POSTER ABSTRACTS

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15.1 Introduction

The poster session is divided in three main topics: (1) observations from the ground, (2) observations from space and (3) theoretical modelling.

15.2 Observations from the Ground

15.2.1 Automated, Remote-Controlled Optical Observation Systems in TLE Research

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The observation phase of Transient Luminous Event (TLE) research has, for the optical part, been dominated by exhaustively long periods of waiting for events, or careful review of tape recordings of the night sky. The 2003 version of the Spritewatch observation system (Allin et al., 2004) represent the first automatic event detection system used in TLE research. Recording both digital video files and single event snapshot images, the system provided both high-quality documentation of TLE events, as well as continuous recordings for back-tracing on interesting times. Within the envelope of a standard personal computer, such an advanced, low cost observation system can be created in short time if no guidance is needed – e.g., to monitor the same region of interest over time. For the 2004 European Sprite campaign, a remotely guided 4-camera system was built, providing for the first time simultaneous recordings of broad-band, wide FOV "patrol" images and three-color, narrow FOV images of TLEs. The system is currently installed and operating from Pic du Midi de Bigorre, 42.9N, 0.01E, 2877 m above MSL.
Refs: T. H. Allin, J. L. Joergensen, T. Neubert and S. Laursen, The Sprite-

M. Füllekrug et al. (eds.),"Sprites, Elves and Intense Lightning Discharges", 377–394.

watch – A semi-automatic, remote-controlled observation system for transient luminous events, *IEEE Trans. on Measurement and Instrumentation, submitted, 2004.*

15.2.2 Observation of Schumann Resonance Transients at Nagycenk, Hungary

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Schumann Resonance (SR) transients are temporary excitations of the Earth-ionosphere waveguide by powerful electromagnetic pulse sources such as high energy lightning flashes in the Extremely Low Frequency (ELF) band (∼3 Hz-3 kHz). These transient excitations can be observed as coherent amplitude excursions of the electromagnetic field components. Geographical location, polarity and charge moment change of a vertical discharge type source can be estimated by processing the recorded time series. Investigation of these properties of a lightning flash has been of great interest as energetic lightning strokes are responsible for the occurrence of transient luminous events (TLEs) in the u pper atmosphere (sprite, ELVES, etc.) SR transients have been monitored at the Széchenyi István Geophysical Observatory (NCK) near Nagycenk, Hungary, since 1998. The poster presents the recording system for SR transients and covers the steps of data processing applied for a typical SR transient.

15.2.3 Post Filtering of Unwanted Powerline and Lightning Effects in VLF

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The dynamic range used in VLF-recordings is normally dominated by the disturbance peaks associated to the global lightning discharges. In addition, in the vicinity of powerlines, the 50 Hz harmonics and the powerline control signals produce disturbances with distinct frequecies to the data. In most cases the magnitude of these unwanted components is decades above the signatures associated to magnetospheric effects in VLF.

Software based post filtering techniques for the used orthogonal VLF-antenna measurement are presented in this poster. Used methods are based on filtering of the single frequencies for the powerline harmonics, and the linear polarisation filtering for the lightning signals.

15.2.4 Infrasonic Signatures of Thunder

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In the framework of the implementation of the Comprehensive Test Ban Treaty, infrasound monitoring of the waves produced by strong explosions will be realized with 60 stations unfolded all around the world. To differentiate natural events from a nuclear test event, we have to study the signature of different kind of natural events frequently observed.
We study here the signature of the infrasonic waves generated by lightning, e.g. the waveform, the frequency content, the variability of the waveform with distance and lightning current, and the lightning detectability. We research also the infrasound waves which could be produced by sprites.
This study is carry out using the data of the Flers infrasound station (France, 48.75N, 0.5W), composed of four microbarographs, obtained during the summer 2003. The detected signals are associated with lightning characteristics (localization, dating, lightning current) provided by Météorage. We realize a statistical study for the summer data and a specific study for a large thunderstorm occurring near the Flers station.
In conclusion, we present a method to differentiate infrasonic waves generated by lightning from those likely produced by sprites.

15.2.5 On the Absorption of ELF Signals in the Earth-Ionosphere Waveguide

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The weakly conductive lower atmosphere, bounded by the higher conductive ground and ionosphere, acts as a waveguide for electromagnetic waves in the ELF and VLF frequency ranges. Transmission properties are especially good in the lower ELF range between approximately 8 Hz and 1 kHz, where wave propagation takes place in the lowest, quasi-transverse, waveguide-mode. The attenuation in this frequency band is low enough, that strong electromagnetic pulses caused by lightning (sferics), can travel along the waveguide for several thousand kilometers. The frequency dependent phase velocity and absorption rate of these guided waves depend on the varying conductivity profile of the atmosphere, especially on the contribution by the lower ionosphere, and should therefore be useful parameters for characterizing this system. In this study, a simple method for determining the absorption rate from observations

on ELF sferics was tested, which uses amplitude measurements of the same sferic at different sites (Golden, 2001).

If the only reliable informations on a sferic are its amplitude at a single station and the location of its generating lightning, the determination of absorption rates or source currents requires rather detailed additional assumptions on the atmosphere and the lightning. Using additional amplitude measurements at a second site greatly simplifies these requirements: assuming only single mode wave propagation and a laterally homogeneous atmosphere between the sites, the dependence of amplitude on distance should be only affected by an exponential decay due to absorption and by a decay due to geometric spreading. Knowing the locations of lightning and stations, the contribution due to geometric spreading can be easily determined and subtracted. The ratio of the so corrected amplitudes can be set into relation to the difference of the source distance, as seen from the different stations, to determine the exponential decay factor, which represents the absorption rate.

The method was tested on a dataset collected during the Sprites'98 campaign: during July and August of 1998 three ELF-measurement stations were operated across western North America. Each station continuously recorded the horizontal magnetic field components, as measured by induction coil magnetometers, with a sampling rate of 2048 Hz. This dataset could have been used for the determination of the necessary lightning locations, as was demonstrated by Füllekrug and Constable (2000). However, for this study this information was taken from the National Lightning Detection Network (NLDN), which was also used for an automatic selection of the used lightnings (only strong CG's, larger than 500 LLP = 89.7 kA). After a first test, using only 16 manually selected, especially strong lightnings, the method was repeated for six automatically selected datasets, three of them using only day data, the other three using only night data.

A comparison of the results shows a significant difference between the determined day or night absorption rates: during daytime values from 3.5 to 3.9 dB/Mm were observed, while during nighttime values range from 2.5 to 2.8 dB/Mm. These results are in good agreement with values estimated earlier by Hughes and Gallenberger (1974), using a different method. The presented method thus is proved to work at least to first order accuracy. A possible application could be the use within a global ELF based lightning detection network, to continuously monitor absorption rate variations. Since these are related to large scale variations of the lower ionosphere, such measurements could form a useful contribution to more localized information, as is already gained from other measurements.

Refs: Füllekrug, M. and Constable, S., Global Triangulation of Intense Lightning discharges, *Geophys. Res. Lett.,* 27(3), 333-336, 2000.

Golden, S., Messung der Absorption atmosphärischer ELF-Impulse, *Diploma*

thesis (in German), Johann Wolfgang Goethe-Universität, Frankfurt am Main, 2001.
Hughes, H. G. and Gallenberger, R. J., Propagation of extremely low-frequency (ELF) atmospherics over a mixed day-night path. *J. Atmos. Terr. Phys.*, 36, 1643-1661, 1974.

15.2.6 A Global Lightning Location Algorithm Based on Electromagnetic Signatures in the Schumann Resonance Band

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A new, improved algorithm has been developed to geolocate intense lightning flashes around the globe. The method uses ELF (Extremely Low Frequency) radiation propagated in the Earth-Ionosphere cavity to locate unusually intense lightning strokes. Two parameters are needed to locate the lightning discharge from a single station: bearing and source-observer distance (SOD). The bearing was obtained using the Poynting vector ($E \times H$), while the SOD was obtained based on the modeling of the electric and magnetic ELF spectra, and the comparison with experimental data. To check the accuracy of our algorithm we used primarily infrared cloud top temperature images of deep convective storms from geostationary satellites (METEOSAT, GOES, GMS). Analysis of ELF data from our field station of 147 events gave an average source-observer distance error of 660 km (7.05%) and azimuth error of 1.9°. Of the 147 events 72% had positive polarity, while the majority (59%) occurred over the oceans.

15.2.7 Neutral and Charged Particles at Low Latitudes. Is their Connection with Thunderstorms Possible ?

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Various electrodynamics processes above thunderstorms give rise to a variety of phenomena, such as energetic electron fluxes, gamma rays, quasi-electrostatic fields, electromagnetic pulses, VLF/LF signals, optical emissions ('red sprites' and 'blue jets'), and so on. Some of them are discussed here in detail. The connection between electron fluxes and lightning flashes at L > 1.8-2.0 is verified theoretically and experimentally (Inan et al., 1988; Inan and Carpenter, 1987). The electron fluxes (Ee 100keV) appeared to coincide with the locations of thunderstorms near the equator were observed on board MIR orbital station (Grigoryan et al., 1997; Bratolyubova-Tsulukidze et al., 2001). However, the mechanism of electron production at high altitudes is not yet evident.

The possibility of satellite neutron observation is of great importance. It was observed during a high-powered exploding wire discharge experiment that 2.10^{10} neutrons were produced. Atmospheric lightning discharges are also high powered and the lightning power properties are similar to the exploding wire discharge plasma. Therefore it was suggested (Stephankis et al., 1972; Libby and Luken, 1973; Libby and Luken, 1975) that $\sim 10^{15}$ neutrons can be produced by lightning discharge. Also on the basis of the experiments (Shyam and Kaushik, 1999) it was concluded, that neutron bursts ($10^8 - 10^9$ magnitudes) are associated with lightning. One of the possible neutron production mechanisms could be protons and deuterons accelerated in lightning discharge and neutron production in nuclear reactions with other elements of the environment. The similar result was obtained using a neutron detection system (the detectors square of 1 m^2, En<0.5 eV) at Lomonosov Moscow State University. The observed neutron bursts were associated with lightning (Bratolyubova-Tsulukidze et al., 2003). The approximate distance of lightning discharges from our detector was $\sim$1 km. Therefore the total number of neutrons produced by one typical lightning discharge may be estimated as 2.5 10^{10}.

15.2.8 Sprites Observed over France on 23 July 2003 in Relation to their Parent Thunderstorm System

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For our research of meteorological aspects associated with sprite events, 23 July 2003 was particularly interesting because of the availability of both cloud-to-ground and intracloud lightning activity data. A large thunderstorm with two convective areas developed over southern France during the late afternoon. About two hours after sunset, the first sprite was detected. In about three hours, 13 sprites were observed, 7 over the northern part and 6 over the southern part of the mesoscale convective complex. Twelve of the thirteen sprites were associated with positive cloud-to-ground flashes, and one could be associated with an intracloud flash. Sprites tended to occur over the stratiform region of the storm system in the area with the coldest (highest) cloud tops. The associated positive flashes were also within or close to this portion of the storm. Sprite-associated +CGs had higher peak currents on average, but the relationship was rather weak. Sprites occurred in the late stages of the two storm areas, with decreasing -CG and IC lightning activity, while +CG activity remained stable or increasing. In these stages, there was a high ratio of +CG flash rate to total flash rate. Overall, the intracloud activity was low during the sprite-producing periods, but sudden bursts of VHF sources produced by intracloud lightning have frequently been observed at the moment of the sprite. The areal coverage of the radar echo was calculated. The result supports the idea that sprite events tend to appear almost exclusively over large thunderstorm systems.

15.2.9 Sprite Observations from Langmuir Laboratory, New Mexico

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The goals of this project are:
1. Image sprites using a high-speed CCD camera (1000 fps +) mounted to a Dobsonian telescope, yielding fine temporal and spatial resolution images of sprites. These images can be used to more closely analyze sprite initiation and streamer propagation, including the transition from column streamers to branches. Combine these images with Wide field-of-view images, photometric data, and charge moment calculations from broadband ELF measurements of sferics.
2. Use photometric data of sprite halos to correlate their occurrence with so-called Early/Fast VLF ionospheric disturbances.
3. Use wide field-of-view images from Langmuir and Jemez Mountains to triangulate sprite locations and deduce accurate altitudes.

Results so far show over 60 sprite images, with two appearing in the high-speed / telescopic field of view. Sprites and sprite halos are visible in photometer data. VLF data has yet to be analyzed.

15.2.10 VLF Signatures Associated with Sprites

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Observations on the nights of July 21-24, 2003 of the ionospheric effects of thunderstorms located in Central France are reported. A camera system in the Pyrenees captured 49 sprites. A narrowband VLF receiver located at Crete observed subionospheric VLF signals from six ground-based transmitters. The amplitude of one of the VLF signals exhibited rapid onset perturbations occurring in nearly one-to-one relationship with the optical sprites. The results of the data analysis are grouped as follows:
1. Study the relationship between sprites and associated VLF signal perturbations

2. Quantify the onset durations of sprite related VLF events
3. Consider the recovery phases and study their variation with time
4. Investigate the non-ducted LEP events observed during these storms and in relation to the sprites.

15.2.11 Stratospheric Electric Field, Magnetic Field and Conductivity Measurements Above Thunderstorms: Implications for Sprite Models

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Electric and magnetic fields and conductivity were measured in the stratosphere (32-34 km altitude) above thunderstorms as part of the Sprite Balloon Campaign 2002-2003 in southeastern Brazil. During the two balloon flights, the payloads measured hundreds of electric field transients, some as large as 130 V/m, correlated with lightning events. Also, conductivity variations over thunderstorms of at least a factor of two different from the fair weather values were measured. Since optical verification of sprites was not achieved during these flights and recent studies (Hu et al. 2002) have found that the probability of sprite production is proportional to the charge moment of the corresponding positive cloud-to-ground (+CG) stroke, we rely on charge moment estimates from remote ELF observations in Onagawa, Japan and Syowa, Antarctica to indicate possible sprite events. Here we present a detailed study of several nearby (<60 km) positive +CG strokes indicated by the ELF charge moment estimate to be probable sprite generators. By using a quasi-static electric field model (Pasko et al. 1997), we show how these large field changes correlated with +CG strokes, along with varying conductivity over thunderstorms, may provide the necessary conditions for sprite development.

15.2.12 Triggering of Positive Lightning and High-Altitude Atmospheric Discharges

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Triggering of electrical atmospheric discharges can be caused by a number of physical mechanisms, among them the non-linear effects concerning the earthquakes.

The cases of earthquake triggering by seismic waves from other earthquakes at the big angular distances in 30-year period have been computed. All evaluations for definition of possible phases of seismic waves and evaluations of

their travel times were conducted with the use of model AK135, built on the basis of model IASPEI91.
The space-time coupling of earthquakes and electrical discharges in atmosphere have been found at big angular distances. The angular distribution of positive cloud to ground discharges (+CG) has been analysed on the Malaysian LDN data, and space-time coupling with exact seismic waves from the earthquakes has been described.
On the base of actual data records, the cases of electromagnetic pulses generation at the big angular distances by seismic waves from the earthquakes have been discovered. The detected signals have sub-millisecond duration and high intensity. The amplitude and time characteristics of sub-millisecond electromagnetic pulses have also been studied. Electromagnetic pulses related with seismic waves can provoke positive lightning and transient luminous events. One of the provoking factors, promoting development +CG and transient luminous events, is passage of seismic waves through a place of event. The known video observations (Mitchell at al. 1997; Vaughan at al. 1997) have been studied together with the NLDN data. Space-time coupling between exact earthquake seismic waves and eight high-altitude electric discharges in atmosphere (6 Red Sprites, Vertical Pulse, Elve) was found on the big angular distances.

15.3 Observations from Space

15.3.1 Transient Luminous Events Explored by the ROCSAT-2/ISUAL Instrument: Observation with the Array Photometer

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In this study, we report preliminary results of TLE observations using the Array Photometer (AP) onboard the ROCSAT-2 satellite. The ROCSAT-2 satellite with a scientific payload named ISUAL (Imager of Sprites/Upper Atmospheric Lightning) is the first satellite which observes transient luminous events from space. The ISUAL is composed of an imager, a spectrophotometer, and an array photometer (AP). The AP provides us spectral information by measuring two wave length ranges of 360-470 nm and 520-750 nm selected by blue and red filters, respectively. Each photometer has 16 channels aligned in vertical and spatial resolution corresponds to $\sim$11 km in the cases of sprites occurring at the limb point 3315 km away from the satellite. The time resolution of 50 or 500 μs enables us to detect fast temporal variation of sprites which have average durations of several to tens of ms. The AP succeeded in detecting clear upward/downward vertical motions of sprites in both the blue and red channels with quite high signal-to-noise ratios compared with ground-based observations. By calculating the Blue/Red (B/R) emission intensity ratio, it is clarified that sprites are bluer in the earlier stage and at lower altitudes.

15.3.2 Fractal Analysis Method Applicability to Terrestrial Gamma-Ray Flashes

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The TGF (Terrestrial Gamma Flashes) were first detected by BATSE experiment (based on 8 NaI(Tl) detector modules consists of 2 detector each: Large Area Detector ⊘20" and 0.5" thick and Spectroscopy detector ⊘5" and 3" in thick) onboard CGRO satellite. Observed TGF had duration 0.01÷20 ms. TGF are produced in a process of bremsstrahlung of the runaway electrons in the middle atmosphere which are accelerated upward by the thundercloud electric field and collide with the material constituting the atmosphere. These electrons are very energetic (E_e ∼1 MeV) and the γ-radiation pattern is directed along the beam. Some short events with duration 1÷16 ms are registered by AVS-F apparatus. The AVS-F (amplitude-time Sun spectrometry) apparatus is intended to study characteristics of fluxes of hard X-rays, γ-rays and neutrons from the Sun and solar flares and to detect and record events like γ-ray bursts. The experiment is carry out at the CORONAS-F special-purpose automatic station (NORAD catalog number 26873, International Designator 2001-032A) that had been launched from Russian kosmodrom Plesetsk at 11:00 UT of 31 July 2001 into a circular orbit oriented towards the Sun with inclination 82.5° and altitude ∼500 km. The AVS-F apparatus uses signals produced by the SONG-D detector (based on the CsI(Tl) crystal ⊘ 20 cm and height of 10 cm, energy deposition ranges of 0.1÷17.0 MeV and and 4.0÷94.0 MeV by up to date calibration data), XSS-1 detector (the semiconductor detector with 3-30 keV energy deposition range) and the anticoincidence signal generated by the plastic scintillation counter of SONG-D. According the AVS-F experiment description, observed short events may be TGF or can caused by following apparatus reasons: fluorescence of CsI(Tl) after charged particle pass through it; fluctuations of photoelectron number or ions of photomultiplier filler after charged particle pass through it; transient processes in electronic system caused by great energy deposition in detector. We use the fractal analysis of temporal profiles for separation TGF because all background fluctuation (including ones leads to apparatus short events) in AVS-F apparatus are Poisson in energy region 0.1÷17 MeV outside the radiation belt and SAA and counts rates time intervals had exponential distribution. Fractal dimension of such temporal profiles is equal to 1.5 if it is possible to consider the mean count rate as constant within studying time interval. We have analyzed 100 temporal profiles with duration 4096 ms in energy region of 0.1÷17 MeV registered by AVS-F apparatus in equatorial regions The mean fractal dimension for 97 analyzed time intervals is D=1.50±0.03 and in 3 cases different values were obtained: D=1.63±0.03, D=1.37±0.03, D=1.62±0.03. These short events are similar to TGF on temporal profiles shape and duration and one of them were registered during strong tropical cyclone Beni. The location of this short event is near cyclone center. Now we study weather condition during other two events.

15.3.3 Searching for Lightning-Induced Terrestrial Gamma Ray Bursts on CORONASF Satellite

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There are few low-altitude satellite or balloonborne measurements (e.g. SAMPEX, LACE) indicating both atmospheric loss cone energetic electrons (Blake et al., 2001) and daughter bremsstrahlung hard X/gamma ray enhancements (Feldman et al., 1996) suggested to be associated with thunderstorms. Seasonal variations in precipitating trapped electrons have been reported those emissions are most enhanced during the northern summer months. We analyze data received by the SOlar Neutron and Gamma rays (SONG) device aboard low altitude (∼500 km) polar orbiting CORONASF satellite, which provides high time resolution measurements (1 s in burst mode) of X/gamma rays in range of 0.037 MeV. The omnidirectional sensor consists of large area CsI scintillator (20×10 cm) surrounded by a 2 cm thick anticoincidence shield for charged particles. X/gamma-ray fluxes measured on satellite altitude are surveyed to discuss the competitive sources of lightning induced gamma ray terrestrial flashes. The preliminary geographic maps of average intensity during October December 002 in the four channels (30-60 keV, 60-150 keV, 150-500 keV and 500-1500 keV) demonstrate intense gamma ray emissions distributed along all longitudes under the outer radiation belt (L∼36). Since these magnetic storm driven enhancements mask the lightning induced electron precipitation events we concentrate on inner zone electron belt (L<2) as well as on the slot region (L∼23). The longitudes outside the South Atlantic Anomaly region which is the region of stable trapped particle population at the satellite altitude are the most convenient to follow. During the geomagnetic quiet time in the studied three months period the CORONASF data reveals either conjugate bounce loss cone and drift loss cone enhanced fluxes observed at

L∼2.2 perhaps associated with underlying lightning documented by the Lightning Imaging Sensor (LIS) on board TRMM satellite.

Refs: Blake, J. B., Inan, U. S., Walt, M., Bell, T. F., Bortnik, J., Chenette, D. L. and Christian, H. J., Lightning-induced energetic electron flux enhancements in the drift loss cone, *J. Geophys. Res.,* 106, 29733-29744, 2001.

Feldman, W. C., Symbalisty, E. M. D., and Roussel-Dupré, R. A., Hard X ray survey of energetic electrons from low Earth orbit, *J. Geophys. Res.,* 101, 5195-5209, 1996.

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15.3.4 Seismo-electromagnetic Emissions

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In the last decades a possible influence of electromagnetic fields of seismic origin in the ionosphere-magnetosphere transition region has been reported in literature. In recent years, a few space experiments also revealed anomalous bursts of charged particles precipitating from the lower boundary of the inner radiation belt. They were thought to be caused by low-frequency seismo-electromagnetic emissions. A temporal correlation between earthquakes with M≥5.0 and anomalous particle bursts collected by the PET-SAMPEX satellite mission is critically investigated and presented in this chapter. A short-term seismic precursor of $\sim 4 \div 5$ hours is observed in the histogram of the time difference between the time occurrence of earthquakes and that of particle burst events. The best correlation is obtained only when considering high-energy electrons (E≥4 MeV) near the loss cone. At present are available only data from space experiments not dedicated to observation of seismo-electromagnetic emission and related phenomena. Results suggest the importance of coordinated and simultaneous ground-based and space investigations specifically dedicated to the subject. The new ESPERIA satellite mission devoted to investigate the seismic influence on the ionosphere-magnetosphere transition region is presented. Proposals for other experiments on board of ESPERIA will allow to study: 1) Relevant phenomena caused by external sources (sun and cosmic rays) or generated inside the magnetospheric cavity, 2) Luminous emissions (Sprites, Blue jets, Elves, Trimpis,...) during thunderstorm activity, 3) Atmospheric & ionospheric structure and dynamics.

15.3.5 First Results of Transient Luminous Event Observations by ISUAL

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The Imager for Upper Atmospheric Lightning (ISUAL) contains a Spectrophotometer with six individual photometers covering the spectral range from the far ultraviolet to the near infrared. The photometers point towards the limb and integrate the light in a field of view of 20×5 degrees. Sudden changes in the amplitude of the output signal are used to trigger the other ISUAL components (Imager and Array Photometer) to collect data. The photometers cover well known spectral ranges of TLE as for instance the N2-1P band at 623-750 nm or the lightning signature at 777.4 nm. In addition there are two photometers for the far-UV (150-280 nm) and near-UV (250-390 nm) that are aimed at spectral signatures of TLE that are only observable from space due to the absorption by atmospheric O_2 towards ground-based instruments. After commissioning of the instrument, the routine observations started on July 1, 2004. We present some of the first detected sprites and elves and discuss their specific spectral signatures and appearance in the images.

15.3.6 Detection of Terrestrial Gamma-ray Flashes with the RHESSI Spacecraft

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We report the detection of Terrestrial Gamma-Ray Flashes (TGFs) with the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI), the second instrument ever to observe this phenomenon. The first instrument to detect these events was the Burst and Transient Source Experiment (BATSE), launched on board the Compton Gamma-Ray Observatory (CGRO) in 1991. We have analyzed 5 months and present here the preliminary results of two TGF burst events. The data show photon energies extend to greater than 15 MeV. Time duration for the events analyzed so far is less than 1 millisecond. RHESSI records every interaction in 1 microsecond time bins and into one of 9 germanium detectors. These events may be caused by electrical discharges in the upper atmosphere related to large lightning storms although there have been alternate models proposed. A relationship with high-altitude optical phenomena, namely sprites and blue jets, has been considered.

15.3.7 ENVISAT Capabilities of Observing High Altitude Optical Phenomena

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The ENVISAT satellite covers the whole Earth in a heliosynchronous polar orbit and was launched on March 1^{st} 2002 and its ten Earth observation instrument began to deliver commissioned data in late 2002. The variety of atmospheric sensors, especially the limb sounders SCIAMACHY, MIPAS and GOMOS is superior to any previous payload for their study. Also, as polar troposphere and lower stratosphere studies demand the knowledge of the emissions from the upper atmosphere, they must be eliminated by a combination of their detection in the signal itself and their theoretical modelling. Outside the auroral regions, high altitude emissions exist too and are worth studying. This is the case for SPRITE related emissions. The final result will be the understanding of the gaseous, energetic and meteoric structure of the mesosphere and thermosphere.

SPRITE studies can be addressed by the eclipse mode of SCIAMACHY, where nadir observations between 220 nm and the middle infrared are performed for dark current study. MIPAS, as an infrared sounder is also a nighttime active instrument. GOMOS as a pure limb sounder has broad footprint and would probably miss SPRITEs and did not report these phenomena until now.

SCIAMACHY nadir night side observations were conducted between December 2002 and September 2004, when the necessity for continuous dark current studies stopped. The data has unfortunately not yet been distributed despite that it is requested by several AO proposals, this is due to the priority given to the validation data base as the ENVISAT atmospheric instruments are not yet fully validated, also environmental objectives in the upper troposphere and lower stratosphere are given priority for distribution as they lead to operational applications. The data are however archived and sample cases will continue to be requested so that a resumption of this mode could be requested on the basis of the existing data.

15.4 Theoretical Modelling

15.4.1 Do sprites Impact Climate? An atmospheric Coupling Approach.

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Understanding of climate change requires a knowledge of the atmospheric response to perturbations. Sprites, believed to be NO_x sources, may cause local perturbations of no large entity. However, because of the highly non linear response of the middle atmosphere to chemical perturbations, feedback processes may cause indirectly important changes in the forcing to the troposphere. If this results in an impact on climate depends on the possibility of the forcing to propagate to the troposphere.
For this reason, we have started a joint effort to model coupling mechanisms of the lower and upper atmosphere. We use a global circulation model (GCM) to study the lower atmosphere and a stratosphere-mesosphere model for the upper regions. Together, they provide an extended view from the troposphere (climate processes) to the middle atmosphere (directly affected by solar forcing and sprites).
Here, we present some of the evaluation results from the SMM model (middle atmosphere) and from the attempt to simulate downward propagation processes as coupling of atmospheric layers.

15.4.2 The Sodankylä Ion Chemistry model: Application of Coupled Ion-neutral Chemistry Modelling

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This poster presents the Sodankylä Ion Chemistry (SIC) model, which is presently being modified in order to model the chemical effects of transient luminous events (TLEs) and artificial ionospheric heating.
The effects of ionisation and electron temperature enhancements during short (10 ms and 100 ms) bursts are shown. For the highest peak ionisation rates applied in the SIC runs, $10^7\ cm^{-3}s^{-1}$ and $10^9\ cm^{-3}s^{-1}$, the concentrations of NO after the bursts are found to be enhanced by 0.3-30 times relative to the background run in the lower altitude range (around 70 km). There the background NO concentration is normally very low. At the NO maximum, around 80 km, the relative enhancement is lower, from a few up to 5 times in the extreme model case.
Although further work is needed to incorporate the known major source of NO_x, reactions with excited N_2 and O_2 molecules, the results indicate that

TLEs can be an important local source of chemically and radiatively active species, such as NO_x. The global significance, however, cannot be estimated without taking into account the effects of transport and the occurrence rate of TLEs.

15.4.3 Simulation of Streamer Propagation Using a PIC-MCC Code: Application to Sprite Ignition

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In order to study electron kinetics in sprite ignition we experiment with the use of Particle In Cell methods with Monte Carlo Collision (PIC-MCC). The aim of our model is to simulate the propagation of a streamer-like discharge, as in Pasko, Raizer, Rycroft and Roussel-Dupre works. A discharge model based on a kinetic description of electrons (Boltzmann-Poisson model) is presented. Then, we present the computational methods used in 'PIC-MCC'. The calculation of a streamer propagation and of a "sprite-like" test case are shown.

15.4.4 Characteristics of Transient Luminous Event Streamers in Weak Electric Fields

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It is well established by now that transient luminous events (TLEs) observed at different altitudes above thunderstorms commonly consist of large numbers of needle-shaped filaments of ionization, called streamers (e.g., Gerken and Inan, 2003; Su et al., 2003; Pasko, 2003; and references cited therein). The strong electric fields $E > E_k$ are needed for the initiation of streamers. The initiated streamers, however, are capable of propagating in fields substantially lower than E_k [e.g., Allen and Ghaffar, 1995], and one of the important questions of the current TLE research, which directly relates to the evaluation of the total volumes of atmosphere affected by the TLE phenomena and possible role of TLEs in establishing a direct path of electrical contact between the tropospheric and mesospheric/lower ionospheric regions, is related to the determination of the minimum electric fields ($E < E_k$) required for the propagation of streamers in air at different pressures. In this talk, we will present our latest simulation results on propagation of streamers in weak ($< E_k$) fields. The results indicate that the peak electric fields and electron densities of streamers in weak fields can be as low as 50% and 10% of those in strong fields, respectively. The velocities of streamers can drop down to as low as $\sim$100 km/s, which agree with those reported in existing streamer literature (e.g., Bazelyan and Raizer, 1998, p. 154) and with the observed speeds of vertical development of blue jets (e.g., Wescott et al., 1995; Pasko et al., 2002). At ground pressure, the decay of plasma in the streamer channel has been noticed in previous studies (e.g., Morrow and Lowke, 1997; Aleksandrov and Bazelyan, 1999). These observations have been attributed to the effects of three-body attachment and recombination processes, which are believed to be the major loss mechanisms of electrons in the streamer channel. In this talk we will discuss the effects of these two processes on streamer dynamics at low air pressures. We will also discuss the model determined minimum fields required for the propagation of streamers of different polarities at TLE altitudes.

15.4.5 Three-Dimensional Subionospheric VLF Electromagnetic Field Scattering by a Highly Conducting Cylinder and Its Application to the Trimpi Effect Problem

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By means of three-dimensional full-wave analytical-numerical technique we consider the diffraction of VLF point source field by a localized perturbation in the lower ionosphere, which is taken as a truncated highly conducting cylinder. There are no restrictions on the shape and sizes of its horizontal cross-section. We are dealing with short distance propagation path (1500 km at most), this is why in our model the Earth's curvature is ignored. The surface impedance concept is additionally used to model the Earth-ionosphere waveguide using given electron density and collision frequency day or night height profiles for unperturbed ionosphere. Our approach is based on the preliminary asymptotic integration of the rigorous two-dimensional integral equation in order to facilitate its further numerical handling, and an original computational algorithm is proposed to obtain a solution of the approximate equation. With the efforts of reducing CPU time, the developed procedure enables us to study both small and comparatively large irregularities.

Our calculations indicate that scattering may be significant not only in the forward, but also in the backward and out of the way directions. A comparison of the behaviours of the field at night and day indicates that the perturbation is more clearly recognized at night than at day. The analysis of the numerical results shows that field has the essential dependence from direction of wave propagation concerning the azimuth of magnetic field. These effects and the influence of the property lower surface are most noticeable for situation of the location of irregularity corresponds to minimum of the amplitude of the attenuation function. The same results were obtained using International Reference Ionosphere model.

15.4.6 Changes of the Lower Ionospheric Electron Concentration due to Solar Cosmic Rays

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Solar proton event (SPE) is an event caused by solar energetic particles or the co-called solar cosmic rays (SCR) with proton energies from an interval of 1-100 MeV. The geomagnetic field bends trajectories of SCR in such a way that they enter the atmosphere in a circle around the geomagnetic pole down to about 65 deg. Energetic particles interact with molecules of the air and cause additional dissociation and ionization. The maximum ionization rate depends on particles energy and on latitude and occurs at upper stratospheric or mesopheric heights. Additional NO_x, OH_y and ions are formed and enter chemical and ion-molecular reactions. Induced changes of the ionopheric D-layer are modeled using a 1-D model photochemical time-dependent model for neutral species (Krivolutsky et al., Adv.Space Res. 27, 1975-1981, 2001) and a 1-D lower ionosphere model with chemistry (Ondraskova, Studia geoph. et geod. 37, 189-208, 1993). Changes of the electron and ion densities, and the most important ionospheric parameters are calculated after SPE with the onset on July 14, 2000 and the results are compared with results obtained previously for the October 19, 1989 SPE. It is found that: the increase of electron density N(e) after the both SPEs is greater than three orders of magnitude at 50-60 km; the increase of N(e) was greater for the July 2000 SPE than for the October 1989 SPE and there is an agreement with absorption measurements; changes of other parameters also show that the magnitude of the ionospheric response depends on season.