ESF Scientific Network on Space Weather and the Earth's Weather and Climate (SPECIAL II)

2nd SPECIAL II Annual Workshop

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European Science Foundation, 1 quai Lezay-Marnésia,
67080 Strasbourg, Cedex, France

The European Science Foundation (ESF) acts as a catalyst for the development of science by bringing together leading scientists and funding agencies to debate, plan and implement pan-European scientific and science policy initiatives.

ESF is the European association of 76 major national funding agencies devoted to scientific research in 29 countries. It represents all scientific disciplines: physical and engineering sciences, life and environmental sciences, medical sciences, humanities and social sciences. The Foundation assists its Member Organisations in two main ways. It brings scientists together in its EUROCORES (ESF Collaborative Research Programmes), Scientific Forward Looks, Programmes, Networks, Exploratory Workshops and European Research Conferences to work on topics of common concern including Research Infrastructures. It also conducts the joint studies of issues of strategic importance in European science policy.

It maintains close relations with other scientific institutions within and outside Europe. By its activities, the ESF adds value by cooperation and coordination across national frontiers and endeavours, offers expert scientific advice on strategic issues, and provides the European forum for science.

Abstracts of Invited Talks / Posters

(in order of conference programme)

SPECIAL Background

ESF / PESC Network:
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Initial Results of Sprite Observations from the Space Shuttle during the MEIDEX

Y. Yair, C. Price, Z. Levin, J. Jospeh, A. Devir, B. Ziv, M. Moalem, P. Israelevich, M. Asfur

The Mediterranean Israeli Dust Experiment (MEIDEX) flew on-board the space shuttle Columbia in January 2003. During the night-side of 29 shuttle orbits there were dedicated observations of the Earth's limb, above forecasted areas of active thunderstorms. This was accomplished with a Xybion IMC-201 multispectral camera (860nm, 665nm, 380nm, 470nm), guided by the astronauts toward the storms with intent of capturing Sprites, Elves and Jets. Two VLF/ELF sites in Israel were simultaneously used to collect electromagnetic data, together with stations in Hungary, USA, Antarctica and Japan. We hope to report initial results from this campaign, and to connect the space based observations of TLEs to the signals observed on the ground.

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The South Pole Beacon experiment

U. S. Inan

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Effects of global circuit on cloud microphysics and precipitation, with possible consequences for circulation changes.

Brian A. Tinsley

Two processes have been proposed for effects of atmospheric ionization affecting clouds;- those of ion-mediated nucleation and electroscavenging. Both can occur in regions of space charge in the conductivity gradients at the upper and lower boundaries of clouds (positive charge at cloud top and negative at cloud base). The space charge is maintained by current flow in the global circuit, that links space weather and changes in potential and conductivity at higher atmospheric levels (caused by solar activity) down to the level of clouds. Both processes appear capable of affecting concentrations of CCN, that affect droplet size and precipitation efficiency, but with different dependencies on altitude, latitude, and the presence of volcanic aerosols. Ion mediated nucleation can also occur far from clouds, where there is no net space charge. For clouds with tops below freezing, and broad droplet size distributions, electroscavenging leads to enhanced contact ice nucleation, that also increases precipitation. Enhanced precipitation enhances latent heat transfer, and in certain circumstances can lead to intensification of winter cyclones, with possible consequences for blocking situations in the general circulation. Also, the current flow is affected by internal atmospheric processes, and changes in clouds globally may also be linked to changes in tropical thunderstorms, that are the main generator in the global electric circuit.

SPECIAL related activities

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Solar variability and climate simulations

U. Cubasch, I. Fischer-Bruns, F. Kaspar, E. Zorita, H. von Storch

A global coupled climate model, similar to those used to project the climate change for the next century, has been forced with estimates of the solar radiation for different timeperiods:
a) the last 150 years,
b) the last 500 years and
c) for 125 kyears bp and 115 kyears bp (Eem).

The global circulation shows a distinct response to the variantions in the forcing. It is for example possible to simulate the low temperatures in Europe during the Late Maunder Minimum and the Dalton Minimum.
Also the simulations of the two time-slices of the Eem show similarities with the temperature and precipitation reconstructions from pollen records. The observed warming during the last 150 years can, however, only partially be explained by variations in solar radiation.

COST 724: Developing the scientific basis for monitoring, modeling and prediting space weather

J. Lilensten, coordinator of the action

A COST action aims at the co-ordination of science activities in Europe. In the current efforts to organise Space Weather in Europe, a new COST action has been approved and will have an inaugural meeting in late spring, 2003.
The main objective of the Action is to develop further within a European framework the science underpinning space weather applications, as well as exploring methods for providing a comprehensive range of space weather services to a variety of users, based on modelling and monitoring of the sun-Earth system.

The general aims of the Space Weather Action will be:

- To co-ordinate European research into modelling and prediction of space weather;
- To promote where necessary the deployment of new instrumentation to satisfy data requirements, and the development of new models;
- To educate potential users of space weather data;
- To gather feedback from users which may be used to improve services;
- To create a forum for exchanging "best practice" among users and providers of space weather services;
- To set standards on data exchange.

The main benefit of a concerted European Space Weather program is that organisations which face hazards from space weather in their day-to-day operations will have a resource which will enable them to manage the risk, and which will have traceable quality standards.

In this talk, I will give an overview of those goals and give the current status of the Action. I will also show what room is left for such a COST action in Europe in the context of the Networks of Excellence, the Pilot Projects, and the Integrated projects. Finally, this talk is meant to be an open window for common discussions and work with the ESF SPECIAL network.

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European high mountain observatories to study the role of cosmic ray fluxes and atmospheric processes

A. Zanini

ATPROMO -- ATmosphere Parameters and Radiation On Mountain Observatories
Proposal for FP6 2003 Priority 1.1.6.3 Global Change and Ecosystems

In the last decades the human activities produced relevant changes in the atmosphere composition. Life on the Earth (human beings, animals and alimentary chain) exists because of the effectiveness of the shielding effect of the atmosphere against the cosmic radiation (ionising component) as well as the UV radiation (non-ionising component). In addition, there is an historical evidence over the past 1000 years indicating that changes in climate have occurred in accord with variability in cosmic ray intensities (Space Science Reviews 00: 1–16, 2000, Kluwer Academic Publishers).

Galactic Cosmic Radiation (GCR), constituted mainly by protons, interacts with the Earth's atmosphere through nuclear collisions producing secondary particles (protons, neutrons, pions gamma quanta and muons) which can penetrate deeper into the atmosphere and dissipate by this way the energy of the particles, generating electromagnetic cascade. The intensity and the composition of the cosmic radiation at Earth strongly depend on the atmospheric parameters and geophysical characteristics (latitude, altitude, geomagnetic field) modulated by solar activity. Recently the scientific community agrees on the need to improve the knowledge on the physical mechanisms linking cosmic ray variation with atmospheric processes, with a special attention to investigate the modification of chemical characteristics in the different layers of the atmosphere, due to new development areas and pollution products, that could act as a relevant factor.

* Recent satellite observations suggest that cosmic rays play an important role in the climate, showing a correlation between cosmic ray intensity and the fraction of the Earth covered by clouds. Since the cosmic ray intensity is modulated by the solar wind, this could provide an important relation to the long-term and large scale mechanism connecting solar and climate variability. These connections could have a significant input for our understanding of solar terrestrial interactions and the corresponding possible contributions to the present global warming.

* A change in cosmic ray fluxes affects the ion density and the air conductivity with impact on lightning in thunderstorms and precipitation; a correlation links cosmic ray flux intensity and ion concentration in the atmosphere.

* An influence of cosmic ray fluxes on precipitation level is observed during solar proton events (SPE) originating from solar flares.

These areas demand a special attention and require systematic studies in attempt to improve the quantitative knowledge, since the lack of exhaustive information up to day.

The High Mountain Observatories already existing in Europe are the most effective Network to establish a large European Research Group, connecting specialists from Western and Eastern European countries, in cosmic ray physics, atmosphere chemistry and physics, radiation dosimetry and biodosimetry, mathematical modelling and computer simulation. In fact, the effects of the intensity variation of comic rays on the “Earth system” are not yet fully understood, and deeper studies on this subject are worldwide required. The realisation of a systematic observation system, with real time access to data, give a substantial contribution in different fields:

* The Network will strengthen the capacity to understand, detect and predict global climate change and to develop strategies for prevention.

* The realisation of the Network allows a control of atmospheric and radioactive pollution. In fact the regular monitoring of charged particles in the atmosphere, together with chemical anthropogenic products, will represent a warning system for nuclear or ecological accidents and allow an early intervention plan.

* The utilisation of high mountain cosmic ray measurements will improve the effectiveness of the system of space weather forecasts for early forewarning of unpredictable bursts of SEP (Solar Energetic Particles), that can be harmful to satellite and aircraft electronic.

The issue is addressed to a systematic monitoring in the High Mountain Observatory Network of the green-house gases, ozone layer thickness, cloud formation and the corresponding processes in atmospheric dynamic, together with the accurate detection and dosimetry of the ionizing component of the cosmic radiation in a wide area in Europe, establishing the infrastructure for effective co-ordination of the investigation. Strengthening and coordinating the existing resources based on High Altitude Observatories in Europe, where the observation and measuring of the atmospheric characteristics and cosmic ray intensity variations are carried out since years, will give a substantial contribution to a definitive understanding of the physical mechanism causally linking the average state of the Heliosphere and the Earth’s climate.

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Perspectives of Grid Computing for the construction of Virtual Labs

S. Unger, Uwe Der, Andreas Hoheisel

An overview on Fraunhofer FIRST's activities will be given. As an institute belonging to Fraunhofer's Information and Communication group FIRST plays an active role in forming and building up the Fraunhofer Resource Grid. The developed technology may serve as a basis for the formation of virtual labs. Perspectives of this technology will be discussed.

WORKING GROUP 1

Thunderstorms, global lightning, and ULF/ELF/VLF radiation associated with climate

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Slow electric currents between thundercloud and ground

Serge Chauzy, Sylvain Coquillat, and Serge Soula

The electric current corresponding to charge transfer between thundercloud and ground represents an essential component of the global electrical circuit. The part due to lightning flashes can be very roughly estimated using data provided by flash detection networks widely intalled over most territories of developped countries. The slow components of thunderstorm current must be specifically measured. Two processes contribute to this exchange: (i) the corona ions transfer from ground to cloud by conduction and convection, (ii) the precipitation current due to the charges carried down by precipitation particles. These two components have been directly measured or indirectly estimated during several field experiments.

Corona charges are produced from ground irregularities under high surface field conditions. Data obtained from simultaneous electric field measurement at the ground and aloft underneath thnunderclouds have been introduced into a dedicated numerical model (PICASSO) in order to estimate the amount of charge transfered from ground to cloud during the lifetime of a thunderstorm. The results show that this amount cannot account for the whole cloud electrification, but might be responsable for the LPCC (low positive cloud center). Up to 60 Coulombs have been found to be transported by conduction and convection processes.

Measurements of electric field, precipitation current density, and rainfall parameters were performed at the ground during the 1999 Mesoscale Alpine Programme (MAP) field experiment. Several days of the period provided substantially charged rainfall of both polarities. The average proportions of each polarity are close but the negative one is slightly larger (54 %). During the deeply convective event on September 17, 1999, the precipitation current density is firstly positive (negative charges brought to the surface), reaches more than 100 nA m-2 and changes its polarity when the rainfall rate is maximum (up to 200 mm h-1). In the case of several shallow convective cells passing over the experimental site on October 3, both charge polarities were observed on the rain produced by electrified cells: first the negative one and then the positive one. A very tight correlation between electric field and precipitation current is observed at the ground, displaying the mirror image effect. The ground electric field appears to be due to the cloud charge whose polarity is opposed to that carried down by the rainfall.

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Lightning discharge preliminary stage cellular automaton model

D. Iudin, V. Yu. Trakhtengerts, A. N. Grigoriev, M. Hayakawa

We consider the thunderstorm (TC) activity on the base of a cellular automaton model on tree-dimensional lattice. Each site of the lattice is related to a time-dependent scalar that characterises potential of the point. In our model the potential differences between the neighbouring sites are growing due to the instability effects. We consider three random-rowth models: the simplest one, when random additions with a normal distribution are added to the electric potentials at the lattice sites at each step of model time; the second, when along with random additions we add an external bias field (so, the first case is just particular case of the second with zero bias); and the last and most complicated case, when potential relief looks like generalised Brownian landscape. In every case, each site, independently of its neighbours, undergoes Brownian motion in the space of electric-potential values. The potential difference growth is limited by some critical value. As soon as this critical value is reached for any two neighbouring sites on the lattice, breakdown between the sites takes place and the lattice bond between the sites becomes a conductor. We assume that such a fine scale spark discharge can initiate breakdowns of the neighbouring lattice bonds ("infect" the neighbours), if the potential difference between the cells exceeds some activation level, which is less than critical one. Interaction of neighbouring cells leads to formation of dynamical chains of microdischarges, which reveal percolation-like behaviour in the wide range of TC parameters. Even a weak macroscopic electric field modifies drastically the structure and dynamical features of the conducting percolation cluster. The important new effect in this situation is a large-scale electric current, which flows through the conducting cluster and redistributes the large-scale electric charge. It is clear with the physical point of view that the large-scale electric field will determine an electrical discharge in TC, if the potential difference on the cluster size is comparable with the critical value. We show that fractal dynamics of electrical microdischarges in a thundercloud can serve as the basis for explanation of main features of a lightning flash on its preliminary stage.

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Lightning induced ozone changes and the role of long-range transport

Volker Grewe

Lightning produces NOx and contributes significantly to the NOx budget. Lightning is one of the largest NOx sources in the tropics and in the upper tropopshere. To estimate the global effect of lightning a climate-chemistry model is applied. A new parameterization for the lightning frequency will be presented and a comparison to observational data given. Estimates on the global and regional effect on ozone will be given based on simulations with the global climate-chemistry model E39/C. Although lightning occurs in the troposphere, the effect on the lowermost stratosphere is not negligable. An analysis with an Lagrangian transport model shows that this area also serves as a region, where airmasses,
which are characterized by high NOx and ozone values (caused by tropical lightning), are transported to higher latitudes and enhance the ozone concentration there.

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Comparison between African and South American "chimneys"

E. R. Williams

The DC global electrical circuit is dominated by three major zones of upwelling in the tropics—South America, Africa and the Maritime Continent. Traditional analysis of the 'DC' global circuit has clearly demonstrated South America as the predominant 'chimney'. However, the early thunder day observations and more recent observations of global lightning and the Earth's Schumann resonances (SR) point to Africa as the dominant player in the 'AC' global circuit. This presentation is concerned with a comparison of the African and South American chimneys on three distinct time scales: the diurnal, the 5-day global wave time scale, and the semiannual time scale. In the lightning/SR realm, Africa is clearly predominant on all time scales. Two hypotheses are examined to account for the systematic difference: the traditional thermal hypothesis and the aerosol hypothesis. Field tests within the South American chimney in 1999 tend to support the thermal hypothesis and these results will be discussed. Finally, comparisons of observations from space with the NASA TRMM (Tropical Rainfall Measuring Mission) satellite and surface thermodynamic measurements provide evidence for higher thundercloud base heights over Africa, a feature that appears to play a key role in the strong continentality of Africa. This strongly continental behavior stands apart from the "green ocean" behavior of South America.

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Diurnal and Seasonal Variations of Schumann Resonance parameters

Colin Price and Alex Melnikov

Since 1998 ELF data in the Schumann resonance (SR) band has been collected at a field site in the Negev Desert, Israel. These data are being used to study the variability of regional and global lightning activity. The three basic parameters of the SR modes are the frequency, amplitude and half-width (damping) of the resonant standing waves. We have analysed the diurnal and seasonal variability of these parameters at our station and a number of other stations. There are very interesting variations in all these parameters at all time scales, most of which need additional theoretical modeling to understand. There is clear evidence of diurnal ionospheric influences as the ELF waves pass through the day-night terminator above our station.

WORKING GROUP 2

Intense tropospheric lightning and mesospheric transient luminous events such as sprites, elves, and blue jets

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Conjugate Sprites Campaign

Umran Inan

Since 2001, several attempts have been made to realize the first detection (or to rule out the existence of) optical effects occurring in the hemisphere geommagnetically conjugate to intense lightning flashes, as has been theoretically predicted by Lehtinen et al. [2001]. The first two of these campaigns were initial efforts, and did not produce conclusive results, for several reasons. In 2003, two new campaigns will be conducted, one in Japan during January 2003 (looking at effects of lightning in Australia) and another in South Africa in summer 2003 (looking at effects of European lightning). In this talk, we will review theoretical predictions, experiment plans, and (hopefully) initial results from the January 2003 campaign.

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The Future of Sprite Research Activities in Europe

T. Neubert

Sprite research activities in Europe have been on the increase since the late 1990ies:

- Annual ground-based campaigns have been conducted from locations in Southern France.
- The European Commission have funded a Research Training Network "Coupling of Atmospheric Layers" (CAL), looking at sprites and jets, and their effects on the atmosphere.
- A mission has been conducted on the ISS during a recent French astronaut visit, with a dual camera operated by the astronaut. The mission identified sprites in nadir imaging.
- The CNES micro-satellite programme currently have the TARANIS mission scheduled to enter a Phase A study for launch in 2007/2008.
- The space shuttle carrying an Israeli MEIDEX experiment has on a number of occasions observed sprites.
- Development of space instrumentation has continued to mature the X- and ?-ray detector technique, and new capabilities for optical imagers.

The talk will discuss the status and plans for the CAL project, ideas for a future "focal area" of ground-based activities in Southern France, and plans for experiments in space.

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Coupling between the atomosphere, the ionosphere, and the magnetosphere, project of Microsatellite TARANIS

E. Blanc and the Taranis team

Strong interactions between the middle and upper regions of the atmosphere and ionosphere are manifested by light emission in the middle and upper atmosphere, known as sprites and elves, gamma radiation of atmospheric origin, electromagnetic emissions recently observed above atmospheric storms. This direct coupling between active storm cells, the thermosphere and the ionosphere - and the considerable energies involved – gives rise to processes unsuspected until now regarding space plasmas as well as the chemistry and dynamics of the middle atmosphere. The electromagnetic and particle emissions could derive from the run away relativistic electrons initiated by the impact of cosmic rays on storm cells. These processes can have a significant effect on the Earth's magnetosphere, in particular by modifying the source terms and loss of the radiation belts. The microsatellite Taranis (Tool for the Analysis of RAdiations from lightNIngs and Sprites) proposes to study the coupling between atmosphere, ionosphere and magnetosphere during atmospheric storms. This has to be carried on a local and global scale in order to understand the physical mechanisms responsible for the impulsive transfers of energy between the neutral atmosphere and plasmas of the ionosphere and magnetosphere. The final goal is to establish the impact of these processes on the Earth's environment. The purpose of this presentation is to describe in a first part the project Taranis, his scientific objectives, the mission and the scientific payload. In a second part the first results of the experiment LSO (Lightning and Sprite Observations), on board of the International Space Station, will be presented. LSO is composed of two micro-cameras, fixed on a ISS window for observations at the horizon or at the nadir. One camera is equipped with a filter and measures the emissions from earth in a specific spectral window, the second works in the visible. The measurements allow the identification of sprites and lightning from space at the nadir. This measurement concept will be used for the camera observations in the future micro-satellite Taranis.

WORKING GROUP X

Solar short wave radiation influences

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The Influence of Solar Variability on the Atmospheric Circulation in Observations and Models

K. Labitzke and K. Matthes

The observed 11-year variations in solar irradiance have been shown to impact the radiation budget of the middle atmosphere.This leads to associated temperature changes and changes in atmospheric circulation as well as to an influence on the ozone layer in the stratosphere.

The correlation of meteorological parameters with the 11-year solar cycle has been studied in several observational analyses for the Northern Hemisphere (e.g., Labitzke and van Loon, 1999). Recently, the Southern Hemisphere was included in these examinations with the global data from the NCEP/NCAR re-analyses (van Loon and Labitzke, 2000). The signal in the Southern Hemisphere is almost a mirror image of that in the Northern Hemisphere.

Simulations with Climate Middle Atmosphere Models are very useful to find a physical mechanism for the influence of solar variability on atmospheric circulation. Recent simulations with such models suggest an indirect dynamical response of the lower stratosphere to the radiative forcing of the upper stratosphere.

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Solar and terrestrial signals in atmospheric ozone

P. Winkler

Vertical ozone profiles have been analysed for periodic and aperiodic signals of the solar cycle and for QBO, volcanoes and tropospheric dynamics. The intentity of the signals depend on height and season. Since the temperature of the middle and upper stratosphere is determined by absorption of solar UV it is of interest whether ozone destruction affects the temperature profile. We find a correlation only in summer, in winter the atmospheric dynamics is so high, that the correlation is disturbed. This analysis allows to document how deep into the atmosphere solar influences can be seen. In addition a literature review of tree ring width shows a solar signal at many places. This demonstrates some sensitivity of trees for the solar cycle and means that these influences might be effective in lower atmospheric layers.

WORKING GROUP 3

Solar wind variability associated with tropospheric dynamics

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Influence of the solar wind variations on atmospheric processes in the southern polar region

O. Troshichev, L.Egorova, V.Vovk

The detail analysis of the aerological data from Vostok station (Antarctica) for 1978-1992 made it possible to find the dramatic changes of the troposphere temperature influenced by strong fluctuations of the interplanetary electric field ESW. The warming is observed at ground level and cooling at h >10 km if the electric field of dawn-dusk direction is enhanced (when IMF DBZ <0). The opposite deviation of the atmospheric temperatures (cooling at the ground level and warming at h >10km) is observed if the dawn-dusk electric field decreases (when DBZ >0). There is a linear relationship between the value of the interplanetary electric field variation and ground temperature at Vostok station: the larger is leap in the electric field the stronger is temperature deviation. The effect reaches maximum within one day and is damped equally quickly. The temperature deviations occur not only while passing the front of the interplanetary shocks but while crossing the layers of interaction between the quasi-stationary slow and fast solar wind fluxes those are not accompanied by the cosmic ray variations at all. The appropriate response to the electric field changes is observed in tropospheric pressure and wind as well. It is suggested that the interplanetary electric field influences the catabatic system of atmospheric circulation, typical of the ice dome in winter Antarctic.

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NAO, solar/geomagnetic activity and QBO

J. Bochnicek, P. Hejda

The changes of pressure, temperature and wind fields in the winter lower troposphere observed in association with changes in solar/geomagnetic activity, NAO index and QBO phases were compared. The analysis was carried out by the method of composites and the statistical significance of the results was estimated using Student's t-test. The monthy mean values of sea level pressure and 700-mb temperature in winter periods 1952-2001 and of 850 mb wind in periods 1964, 1967-1969, 1971-2001 were taken from NCAR Research Data Sets.

The results were compared with (Kodera, Geophys. Res. Lett., 29, art. no - 1218, 2002).

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Evaluation of Contribution of the Solar Wind Energy to Electrodynamics of Stratosphere in Frame work of Global Electric Circuit Conception

A.V. Shirochkov, L. Makarova

The solar wind is a permanent source of electromagnetic energy constantly supplied to the near-Earth space and its role is evaluated properly in magnetospheric and ionospheric (to lesser extent) studies. We made extensive studies of the direct solar wind influence on the thermodynamic features of the middle atmosphere by analyzing data of the rocket and balloon sounding. Data of many stations covering latitudinal belt 80o N-55o N and 90o S-65o S- were used. It was found that the stratospheric temperature closely correlated with the solar wind energy expressed as the subsolar distance between the Earth and magnetopause. The best coupling between these two parameters (r>0,8) was obtained for altitudes 22-26 km with decreasing (but meaningful) coupling up and dawn from these heights. Similar dependence between this space parameter and ozone density in its stratospheric maximum was obtained also. As a very important factor a strong (r=0,78) coupling between magnetopause position and magnitude of atmospheric electric field measured by high-altitude balloons above South Pole Station must be mentioned. All these findings allowed us to propose concept of the global electric circuit as a physical mechanism for explanation of a direct coupling between the solar wind and the middle atmosphere. We suggest a new, modified version of the circuit where an external Electro-motive Force generator driven by the solar wind energy is located at dayside magnetopause. The passive elements of this circuit are the ionospheric E-layer (external element of previous version of the circuit), stratospheric conducting layer of heavy ions (h=20-25 km) and conducting layer of the Earth surface. In this configuration a previous scheme of the global electric circuit is a part of the proposed version of it. The changes of stratospheric temperature could be explained as a result of atmosphere heating by electric current flowing through a heavy ions layer which is one of elements of global electric circuit. We got amount of Joule heating equal to 1,1.10-1 kal/m3 per hour in stratosphere (h=20-30km), that is comparable with heating of ozone layer by solar UV radiation. Some numerical calculations are presented to prove the proposed ideas.

Poster Viewing

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The relation between AC and DC global circuit measurements (POSTER)

M. Füllekrug, Steve Constable

Particularly intense positive cloud-to-ground lightning discharges can produce transient optical emissions in the mesosphere, denoted sprites. Video observations of sprites in North America are compared to remote sensing of the causative positive lightning discharge with ULF/ELF electromagnetic field recordings. This methodology exhibits a detection efficiency of sprites approximately 80 %.

A global network of ULF/ELF magnetic field sensors is used to triangulate intense lightning discharges on the planetary scale.

The observed lightning discharges are positive or negative with varying intensities and occur over the continents or the oceans at different times during the day. The local time dependence of the lightning discharge intensities is indicative of the meteorological boundary conditions for particularly intense lightning to occur. The universal time dependence characterizes the contribution of intense lightning discharges to the global atmospheric electric circuit. This diurnal variation of intense lightning discharges in the global atmospheric electric circuit is discriminated with respect to the lightning discharge properties, i.e., intensity, polarity, and oceanic or continental origin.

The quantitative analysis shows that only positive lightning flashes significantly contribute to an actual reduction of the total charge in DC global circuit by approximately .1-1 %. Consequently, DC field measurements with an accuracy of 1E-4 (i.e. 16 bit) may be able to pick up the signal from intense lightning discharges by use of superposed epoch analysis.

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Long-term surface measurements of atmospheric electricity (POSTER)

R.G.Harrison

Surface atmospheric electrical measurements extend back in the UK into the late eighteenth century, but these are of variable quality. Reliable quantitative instruments were developed by Lord Kelvin and deployed from 1860 at Kew Observatory, near London. Continuous Potential Gradient (PG) measurements were made at Kew from 1898, and two further observatories were established at Eskdalemuir, Scotland in 1908 and Lerwick, Shetland in 1926. Observations at all three stations ceased in the early 1980s, but it has recently become clear that the records are still available, at, for almost the entire period, 6 hourly resolution. These are therefore some of the longest sets of high resolution PG data available at fixed surface stations, which can now be analysed in the context of climate variability. The Kew PG data is strongly influenced by smoke pollution, but Eskdalemuir and Lerwick are remote sites, which were originally selected to be distant from centres of human activity. As with all surface layer atmospheric electrical observations however, weather and boundary layer conditions influence the usefulness of the data. There is strong evidence for the presence of global signals in the data, including the Carnegie cycle. Results will be presented illustrating seasonal variations in the global signals, and direct comparisons made between instantaneous results obtained during the Carnegie cruises and the simultaneous UK observations. These support the concept of a global atmospheric electrical circuit.

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A Quantitative Model of Global Thunderstorms Effects on the Global Ionospheric Electrostatic Potential Distributions (POSTER)

M. Kartalev, M. J. Rycroft, V. O. Papitashvili

We report on an attempt to examine quantitatively (but indirectly) a classical picture of the "global electric circuit": a hypothesis that electric currents flown from global thunderstorms upward into the ionosphere (known also as Wilson's currents) can cause a steady charging of the ionosphere (representing the upper plate of the "geocapacitor"). For this purpose, we applied our (earlier developed) numerical model of the global ionospheric electrostatic potential distribution. This model consists of a "thin shell" ionosphere (i.e., 2-D for the electric potential formulated in the magnetic field line coordinates) and the global computational region which includes both conjugate ionospheres as separate sub-domains. In this model we account for the interhemispheric field-aligned currents (which supposed to be equal in the conjugate points) and the realistic ionospheric conductivity. As a reference, we take the electrostatic potential over the polar regions calculated from the experimental, data-based model of the high-latitude field-aligned currents and then obtain the global (but non-uniform) potential distribution. To study the effects of the "global electric circuit", we add into our global model some additional currents simulating the thunderstorm effects on the ionospheric shell. To follow the quasi-realistic approach, we apply these additional "thunderstorm" currents over three main active regions: Africa, Asia/Oceania, and America. Varying the intensities of these "thunderstorm" currents, we can investigate self-consistently how our global model is affected when these currents spread over the globe and through the magnetosphere along the geomagnetic field lines to the opposite hemisphere. The model shows that a considerable effect on the global electric circuit can only be achieved if the "thunderstorm" currents will be unrealistically high, concluding that the global contribution from real thunderstorm currents into the ionospheric electric potential is rather insignificant

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Cosmic ray decreases and geomagnetic activity: list of events (POSTER)

K. Kudela, R. Brenkus

For the period 1982-2002 the decreases of cosmic ray (CR) intensity at neutron monitors are summarized and compared with the simultaneous changes of Dst. Data from three neutron monitors with different vertical cutoff rigidities are used, namely Oulu (~0.8 GV), Lomnicky Stit (~4 GV) and Haleakala/Huancayo (~13 GV). The Dst development during different periods of CR decreases are rather complex. Along with the events when CR decreases are accompanied by corresponding Dst depressions, there are several effects when geomagnetic activity (measured by Dst) is not changing strongly. One of the recent events of the latter type, namely FD observed on November 17-18, 2002 is discussed in more detail. The list can be useful for the case studies of the relations between CR and atmospheric effects and for eventual discrimination between the CR and geomagnetic influence on the atmosphere.

ESF / PESC Network:
"Space Weather and the Earth's Weather and Climate (SPECIAL II)"

Finding Space Weather – Earth's Weather Relationships by Using Dynamic Spectra of Daily Frequency Range of Schumann Resonances (POSTER)

G. Satori, Bertalan ZIEGER

The daily frequency range (DFR) of Schumann resonances (SR) is the band in which the resonance frequency shifts up and down during a day. The DFR is related to the size of the region where the random lightning discharges are distributed. The wider, the region is, the smaller the DFR becomes, and vice versa. Long term time series of DFR were built up based on SR observations at Nagycenk, Hungary. Dynamic spectra of DFR time series in the range of periods from 2 days up to 1 year were computed to find periodical variations in DFR, consequently in the size of thunderstorm regions and then to select periods which may have extraterrestrial origins.

WORKING GROUP 4

Ionospheric effects on the global atmospheric circuit

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A review on thunderstorm effects on the ionosphere observed with ground based radars and in situ with rockets

Christos Haldoupis

After the discovery of transient optical emissions that extend above areas of enhanced thunderstorm activity upward to the mesosphere and lower ionosphere, considerable attention has been devoted to these and related phenomena. Although most of the upper atmospheric electricity research was directed towards the study and understanding of the spectacular high altitude optical emissions, like the red-sprites and blue jets, there is also work on relevant ionospheric effects but it is limited. Given the large electromagnetic energy radiated and the intense quasi-static electric fields produced from atmospheric electrical discharges in the upper atmosphere and their subsequent interactions with the ionospheric plasma, we anticipate a potential for future studies of lightning induced transient ionospheric responses and signatures. In this presentation we review the existing literature on thunderstorm-triggered ionospheric effects which have been detected with HF and VHF radars as well as in situ with rocket probes. These include overdense radar reflections and underdense backscatter echoes from the lower ionosphere, explosive spread F cases, and small scale plasma structures produced by severe weather-related gravity waves. The scope here is to assess the present state of knowledge and provide input for more future studies.

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3-D Monitoring of Ionospheric Electron Density using GPS

C. Jacobi, N. Jakowski, C. Stolle, S. Schlüter

When GPS navigation system radio waves are passing trough the ionosphere and plasmasphere to a receiver on the ground or on board a low-Earth Orbiter (LEO), owing to the free electrons there they are subject to delays in phase, travel time and polarisation. This enables us to measure the Total Electron Content (TEC) on the path between the GPS satellite and the receiver. These integrated TEC values can be used for three-dimensional reconstruction of ionospheric electron density patterns. Here a tomographic approach is presented, which uses ground-based GPS measurements and data from the CHAMP satellite mission. As a tomographic case study, a plasma convection event has been chosen. Since the input data is sparsely distributed and patchy, an algebraic iterative algorithm is used. It is shown that including limb sounding GPS from LEO satellites improves reconstructions of the vertical structure of the ionosphere by its horizontally viewing rays. The results are validated using ionosonde profiles.

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Ionospheric and Atmospheric Effects Caused by Precipitating Fluxes of Relativistic Electrons

L.N.Makarova, A. V Shirochkov

Precipitating fluxes of theelectrons of relativistic and subrelativistic energies (E>300 keV) play a significant role in energetic balance of the middle atmosphere and lower ionosphere. It was found recently that precipitation of relativistic electrons is a component of the global geomagnetic storms. In this paper the ionospheric and atmospheric effects caused by the fluxes of precipitating relativistic electrons are discussed. These fluxes produced excessive anomalous ionization in ionospheric D-region which is a great obstacle for ionospheric propagation of radiowaves. In the middle atmosphere these fluxes are effectife killers of mesospheric ozone molecules. The fluxes of relativistic electrons with very hard energetic spectra could penetrate to stratospheric altitudes and consequently diminish ozone content at these heights. Besides that excessive content of NO molecules produced by the relativistic electrons fluxes could descend to stratosphere and produce additional depletion of ozone in its main layer. We present original methods of evaluation of the ionization rates produced by relativistic electrons. We investigate conditions in the solar wind and interplanetary magnetic field preceding appearance of the relativistic electrons bursts. The mysterious cases of simultaneous apparance of the solar protons and relativistic electrons fluxes are considered also. Possible ways of modulation of the global electric circuit elements by the relativistic electron fluxes are discussed.

WORKING GROUP 5

Energetic charged particles and cosmic rays, and their relation to cloud morphology, dynamics and microphysics

ESF / PESC Network:
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Galactic cosmic rays and climate change through Earth history

Jens E. Wendler, Jens Lehmann, Ines Wendler, Helmut Willems*
***GATES Project – Bremen University, Germany**

It was suggested recently (Shaviv, 2002) that long-term variations in the flux of galactic cosmic rays (CRF) are caused by cyclic encounters of the solar system with spiral arms of the galaxy. This about 143 Million years long cycle of spiral arm passages appears to be correlated with alternations between generally cooler and warmer global climate stages in Earth history. Starting approximately in the Devonian these climate epochs can be characterized using sufficiently large geological data sets. The hypothesis of a cosmic ray – climate link on long-term timescales can be supported by several examples. However, it has to be kept in mind that this link is not even understood for the very young Earth history.

The cool periods of the late Devonian, Carboniferous, lower Permian, Jurassic, lower Cretaceous and the current ice age epoch do alternate with periods of particular warmth namely the late Permian strongly evaporitic time and the hot mid-Cretaceous. The latter period, about 100 Million years ago, is chosen as the starting point of our research project GATES which aims at investigating the upper Cretaceous gradual cooling trend. Several cooling events during this period of 50 Ma indicate stepwise climate deterioration. What triggered these events?

As known from the study of Quaternary sediments, cool and dry climates are related to geomagnetic reversals, a fact that might be true for the further past as well. The link between magnetic field intensity and climate appears to be the shielding from cosmic rays. Cosmogenic isotopes can be used to reconstruct the CRF. Studies of atmosphere physics and empiric observations indicate that the cloud formation is somehow controlled by the CRF - but how does it change the global climate? Why do we have indication for cool and dry conditions during periods of high CRF when actually more clouds should have formed? To understand these mechanisms it is necessary to observe the recent atmosphere. By tracking back the path from the Recent into the sedimentary record within a new multi-scientific research field we should get more insight into the extraterrestrial forcing of the Earth´s climate.

Reference

Shaviv, N., 2002. Cosmic ray diffusion from the galactic spiral arms, iron meteorites, and a possible climate connection. Physical review letters 89/5.

ESF / PESC Network:
"Space Weather and the Earth's Weather and Climate (SPECIAL II)"

Solar energetic particles and the atmosphere

M.-B. Kallenrode for the BOB collaboration

Precipitating energetic particles following large solar eruptions ionize the atmosphere down to the middle stratosphere. This ionization leads to chemical modifications, such as ozone depletion. The ozone depletion depends on the properties of the particle event, the atmospheric conditions (winter or summer, circulation) and on the geomagnetic field. With numerical models, crucial features in all three regimes have been identified by the BOB (Braunschweig-Osnabrueck-Bremen) collaboration. In this talk first results will be presented.

ESF / PESC Network:
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Ozone layer and Forbush decreases of the galactic cosmic rays

A. J. Lastovicka, Peter Krizan

The galactic cosmic rays (GCRs)seem to be one of the key elements in extraterrestrial effects on tropospheric and lower stratospheric processes. The total ozone is formed prevailingly by the lower stratospheric ozone content, therefore it can serve as a suitable quantity for studying the effects of GCRs on the lower stratosphere. The results show that sufficiently strong and significant effects of Forbush decreases of GCRs on total ozone occur under the same conditions as effects of geomagnetic storms: strong events, winter, high solar activity, east phase of the QBO. This is in line with Tinsley's hypothesis that the effects of geomagnetic storms on the the troposphere (and lowermost stratosphere) act through the storm-related Forbush decreases of GCRs.

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Forecasting regional cloudness and cloud top temperature by neural networks

Y.Tulunay, S.Mentes, E.Tulunay, T.Senalp, E.Akcan

Natural processes are highly complex and non-linear and mathematical modeling of those is usually difficult. For those cases data driven modeling methods are used in parallel with mathematical modeling. It is demonstrated here that the data driven models, such as the models based on the Neural Network based approach are promising to forecast the regional behavior of weather parameters. In this paper a case study will demonstrate the Neural Network modeling. That is the regional amount of cloudness and cloud top temperature will be forecast. It is proposed that the data driven approaches are applicable to learn and model the physical phenomena under the direct interest of any natural study task. The only basic requirement for this is the availability of representative data for the phenomena.

In this paper as an interesting and useful test case, the region in between (21.25N, 8.75W – 48.75E) and (58.75N, 8.75W – 48.75E) is considered and cloudness and cloud top temperature values will be forecast one month ahead for the years 1989 and 1990. The results obtained by using Neural Network based model will be demonstrated.

The Report

Data Preparation

In this work, the input parameters for the Neural Network based model are,

1) Year: y
2) Month: m
3) Latitude: La
4) Longitude: Lo
5) Present Coludness: C(m, La, Lo)
6) Present Cloud Top Temperature: T(m, La, Lo)
7) First Difference of C: FDC(m, La, Lo) = C(m, La, Lo) – C(m-1, La, Lo)
8) First Difference of T: FDT(m, La, Lo) = T(m, La, Lo) – T(m-1, La, Lo)
9) Second Difference of C: SDC(m, La, Lo) = FDC(m, La, Lo) – FDC(m-1, La, Lo)
10) Second Difference of T: SDT(m, La, Lo) = FDT(m, La, Lo) – FDT(m-1, La, Lo)
11) Relative Difference of C: RDC(m, La, Lo) = FDC(m, La, Lo) / C(m, La, Lo)
12) Relative Difference of T: RDT(m, La, Lo) = FDT(m, La, Lo) / T(m, La, Lo)

The outputs will be,
1) One month ahead forecast of Cloudness: C(m+1, La, Lo)
2) One month ahead forecast of Cloud Top Temperature: T(m+1, La, Lo)

The input parameters are selected according to the Table 1.

Table 1.

Phase	***Year and Month***
Train	1984 Apr-Dec, 1985 Jan-Dec, 1986 Jan-Dec
Test	1989 Apr-Dec, 1990 Jan-Dec
Validation	1989 Apr-Dec, 1990 Jan-Dec

The Neural Network Model

Feedforward Neural Network architecture with 12 inputs in the input layer, one hidden layer with 25 hidden neurons and 2 outputs in the output layer is created. In the development mode, the network is trained with Levenberg-Marquardt Backpropagation Algorithm with the data explained in the “Data Preparation”.

In the operation mode, the regional cloudness and cloud top temperature values will be forecast one month in advance. The operation mode results and the error analysis will be given in the “Results” section.

WORKING GROUP 6

Electrical microphysics of ions and aerosols and their significance for clouds

ESF / PESC Network:
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Selective ion charging of droplets in thunderstorms under arbitrary oriented electric field

A. E. Sorokin

The paper continues and extends the previous work [1]. Coupling of an aerosol particle modelled as an ideal conducting sphere to the moving ionized gas has been investigated in the presence of an arbitrarily directed external electric field. Trajectory approach has been used. The trajectory section in $y = 0$ plane is in Fig 1, left. The topology of trajectories depends on regime of gas flow, parameter $|\xi_{\pm}| = B_{\pm}E_{\infty}/U_{\infty}$, angle α. Attachment coefficients for ions have been found analytically and numerically including the

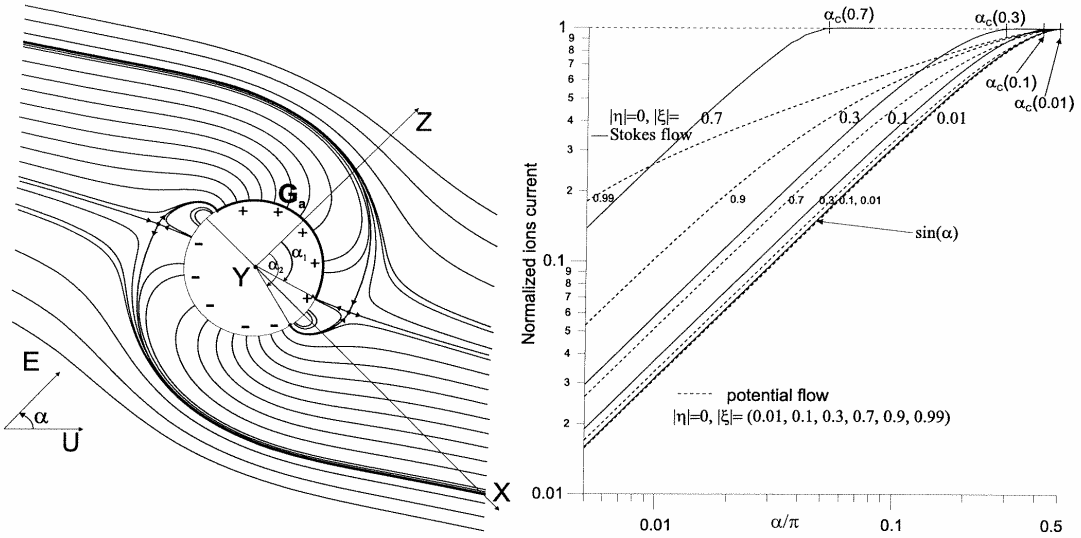

Figure 1: Left: Negative ions trajectories, $Y = 0$ plane, $\alpha = 0.25\pi$, $|\xi_{-}| = 0.25$, $\eta_{-} = 0$. Right:Negative ions current on the aerosol as function of α. Solid lines stand for the Stokes flow, dashed - for the potential flow.

important case when the electric field $\mathbf{E}_{\infty}$ and gas flow velocity $\mathbf{U}_{\infty}$ are not collinear. The sample curves for neutral spherical droplet are presented in Fig 1, right. In the limit of low electric fields, $|\xi_{\pm}| \to 0$, the current for both flow regimes is equal to $\sin(\alpha)$. The stationary charge of the individual isolated aerosol as function of angle between $\mathbf{E}_{\infty}$ and $\mathbf{U}_{\infty}$ has been examined. Also the assemble of identical droplets which flow down under electric field has been analyzed. The stationary droplet charge density as a function of ion concentration and α has been investigated.

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"Space Weather and the Earth's Weather and Climate (SPECIAL II)"

Atmospheric ion mobility spectra at cloud-forming altitudes

K. Aplin

The electrical microphysics affecting clouds is currently poorly understood, despite the possible relevance of ionisation for cloud formation processes [1].

Atmospheric ion mobility spectra can be used to identify tropospheric ion growth leading to condensation nucleus formation. However, such measurements are rare, although modern ion instrumentation is available [2].

Developments in the operating theory of the classical instrument for ion measurement, the aspirated cylindrical capacitor, will be described, which enable ion mobility spectrum information to be extracted from the rate of voltage decay of the aspirated capacitor in air. In this presentation, data from historical balloon-borne ion counter ascents during the 1958 solar maximum [3] will be reanalysed. New ion mobility spectra during a period of minimum cosmic ray ionisation will be extracted from simple voltage time series. Such data recovery will increase the amount of atmospheric ion spectra available for analysis, and permit further investigation of solar effects on ionisation.

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WORKING GROUP 7

Global atmospheric electric circuit and current density variability affecting cloud microphysics

ESF / PESC Network:
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The Global Atmospheric Circuit

W. Kundt

I shall update my earlier claim [JASTP 61, 955-963 (1999)] that the geocapacitor - between the iono- sphere and the ground - is permanently charged by the negative `drizzle´ of the `heavy´ aerosols. All thunderstorms are discharges of this circuit.

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Some thoughts on modelling the global atmospheric electric circuit

M. J. Rycroft

There is a need to create a model of the global atmospheric electric circuit which incorporates both spatial and temporal variations. In the charging part of the circuit, there are strong diurnal (U.T.) variations due to the spherical asymmetry (geographic distribution) of thunderstorms, variations due to the evolution of individual thunderstorms and their constituent cells (up to 1 hour), and variations associated with cloud-to-ground strokes (microseconds to ms) and with upward lightning (sprites, ms to s). In the ionospheric part of the circuit, not really an equipotential surface, there are marked day-to-day and semi-annual variations associated with space weather events and with variations of geomagnetic activity. In the fair weather part of the circuit, the electrical conductivity of the middle atmosphere at geomagnetic mid-latitudes, especially on the eastern flank of the South Atlantic Geomagnetic Anomaly, is enhanced during relativistic electron precipitation events. Stratospheric and tropospheric conductivity should be reduced - and cloud microphysics may be changed - during Forbush decreases and around solar maximum; the presence of volcanic aerosols should also reduce the stratospheric conductivity. In the return part of the circuit, conductivity variations of the boundary layer below thunderstorms at low latitudes, associated with cosmic ray flux changes, are likely to be crucial. A conceptual model incorporating these effects, some of which are non-linear, is proposed.

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Global atmospheric electric circuit as an open dissipative system

E. Mareev, S. V. Anisimov

Recent experimental and theoretical studies make it possible to analyze the global atmospheric electric circuit as a hierarchy of multi-scale dissipative systems. We consider the global circuit as a thermodynamically open system driven by the external sources of energy. The main contribution stems from the solar radiation which is partially absorbed by the land, ocean and atmosphere causing convective motion, winds and water phase transformations and accompanying by the electrical energy generation in the atmosphere. Other potential sources of energy are the geothermal energy flux, solar wind and galactic cosmic rays. We present the estimations showing the energy input into the large-scale structure growth, fine structure generation and micro-scale electric field perturbations caused by highly charged hydrometeors.

The energy flow from global to local scales through the atmospheric electric circuit is accompanied by the generation of multi-scale dissipative structures [1], including fine structure of thunderclouds and aeroelectric structures in the boundary layer. We consider briefly the mechanisms of dissipative instabilities leading to these structures generation. In particular, analytical solutions describing the formation of dynamical structures for electric field and space charge density in the boundary layer have been found. Under some simplifications this model leads to the modified Burgers equation for the nonstationary space charge density perturbations of the finite magnitude with the electro-kinetic Reynolds number as a control parameter.

A thunderstorm as a generator of the global circuit is a key element in the field. We have considered the evolution of electric field and space charge of a thunderstorm cloud in the framework of a diffusion equation for the electric field, which has auto-wave solutions, describing the dynamics electric charge regions separated in the cloud space. Asymptotic values for the velocity and thickness of the space charge front has been found, controlled by the diffusion and parameters of the separation and dissipation currents. The estimates of the electrostatic energy growth rate for a thunderstorm cell are performed at the stage of its intensive development [2]. Further progress in understanding the global curcuit requires also the role of mesoscale convective systems [3] and lightning induced transients in the global circuit dynamics, including transient luminous events in the middle atmosphere [4].

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The atmosperic electric field in the southern polar region and thunderstorm activity

Y.A. Frank-Kamenetsky, O.Troshichev, G.Burns, M.Fuellekrug, A.Rodger, V.Morozov

Observations of the atmospheric, near-surface vertical electric field Ez have been carried out at the Russian Antarctic station Vostok since 1998 under the framework of a cooperative Russian-Australian project. Only data satisfying "fair weather" conditions are selected for the subsequent analyses. Behavior of Ez field at Vostok station is compared with thunderstorm flushes determined with an accuracy of microseconds from spacecraft measurements in April 1998 and with simultaneous VLF emission measurements at Halley (Antarctica). We find no correlation between Ez and the lightning flashes intensity, or between Ez and VLF emissions, although significant correlation between Ez and VLF emissions is observed in particular cases. The same statistical results have been obtained from a comparison of hourly averaged values. Moreover, even the mean diurnal variation of electric field derived for 10 fine weather days in April 1998 turned out to be inconsistent with the mean diurnal variation of the lightning flashes for the same days. Reasons of these inconsistencies are discussed.

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Ground middle latitude aeroelectrical observations in geoelectromagnetic complete set

S. V. Anisimov

Recent knowledge concerning solar-terrestrial relations has brought an essentially new approach to appreciate the aero-electrical processes in the Earth;s environment [1-3]. The global atmospheric electrical circuit, according to its classical definition, represents the current contour formed by bottom ionosphere and terrestrial surface conducting layers, with thunderstorm generators as the basic electrical sources, and the areas of a free atmosphere as zones of returnable currents. The global electrical circuit has the properties determinable by physical behaviors of the magnetosphere, ionosphere, atmosphere and lithosphere. Atmospheric electricity is an integral part of the global electrical circuit. An extensive database obtained after long-term ground-based aero-electrical measurements, is a background for experimental research of global electrical circuit formation. In particular, the database of the mid-latitude Borok Geophysical Observatory (http://geobrk.adm.yar.ru:1352) contributes substantially to the study of the Earth's electromagnetic environment [4].

The mid-latitude Borok Geophysical Observatory (58.03 N, 38.97 E) is equipped by the experimental complex for the field digital recording of the following geophysical fields: 3-components and total intensity of magnetic field in network of INTERMAGNET; 3-components of magnetic field variations in network of SAMNET; 3-component of ULF magnetic field by induction magnetometers; 3-components of telluric currents; riometric observations of cosmic radio noise absorption at frequency 32 MHz; multi-frequency Doppler sounding; atmospheric electric field by the electrostatic fluxmeter ("field mill"); vertical atmospheric electric current by the current collector; atmospheric pressure by the microbarograph.

The fragments of amplitude;time registration of geophysical fields, including the atmospheric electric field and current, have been pointed out for aeroelectric response of some magnetic storms events in 2000-2002. The remote receiving of electric field variations is carried out by means of «field mill» lines for aeroelectrical structure detection [5]. The structural-temporal profiles of the electric-field dynamics under fair weather and fog conditions were studied. The analysis of observation fields enables to represent the global electric circuit as an aggregation of electrical structures with different spatio-temporal scales.

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The future of SPECIAL

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GRID computing and virtual institutes

K. Jeffery