AE42A-0797 1330h POSTER

Measurement of Externally Driven D Region Ionospheric Variability

Zhenggang Cheng[1] (919-660-5232; zc@ee.duke.edu)

Steven Andrew Cummer[1] (919-660-5256; cummer@ee.duke.edu)

[1] Duke University, 130 Hudson Hall Duke University, Durham, NC 27708, United States

Very low frequency (VLF) electromagnetic pulses launched from lightning, which are called sferics, are almost entirely reflected by the ionosphere below 100 km altitude and thus contain information about the D region ionosphere. In this work we examine the effects of three different external sources on the D region ionosphere. The first is lightning itself. Powerful electromagnetic pulses radiated from lightning discharges can cause direct heating and ionization of the lower ionosphere. Using VLF energy radiated from lightning that occurred before and after a big lightning discharge, we can measure D region ionosphere disturbance caused by big lightning flash. Our results will be compared to theoretical predictions (e.g. Taranenko et al., GRL, 1993). With the same measurement technique, we also measure the D region ionosphere variability due to solar flares such as X-class/M-class flares and relativistic electron precipitation. The daytime ionospheric change produced by big solar flares is clear. Using SAMPEX energetic particle data we also find clear nighttime ionospheric changes when significant particle precipitation is present.

AE42A-0798 1330h POSTER

The Use of the Waveguide Cutoff Region to Monitor Ionospheric Height Through the Day-Night Boundary

Kunal K Surana[1] (617-452-5979; kunal@mit.edu)

Earle Williams[2] (781-981-3744; earlew@ll.mit.edu)

[1] Massachusetts Institute of Technology, Electrical Engineering and Computer Science, Cambridge, MA 02139, United States

[2] Massachusetts Institute of Technology , Parsons Laboratory, 48-211, Cambridge, MA 02139, United States

The use of electromagnetic waves to measure the height of the ionosphere is a well-known concept, as in any ionosonde. However, the use of lightning as a tool to measure the ionospheric height is less well explored. Using a wideband electric antenna in West Greenwich, Rhode Island with a flat frequency response across the ELF-to-VLF transition region, this study purports to do just that. A preliminary study for a single day has revealed that the effective ionospheric height rises from 60 km during the day to almost 90 km at night, and that this change in height occurs over a short period of time - less than 30 minutes. Given that the effects of dispersion and waveguide attenuation at VLF are different for day and night, different approaches are used at different times. The two main approaches are outlined below:

1) During nighttime, tweek sferics are prevalent and the tranverse resonances of the Earth-ionosphere waveguide are weakly damped. In this case, frequency-time spectrograms are used to determine the cutoff frequency and asymptotically, the tranverse resonance frequencies. The effective ionospheric height is easily calculated from these results.

2) During daytime, VLF attenuation is enhanced and the quality factor of the transverse resonances much reduced. Consequently, we appeal to the extraction of the waveguide cutoff frequency from simple FFT's of individual sferics waveforms. This frequency is picked in the steep rise to VLF energy out of the broader frequency region with reduced waveguide energy. Attention will also be given to the locations and characteristics of lightning flashes that provide the best estimates for effective ionospheric height, by any method.

AE42A-0799 1330h POSTER

ELF/VLF monitoring of lightning activity in Taiwan*

Yun-Chin Wang[1] (l2890102@phys.ncku.edu.tw); C.L. Kuo[1] (johnny@phys.ncku.edu.tw); A.B. Chen[1] (alfred@phys.ncku.edu.tw); R.R. Hsu[1] (rrhsu@phys.ncku.edu.tw); H.T. Su[1] (htsu@phys.ncku.edu.tw); L.C. Lee[1,2] (loulee@nspo.gov.tw)

[1] Department of Physics, National Cheng Kung University, No.1, Ta-Hsueh Road, Tainan 701, Taiwan

[2] National Space Program Office, 8F, 9, Prosperity 1st Road, Science-Based Industrial Park, Hsin-Chu 300, Taiwan

Currently, there are two long-range lightning monitoring systems operating in Taiwan; one is a VLF/ELF electric field detection system and the other one is an ELF (SR) magnetic field system. The electric field system detect the electric sferics emitted by lightning in the 1 Hz to 22 kHz range. The magnetic system operates in the frequency range of 1 Hz to 100 Hz. In the 2003 Taiwan Sprites campaign, these two systems worked in parallel with a set of ICCD cameras to study oceanic sprites occurring in the South China Sea. From the ELF and optical data, the correlation between optical luminosity of sprites and amplitudes of their associate ELF emission was found. We will also discuss the possible correlation between the morphology of sprites and the waveform of their associate ELF signals. * This work was partially supported by 92-NSPO(B)-ISUAL-FA09-01 and NSC 92-2111-M-006-002

AE42A-0800 1330h POSTER

The Structure of Sporadic-E Layer Suggested by the In-situ Electron Number Density Profile Obtained During the SEEK-2 Campaign

Makoto Wakabayashi[1] (+81-22-217-6518; waka@stpp1.geophys.tohoku.ac.jp)

Takayuki Ono[1] (+81-22-217-6514; ono@stpp1.geophys.tohoku.ac.jp)

[1] Graduate School of Science, Tohoku University , Aramaki, Aoba-ku, Sendai 980-8578, Japan

To understand the generation mechanism of QP echoes, the SEEK-2 campaign was carried out on August 3, 2002. It has been planned as an in-situ observation using two sounding rockets and ground-based instruments. Based on the electron number density measured by using the Impedance Probe during the rocket experiments, there have been found very similar peak structures of electron density in each profile. This similarity might be an important signature to understand the generation mechanism of QP echoes. It is also suggested that there was significant horizontal modulation of electron number density at the altitude of Es layer, suggested by comparison of Impedance Probe and Beacon observation results. The 3-D structure of Es layer is very important to understand the process of QP echoes generation, however there were few studies on the 3-D picture of Es layers. The purpose of this paper is to discuss on the possibility to realize the 3-D Es structure mentioned above. NEI(Number density of electrons by Impedance probe) was installed in S310-31 and 32 sounding rockets which were used during the SEEK-2 campaign, they launched at 23:24JST and 23:39JST respectively. The altitude profiles obtained by the measurement of electron number density showed very sharp peak due to the Es layer at the altitude of around 105km (number density is about 10^5 /cc). This feature is very similar among the four profiles, so it is possible to infer that there is very large structure horizontally expanded more than 100km. In addition, there are large modulation of electron number density in the Es layer suggested by the comparison between NEI and Beacon measurement. The estimated magnitude of the modulation is ranging from 10^5 to 10^4 /cc. Based on these facts, it becomes possible to estimate the 3-D structure of Es layer. About 3-D structure of Es layer estimated by radar observation results have already reported in several issues, as an example, [Chu, Yen-Hsyang et al., 2002]. In this paper, 3-D structure of Es layer estimated by in-situ observation result is discussed by comparing to the other results obtained during SEEK-2 or theoretical studies of QP echoes generation [R. B. Cosgrove et al., 2001], and recent progress of study on the irregular structure of Es layer.

AE51A MCC: 2000 Friday 0800h

Electrical Effects of Thunderstorms on the Middle and Upper Atmosphere III *(joint with A, SA, SM)*

Presiding: **D D Sentman,** Geophysical Institute, University of Alaska, Fairbanks**; V P Pasko,** Pennsylvania State University

AE51A-01 0800h INVITED

Strong Electric Fields from Positive Lightning Strokes in the Stratosphere: Implications for Sprites

Robert H Holzworth[1] (206 685 7410; bobholz@washington.edu); Michael P. McCarthy[1]; Jeremy N. Thomas[1]; Timothy M. Chinowsky[2]; Michael J. Taylor[3]; Osmar Pinto[4]

[1] Earth and Space Sciences University of Washington, Box 351310, Seattle, WA 98195-1310, United States

[2] Electrical Engineering University of Washington, EE/CSE ROOM M234, Seattle, WA 98195-2500, United States

[3] Space Dynamics Laboratory, Utah State University, Logan, UT 84322-4145, United States

[4] Atmospheric Electricity Group, DGE/INPE, Sao Jose dos Campos, SP 12240-540, Brazil

A balloon payload launched in Brazil has measured vector electric fields from lightning at least an order of magnitude larger than previously reported above 30 km in the stratosphere. During the flight hundreds of lightning events were recorded, including several positive cloud to ground lightning strokes. A two stroke flash, with small (15kA peak current) and moderate (53 kA) positive strokes at a horizontal range of 34 km, produced fields over 130 V/m at 34 km altitude. On-board optical lightning detection, recorded with GPS timing, coupled with ground based lightning location gives high time resolution for study of the electric field transient propagation. These measurements imply that lightning electric fields in the mesosphere over large thunderstorms may be much larger than previously measured.

URL: http://www.ess.washington.edu/Space/AtmosElec/Brazil.html

AE51A-02 0820h

Investigating sprite energetics over Brazil in association with small/frontal storms

Michael J Taylor[1] (435-797-3919; mtaylor@cc.usu.edu); Piere D Pautet[1] (pautet@cc.usu.edu); Matt Bailey[1] (mattbailey@cc.usu.edu); Fernanda SaoSabbas[2]; Osmar Pinto[2]; Robert Holzworth[3]; Mitsuteru Sato[4]

[1] Center for Atmospheric and Space Sciences, Utah State University, Logan, UT 84322, United States

[2] INPE, INPE, Sao Jose dos Campos, SP 00000, Brazil

[3] University of Washington, University of Washington, Seattle, WA 00000, United States

[4] Tohoku University, Tohoku University, Sendai 00000, Japan

As part of the sprites 2002 balloon campaign, a suite of intensified CCD cameras were used to obtain novel data on the occurrence and properties of sprites over south eastern Brazil. Measurements were made from a field station at Cachoeira Paulista (23S, 45W), and from an Embraer aircraft both operated by the INPE (Instituto Nacional de Pesquisas Espaciais). A total of eighteen transient optical events were recorded, sixteen of which exhibited vertical structures typically associated with sprites, while the other two were disc-like events, characteristic of sprite halos or elves. Coordinated measurements by the ELAT Brazilian lightning network show that all but three of these transient events were associated with positive lightning discharges generated by relatively small thunderstorms, that were induced primarily in association with the passage of strong cold fronts. Furthermore, simultaneous ELF data obtained from Syowa Station, Antarctica and Onagawa, Japan, indicate that the charge moments associated with these events ranged from 240 to 1500 C.km with a predominance of 400-600 C.km. These observations provide the first quantitative measurements of sprites over Brazil. Although our data acquisition was limited by prevailing weather conditions, the results indicate that sprites occur relatively frequently over south eastern Brazil during the fall and spring time periods, mostly in association with rapidly developing small storms or with frontal systems.

AE51A-03 0835h

Sprites and lightning observation system installed at ESRANGE, Kiruna

Yukihiro Takahashi[1] (yukihiro@pat.geophys.tohoku.ac.jp); Mitsuteru Sato[1] (msato@pat.geophys.tohoku.ac.jp); Atushi Ohkubo[1] (ohkubo@pat.geophys.tohoku.ac.jp); Hiroshi Fukunishi[1] (fuku@pat.geophys.tohoku.ac.jp); Satonori Nozawa[2] (nozawa@stelab.nogayo-u.ac.jp); Ryoichi Fujii[2] (rfujii@stelab.nogayo-u.ac.jp)

[1]Dept.Geophysics, Tohoku University, Aramaki, Aoba-ku, SEndai 980-8578, Japan

[2]STE Lab, Nagoya Unuversity, Frocho, Chikusa-ku, Nagoya 464-01, Japan

Activities of sprites and elves were first recorded in the west coast of Japan when a cold front passed over Japan by Tohoku University group in 1998. This fact strongly predicts occurrence of sprites and elves in other areas in wintertime, such as Northern Scandinavia where large positive CGs are occurring in wintertime. Once sprites and/or elves in the polar region are detected, it would be expected that many important phenomena are occurring: the interaction between the lightning-induced phenomena and the polar ionosphere/magnetosphere by electron density enhancement and by field-aligned current connection, high energy particle supply to the magnetosphere and so on. In order to conduct the sprites/elves imaging in the polar region, we improved an image-intensified CCD camera at ESRANGE, Kiruna, Sweden in August 2003, and also installed VLF receiver there. Further, we set up 2-components ELF receivers as the third station of the ELF world network of Tohoku University. All equipments are remotely controlled from Japan using network. A careful examination of Scandinavian lightning data provided by SINTEF and ELF recordings by Tohoku University shows there exist some strong cloud-ground discharges with a sufficient charge moment to produce sprites in January and February in the polar region.

AE51A-04 0850h INVITED

Role of Neutral Density and Conductivity Perturbations in Determining Sprite Initiation Locations

Fernanda T São Sabbas[1] (++55-12-3945-7154; fsaosabbas@dae.inpe.br)

Davis D Sentman[2] (++1-907-474-6442; dsentman@gi.alaska.edu)

Antonius Otto[2] (ao@how.gi.alaska.edu)

[1]Instituto Nacional de Pesquisas Espaciais - INPE, Aeronomy Division - DAE/INPE Av. dos Astronautas 1758 Jd. Granja, São José dos Campos, SP 12227-010, Brazil

[2]University of Alaska Fairbanks - UAF, Geophysical Institute, UAF, Fairbanks, AK 99775-7320, United States

Multiple sprites are often observed to occur simultaneously, laterally displaced from the underlying causative cloud-to-ground (CG) lightning discharge. The causes of this lateral displacement are presently not understood. This paper investigates the role of neutral density perturbations in determining the locations of sprite initiation. The work was motivated by two previous studies: (1) A detailed statistical showing that the distribution of sprite offsets relative to the underlying lightning had a mean of 40 km [São Sabbas et al., 2003]. (2) A follow-up study for the same observations showing that the maximum sprite and -CG production of the system were simultaneously reached at the time of maximum contiguous cloud cover of the coldest region, corresponding to the period of greatest convective activity of the system [São Sabbas and Sentman, 2003]. Thunderstorm convective activity is a potential source of gravity waves and mesospheric turbulence, which create an inhomogeneous neutral density background. For this paper computer simulations of the temporal-spatial evolution of lightning-induced electric fields in an inhomogeneous mesospheric neutral density and conductivity were performed. The results indicate that electrical breakdown is facilitated in isolated regions of density depletions at sprite initiation altitudes. These spatially distributed breakdown regions provide the seed electrons necessary for sprite generation, and may account for the observed sprite offsets. Furthermore, neutral density depletions may play a critical role in setting the overall sprite activity level above a thunderstorm.

AE51A-05 0910h INVITED

Remote Sensing of the Mesosphere by Means of Telescopic Observations of Sprites

Elizabeth Gerken[1] ((607)255-9070; gerken@nova.stanford.edu)

Umran Inan[2] ((650)723-4994; inan@nova.stanford.edu)

[1]Cornell University, 303 Rhodes Hall, ECE Department, Ithaca, NY 14853, United States

[2]Stanford University, 350 Serra Mall Room 356, Stanford, CA 94305-9515, United States

Telescopic imaging of sprites reveals fine structure covering a wide range of morphologies and time scales [*Gerken et al.,* 2000]. Theoretical explanations of observed spatial fine structures and diffuse glow in sprites were put forth in the context of a streamer-based model of electrical breakdown above thunderstorms [*Raizer et al.,* 1998; *Pasko et al.,* 1998]. Streamer properties depend on the background electron, ion and neutral atmospheric densities as well as the polarity of the streamer. In high altitude discharges such as sprites, which may extend over an altitude span of 50 - 100 km, the atmospheric neutral density decreases exponentially with altitude while the electron number density exponentially increases with altitude. Consequently, streamer properties are observed to vary throughout the altitude extent of a sprite. Theoretically, it should be possible to use observed streamer properties to gain insight into the natural background densities in the vicinity of a sprite. Since this region of the atmosphere is particularly difficult to study by other methods, sprites may thus serve as a useful tool in collecting data on the atmospheric composition at mesospheric altitudes. Many sprites were observed by the Stanford University telescopic imager during a large storm on July 13, 1998. Case studies of selected sprite events during this storm are presented and the relationships between observed sprite properties and parameters of the mesosphere are discussed.

AE51A-06 0930h

Observations of Thunderstorm Effects on Middle-Atmosphere Ionizable Constituents

Charles L Croskey[1] (814-865-2357; CCroskey@psu.edu)

John D Mitchell[1] (814-865-2359; jdm4@psu.edu)

Martin Friedrich[2] (Friedrich@inw.tu-graz.ac.at)

John W Meriwether[3] (864-656-0915; john.meriwether@ces.clemson.edu)

[1]Communications and Space Sciences Laboratory, Dept. of Electrical Engineering The Pennsylvania State University 303 Electrical Engineering East, University Park, PA 16802, United States

[2]Dept. of Communications and Wave Propagation, Technical University of Graz, Graz A-8010, Austria

[3]Dept. of Physics and Astronomy, Clemson University 208 Kinard Laboratory, Clemson, SC 29634, United States

A coordinated rocket and ground-based program to investigate the effects of nearby thunderstorm activity on middle-atmosphere ionizable constituents was conducted at Wallops Island, VA. The first rocket payload was launched in darkness at 0632 UT on May 10, 2002. On the previous evening a significant weather front passed over the Appalachian mountains in Virginia approximately seven and a half hours before the time of the rocket launch. The front continued eastward to the Eastern Shore of Virginia and passed the rocket apogee location about three hours before the launch. A ground-based optical imager provided by Clemson University observed spherical wave structure in both the 557.7 nm and OH images after the front had passed over the launch range. An identical payload was launched at 0626 UT on May 16, 2002. There was no tropospheric convective activity in the area at the time of this launch or during the entire preceding evening. No obvious spherical wave structure was seen in the imager data during this evening. Four Gerdien condenser instruments, which measured ion conductivity, mobility, and concentration, were located at the front of each payload. Positioned in the center electrode of each Gerdien condenser was an RF-excited UV source. A different rare gas and window combination used with each lamp provided the sources for investigating the ionization/photodetachment properties of the aerosols. The lamp wavelengths ranged from 123.6 nm (10 eV) to 365 nm (3.4 eV). The payload also included a fixed-bias Langmuir probe for observation of both the background and lamp-induced electron concentrations. Absolute calibration of the Langmuir data was provided by an on-board Faraday radio-wave propagation experiment. While the main focus of the experiment was to identify thunderstorm-associated effects on mesospheric particles, the data during the disturbed evening additionally showed a significant change in the concentration of gas-phase ions (presumably, NO+) produced by the 123.6-nm UV source. This difference in response between the two evenings is thought to be related to changes in the neutral density temperature, produced either by gravity waves or electrostatic heating from the thunderstorm activity.

AE51A-07 0945h

The Upward Directed Poynting Flux over a Thunderstorm

William M Farrell[1] (william.farrell@gsfc.nasa.gov); Richard A Goldberg[1]; Richard J Blakeslee[2]; Steve A Cummer[3]; Michael D Deschj[1]; Doug M Mach[2]; John D Mitchell[4]; Charles L Croskey[4]

[1]Laboratory for Extraterrestrial Physics, NASA/Goddard SFC, Greenbelt 20771

[2]Global Hydrology and Climate Center, NASA/Marshall SFC, Huntsville 35805

[3]Dept. of Computer and Electrical Engineering, Duke Univ., Durham 27708

[4]Dept. of Electrical Engineering, Penn State Univ, State College 16803

In August of 2002, NASA carried out the Altus Cumulus Electrification Study (ACES) to investigate the lightning/storm relationship, to quantify the storm electrical budget, and to validate the TRMM lightning sensor (LIS) data. The platform was General Atomic's Altus uninhabited aerial vehicle (UAV) which allowed long-duration, close-proximity monitoring of storms from their births to deaths. The platform carried a set of DC Field Mill sensors to measure electrostatic fields, AC electric and magnetic field sensors for deriving the Poynting flux, a Gerdien conductivity probe, optical sensors, and a flight payload data system. The data system collected low rate data, and also cloud be event-triggered into high rate mode for approximately 0.3 seconds about lightning strikes. During the month long mission, 11 scientific flights occurred yielding over 4300 high rate triggered events. An objective of this study was to determine the amount of upward radiated power into the middle atmosphere and ionosphere, and determine contribution of the radiated power to the global atmospheric electric circuit. In this work, we show upward Poynting flux measurements between 10 Hz -100 kHz from some specific thunderstorm overflights. We find that upward radiated powers from lightning strikes can be large. However, displacement currents are also comparatively large, suggesting that the radiation impedance above a thunderstorm is relatively low (150 Ohms at 10 kHz). This radiation impedence is calculated as a function of frequency. The effect of the radiated power on the global circuit will be discussed.

AE51B MCC: 3010 Friday 1020h

The Physics of Lightning and Storm Electrification III *(joint with A, NG)*

Presiding: **L D Carey,** Texas A&M University**; A Jacobson,** Los Alamos National Laboratory

AE51B-01 1020h INVITED

Model Studies of Lightning in Thunderstorms

Edward R Mansell[1] (mansell@ou.edu)

Kristin Kuhlman[1] (kkuhlman@ou.edu)

Conrad L Ziegler[2] (conrad.ziegler@noaa.gov)

Jerry M Straka[3] (jstraka@ou.edu)

Donald R MacGorman[2] (don.macgorman@noaa.gov)

[1]CIMMS/Univ. of Oklahoma, NSSL 1313 Halley Cir., Norman, OK 73069, United States

[2]Natl. Severe Storms Lab, 1313 Halley Cir., Norman, OK 73069, United States

[3]Univ. of Oklahoma/School of Meteor., 100 E. Boyd St., Norman, OK 73019, United States

The OU/NSSL cloud-scale model has a microphysics package designed to treat a variety of convective events and has numerous noninductive graupel-ice charge separation schemes based on different laboratory results. Other features are a branched 3-D lightning scheme and a recently-added explicit treatment of small ion processes. Model results suggest that lower charge regions can be generated by either inductive or noninductive processes. Inductive graupel-droplet interactions were