Introduction: IGY and the Observatory

As evaluated 50 years later (at the US002 session of IUGG General Assembly in Perugia), the International Geophysical Year (IGY) has meant a remarkable progress to the scientific disciplines represented in IUGG. The polar regions, the deep oceans, the Earth's interior, its atmosphere and the space beyond were explored at an unprecedented rate. New technologies like satellites and computers facilitated measurements, data collection and analysis and were applied in a global effort and with an extraordinary station density.

The Nagycenk Geophysical Observatory (Ádám and Verő 1958, Ádám et al. 1981, Bencze and Märcz 1981, Verő 1996, 2001, 2002) is one of the direct products of the International Geophysical Year 1957–1958.

IUGG/IAGA and the Observatory

Since that time, the Nagycenk Observatory has become an indispensable data source of earth science observations, related to electromagnetic phenomena in the Earth and in near-Earth space. By measuring the electromagnetic field on the Earth in a wide frequency range, the observatory data are relevant to the investigation of the following inter-related domains: Sun, interplanetary field, magnetosphere, ionosphere, atmosphere, Earth's crust, mantle and core, and their processes varying with time. (See the Annual Reports of the Observatory.)

The Institute, where the Observatory belongs to (Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences, www.ggki.hu), all the three classical ways of scientific research: theory, numerical simulation and physical measurements are characteristic, and among the physical measurements the observatory measurements are our permanent data source (while the field works and the laboratory experiments are intermittent tools).

The name of the institute is "Geodetic and Geophysical", and the name of IUGG (founded in 1919, due to the activity among others by Baron Loránd Eötvös, but Hungary could became its member only in 1930) means International Union of "Geodesy and Geophysics" (www.iugg.org). The departments of the Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences (Geodesy, Seismology and Geophysics) are closely related to three of the seven (from 2007: eight) member associations of IUGG: IAG (International Association of Geodesy, www.iag-aig.org), IASPEI (International Association of Seismology and Physics of the Earth's Interior, www.iaspei.org) and IAGA (International Association of Geomagnetism and Aeronomy, www.iugg.org/iaga). In such a way, the Geodetic and Geophysical Research Institute provides the largest component of Hungarian IUGG activities.

The Nagycenk Observatory is a part of the Geophysical Department. Activities of its three groups (Geomagnetism, Aeronomy and Electromagnetic induction) are related to all the five IAGA divisions. The research in Sopron (feeded, first of all, by observatory data from Nagycenk) has been recognised by the IAGA in a special way: the 11th IAGA Scientific Assembly will be held in Sopron, August 23–30, 2009 (www.iaga2007sopron.hu, see in details in the Appendix).

IGY+50 and the Observatory

The IGY+50 events in Hungary start with the 50th birthday of the Nagycenk Observatory, to be held together with the Hungarian launching event of international geoscience years of 2007–2009 (Annual Meeting of Hungarian Geologists and Geophysicists, September 19–22, 2007).

All over the world several initiatives have been formed to celebrate IGY+50: the most general one is the International Year of Planet Earth 2007–2009 (www.yearofplanetearth.org, Szarka 2006, Ádám 2007), which is a UN year in 2008. The International Polar Year 2007–2009 (Bindschadler 2007, www.ipy.org, which is actually the fourth polar year: the third one was a part of the IGY itself) investigates the two polar regions (including their electromagnetic phenomena), while the International Heliophysical Year 2007–2008 (e.g., Baker 2007, Kecskeméty 2007, www.ihy2007.org) focuses on the heliosphere, where the new word "heliophysics" is a generalization experiment of the word "geophysics".

There have been and will be observatory-related events devoted to these three international geophysical years of 2007–2008, and also to the so-called GEOSS (Global Earth Obervation System of Systems). However, the observatory has the closest relationship with the Electronic Geophysical Year (www.egy.org), which is the IGY+50 initiative of IAGA.

It is self-understanding, that the Observatory has been and will be serving as a basis of international scientific co-operations. Its geomagnetic part, e.g., is a member of the IAGA-promoted INTERMAGNET network. Reports, research papers and rememberings in this book provide further examples.

Electronic Geophysical Year and the Observatory

The Electronic Geophysical Year, 2007-2008 (*e*GY) provides an opportunity for the international geoscientific community to focus effort on a 21st Century e-Science approach to issues of data stewardship: open access to data, data preservation, data discovery, data rescue, capacity building, and outreach. (Barton 2007, Parsons 2007). The development of Virtual Observatories and Laboratories is a central feature of *e*GY. In the VxO series, where x denotes the physical parameter, we find the following international initiatives: VCO (Virtual Carbon Observatory), VGMO (Virtual Geomagnetic Observatory), VHO (Virtual Heliophysical Observatory), ViRBO (Virtual Radiation Belt Observatory), VMO (Virtual Magnetospheric Observatories), VOO (Virtual Ocean Observatory), VSN (Virtual Seismic Network), VSO (Virtual Solar Observatory), AVO (Astrophysical Virtual Observatory), while NVO will be the US National Virtual Observatory. The Nagycenk Observatory data are relevant to VGMO, VHO, ViRBO, VMO, and most probably to VSN.

Conclusions for the next 50 years

The natural electromagnetic fields and their time variation contain information about the entire world, including the changing Earth and the whole heliospace. In order to understand e.g. the variable conditions in the near-Earth space (known as space weather), the energy coupling between the solar wind and the Earths magnetosphere (which might influence the Earth's climate), or the geophysical processes within the Earth, such monitoring measurements, as have been carried out since the IGY in the Nagycenk Geophysical Observatory, are absolutely indispensable: not only for the international scientific community, but also for the sustainability of human societies.

At the Perugia IUGG General Assembly the member associations gave an overview over the accomplishments in their fields during IGY and in the 50 years since. As Charles Barton, the resigning president of IAGA pointed out (Barton 2007): the question "What YOU have provided in terms of data to the scientific community?", will be more and more important in the future. The Nagycenk Observatory gives to this question a reassuring answer.

Acknowledgements

The observatory-related research of the Geophysical Department is supported first of all by the Hungarian Academy of Sciences, and recently (2006–2008) it is additionally supported by the Hungarian Scientific Research Fund (OTKA), project number NI 61013.

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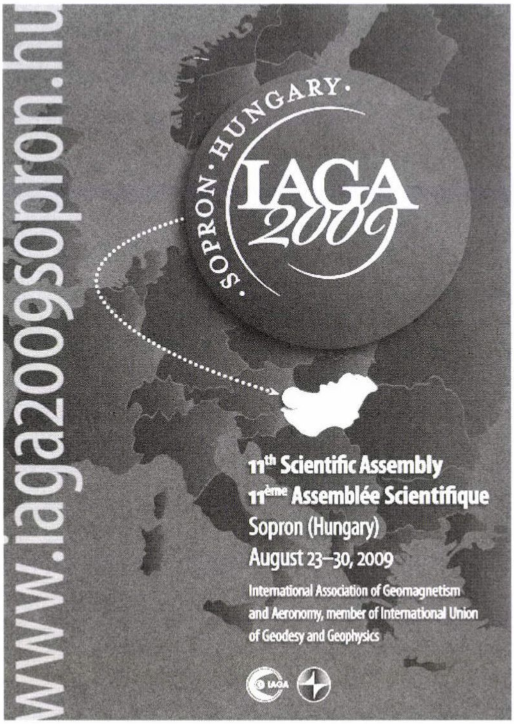
Appendix – The 11th Scientific Assembly of IAGA

You are cordially invited to attend the IAGA 11th Scientific Assembly, to be held August 23–30, 2009 in Sopron, Hungary.

The Assembly will be held in the Liszt Ferenc Conference and Culture Centre (LFCCC) and nearby buildings (in the developing "Sopron Downtown Convention District"). LFCCC will serve as the headquarter (with the registration area, opening and closing ceremony, association lectures, and part of the sessions). The other part of the sessions and the poster presentations will be held in other buildings. All lecture and poster halls are within less than 5 minutes of each other on foot.

The scientific program of the meeting, which will cover all areas of IAGA science, will be defined by IAGA and its scientific bodies. It will be announced in the Second Circular, which will give all relevant information on how to submit an abstract and how to register for the meeting.

The scientific program starts on August 24 (Monday) and ends on August 29 (Saturday). The posters will be on show for six days, as well as the planned exhibition. About 600 oral presentations, 600 posters, and two association lectures are expected.



The poster of the Assembly (designed by Márton Juhász, University of West Hungary)

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I. OBSERVATORY REPORTS 2005–2006

1. DESCRIPTION OF THE OBSERVATORY

V. WESZTERGOM

Nagycenk Geophysical Observatory was founded in 1956–1957 and it has been operated since then by the Geodetic and Geophysical Institute of the Hungarian Academy of Sciences.

The observatory is situated about 10 km to E of the city Sopron and 60 km SE of Vienna, on the southern shore of lake Fertő. The observatory lies on thick conductive sediment preserving the site from far industrial noise and it is surrounded by the Fertő-Hanság National Park which helps to shelter the long term measurements from any change caused by nearby manmade activity.

The co-ordinates of the observatory

3-character IAGA code: **NCK**

Geographic co-ordinates:

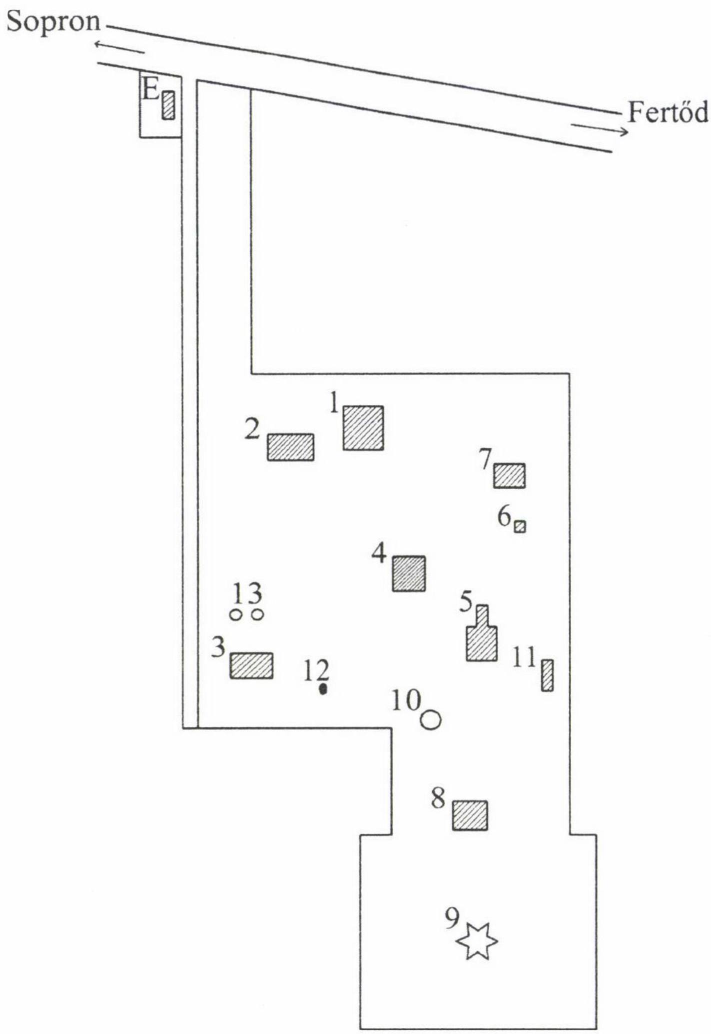
φ	=	47°38′ (N)
λ	=	16°43′ (E)
Altitude	=	153.70 m (magnetic house)
McIllwain L	=	1.9

Measurements and reports started in 1957 (International Geophysical Year) with earth current data. The potential differences are measured in N-S and E-W directions with electrode spacings of 500 m. Low polarization lead plate electrodes are buried about 2 m below the surface. Potential differences are recorded with 1 sec and 10 sec sampling rate.

Continuous observation of atmospheric electricity started in 1962. Slow variation (DC component of vertical atmospheric electric field) is measured between the ground and an electrode (at 1 m height) around which the potential is equalized by means of a radioactive collector. Potential gradient is recorded with 15 sec sampling rate.

The publication of point discharge data has been abandoned from the year 2002.

Table I. Observatory site diagram



E – Entrance, 1 – Main building with staff hostel and electronic laboratory, 2 – Telluric instruments and office, 3 – Atmospheric electricity centre (laboratory of Schumann resonance, potential gradient, point discharge and radiovawe absorption measurements), 4 – Magnetic absolute house with four pillars, 5 – Underground magnetic variometer chambers, 6 – Proton magnetometer (DI/DD) hut, 7 – Computer centre (data loggers, server of local network, satellite transmitter) 8 – Ionosonde station, electric and mechanical workshop, 9 – Ionosonde D-antenna, 10 – Meteorological station, 11 – ELF induction coil chamber, 12 Ball antenna (Schumann resonance antenna), 13 – Potential gradient sensors

Continuous observation of geomagnetic elements with control of the absolute observations began in 1961. The observatory has belonged to the INTERMAGNET co-operation since 1993. Data are transmitted via METEOSAT satellite and computer network to geomagnetic information nodes and made also available to the international research community on CD ROM.

The observatory is the northernmost station of the South European Ground Magnetometer Array (SEGMA). The SEGMA stations in Austria, in Hungary and in Italy are located between $L = 1.56$ and $L = 1.88$. All of them are equipped with high resolution CHIMAG magnetometer. The magnetic field vector is recorded with a nominal sampling rate of 16 Hz but on special occasions the station has the maximum sampling rates up to 64 Hz.

The early nineties are to be considered as a transition period in the observatory again. Schumann resonance measurements started in 1993, an ionosonde station type IPS 42 works since 1996, the new digital ionosonde (type VISRC-2 made by the Space Research Center of the Polish Academy of Sciences) is to be put in operation in 2007. A scientific meteorological station was installed in 1996. ELF-VLF (whistler) observations is going on since 2003. The meteorological station is based on a Campbell CR10X measurement and control modul, temperature, humidity, wind speed, wind direction, rainfall and radiation sensors.

2. GEOMAGNETISM

ELECTRIC ACTIVITY INDICES

The 3-hour electric activity indices T for the E_x and E_y component, have a linear scale with a step of 1.8 mV/Km. The range of values is 0 to 9.

Values in brackets mean extrapolated data, where the lacking intervals were substituted by the average of recorded intervals.

Times are given in UT.

A detailed description of the processing and compilation is found in the Report of the Observatory for 1966 in German and Ádám A, Verő J, Cz. Miletits J, Holló L, Wallner Á: The geophysical observatory near Nagycenk. I. Electromagnetic measurements and processing of data (*Acta Geod. Geoph. Mont. Hung.*, 16, 1981, 333).

See CD (data visualization: program Seenck.exe, menu item Tellurics/Indices; path: \Nckobs\Tell\Indices\).

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050206	11221142	14
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050208	45465796	46
050209	36465456	39
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050715	01112121	9	050825	44224852	31
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Date	T	Sum
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050911	99979997	68
050912	34976999	56
050913	94379063	41
050914	21324451	22
050915	21799974	48
050916	32335152	24
050917	12214542	21
050918	11322111	12
050919	11111110	7
050920	01111110	6
050921	11111000	5
050922	11112220	10
050923	21211011	9
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050926	42322144	22
050927	41112115	16
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050929	32221211	14
050930	01124224	16
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051006	11111110	7
051007	21122135	17
051008	87757194	48
051009	21332033	17
051010	32232112	16
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051013	10121131	10
051014	01121001	6
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051016	01121113	10
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060112	21100000	4
060113	00010111	4
060114	10001020	4
060115	20010131	8
060116	12243555	27
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060119	11111113	10
060120	11111320	10
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060124	21211100	8
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Date	T	Sum
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060901	41223466	28
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Date	T	Sum	Date	T	Sum
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Date	T	Sum
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061212	36328574	38
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MAGNETIC MEASUREMENTS AND DATA PROCESSING

V. WESZTERGOM

Recording of geomagnetic variations

Geomagnetic variations are recorded by the ARGOS system. ARGOS (developed by the Geomagnetism Group of British Geological Survey) is a PC based automatic observatory equipped with triaxial fluxgate and a proton magnetometer in a DD/DI configuration. The fluxgate variometer sensors are aligned in X, Y, Z directions. 10 second samples are used to provide minute values centred on the minute by means of a 7-point cosine filter. Reported elements are: H (horizontal), Z (vertical), D (declination) and F (total force). From the year 1993 on the minute values are transmitted through the METEOSAT satellite to the Edinburgh Geomagnetic Information Node.

Table I. Main specifications of ARGOS used in Nagycenk Observatory

Device	Resolution	Dynamic range	Temperature coeff.
Triaxial Fluxgate Magnetometer	0.1 nT	±500 nT/±400 nT	$\sim$ 1 nT/°C
Proton Magnetometer (ELSEC 820)	0.1 nT	10000–90000 nT	–

DI/DD coil system consists of two orthogonal sets of Helmholtz coils (proton head is mounted at the centre). Coils orientated so that one provides bias fields approximately perpendicular to F vector in the magnetic meridian and the other provides bias fields approximately perpendicular to F in the horizontal plane. DD and DI relative to the initial values (D0. I0) are calculated. DD/DI proton magnetometer is used in every tenth minutes from which F and almost absolute values of D an I are obtained.

Satellite transmitter, 6800 Series of Data Collection Platform, was supplied by Space Technology Systems. Power output to antenna (two linearly-polarised Yagi arranged to give circular polarisation) is 4 watts at 402 MHz. Data storage capacity is 2 × 40 kbytes.

Timing is produced by the IBM clock corrected by the high stability crystal built in the Proton Magnetometer.

To ensure continuous recording a high stability torsion photoelectric magnetometer (type PSM-8711) has been run from 1 January 1998. Data along with telluric data are logged by a DR-02 type digital recording system. The PSM magnetometer records the H, D and Z component with an exceptionally high parameter stability. The baseline variation has never exceeded 1.5 nT/year. Maximum resolution is 3 pT, sampling rate applied is 10 s. Frequency response: 0.3 Hz to DC. Sensitivity to tilting: less than 10 nT/′.

Data are stored in the internal memory of the digital data logger DR-02. Both the PSM and the DR-02 was developed and provided by the Institute of Geophysics Polish Academy of Sciences.

Absolute control, baselines

Baselines of the variometer systems are derived from absolute observations. Prior to 1989 the baseline was controlled by two QHM, one declinometer and one BMZ. From 1989 till the end of 1994 the standard instrument for absolute measurements was the vector proton magnetometer (NVP) constructed in Niemegk Observatory. In 1994 an Overhauser proton magnetometer (type: GSM 19 of GEM Systems) and a fluxgate theodolite (developed by the Danish Meteorological Institute) was purchased. Since then the standard instruments are the fluxgate theodolite for I and D and the Overhauser effect proton magnetometer for F.

To determine the momentary angle of declination four observations (four null positions in the horizontal plane) are taken and it is repeated at least two times. Generally the closer azimuth mark is used but it is checked regularly with the far azimuth mark. Inclination angle is determined in the plain of the momentary magnetic meridian in the same way as D. Total intensity is measured simultaneously with I-measurements on the next (F) pillar with the Overhauser magnetometer. Absolute values of all geomagnetic elements are referred to the same pillar of the absolute hut. Observation is made weekly, occasionally more often.

Absolute measurements are supplemented by quasi absolute baseline reference measurements. Declination, inclination and total intensity are determined by means of a proton vector magnetometer in every ten minutes.

Data processing and availability

Sampling rate of magnetic variation data is 10s both for ARGOS and PSM. Minute mean values are produced with digital filter from the raw sampled data. According to the IAGA recommendation minute mean values are stored. Hourly means are calculated from minute means, yearly means are derived from hourly means. Final absolute values of H, D and Z field component are obtained from smoothed baselines.

ARGOS data are compared continuously to PSM data and gaps are filled.

Data are logged on floppy disk too. In addition to logging data to disk INTERMAGNET V2.8 format satellite transmission packets are sent to DCP.

Presentation of the results

- plot of hourly mean values of H, D, Z
- plot of daily mean values of H, D, Z
- tables of geomagnetic activity indices, K
- table of annual mean values of geomagnetic elements
- special phenomena: SSC, sfe

See CD (data visualization: program Seenck.exe, menu item Magnetics; path: \Nckobs\Magn\).

GEOMAGNETIC DATA

Hourly mean values of H, D, Z and F

Hourly means are derived from minute means corrected using absolute observations. The units of the elements are 0.1 nT, Declination is also scaled to 0.1 nT. Minute means of F are calculated from H and Z. F values are checked by comparing them with proton magnetometer readings taken at every 10 minutes.

Daily mean values of H, D, Z and F

Daily mean values are calculated from hourly mean values.

Geomagnetic activity indices: K-index

The K-index is determined from the amplitude ranges of H and D components for each three-hour Universal Time interval. Limit for K=9 is 350 nT in Nagycenk.

Special phenomena

List of special events is based on both magnetic and earth current records. Tables are given for SSC-s and sfe.

Annual mean values of geomagnetic elements

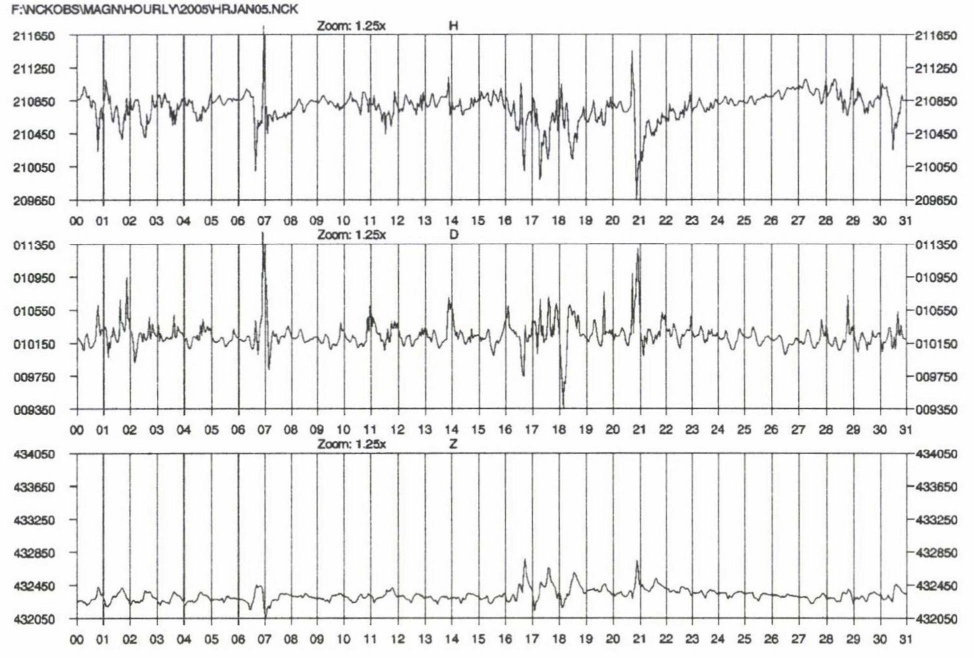
Table contains yearly means of the geomagnetic elements 1961 to 1993 in nT. These values are the results of a reevaluation of previously published data, including corrections eliminating disturbances caused by construction works in the observatory. Corrected values are noted by asterisk.

Times in this section are given in UT!

See CD (data visualization: program Seenck.exe, menu item Magnetics; path: \\Nckobs\\Magn\\).

Hourly mean values of H, D, Z

2005–2006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D
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010950
010550
010150
009750
009350
Z
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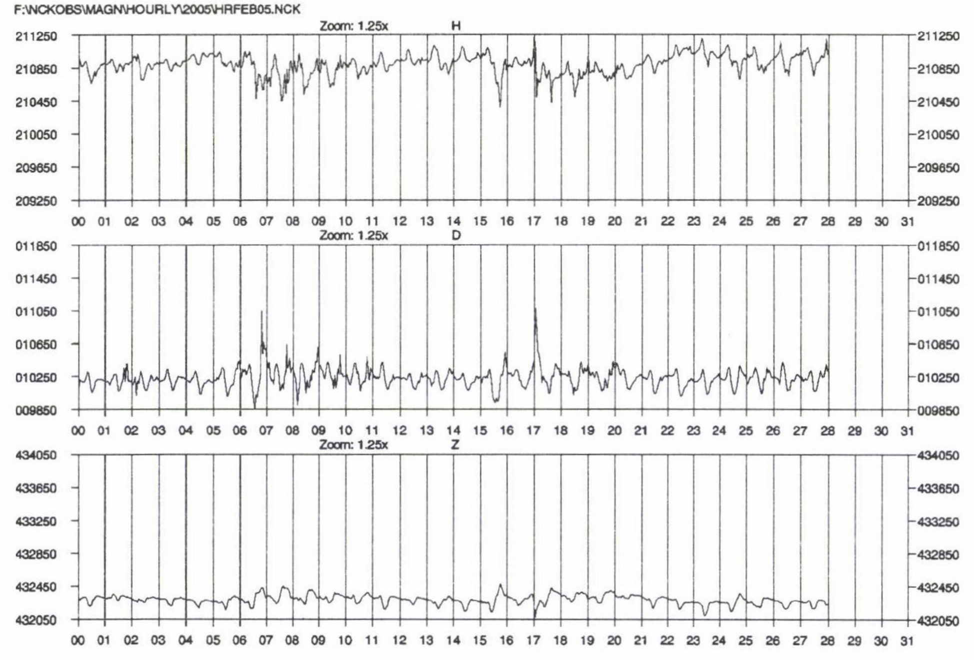
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Z
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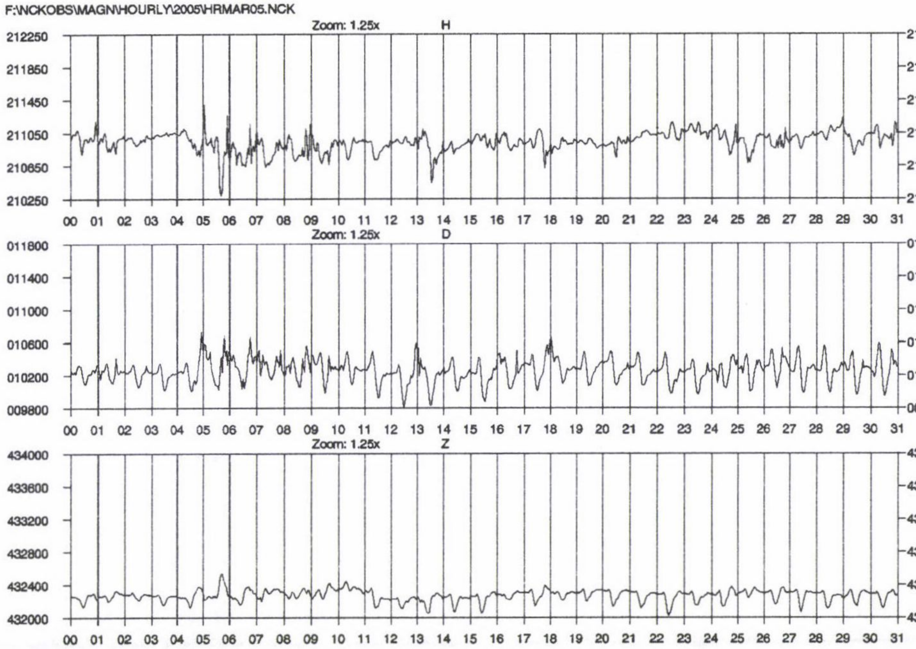
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211050
210650
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Zoom: 1.25x D
011800
011400
011000
010600
010200
009800
00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Zoom: 1.25x Z
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433600
433200
432800
432400
432000
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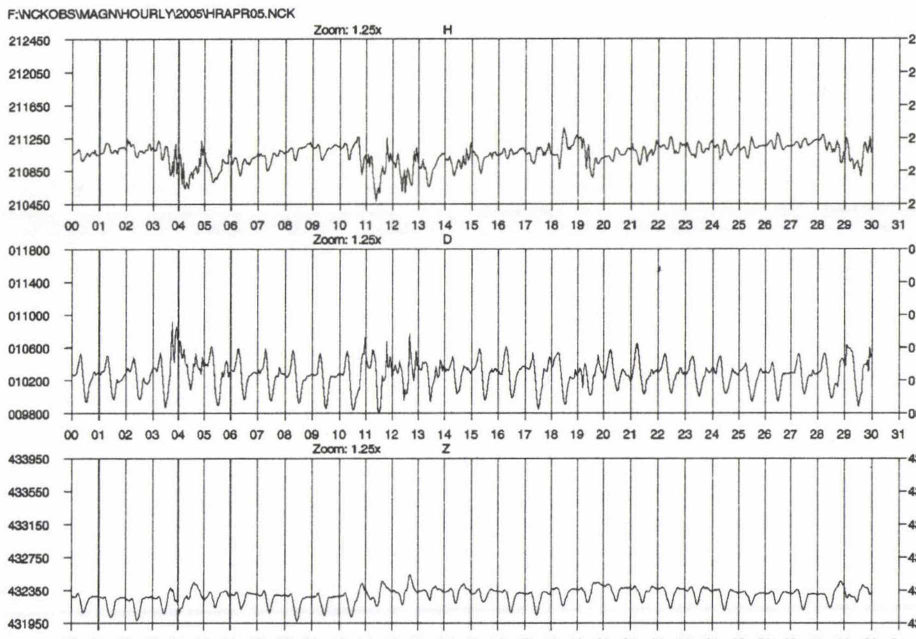
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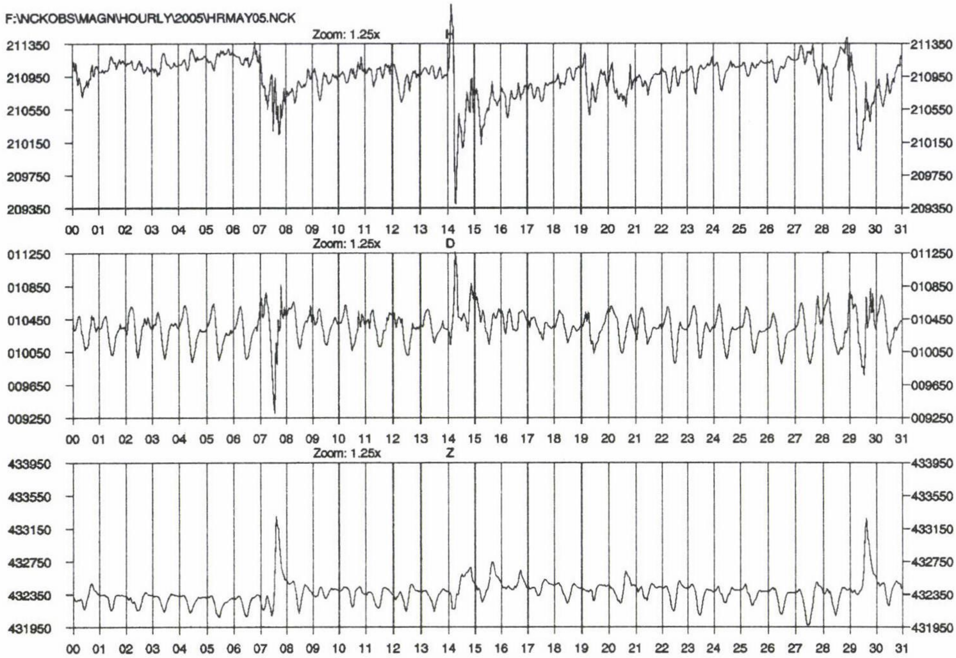
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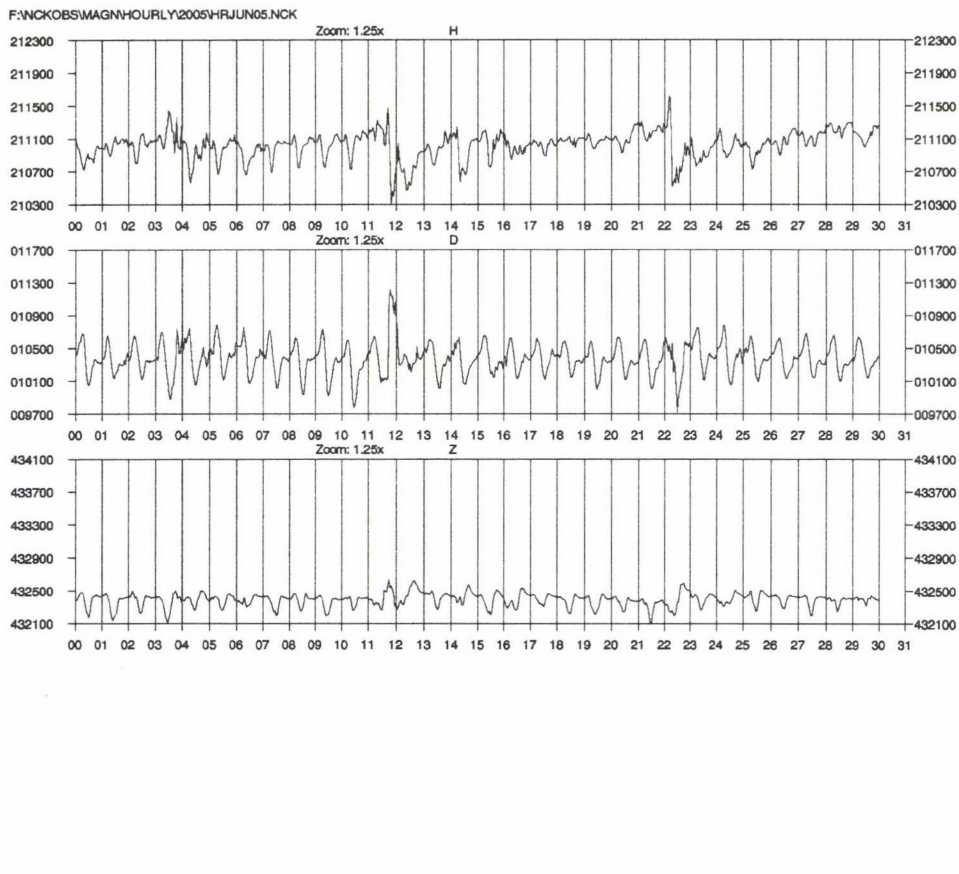
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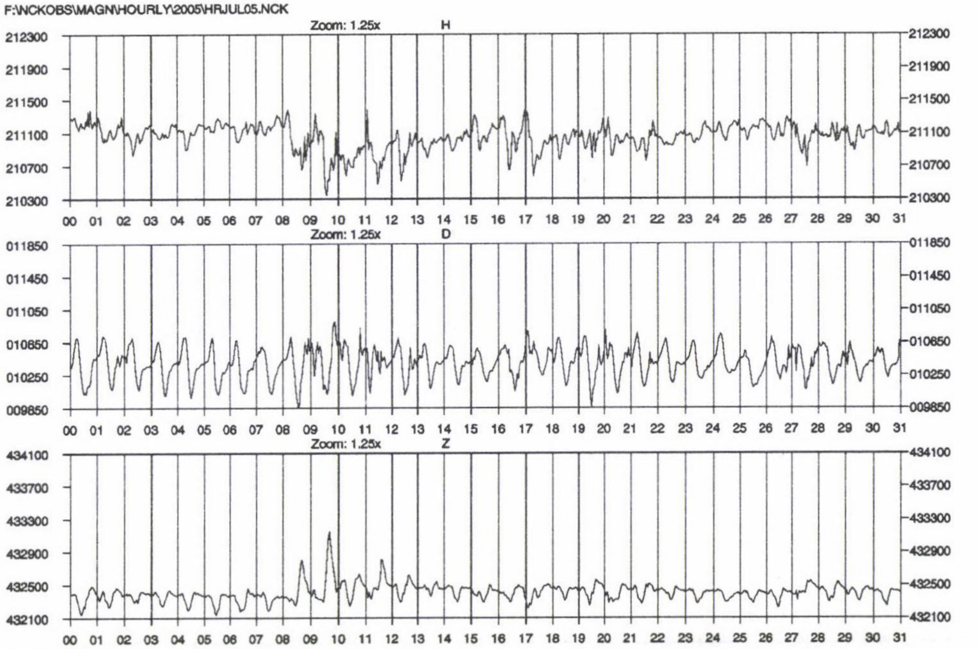
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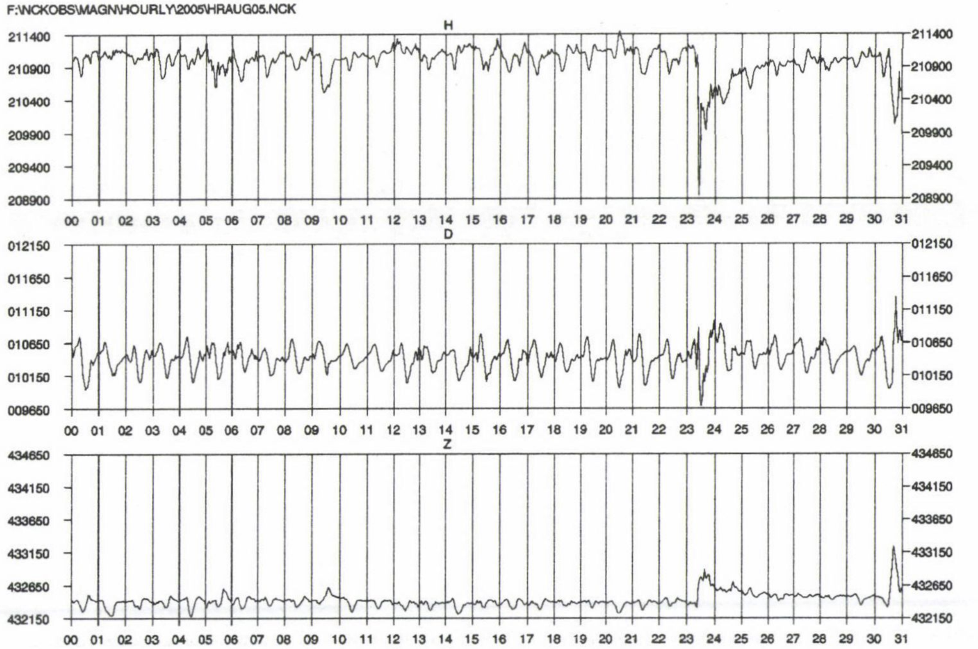
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Z
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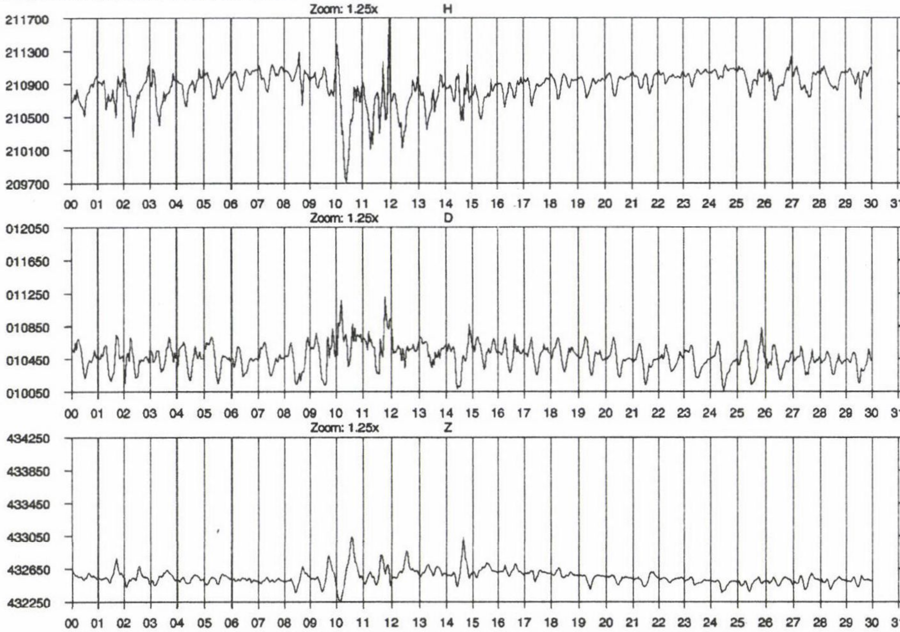

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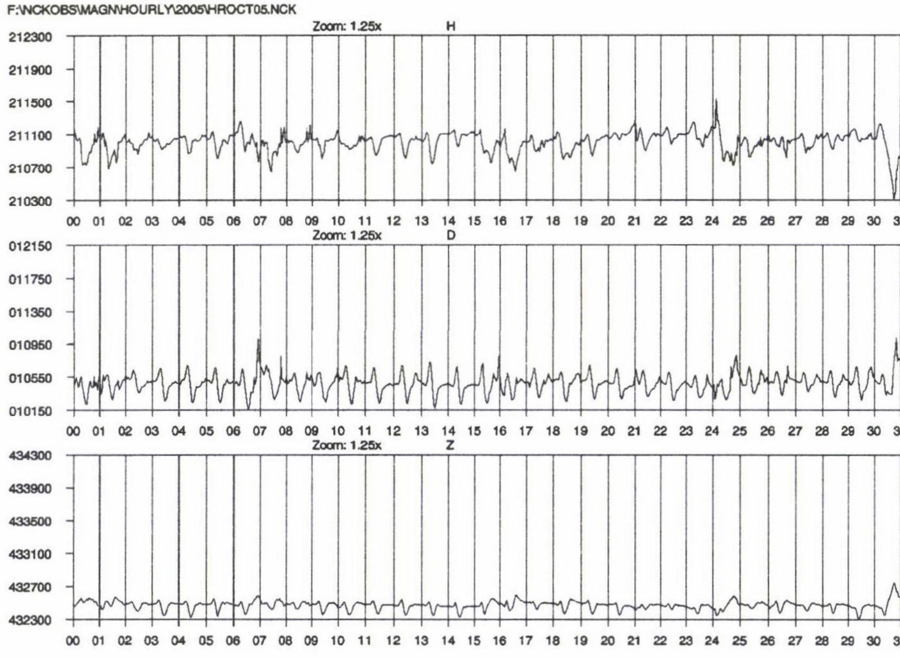

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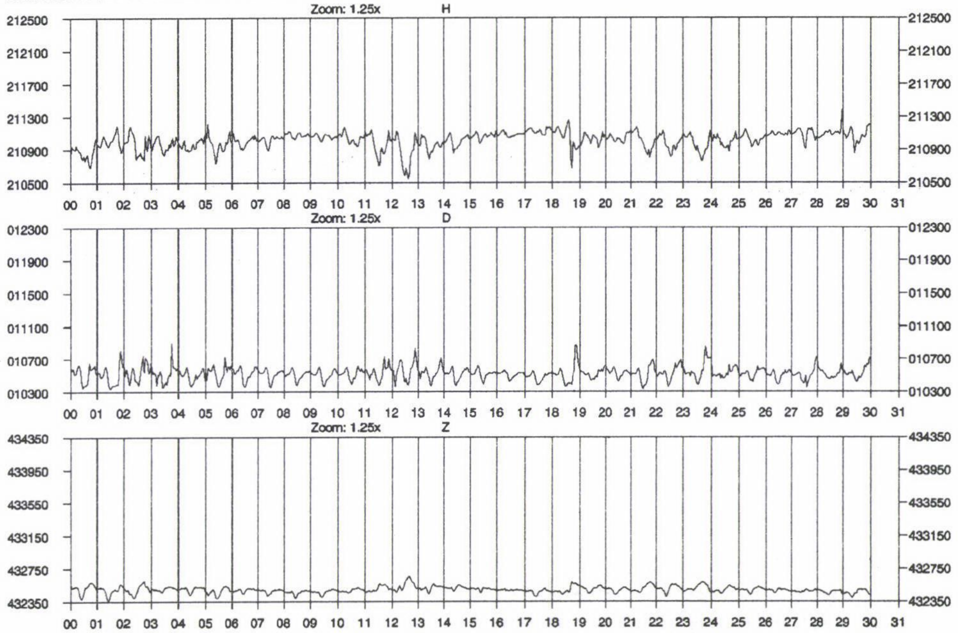

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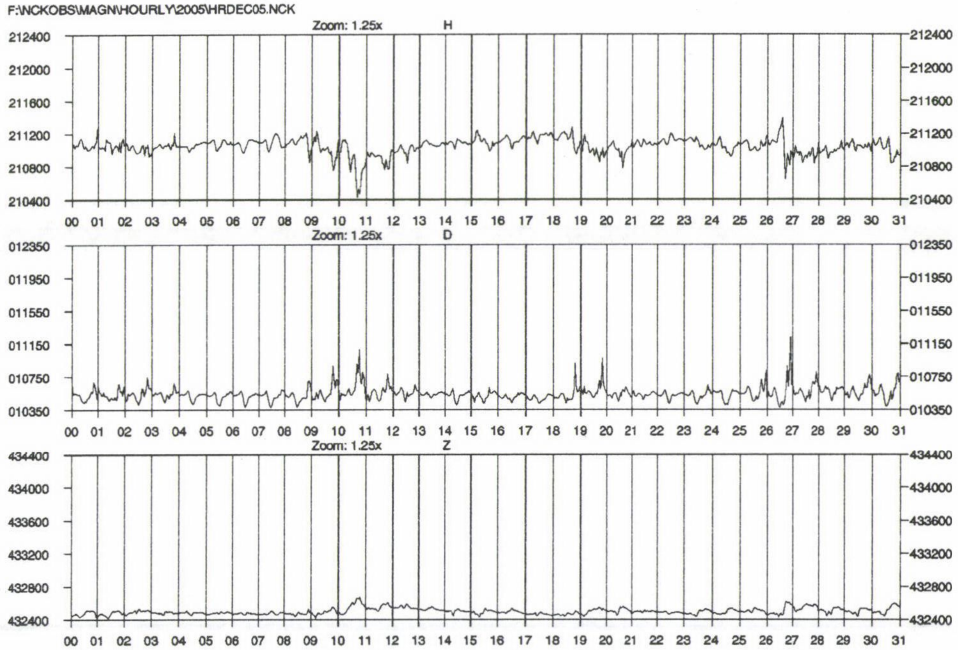

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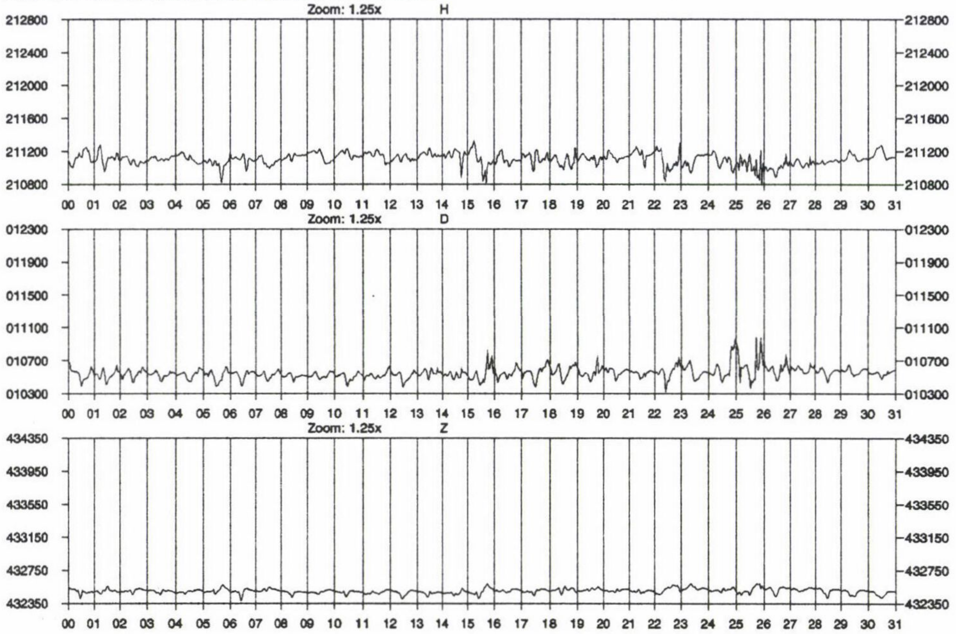

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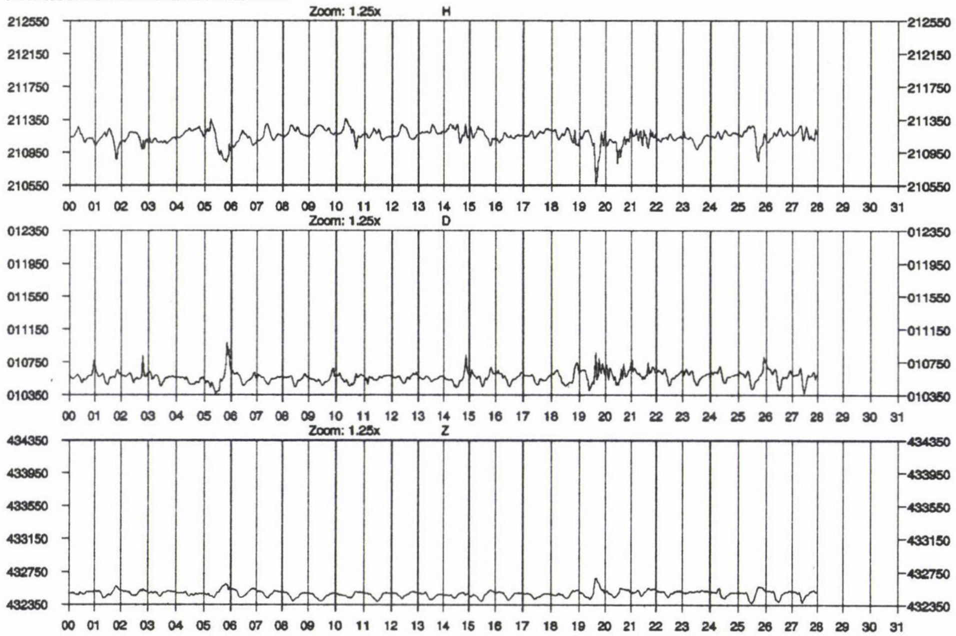

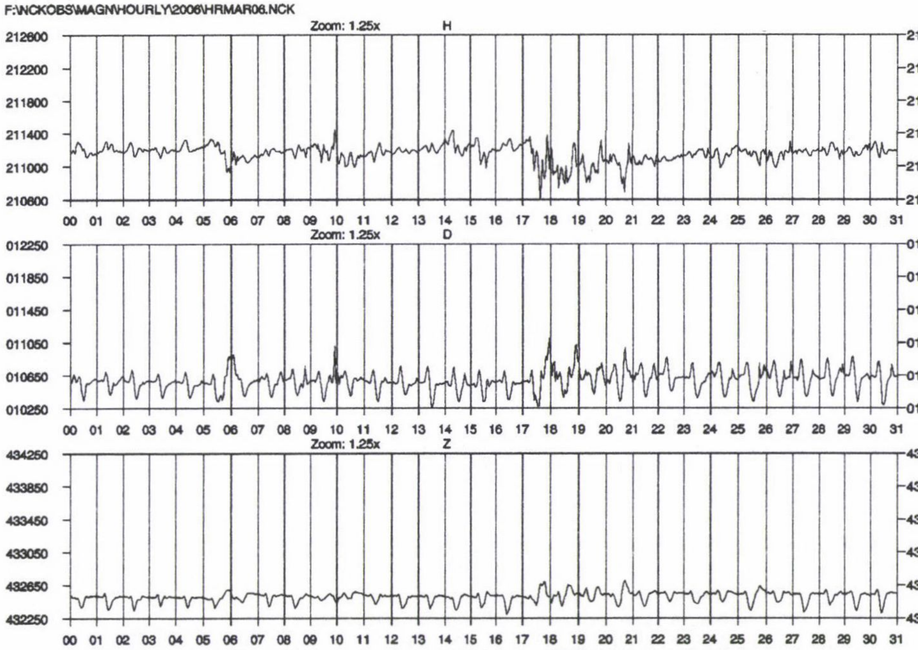
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010250
Zoom: 1.25x Z
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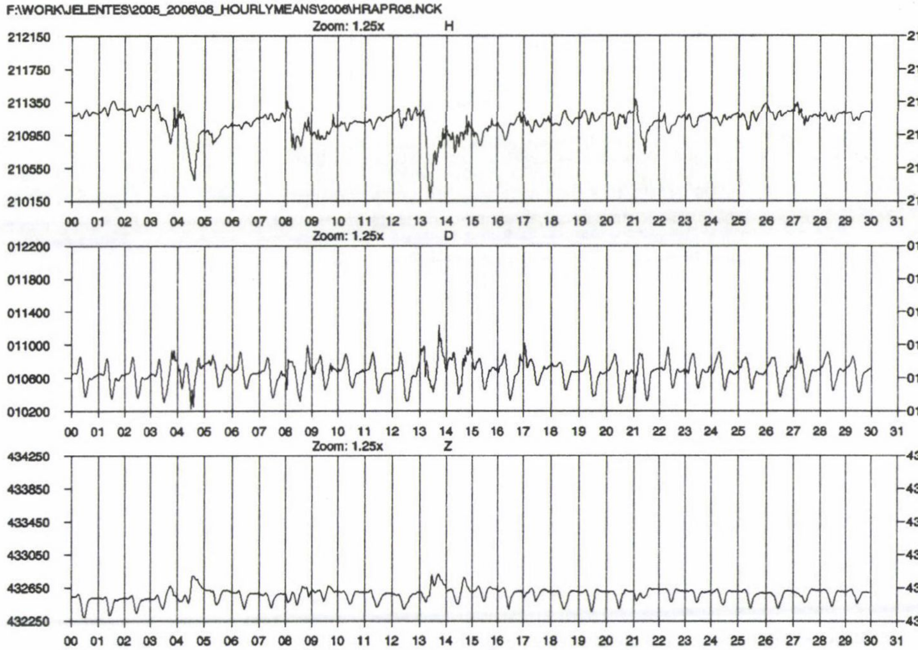
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Zoom: 1.25x Z
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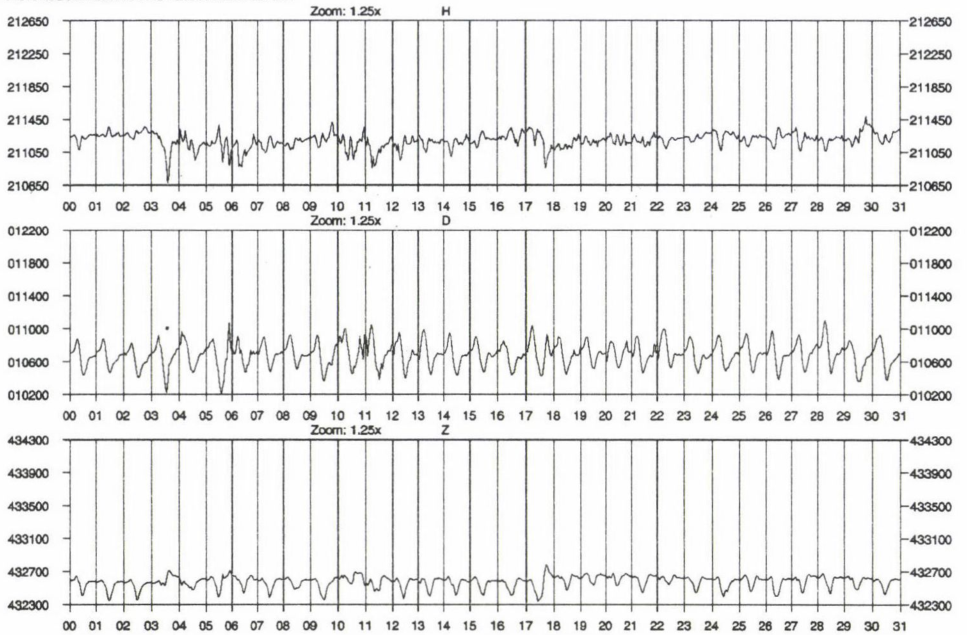

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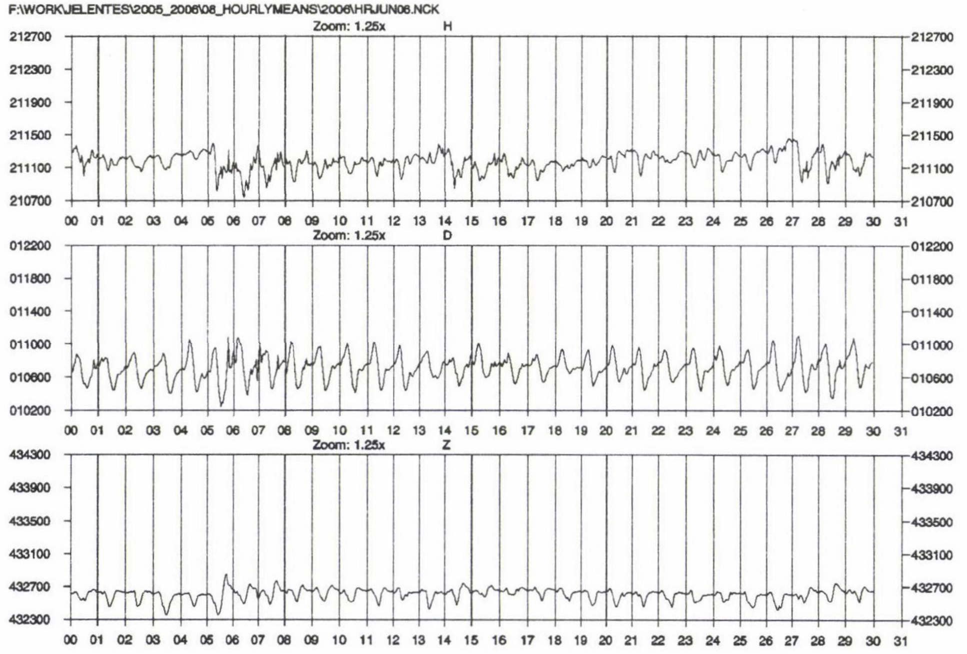

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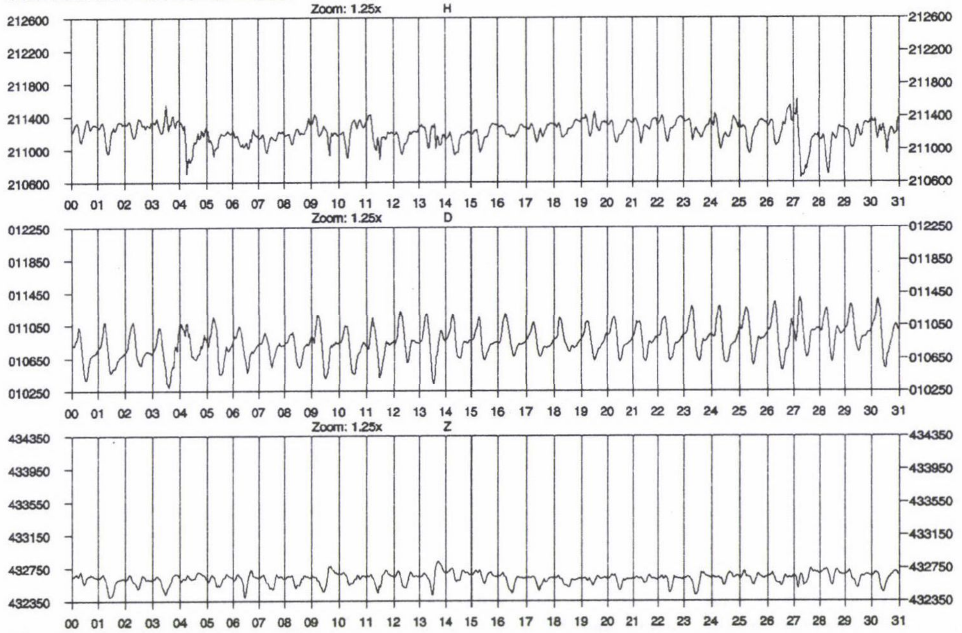

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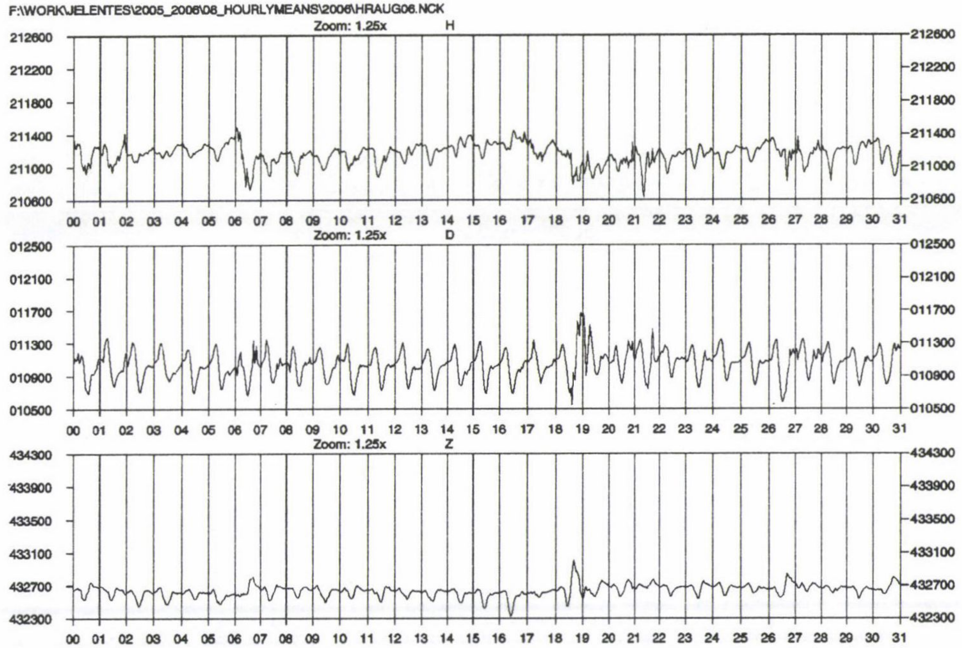

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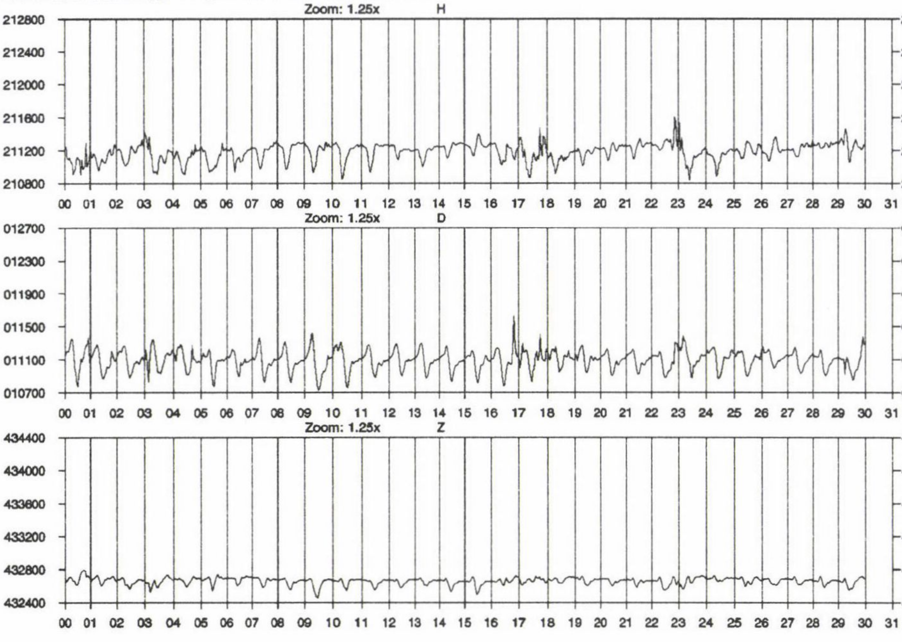

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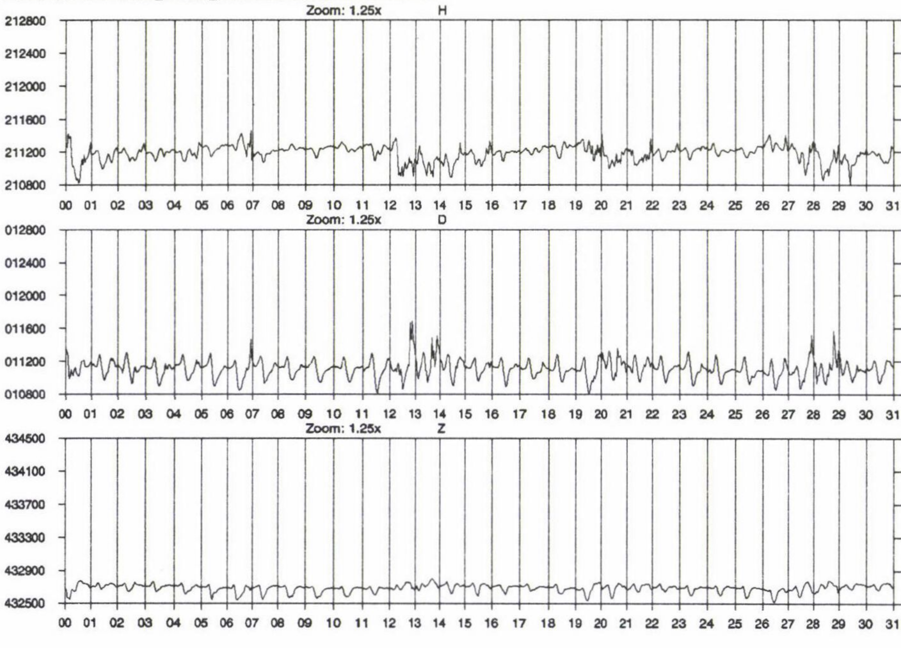

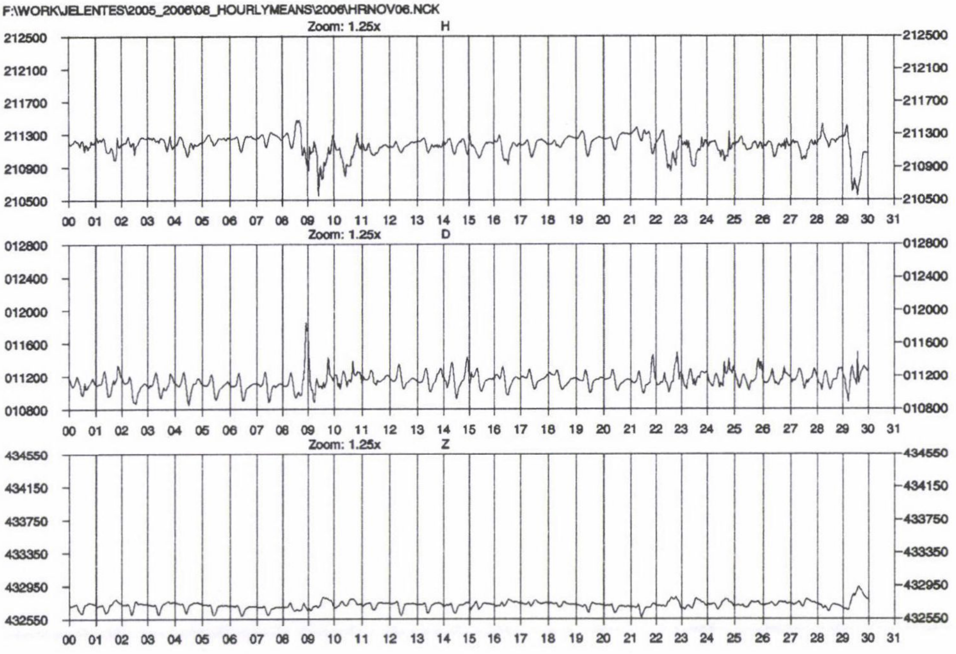
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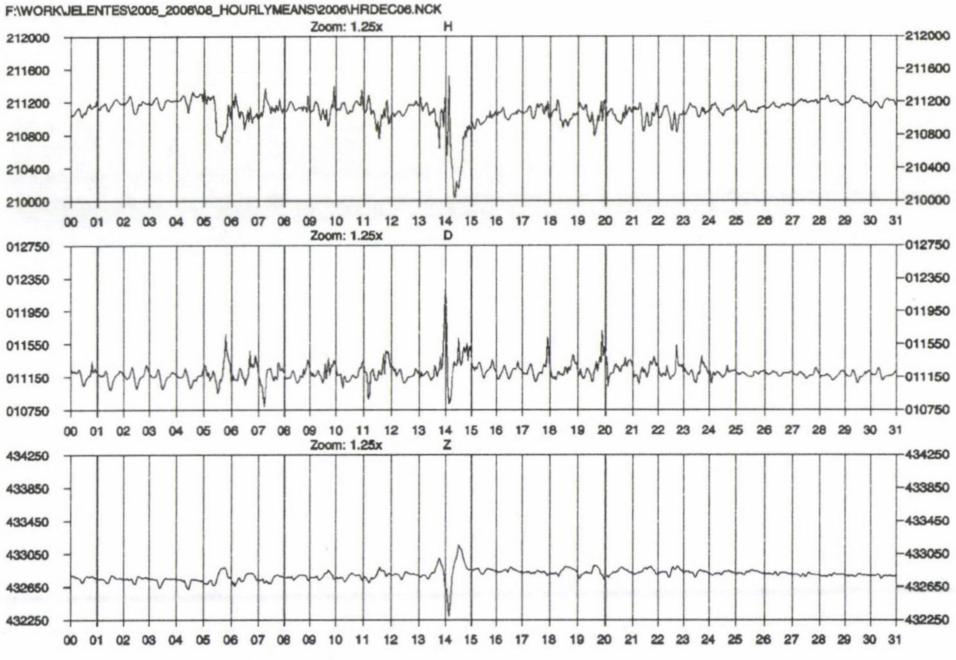
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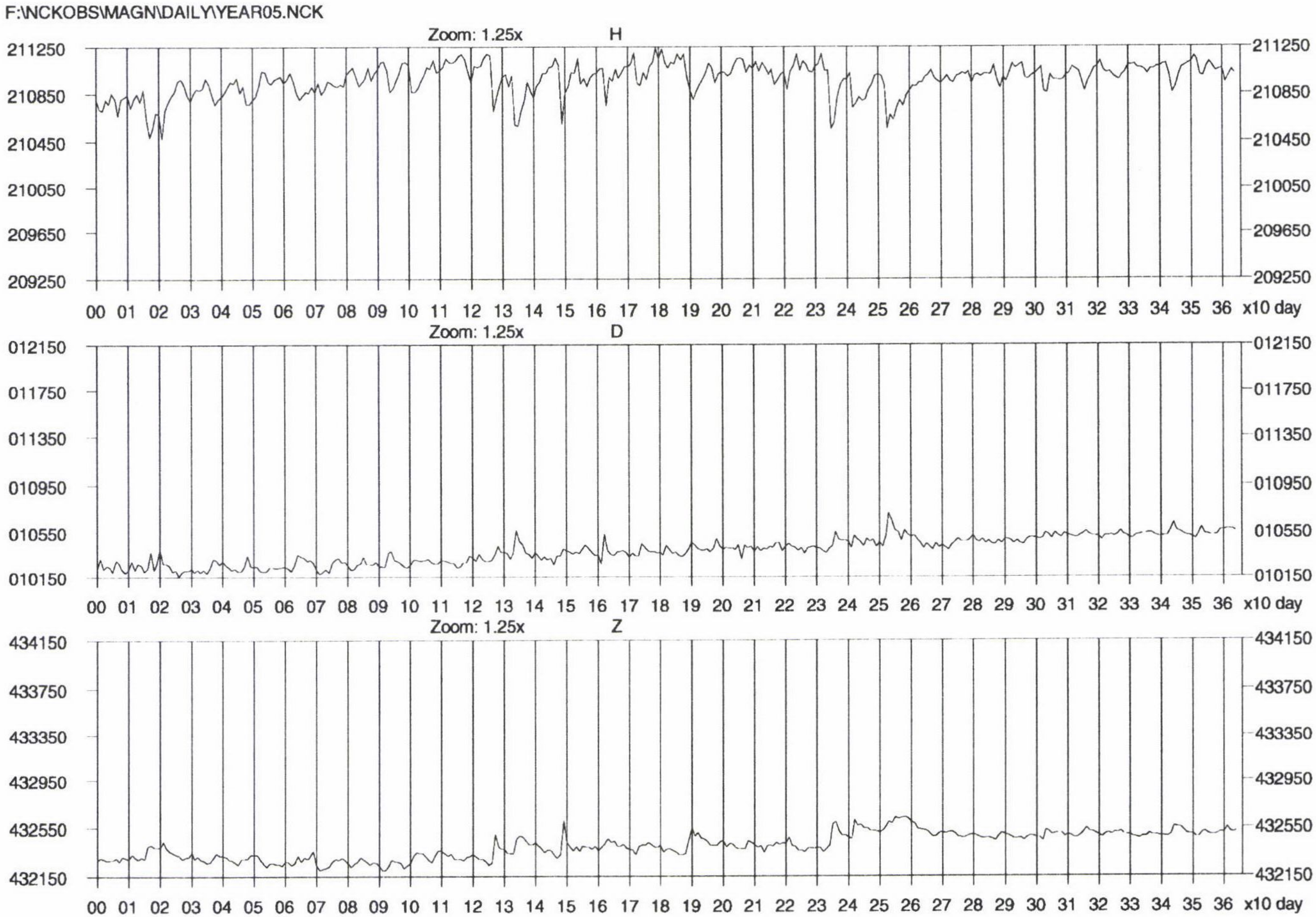
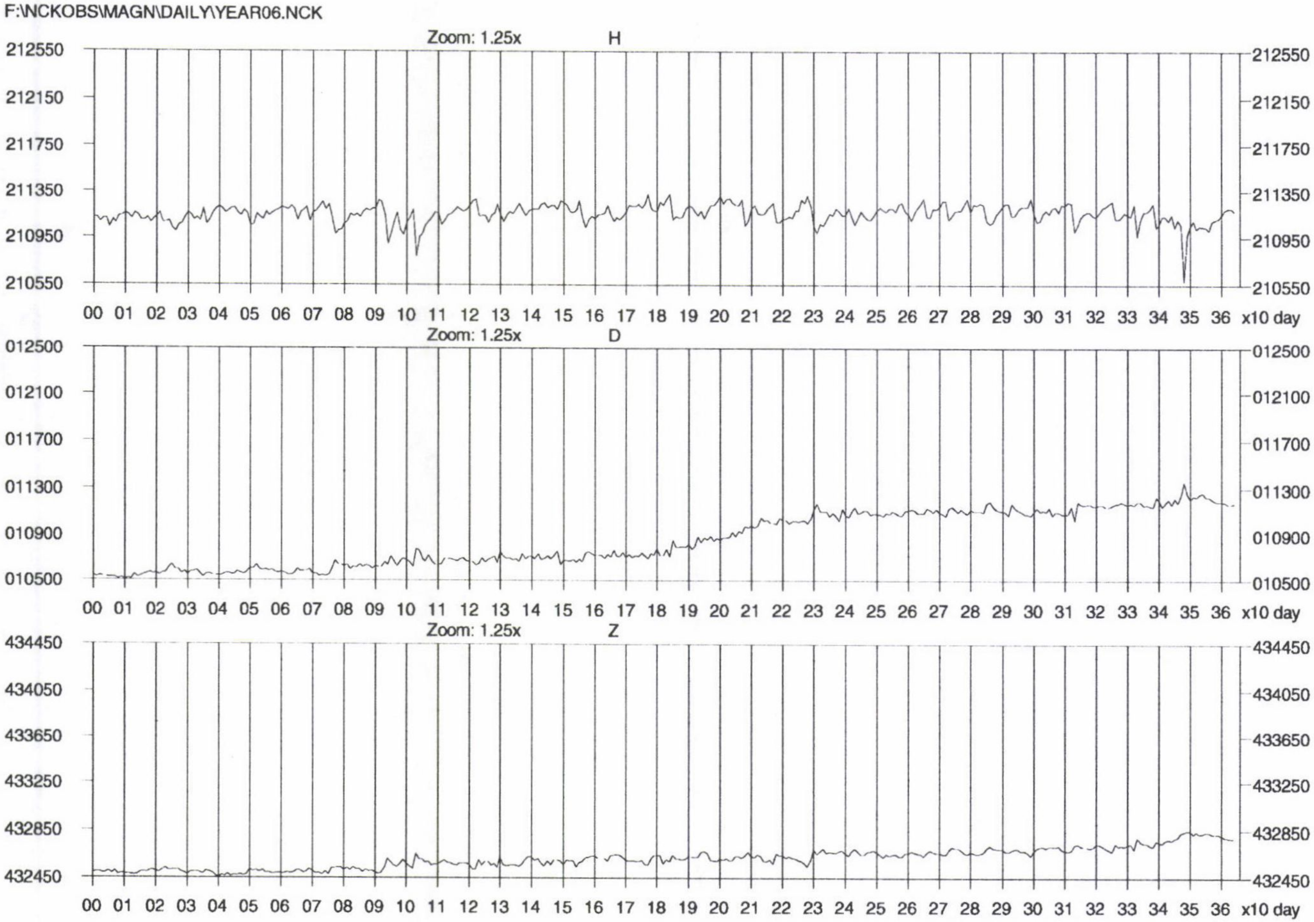
Daily mean values of H, D, Z

2005–2006



Daily mean values 2005



Daily mean values 2006

Hourly mean values of H, D, Z

2005–2006

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060129	10100101	4
060130	00000000	0
060131	01001100	3
060201	00001002	3
060202	10010122	7
060203	00020141	8
060204	33111100	10
060205	10111021	7
060206	23114344	22
060207	21000022	7
060208	20010000	3
060209	00101022	6
060210	10000034	8
060211	11111310	9
060212	33111200	11
060213	00000211	4
060214	00000000	0
060215	01221144	15
060216	32211122	14
060217	12111002	8
060218	00001011	3
060219	21111132	12
060220	22235544	27
060221	33244444	28
060222	43332422	23
060223	11111012	8
060224	31121000	8
060225	20100000	3
060226	12012223	13
060227	10001013	6
060228	00021123	9
060301	42123100	13
060302	00000011	2
060303	10000120	4
060304	11010002	5
060305	00000001	1
060306	00012244	13
060307	32311031	14
060308	10002032	8
060309	11000132	8
060310	12333325	22
060311	32321212	16
060312	00221230	10
060313	00010010	2
060314	00021013	7
060315	22333441	22
060316	11122412	14
060317	00000011	2
060318	01344656	29
060319	65545354	37
060320	44333355	30
060321	23123544	24
060322	32211143	17
060323	11100002	5

Date	K	Sum	Date	K	Sum
060324	00011123	8	060504	01225333	19
060325	22100130	9	060505	43121101	13
060326	10011343	13	060506	12013554	21
060327	33101303	14	060507	33543332	26
060328	02111122	10	060508	22111010	8
060329	01011033	9	060509	00011102	5
060330	10010033	8	060510	00001133	8
060331	10111031	8	060511	33344344	28
060401	00000100	1	060512	33324223	22
060402	00002001	3	060513	42123233	20
060403	00000102	3	060514	32211222	15
060404	00221245	16	060515	11001112	7
060405	43336342	28	060516	00000000	0
060406	12222122	14	060517	12012202	10
060407	10100000	2	060518	21342542	23
060408	20021022	9	060519	22222233	18
060409	65433345	33	060520	21111221	11
060410	33322332	21	060521	31020332	14
060411	11001102	6	060522	32122324	19
060412	00010110	3	060523	31101000	6
060413	12133333	19	060524	01022200	7
060414	45444643	34	060525	03100023	9
060415	33344554	31	060526	01001100	3
060416	32222332	19	060527	00000001	1
060417	20101123	10	060528	11122111	10
060418	42110212	13	060529	10001002	4
060419	20001011	5	060530	10015332	15
060420	01033210	10	060531	31112112	12
060421	00022422	12	060601	23232332	20
060422	43333321	22	060602	23321321	17
060423	12211002	9	060603	21203211	12
060424	32121002	11	060604	11012000	5
060425	31011110	8	060605	11001211	7
060426	10010110	4	060606	22454463	30
060427	10111221	9	060607	43334445	30
060428	31432111	16	060608	33433433	26
060429	10010002	4	060609	42232332	21
060430	00000000	0	060610	21113332	16
060501	01110000	3	060611	22012112	11
060502	10101012	6	060612	00012212	8
060503	11100112	7	060613	10001001	3

Date	K	Sum
060614	20121334	16
060615	33433333	25
060616	22121242	16
060617	23323330	19
060618	01221212	11
060619	21000000	3
060620	20011110	6
060621	00000101	2
060622	11111120	8
060623	01000100	2
060624	00012221	8
060625	20210101	7
060626	00010000	1
060627	10112323	13
060628	33235233	24
060629	32233333	22
060630	12223321	16
060701	12001010	5
060702	00100201	4
060703	02010222	9
060704	12225444	24
060705	44533333	28
060706	43222222	19
060707	11223332	17
060708	00100001	2
060709	01000014	6
060710	32123432	20
060711	01023333	15
060712	33255222	24
060713	23221012	13
060714	22134433	22
060715	12113101	10
060716	01001101	4
060717	10111121	8
060718	00010110	3
060719	10000001	2
060720	12102111	9
060721	11000010	3
060722	12121103	11
060723	21110112	9
060724	22221313	16
060725	33202223	17
060726	32022201	12
060727	10013334	15
060728	55432311	24
060729	20001121	7
060730	22100102	8
060731	23345324	26
060801	34334412	24
060802	22233214	19
060803	32011012	10
060804	00000011	2
060805	12000010	4
060806	00111200	5
060807	44454543	33
060808	22323331	19
060809	23133013	16
060810	10001013	6
060811	12222211	13
060812	13112221	13
060813	00000010	1
060814	11000011	4
060815	00020302	7
060816	21012112	10
060817	00322223	14
060818	34332333	24
060819	21036466	28
060820	66212232	24
060821	23112335	20
060822	41544542	29
060823	22311001	10
060824	20002312	10
060825	00000000	0
060826	10001021	5
060827	21133543	22
060828	43222333	22
060829	31232331	18
060830	10112332	13
060831	11312344	19
060901	30333455	26
060902	32122143	18
060903	22112213	14

Date	K	Sum	Date	K	Sum
060904	45432333	27	061015	22232343	21
060905	22132432	19	061016	10001133	9
060906	11012140	10	061017	00001101	3
060907	11313321	15	061018	11000020	4
060908	10112212	10	061019	00020000	2
060909	20100000	3	061020	11323433	20
060910	10101122	8	061021	43233653	29
060911	32221101	12	061022	23223344	23
060912	20121111	9	061023	10110103	7
060913	12221000	8	061024	00121032	9
060914	12111101	8	061025	11010100	4
060915	10100000	2	061026	01011000	3
060916	01021202	8	061027	11000133	9
060917	11134253	20	061028	11233445	23
060918	43333454	29	061029	43333355	29
060919	22333322	20	061030	42241311	18
060920	22100110	7	061031	30001223	11
060921	00011011	4	061101	11103222	12
060922	00010021	4	061102	30002343	15
060923	10001235	12	061103	21033120	12
060924	55344233	29	061104	32120332	16
060925	30143113	16	061105	00112210	7
060926	12122233	16	061106	00100002	3
060927	31011200	8	061107	00000000	0
060928	20111113	10	061108	10000110	3
060929	30002230	10	061109	10001346	15
060930	13442324	23	061110	54464353	34
061001	55334423	29	061111	43333544	29
061002	10212232	13	061112	32222000	11
061003	21224313	18	061113	10000000	1
061004	01000320	6	061114	01011223	10
061005	10011022	7	061115	32010033	12
061006	00120001	4	061116	42110100	9
061007	00002345	14	061117	22003100	8
061008	31022122	13	061118	00000000	0
061009	01010022	6	061119	21130001	8
061010	21110011	7	061120	00001000	1
061011	10011100	4	061121	20001000	3
061012	20011213	10	061122	00032042	11
061013	22344466	31	061123	11333444	23
061014	43242554	29	061124	33433332	24

Date	K	Sum
061125	32322453	24
061126	33223144	22
061127	21231331	16
061128	11122313	14
061129	23110112	11
061130	33446421	27
061201	00011242	10
061202	00001010	2
061203	12000121	7
061204	00000011	2
061205	00041112	9
061206	43344454	31
061207	54444534	33
061208	35443353	30
061209	21100434	15
061210	23234535	27
061211	33321035	20
061212	35325554	32
061213	33110013	12
061214	32225567	32
061215	87446554	43
061216	32121343	19
061217	20100130	7
061218	21021335	17
061219	23133323	20
061220	43324455	30
061221	53333433	27
061222	33433343	26
061223	22323542	23
061224	21123442	19
061225	32212311	15
061226	10202210	8
061227	00000000	0
061228	00000031	4
061229	10000110	3
061230	10020120	6
061231	10010101	4

Special phenomena

SSC-s 2005–2006

Date	CET (UT+1h)	Ampl. in H(nT)	Hx	Hy	Hz	Remark
050121	1811	63	+	-	+	
050515	0333	90	+	-	-	
050614	1935	50	+	-	-	
050711	1206	29	+	-	-	
050717	0235	15	+	-	+	
050824	0957	53	+	-	-	
050902	1519	10	+	-	+	
050909	1501	36	+	-	+	
050911	0214	13	+	-	+	
060101	1504	17	+	-	-	?
060709	2235	33	+	-	+	
060727	1452	21	+	-	-	
060807	0129	24	+	-	+	
060818	0214	6	+	-	+	
060819	1231	22	+	-	+	
060904	0119	32	+	-	+	
061208	0533	31	+	-	+	
061214	1514	36	+	-	-	
061216	1853	28	+	-	+	

Special phenomena

sfe 2005–2006

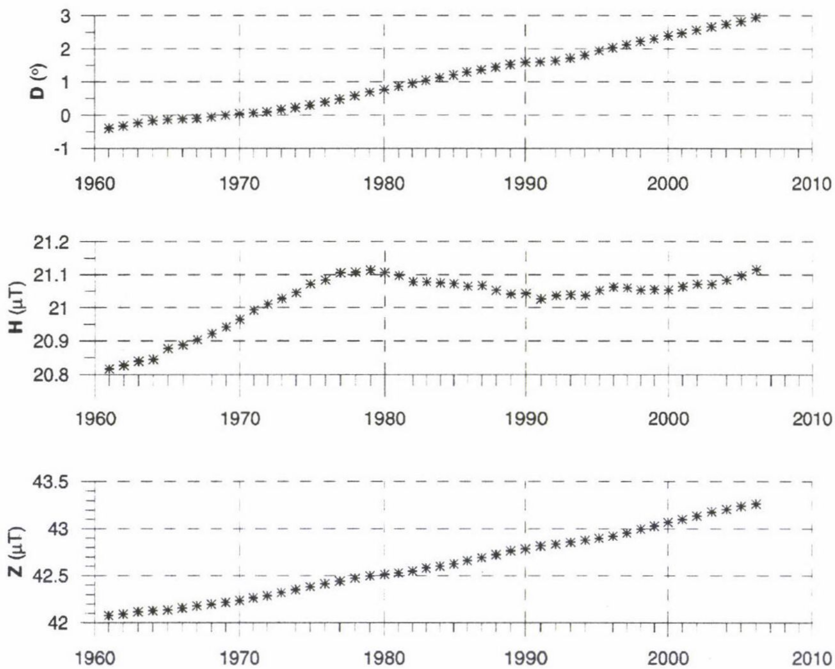
Date	Beginning GMT	Maximum GMT	End GMT	Ampl. nT	Sign Hx	Hy	Hz	Remark
050606	0737	0744	0752	8	–	–	+	
051014	0927	0932	0935	5	–	+	–	
051021	1013	1017	1022	3	–	+	–	
051102	0804	0809	0814	5	–	+	–	
060127	1003	1007	1010	10	–	+	–	?
060323	0844	0850	0856	5	–	+	–	
060331	1040	1048	1103	7	–	+	–	
060703	0551	0556	0600	6	–	+	–	
060724	0837	0843	0847	8	–	+	+	
061122	1101	1105	1111	12	–	+	–	
061122	1336	1342	1348	13	–	+	+	
061125	0932	0936	0938	8	–	+	–	
061210	1141	1146	1151	8	–	+	+	

Annual mean values of geomagnetic elements

Year	D	H nT	Z nT	I	X nT	Y nT	F nT
1961	−0°23.6′	20816	42077	63°40.7′	20816	−143	46944
1962	−0°19.6′	20827	42093	63°40.5′	20827	−119	46964
1963	−0°14.3′	20839	42116	63°40.4′	20839	−87	46990
1964	−0°10.5′	20845	42126	63°40.4′	20845	−64	47001
1965	−0°08.1′	20877	42137	63°38.6′	20877	−49	47025
1966	−0°06.8′	20888	42156	63°38.5′	20888	−41	47047
1967	−0°06.0′	20903	42179	63°38.3′	20903	−36	47074
1968	−0°03.0′	20921	42196	63°37.7′	20921	−18	47098
1969	0°00.2′	20942	42214	63°36.9′	20942	1	47123
1970	0°02.8′	20964	42235	63°36.1′	20964	17	47152
1971	0°04.3′	20992	42262	63°35.2′	20992	26	47188
1972	0°06.5′	21011	42286	63°34.7′	21011	40	47218
1973	0°10.2′	21028	42317	63°34.6′	21028	62	47254
1974	0°13.6′	21046	42350	63°34.5′	21046	83	47291
1975	0°18.5′	21072	42380	63°33.8′	21072	113	47330
1976	0°23.8′	21084	42413	63°34.0′	21084	146	47365
1977	0°28.8′	21106	42443*	63°33.6′*	21105	177	47401*
1978	0°34.6′	21108	42473*	63°34.4′*	21107	212	47429*
1979	0°41.4′	21113*	42496*	63°34.8′*	21112*	254	47452*
1980	0°46.3′	21107*	42512*	63°35.8′*	21105*	284	47463*
1981	0°52.4′	21097*	42530*	63°37.0′*	21095*	322	47475*
1982	0°57.5′	21078	42549	63°38.8′	21075	353	47484
1983	1°02.7′	21078	42581	63°39.8′	21074	384	47512
1984	1°08.1′	21075	42601	63°40.7′	21071	417	47529
1985	1°12.7′	21073	42625	63°41.7′	21068	446	47550
1986	1°17.8′	21065	42660	63°43.1′	21060	477	47577
1987	1°21.9′	21067	42689	63°44.0′	21061	502	47604
1988	1°26.6′	21052	42723	63°46.0′	21045	530	47628
1989	1°31.3′	21041	42761	63°48.0′	21034	559	47657
1990	1°35.5′	21044	42782	63°48.3′	21036	584	47678
1991	1°36.3′	21027	42816	63°50.4′	21019	589	47701
1992	1°38.1′	21037	42834	63°50.4′	21028	600	47721
1993	1°43.2′	21039	42853	63°51.0′	21030	631	47739
1994	1°48.4′	21037	42877	63°52.0′	21026	663	47760
1995	1°56.6′	21052	42898	63°51.7′	21039	713	47785
1996	2°02.0′	21062	42920	63°51.7′	21048	747	47809
1997	2°07.5′	21060	42955	63°52.9′	21045	781	47839
1998	2°13.7′	21053	42997	63°54.7′	21037	819	47875
1999	2°18.3′	21055	43030	63°55.6′	21038	847	47905

Year	D	H nT	Z nT	I	X nT	Y nT	F nT
2000	2°23.7′	21054	43068	63°56.9′	21035	880	47938
2001	2°28.4′	21064	43099	63°57.2′	21045	909	47972
2002	2°33.7′	21072	43136	63°57.9′	21051	942	48008
2003	2°39.6′	21071	43180	63°59.3′	21048	978	48047
2004	2°44.4′	21084	43208	63°59.4′	21060	1008	48078
2005	2°49.2′	21097	43240	63°59.5′	21071	1038	48112
2006	2°57.0′	21116	43261	63°59.0′	21088	1087	48140

The yearly means of geomagnetic absolute values in D, H and Z in the Observatory Nagycenk between 1961 and 2006



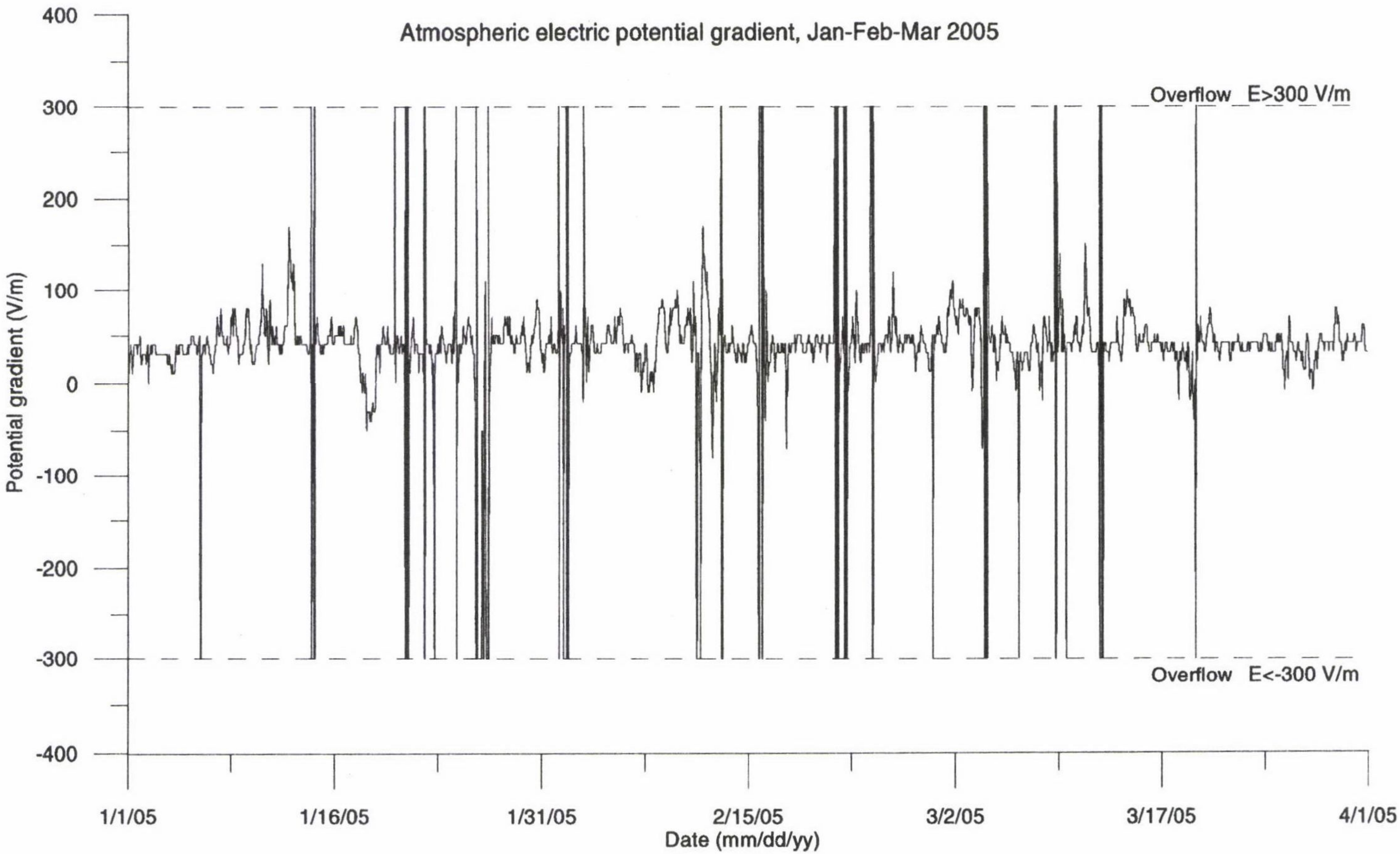
3. ATMOSPHERIC ELECTRICITY AND THE IONOSPHERE

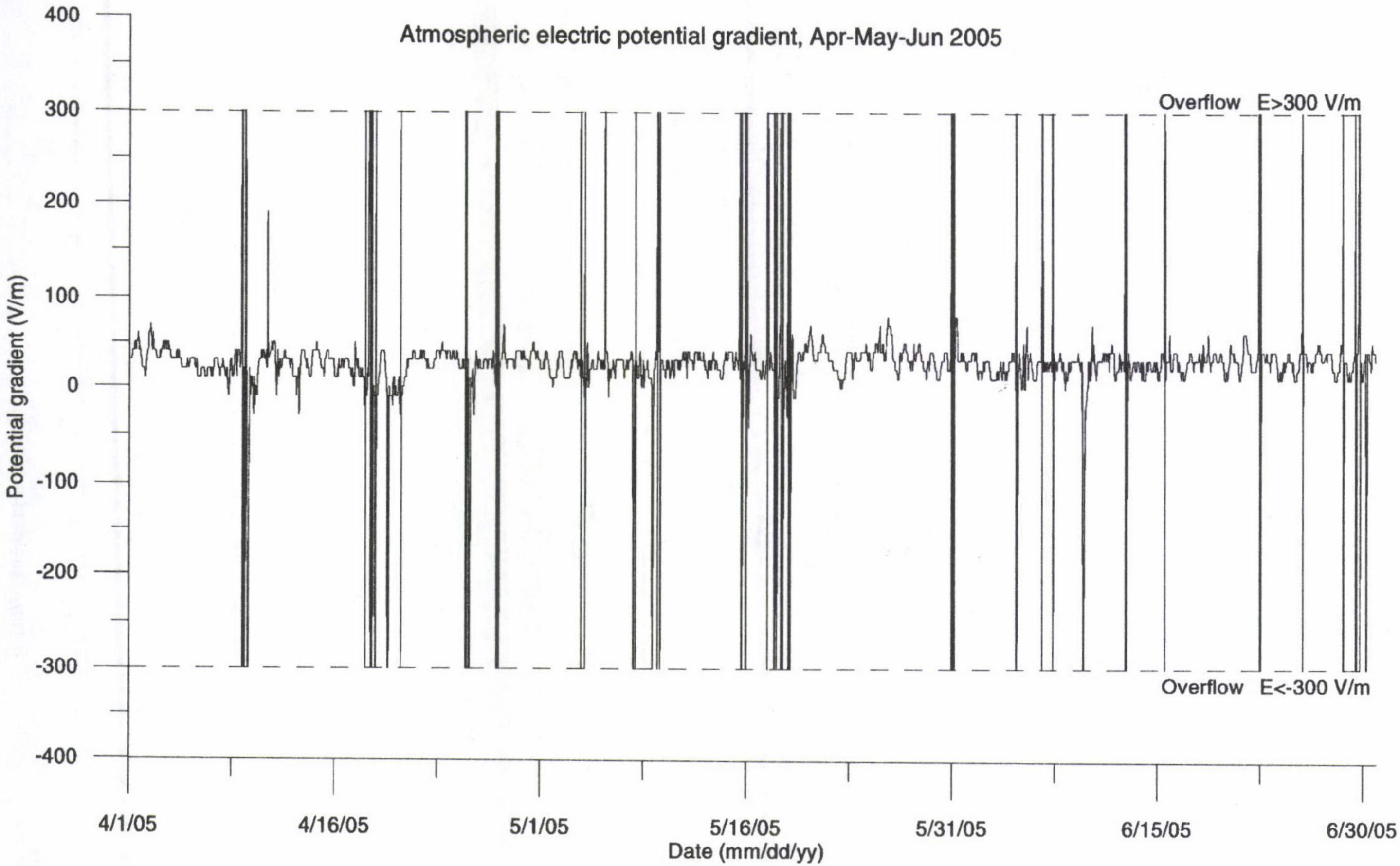
ATMOSPHERIC ELECTRICITY DATA

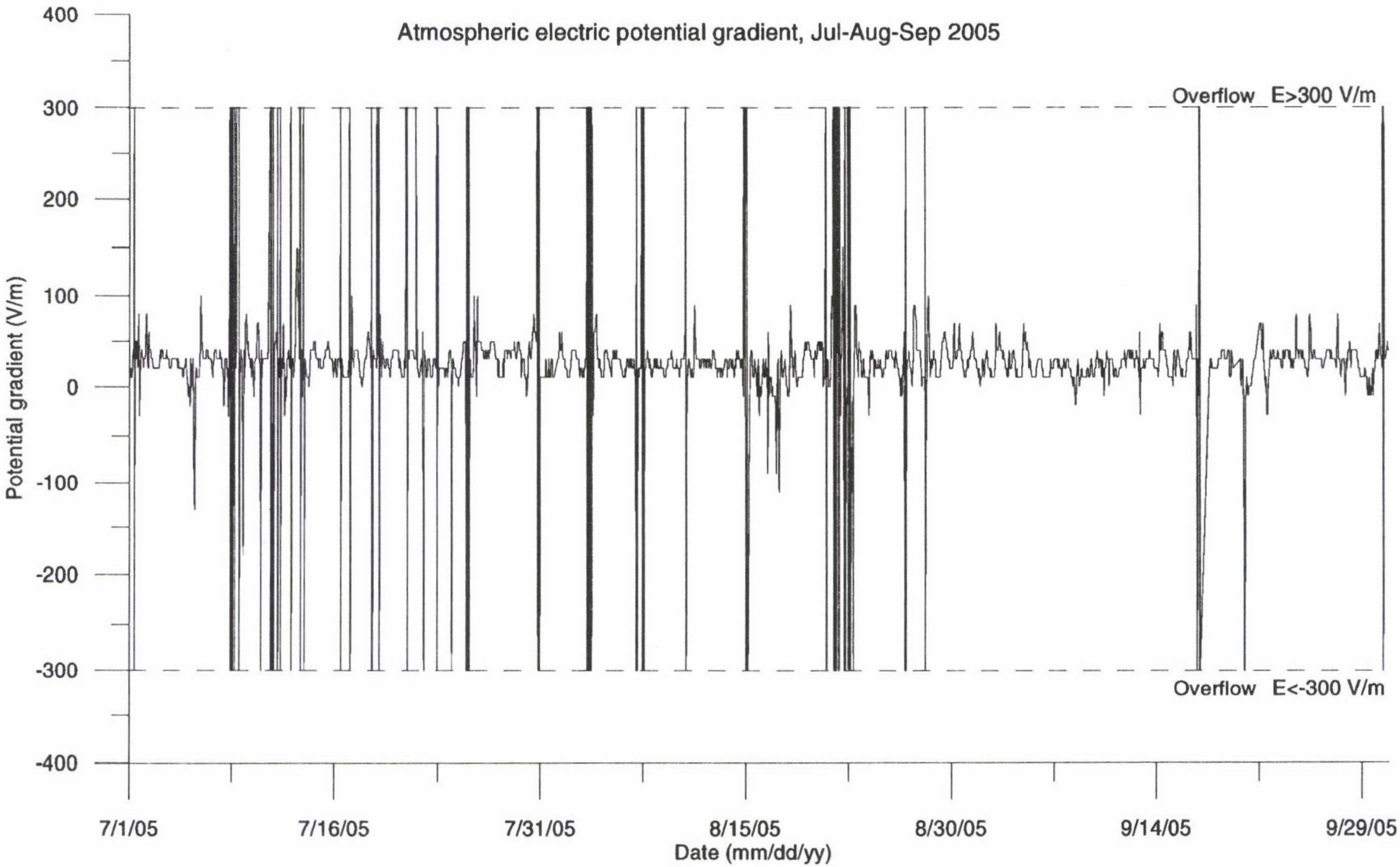
Hourly means of the potential gradient

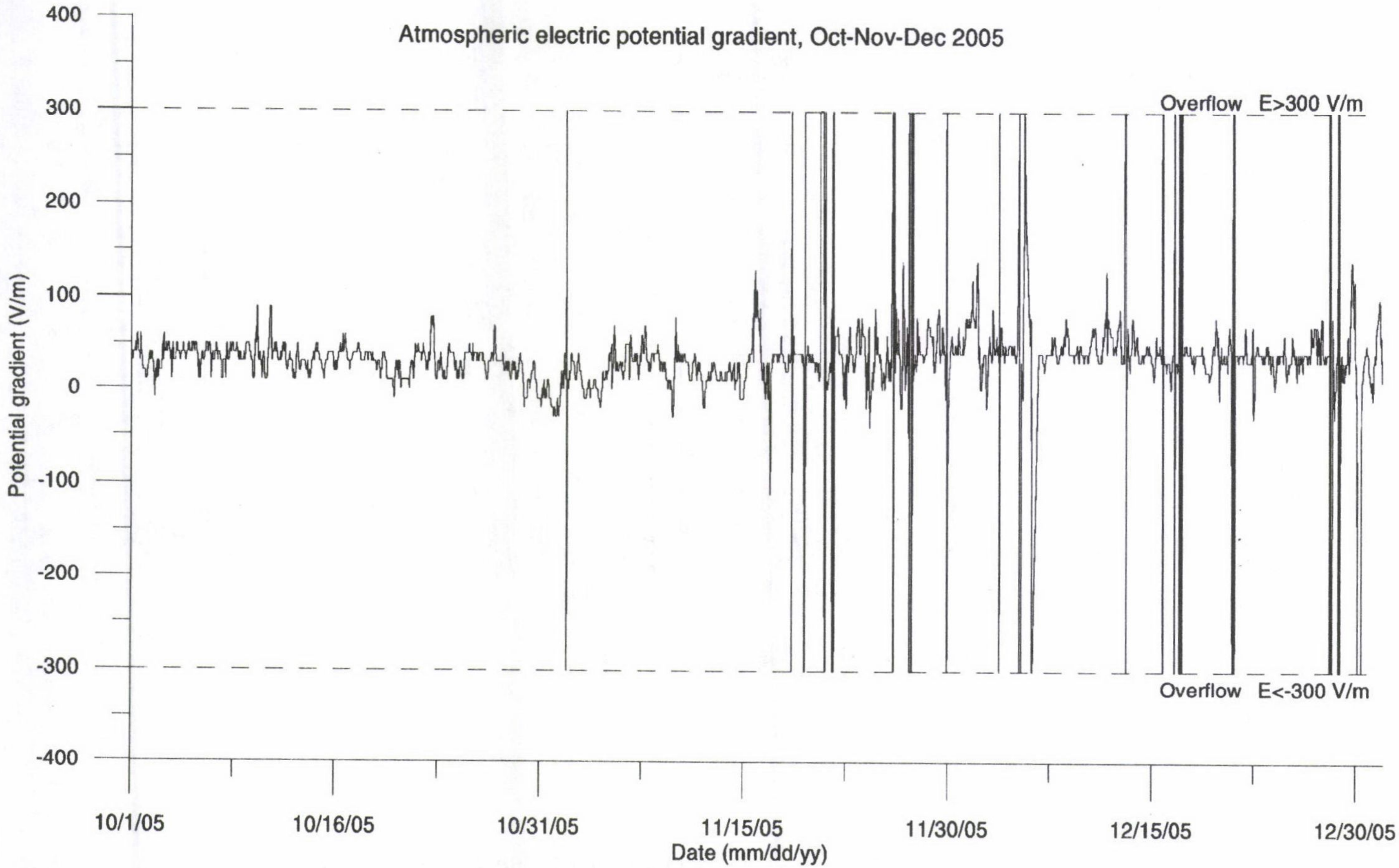
Atmospheric electricity data have been published since 1962. This table contains the hourly average values of the potential gradient expressed in V/m. The date column gives year, month, day (e.g. 990101 indicates 1999 January 1). Hourly averages have been taken only from hours having a recording period of 30 minutes or more. If values were available only for part of an hour the average is entered in square brackets [ ]. These data have been used in the determination of the daily means. Values uncertain for some reason are entered in round brackets ( ) and have not been used in calculating daily means. Daily means of each day with 24 hours of recording are entered. However, loss of a maximum of one hour's data out of twelve (for example, on account of instrument maintenance or calibration) has not precluded entering this mean value. In hours marked by S the value of the potential gradient exceeded permanently or several times the measuring limits of the equipment making the determination of an hourly average impossible. The direction of the deviations is marked by signs. OBS indicates that the potential gradient exceeded the measuring limits of the equipment both in positive and negative directions. Gaps of some days are generally due to missing records. Data are presented in universal time (GMT).

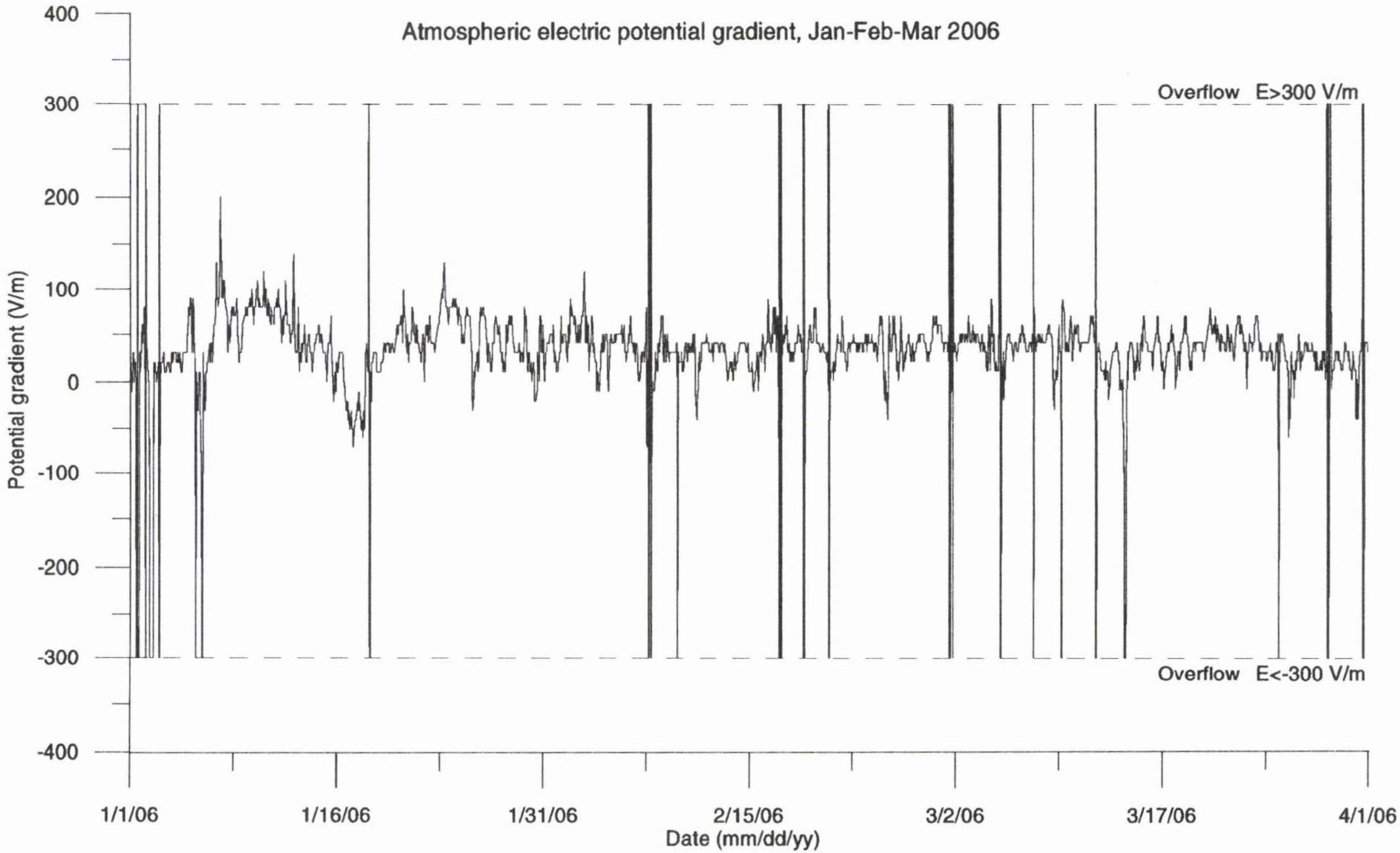
See CD (data visualization: program Seenck.exe, menu item AtmElectr/ Potgrad; path: \Nckobs\Atmelect\Potgrad\).

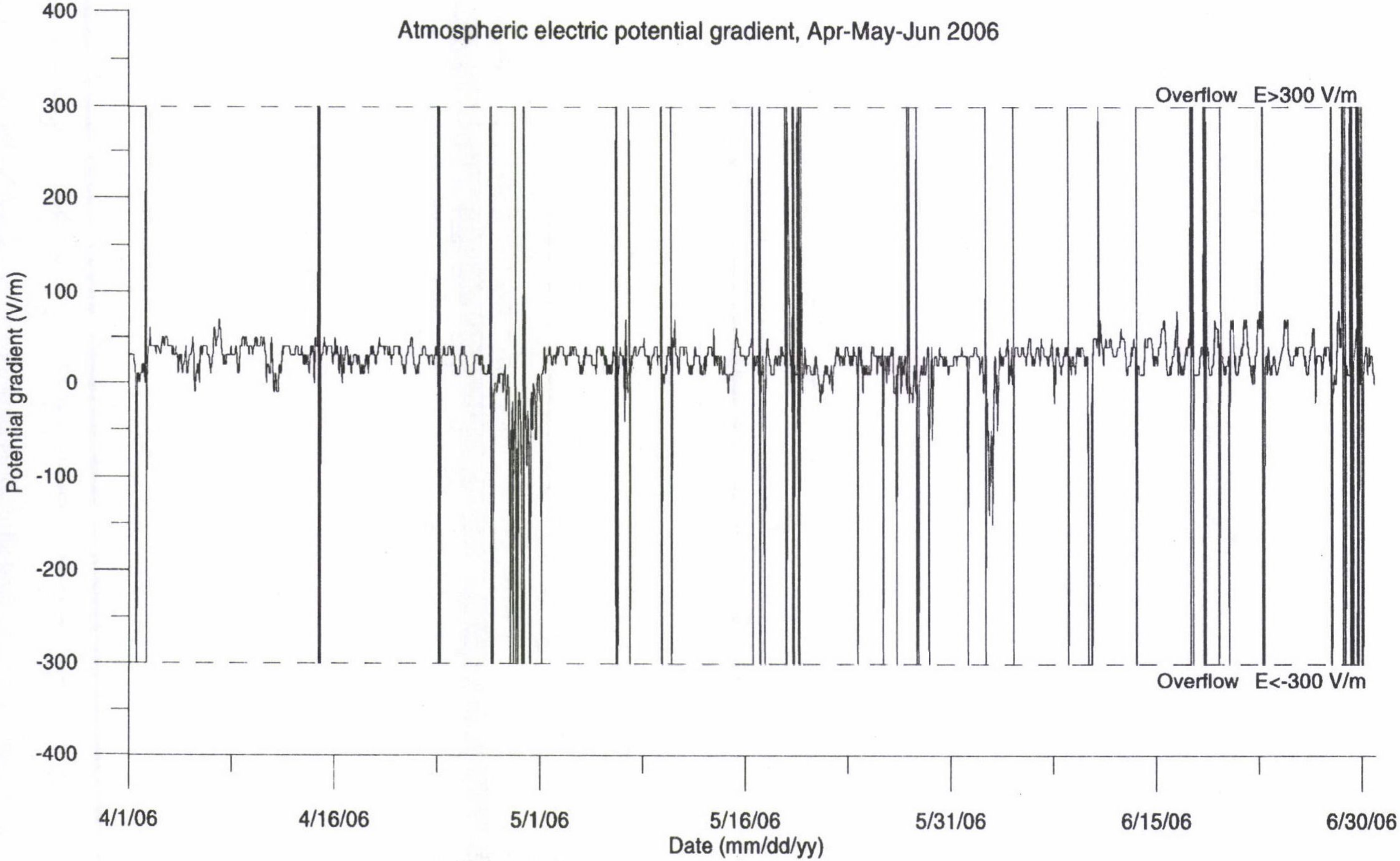

Atmospheric electric potential gradient, Jan-Feb-Mar 2005
Overflow E>300 V/m
Overflow E<-300 V/m
Potential gradient (V/m)
400
300
200
100
0
-100
-200
-300
-400
1/1/05
1/16/05
1/31/05
2/15/05
3/2/05
3/17/05
4/1/05
Date (mm/dd/yy)

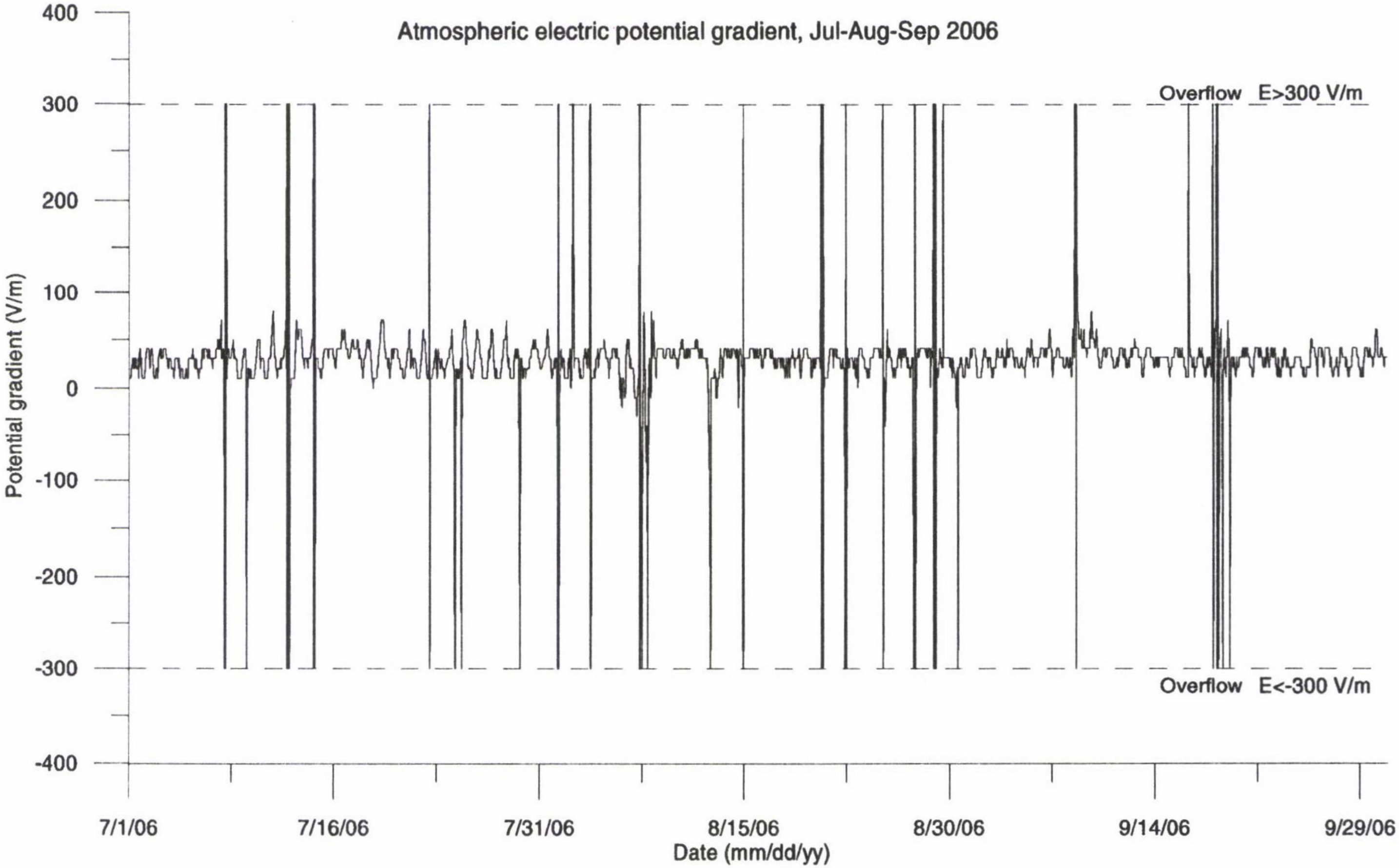

Atmospheric electric potential gradient, Apr-May-Jun 2005
Overflow E>300 V/m
Overflow E<-300 V/m
Potential gradient (V/m)
400
300
200
100
0
-100
-200
-300
-400
4/1/05
4/16/05
5/1/05
5/16/05
5/31/05
6/15/05
6/30/05
Date (mm/dd/yy)

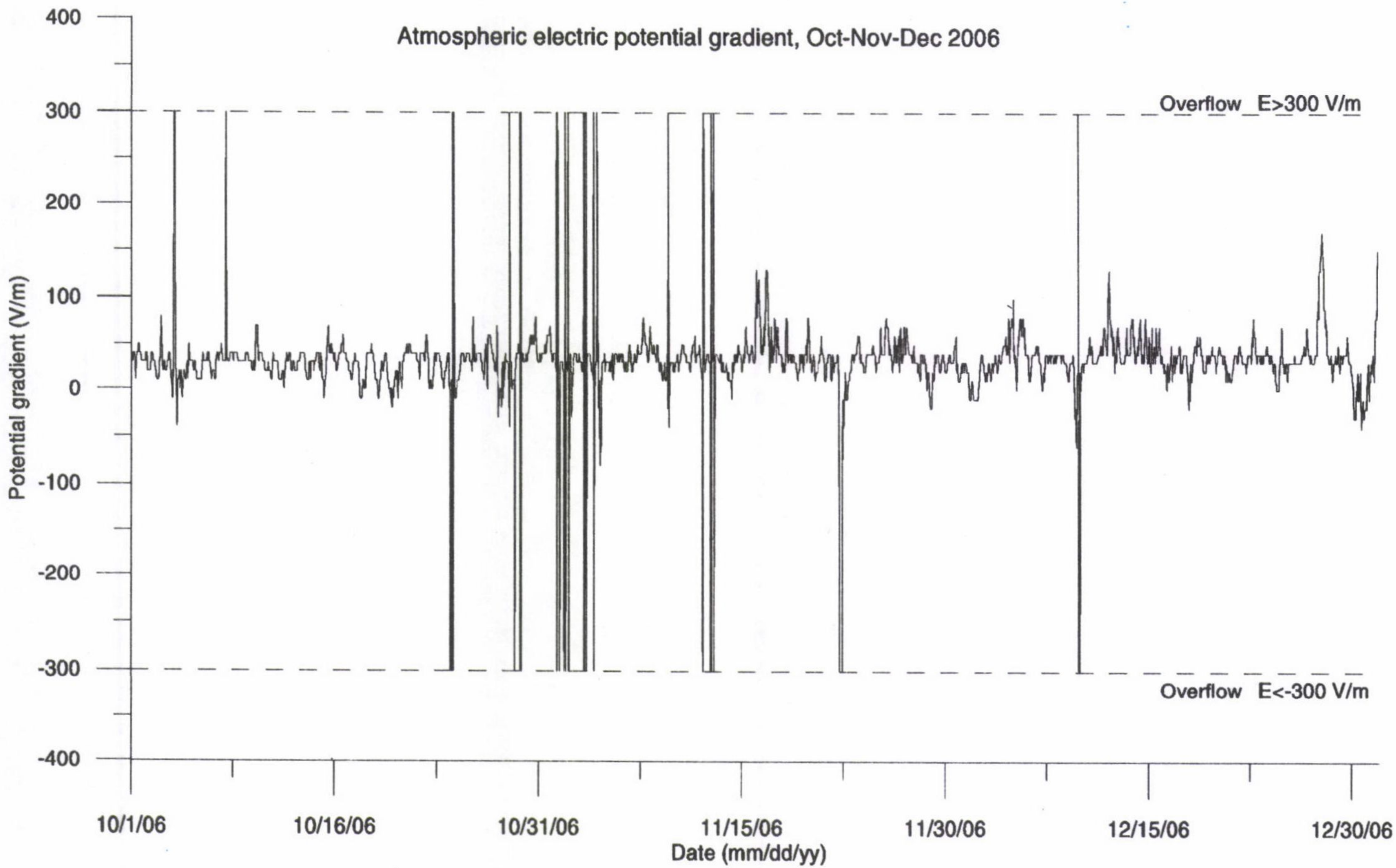

Atmospheric electric potential gradient, Jul-Aug-Sep 2005
Potential gradient (V/m)
400
300
200
100
0
-100
-200
-300
-400
Overflow E>300 V/m
Overflow E<-300 V/m
7/1/05
7/16/05
7/31/05
8/15/05
8/30/05
9/14/05
9/29/05
Date (mm/dd/yy)


Atmospheric electric potential gradient, Oct-Nov-Dec 2005
Overflow E>300 V/m
Overflow E<-300 V/m
Potential gradient (V/m)
400
300
200
100
0
-100
-200
-300
-400
10/1/05
10/16/05
10/31/05
11/15/05
11/30/05
12/15/05
12/30/05
Date (mm/dd/yy)


Atmospheric electric potential gradient, Jan-Feb-Mar 2006
Overflow E>300 V/m
Overflow E<-300 V/m
Potential gradient (V/m)
400
300
200
100
0
-100
-200
-300
-400
1/1/06
1/16/06
1/31/06
2/15/06
3/2/06
3/17/06
4/1/06
Date (mm/dd/yy)


Atmospheric electric potential gradient, Apr-May-Jun 2006
Overflow E>300 V/m
Overflow E<-300 V/m
Potential gradient (V/m)
400
300
200
100
0
-100
-200
-300
-400
4/1/06
4/16/06
5/1/06
5/16/06
5/31/06
6/15/06
6/30/06
Date (mm/dd/yy)


Atmospheric electric potential gradient, Jul-Aug-Sep 2006
Overflow E>300 V/m
Overflow E<-300 V/m
Potential gradient (V/m)
400
300
200
100
0
-100
-200
-300
-400
7/1/06
7/16/06
7/31/06
8/15/06
8/30/06
9/14/06
9/29/06
Date (mm/dd/yy)


Atmospheric electric potential gradient, Oct-Nov-Dec 2006
Potential gradient (V/m)
400
300
200
100
0
-100
-200
-300
-400
Overflow E>300 V/m
Overflow E<-300 V/m
10/1/06
10/16/06
10/31/06
11/15/06
11/30/06
12/15/06
12/30/06
Date (mm/dd/yy)

SCHUMANN RESONANCE OBSERVATIONS

G. SÁTORI

Schumann resonances are the electromagnetic eigenmodes of the Earth-ionosphere cavity maintained by the world thunderstorm activity (Schumann 1952).

The first efforts were already made in sixties to record the variations of the natural electromagnetic energy source in the Schumann resonance (SR) frequency range. P Bencze constructed an equipment for measuring SR and reported on the first results together with A Ádám (Ádám and Bencze 1963).

The experiments were renewed in eighties to realize the continuous measurements of Schumann resonance frequencies and amplitudes. Since May of 1993, the vertical electric field component in SR frequency range between 2 and 25 Hz has regularly been measured in the Nagycenk Observatory (47.6°N, 16.7°E) using a very stable ball-antenna, a preamplifier with high input impedance and low noise, an amplifier and a personal computer with high speed, multi-channel AD-converter. The complex demodulation as a spectral technique has been applied for the quasi-continuous determination of the actual peak-frequencies and the corresponding amplitudes of the first three SR modes (Sátori et al. 1996).

Using convolution filters the phase-variations of the complex wave vector relating to the central period of the filters are determined. By computing the phase changes versus time the frequency (and the amplitude) can also be monitored in time. Using this spectral technique, the frequency can be determined within a given range of frequencies, in the case applied here in the frequency range of the first three Schumann-resonance modes, namely between 7–9 Hz, 13–15 Hz and 19–21 Hz. An alternate sampling and computation process yields a quasi real-time technique.

The horizontal magnetic field components (north-south and east-west) have regularly been measured since January of 1997 using induction coils. The spectral technique is the same as in case of the vertical electric field component.

The electronics of the SR recording system was developed by J Pongrácz and J Horváth, the ball-antenna was constructed by Gy Pálla.

Recording SR-transients started in the frame of US-Hungarian Joint Found (JF.554) in 1998. These events, so called Q-bursts, are excited by individual energetic lighning strokes.

The hourly averages of the peak-frequencies and the amplitudes for the first three modes and SR transients for selected time periods (international campaignes) are available (e-mail: satori@ggki.hu). Figure 1 shows Schumann resonance recording system with the ball-antenna for the measurement of the vertical electric field component, as well as the two induction coils for the horizontal north-south and east-west magnetic field components. Figure 2, as example, exhibits the daily frequency and amplitude variations of the first three modes characteristic for a winter month. Figure 3 depicts a SR-transient.

Some results based on SR observations

The observation of Schumann resonances is important from the point of view of the world thunderstorm activity in the troposphere, as well as the different emissions (red sprite, blue jet, elves) induced by lightning strokes and large scale influences of extraterrestrial origin in the lowest ionosphere.

The semiannual variations of SR amplitudes measured at the Nagycenk Observatory, Central Europe, are the manifestation of the semiannual variation of the surface air temperature in the tropical continental regions (Sátori and Zieger 1996). The latter is due to the semiannual wave of solar insolation with maxima at the equinoxes. The magnitude of the semiannual temperature variation is about 1.5–2.0 °C. The high significance level of the semiannual variation of the SR amplitudes at Nagycenk shows that the quality of this SR data set makes it suitable for detecting temperature variations at the level of some tenths of a degree centigrade. In this way, the observation of the SR amplitudes/intensities have great importance from the point of view of global climatic changes.

Parameters of global thunderstorm activity were deduced from the long term Schumann resonance records at Nagycenk (Nickolaenko et al. 1998).

The ENSO (El Niño Southern Oscillation) phenomenon is among others characterized by sea surface temperature anomaly in the equatorial Pacific which can affect weather patterns around the world. A meridional redistribution of the world thunderstorm activity was deduced from the variations of SR frequencies on the ENSO time scale observed at Nagycenk (Sátori and Zieger 1999).

Lightning properties of the two tropical continental chimneys, the Congo and Amazon basins were compared based on Schumann resonance measurements at Nagycenk, Hungary and Rhode Island, USA and satellite observations (Williams and Sátori 2004).

See CD (data visualization: program Seenck.exe, menu item SchumannRes: path: \Nckobs\Schumann\).

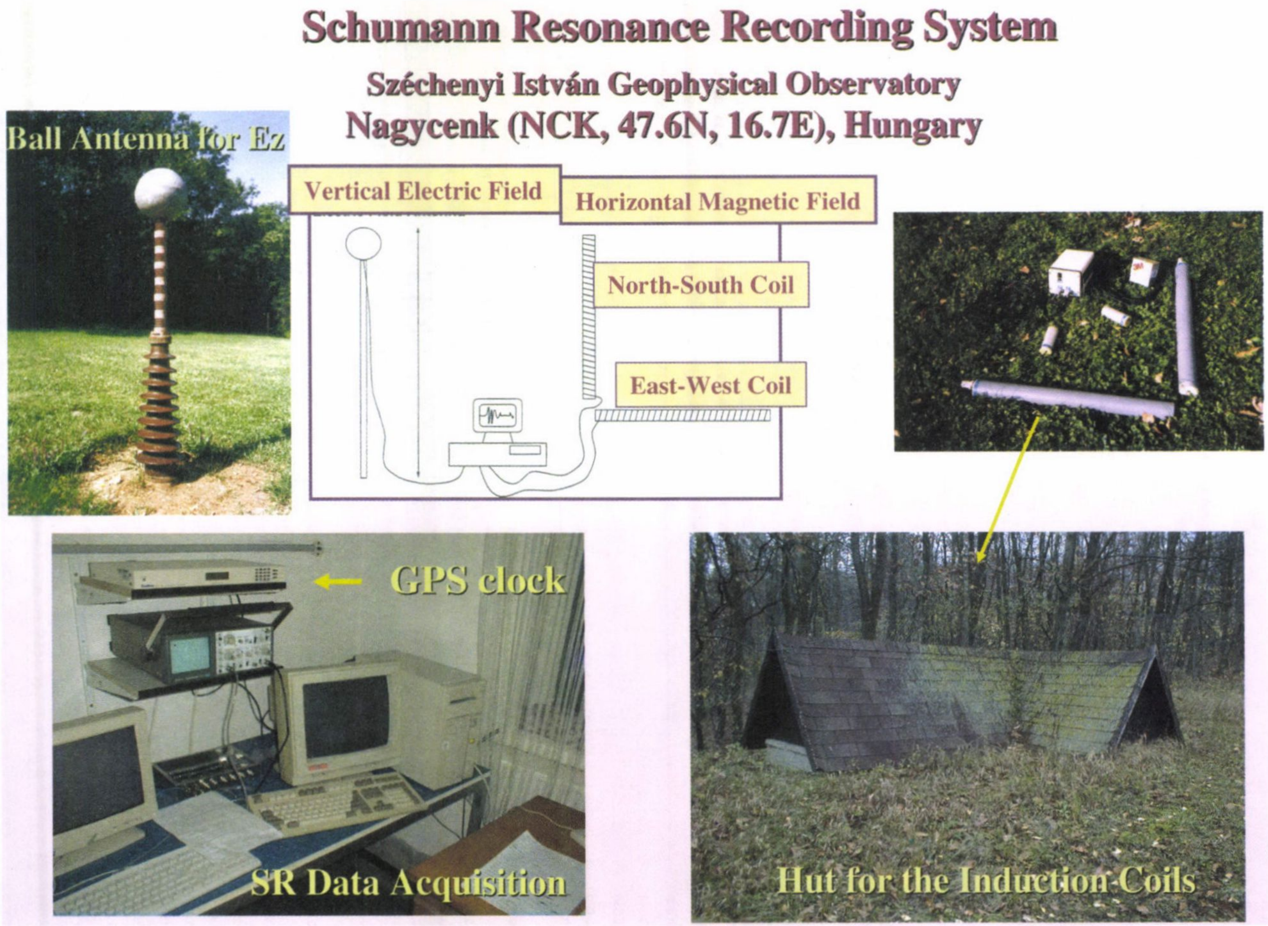

Schumann Resonance Recording System
Széchenyi István Geophysical Observatory
Nagycenk (NCK, 47.6N, 16.7E), Hungary
Ball Antenna for Ez
Vertical Electric Field
Horizontal Magnetic Field
North-South Coil
East-West Coil
GPS clock
SR Data Acquisition
Hut for the Induction Coils

Fig. 1.

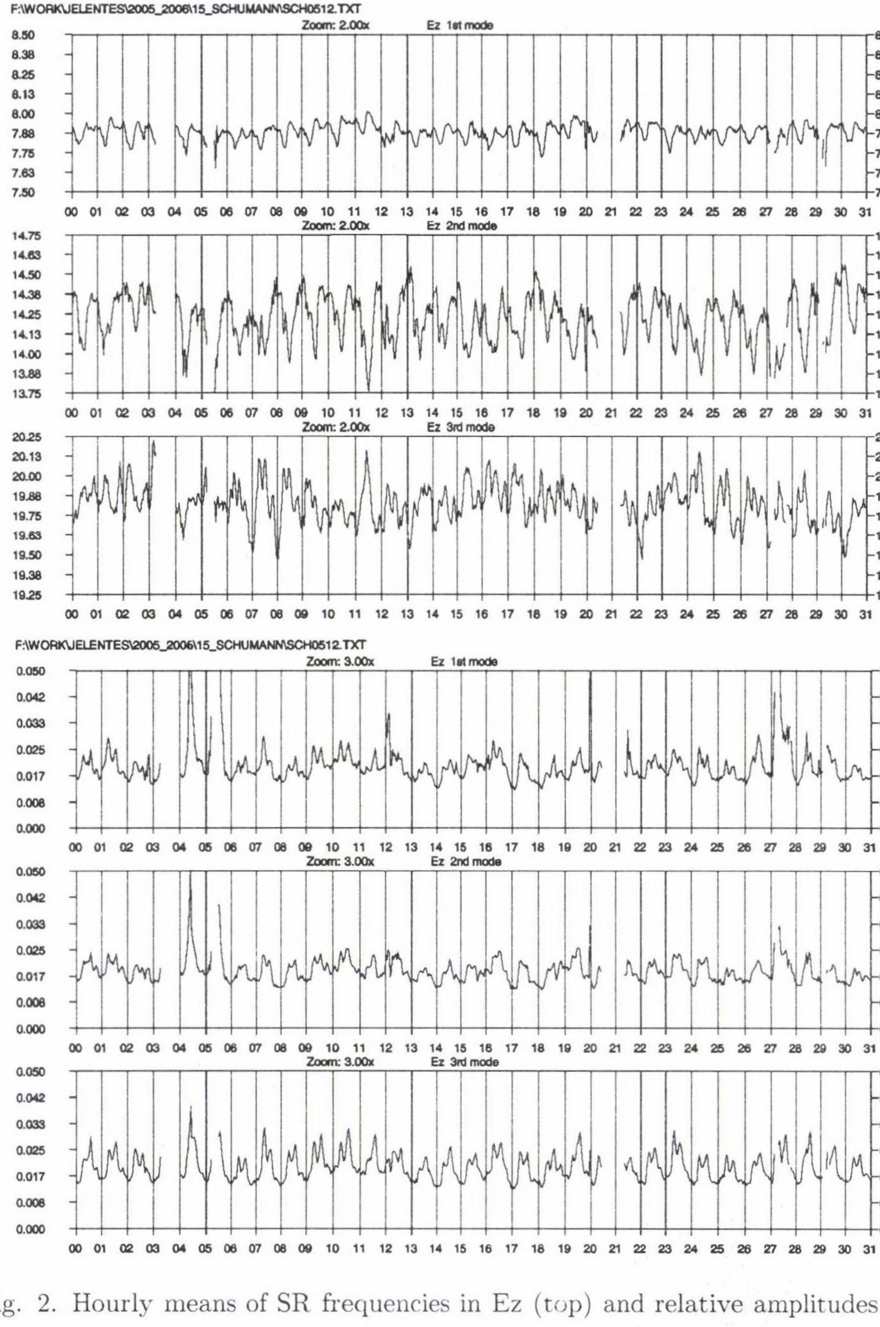


Fig. 2. Hourly means of SR frequencies in Ez (top) and relative amplitudes in V (bottom) measured for the first three modes in the days of December, 2002

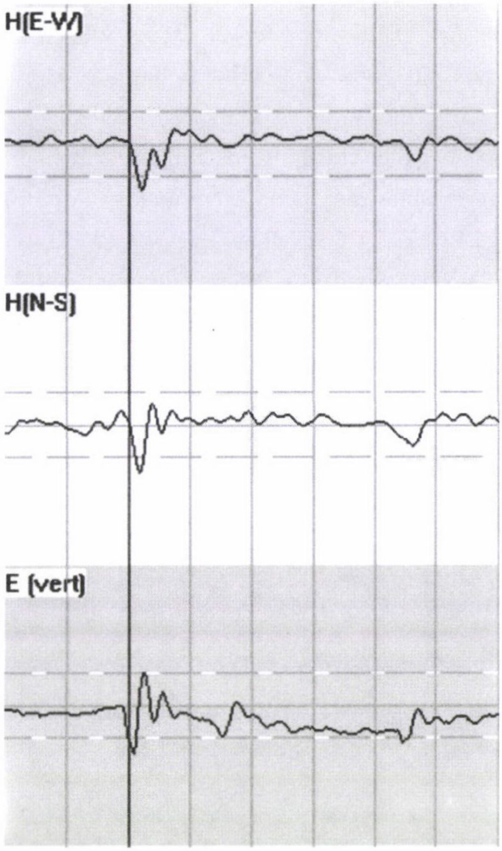


Fig. 3. SR-transient recorded at Nagycenk. Time markers include intervals of 100 ms. The horizontal broken lines indicate the trigger level of ±0.6 V

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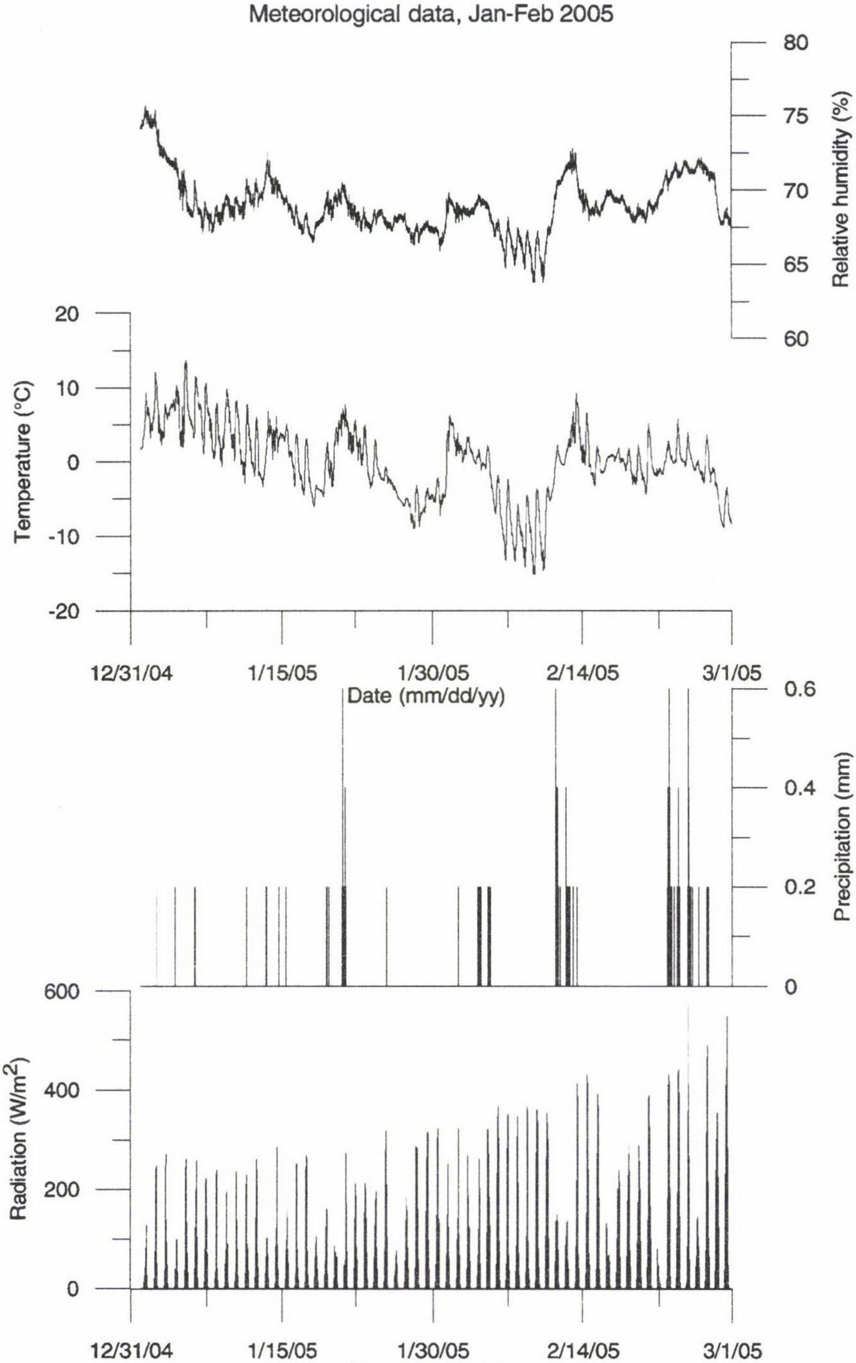
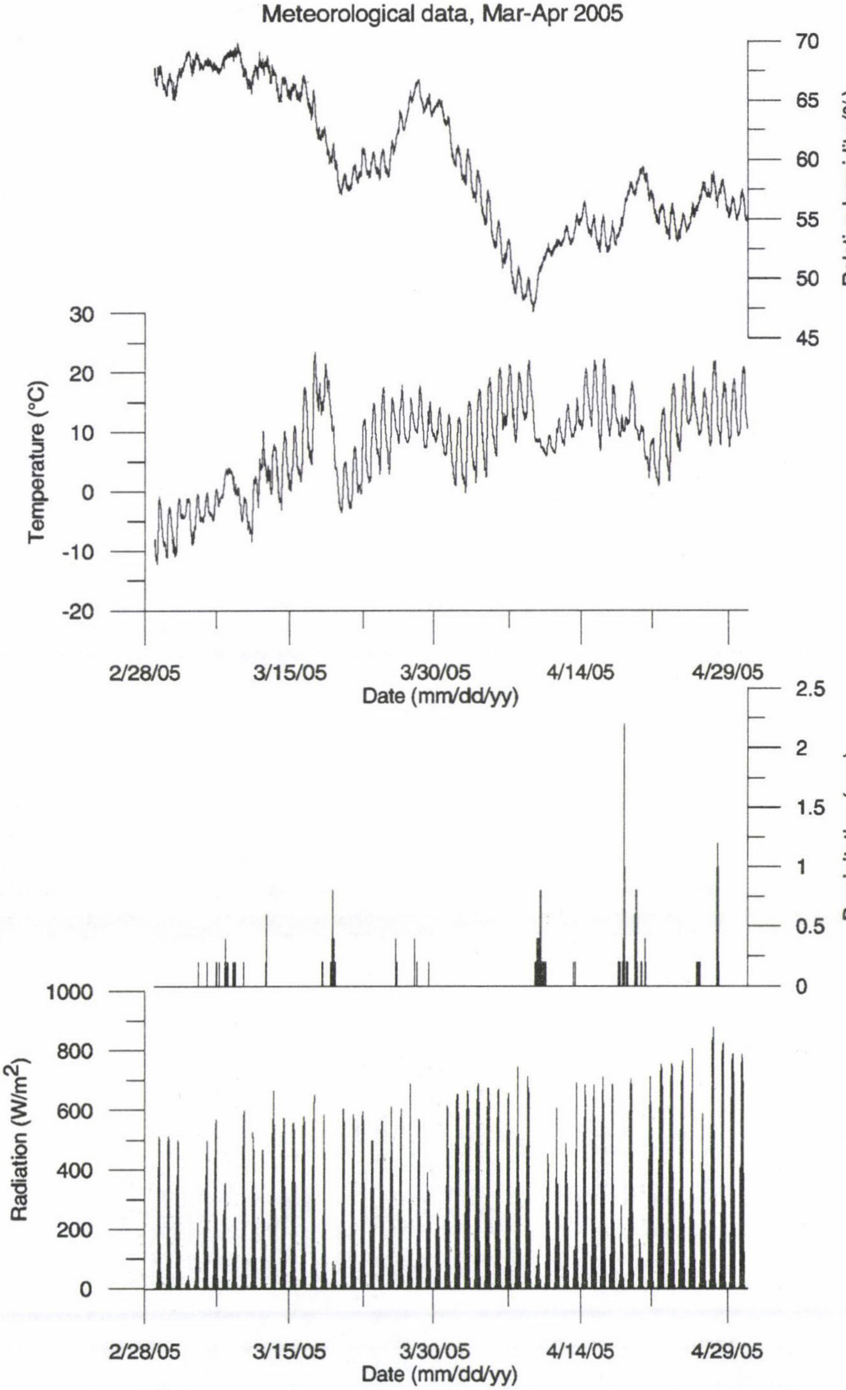
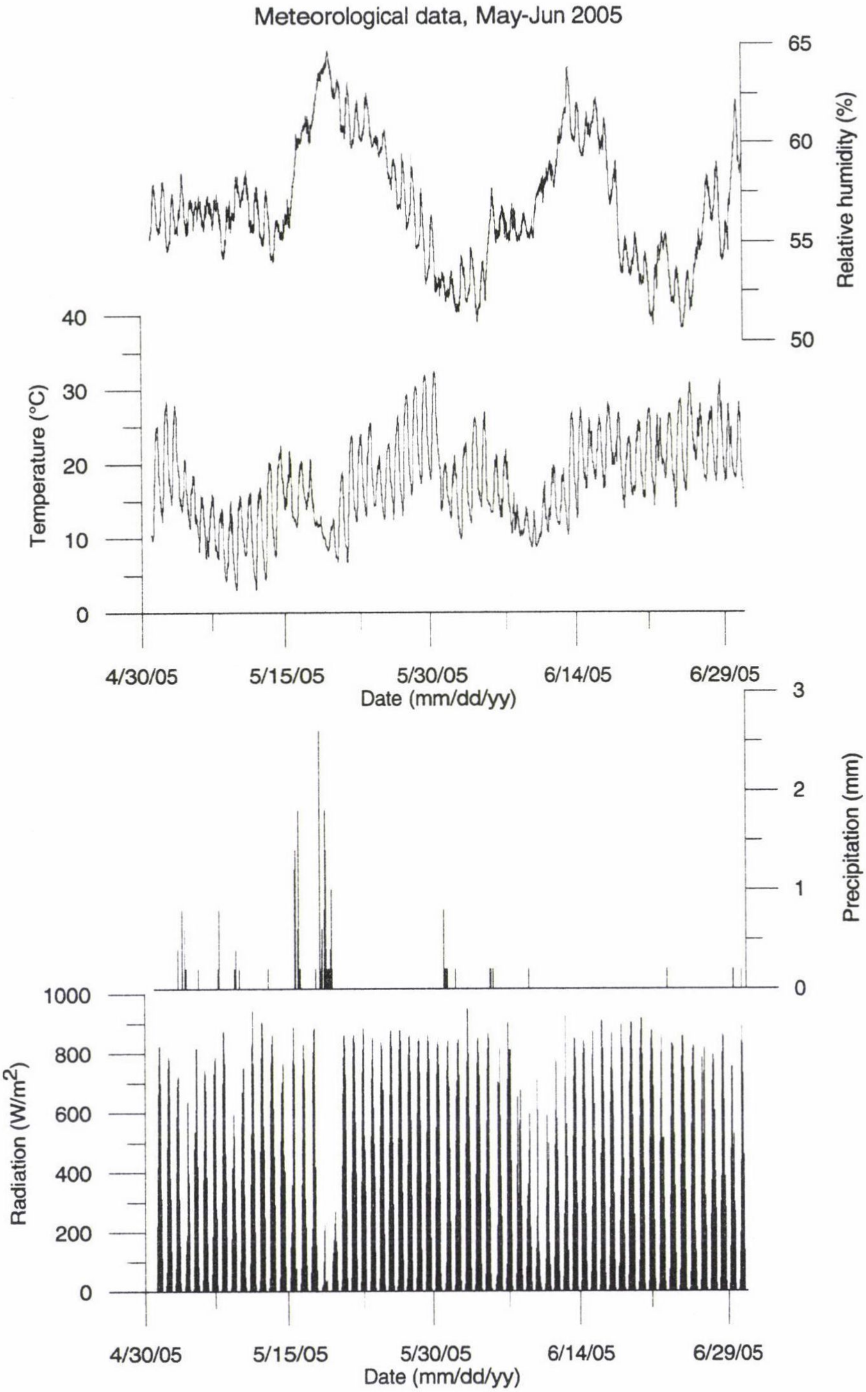
4. METEOROLOGICAL OBSERVATIONS

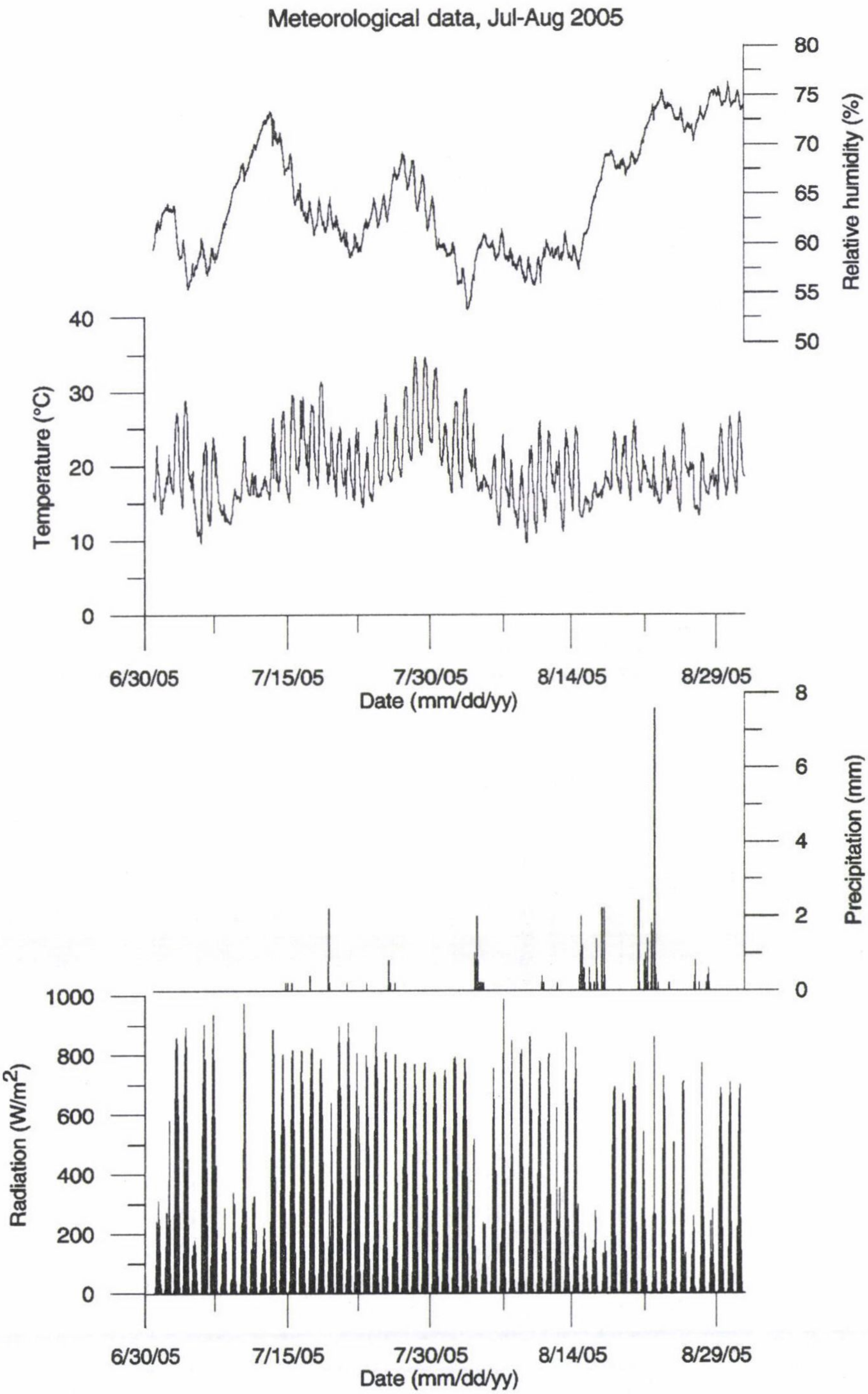
2005–2006



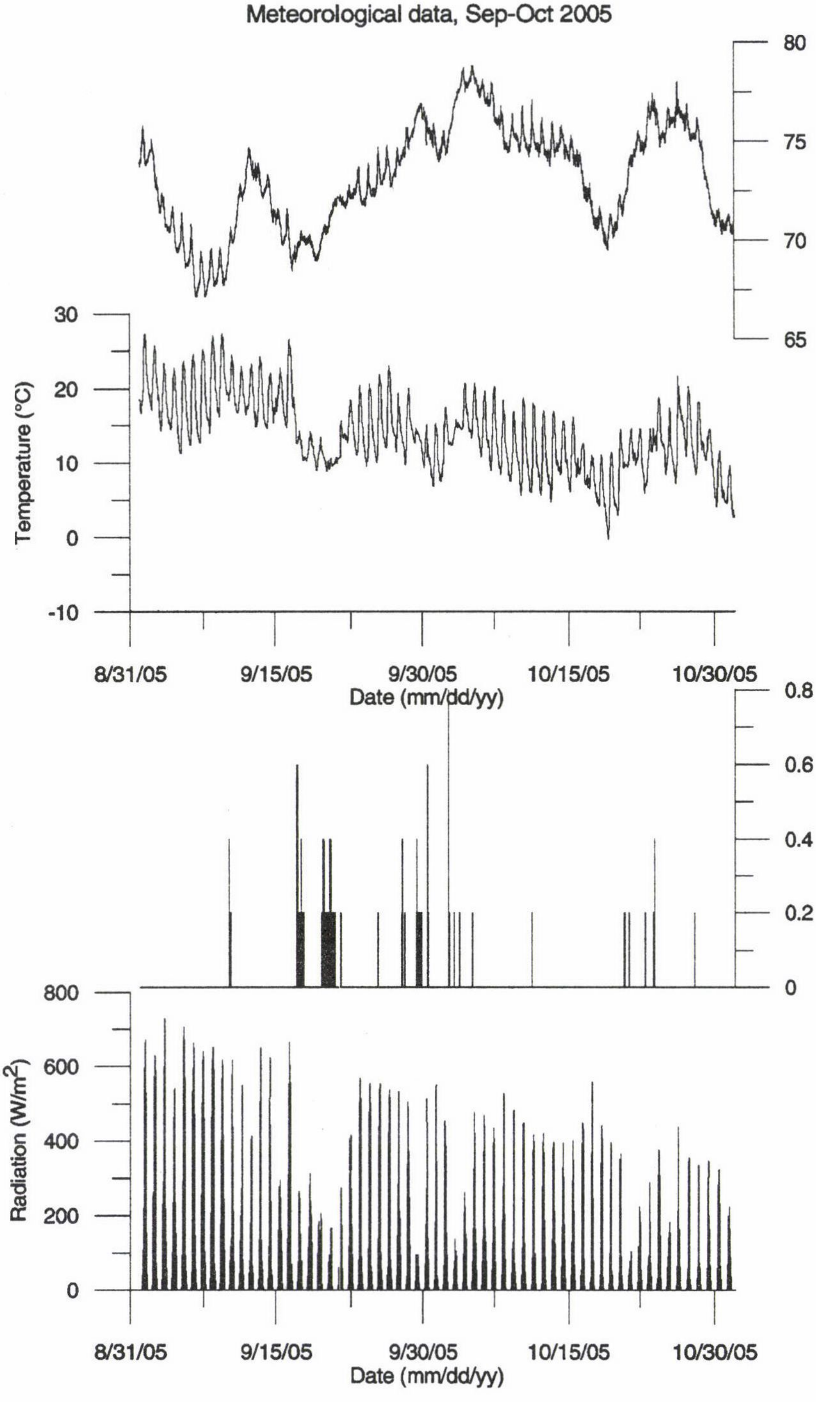
Meteorological data, Jan-Feb 2005
80
75
70
65
60
Relative humidity (%)
20
10
0
-10
-20
Temperature (°C)
12/31/04
1/15/05
1/30/05
2/14/05
3/1/05
Date (mm/dd/yy)
0.6
0.4
0.2
0
Precipitation (mm)
600
400
200
0
Radiation (W/m²)
12/31/04
1/15/05
1/30/05
2/14/05
3/1/05
Date (mm/dd/yy)

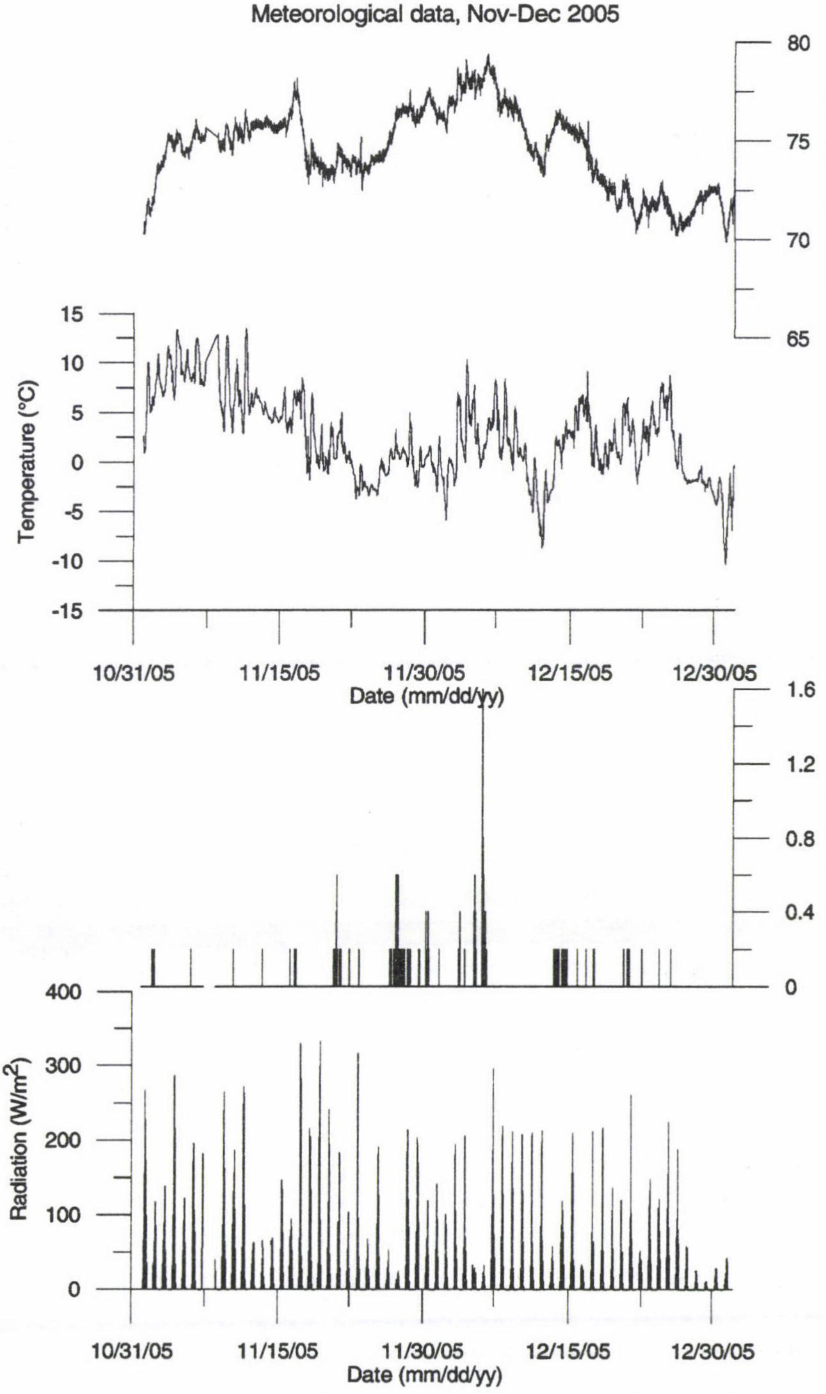

Meteorological data, Mar-Apr 2005
Relative humidity (%)
70
65
60
55
50
45
Temperature (°C)
30
20
10
0
-10
-20
2/28/05
3/15/05
3/30/05
4/14/05
4/29/05
Date (mm/dd/yy)
Precipitation (mm)
2.5
2
1.5
1
0.5
0
Radiation (W/m2)
1000
800
600
400
200
0
2/28/05
3/15/05
3/30/05
4/14/05
4/29/05
Date (mm/dd/yy)


Meteorological data, May-Jun 2005
65
60
55
50
Relative humidity (%)
40
30
20
10
0
Temperature (°C)
4/30/05
5/15/05
5/30/05
6/14/05
6/29/05
Date (mm/dd/yy)
3
2
1
0
Precipitation (mm)
1000
800
600
400
200
0
Radiation (W/m2)
4/30/05
5/15/05
5/30/05
6/14/05
6/29/05
Date (mm/dd/yy)

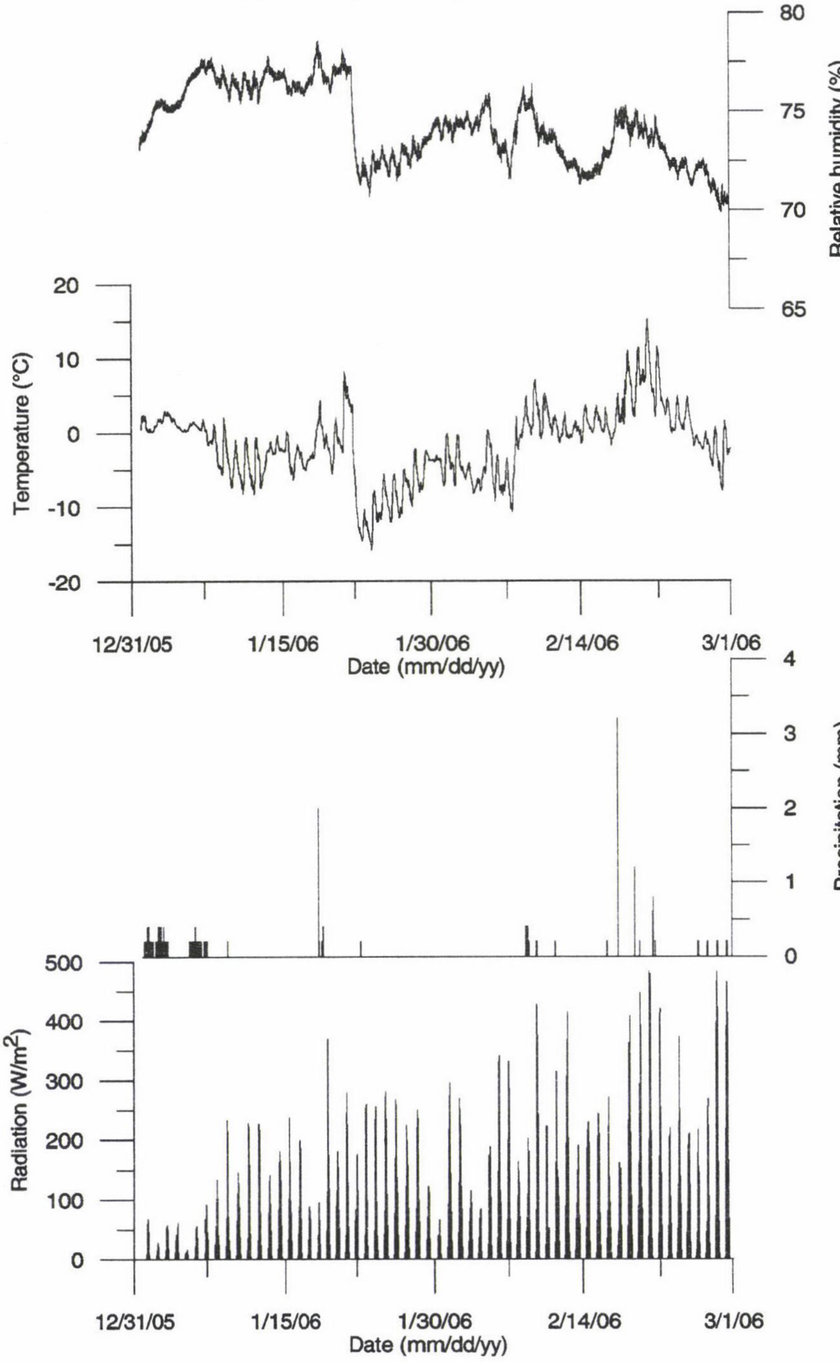


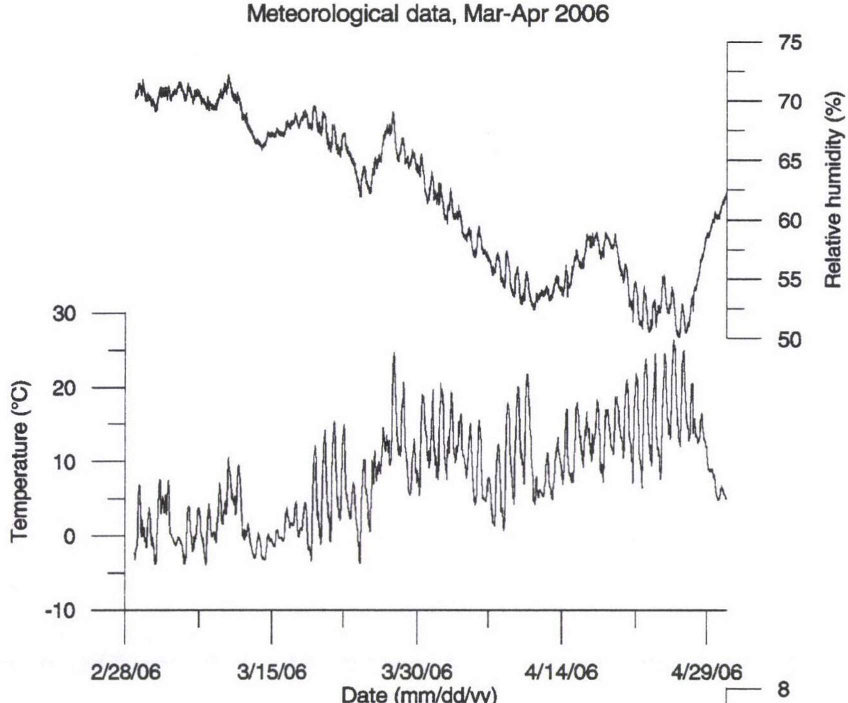
Meteorological data, Jul-Aug 2005
Relative humidity (%)
80
75
70
65
60
55
50
Temperature (°C)
40
30
20
10
0
6/30/05
7/15/05
7/30/05
8/14/05
8/29/05
Date (mm/dd/yy)
Precipitation (mm)
8
6
4
2
0
Radiation (W/m²)
1000
800
600
400
200
0
6/30/05
7/15/05
7/30/05
8/14/05
8/29/05
Date (mm/dd/yy)


Meteorological data, Sep-Oct 2005
Relative humidity (%)
80
75
70
65
Temperature (°C)
30
20
10
0
-10
8/31/05
9/15/05
9/30/05
10/15/05
10/30/05
Date (mm/dd/yy)
Precipitation (mm)
0.8
0.6
0.4
0.2
0
Radiation (W/m²)
800
600
400
200
0
8/31/05
9/15/05
9/30/05
10/15/05
10/30/05
Date (mm/dd/yy)

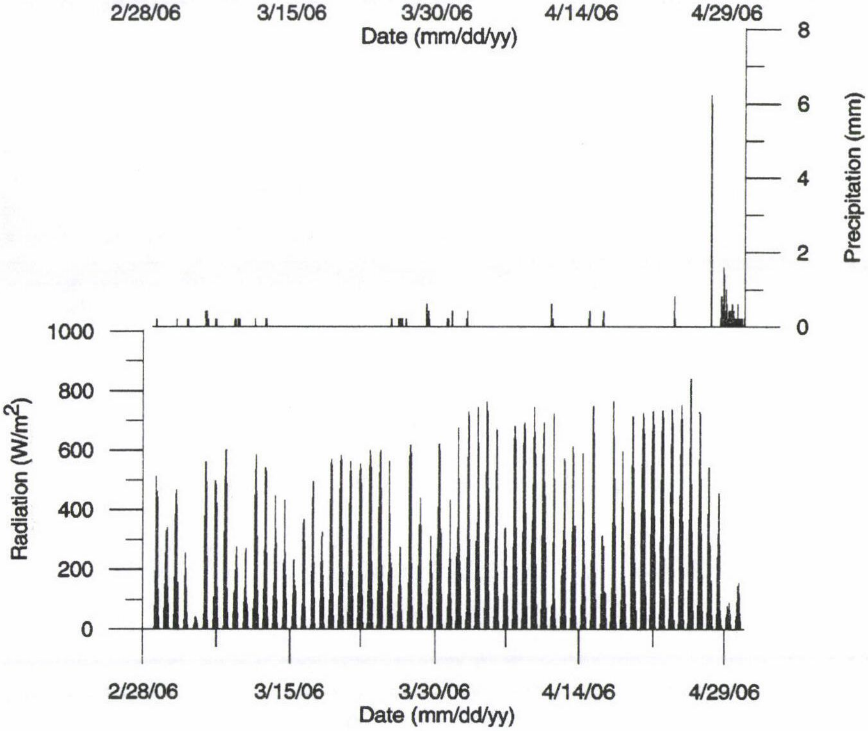

Meteorological data, Nov-Dec 2005
80
75
70
65
Relative humidity (%)
15
10
5
0
-5
-10
-15
Temperature (°C)
10/31/05
11/15/05
11/30/05
12/15/05
12/30/05
Date (mm/dd/yy)
1.6
1.2
0.8
0.4
0
Precipitation (mm)
400
300
200
100
0
Radiation (W/m2)
10/31/05
11/15/05
11/30/05
12/15/05
12/30/05
Date (mm/dd/yy)

Meteorological data, Jan-Feb 2006

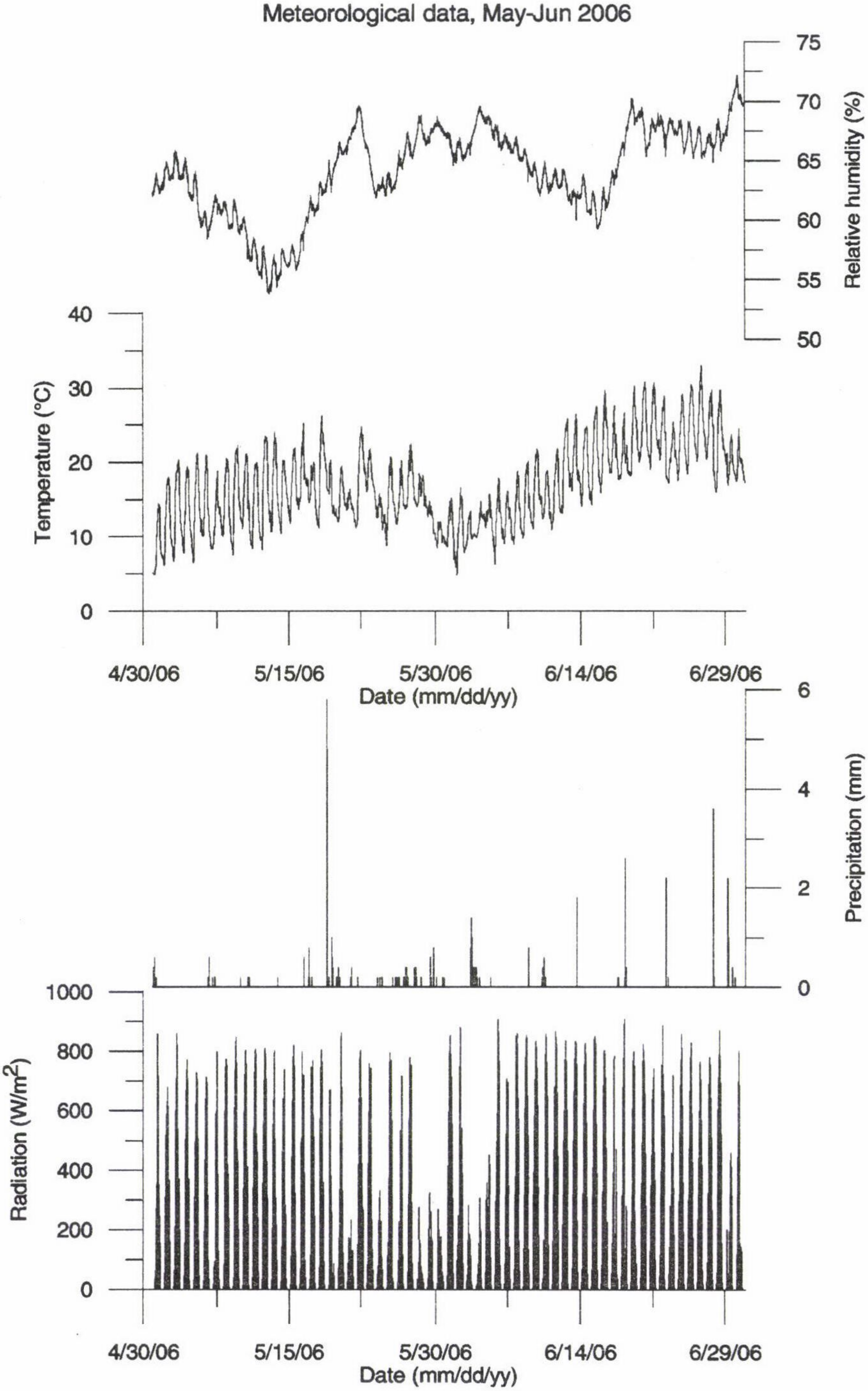


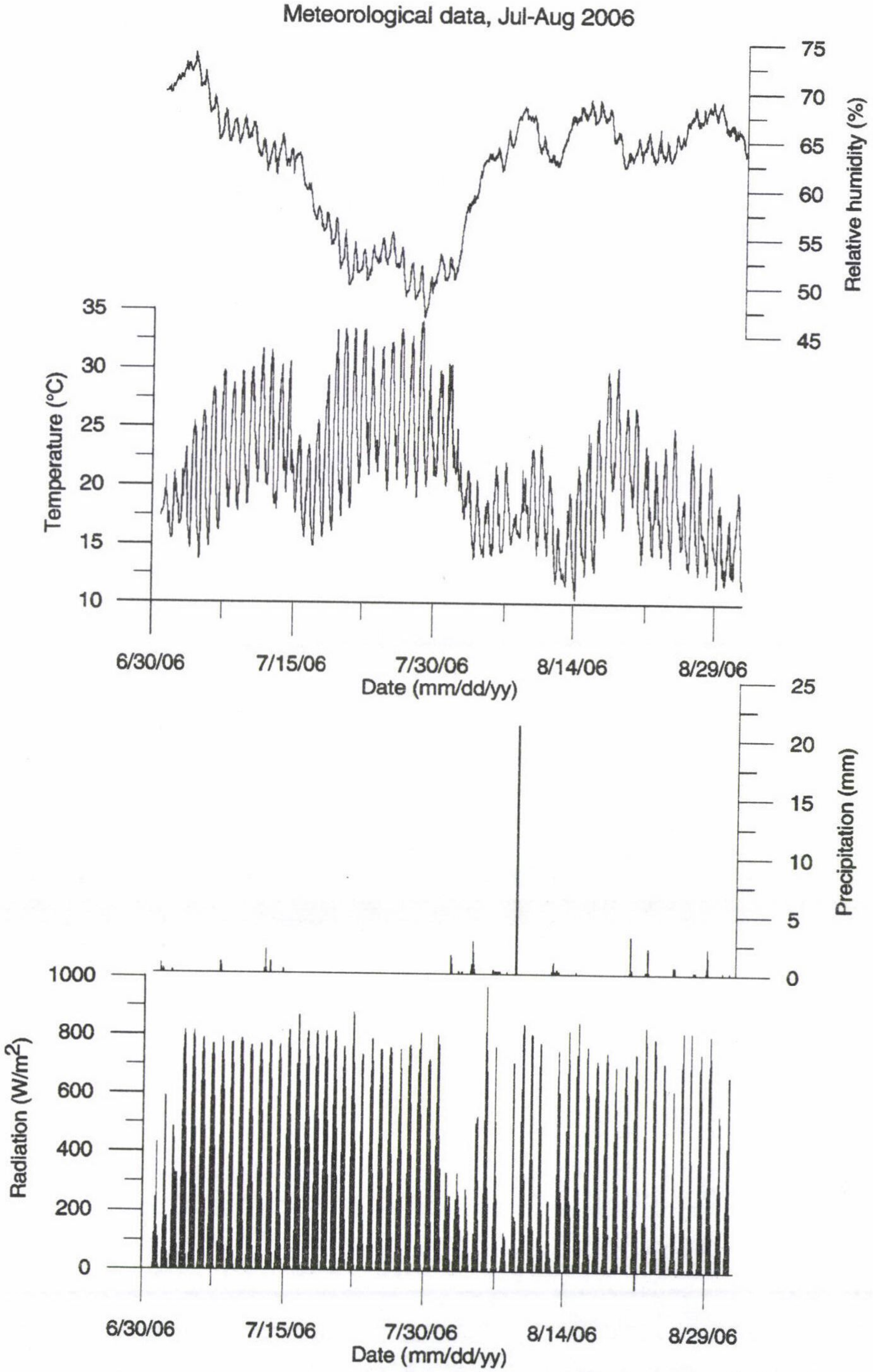


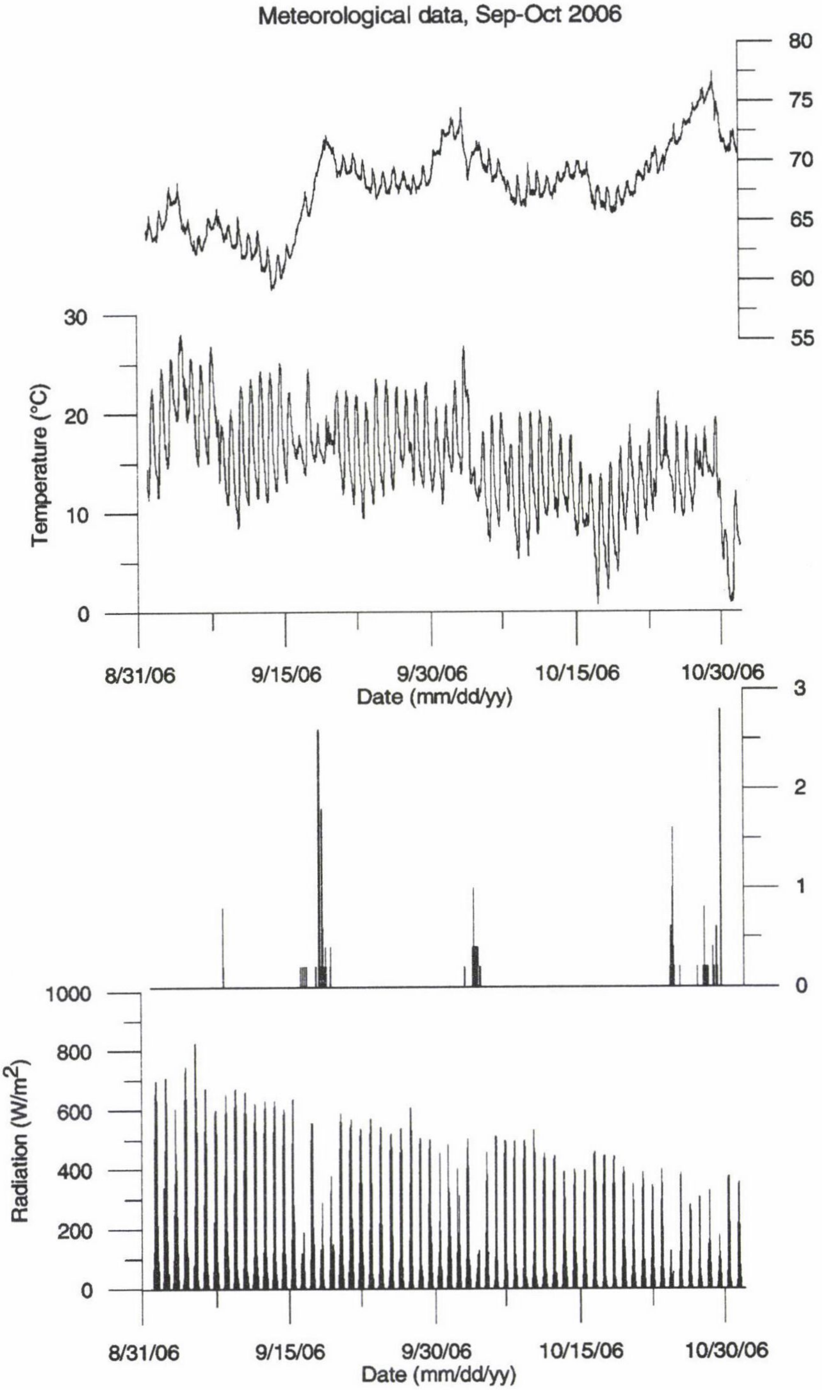
Meteorological data, Mar-Apr 2006
Relative humidity (%)
75
70
65
60
55
50
Temperature (°C)
30
20
10
0
-10
2/28/06
3/15/06
3/30/06
4/14/06
4/29/06
Date (mm/dd/yy)



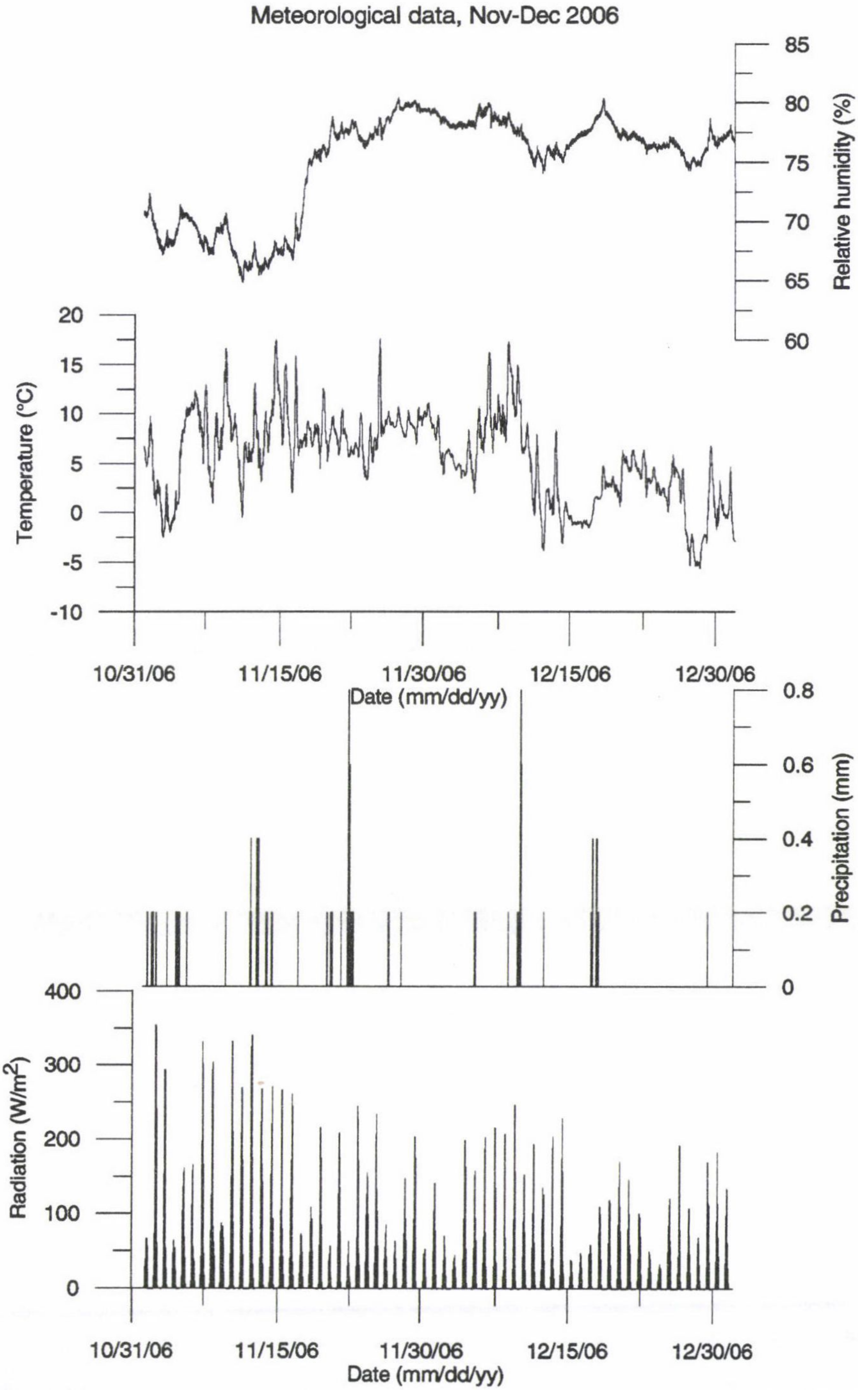
Precipitation (mm)
8
6
4
2
0
Radiation (W/m2)
1000
800
600
400
200
0
2/28/06
3/15/06
3/30/06
4/14/06
4/29/06
Date (mm/dd/yy)


Meteorological data, May-Jun 2006
75
70
65
60
55
50
Relative humidity (%)
40
30
20
10
0
Temperature (°C)
4/30/06
5/15/06
5/30/06
6/14/06
6/29/06
Date (mm/dd/yy)
6
4
2
0
Precipitation (mm)
1000
800
600
400
200
0
Radiation (W/m2)
4/30/06
5/15/06
5/30/06
6/14/06
6/29/06
Date (mm/dd/yy)


Meteorological data, Jul-Aug 2006
Relative humidity (%)
75
70
65
60
55
50
45
Temperature (°C)
35
30
25
20
15
10
6/30/06
7/15/06
7/30/06
8/14/06
8/29/06
Date (mm/dd/yy)
Precipitation (mm)
25
20
15
10
5
0
Radiation (W/m2)
1000
800
600
400
200
0
6/30/06
7/15/06
7/30/06
8/14/06
8/29/06
Date (mm/dd/yy)



Meteorological data, Sep-Oct 2006
Relative humidity (%)
80
75
70
65
60
55
Temperature (°C)
30
20
10
0
8/31/06
9/15/06
9/30/06
10/15/06
10/30/06
Date (mm/dd/yy)
Precipitation (mm)
3
2
1
0
Radiation (W/m2)
1000
800
600
400
200
0
8/31/06
9/15/06
9/30/06
10/15/06
10/30/06
Date (mm/dd/yy)


Meteorological data, Nov-Dec 2006
Relative humidity (%)
85
80
75
70
65
60
Temperature (°C)
20
15
10
5
0
-5
-10
10/31/06
11/15/06
11/30/06
12/15/06
12/30/06
Date (mm/dd/yy)
Precipitation (mm)
0.8
0.6
0.4
0.2
0
Radiation (W/m2)
400
300
200
100
0
10/31/06
11/15/06
11/30/06
12/15/06
12/30/06
Date (mm/dd/yy)

II. LATEST STUDIES

LIGHTNING INDUCED SCHUMANN RESONANCE TRANSIENTS AND SPRITES

J. Bór and G. Sátori

The results presented here is a contribution to the EUROSPRITE2003 campaign (Neubert et al. 2005) based on the observations of Schumann resonance transients recorded at the Széchenyi István Geophysical Observatory at Nagycenk.

Electromagnetic waves radiated by a lightning discharge in the lowest band of the ELF (Extremely Low Frequency: 3 Hz–3 kHz) range can excite the earth-ionosphere cavity. The resonance frequencies, known as Schumann resonances (SR) (Schumann 1952), are determined by the effective circumference of the earth and the phase speed of electromagnetic waves in the earth-ionosphere waveguide. The fundamental resonant frequency is close to 8 Hz, with higher-order modes spaced at intervals of about 6 Hz. Schumann resonance observations started in the Széchenyi István Geophysical Observatory at Nagycenk in 1993 (Sátori et al. 1996). Energetic lightning discharges excite the cavity, and the pulsed discrete variations, lasting for a fraction of a second, appear as coherent signals in the vertical electric and horizontal magnetic field components superimposed on the background ELF noise.

The energetic and mainly positive cloud-to-ground discharges (+CG) are very often accompanied by transient luminous events (TLEs) occurring between the top of the thunderstorms and the lower ionosphere. One of the TLEs, known as sprite, occupies huge space with vertical extension of 30–60 km and diameter of 5–15 km. Their lifetime is only some tens milliseconds. This was the reason why they were discovered rather late in 1989, apart from anecdotal evidences for many years, and documented in scientific journal in 1990 (Frantz 1990).

The charge moment (CM) change of a discharge is the amount of charge times the distance it has been moved. This parameter has been shown to be more relevant in quantifying the ability of a lightning stroke to generate TLEs than the often measured peak current of a discharge (Huang et al. 1999).

From SR transients, one can estimate the CM change of a flash. SRs were detected during the TLE observation campaign in the frequency band 5–30 Hz

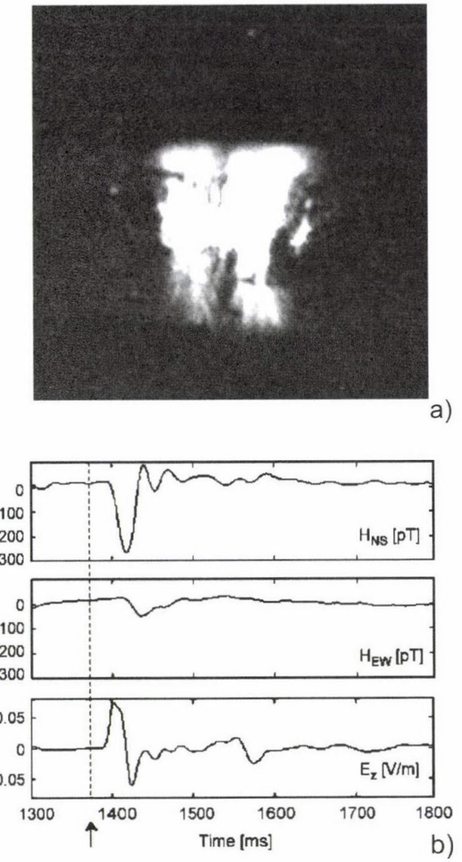


Fig. 1. a) Sprite on August 28, 2003 at 23:11:10.839 UT. b) SR transients recorded in the horizontal magnetic (HNS and HEW) and vertical electric EZ field components at Nagycenk, Hungary. The estimated charge moment change is about 2200 Ckm. The arrow and dashed line mark the time of sprite

at Nagycenk, Hungary. The CM changes associated with the +CGs that were identified for sprite events (a group of TLEs) were calculated by using one of the methods described by Huang et al. (1999), which assumes an exponential decay of the lightning current. Spectra of the SR field components depend on the source-observer distance, which is known from lightning detection networks. The ratio of the observed and theoretical spectra of each SR field component computed for the distance of the causative flash gives the current moment spectrum of the discharge. CM estimation is based on finding that exponential function for which the Fourier transform gives the best approximation of the current moment spectrum (Burke and Jones 1996, Huang et al. 1999). Theoretical spectra are calculated assuming

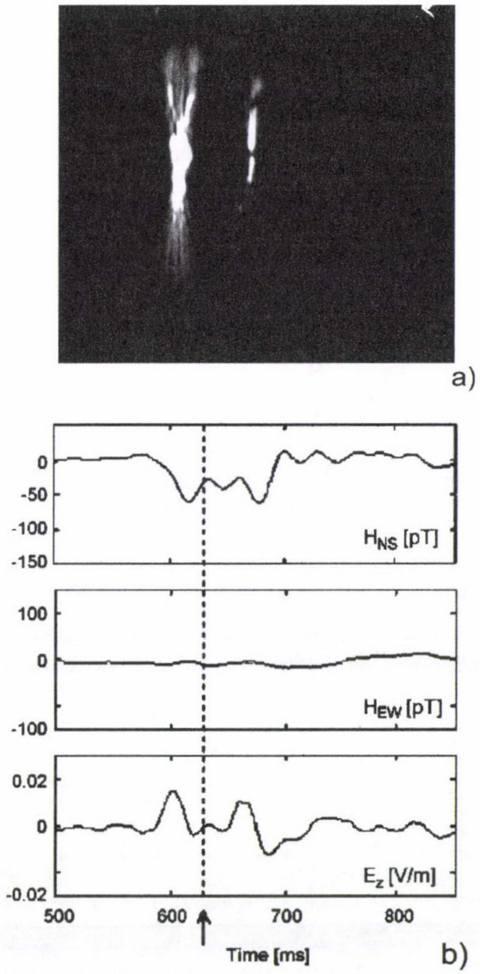


Fig. 2. a) Sprite generated by intracloud (IC) discharges on July 23, 2003 at 21:34:58.160 UT. b) SR transients recorded at Nagycenk, Hungary. Dashed line indicates the time of the sprite. The charge moment change is 800 Ckm computed from the SR transient following the sprite

a vertical dipole discharge approximation (Wait 1962), and EM wave propagation from the source to the observer in the earth-ionosphere waveguide with a perfectly conducting ground and an ionospheric conductivity that is isotropic and given by the mean of three conductivity profiles (Jones 1967). The method has been shown to give good correspondence between measured and observed spectra (Jones and Kemp 1970).

One example of a sprite over South-Eastern France on August 28 at 23:11:10.839 UT, and the SR transient from the causative +CG are shown in Fig. 1. The CM

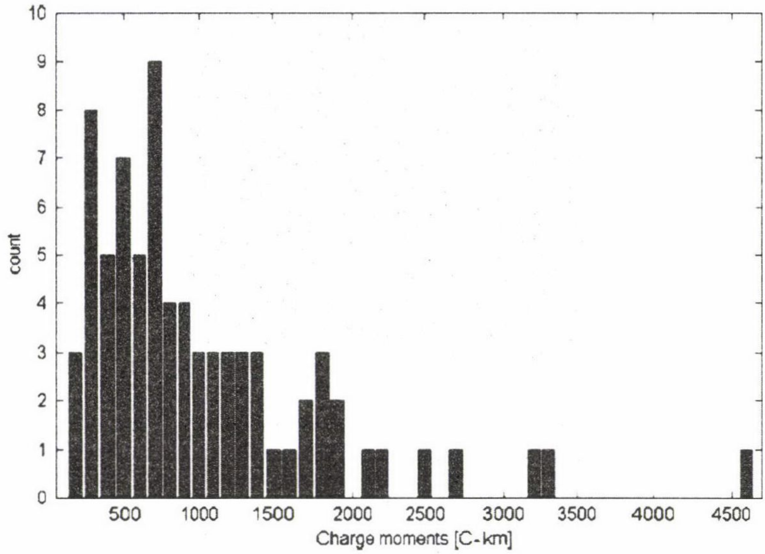


Fig. 3. Histogram of charge moment (CM) changes deduced from 76 Schumann resonance (SR) transients recorded at Nagycenk, Hungary and excited by sprite producing parent strokes

change estimated for this event is 2200 Ckm. Another example of sprite generated by intracloud (IC) discharges on July 23, 2003 at 21:34:58.160 UT and SR transients recorded at Nagycenk, Hungary are presented in Fig. 2. The distribution of CM change estimates is shown in Fig. 3. Out of the 101 TLE events, 76 SRs were suitable to deduce CM changes. The largest value reached is about 4500 Ckm, while the typical values are about 300–700 Ckm.

Acknowledgement

This work was supported by the Hungarian Scientific Research Fund NI 61013.

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VARIATION OF GEOMAGNETIC ACTIVITY — A STUDY BASED ON 50 YEARS TELLURIC OBSERVATIONS AT NAGYCENK OBSERVATORY

Á. Kis, A. Koppán, I. Lemperger, T. Prodán,
J. Szendrői, J. Verő, V. Wesztergom

Introduction

From the ground based magnetometer measurement different activity indices are obtained. Some of them cover many solar cycles: K index was introduced by Bartels in 1939, Ap index is available since 1932. Many features of the geomagnetic and solar activity have been discovered by spectral and statistical analysis of the uninterrupted time series of indices. Beside the well known 11 year and annual cycle, and the coronal holes related 27 days recurrence period, a 13.5 day period was found recently. The semi-annual and annual variabilities are related to the tilt of the Earth's orbit to the Sun's rotation axis. The 11 year variability of the geomagnetic activity is more or less correlated with the solar activity cycles but in the geomagnetic activity three major peaks appear according to the dominance of different sources.

Nagycenk Observatory has been providing a special activity index called T scaled from continuous telluric (geoelectric) recording. The telluric field is generated by the time variation of the geomagnetic field (curl $\mathbf{E} = -\partial B/\partial t$) therefore T characterises the higher frequencies in comparison with the magnetic range indices (since $\mathbf{E}$ is proportional with the angular frequency of the geomagnetic variation). Statistical analysis of T confirms the main characteristics of geomagnetic activity known from numerous former studies (e.g. Schreiber 1998) but slight differences are found due to the dominating higher frequency variations like giant pulsations.

T index data series

The high time resolution Earth current measurements started in 1957 at Nagycenk Geophysical Observatory (NGO). The 3 hour T index is scaled from 0 to 9 characterizing the geoelectric activity during 3 hour intervals corresponding to the largest range covered by the variation of Ex and Ey. The (daily) T index is the sum of the corresponding three hour T index values. The ten classes of the range are scaled with a linear step of 1.8 mV/km. Before the digital recording, i.e. from 1957 to the early nineties, the data series of the T index were obtained from the so-called normal run Earth current recordings (25 mm/hour). To ensure a continuous digital data for almost five decades, the earlier data has been carefully transformed to digital format by hand. This way we obtained a uniform (digital) data series for the past 48 years. The 3-hour interval proved to be an adequate indicator of geomagnetic transient events and to provide a suitable time resolution as well.

Like any other geoelectric and geomagnetic indices, the T index also has its limitations. The activity level is strongly affected by the local time, by the geomagnetic latitude and by the local geological structure (i.e., the spatial distribution of the conductivity): the latter can strongly influence the electric field. According to the earlier investigations (Ádám and Verő 1967, 1981) the observatory lies on the slope of a local crystalline basement. The thickness of the conductive sediment is about 1500 m. This fact implies that the periods of the variations shorter than 8 min lie in the magnetotelluric (MT) S-interval, i.e. in the increasing branch of MT sounding curves, which represent the high-resistivity basement. This means that the phase shift between the electric and the magnetic field is close to zero and the surface impedance is nearly constant.

Corresponding to the outlined conditions, the magnetic and electric variations expressed in nT and mV/km, respectively, have the same numerical value during normal (i.e. quiet) daily variations. The numerical value of electric variations are about 2–5 times larger than the corresponding magnetic ones during in the period range of substorms and about 100 times larger in the scale frequency of pulsations. Slight anisotropy is caused by regional effects. The transfer function between the magnetic and electric field components is routinely determined in order to check the scale value of the measurements in the observatory.

The thick conductive sediment preserves the observation site from the man-made disturbances. General analysis of the man-made ULF noise was carried out by Villante et al. (2004) at NGO and other observatories. From this analysis it was concluded that the man-made noise amplitude at NGO is orders of magnitude lower than the variations caused by natural effects, however the spectral analysis of long time data series might be influenced by working days of stronger effects and reduced weekend noise levels. To conclude, the T index determined from records at NGO is minimally distorted and it can be regarded as a valuable and representative indicator of geomagnetic induction.

Analysis of the T index

Fore some reasons the geoelectric field is seldom measured continuously and its nature is much less known than the characteristics of the geomagnetic field. The knowledge of the long term characteristics of the geoelectric field is of increasing importance in several space weather applications, especially in geomagnetic risk assessments. This fact also increases the value of the T index data series.

In our study we present a statistical analysis of the T index for the recent 47 years and its correlation with solar activity and the Ap index.

Fig. 1 presents from top to bottom the T index and the sunspot number versus time for the time period under investigation. Both the T index and the sunspot number data series were smoothed with a 1-year running average in order to filter out the high- frequency fluctuations and to be able to study the long-term variations. The sunspot number variation, which reflects the changes in solar activity, seems to have minimal effect on the T index variation, i.e. on the geoelectric activity.

Fig. 2 presents the unbiased covariance value between the T index and the total sunspot number. As it can be seen, the unbiased covariance does not have a maximum value at year 0, instead it has a local maximum at ~ 2.7 years.

Figure 3 presents the Ap index versus the T index. Both the Ap and the T indices were one year averaged. It can be seen that the Ap and the T indices are almost linearly correlated. This is clearly demonstrated on the upper panel of Fig. 4, where the unbiased covariance between the 27 day averaged T and the Ap indices is shown. The lower panel in Fig. 4. presents the T index versus the Ap index. The occurrence of high geomagnetic activity and its coincidence with high value of the induced electric fields shows that the Ap and the T indices reflect essentially the same geoelectromagnetic activity. The almost linear relation between the Ap and

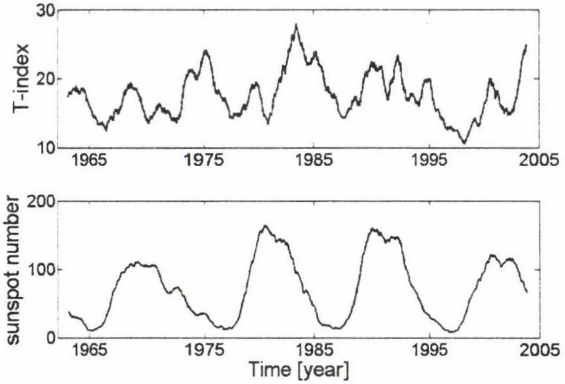

Fig. 1. Fifty years of T index (top) and sunspot number (bottom) data smoothed with one year running average are plotted

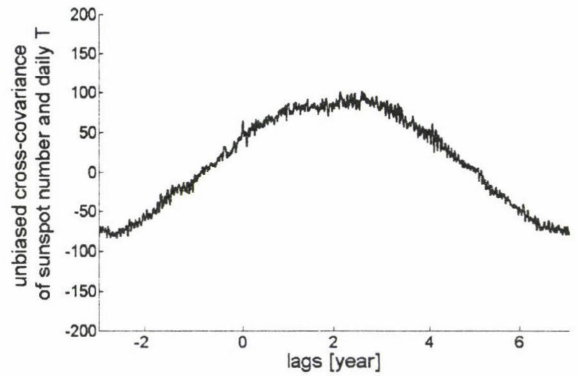

Fig. 2. Unbiased cross-covariance between sunspot number and T index

the T indices suggests that the Ap indices can be calculated from the T indices. However, some differences might result between the observed and the calculated Ap indices, since the T index is influenced by the pulsation activity.

In order to study the average variation of the T index, we superposed and normalized the T index values for each year beginning with the year 1957 up to 2005. As it can be observed in Fig. 5, the yearly averaged T index presents two maximums during one year time period. This yearly average wave has a clear six-month periodicity. Both equinoctial maxima are roughly of the same level, however the summer values are slightly higher than the winter ones. This deeper winter activity in our opinion might be connected to the winter anomaly, which is a decrease of the pulsation activity in high solar activity years.

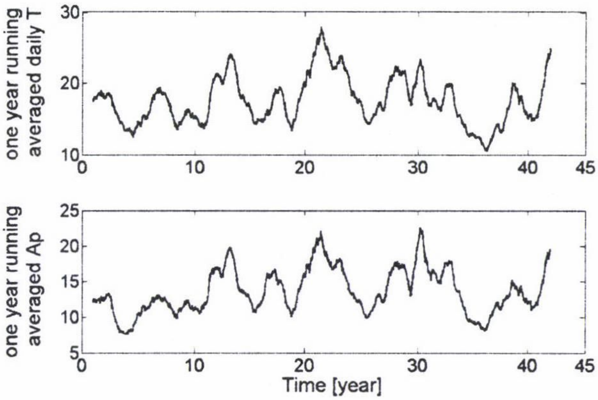

Fig. 3. One year running average smoothed T (top) and Ap (bottom) indices

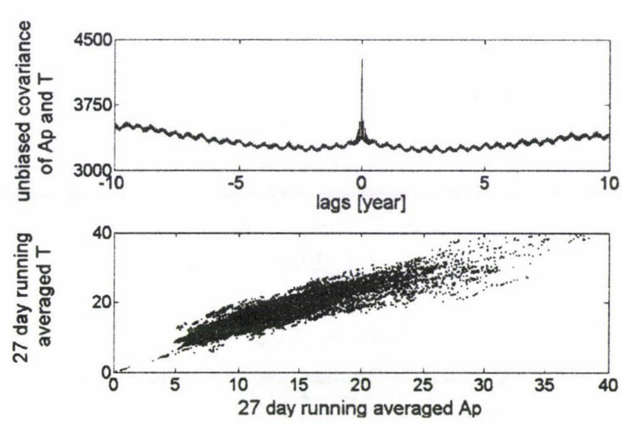

Fig. 4. Unbiased covariance of Ap and T indices (top), 27 day running average smoothed T versus Ap (bottom)

In the power spectrum of daily T sums shown Fig. 6 a significant peak occur at 11 years which can be related to the solar cycle. At shorter periods there is a lot of peaks between 1 and 11 years possibly resulting from the irregular form of solar cycle wave. The well known half-year wave of geoelectromagnetic activity is the strongest in its period range but there is also a yearly wave which can be due to a change in the direction of the geomagnetic disturbance vectors as the resistivity tensor of the Nagycenk Observatory is slightly elongated towards E-W (or ENE-WSW).

The next higher frequency group of peaks belongs to the 27-day rotation of the Sun together with its second and third harmonics moreover as rather small peak at about 28 days might be due to the influence of the Moon. The 13.5 day

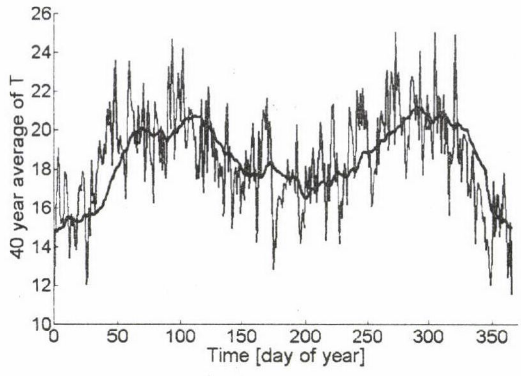

Fig. 5. Forty year average of daily T index at each day of year and its 27-day running average curve

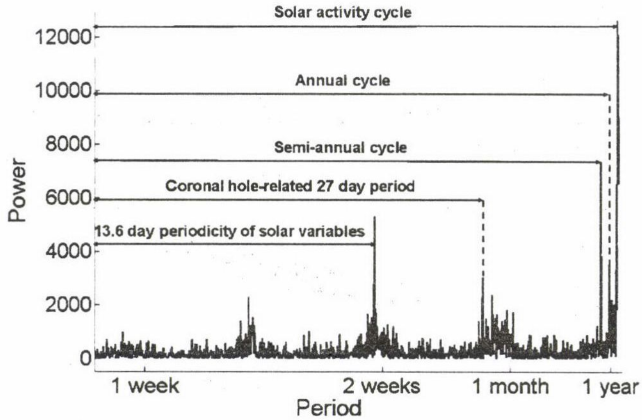

Fig. 6. The well known spectral peaks are indicated on the spectra of the T index. (The 11 year solar cycle is the outside right peak)

quasy- periodicity peak also clearly appears on the spectra produced by two-stream structures (Mursula and Zieger 1996).

Conclusions

Nearly fifty years long time series of the NCK observatory is a representative, homogeneous and unique data set for statistical analysis of the long-term variation of the geomagnetic induction effect.

The present study compared earth-current (telluric) activity index T with sunspot number and geomagnetic Ap indices. Occurrence of high geomagnetically induced electric fields and their coincidence with the phases of solar activity is less clear than that of maximum magnetic activity but it was shown that Ap and T indices reflect essentially the same geoelectromagnetic activity which is turn correlated with sunspot number. As the weights of variations with different periods are rather different in geomagnetic and earth-current indices there are also differences between the two kinds of activities. It is tried to identify such differences between the two time series and also in the connection with solar activity time series. Several kinds of differences result from the influence of the pulsation activity on the T index. With the help of a polynomial connection between Kp and T indices expected values can be computed from Kp for T. The difference of the observed and computed T indices may contain information about the effect of changing spectrum of geoelectromagnetic activity on these indices.

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CONNECTION BETWEEN WHISTLERS AND Pc3 PULSATION ACTIVITY AT TIME PERIODS OF QUIET AND DISTURBED GEOMAGNETIC CONDITIONS

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We investigate the connection between whistlers and Pc3 pulsation activity. For our investigation we used magnetic data provided by the Nagycenk Geophysical Observatory ($L \sim 2$) and whistler data from the nearby Tihany Geophysical Observatory recorded in year 2003. Both whistler and Pc3 pulsation data is hourly data. The whistler data provides the number of whistlers observed in one hour time period, while the Pc3 pulsation data presents the maximum amplitude value in the frequency range of Pc3 pulsations for the same time period. Our results show that in contrary to previous results (Verő et al., 1997) there is no visible correlation between the Pc3 pulsation intensity and the whistler occurance frequency. However, for the time periods of strong geomagnetic disturbances the appearance of whistlers in unusually large numbers is followed by Pc3 activity of large intensity.

Introduction

Two of the most important physical phenomena which are closely related to the plasma condition of the magnetosphere are the whistler waves and the Pc3 type geomagnetic pulsations. The practical advantage of whistlers and pulsations is that both can be studied by using ground measurements, therefore the data is more easily accessible than the data provided by sophisticated and expensive in-situ satellite measurements. Generally speaking, mid-latitude geomagnetic pulsations can be divided into two typical groups. While both types draw their energy from the so-called upstream waves (from now on: UW), the first type is driven directly by UW which are only slightly modified during their travel through the magnetosphere and as a consequence in the limited range of mid-latitudes they have practically the same period (and frequency). On the other hand, the second type is generated by a resonance mechanism of the geomagnetic field lines due to excitation by UW. The latter type of pulsation is called Field Line Resonance (FLR). The period (and the frequency) of FLR is a function of latitude. The variation of the FLR-type pulsation frequency with latitude is easy to understand if we take into consideration that the geomagnetic field line length changes with latitude. It is worth mentioning that the exact physical mechanism of energy transfer and coupling from the UW to the ground is not completely understood neither in the case of UW-type pulsation nor in the case of FLR. In order to be able to distinguish between UW and FLR type pulsations several meridional arrays were organised with the Nagycenk Observatory (NCK) in the center. In the first array, periods changed with latitude in roughly half of the events, sometimes smoothly, sometimes stepwise with latitude (Cz. Miletis 1980). Based on the results of the continuous studies became evident that by using data from a network of meridional array geomagnetic observatories FLR and UW type pulsations can be identified with high accuracy. A more comprehensive description of the results can be found in the review article by Verő (1986). The whistler waves have their source in terrestrial lightning. It is widely accepted the idea that at lightning a non-monochromatic very low frequency (VLF) wave package is generated which is (at least partially) able to step out into the magnetosphere. Afterwards this wave is traveling parallel mostly to the geomagnetic field lines and can be detected on-ground on the conjugate point of the field line on the other hemisphere. During its propagation in the magnetospheric region the wave package becomes highly dispersed. Maeda and Kimura (1956) were the first to show that propagation along the field lines would be impossible without 'ducts'. Smith (1960) and Smith et al. (1960) presented the theory for the propagation in ducts. Walker (1976), Laird and Nunn (1975) and Strangeways (1982) contributed significantly to this theory. Ducts have no sharp boundaries; they are more smoothly varying enhancements in electron density. Also it is known that the same whistler may propagate in numerous close ducts. However, the existence of these ducts still it is as open question. Multiple whistlers, which result from the same lightning, but propagate on different paths, support the idea of the existence of ducts. Lichtenberger (1994) determined the angle between the propagation of whistlers and the direction of the magnetic field. These angle values (10 to 15 degrees) also support the existence of ducts since without a duct the angle would be much larger. On the other hand, there are recently published new results which question the necessity of ducts in the propagation mechanism of whistlers (O. Ferencz et al. 2006). For a detailed discussion and description on whistlers see Cs. Ferencz et al. (2001).

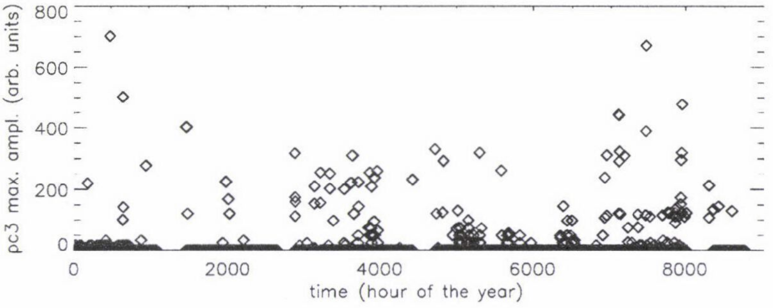

Fig. 1. Maximum amplitude in Pc3 activity versus time recorded in year 2003 at NCK. Each diamond-shaped symbol represents the maximum amplitude in Pc3 frequency range for the respective one-hour time period in a linear-linear scale. This method (i.e. taking the maximum value instead of an averaged value) gives back more accurately the intensity of the individual events

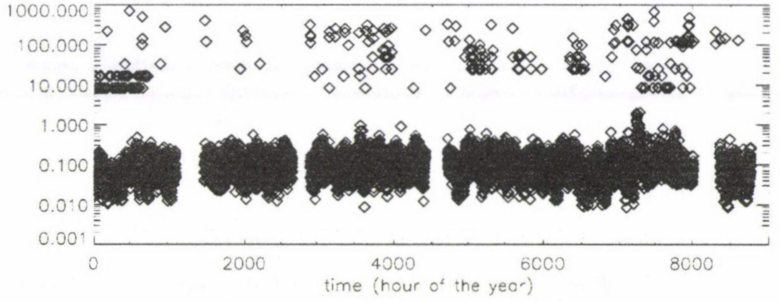

Fig. 2. Maximum amplitude in Pc3 activity versus time in lin-log scale

Verő et al. (1997) analyzed the supposition that whistler ducts and geomagnetic field line shells are closely connected with each other as they appear simultaneously with enhanced probability. They found a very close connection between the oocurance frequency of whistlers and geomagnetic Pc3 pulsation activity. According to their results the connection is nearly linear; if there are no whistlers, the pulsation activity is either extremely low or no pulsation activity exists. In our study we expand these earlier studies by verifying the connection between the Pc3 pulsation activity and whistlers. We approached the problem by using statistical methods, but we analyze individual events also.

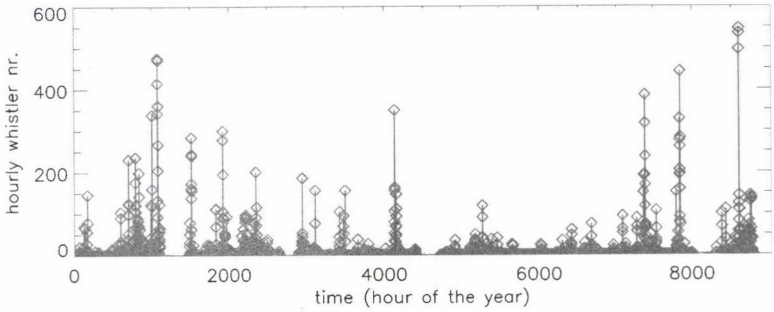

Fig. 3. Maximum amplitude in Pc3 activity versus time in lin-log scale.

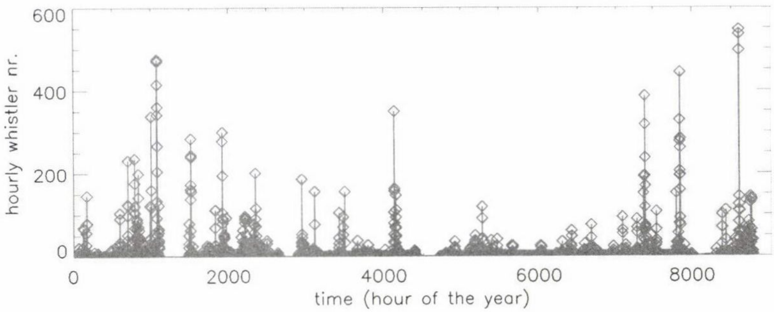

Fig. 4. Pc3 activity and whistler number versus time for the year 2003

Observations and Discussion

Statistical Results: General Behavior

For our investigation we used magnetic data provided by the Nagycenk Geophysical Observatory (NCK) situated at L∼2 and whistler data from the nearby Tihany Geophysical Observatory (TGO) recorded in year 2003. Both whistler and Pc3 pulsation data is hourly data. The whistler data provides the number of whistlers observed in one hour time period, while the Pc3 pulsation data presents the maximum amplitude value in the frequency range of Pc3 pulsations for the same time period. This method (i.e. taking the maximum value instead of an hourly averaged value) gives back more accurately in our opinion the intensity of the individual events. Figure 1 presents the maximum amplitude in Pc3 pulsation activity (from now on: Pc3 activity) in arbitrary units versus time in linear-linear scale recorded in year 2003. Each diamond-shaped symbol represents the maximum amplitude in Pc3 frequency range for the respective one-hour time period. Figure 2 also presents the Pc3 activity versus time, but in a linear-logarithmic scale. It can be seen that

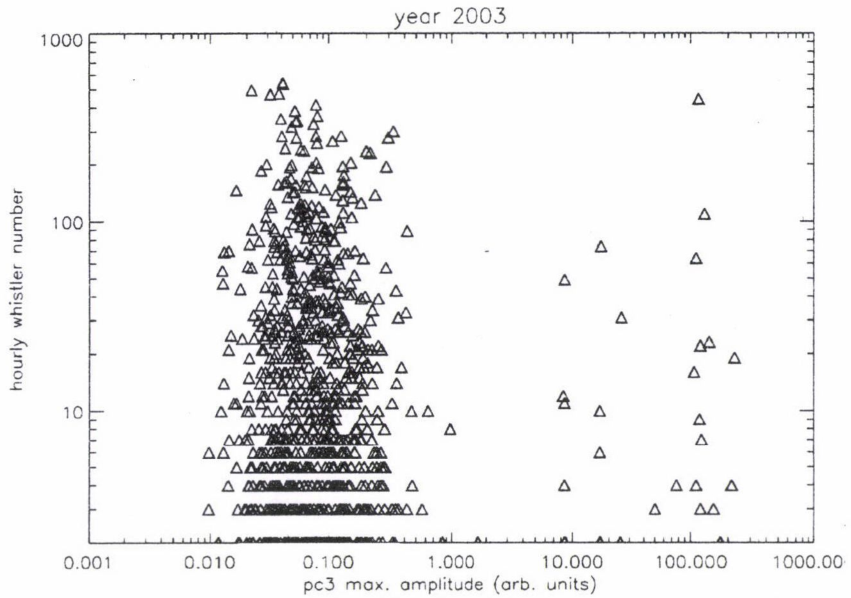

Fig. 5. Whistler number versus Pc3 activity for the year 2003 presented in log-log scale

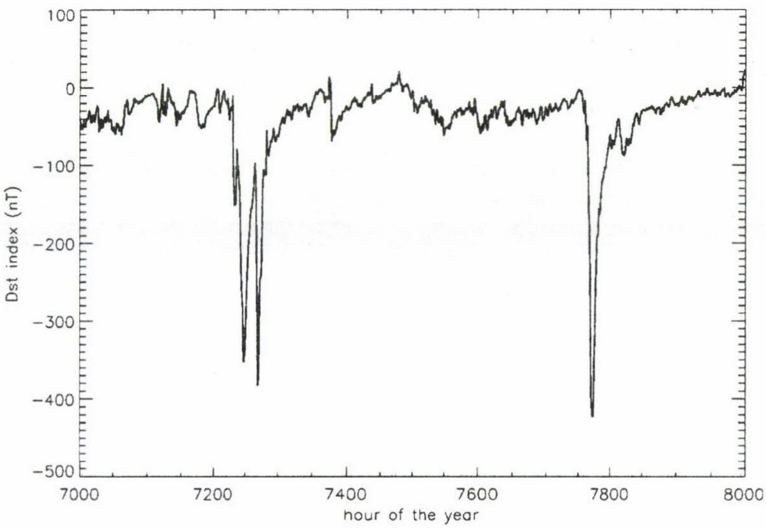

Fig. 6. Dst index versus time

besides the more quiet time periods there are to be found a significant number of events which are characterized with orders of magnitude higher Pc3 activity. The time gaps where the pulsation activity value is missing are due to lack of reliable

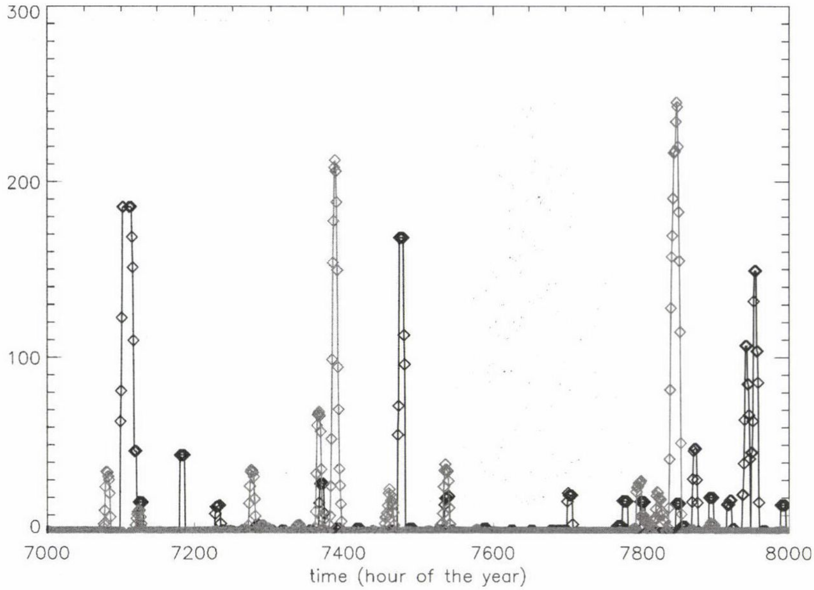

Fig. 7. Pc3 activity and whistler number versus time

data from the observatory records. Figure 3 presents the number of whistlers (i.e. the number of whistlers observed during one hour time period) versus time for the year 2003. It can be seen that there are events with very high whistler occurrence and it seems that these events appear more in groups rather than being scattered in time. In Figure 4 for better visibility we over plotted the Pc3 activity and the number of whistlers versus time in linear-linear scale. In order to investigate the connection between the whistlers and the Pc3 activity we plotted the hourly whistler number versus the maximum value of Pc3 activity for the same hour in Figure 5. It can be seen that the number of whistlers is not correlated with the Pc3 activity. Whistlers occur in high numbers during times of low Pc3 activity and high Pc3 activity does not necessary means the presence of whistlers in high numbers. This is in contradiction with the results by Verő et al. (1997), who found a clear, almost linear connection between the whistler number and the Pc3 activity. The explanation of the discrepancy between the previous and our results might be that for our investigation we used an hourly Pc3 activity, while Verő et al. (1997) used a daily pulsation index. The fact that by using an hourly Pc3 activity we were not able to reproduce the previous results shows the complexity of the problem. For an exact answer more investigation is needed. For now we can only conclude, that we found no evidence of correlation between the hourly occurrence frequency of whistlers and the hourly Pc3 activity.

Individual Events

In our study of individual events we focused on time periods of strong geomagnetic disturbances. We choose two events from the year 2003. when the geomagnetic Dst index indicates the occurrence of large geomagnetic storms. Figure 6 presents the Dst index versus time from the last period of year 2003. It can be seen that during this time period two major geomagnetic disturbance events occurred. Figure 7 presents the hourly whistler number and the Pc3 activity for the same time period. If we compare Figure 6 and with Figure 7 we can observe that after the strong geomagnetic disturbances (reflected in the Dst index) whistlers appear in an unusually high number, which is followed by intense Pc3 activity. The sequence of events is the same in both cases, however the time periods between them is not exactly the same. In our opinion this might be the consequence of changes in the value of plasma parameters in the near Earth environment. In order to completely understand the physical mechanism which leads to this chain of events further analysis is needed. In any case, our results are the first to suggest that a strong geomagnetic storm changes the near Earth plasma environment in such a way, that leads to an unusually high whistler occurance and enhanced Pc3 activity.

Acknowledgements

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TIME VARIATION OF ELECTRIC POTENTIAL DIFFERENCES ON TREE TRUNK

A. Koppán, L. Szarka, V. Wesztergom

Introduction

Bioelectric phenomena at tissue and organism levels are sometimes less known in plants than in animals, although the problem of plants seems to be simpler than that of animals or humans. In situ electrical measurements on plants especially on trees have proven to be very difficult. Investigation of bioelectric phenomena of trees became widespread in the last decades, but many question remained unanswered. e.g. the true relationship between life- functions of the tree and the measured electric signals. The effect of the environment on the electric signals is also not yet fully explained.

Measurements and some results

We started the first bioelectric experiments in 1995, primarily focusing on the measurements of electric potential differences (EPD) on the tree trunks. The EPDs were recorded continuously for four years (between 17.05.1997 and 28.02.2002) at the Széchenyi István Geophysical Observatory. As shown in Fig. 1 a–b, sixteen non-polarizing electrodes were inserted beneath the cambium into the sapwood of a turkey oak (Quercus cerris L.) at four height levels (at 0, 2, 4 and 6 m), and at each height level four electrodes (corresponding to S, W, N and E sides of the tree) were installed. The EPDs were measured between the trunk electrodes and a common ground. The sampling interval was kept as short as 1 sec. and 1 minute mean values were continuously recorded.

The electric potential differences on tree trunks change over time. The most noticeable variation is the regular daily fluctuation whose amplitude is a few tens of mV. The daily activity is most likely related to the transpirations daily rhythm. The amplitude of the daily fluctuations shows a characteristic seasonal variation as well, with two maxima. The first peak occurs at frondescence (due to the very intense transport processes within the tree), while the second one appears in early summer (Koppán et al. 2000). Beyond the temporal changes we investigated the spatial variations of EDPs. too (Koppán et al. 2005).

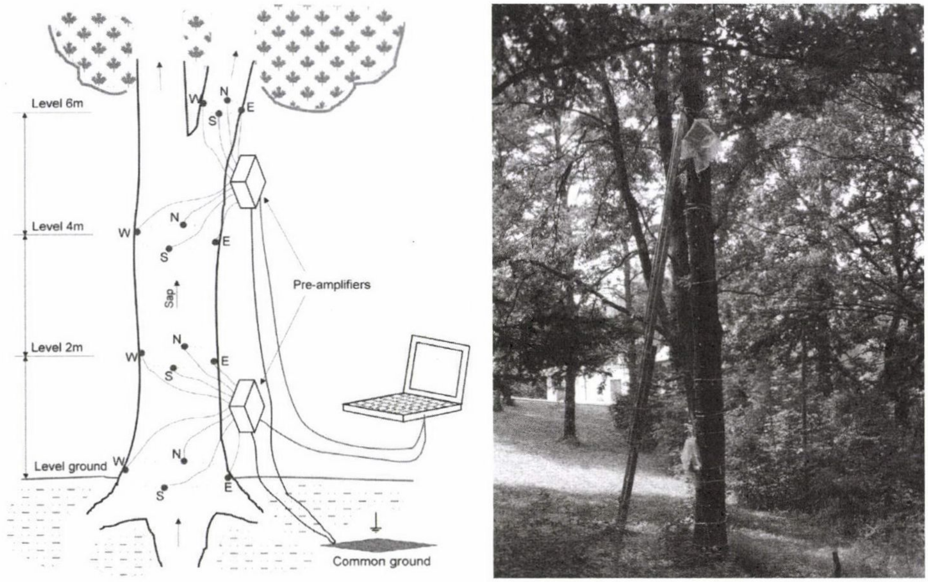

Fig. 1. The electric potential difference measuring system in the Nagycenk Observatory

After determining the variations of the electric potential differences and their characteristics the next step was to define which internal processes and environmental parameters might be the source for the formation and changes of the electric potential differences. The most important internal process is the axial water transport in the tree trunk. This fact is confirmed by the correlation analysis of the sap flow and electric potential difference data (Fig. 2.), which showed a close connection between the two data series. The sap flow was simultaneously recorded from July 1999 to December 1999 with Graniers radial flowmeter technique (Granier 1987) by using a four-channel (four thermocouples) system.

In order to understand the tree - environment interactions, it is important to study, which environmental factors could directly or indirectly affect the EPDs. We revealed relationships between the variations of the EPDs and various meteorological/geophysical parameters (recorded at the Observatory) by using a multivariate statistical analysis, although the assessment of the results is difficult due to the many unseparable external and internal factors, acting simultaneously. Such measurements are carried out nowadays in frame of a complex geoenvironmental project, in cooperation with the University of West-Hungary (Gribovszki et al. 2004).

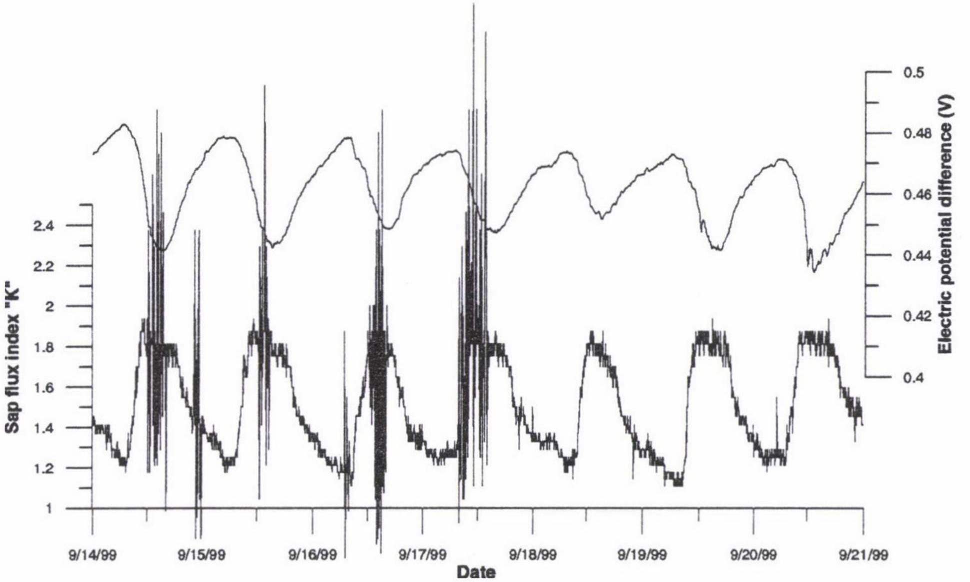

Fig. 2. Variation of electric potential differences (top) and the sap flux index "Kö (bottom) derived from Granier (1987) thermometric method (14–20 September 1999)

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A STUDY ON THE LONG TERM BEHAVIOR OF THE IMPEDANCE TENSOR AT NAGYCENK GEOPHYSICAL OBSERVATORY

I. LEMPERGER, Á. KIS, A. NOVÁK, J. SZENDRŐI,
V. WESZTERGOM, P. BENCZE, L. SZARKA

In the Observatory, a parallel monitoring and registration of geomagnetic and telluric variations has been carried on for more then fifty years. At the first approach we started to compare the spectral energy distribution of the minute mean value horizontal telluric and magnetic components of the last four years. The impedance tensors spectra have been calculated by using one day time intervals for the whole four years. Based on the plane wave assumption we expected some stable behavior of the transfer function. On the contrary certain periods has been found in the time variation of some spectral component. This appeared mostly in the phase of the tensor elements. Dominant spectral peaks have been shown at periods of 93 days and one year related to seasonal variation and the Earth orbiting respectively. So as to extend our examination on longer time interval, we started to digitize the analogue telluric and magnetic records we archived since 1962. We also propose to investigate the deviation of estimated apparent resistivity curves resulting from the above variation of the impedance tensor and to analyse the long term behavior of some magnetotelluric invariants.

Introduction

Magnetotelluric studies provide important contribution to our knowledge of the subsurface structures. Assuming that the resistivity horizontally homogeneous and the EM field variations are also homogenous at the characteristic scale size of the studied area the resistivity distribution can be derived directly from electric and magnetic field observation. The rate of the variation of horizontal electric and magnetic field at each frequency band is namely the impedance function. The apparent resistivity values obtained by this transfer function on different frequencies is related to the electrical resistivity in different depth below the surface. Longer period samples deeper structures. But the values of this transfer function depends on the underground conductivity distribution as well as on the geometry of the source. Thus the well-known magnetotelluric data processing and analysis results systematic error so called source effect. In most cases the plane wave assumption gives good approach (Cagniard 1953, Price 1953), but at high latitudes the auroral electrojet and at low latitudes (the magnetic equator) the equatorial electrojet causes such a distortion. This paper is a brief summary of our works focusing on the possible source effect in mid latitudes especially which can be shown based on the data of the Nagycenk Geophysical Observatory.

Geomagnetic and telluric data

The Széchenyi István Geophysical Obsevatory was founded in 1957. Since the beginning the observatory provides continuous earth current and geomagnetic observations with control of absolute measurements. The potential differences are measured in North-South and East-West directions with electrode spacing of 500 m and recorded with 1 sec and 10 sec sampling rate. Low polarization lead plate electrodes are buried about 2 m below the surface. Resolution of recording is 20000 mV/km/2^{14} bit. Geomagnetic variations are recorded by the ARGOS system which is developed by the Geomagnetism Group of British Geological Survey as a PC based automatic observatory equipped with triaxial fluxgate and proton magnetometer in DD/DI configuration. 10 second samples are used to provide minute values centered on the minute by means of a 7-point cosine filter. The resolution and dynamic range of the triaxial fluxgate and the proton magnetometer is 0.1 nT, ± 500 nT/± 400 nT and 0.1 nT, 10000–90000 nT respectively.

The data recorded by the ARGOS system had been checked on before archiving and in cases of system failure the missing data has been rectified by means of the geomagnetic time serial measured by the backup system (DR02).

The observatory lies on a thick conductive sediment and is surrounded by a National Park preserving the site from far industrial noise and manmade activity. The selected interval is a four year period (2000–2003), which is in the ascending phase of the solar activity just after the minimum.

Data Processing

As mentioned above the geomagnetic data used in this work was free of gaps so no interpolation should be applied. Whereas the telluric time serial was not continuous, in cases of few minute long missing intervals spline interpolation seemed to provide reliable data. Unfortunately in the last days of June, 2000 we had a 2–3 day long system failure which was impossible to bridge accurately. Except that critical interval less than 100 data sample had been interpolated and none of the gaps was longer than 10 samples (100 seconds) in the subinterval processed used for further processing (1024 days from the date 01.04.2000). The telluric data should be presented with 1 minute sample rate for compatibility. This could be accomplished by means of the same type of digital filter which is applied on the raw 10 second sampled geomagnetic data. The recorded minute value time series of H, D, Z geomagnetic elements has been transformed to X, Y and Z components. To obtain the optimal temporal and spectral resolution of the impedance function we performed the processing on two different scaling. In the first approach the geomagnetic and the telluric data had been split into four-day pieces as basic elements of the whole dataset. As the ensuing data processing proved, this time resolution was not satisfactory for many reasons. Therefore the elementary unit of the time series considered to be one day long (1440 minute sample). These time segments have been processed by the method of J Verő (Verő 1972).

The main phases of data process are as follows:

1. *Separation of signals with different periods*

   The task is completed by a convolution type filter truncated with a Hanning window. The filter functions are the following:

   $$F(t) = \frac{1}{2\pi t}\left(\sin\frac{2\pi t}{p_1} - \sin\frac{2\pi t}{p_2}\right)\left(\cos\frac{2\pi t}{T} + 1\right) \quad F(0) = \frac{2d}{p_1} - \frac{2d}{p_1}$$

   for the in-phase component.

   $$G(t) = \frac{1}{2\pi t}\left(\cos\frac{2\pi t}{p_1} - \cos\frac{2\pi t}{p_2}\right)\left(\cos\frac{2\pi t}{T} + 1\right) \quad G(0) = 0$$

   for the out-phase component.

   p_1 – lower period limit, p_2 – upper period limit, d – digitization interval.

   The estimations have been processed on periods with relation quotients of 1.1.

2. *Selection of information that can be used for the determination of the tensor*

   Randomly appearing leakage currents, digitization errors or simply a temporary disappearance of certain period bands may produce a decrease in coherency. Such intervals must be excluded from further processing. The selection is based on coherence analysis between cross-channels. In the further processing the coherence threshold has been set to 0.8.

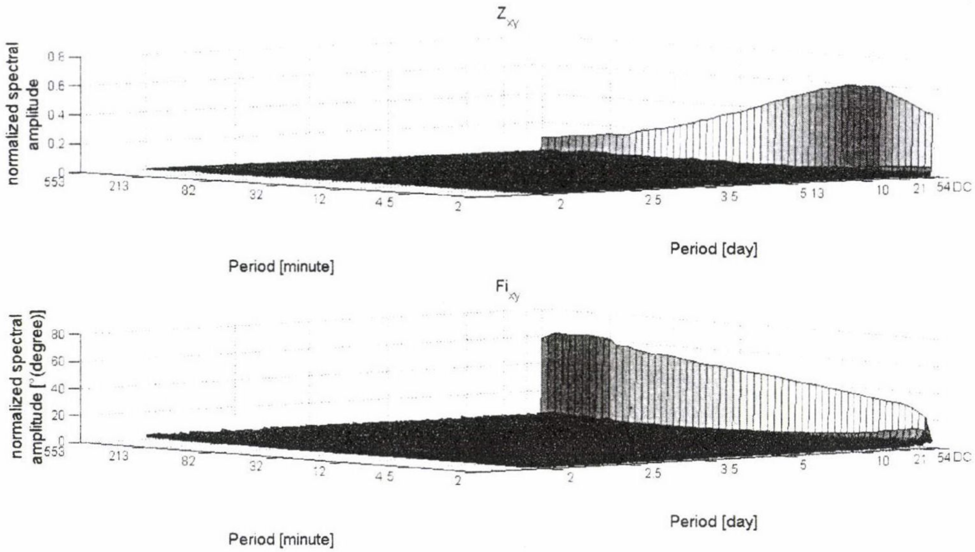

Fig. 1. Spectral components of long term variation of the modulus and phase of Z_{xy} impedance tensor element

3. *Computation of the elements of the impedance tensor*

The detailed description of method used for the computation of the impedance tensor elements can be found by Verő (1972). The formulas are the following:

$$Z_{xx} = \frac{|E_x|}{|H_x|}\frac{\mathrm{Coh}(E_x, H_x) - \mathrm{Coh}(E_x, H_y)\mathrm{Coh}(H_y, H_x)}{1 - |\mathrm{Coh}(H_x, H_y)|^2}$$

$$Z_{xy} = \frac{|E_x|}{|H_y|}\frac{\mathrm{Coh}(E_x, H_y) - \mathrm{Coh}(E_x, H_x)\mathrm{Coh}(H_x, H_y)}{1 - |\mathrm{Coh}(H_x, H_y)|^2}$$

$$Z_{yx} = \frac{|E_y|}{|H_x|}\frac{\mathrm{Coh}(E_y, H_x) - \mathrm{Coh}(E_y, H_y)\mathrm{Coh}(H_y, H_x)}{1 - |\mathrm{Coh}(H_x, H_y)|^2}$$

$$Z_{yy} = \frac{|E_y|}{|H_y|}\frac{\mathrm{Coh}(E_y, H_y) - \mathrm{Coh}(E_y, H_x)\mathrm{Coh}(H_x, H_y)}{1 - |\mathrm{Coh}(H_x, H_y)|^2}$$

4. *Spectral analysis of impedance elements*

The long term variation of each impedance element at each frequency has been examined through Fourier-decomposition. The transformation has been carried out on both modulus and phase of the elements. The results of Z_{xy} element are displayed on Fig. 1.

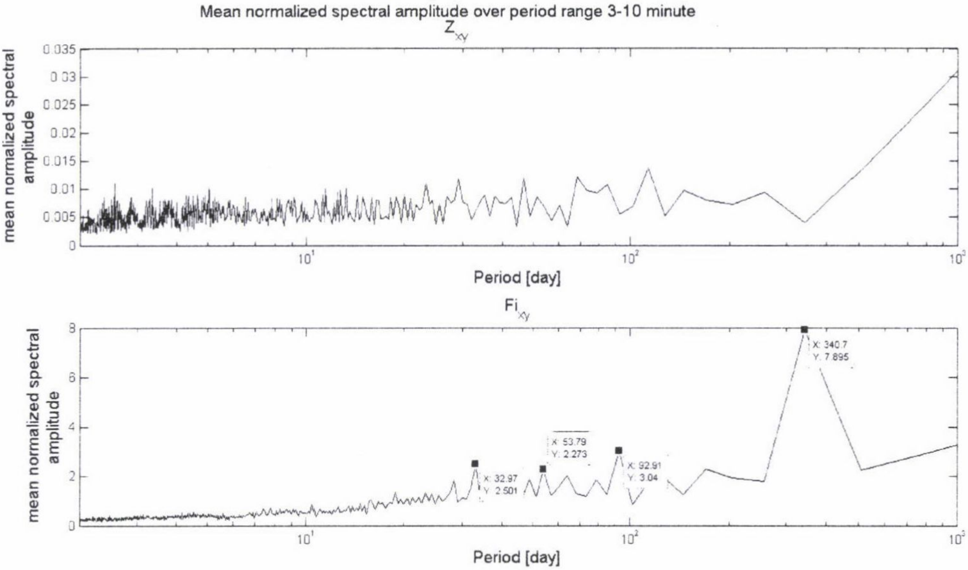

Fig. 2. Mean spectral amplitude of the Z_{xy} and φxy variation in the range 3–10 minutes

On Fig. 1 no significant Fourier component can be recognised beside the DC in the whole periodrange of 2 min–8 hours. However, the detailed examination of the behavior of the period range 3–10 minutes results some peaks in the long term spectra, fee Fig. 2 Some of them can be associated with well known processes like the annual (340 days), the seasonal (93 days) and the 2nd harmonic of the Carrington period (54 days). The clear Carrington period doesnt produce significant peak and the Lunar cycle doesnt appear either. A 33 day component also appears which can hardly be explained, although the same spectral component has been recognized in the statistical analysis of the CME ejection of the Northern hemisphere of the Sun. (The 340 day long component can be identified as annual variation, the 15 day difference is an artifact because the applied Fourier-window was set to 1024 days, less then 3 years.) Note that no such components can be recognized on the spectra of $|Z_{xy}|$.

To clarify how the peaks come, spectral analysis of H and E field polarization has been carried out, see Fig. 3, Fig. 4.

Note that the peaks of the spectral decomposition of φxy can be obtained as the peaks that appear on the polarization pattern of the H but is not present in the E polarization variation, namely the annual and seasonal components. Detailed

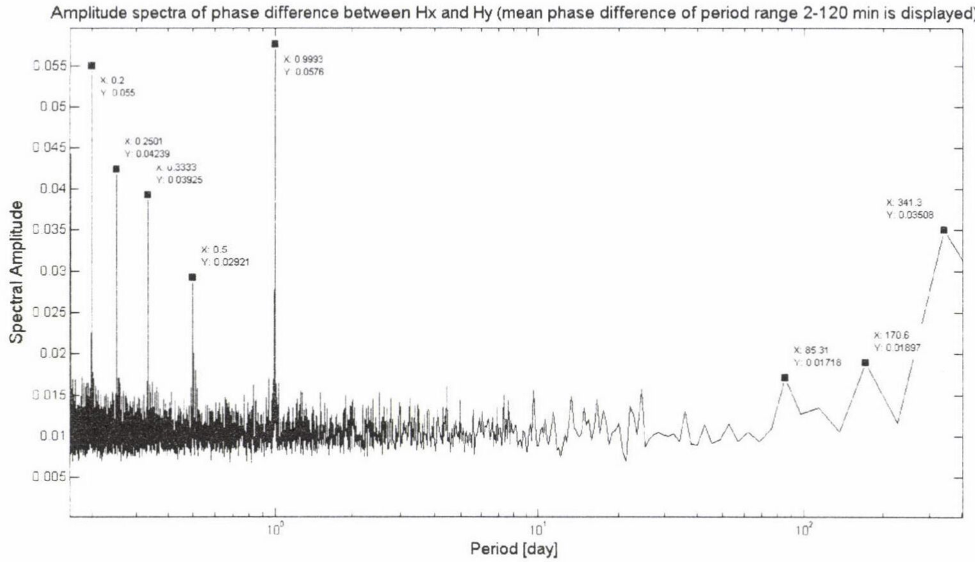

Fig. 3. Periodicity in the polarization pattern of horizontal geomagnetic field

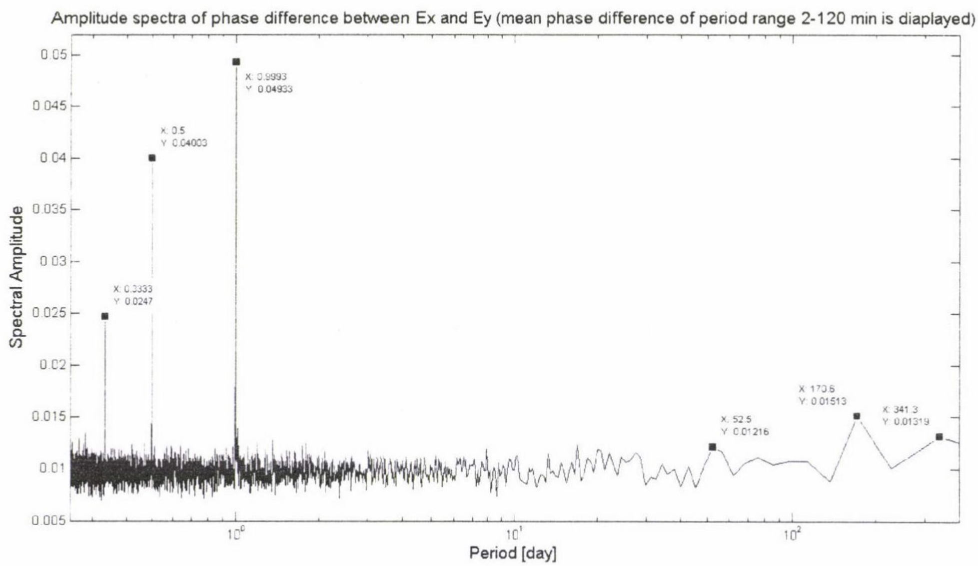

Fig. 4. Periodicity in the polarization pattern of the telluric field

analysis of long term periodicities has been carried out at each frequency which φxy has been calculated, but no subrange shows different behavior then the mean shown above. (The figures of recognized periodicities dont match on Fig. 2 and

Fig. 3 because the applied Fourier window is different.) Further examination of the long term behavior of the impedance tensor is in progress to clarify the physical processes and the coupling between the well known periods and the long term behavior of the impedance tensor. Detailed analysis of Z on more extended time interval is also proposed. The digitization of earlier analogue registrations is already set up.

Acknowledgement

This work is supported by the Hungarian Scientific Research Fund NI 61013.

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LONG-TERM CHANGES IN ATMOSPHERIC ELECTRICITY OBSERVED AT EUROPEAN STATIONS DURING SEVERAL DECADES IN THE LAST CENTURY

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Based on observations carried out at several stations in Europe, long-term changes have been reported for different atmospheric electrical parameters. Data series analysed have covered different periods ranging from the beginning of the twentieth century till the present. The potential gradient (PG) is the most commonly available quantity. A long-term PG decline seems apparent both in western Europe, e.g. UK (Eskdalemuir), Portugal (Serra do Pilar) and in the Middle European area, e.g. Hungary (Nagycenk). These changes were detected during different periods of the last century at the different sites, which are summarised in terms of the suitability of the data for global circuit studies. Records recently recovered also indicate a PG decline in the Russian area (Irkutsk), distant from stations investigated previously. In addition to the PG, air-Earth current density has also shown a decreasing trend at two distant stations in the 1970s, at Kew and Athens. The ionospheric potential is important for studying the atmospheric electrical global circuit. Balloon soundings of the ionospheric potential are consistent with the long term surface changes observed in the earlier period (up till 1971).

Keywords: meteorology and atmospheric dynamics (atmospheric electricity); analysis of atmospheric electrical data on a long time scale

1. Introduction

Early results on long-term changes in the atmospheric electrical potential gradient (PG) were derived from measurements carried out at Davos, Switzerland, at the beginning of the last century (1909/10, 1913, and 1923/26). The PG decline detected there was attributed to a local effect, arising from the decrease of the mean aerosol content in Davos valley causing, in turn, an increased local air conductivity (Israël 1973).

Subsequently the PG data for two stations in the UK was investigated: Eskdalemuir, Scotland (55°19' N, 30°12' W) and Lerwick, Shetland, (60°08' N, 1°11' W), for periods between 1911 and 1981 (Harrison 2002). This work also presented distinct long-term decreases in PG. In explaining these findings, a connection was made between the decrease of galactic cosmic rays (GCR) found in the twentieth century, and the reduction in the ionospheric potential (V_I). The V_I change could explain the decrease of surface PG. Data obtained at another station in Europe, at Nagycenk in Hungary (47°38' N, 16°43' E), also hinted at a quite continuous PG decline (Märcz et al. 1997). The Nagycenk PG data have covered more than four decades in the second half of the twentieth century and continue.

2. Recent results on long-term changes in atmospheric electrical parameters

These first studies were extended to consider the long-term decline in atmospheric electricity at two distant stations simultaneously (Märcz and Harrison 2003). Despite the disturbing influence of nuclear weapon testing on the PG measurements at Eskdalemuir and a certain environmental effect caused by growing trees at Nagycenk, the PG data still showed small continued decreases at both stations, even with the considerable distance between them. In addition to the PG, Märcz and Harrison (2003) analysed vertical air-Earth current density data obtained at Kew in the UK (51°28' N, 0°19' W). A decline also appeared in this atmospheric electrical parameter which is known to be less strongly influenced by local surface effects (see Fig. 1).

In further work, Märcz and Harrison (2005) investigated the behaviour of atmospheric electrical parameters determined at two further stations in Europe. Both dawn and evening PG data of Serra do Pilar (Portugal, 41°08' N, 8°36' W) show a decreasing trend during the 1960s. At Athens (Greece, 37°58' N, 23°43' E) PG, air-Earth current density, positive air conductivity data (continuously from the mid-sixties to 1977), as well as positive small and large ion number concentrations are available. Consequently more complex analyses could be performed. As regards the PG, an increasing trend at Athens was attributed to the decrease of air conductivity in an increasingly polluted urban area. This was confirmed in the number concentrations of small and large ions. The dawn data of the air-Earth current density revealed a decreasing trend at Athens, during the 1960s and 1970s. Moreover, ionospheric potential soundings, carried out in Germany during the beginning of the same period, also hinted at a decrease of the V_I values. Thus, it appears that

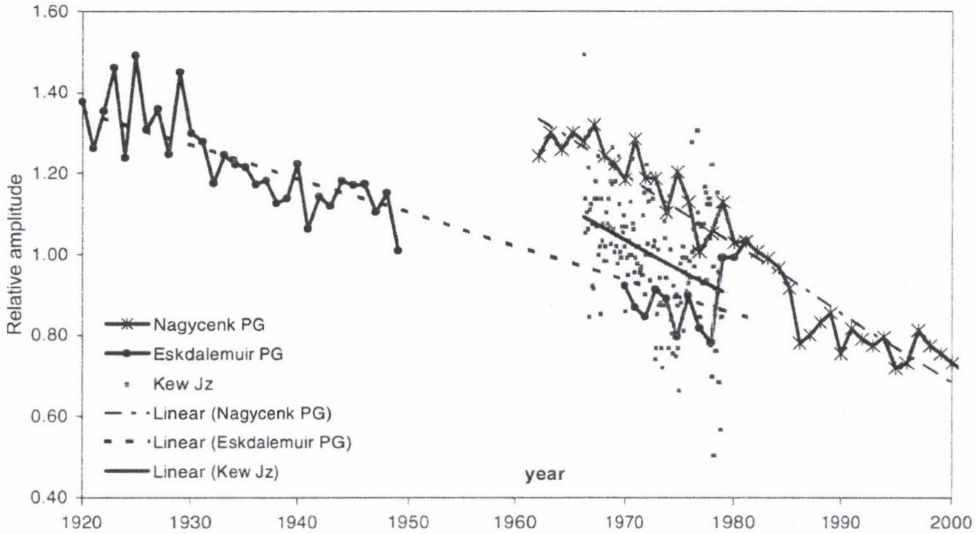

Fig. 1. Relative changes in PG at Eskdalemuir (circles) and Nagycenk (stars), using the mean values of PG found at Eskdalemuir from 1920 to 1981 (190 V/m) and Nagycenk from 1962 to 2001 (52 V/m) for normalisation. (The period of weapon tests, between 1950 and 1970, has been omitted from the Eskdalemuir data for clarity.) Relative changes are also shown in the monthly air Earth current J_z measurement made at Kew (London) from 1966 to 1978 (squares), which had a mean value of 1.4 pA/m^2

the air-Earth current density measured at the surface responds to changes in the global circuit.

Märcz and Harrison (2005) tabulated the varied results available for summarizing atmospheric electricity changes in Europe during the last century. The work presented a table considering the priority which should be given to the disparate observations. Firstly, ionosopheric potential is the principal quantity for studying the atmospheric electrical global circuit, followed by the air-Earth current density. In the case of the potential gradient, the quality of air at measurement site was taken into account by ranking it as oceanic air, mountain air, continental rural air and, finally, urban air. For detecting global effects in the PG, the best possibility would be in oceanic air while the worst conditions are connected with urban air.

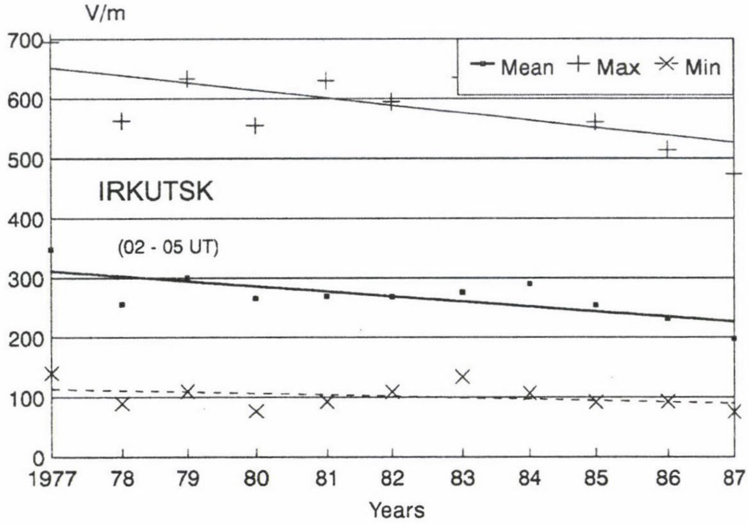

Fig. 2. Changes in dawn values of PG (based on data from 0200 to 0500 UT) at Irkutsk station (Russia) between 1977 and 1987 (see also text)

3. Signatures of long-term changes in atmospheric electrical potential gradient at a surface station in Russia

Atmospheric electrical measurements were carried out at some stations in Russia, in the twentieth century (Data in Publications of the USSR State Committee for Hydrometeorology). As mentioned previously, data obtained at Serra do Pilar covered the period of the sixties, and those at Athens were continuously available from 1965 to 1977. For Irkutsk station (52°16' N, 104° E) in Russia, unbroken potential gradient series are available between 1977 and 1987. Thus, the behaviour of surface PG measurements may be investigated into an additional decade. Moreover, the station is situated in a rather different area from the locations previously analysed, in the western part of Asia, bordering on the European area.

Following the approach of Märcz and Harrison (2005), yearly means of the Irkutsk PG were determined for dawn hours (between 0200 and 0500 UT). In order to yield a more complete perspective, two additional data series have also been derived: dawn maxima and minima of each year, based on the three highest and the three lowest PG values appearing in individual months. The Irkutsk results are presented in Fig. 2, in which the yearly mean values of PG at dawn are seen to show a distinct decreasing trend. The PG drops from an initial value around 350 V/m in 1977 to about 200 V/m in 1987.

It seems therefore that a PG decline is also present at Irkutsk, as for the PG at several other surface stations (Eskdalemuir, Nagycenk, Serra do Pilar) analysed previously. Despite the larger fluctuations appearing in the maximum values derived for individual years, these results also confirm the decreasing trend revealed by the yearly means. In the case of dawn PG minima no clear tendency can be seen, however in general long-term changes in Irkutsk are not dissimilar to those detected elsewhere.

For yielding a general view and making possible appropriate comparisons, Table I has been compiled which includes results from previous work and those from this present paper. As well as the findings for Irkutsk, it summarizes the result derived for different atmospheric electrical parameters on long time-scales at several European stations.

4. Summary

As mentioned previously, ionospheric potential and air-Earth current density would be the most suitable measurements for tracing long-term changes in atmospheric electricity. However such long-term measurements spanning the twentieth century have not been made. The PG measured at the surface is the least preferable quantity, but provides the most abundant source of data for studies of the global circuit. The PG is affected by local influences, especially at continental surface stations. Nevertheless PG data are generally available for many more stations and for longer periods than those derived for air-Earth current density or the ionospheric potential. Consequently it is necessary to include PG data in investigations aimed at detection of long-term changes possibly due to global effects, even if the separation of local and global effects precludes a straightforward interpretation of either.

Table I. Summary of 20th Century atmospheric electricity changes

Station	Parameter	Situation	Season	Selection method	Samples	Start	Finish	Midpoint	Annual change	r (lin. fit)	Reference
Weissenau	V_I	Balloon sounding		all	293	1959	1971	1965	−3.4% ±0.5%	0.44	Märcz and Harrison (2005)
Weissenau	V_I	Balloon sounding		Sounding Class 1,2,3	91	1965	1971	1968	−2.7% ±1.0%	0.26	Märcz and Harrison (2005)
Kew	J_z	Continental (urban)	annual	15UT	13	1966	1978	1972	−1.4%		Märcz and Harrison (2003)
Athens	J_z	Continental (urban)	annual	dawn	10	1968	1977	1972.5	−3.2% ±2.0%	0.50	Märcz and Harrison (2005)
Carnegie and *Meteor* cruises	PG	Atlantic oceanic air	February-March-April	Fair Weather data, seasonal mean	2	1929	1968	1948.5	−0.6%		Harrison (2004a)
Wank	PG	Mountain air	annual	Carnegie cycle days	13	1972	1984	1978	−1.2%		Harrison (2004b)
Eskdalemuir	PG	Continental (rural)	annual	All 0a days	31	1920	1950	1935	−0.7%		Harrison (2003)
Nagycenk	PG	Continental (rural)	annual	dawn	40	1962	2001	1981.5	−1.4%		Märcz and Harrison (2003)
Serra do Pilar	PG	Continental (rural)		dawn	11	1960	1971	1965.5	−6.5% ±1.5%	0.83	Märcz and Harrison (2005)
Serra do Pilar	PG	Continental (rural)		evening	11	1960	1971	1965.5	−2.1% ±1.2%	0.52	Märcz and Harrison (2005)
Kew	PG	ontinental (urban)	July	all	53	1898	1950	1924	−0.3%		Harrison and Aplin (2002)
Irkutsk	PG	Continental (urban)	annual	all	11	1977	1987	1982	−3.1% ±2.0%	0.73	*Present work*

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ON THE DYNAMICS OF SEASONAL REDISTRIBUTION OF GLOBAL LIGHTNING AS SHOWN BY SCHUMANN RESONANCE OBSERVATIONS IN THE SZÉCHENYI ISTVÁN GEOPHYSICAL OBSERVATORY AT NAGYCENK

G. SÁTORI

"Single station - global sense" idea is demonstrated in this study. The results presented here are valid in global sense and they are based on Schumann resonance observations in the Széchenyi István Geophysical Observatory at Nagycenk, Hungary. The daily Schumann resonance frequency (SRF) patterns are mainly determined by the lightning source-observer configuration. This configuration changes during the north-south seasonal lightning migration, consequently the daily SRF patterns vary, too. Four basic types of daily SRF patterns have been distinguished corresponding to the four seasons observed for each SR mode at Nagycenk, Hungary. Cross-correlation analysis has been used between the monthly means of daily SRF patterns in two adjacent months to identify the seasons. The number of months with daily SRF patterns characteristic for a season was different. Similar daily SRF patterns have been observed during five months (Nov–Dec–Jan–Feb–March) in the Southern hemisphere summer, in two months in both transition (spring and fall) seasons and during three months (June–July–August) in the Northern hemisphere summer. The same time sequences (four seasons with different lengths) can be recognized in the meridional lightning distributions observed by OTD (Optical Transient Detector) and LIS (Lightning Imagine Sensor) as disclosed by the seasonal distributions of the daily SRF patterns.

The ratio of land area to ocean area is smaller in the Southern hemisphere than in the Northern hemisphere. The oceanic surface thermodynamics can influence the tropospheric thermal properties of the Southern hemisphere lands embedded in the oceans. The large oceanic thermal inertia seems to be manifested in the dynamics (speed) of the north-south lightning migration identified by the long lasting southern position of global lightning in the Southern hemisphere summer and by the time lag of the northward lightning migration as compared to the "solar marsh" in spring in spite of the fact that lightning is first of all a land related phenomenon. The spring-fall asymmetry of the migration speed is attributed to the different thermodynamical properties of land and ocean.

Schumann Resonance Frequency (SRF)

The diurnal pattern of SRF is highly determined by the angular distance between the lightning source and the observer and characteristic for each SR mode and field component (Sentman 1995, Sátori 1996, Nickolaenko et al. 1998, Musthak 1999). The diurnal pattern of SRF is preserved if the source-observer distance is stable and it changes if the source moves with respect to the observer. In this way the time history of the north-south migration can be followed by the variations of SRF.

SRF data have been available in hourly time resolution from May 1993 up to the present at Nagycenk, Hungary. At first, the monthly means of the diurnal patterns of SRF have been computed. Collection of the SRF patterns into groups has been done by cross-correlation analysis. SRF patterns have got to a group depending on the values of the correlation coefficients in two adjacent months. Very high correlation coefficients (> 0.95) presented themselves in summer months of both hemispheres but with different number of months. The rest of the SRF patterns with lower correlation coefficients has got to the group of the transition (spring or fall) seasons. Just the sudden decrease of the correlation coefficients due to changing SRF patterns indicates the quick variations in the source-observer geometry in these transition seasons. Four characteristic shapes of mean daily SRF were identified corresponding to the four seasons separately for the 1st and 2nd SR modes as shown in Fig. 1a,b.

OTD/LIS Lightning Observations

OTD/LIS lightning data have been used (Christian et al. 2003) to reveal the results exhibited by SRF on the dynamics of the north-south migration of lightning. Meridional lightning distributions have been determined in world-wide sense (Fig. 2a) and then for the longitudinal range of Americas (Fig. 2b), Africa/Europe (Fig. 2c), as well as, the Maritime Continent /Asia (Fig. 2d) in every month. The same correlation analysis has been done for the OTD/LIS data as in case of SRF. The four seasons were identified by the similar meridional lightning distributions. The different duration of the Northern and Southern hemisphere summers is again striking. The meridional lightning distribution exhibits rather stable position int he Southern hemisphere during five months (Nov–Dec–Jan–Feb–March) both in global sense and the different longitudinal ranges with exception of the Maritime Continent/Asia where it is only four months while the lightning distribution is only

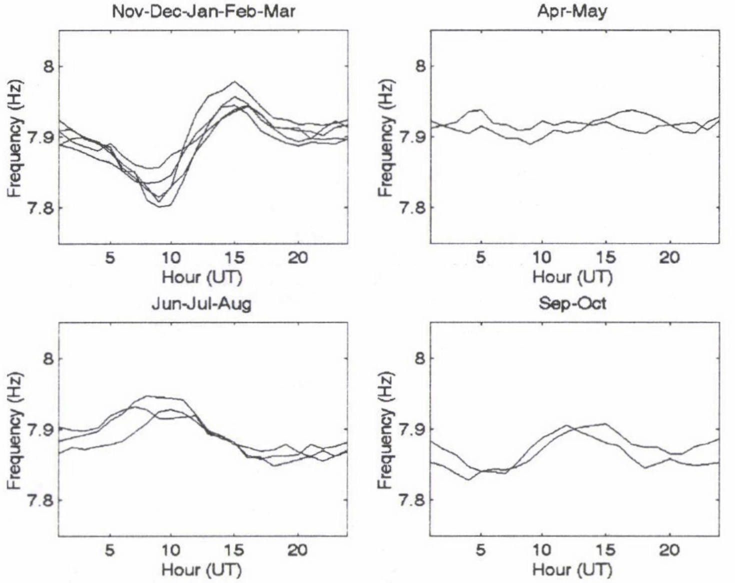

Fig. 1a. Monthly means of the diurnal frequency patterns in four seasons in case of the 1st SR mode as observed int he Széchenyi István Geophyiscal Observatory at Nagycenk

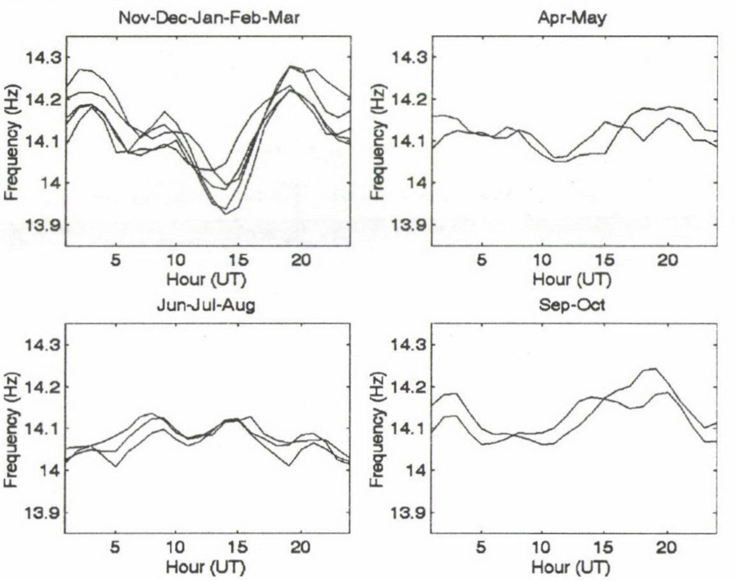

Fig. 1b. Monthly means of the diurnal frequency patterns in four seasons in case of the 2nd SR mode as observed int he Széchenyi István Geophyiscal Observatory at Nagycenk

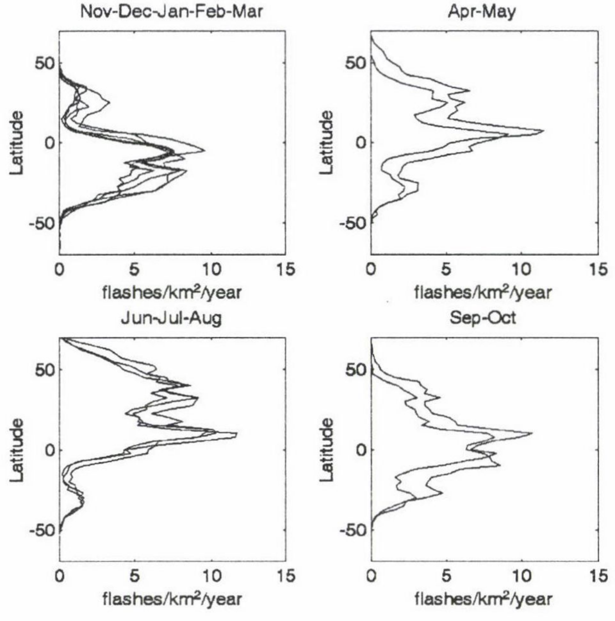

Fig. 2a. Global meridional lightning distributions observed by OTD/LIS satellites in the four seasons grouped on the base of the result of the cross-correlation analysis

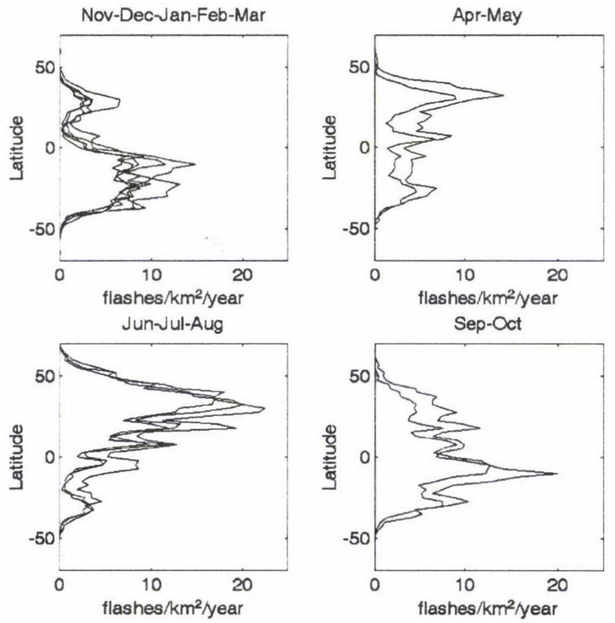

Fig. 2b. Meridional lightning distributions in Americas observed by OTD/LIS satellites in the four seasons grouped on the base of the result of the cross-correlation analysis

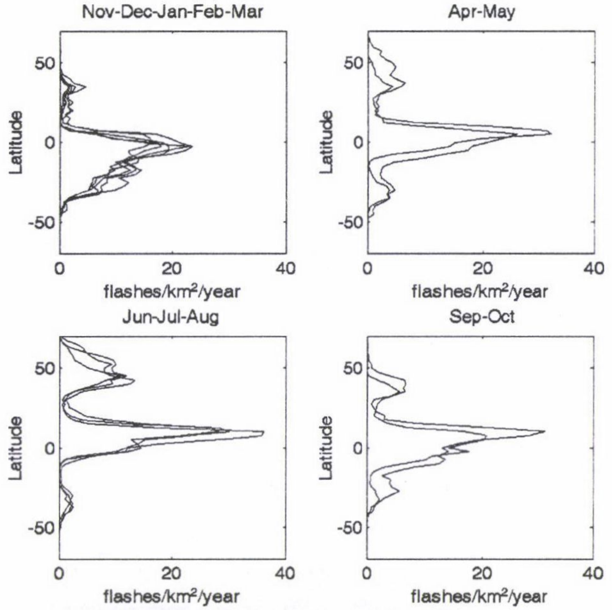

Fig. 2c. Meridional lightning distributions in Africa/Europe observed by OTD/LIS satellites in the four seasons grouped on the base of the result of the cross-correlation analysis

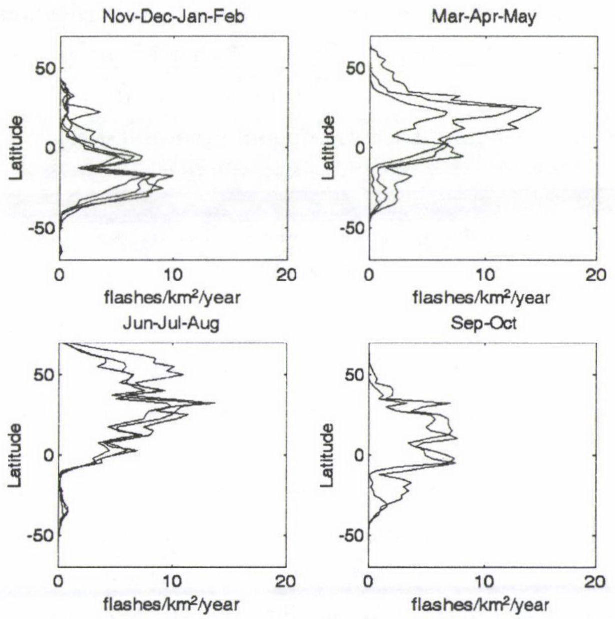

Fig. 2d. Meridional lightning distributions in Asia/Maritime Continent observed by OTD/LIS satellites in the four seasons grouped on the base of the result of the cross-correlation analysis

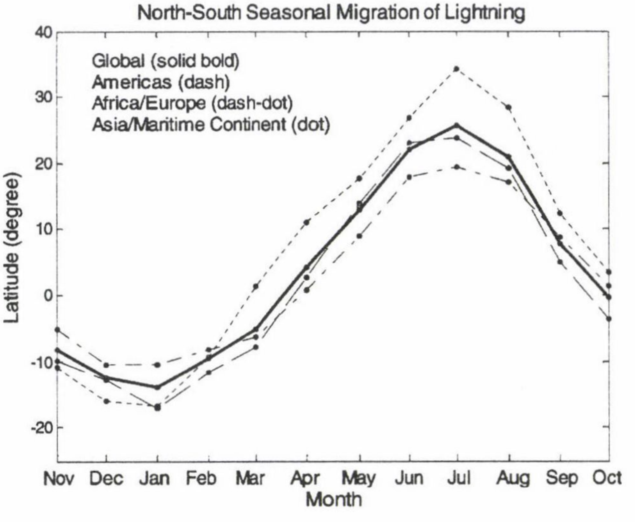

Fig. 3. The latitudinal positions indicate a longish dwell time of lightning in the Southern hemisphere summer, especially in America and Africa

stable for three months in the Northern hemisphere summer bot hon global sense and in the three main land regions.

The latitude of the center of the meridional lightning distribution was computed in every month in case of global lightning and that of the three main lightning regions as shown in Fig. 3. The latitudinal range covered by the annual lightning migration is the narrowest for Africa/Europe and the widest for the Asia/Maritime Continent.

Discussion

The global lightning doesn't follow the Sun in the Northern hemisphere winter months of the year during its northward migration from the southern latitudes to the northern ones (Fig. 4.). There is about one month time lag with respect to the "solar march" in spite of the fact that lightning is dominantly a land related temperature dependent phenomenon. The time lag rapidly disappears between August and September when the migration speed is the highest backward in south direction. This behavior of the global lightning has been recognized by Schumann resonance frequencies and revealed by satellite (OTD/LIS) lightning observations.

Figure 5 shows annual surface air temperature variations for some land stations in both hemispheres and in the South Pacific. The temperature profiles of tropical

South Pacific and Southern hemisphere lands exhibit common characters with high and rather stable temperatures from November to March while the temperature maximum is confined only for three months (June–July–August) in the Northern hemisphere lands.

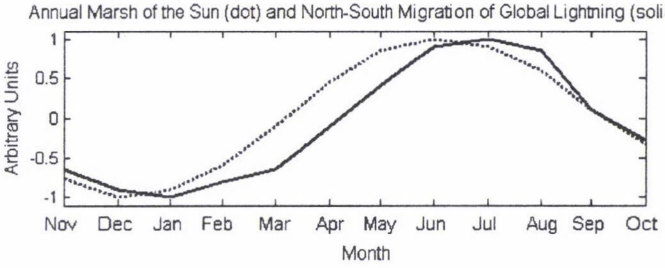

Fig. 4. Annual marsh of the Sun and the world lightning centers

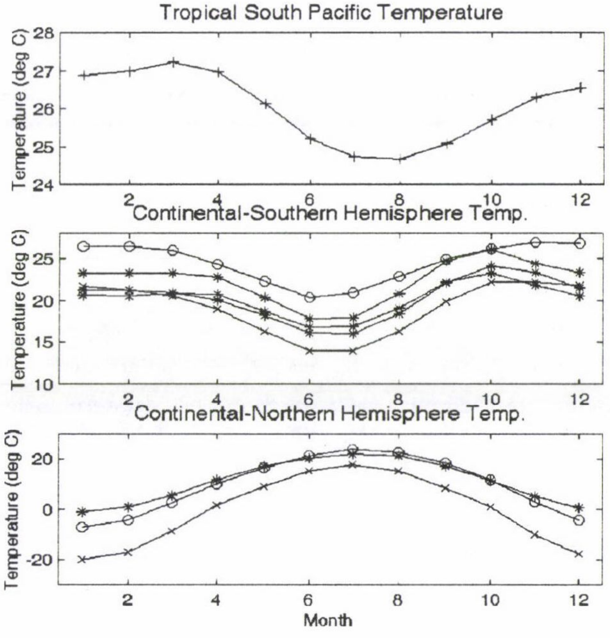

Fig. 5. Annual surface air temperature variations in the South Pacific and for some land stations in both hemispheres

Conclusion

The oceanic surface thermodynamics can influence the tropospheric thermal properties of the Southern hemisphere lands embedded in the oceans. The large oceanic thermal inertia seems to be manifested in the dynamics (speed) of the north-south lightning migration identified by the long lasting southern position of global lightning in the Southern hemisphere summer and by the time lag of the northward lightning migration in spring in spite of the fact that lightning is first of all a land related phenomenon. The spring-fall asymmetry of the migration speed is attributed to the different thermodynamical properties of land and ocean.

Acknowledgement

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Long-term variations in pulsation activity and their relationship to solar wind velocity, geomagnetic activity, and $F2$ region electron density

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Abstract

Significant 11-year, annual, and semiannual variations of the total pulsation activity at the mid-latitude station Nagycenk are reported and compared with solar wind velocity, geomagnetic activity, and $F2$ region electron density. Monthly average data from 1957 through 1989 were analyzed using the discrete convolution filtering technique. The 11-year variation of the total pulsation activity is closely related to the 11-year solar wind cycle supposedly through solar wind controlled pulsations. Its annual variation reflects the combination of two effects: one is the annual variation of the solar wind due to interstellar wind, and the other is some damping mechanism related to $F2$ region electron density. The nature of this ionospheric damping has not been clarified yet. The semiannual variation of the total pulsation activity, however, seems to be controlled mainly by the geomagnetic activity. Occurrence frequency and amplitude data for pulsations in 12 period bands ranging from 1 s up to 10 min were also involved in order to clarify the contribution of different types of pulsations to the total pulsation activity. It was found that the total pulsation activity refers mainly to Pc3 pulsations and, that the pulsations with a period of 20–25 s, which correspond to the eigenperiod of field line resonance at $L < 2$, have the strongest correlation with solar wind velocity.

Index Terms: 2752 Magnetospheric Physics: MHD waves and instabilities; 2736 Magnetospheric Physics: Magnetosphere-ionosphere interactions; 2784 Magnetospheric Physics: Solar wind-magnetosphere interactions.

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III. REMEMBERINGS

MY RESEARCH (DEVELOPMENTS) CONNECTED TO THE OBSERVATORY

A. ÁDÁM

1. An appropriate place is looking for the electromagnetic observatory

Professor K. Kántás, the director of the Geophysical Research Laboratory of the Hungarian Academy of Sciences in Sopron and head of the Department for Physics and Geophysics at the Technical University also in Sopron planned to built up an electromagnetic (EM) observatory near Sopron to participate at the joint research works of the in-coming International Geophysical Year in 1957. It was our task (Antal Ádám, Pál Bencze, Ákos Wallner) in 1955 to find an electromagnetically noise free, and geologically quiet place for the observatory. Professor Kántás was thinking about the nearby area of the Hungarian-Austrian border in the Sopron Mountains where nobody could disturb the measurements being an area severely guarded by the military. We selected the surrounding of the Muck peak and started with magnetic measurements with Schmidt-type magnetometers. Meantime, we have to ask the frontier guards to check us with their (iron) arms at a distance far away enough, not disturbing the measuring results. At the second step a horizontal loop of great surface has been laid out to measure the time variations of the vertical magnetic field to detect the electric inhomogeneities of the subsoil. (It was a very hard work to use a lot of cable drums for building up a great loop.) From geophysical point-of-view this area could satisfy our requirement, nevertheless, it has to be rejected being closely guarded border region and therefore entering it always needed special permission from the frontier guards.

To eliminate these inconveniences Pál Bencze continued to search for a more appropriate place and he found it at the southern shore of the Lake Fertő in a calmly ascending hill (terrace) near the linden-tree alley of the famous Széchenyi family. Later P. Bencze looked after the observatory building here in 1956–1957.

The telluric recording started in August 1957 according to the programme of International Geophysical Year.

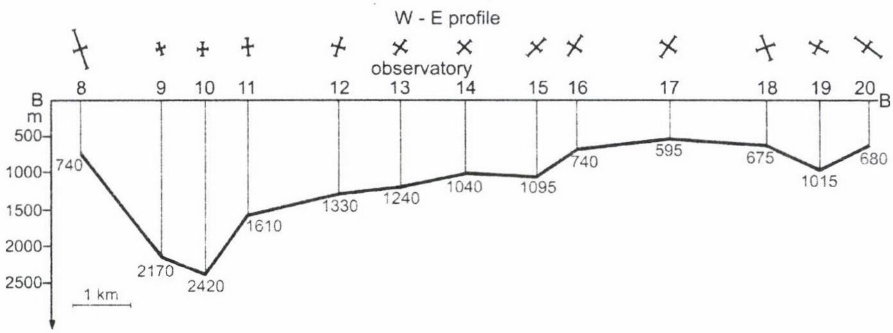

Fig. 1. Basement depth (or thickness of the sediment) deduced from telluric measurements along a profile south of Lake Fertő (Wallner 1977)

2. The geological and geophysical structure of the observatory as it has been described – among others – by Ádám et al. (2000)

A short summary is cited here from this paper: The crystalline schists of Sopron Mountains are thrust into a depth of about 2000 m along NE-SW striking fault towards SE from Sopron in the line Balf-Kópháza-Harka. The deep range beginning here is closed toward E by a high corresponding to the Mihályi gravitational maximum. The crystalline basement has an amphitheatre-like structure open towards SW in the vicinity of the village Nagycenk. The observatory lies on the northern slope of this local deep. The thickness of sediments is here about 1500 m.

This structure was originally determined by gravity and reflection seismics (report has been given by Szénás, 1957), later by detailed telluric (Wallner 1977) and magnetotelluric measurements (e.g. Ádám 1963, Ádám and Verő 1967). (An E-W telluric profile is shown in Fig. 1 (Wallner 1977).) (See later the magnetotelluric results.)

3. Early instrumentation of the observatory and start of the pulsation research

The first recording instrument of the observatory was the T9 type telluric recorder (Fig. 2) (Ádám 1958, Ádám and Verő 1958) manufactured in the section of the Geophysical Instrument Factory (Budapest) allocated to our Laboratory to provide those 60 instruments of our design ordered by the Chinese Geological Ministry Peking after a successful exhibition and field test telluric measurements in China in late 1955 and early 1956.

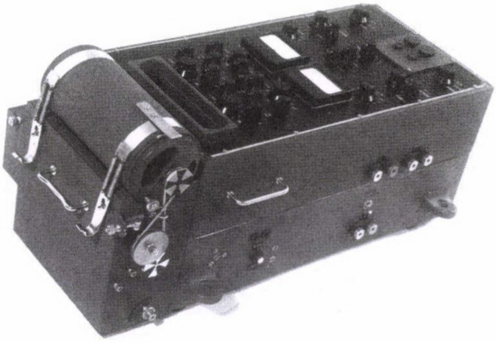

Fig. 2. Photo of the T9 telluric recorder (Ádám 1958)

During my stay in Peking Prof. Kántás initiated a synchronous telluric measurement between Peking and Sopron between January 9 and 14. I measured with Ernő Takács in the Peking Geomagnetic Observatory. My colleagues in the Laboratory and in the Geophysical Department of the University did it near Sopron. By comparing of the recordings we stated that the day-type Pc pulsations have a very large dimension (in our case the longitude difference between the measuring sites was almost 100°). These results were published by Prof. Kántás (1956) in a Chinese geophysical journal, and we also referred them e.g. by Ádám et al. (1966). A figure from this paper (Fig. 3) shows the parallel variation of the total telluric field and their correlation. — This experiment can be taken as the beginning of the long research of the electromagnetic pulsations in our institute.

4. Study of the inhomogeneities of the basement structure of the Pannonian Basin by telluric currents using the observatory as the basic station

The lot of telluric instruments manufactured in the Sopron section of the Geophysical Instrument Factory (Budapest) had to be tested by field measurements. We used this occasion and/or possibility to carry out synchronous measurements with these instruments in different parts of the country. In addition we collected the telluric recordings made by partner institutions/companies (e.g. ELGI, OKGT, MU) in their base stations in countryside. All data obtained by this way have been referred to those of our Nagycenk observatory where the continuous recording of the telluric field ran since August 1957.

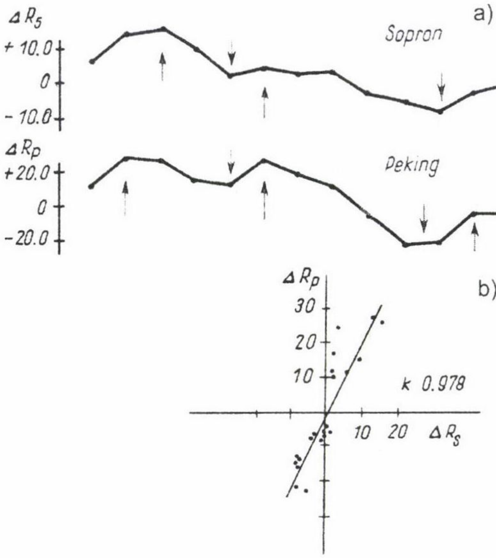

Fig. 3. a) Time variations of the total telluric field measurement simultaneously in Peking and Sopron in January 1956. b) The relation between the above values (Ádám et al. 1966)

The data processing of the recordings has been by determination of the telluric absolute ellipses (using Verő's gradient method (1960)) after separation corresponding to dominant period ranges of the telluric field. We got by this technique relative telluric frequency sounding curves for more than 60 stations in the country. These enabled us to construct different telluric maps reflecting the deep structure of the Pannonian Basin as follows:

- The first telluric isoarea map of the whole country at 25 s showing the main features of the basement of the Pannonian Basin (Fig. 4). This was the base of early tectonic speculations of V. Scheffer on the Vardar threshold in the Pannonian Basin.

- Relative frequency sounding maps constructed from the different segments of the curves corresponding to period differences, e.g. 10–25 s, 25–100 s, 100–500 s, 500–1000 s. The map of 25–100 s clearly shows with the negative values the – later very detailed studied – Transdanubian Conductivity Anomaly (Fig. 5).

About this results we published papers in Hungarian and in German, too, especially in the *Freiberger Forschungshefte* (Ádám and Verő 1964, 1965, 1967).

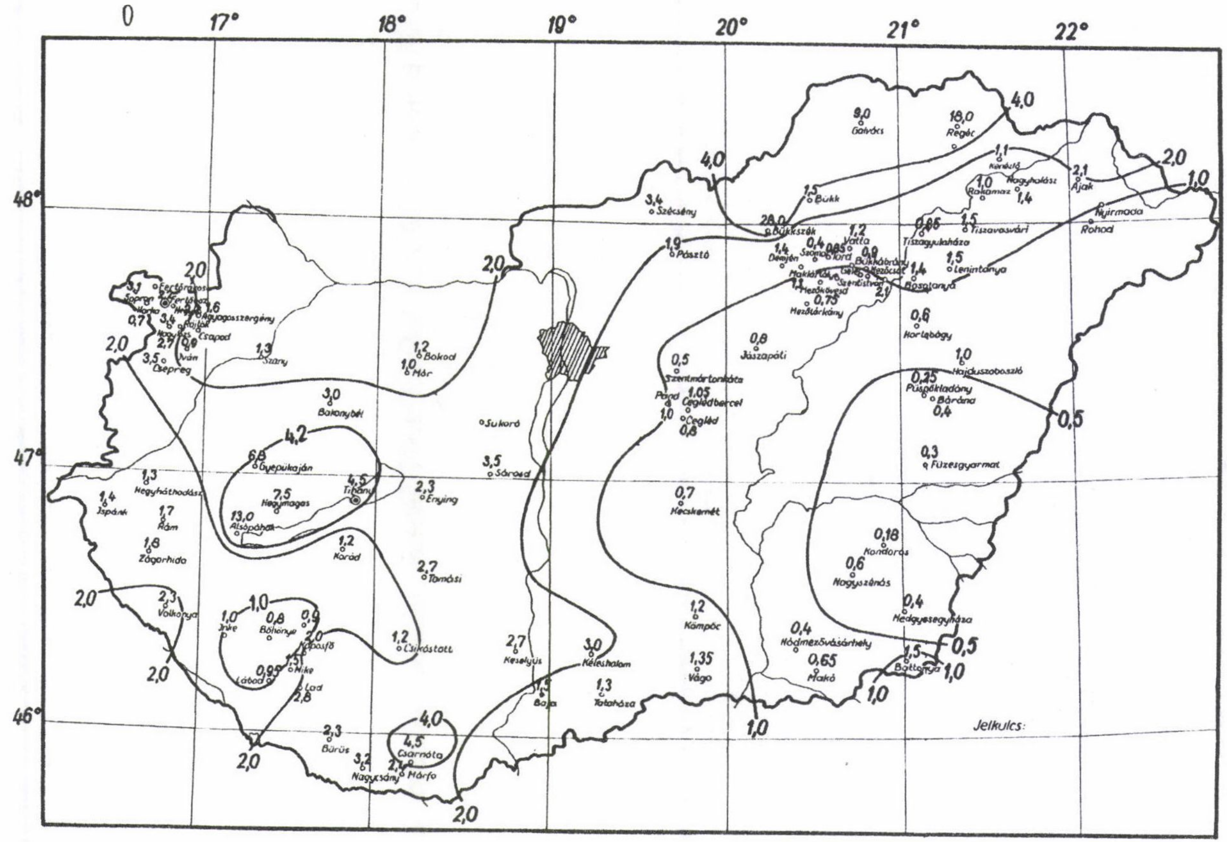

Fig. 4. Telluric isoarea map of Hungary determined with 25 s variations (Ádám and Verő 1967)

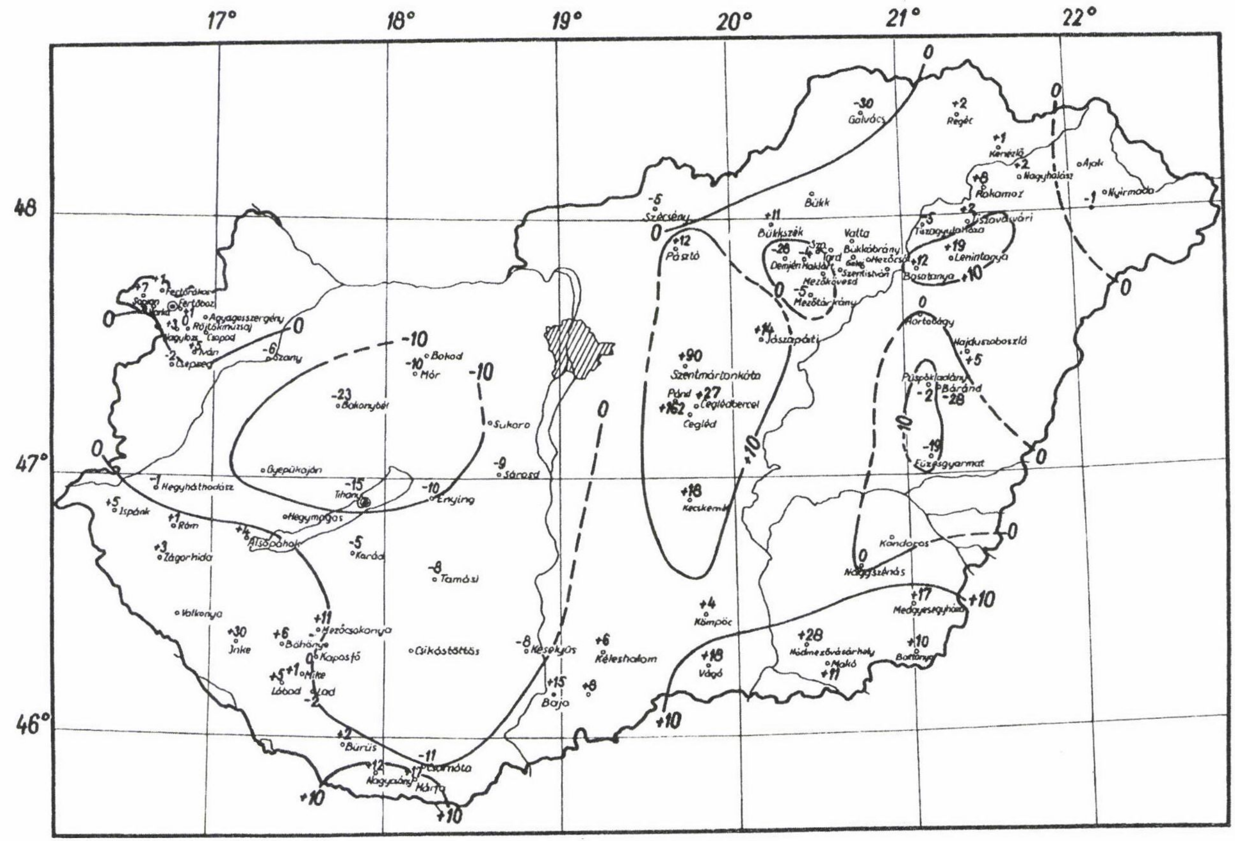

Fig. 5. Map t_{25-100} of Hungary on the basis of relative telluric frequency soundings (Ádám and Verő 1967)

5. Instrument developments based on the experiments got in the observatory

The first results we obtained by the magnetotelluric (MT) method and the automatization of the telluric measurements required new instrument developments. First the T9 telluric recorder —manufactured in great series in Sopron — was updated. More simple and reliable switches and film/paper rolling mechanism were used in the new T14 instrument which also got a more attractive designed form. This new recorder served for a long time in our observatory for the so-called "quick recording of pulsations". This recorder served in the partner institutions not only for the telluric/magnetotelluric measurements, but for the very long range geoelectric soundings (in some cases AB > 10 km) too, having a very special isolation system between the current and high voltage circuits in it.

To determine the telluric absolute ellipses (Ádám et al. 1962) in a more simple way we designed a so-called "total-variation counter" (Fig. 6). "Total" means sum of the absolute values of all variations. This instrument measures the total variations of the 3 components of the telluric fields by optically digitizing them with help of a cylinder mirror with surface divided by 0.5 mm wide reflecting or not reflecting parts. In the focus of the mirror there is a phototransducer connected to the counter through appropriate electronics. The time variation of the 3 telluric components — represented by the deviations of the galvanometers — can be counted in unites of 0.5 mm for any time interval. About successful experiments in the observatory has been reported by Ádám et al. (1968). This was the first digital geoelectric instrument. The idea of this instrument had been realized by ELGI in its TEM80 which is already fully electronized.

Great efforts have been done to develop highly sensitive magnetic instruments for MT. We opened into two directions. A fluid damped static variometer has been designed following the principle of the Schlumberger galvanometers. In this respect our partners were in the Geophysical Instrument Factory - Aurél Ponori Thewrewk and L. Major. This basic instrument has been built into a phototransducer to get high sensitivity (in scale value 0.01 nT on the recorder) (Ádám and Major 1967) (see Fig. 7). This variometer served a lot in our almost all long period magnetotelluric soundings before buying the digital MT instrument from the Polish Geophysical Institute (Warsawa).

Fig. 6. Photo of the total variation counter

For recording magnetic variations of higher frequency than 0.1 Hz different types of induction coils have been developed partly for our observatory (e.g. for the pearl type pulsations and ELF signals) partly for our partners (ELGI, OKGT, etc.) who had to study the layer structure of the sediments by magnetotellurics not only the total thickness of the sediment cover. (The pearl type pulsations record in the observatory was later strongly disturbed by the electrification of the nearby railway.)

Our induction coil consisted of 2 m long supermalloy core with a coil of 500.000 turns. Its scale value could reach the μT (Ádám and Horváth 1976). ELGI started with this coil to develop its first digital MT system (DEF1). Of course, all our experiments have been done in our observatory.

Our greatest instrument development was to design a five channel audiomagnetotelluric (AMT) instrument for synoptic registration and tensorial measurements with field data processing in a co-operation with the Geophysical Department of the Oulu University (Finland). This instrument contains the full magnetotelluric data processing software completed by that one for the determination of the complex induction vector (MV) for 12 frequencies from 4.3 Hz to 2300 Hz (Fig. 8). The on-line measurements of all MT and MV data in the 80's was a great success. A lot of investigation in the Eastern Alps and in the Southern Bohemian Massif have been carried out by using this instrument (Ádám et al. 1988, Arič et al. 1997).

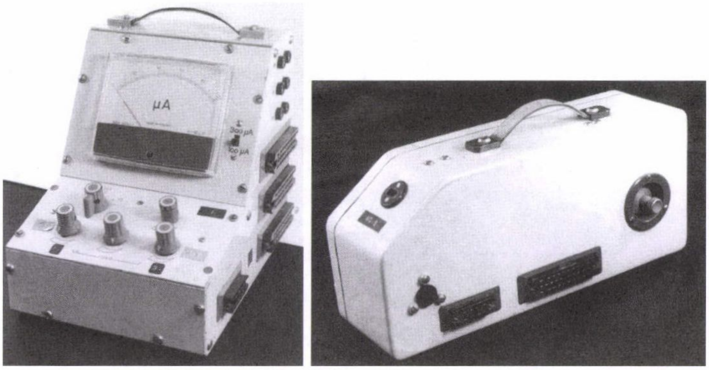

Fig. 7. Photo of the MTV-2 variometer (Ádám and Major 1967)

6. The Observatory as "magnetotelluric etalon" in Hungary

Our magnetotelluric measurements started at the very beginning of the sixties (last century) both in the field (Ádám and Bencze 1961) and in the observatory. The MT results obtained in the observatory initiated a lot of new ideas concerning the anisotropy of the distribution of the (MT) electric resistivity, the deep structure of the Earth in the Pannonian Basin, etc. (Ádám 1963). Methods have been elaborated for the determination of the magnetotelluric anisotropy for a large period domain (Ádám 1964). Later in papers (e.g. in the *Nature*, Stegena et al. 1971) it has been emphasized that the magnetotelluric anisotropy could be a useful tool in the study of the plate tectonics. On the MT sounding curves of the observatory it has been at first detected that the conductive asthenosphere — corresponding

Fig. 8. On-line audiomagnetotellurics instrument (Ádám et al. 1988)

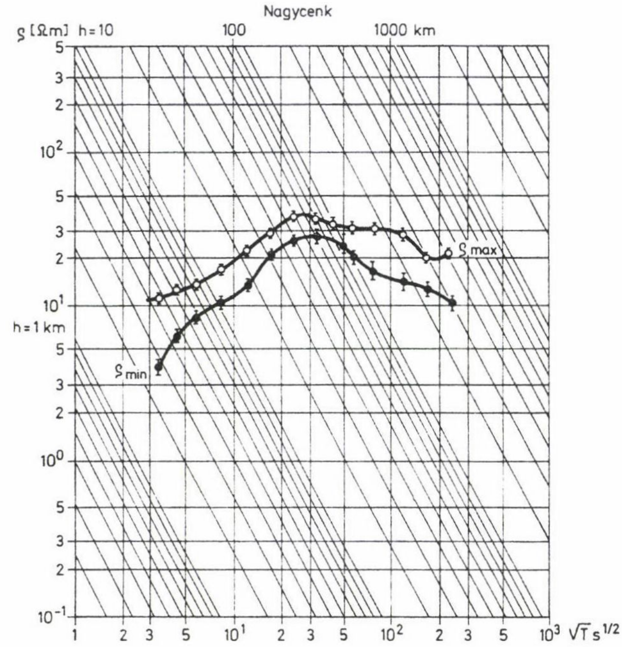

Fig. 9. MT sounding curves measured in the observatory (Ádám et al. 1981)

to the Gutenberg's low velocity layer in the upper mantle — has a very shallow position — 60 km depth — in the hot Pannonian Basin (Ádám 1963). Later this statement stimulated me to find relation between the depth of the asthenosphere and the regional heat flow in general (Ádám 1978). A resistivity decrease corresponding to the mineral phase transition at the depth 410 km also appeared in the magnetotelluric sounding curves of the observatory (Ádám and Verő 1967, Ádám et al. 1981). (See here one of the most complete MT sounding curves in Fig. 9.)

The observatory during the 80's became an etalon for testing of different magnetotelluric instruments partly developed in the country (e.g. ELGI) or imported (e.g. OKGT). One of the most precise sounding has been done by the OKGT's Phoenix MT instruments in 3 nearby sites of the observatory using the "remote reference stations" (Report of Z. Nagy, 1986).

By this measurements the geoelectric structure of the subsoil of the observatory also become better known.

7. Summary

Of course, the mentioned different experiments which were carried out in our observatory during decades are "only" additional works to the primary task of an observatory i.e.: to record the geomagnetic/ionospheric etc. variations for long time study of the physics of Earth and its environment (magnetosphere, ionosphere, Sun-Earth relation, space weather, etc.). Thus changes in the geoelectromagnetic transfer functions have been detected during the solar eclipse August 11, 1999 (Ádám et al. 2005).

Our observatory has been prepared for its primary tasks since the very beginning of its activity (August 1957) by application and completion of its instrument pool. The mentioned "additional" works and their results partly helped to make acquaintance with the geophysical (geological) background of the observatory, partly helped to develop instrument in physically known circumstances which later served the observatory in his activity.

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ATMOSPHERIC ELECTRIC AND IONOSPHERIC MEASUREMENTS IN THE GEOPHYSICAL OBSERVATORY NAGYCENK: SOME EARLIER AND RECENT RESULTS

P. Bencze

Measurements planned in the Geophysical Observatory Nagycenk of the Geodetic and Geophysical Institute of the Hungarian Academy of Sciences in Sopron were aimed at investigation of the electromagnetic field of the Earth. Thus, besides geomagnetic and earth (telluric) currents — as horizontal electric components of the electromagnetic field atmospheric electric measurements (vertical electric component) were also intended. At that time — at the end of the nineteen fifties, it was thought that the atmospheric electric field corresponds to the vertical electric component of the electromagnetic field. Shortly, it turned out that this does not correspond to the facts, however, atmospheric electric measurements were continued.

As it was not possible to buy atmospheric electric instruments, it was necessary to construct and build them in the Laboratory. The relatively most simple instruments were an equipment for recording of point discharge currents and an apparatus for measurement of the atmospheric electric potential gradient (field strength).

Point discharge currents are recorded using a tip made of rust-proof steel put at the end of a mast on the roof of the atmospheric electric station in a height of 8 m. Currents are recording with a sensitive galvanometer. The potential gradient is measured by a radioactive collector placed in a height of 1 m above the ground and the grid current of a (radio) tube operated in an inverted connection. The potential gradient measuring equipment has been checked by removing the radioactive preparation, and connecting a resistance of 10^12 ohm parallel with the resultant resistance consisting of the isolation resistance of the collector, from the input resistance of the tube electrometer and from the inner resistance of a quadrant electrometer (Bencze and Märcz 1980). Applying a known voltage to this circuit and measuring the voltage on the above mentioned resultant resistance the insulation, the input and the transitional resistances representing the transitional resistance of the radioactive preparation could be determined. In this way devi-

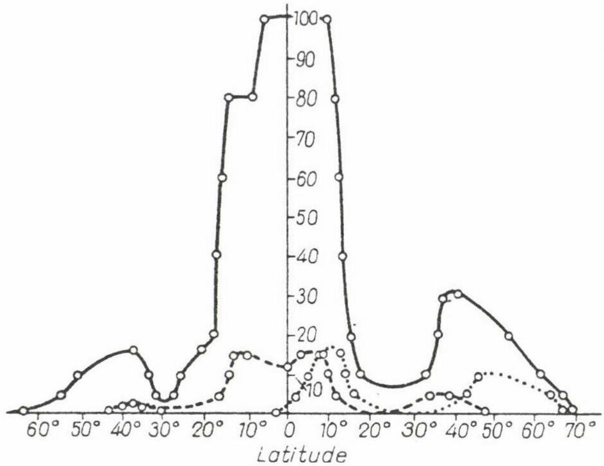

Fig. 1. Latitude variation of thunderstorm activity. ······ average number of thunderstorm days for July, ---- average number of thunderstorm days for October, —— average number of thunderstorm days per year

ation of the potential gradient measured by the equipment and the actual value could be computed. Both measurements are carried out since 1960 and continued to date (Bencze and Märcz 1967a, 1981, Bencze 2001a, 2001b). Processed data were published in the Geophysical Observatory Reports.

Recording of point discharge currents is motivated by determination of the electric charge exchange between the Earth's surface and higher layers of the atmosphere. Quantity of charge transported by point discharge currents is established by the determination of the area formed by the recorded current variations and the base line (Bencze and Märcz 1963). It has been found that diurnal variation of both positive and negative charges indicate a maximum in the afternoon, as well as quantity of negative charges is greater, than that of positive charges. Concerning the seasonal variation, both positive and negative charges show maximum values in summer. The seasonal variation of the quantities of charge transported by point discharge has been explained by latitudinal variation of thunderstorm activity, thunderstorm area shifted in winter to the south (Bencze 1963) (Fig. 1).

Most interesting results of the point discharge observations seem to be results of a detailed analysis and classification of point discharge current variations according to the type of their temporal variation. Point discharge is produced by enhanced atmospheric electric field at peaks, edges, which takes place as a result of charge separation in clouds. Charge separation is initiated by upwelling air in low pressure

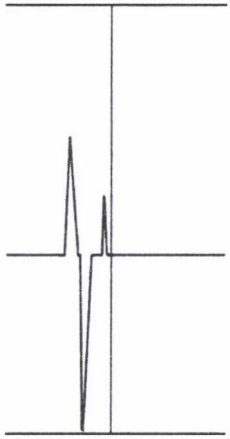

Fig. 2. Point discharge currents produced by a thundercloud of positive polarity

areas in the lower atmosphere. Study of current variations has shown that there are essentially single current variations of positive or negative sign, variations consisting of positive and negative currents following each other, and a series of positive – negative – positive current variations, or variations in reversed order (Bencze 1966). Single variations of positive or negative sign can be attributed to unipolar clouds. A pair of positive or negative departures may be due to successive unipolar clouds. A series of positive – negative – positive field variations can be due to a thunder cloud equivalent to an electric dipole with a positive charge center above and a negative one below. Thus, a thundercloud of such polarity approaching the observing site first effect of the upper positive pole would prevail followed in time by the effect of the lower negative pole with the thundercloud above the observing site and then again the effect of the upper pole would prevail as the thundercloud is moving off (Fig. 2). In case of the series negative – positive – negative, effect of an electric dipole of opposite polarity is observed.

Measurement of the atmospheric electric potential gradient were used not only for determination of its daily variation, which is characteristic of the environment's undisturbed state from atmospheric electric point of view (undisturbed state means no larger deviation from the daily variation observed above oceans). In continental areas, there are only a few places, first of all high mountains, where these undisturbed conditions are given. Our measurements have shown that the daily variation of the atmospheric electric potential gradient is only a little disturbed, first of all in winter (Bencze and Märcz 1967a).

The main topic of study of the atmospheric electric potential gradient in these years has been investigation of temporal variations (fluctuations) of the potential gradient called atmospheric electric agitation. Fluctuations have been divided into four arbitrary selected period bands (0–6, 6–12, 12–24 and 24–60 min) and daily, as well as seasonal variation in the mean amplitude of these period bands determined (Bencze 1964). The daily variation of these period bands indicates different form, however, the seasonal variation shows winter maximum in case of all period bands. It has been established that both location of the station and effect of the global thunderstorm activity are responsible for the atmospheric electric agitation. It has also been found that the mean amplitude of the agitation is proportional to the magnitude of the atmospheric electric potential gradient. In a further study, connection of agitation with amplitude of the potential gradient and the wind, with sky cover and different air masses is analysed (Bencze 1965). Daily variation of the occurrence frequency shown by the agitation of the period band 0–6 min indicated daily variation with maximum occurrence by day in summer months, but afternoon maximum in winter months. Occurrence frequency was greater in winter, than in summer. In case of the period band 6–12 min, daily variation of the occurrence frequency indicated maximum occurrence by day in summer, but maxima shifted to night in the winter months. Occurrence frequency of this period band is greater in winter than in summer, however magnitude of the occurrence frequency decreased as compared with the former period band. The occurrence frequency of the period band 12–24 min shows similar variations, however, magnitude of the occurrence frequency decreased further. Considering the occurrence frequency of the period band 24–60 min, the daily variation does not follow a systematic change in course of the year, but magnitude of the occurrence frequency increased significantly. A study of the daily and seasonal variations of the dominant period band on the basis of their occurrence frequency has shown that in summer agitation belonging to the 0–6 and 6–12 min bands are the most frequent, while in winter the 12–24 and 24–60 min period bands are dominant.

For registration of the less affected by local conditions (atmospheric pollution, humidity, wind) characteristic of the global atmospheric electric circuit is the vertical current occurring in fine weather areas of the Earth as load maintained by the global thunderstorm activity as generator in the circuit. Thus, the circuit consists of a generator connected to the atmospheric electric equalising layer in the bottom of the ionosphere. The circuit is continued in this layer in the direction of fine weather

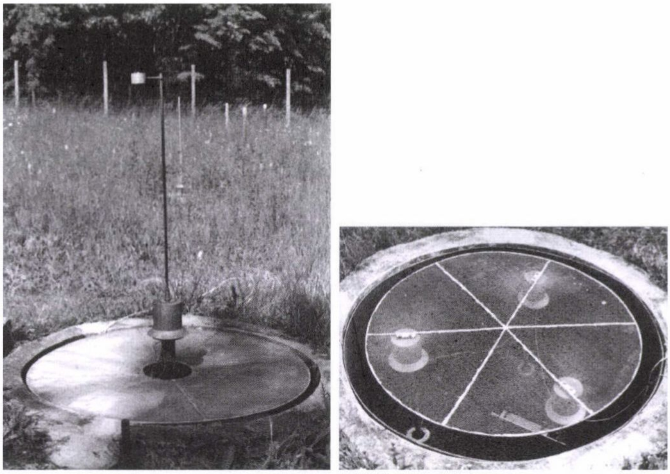

Fig. 3. Collector screen for measurement of the vertical current

areas, there closed to the ground by the vertical current and back to thunderstorm areas. Besides vertical current the potential gradient and conductivity are characteristics of the atmospheric electric circuit. For registration of the vertical currents a collector screen of 1 m^2 surface was placed to ground level isolated (Fig. 3). The vertical current was recorded by a picoampermeter of high input resistance (Bencze et al. 1984). Unfortunately registration of vertical current have only been carried out up to one or two years.

The atmospheric electric field has not only a static part, but also an electromagnetic field, too, originating in lightning discharges. Experiments for registration of the ELF (extremely low frequency) band of this electromagnetic field began in order to extend the ULF frequency band used in magnetotellurics to higher frequencies. An inverted long wave-length L antenna and amplifier of a portable seismic equipment and a hot-wire recorder were used to record variations in this frequency band including Schumann resonances (Ádám and Bencze 1963).

Concerning ionospheric investigations, they began in the middle of the nineteen sixties. After it turned out that the atmospheric electric field does not correspond to the vertical electric component of the Earth's electromagnetic field. The ionosphere is closely coupled to the geomagnetic field e.g. by ionospheric current systems, the magnetic field of which appears in form of variations of the geomagnetic field. According to an agreement with the National Meteorological Institute, where vertical incidence sounding of the ionosphere has been carried out since the beginning of

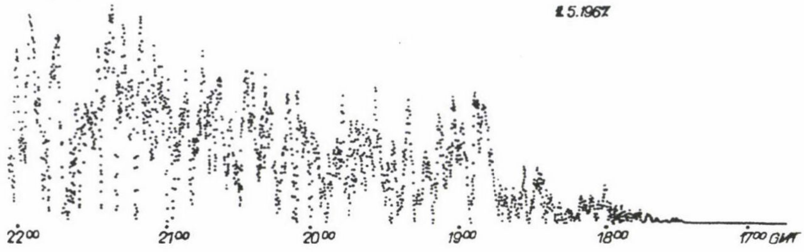

Fig. 4. Sky wave record

the International Geophysical Year 1957–1958 and thus, the upper ionosphere has been studied, the Geophysical Research Laboratory of the Hungarian Academy of Sciences began the investigation of the lower ionosphere. At that time, the most simple procedures for study of the lower ionosphere used commercial transmitters working in the LF, MF and HF frequency bands. Frequency of the selected transmitter depends on the height region, from where information on the state of the ionosphere is needed. Concerning distance of the station, the transmitter should not be farther than a distance, which can be reached by radio waves needing only one single reflection from the ionosphere.

As transmitted radio waves are propagating partly along the Earth's surface (ground wave), partly backscattered from the ionosphere (sky wave), the two types of waves must be separated to get information about the state of the ionosphere. Sky waves bearing information can be separated from ground waves, if using a frame antenna it is just in a plane perpendicular to the transmitter-receiver direction. These waves are amplified by a heterodyne receiver tuned solely to the wave- length of the selected transmitter. Constancy of the receiver's tuning is achieved by using crystal filters in the different stages (Bencze et al. 1976). If sky waves of LF or MF transmitters reflected from altitudes of about 100 km are used, their relative amplitude can only be determined by day in case of large amplification receiver. Sky waves are namely, strongly absorbed by day in the D-region of the ionosphere, on the contrary, at night smaller amplification is also enough because of the vanishing D-region (Fig. 4). This method called A3 method enables determination of the ionospheric radio wave absorption. Initially two radio stations were selected, Ceskoslovensko (272 kHz) and Budapest (539 kHz). However, for application of this method, the field strength (transmitter power) of the transmitter must be constant. Unfortunately, transmitter power of Budapest was changed during the day, thus it was not suit-

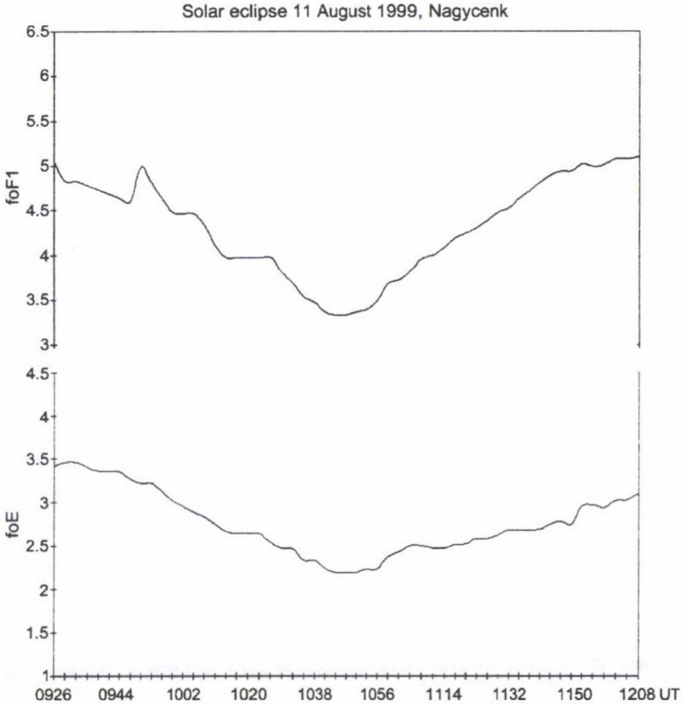

Fig. 5. Variations of the critical frequencies foE and foF1 proportional to the maximum electron density in the E and F1 regions related to the total solar eclipse of August 11, 1999

able for us. Processing of data proved that the so called winter anomaly of ionospheric absorption is also present at the latitude of our observatory (Bencze and Märcz 1967b). This anomaly is due to excess ionization in winter caused by enhanced transport of NO, an easily ionisable component of the atmosphere from above.

Experiments related to vertical incidence sounding of the ionosphere began in 1992 following reduction of the staff in the Hungarian Meteorological Service. Time table of the staff reduction was to abolish those activities, which are only loosely linked to meteorology. Thus, vertical incidence sounding carried out in framework of the Meteorological Service in Békéscsaba has also been stopped. The equipment, an ionosonde type IPS 42 made in Australia was offered to our Institute. Installation of the ionosonde in our observatory took a long time. It was necessary to build the antenna system (transmitter and receiver) fixed to a tower of 30 m height. For placing the tower, increase of the observatory area was needed not to disturb measurement of the absolute value of the geomagnetic field components. The transferred

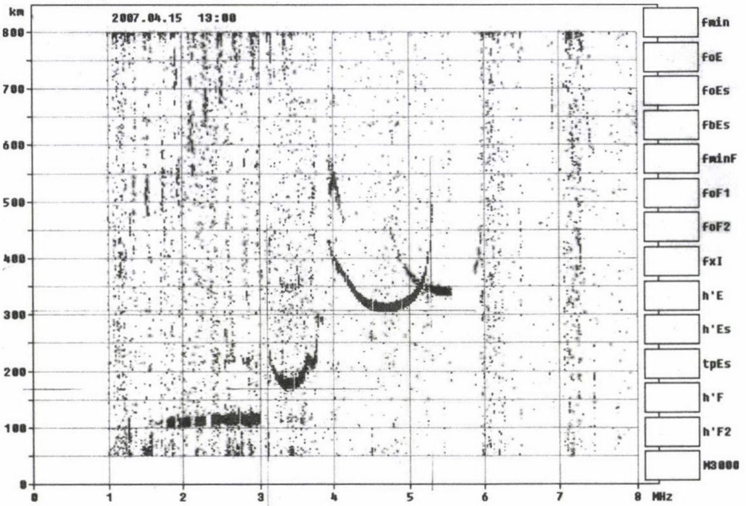

Fig. 6. Ionogram recorded by the new ionosonde

ionosonde worked in analogue mode and this circumstance necessitated conversion of the equipment into digital mode. This has been done by J. Titheridge, who developed both the additional hardware and software parts for IPS 42 ionosondes. However the ionosonde could not produce ionograms of good quality, since the high frequency part of the ionogram was mostly not usable. But the low frequency part of the ionogram could be used e.g. for study of ionospheric sporadic E for estimation of the distance between patches of increased electron density within the stratification (Bencze et al. 2004). Another possibility of using the ionosonde proved to be the total solar eclipse of August 11, 1999. During the eclipse soundings were made every 3 minute and this frequent measurements enabled determination of electron density change in the E, F1 regions of the ionosphere, decrease of electron density with advance of the totality and its return to value observed before the eclipse (Bencze et al. 2007) (Fig. 5).

Meanwhile a new ionosonde constructed in the Space Research Center of the Polish Academy of Sciences arrived, which works with two identical antennas perpendicular to one another. This exact symmetry is needed because both the transmitter and the receiver antenna are used both for transmission and reception. This construction enables the possibility of drift measurements. An ionogram is shown in Fig. 6.

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SUMMARY OF RESULTS OF PULSATION RESEARCH AT THE NAGYCENK OBSERVATORY

J. VERŐ

1. History, instruments, magnetotellurics

Since the establishment of the Nagycenk Observatory I supervised there the earth current records of several kinds. I also compiled the corresponding part of the Observatory Reports during the following three decades. The first presentation of the results of the observatory took place in 1958 at the Assembly of the German Geophysical Society in Leipzig. Later in the nineties I wrote several times about the history of the observatory. In connection with the solar eclipse in 1999 we investigated the effect of the eclipse on magnetotelluric parameters.

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2. Pulsation indices

It has been decided at beginning of the operation of the observatory to emphasize the description of the geomagnetic activity by means of indices for as many period bands as possible. An especially dens characterization was introduced in the period range of pulsations. The final version of the pulsations indices was described in a series of papers together with some examples of their use. Pulsation indices were published in the yearly reports of the observatory.

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3. Comparison between distant observatories

The earliest comparison of pulsation parameters between Hungary and China took place in the mid-fifties by A. Ádám. Such comparison led to the discovery of an UT component in the pulsation activity. Later geomagnetic arrays were used for the distinction of field line resonances (FLR) and upstream waves (UW) both types were traced at auroral and equatorial latitudes, too.

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4. Field line resonance – Magnetospheric-ionospheric effect

The first investigations concerning ionospheric, magnetospheric effects aimed at the identification of certain connections with pulsations as e.g. the existence of a "memory" in the magnetosphere. A change of stations was operated in the late seventies and our group was the first to report a non-continuous period changes with latitude, that was the indications of the shell structure of FLR.

Comparisons of in situ measured satellite data with surface pulsation data reveal modification of incoming UW. In the following years a central problem of our investigations was to distinguish FLR and UW, thus papers in these to section are mostly dealing with both types.

The development of computers enabled us to used more sophisticated methods as dynamic spectra to study FLR. The first paper (1988) using this tool has shown that both types clearly appear at a station pair at L 1.9 and 3.3. Afterwards a five station change enabled us to study the temporal behaviour of the two types.

A detailed study of the beating phenomenon led to the estimation of the parameters of the resonant shells (thickness at the ground 100 km change of the period with latitude 10%/degree, number of waves in a beat about 10).

The mentioned chain of pulsation stations with some modification was operated again for the study of observed similarities between resonant shells of pulsations and whistlers ducts. A multi-station study of the pulsation activity during the 1999 total solar eclipse confirmed the switch-off FLR activity during the totality.

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5. Upstream waves – Effects of solar wind and of interplanetary magnetic field

Geomagnetic impulses originating from the interplanetary medium often cause changes in the pulsation spectrum thus indicate interplanetary origin of the pulsations. As soon as interplanetary data became available data of the Nagycenk Observatory offered excellent possibility to compare interplanetary and pulsations data. Many citations to the two corresponding papers signalized that they were accepted as final proof of these connections. Changes in the direction of the interplanetary magnetic field (IMF) were found to immediately influence pulsation activity. The connection between IMF, solar wind and UW were repeatedly re-examined, when new aspects emerged.

By a comparison of in situ satellite data in the solar wind and surface pulsation data we detected the amplification of surface pulsation amplitudes some 3–4 minutes after the appearance of UW in the solar wind.

The geomagnetic array mentioned in connection with FLR enabled us to fined very quick transitions between UW and FLR. These transitions are connected to sudden changes in the IMF which destroy the existing resonant system. For the build-up of a new resonance a time interval of several minutes is necessary.

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6. Winter anomaly

The winter anomaly, i.e. the strong attenuation of pulsation amplitudes during winter in years of high solar activity was discovered at the Nagycenk Observatory. Investigations in connection with this anomaly revealed several characteristic, as the appearance of the anomaly in the Southern hemisphere winter too. but with less intensity, the existence of a threshold in plasmaspheric-ionospheric plasmadensity, bellow which the anomaly does not appear. This threshold in foF2 is about 10–11 MHz and is slightly variable. The anomaly seems to be maintained during the very low night-time pulsation activity, too. Curiously, the attenuation is connected with the equatorial plasma density at L 2 even if it is essentially bound to hemispheres.

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7. Long period variations

Indices were introduced at the Nagycenk Observatory for longer (periods 2–60 min) variations, too. Using them we found a delay of about one day in the activity of the 6–20 min period variations with respect to the 2–6 and 20–60 min period bands. In the latter band a secondary maximum of activity was found around local noon, in addition to the midnight maximum.

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HISTORY OF MAGNETIC OBSERVATION

Á. WALLNER

The continuous recording of geomagnetic field was started in Hungary in Ógyalla (today Hurbanovo, Slovakia) at the end of the 19th century. In 1918 Ógyalla was annexed to Czechoslovakia. From 1918 till 1938 geomagnetic recording was restricted to the recording of declination. Between 1938 and 1945 Ógyalla belonged again to Hungary. The Hungarian Institute of Meteorology restarted the systematic measurement of the geomagnetic field under the leadership of Prof. Dr. György Barta at the end of 1938. After World War II, as Ógyalla became again part of Czechoslovakia, Prof. Barta started a provisional observatory in Budakeszi, and made efforts to establish a new geomagnetic observartory in Tihany. Thanks to his activity the new Observatory of the Eötvös Loránd Geophysical Institute in Tihany began his recording activity in 1954.

The International Geophysical Year 1957–1958 brought about the idea to establish a second geophysical observatory in Hungary by the Geophysical Research Laboratory of the Hungarian Academy of Sciences. The main aim was to record the natural electromagnetic field in a wide range, including variations of atmospheric, ionospheric, magnetospheric and extraterrestrial origin. Therefore we had to find a place with quiet geological conditions being free from man-made electric disturbances, and where the latter condition could be maintained in the future, too. We found a place, where these conditions were fulfilled, near to the southern shore of the Lake Fertő, between the villages Fertőboz and Hidegség. The place has been in the neighbourhood of Nagycenk, where count István Széchenyi the founder of the Hungarian Academy of Sciences is buried, therefore the Observatory was always called: Geophysical Observatory near Nagycenk, and is named now Széchenyi István Geophysical Observatory of the Hungarian Academy of Sciences.

The environment of the observatory has legal protection against industrialization causing vagabond currents.

The recording of earth (telluric) current was started in 1957 with instruments produced in the Laboratory. It was, however, necessary to complete earth current recordings with those of the geomagnetic field, too.

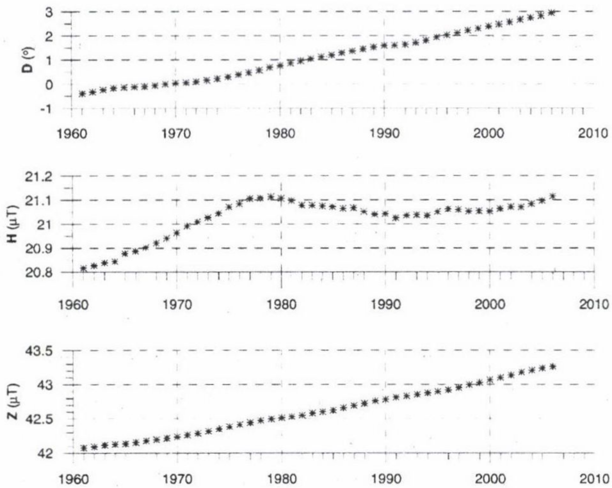


Fig. 1. The yearly means of geomagnetic absolute values in D, H and Z in the Observatory Nagycenk between 1961 and 2006

Geomagnetic instruments, namely variometer sets for recording H, D and Z components, as well as those for the measurement of the absolute values of these components had to be imported from abroad. This was not an easy thing among the economical conditions of the country in the late fifties. Two antimagnetic houses had to be built for the measurements, one for the continuous recordings (called relative house) and the other for the measurement of the geomagnetic absolute values (called absolute house). They were built from limestone, the roof from reed.

The continuous recording of the geomagnetic components H, D and Z, and the weekly measurement of the absolute value of these elements were started in July, 1960. The instrumentation was: two variometer sets of the type La Cour (made in Denmark) recording to 30 × 40 cm photo-paper sheets, two QHM-s (quartz-horizontal-magnetometer), one BMZ (balance-magnetic-zero) (also made in Denmark), a magnetic declinatorium and an Earth inductor (Askania). The magnetic declinatorium originally served in the Observatory Ógyalla, then in Budakeszi and in Tihany, but was later replaced by a magnetic theodolite in Tihany. Nevertheless, it was a very accurate instrument, and easy to handle. The Hungarian Television made a report in the Observatory in the late seventies, in course of which this old instrument was the most successful for the reporters, the longest report dealt with the measurement of magnetic declination by means of this ancient declinatorium.

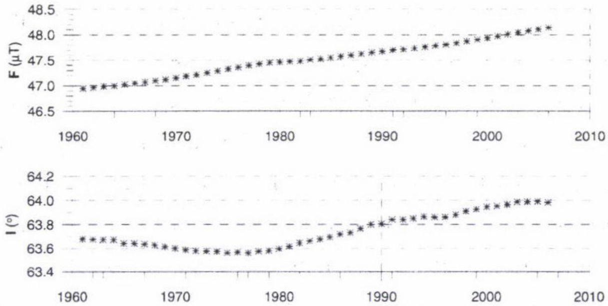


Fig. 2. The yearly means of the geomagnetic total field F, and the Inclination angle I in the Observatory Nagycenk betyween 1961 and 2006

The QHM and BMZ instruments were compared in several geomagnetic observatories. Comparison measurements were made each years with Tihany, but several times in Niemegk (formerly GDR), too. The transport of the magnetic instruments into a foreign country was often rendered difficult by customs. When I travelled to Niemegk in 1967, I was ordered to get down from the international train in border station Sturovo (CSR) in order to make a declaration on the instruments being in my luggage, for which I had already get a customs permission in Sopron. Fortunately this formality took only about 15 minutes and the train waited till I came back.

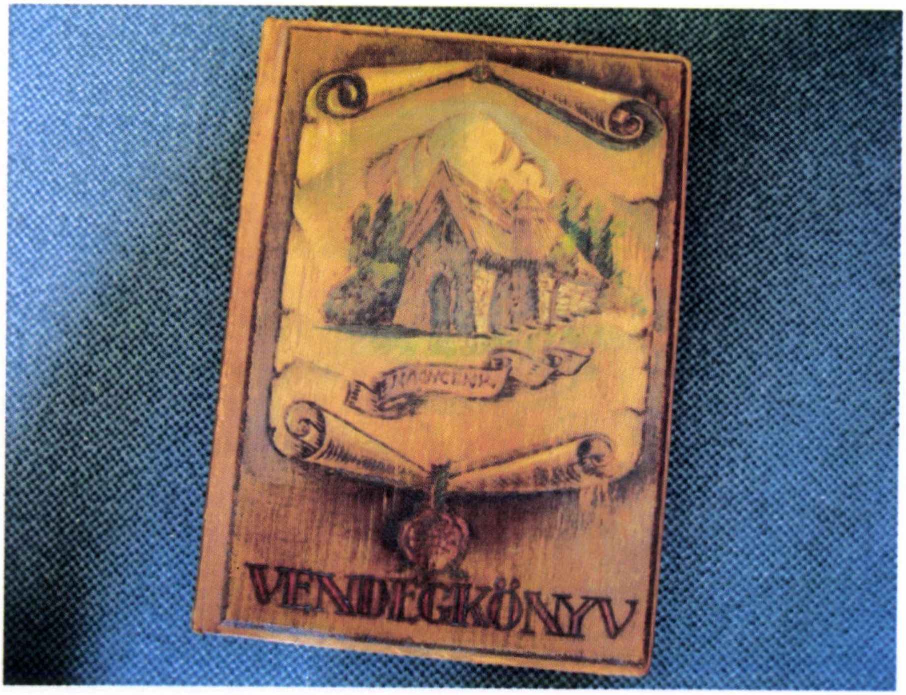
The conventional magnetic instruments described formerly, were used until 1989. From 1989 till 1991 the measurements of magnetic absolute values were made with a vector proton magnetometer developed in the Observatory Niemegk. Since 1991 absolute measurements have been made by a triaxial fluxgate magnetometer a proton magnetometer (ELSEC 820).

Digital recording of the geomagnetic variations was also started by an ARGOS system (bought from the British Geological Survey) in 1991. The analogous photographic recording was run parallel during about one year.

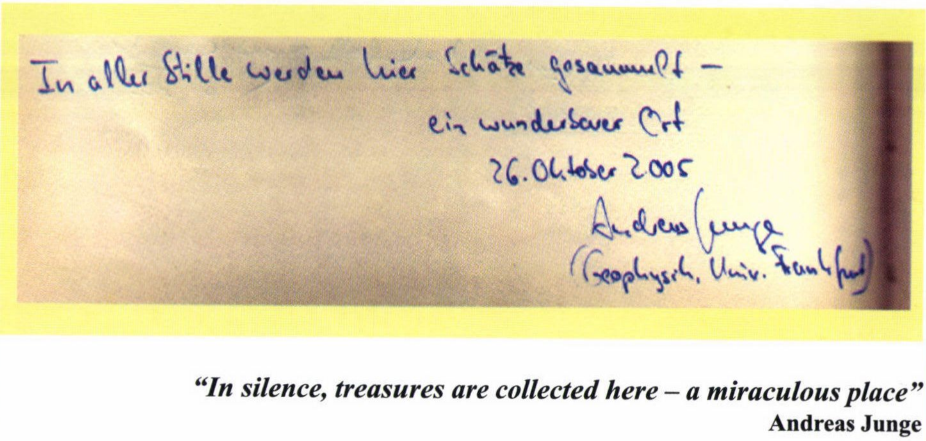
Observatory reports of geomagnetic data has been published each year since 1961. As the observatory had in the first times the main aim of the continuous monitoring of the Earth's electromagnetic field of external origin, the chapter Geomagnetism was compiled in coincidence with the chapter Earth Currents. The activity indices reported were determined according to a linear scale, which increased by 7 nT broad steps. Only monthly and yearly averages of the absolute values of the elements were given. Since the beginning of the nineties, however, as the participation in INTERMAGNET was started. Since that the reports on geomagnetic measurements are compiled in accordance with the requirement of INTERMAGNET. Activity indices have been determined according to Bartels.

Besides the yearly publication of geomagnetic data in the Observatory Reports, we have direct contacts with other obeservatories, too. Since the end of the seventies special events (SSCs and solar flares) have been reported to the Ebro Observatory (Spain). Close connections and data changes took place from time to time with the Observatories Wien-Kobenzl, Niemegk, Prahatice, Belsk, Hurbanovo.

It is of interest to show the trend of the geomagnetic secular variation in the Observatory. In order to that the yearly mean values of the geomagnetic elements were plotted for the last 45 years, i.e. from 1961 until 2006. Figure 1 shows the yearly means of declination, of the horizontal and vertical components. A continuous increase in Z (and consequently in the total field (F), too, see Fig. 2), and an eastward trend in declination can be observed, while the trend of increase was stopped in H (horizontal intensity) in the late seventies, and even a small decrease arose until 1992. Since that the increasing trend appears again, but only in smaller degree. Thus the angle of Inclination (I) increased between 1978 and 2003 (Fig. 2).

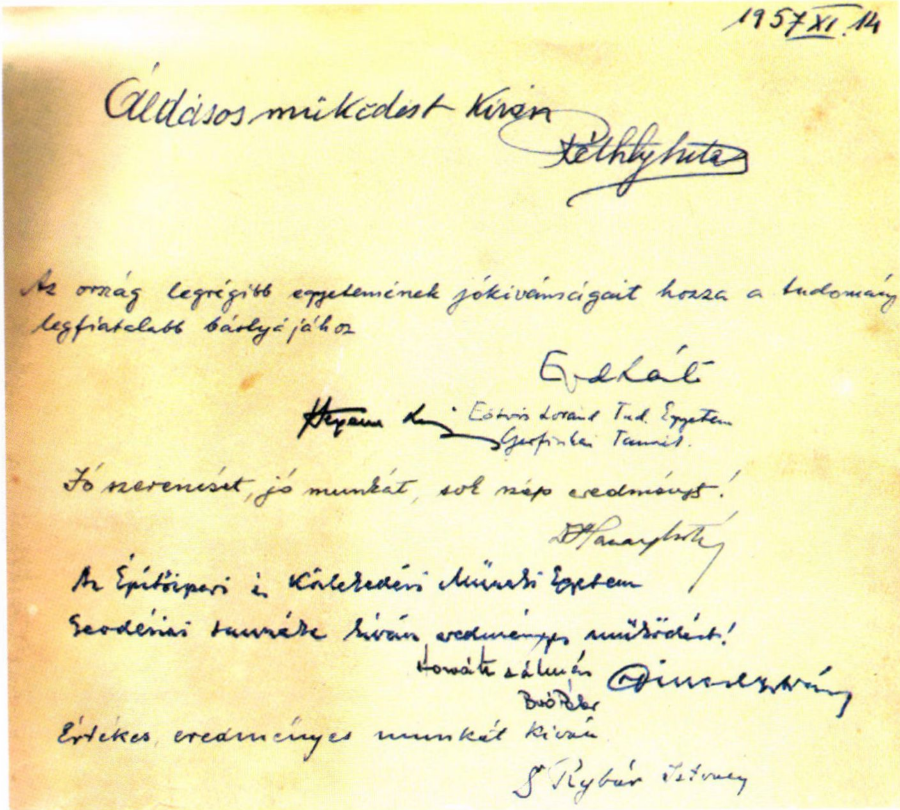


Guestbook of the Observatory


In aller Stille werden hier Schätze gesammelt –
ein wunderbarer Ort
26. Oktober 2005
Andreas Junge
(Geophysik, Univ. Frankfurt)

"In silence, treasures are collected here – a miraculous place"

Andreas Junge



1957. XI. 14

Áldásos működést kíván

Az ország legrégibb egyetemének jókívánságait hozza a tudomány legfiatalabb bástyájához

Eötvös Loránd Tud. Egyetem Geofizikai Tanszék.

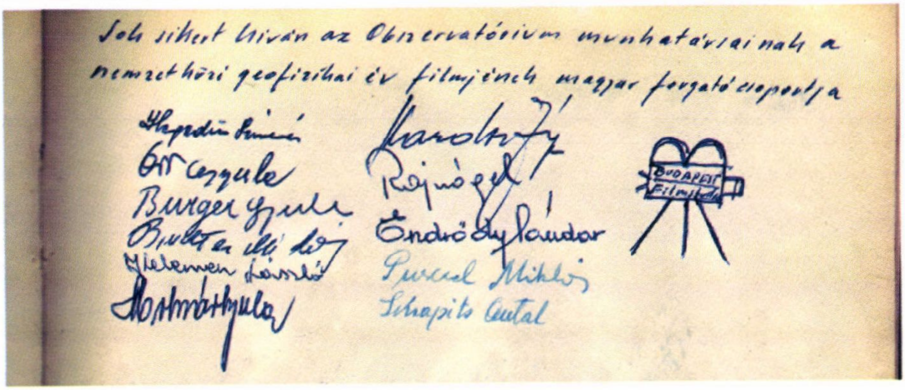
Jó szerencsét, jó munkát, sok szép eredményt!

Az Építőipari és Közlekedési Műszaki Egyetem Geodéziai tanszéke kíván eredményes működést!

Értékes, eredményes munkát kíván

Rybár István

The first notes, November 14, 1957

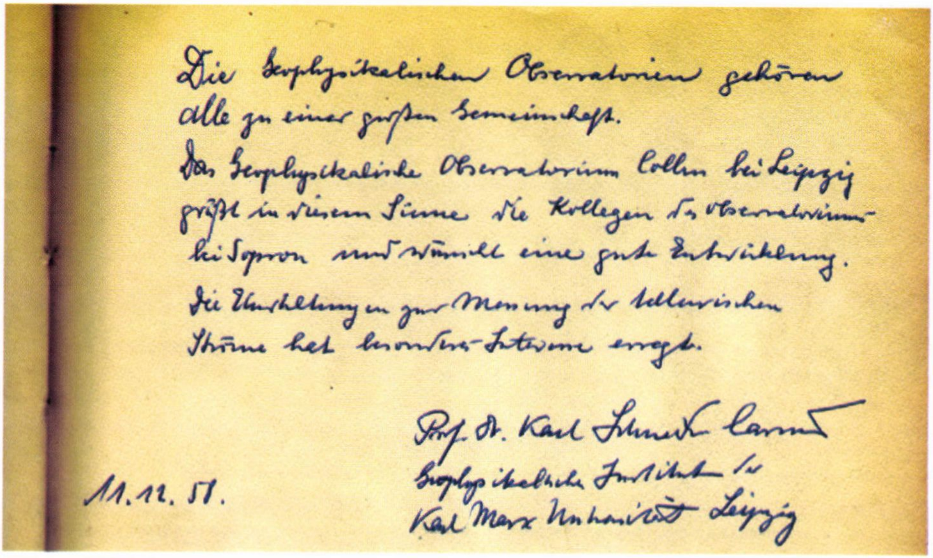


Sok sikert kíván az Obszervatórium munkatársainak a nemzetközi geofizikai év filmjének magyar forgató csoportja

Burger Gyula

Endrődy Sándor

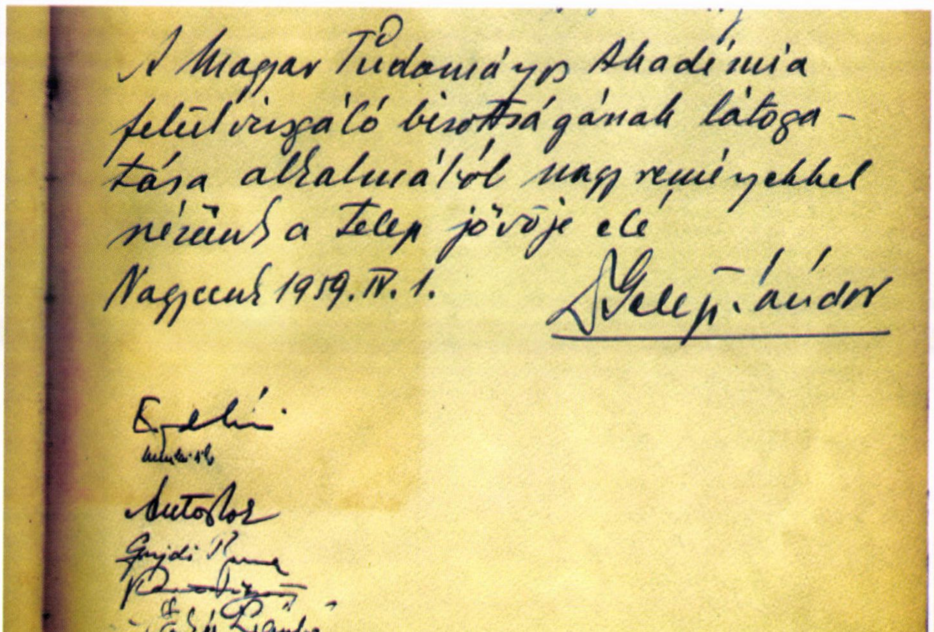
November, 1958


Die Geophysikalischen Observatorien gehören alle zu einer großen Gemeinschaft.
Das Geophysikalische Observatorium Collm bei Leipzig grüßt in diesem Sinne die Kollegen des Observatoriums bei Sopron und wünscht eine gute Entwicklung.
Die Einrichtungen zur Messung der tellurischen Ströme hat besonderes Interesse erregt.

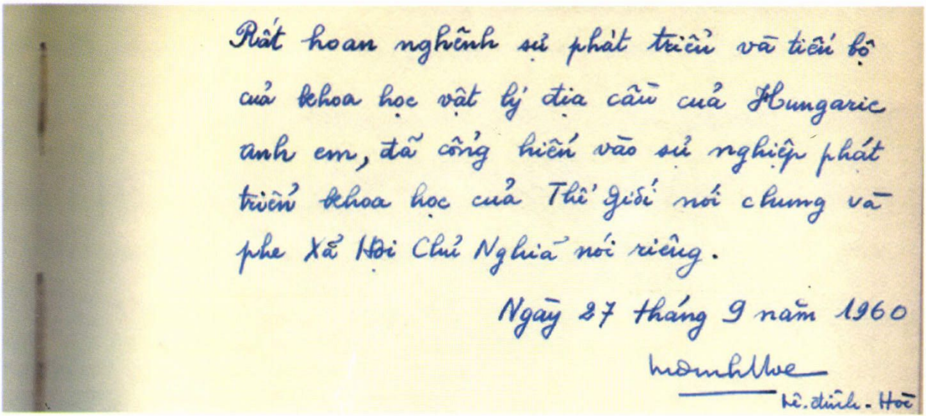
Prof. Dr. Karl Schneider-Carius
Geophysikalisches Institut der
Karl Marx Universität Leipzig

11.12.58.

December 11, 1958


A Magyar Tudományos Akadémia felülvizsgáló bizottságának látogatása alkalmából nagy reményekkel nézünk a telep jövője elé.
Nagycenk 1959.IV.1.

April 1, 1959

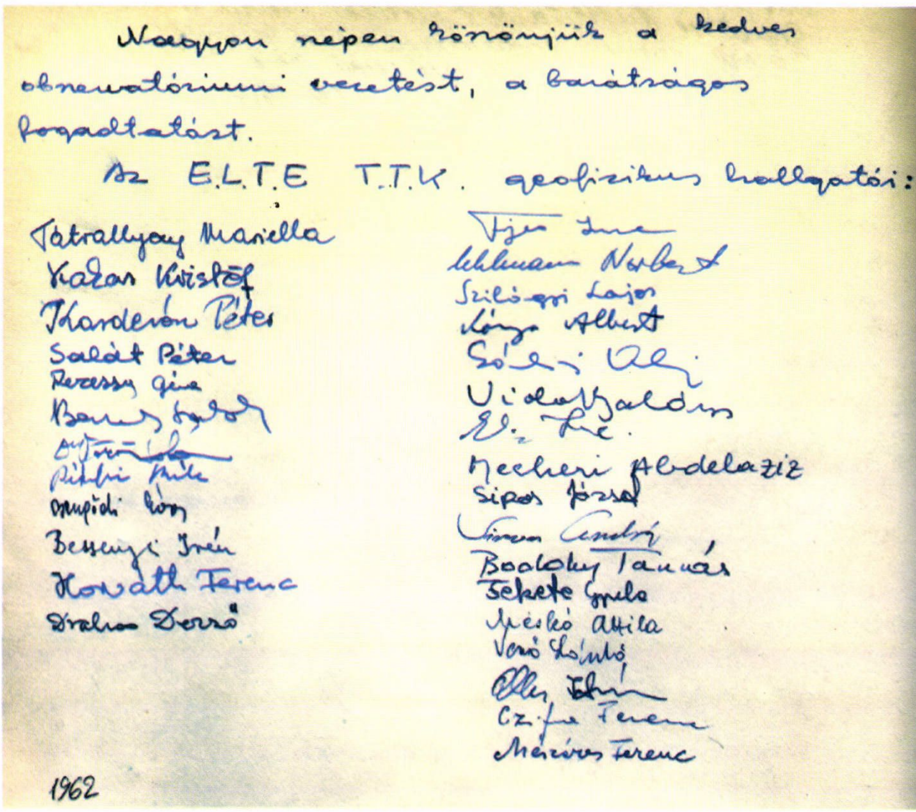

Rất hoan nghênh sự phát triển và tiến bộ của khoa học vật lý địa cầu của Hungarie anh em, đã cống hiến vào sự nghiệp phát triển khoa học của Thế giới nói chung và phe Xã Hội Chủ Nghĩa nói riêng.

Ngày 27 tháng 9 năm 1960

[illegible]

Lê-đình-Hoè

September 27, 1960


Nagyon szépen köszönjük a kedves obszervatóriumi vezetést, a barátságos fogadtatást.

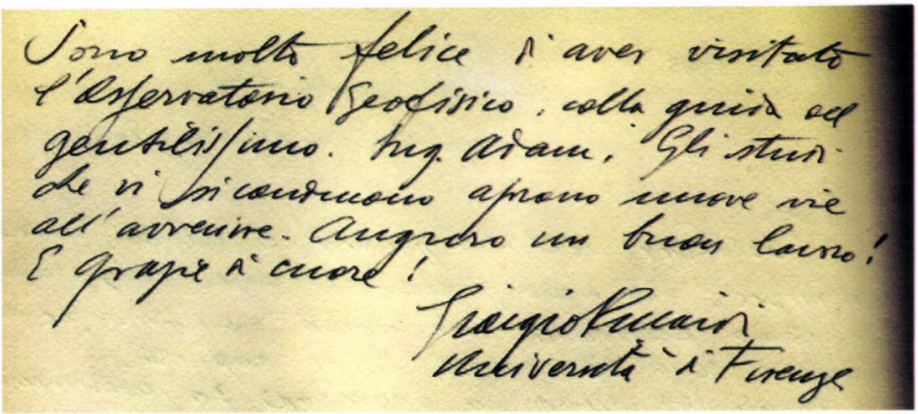
Az E.L.T.E T.T.K. geofizikus hallgatói:

Tátrallyay Mariella
Kazár Kristóf
Kardeván Péter
Salát Péter
Rezessy Géza
[illegible]
[illegible]
[illegible]
[illegible]
Bessenyei Irén
Horváth Ferenc
Drahos Dezső

[illegible]
Lehmann Norbert
Szilágyi Lajos
[illegible] Albert
[illegible]
[illegible]
[illegible]
Mecheri Abdelaziz
Sipos József
[illegible]
Bodoky Tamás
Fekete Gyula
Meskó Attila
Verő László
[illegible]
Czifra Ferenc
Mészáros Ferenc

1962

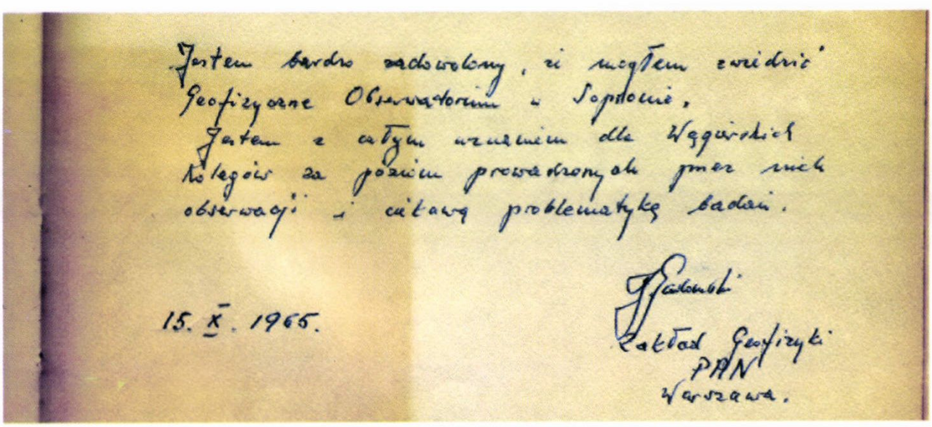
1962



Sono molto felice d'aver visitato l'Osservatorio Geofisico, colla guida del gentilissimo Ing. Adam. Gli studi che vi si conducono aprono nuove vie all'avvenire. Auguro un buon lavoro! E grazie di cuore!

Giorgio Piccardi
Università di Firenze

November 22, 1963



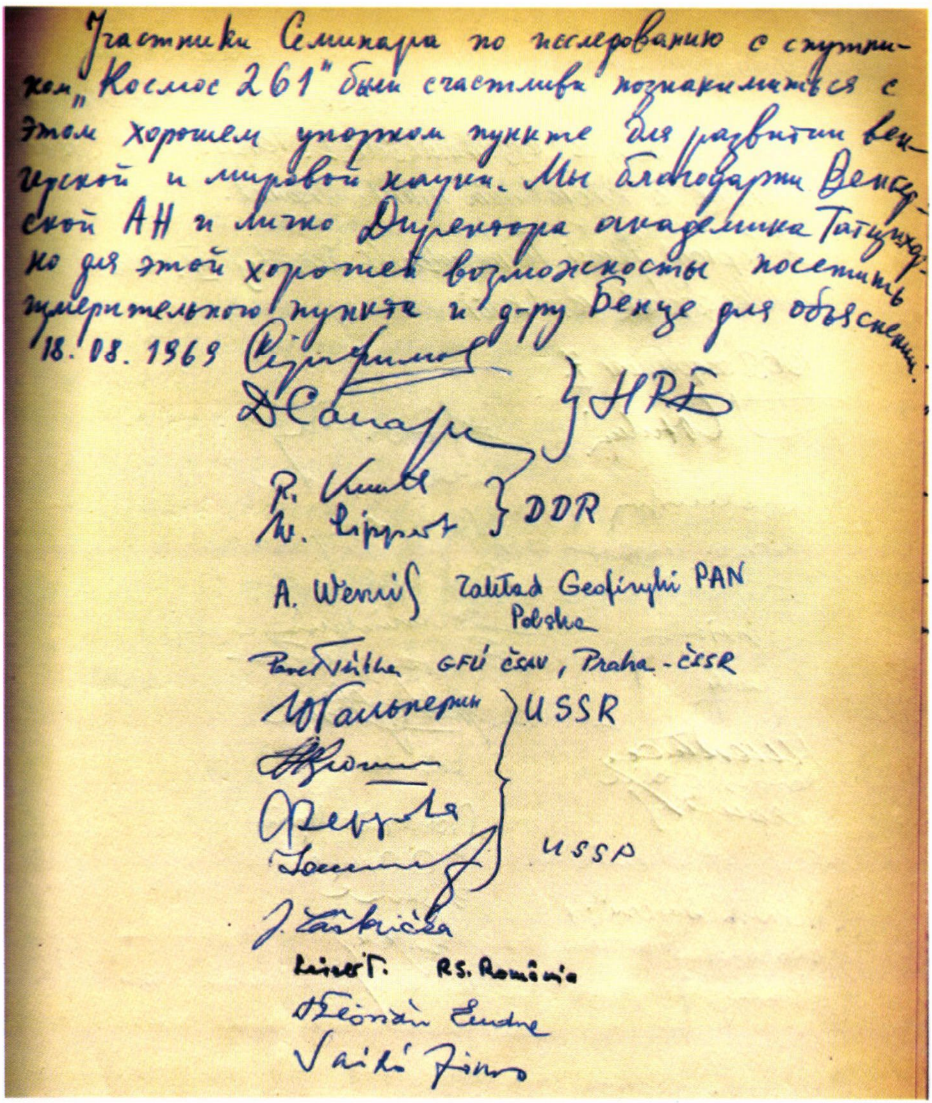
Jestem bardzo zadowolony, że mogłem zwiedzić Geofizyczne Obserwatorium w Sopronie.
Jestem z całym uznaniem dla Węgierskich Kolegów za poziom prowadzonych przez nich obserwacji i ciekawą problematykę badań.

[illegible]

15. X. 1965.

Zakład Geofizyki
PAN
Warszawa.

October 15, 1965


Участники Семинара по исследованию с спутником „Космос 261" были счастливы познакомиться с этим хорошим упорном пункте для развития венгерской и мировой науки. Мы благодарим Венгерской АН и лично Директора академика Татцаго для этой хорошей возможносты посетить измерительного пункта и д-ру Бенце для объяснения.

18. 08. 1969

} НРБ

R. Knuth
W. Lippert } DDR

A. Wernik Zakład Geofizyki PAN Polska

Pavel Tříska GFÚ ČSAV, Praha - ČSSR

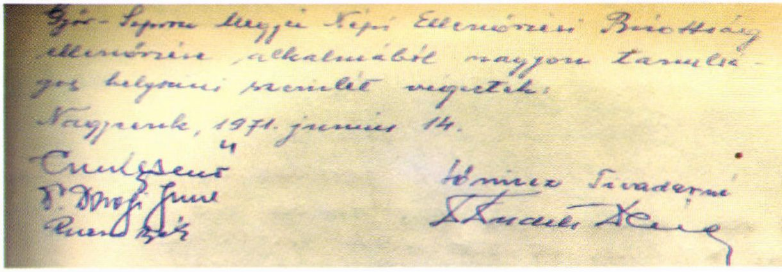
Ю. Гальперин } USSR

USSR

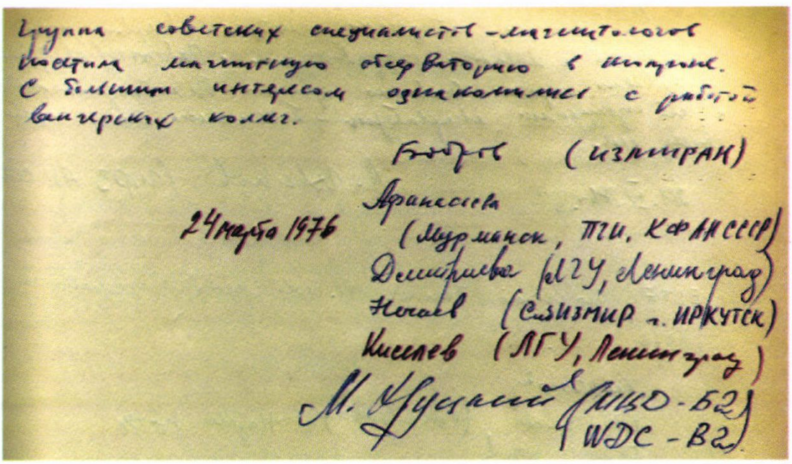
J. Laštovička

RS. România

August 18, 1969


Győr-Sopron Megyei Népi Ellenőrzési Bizottság ellenőrzése alkalmából nagyon tanulságos helyszíni szemlét végeztek.
Nagycenk, 1971. június 14.

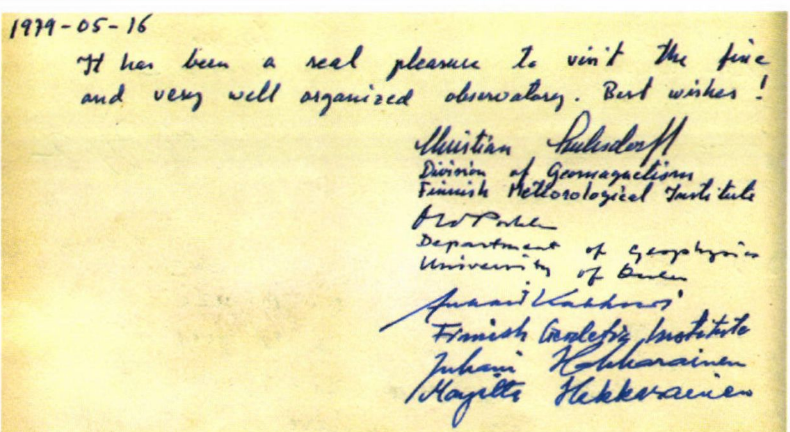
June 14, 1971


Группа советских специалистов-магнитологов посетили магнитную обсерваторию в Нагыценке. С большим интересом ознакомились с работой венгерских коллег.

24 марта 1976

Бобров (ИЗМИРАН)
Афанасьева (Мурманск, ПГИ, КФАН СССР)
Дмитриева (ЛГУ, Ленинград)
[illegible] (СибИЗМИР г. Иркутск)
Киселев (ЛГУ, Ленинград)
М. [illegible] (МЦД-Б2) (WDC-B2)

March 24, 1976


1979-05-16
It has been a real pleasure to visit the fine and very well organized observatory. Best wishes!

Christian Sucksdorff
Division of Geomagnetism
Finnish Meteorological Institute
[illegible]
Department of Geophysics
University of Oulu
[illegible]
Finnish Geodetic Institute
Juhani [illegible]
Marjatta [illegible]

May 16, 1979

I am most grateful for this opportunity to renew my acquaintance with Dr Noda and Dr Verö and I look forward to collaboration in our work that will let me return on a warmer day!

Wm H Stuart

I.G.S. Edinburgh.

I have enjoyed very much my short stay in Sopron and short visit to the observatory at Nagycenk. I am grateful to Dr Ádám and others for making this visit possible and for their hospitality.

Frank Frischknecht

Denver, Colorado

The visit to Sopren has been very special because of the hospitality of our hosts. Dr. Ádám and his colleges can be proud not only of theirs scientific work but their fine abilities as hosts. I am looking forward to returning.

Bruce D Smith

USGS DENVER, COLORADO

1981 August 24

Mit dem großen Dank für Ihre freundliche Einladung

Naoshi Fukushima

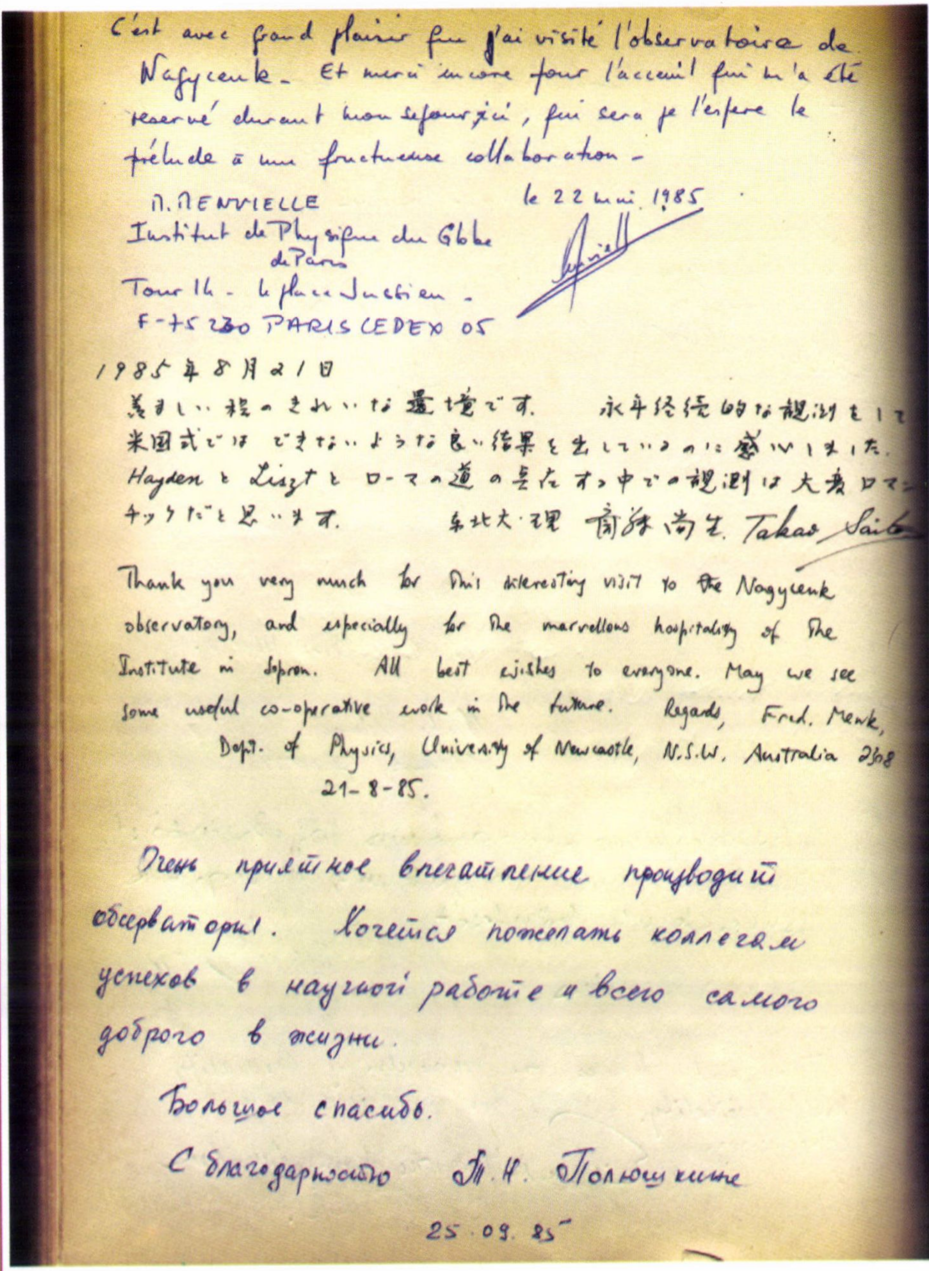
Geophys. Res. Lab. Univ. Tokyo

福島直

Address: 東京大学理学部

地球物理研究施設

1981


C'est avec grand plaisir que j'ai visité l'observatoire de Nagycenk. Et merci encore pour l'accueil qui m'a été réservé durant mon séjour ici, qui sera je l'espère le prélude à une fructueuse collaboration.

M. MENVIELLE
Institut de Physique du Globe de Paris
Tour 14 - 4 place Jussieu -
F-75230 PARIS CEDEX 05

le 22 mai 1985

1985年8月21日
美しい緑のきれいな環境です。 永年継続的な観測をして米国式ではできないような良い結果を出しているのに感心しました。Hayden と Liszt と ローマの道のまっただ中での観測は大変ロマンチックだと思います。 東北大・理 齋藤尚生 Takao Saito

Thank you very much for this interesting visit to the Nagycenk observatory, and especially for the marvellous hospitality of the Institute in Sopron. All best wishes to everyone. May we see some useful co-operative work in the future. Regards, Fred. Menk,
Dept. of Physics, University of Newcastle, N.S.W. Australia 2308
21-8-85.

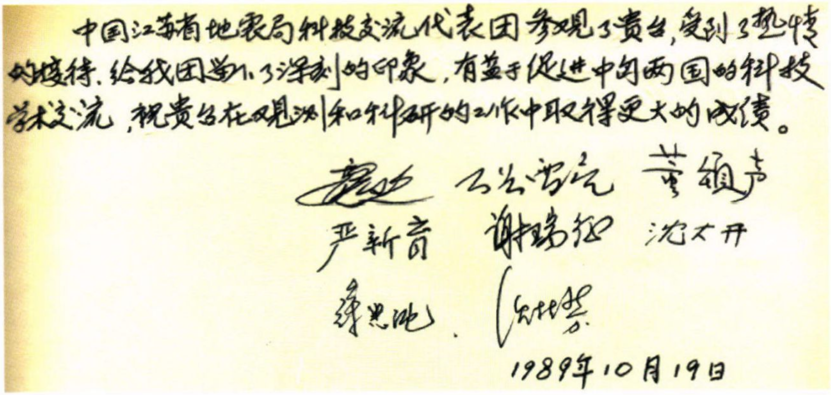
Очень приятное впечатление производит обсерватория. Хочется пожелать коллегам успехов в научной работе и всего самого доброго в жизни.

Большое спасибо.

С благодарностью П.Н. Полюшкина

25.09.85

1985



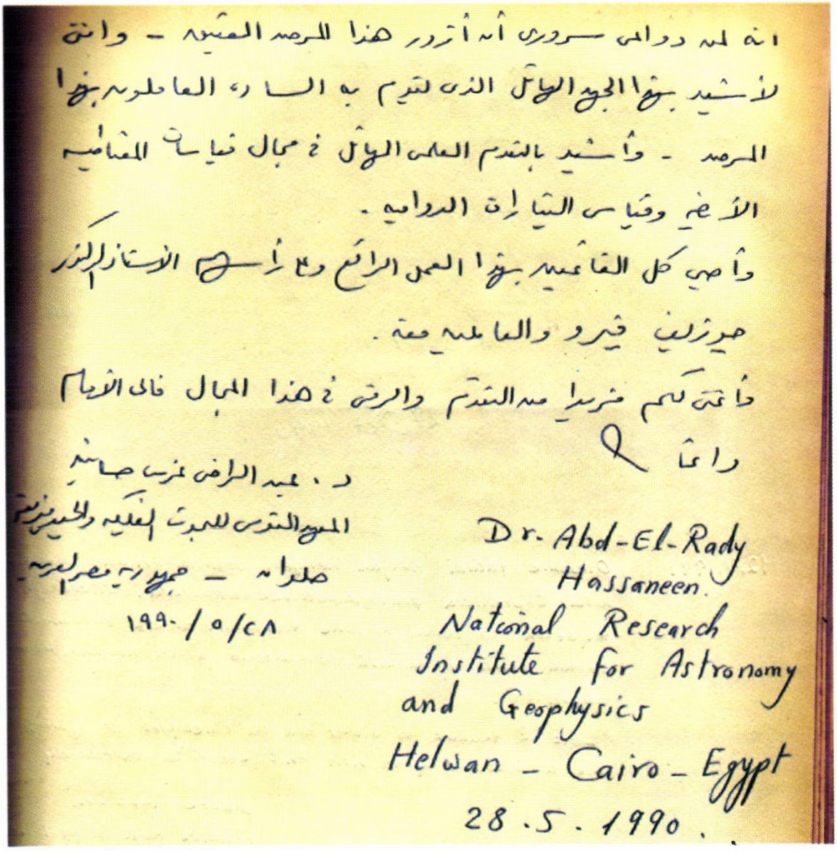
中国江苏省地震局科技交流代表团参观了贵台，受到了热情的接待，给我团留下了深刻的印象，有益于促进中匈两国的科技学术交流，祝贵台在观测和科研的工作中取得更大的成绩。

董颂声

严新育　谢瑞征　沈大开

1989年10月19日

October 19, 1989

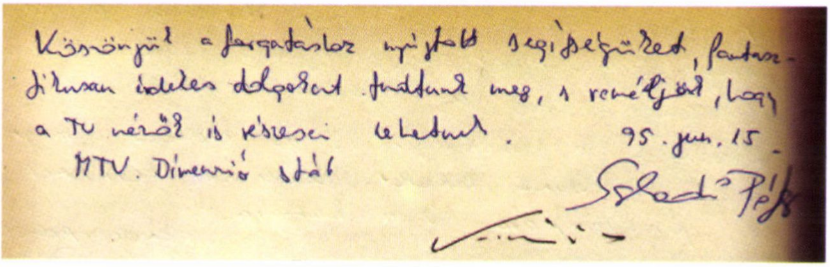


انه لمن دواعي سروري أن أزور هذا المرصد العريق – وانني
لأشيد بهذا الجهد الهائل الذي تقوم به السادة العاملون بهذا
المرصد – وأشيد بالتقدم العلمي الهائل في مجال قياسات المغناطيسية
الأرضية وقياس التيارات الدوامية.
وأهنئ كل القائمين بهذا العمل الرائع ومع تحية الأستاذ الدكتور
هيرزليف فيرو والعاملين معه.
وأتمنى لكم مزيدا من التقدم والرقي في هذا المجال فإلى الأمام
دائما

د. عبد الراضي حسانين
المعهد القومي للبحوث الفلكية والجيوفيزيقية
حلوان – جمهورية مصر العربية
١٩٩٠/٥/٢٨

Dr. Abd-El-Rady Hassaneen.
National Research Institute for Astronomy and Geophysics
Helwan – Cairo – Egypt
28.5.1990.

May 28, 1990

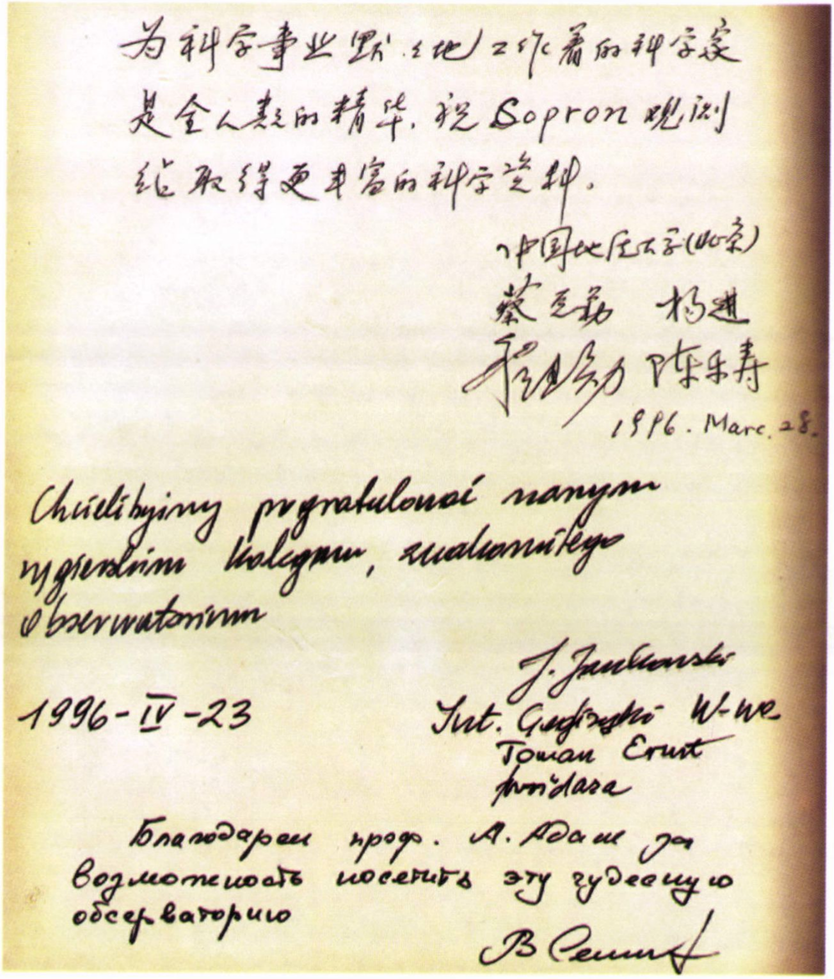


Köszönjük a forgatáshoz nyújtott segítségüket, fantasztikusan érdekes dolgokat tudtunk meg, s reméljük, hogy a TV nézők is érdekesnek találják.

95. jun. 15.

MTV. Dimenzió stáb

June 15, 1995



为科学事业默默地工作着的科学家是全人类的精华。祝Sopron观测站取得更丰富的科学资料。

中国地质大学(北京)

杨进

陈乐寿

1996. Marc. 28.

Chciałbym pogratulować naszym węgierskim kolegom wspaniałego obserwatorium

J. Jankowski

1996-IV-23

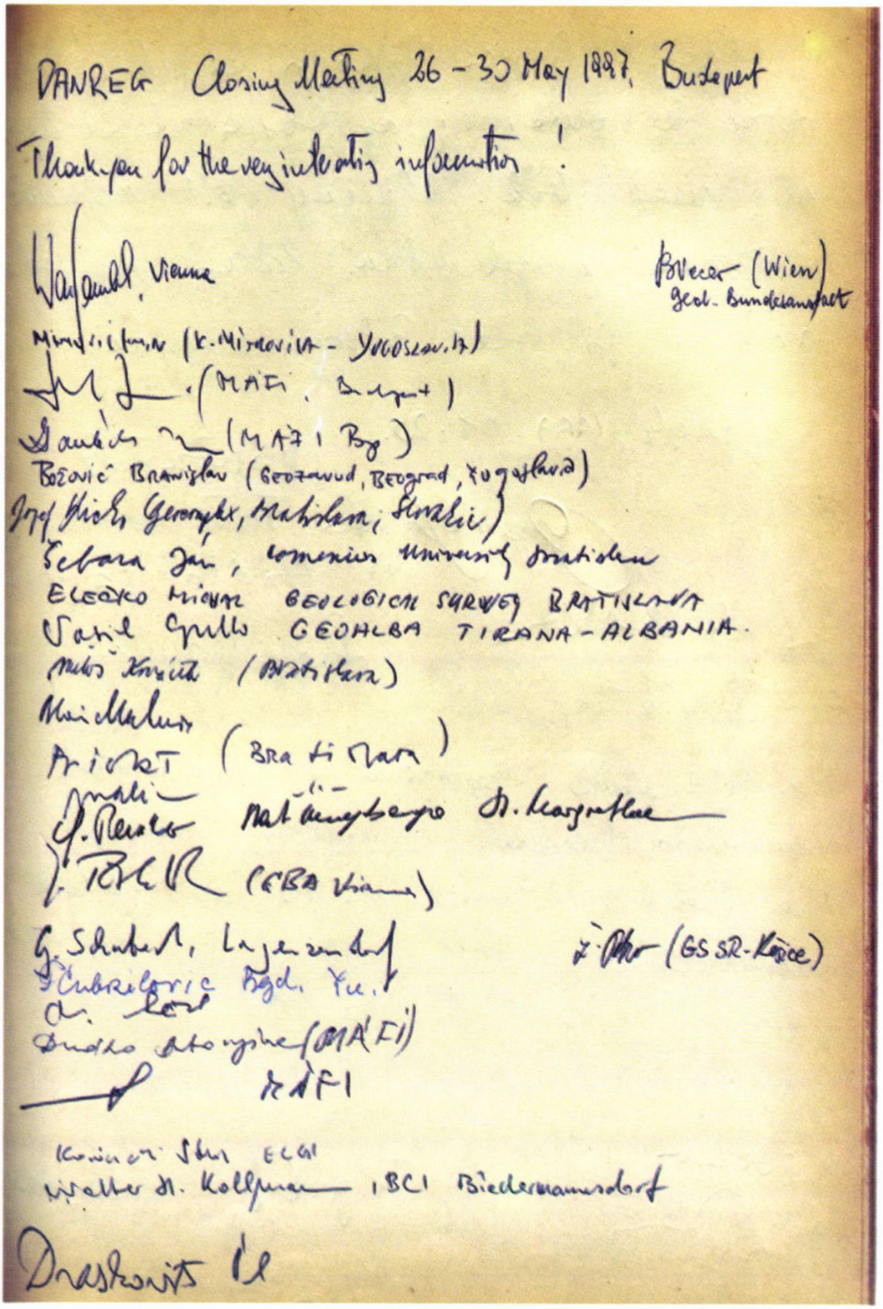
Inst. Geofizyki W-wa

Toman Ernst

Благодарю проф. А. Адама за возможность посетить эту чудесную обсерваторию

В. Семенов

March-April, 1996


DANREG Closing Meeting 26 – 30 May 1997, Budapest

Thank you for the very interesting information!

Wessely, Vienna

B. Vecer (Wien) Geol. Bundesanstalt

(K. Mirkovic – Yugoslavia)

(MÁFI, Budapest)

(MÁFI Bp)

Božović Branislav (Geozavod, Beograd, Yugoslavia)

Jozef Michalík, Geologický, Bratislava, Slovakia)

Sebara Ján, Comenius University Bratislava

Elečko Michal Geological Survey Bratislava

Vasil Gjullo GEOALBA TIRANA-ALBANIA.

Miloš Kováčik (Bratislava)

(Bratislava)

(GBA Vienna)

G. Schubert, Langenzersdorf

(GS SR-Košice)

Čubrilović Bgd. Yu.

(MÁFI)

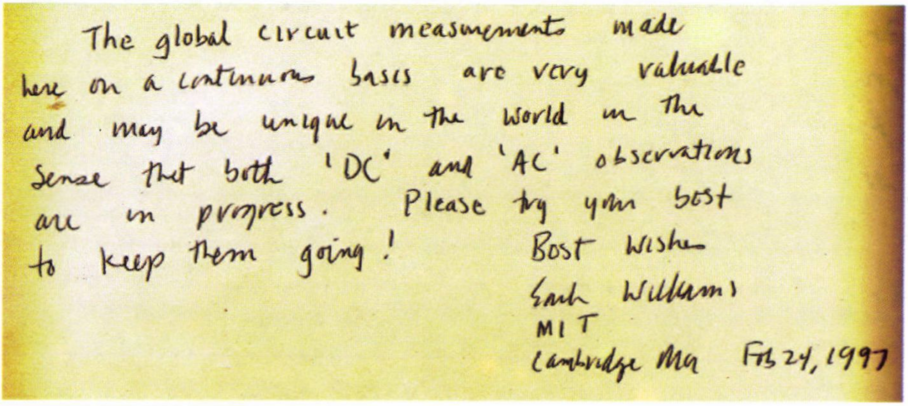
MÁFI

ELGI

Walter H. Kollmann, BCI Biedermannsdorf

Draskovits

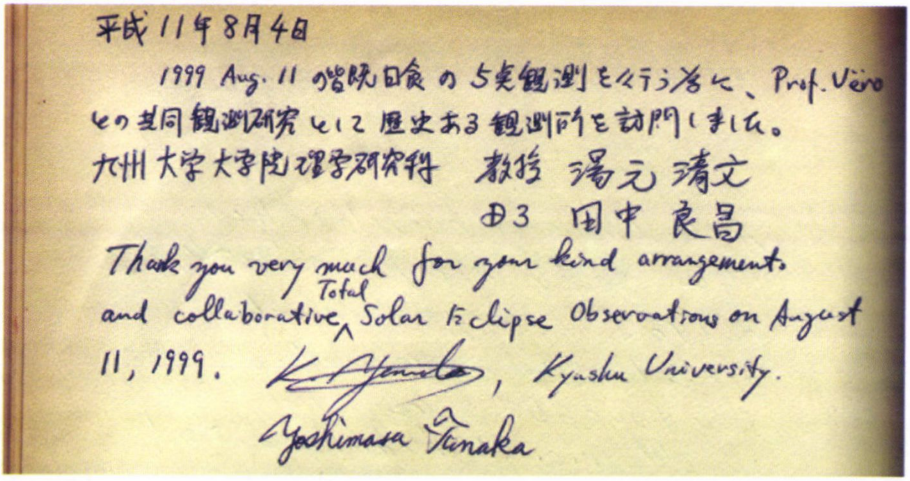
May, 1997



The global circuit measurements made here on a continuous basis are very valuable and may be unique in the world in the sense that both 'DC' and 'AC' observations are in progress. Please try your best to keep them going!

Best Wishes
Earle Williams
MIT
Cambridge Ma Feb 24, 1997

February 24, 1997



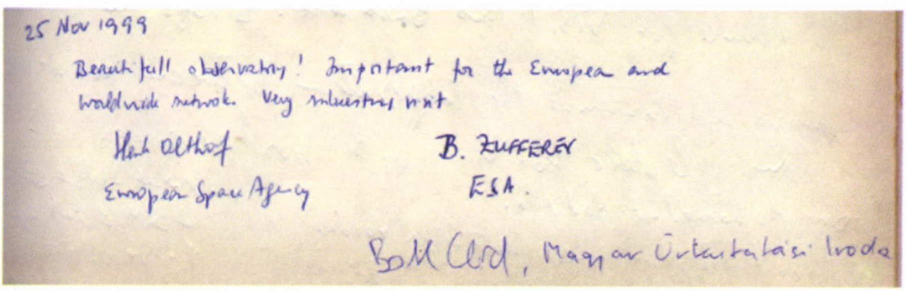
平成11年8月4日

1999 Aug. 11 の皆既日食の共同観測を行う為に、Prof. Vero との共同観測研究として歴史ある観測所を訪問しました。

九州大学大学院理学研究科 教授 湯元清文
D3 田中良昌

Thank you very much for your kind arrangements and collaborative Total Solar Eclipse Observations on August 11, 1999. K. Yumoto, Kyushu University.
Yoshimasa Tanaka

August 11, 1999



25 Nov 1999

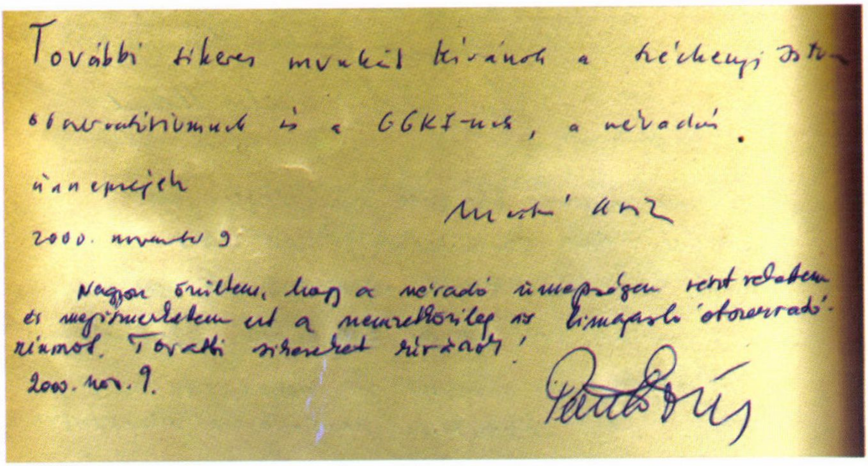
Beautifull observatory! Important for the European and worldwide network. Very interesting visit

Henk Olthof
European Space Agency

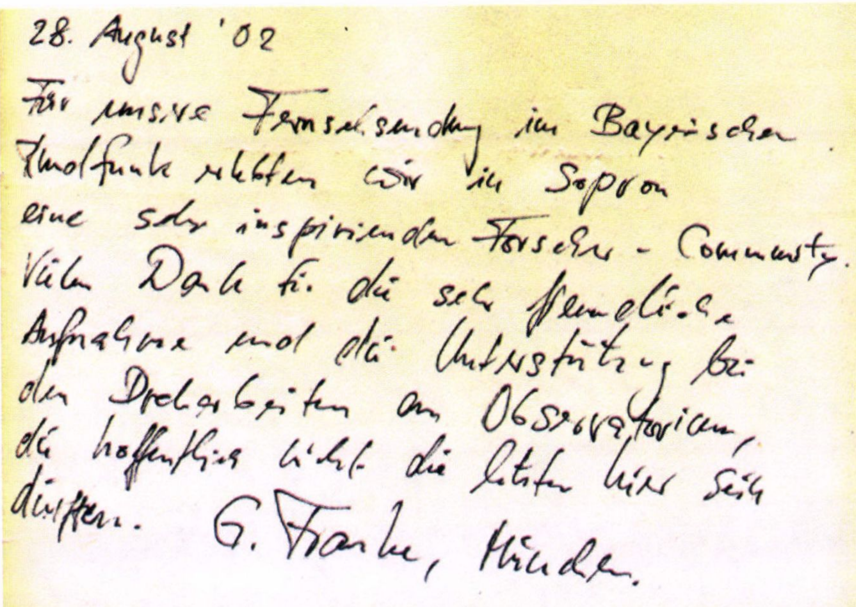
B. ZUFFEREY
ESA.

[illegible], Magyar Űrkutatási Iroda

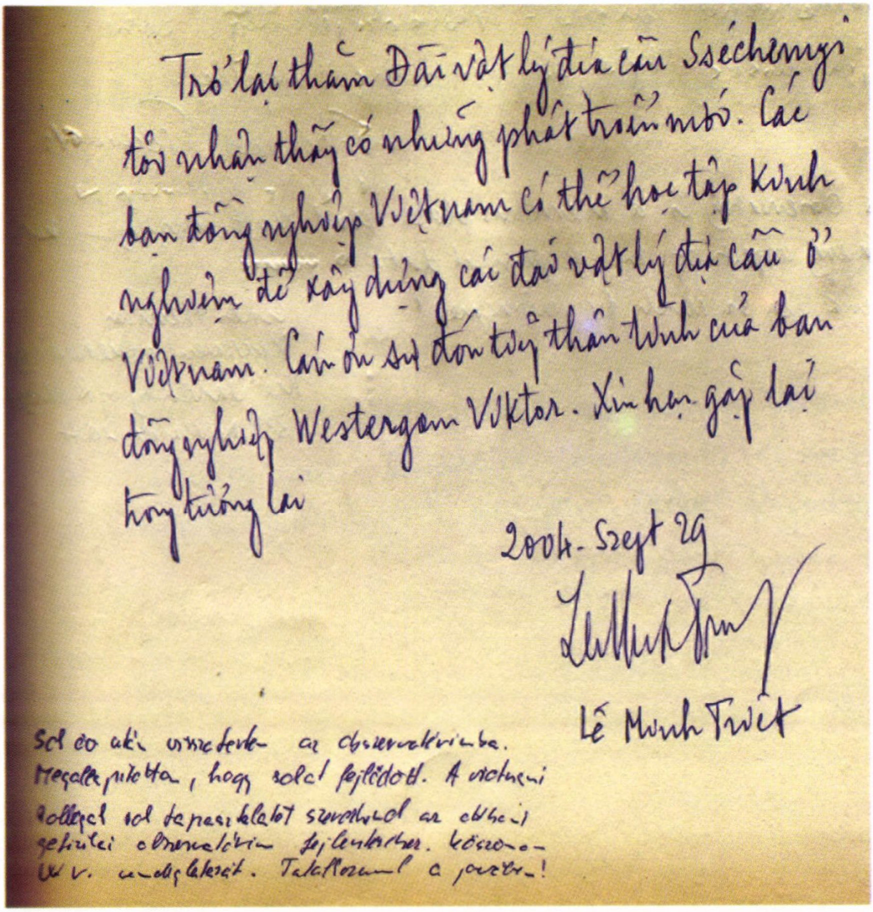
November 25, 1999



November 9, 2000



August 28, 2002



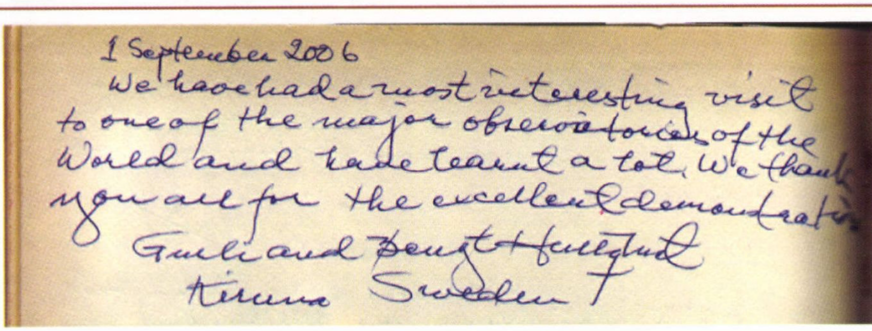
Trở lại thăm Đài vật lý địa cầu Széchenyi tôi nhận thấy có những phát triển mới. Các bạn đồng nghiệp Việt Nam có thể học tập kinh nghiệm để xây dựng các đài vật lý địa cầu ở Việt Nam. Cảm ơn sự đón tiếp thân tình của bạn đồng nghiệp Westergom Viktor. Xin hẹn gặp lại trong tương lai

2004- Szept 29

Lê Minh Triết

Sok év után visszatértem az obszervatóriumba. Megállapította, hogy sokat fejlődött. A vietnami kollégák sok tapasztalatot szerezhetnek az otthoni geofizikai obszervatórium fejlesztéséhez. Köszönöm W. V. vendéglátását. Találkozunk a jövőben!

September 29, 2004



1 September 2006

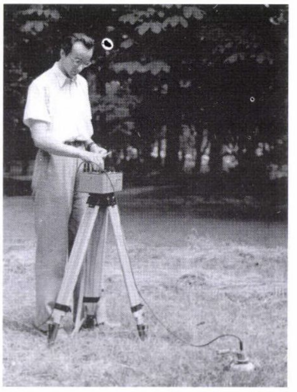
We have had a most interesting visit to one of the major observatories of the World and have learnt a lot. We thank you all for the excellent demonstration.

Gunli and Bengt Hultqvist

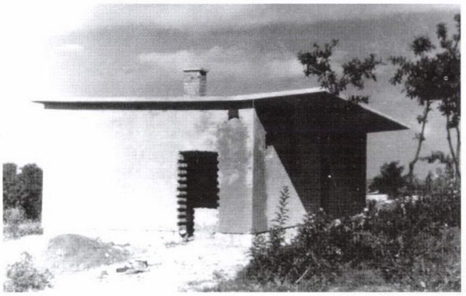
Kiruna Sweden

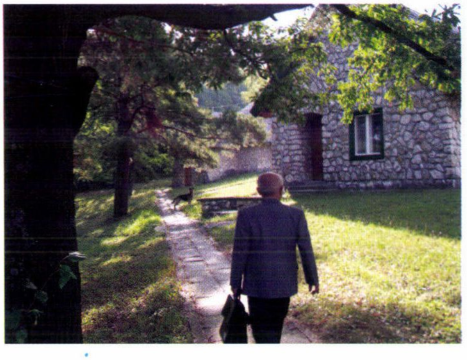
September 1, 2006

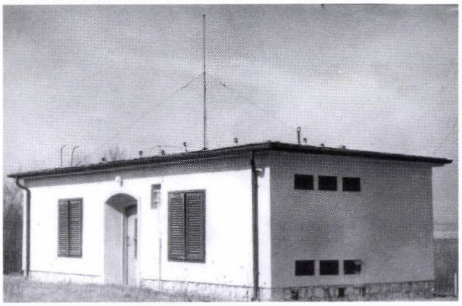
The Observatory site is searched for



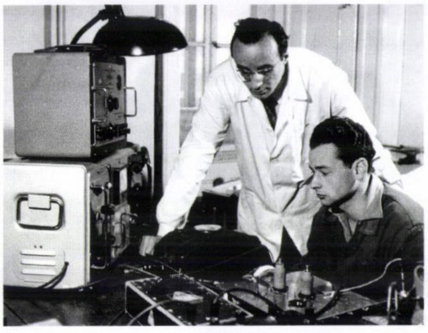
At that time and nowadays







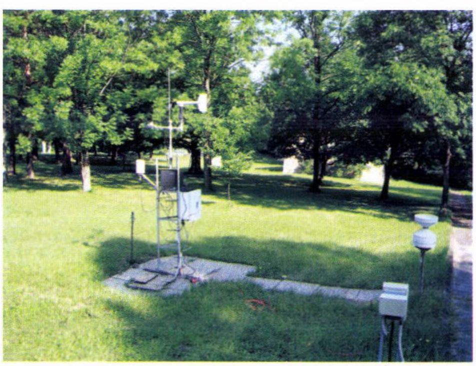




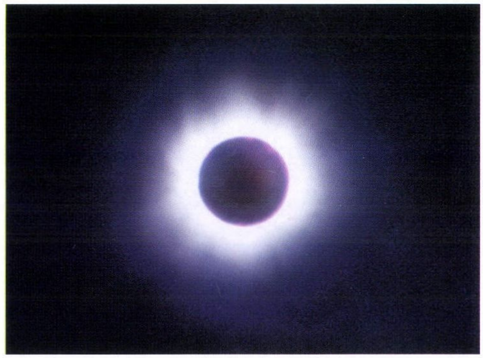


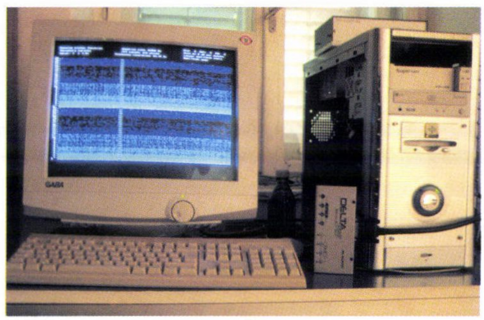












Name-giving ceremony, November 9, 2000







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