NEWSLETTER ON ATMOSPHERIC ELECTRICITY

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AMS COMMITTEE ON ATMOSPHERIC ELECTRICITY

AGU COMMITTEE ON ATMOSPHERIC AND SPACE ELECTRICITY

INTERNATIONAL COMMISSION ON ATMOS. ELECTRICITY

Announcements

Future Newsletter Contributions. Contributions to the next edition of this Newsletter are welcome and should be submitted to Earle Williams, Secretary of the ICAE, by e-mail (preferably) (earlew@juliet.ll.mit.edu) or by fax (617-253-6208) by April 1, 1996. Mark your calendars!

AGU CASE NEWS (From John Willett):

As most of you know, the Committee on Atmospheric and Space Electricity (CASE) is chartered by the American Geophysical Union (AGU) to promote interdisciplinary collaboration among meteorologists, atmospheric electricians, middle-atmospheric electrodynamicists, upper-atmospheric physicists, and others interested in electrical processes in atmospheres. CASE meetings are open and are generally held one early-December evening at the AGU Fall Annual Meeting in San Francisco. Thanks are due to the AGU for continuing to share the printing and mailing costs of this Newsletter with the ICAE.

The current term for the Committee ends this Spring. Nominations of new members and a new Chairperson are hereby solicited. Please convey your nominations to the current Chairperson, John C. Willett. The present CASE membership (with some E-mail-address corrections) is:

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John C. Willett, PL/GPAA, 29 Randolph Rd., Hanscom AFB, MA 01731-3010. Phone: 617-377-5954. E-mail: willett@zircon.plh.af.mil

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A tentative agenda for the next CASE meeting, which will be held Thursday night, December 14, at 8:00 PM in the Pacific B room of the Marriott (55 4th St., near the Moscone Center), is as follows:

Old Business:

1) Schedule Conflicts with ICAE Meetings -- Earle Williams
2) Nominations for Awards and Fellows -- Bob Holzworth
3) Poster Sessions at the Fall Meeting -- John Willett

New Business:

4) IUGG/IAMAS M7 Symposium -- Bob Holzworth?
5) Middle-Atmosphere Update -- Dick Goldberg
6) AMS Atmospheric Electricity Committee -- new Chairperson?
7) Funding Sources -- John Willett. Please send any information you have on funding sources (aside from Ron Taylor at NSF and Jim Kroll at AFOSR) to John Willett ASAP.

8) Division of JGR Atmospheres -- Tom Marshall
9) Subdivision of AGU AS Section -- John Willett
10) LDAR, an Example of NASA/KSC Contributions to Science --John Willett
11) Fall Meeting Scheduling -- John Willett
12) CASE-Related Articles in EOS -- John Willett

13) Is the Database Listing Dead? -- John Willett
14) Nomination of New CASE -- John Willett
15) Upcoming Experiments -- Open. Please be prepared to share any opportunities for collaboration with the community.

The policy of the current chairman of the CASE is to encourage the BRIEF announcement at our annual committee meeting of upcoming field experiments and other projects that offer significant opportunities for collaboration. In view of the contextQthe AGU meeting itselfQand to avoid duplication of the new database listings to be published annually in this newsletter (but see below), oral reporting of recent experimental programs will be discouraged. Please suggest other agenda items via E-mail to John Willett ASAP!

ANNUAL CASE DATABASE LISTING --- 1995

No listings received during the past year!

The organizers of the upcoming 10th International Conference on Atmospheric Electricity in Osaka, Japan, 10-14 June, 1996, have requested the publication of refereed conference proceedings in a Special Section of the Journal of Geophysical Research (JGR), Atmospheres, as was done for the previous three ICAE Conferences. Accordingly, the CASE has prepared a National Science Foundation (NSF) grant proposal for submission by the AGU. It is intended to obtain funding for (a) English-language editorial assistance from knowledgeable graduate students to non-English-speaking authors whose papers have been accepted by the Guest Editor, (b) publication of papers whose authors cannot afford the JGR page charges, and (c) printing of a reprint volume of the Special Section to be distributed to conference attendees who are not JGR Atmospheres, subscribers. In view of the substantial cost of attending the Osaka Conference, we are also requesting from NSF (d) partial travel support for individual US scientists who would otherwise be unable to attend. Travel-grant application forms are available from:

AGU-Patricia Azriel
2000 Florida Avenue, N.W.
Washington, D.C. 20009
pazriel@kosmos.agu.org

Application Deadline: March 1, 1996 Graduate students (with recommendation of advisor), minorities, and retired scientists are specifically encouraged to apply.

AMS / CASE NEWS (From Bob Holzworth):

1. The IUGG95 M7 Symposium on Atmospheric Electricity Special Section has passed the first deadline for paper submission (October 31, 1995). Papers submitted after that date may make the publication, but cannot hold up the JGR issue. We are planning to have the Special Section in print by the ICAE meeting in Japan next summer.

2. ICAE Japan 96 will also have a special section of JGR. A proposal to support that effort, along with travel grants to students and needy scientists will be submitted by AGU to NSF shortly (coordinated by John Willett). Watch for travel grant announcements for the ICAE meeting sometime in the early spring in EOS.

AMS Glossary Revision:

Dick Orville is serving on the American Meteorological Society's Editorial Board for the revision of the AMS Glossary. First published in 1957, the second edition is scheduled for publication in 1997. Orville's responsibility is atmospheric electricity. Colleagues interested in assisting in the revision of the Glossary should contact Orville (orville@ariel.tamu.edu), or Department of Meteorology, Texas A&M University, College Station, Texas 77843-3150. As with most editorial responsibilities, there is no pay, no recognition, and few reimbursements for expenses. The satisfaction will come from seeing the revision done correctly. I am interested in letting the community know that the revision is underway. I am seeking people that have an editorial interest, good ideas, and a willingness to see that we cover the field of atmospheric electricity in a thorough way.

31st COSPAR SCIENTIFIC ASSEMBLY

Birmingham, United Kingdom, 14-21 July 1996 One day meeting on 18 July: Electrodynamics of the low and sub-auroral middle atmosphere

The results will concern the electrodynamics of the low latitude middle atmosphere, i.e. conductivity and electric field. Effect of tropical lightning on middle atmospheric electrodynamics. However, sub-auroral latitude middle atmosphere phenomenon will also be considered (to include long duration balloon flight results) and some balloon and rocket results. Lightning effects on ionosphere and middle atmosphere and lightning above thunder clouds. The sprites and jets phenomena will be discussed. Ionisation in stratosphere and mesosphere due to lightning. Main Scientific Organizer: Dr. S.P. Gupta, Physical Research Laboratory, Ohmedabad 380 009, India; fax no.: 91-79-460502.

For further details contact: Cospar Secretariat, 51 Bd de Montmorency, 75016 Paris, France; fax no.: 331-405-09287 Abstract deadline: January 1, 1996

ICAE 96, Osaka

Zen Kawasaki reports: We have received 210 abstracts for this conference. Forty came from Russia, fifty domestic, and the rest came from U.S., EC, Asia, South America and so on. All papers are now being reviewed, and we have the first program committee on November 24. At the program committee the tentative schedule will be fixed, and the paper selection results will be announced. We hope we will be able to deliver the advanced program in early January. The conference committee would like to encourage young scientists and scientists in developing countries to apply for funds for participation in ICAE 96, Osaka. The scientists who are chosen by the committee will be given about 100,000 Japanese yen. The committee is ready to receive applications! The only necessary condition for application is the presentation of a paper at ICAE 96, Osaka. There is no fixed form for the appilcation, but please apply in English or Japanese. The official language is English. The application form should be sent to the Conference Secretary, Zen Kawasaki. In early or mid March all applicants will be informed of the Committee's decisions.

13th International Wroclaw Symposium

A Lightning Session is planned for the 13th International Wroclaw Symposium and Exhibition on Electromagnetic Compatibility, June 25P28, 1996. Interesed person should contact Prof. Michel Ianoz, LREPDE, EPFL, Lausanne, CHP1015, Switzerland, email: michel.iaonz@pre.de.epfl.ch.

National Commission on Atmospheric Electricity, Subsection "Electromagnetic Fields of the Atmosphere"

The NCAE has distributed the first announcement to the ICAE concerning the 10th International Conference on Atmospheric Electricity among Russian scientists who are active in the field of atmospheric electricity. Russian scientists submitted more than thirty abstracts of papers to the 10th International Conference. NCAE and Subsection EFA plan to conduct a seminar on the problem of remote measurement of lightning discharge characteristics during the XIV All-Russia Symposium RRadar investigation of natural mediums, S which will be held in the Spring of 1996 in St. Petersburg. Address of NCAE: Prof. Vladimir D. Stepanenko, Dr. Yakov M. Shvarts, A.I. Voeikov Main Geophysical Observatory, 7 Karbyshev Str., 194018, St. Petersburg, Russia.

Radar and Aircraft Cloud Electrification Study (RACES) Update (South Dakota School Mining and Technology):

John Helsdon and Andy Detwiler are seeking additional researchers interested in a field program to obtain an extensive set of microphysical and electrical observations on hailstorms. MacGorman and others have observed anomalous lightning activity connected with the development of large hail in thunderstorms. Various hypotheses have been advanced to explain this anomalous behavior, but detailed observations needed to test these hypotheses are lacking. An additional component to RACES now being considered is an Atmospheric Chemistry thrust involving the sampling of lightning-produced NOx within and around such storms.

At this time it appears that 1997 would be the next possible summer to attempt RACES. (Fieldwork planned for the Socorro, NM area during the summer of 1996 will use many of the facilities desired for RACES, making 1996 a poor year to conduct RACES.) The possibility that RACES might be implemented in conjunction with another 1997 hailstorm field program in Bismarck, ND has become remote, due to funding cuts in the NOAA program that would have funded that work. The other site considered for RACES operations is the CSU-CHILL radar site near Greeley, CO. This site remains a viable choice for 1997. Excellent support facilities are available at the CHILL site, and CHILL staff have developed expertise in deploying aircraft and surface vehicles to intercept storms and obtain unique observations. Steve Rutledge and Larry Carey of CSU have already begun to collect electrical and multiparameter radar observations on severe hailstorms occurring in the vicinity of CHILL, using fixed and mobile surface electric field and field change observations in addition to the radar. A project like RACES, deploying additional observing systems, can build on these observations.

We hope to have further discussions concerning RACES with colleagues attending the Fall AGU meeting as well as with others as opportunities present themselves. In order to request NSF facilities, such as the CSU-CHILL radar, aircraft, CLASS sounding systems, etc., for a project in 1997, it will be necessary to have at least one proposal, along with requests for the desired facilities, submitted to NSF by 15 June 1996. Anyone interested in participating in RACES should contact Andy Detwiler (andy@nimbus.ias.sdsmt.edu) or John

Helsdon (jhelsdon@lightning.ias.sdsmt.edu) by e-mail and/or make you intentions known at the Fall AGU meeting. Come to the RACES in 1997.

Research Activity by Organization

ASTeR Inc. / Mission Reserach Corp. (Ft. Collins, CO)

The SPRITES '95 field program was conducted at the Yucca Ridge Field Station, 20 km northeast of Ft. Collins, between 15 June and 6 August 1995. The program ultimately involved over 45 scientists and staff from 16 organizations and three countries. The 1995 season was somewhat more muted than the prior two years due to very dry conditions over much of the High Plains. Yet sprites were imaged on 25 nights with at least 700 video samples obtained.

ASTeR, Inc. (Walt Lyons, Tom Nelson, Liv Lyons) deployed two red sensitive Xybion ISS-255 low-light cameras, 1-10 kHz and 1-100 kHz VLF receivers, and a pointing photometer (designed by Jack Winckler). The video and VLF audio were logged onto S-VHS tape, along with the STAR Lab VLF audio, with GPS time stamping. In addition, magnetometer coils provided by MIT (Earle Williams) were installed to begin local measurements of Q-burst signatures to compare to other sites such as in Rhode Island (MIT) and the Kennedy Space Center (Carl Lennon, Launa Maier). The MIT team (Earle Williams, Charles Wong) obtained numerous Schumann resonance Q-bursts signatures coincident with optical sprite observation at the Rhode Island site. ELF and VLF measurements were also taken by Pennsylvania State University (Les Hale and Lee Marshall). The photometer, ELF and VLF signals were also digitally sampled in 1500 ms windows on an event basis (Bob Nemzek). The STAR Lab, Stanford University (Umran Inan, Bill Trabucco, Steve Reising, Alexander Slingleland) monitored continuous narrowband VLF observations at an array of sites along the west coast, VLF broadband and narrowband observations at Yucca Ridge and a the conjugate region at Palmer Station, and narrowband observations from a narrowband receiver mobile van positioned in line with the storm. Mission Research Corp/Nashua (Russ Armstrong and Jeff Shorter) deployed a sensitive photometer to look for the 4278 Angstrom band. Near the end of the program, Lawrence Livermore National Lab (John Molitoris and Colin Price) operated the new infrared and optical camera system (IROCS) for high temporal resolution (1-2 ms) sampling of sprite optical and IR emissions. Lockheed Martin (Steve Mende, Rick Rairden) obtained numerous spectra coordinated with low-light imagery. The University of Otago, New Zealand (Richard Dowden) deployed dual VLF receivers in Colorado for VLF interferometry in detecting RORD phenomena. Tohoku University, Sendai, Japan (Profs. Fukunishi, Takahashi and Kubota) operated four sensitive photometers monitoring two optical bands at two separate altitudes above storm tops. A 2-30 mHz tunable radar was operated for several days by SRI International (Roland Tsunoda). Bistatic VHF measurements by GeoSpace Research (Frank Djuth, Mathew Cox, Ken Williams) monitored WWV signals and 28 mHz transmissions in LaSalle, CO at a receiver in central Illinois to coordinate observations with optical sprite reports. Utah State University, Space Dynamics Labs (Mike Taylor, Peter Mace) operated a van with four camera systems, including a multi-spectral fish-eye system designed to map airglow variations.

Additional spectrometers and low-light cameras were operated by the Geophysical Institute, University of Alaska (Dave Sentman, Gene Wescott) atop a mountain peak west of Denver. When possible, optical measurements were obtained during overflights of NASA's Optical Transient Detector (OTD) (Dennis Boccippio) with possible coordinated measurements being obtained on 4 July. Coordination with overflights of the Space Shuttle (NASA MSFC, Otha Vaughan), the HALOE satellite (NASA Langley, Guy Beaver), Alexis/Blackbeard TIPPS and SIPPS reports (LANL, Bob Franz and Dave Smith) was attempted when possible. Data on confirmed sprite times will be used for comparison to times of TIPPS and SIPPS by Los Alamos National Lab (Bob Franz).

Coordination with the National Severe Storms Lab (Dave Rust, Tom Marshall) was successfully accomplished. A mobile van was positioned beneath the anvil on the far side of what was most likely a sprite-producing MCS. Low clouds in Colorado prevented visual confirmation. Several electric field mill launches into the region above sprite producing anvils were made.

A 15 day monitoring program during August, 1995 was undertaken at KSC using the image intensified cameras to conduct a Rsprite inventoryS above east central Florida. These measurements were made in conjunction with the LDAR system (Carl Lennon, Launa Maier). Unfortunately, dry conditions and severe haze due to an ongoing heat wave, followed by a week of clouds and rain associated with T.S. Jerry precluded viewing any sprites (even lightning was almost entirely absent).

A number of important results have already emerged from SPRITES '95. Many of the results will be presented at the AGU meeting in San Francisco and several have already been published by or submitted to Nature and GRL. In addition to sprites, the Tohoku University team has confirmed from ground-based sensors the presence of a brief (~1 ms) brightening of the airglow layer (now called "elves") as a distinct phenomenon. It appears to be a response to the lightning EMP. ASTeR also imaged a Rblue jetS from the ground for the first time. Triangulation of sprite locations from the YRFS and Mt. Evans cameras should provide additional information on the relationship between sprites and their parent +CG. High speed optical and infrared imagers may have been successful in determining the direction of propagation of sprites and whether they possessed a detectable thermal signature. Numerous optical spectra were obtained by Lockheed Martin which confirm the presence of the N2 1 PG system. MRC found evidence as well using the photometric data of the 4278 Angstrom band. The requirement that storm systems contain positive cloud-to-ground flashes and posses anvil areas >20,000 km2 proved a virtually 100% accurate forecasting tool. In the RF, STAR Lab confirmed that distinct audio signatures in the VLF appear to be correlated with sprites and elves. Similar results were reported by the University of Otago. ELF Q-burst measurements were repeatedly found to be correlated with sprites by the MIT and Penn State investigators. Several techniques from automatically detecting and locating sprites seem plausible based upon initial results. The Utah State cameras obtained excellent images of waves in the airglow layer possibly emanating from the parent sprite-generated thunderstorm complex over Nebraska.

Parties interested in comparing their independent 1995 measurements with the Yucca Ridge data set should contact Walt Lyons at ASTeR (970-568-7664; Fax 970-482-8627; e-mail: lyonsccm@csn.org

Atmospheric Environment Service (Toronto, ONT, Canada)

Various studies relating lightning to the forecasting and climatology of thunderstorms have been made by Stephen Clodman. This research has used direction finder cloud-to-ground Ontario flash data (similar to U.S. National Lightning Detection Network data). a) Quasi-stationary storms with very high point flash densities and rainfalls have been examined. These storms are favored by the lakes and terrain of the area. b) A lightning climatology study of the southeastern Great Lakes area has been made, together with William Chisholm of Ontario Hydro. Large spatial variations in lightning frequency over the area are related to terrain, land use, and lake effects. The data also show lightning decreasing downwind of Toronto, which is contrary to the usual results about urban effects on convection. c) Lightning and radar data have been systematically related in detail, to show network lightning data use for forecasting severe weather. Time variations have been compared for storm CG flash rate and radar reflectivity index. Spatial locations of lightning clusters and radar echo centers have also been compared; there are interesting cases of the flashes being concentrated well away from the radar echo center. Also, high flash rates can occur over several hours in certain storms which look fairly modest on radar.

The current work is being done in collaboration with Dr. Earle Williams (M.I.T.). Lightning and radar data are being carefully compared, using the detailed operational radar data available in the area, to study a few severe storms with positive CG flashes. Even moderate numbers and proportions of positive flashes have predictive value. Currently, we are examining three storm systems in our area on 28 August 1990 (same day as the "Plainfield tornado"). These systems show interesting consistencies in the arrangement of positive, negative, and no-CG flash areas.

University at Albany, SUNY (Albany, NY)

We had another very fruitful summer making video recordings of lightning from a three-station network in the Albany area. Despite an unusually dry summer, we were still able to record several hundred flashes, many of which can be located by all three sites. A paper summarizing these results relative to NLDN performance in this locale will be presented at the Fall AGU meeting by Dan Davis. Dan is finishing his master's degree in physics, but is deeply involved in NLDN and other lightning research projects, such as analysis of some of the time-resolved photographic records available from past triggered lightning campaigns. Indeed, V. Idone hopes to secure funding that will allow the execution of several improved photographic experiments on triggered lightning at Camp Blanding this next summer. These would be carried out in collaboration with John Willett of AFGL and M. Uman/V. Rakov of the University of Florida. If we do, in fact, participate, Dan "the Wildman" Davis will be a key participant in this project as well.

Bernard Vonnegut reports that proponents of convective cloud electrification mechanisms recognize that an uncertainty in the precipitation mechanism arises because of the doubtful assumption that the electric charges and energy primarily responsible for lightning are provided by falling precipitation. It is encouraging that investigations continue that are directed to providing accurate determinations of the charges carried by falling precipitation particles.

Proponents of cloud electrification by falling precipitation are correct in recognizing that a serious weakness of convective mechanisms is the unproven assumption that there are downdrafts in the upper part of the thunderstorm capable of carrying electrified cloud particles into the lower portions of the cloud. In Grenet's first publication of his convective electrification hypothesis he recognized this possible deficiency of his idea and stressed the importance of "investigations of the movements of the interior of thunderstorm clouds."

Unfortunately there have been no comparable efforts to determine whether the air movements of the cloud would be capable of carrying space charge in the manner suggested by Grenet. With the advent of polarizing radar it is now possible to test the convective hypothesis by dropping radar chaff on the top of a thundercloud and then seeing where it goes. Because it is important for the future progress of atmospheric electricity, it is time that this experiment be carried out.

University of Arizona (Tucson, AZ)

Philip Krider, John Willett, and Christiane Leteinturier have completed an analysis of the submicrosecond E-fields that are radiated during the onset of natural first strokes that will be published shortly in the *J. Geophys. Res.*

Data from the large-area network of electric field mills at the NASA Kennedy Space Center are being used to study electrification in Florida thunderstorms, to locate lightning-caused changes in the cloud charge distributions, and to estimate the location and magnitude of the cloud charging currents. Data from the NCAR CP-2 dual-polarization radar provide the cloud reflectivity factors and other information about the cloud microphysics. In a paper to be published in the *J. Appl. Meteorology,* Art Jameson of Applied Research Corporation, in collaboration with Martin Murphy and Philip Krider, have examined the CP-2 signatures during the onset of electrification. The key finding is that the onset of electrification coincides with the freezing of large raindrops. Donald Schiber and Philip Krider are comparing the locations and magnitudes of lightning-caused changes in the cloud charge distribution with LDAR lightning channel reconstructions. This work is in collaboration with Launa Maier of the NASA-KSC and William Koshak of the NASA-MSFC.

Charles Weidman has been measuring the optical radiation from return strokes in the near IR spectral region, and also the velocity of return strokes near the ground in both natural and triggered lightning.

Colorado State University (Ft. Collins, CO)

Walt Petersen and Steve Rutledge have been examining cloud electrification and use of cloud-to-ground lightning (CG) data on a variety of spatial scales. The relationship between CG flash density and total rainfall is being investigated over different climatic regimes on spatial scales of 105 km2, and time scales of a month or more. Over these spatial and temporal scales, our results suggest that the ratio of CG flash density to total rainmass is fairly stable for distinct climate regimes, though more information is needed for oceanic regions. If the CG/rainmass ratio remains well defined, it may be possible to use CG flash density as an additional constraint for rainfall estimation algorithms (satellite or ground based) that attempt to calculate rainfall over large spatial and temporal scales.

On the convective scale, Petersen and Rutledge have commenced collaborative cloud modeling activities with B. Ferrier of NASA Goddard (1-D, time dependent model incorporating a 4-class ice scheme) and J. Helsdon and R. Farley at the South Dakota School of Mines (Storm Electrification model; SEM). The goal of the modeling experiments is to examine the sensitivity of cloud kinematic, microphysical and electrical evolution to small changes in the temperature and moisture profiles of both tropical maritime and continental environments. Preliminary results using the Ferrier 1D model indicate that under similar amounts of low level forcing, small differences in sounding profiles (e.g., increases in mixed layer wet-bulb potential temperatures of ~0.5 C) have a marked effect on the resulting convective intensity. Results from the 1-D model will be merged with a simple electrification scheme to examine relative differences in electrical evolution between modeled clouds. In turn, these results will be compared with output from the more advanced 2-D SEM.

Terry Schuur and Steve Rutledge have developed a 2-D model to investigate the electrification processes of mesoscale convective systems. The model is configured to allow for an investigation of both local charge generation through a variety of in situ processes and advection of charge from the convective region. Currently, parameterizations are included in the model for charge generation due to non-inductive charge transfer during ice/ice collisions and vapor growth. Preliminary results indicate that non-inductive charging is effective in developing charge density magnitudes of up to 5 nC/m3 once liquid water contents reach 0.2 g/m3. Additionally, in the mixed phase region, the model-generated charge distribution exhibited a remarkable similarity to profiles derived from balloon-borne electric field meter ascents made during the COPS91 experiment.

During the past spring and summer, a successful thunderstorm electrification field project was conducted with the CSU-CHILL multiparameter (S band) radar. Radar observations of over twenty thunderstorms in varying mesoscale conditions were supplemented by flat plate antenna, corona point sensor, field mill, and NLDN (National Lightning Detection Network) cloud-to-ground (CG) lightning data. Other complementary data sources such as in-situ observations from the South Dakota School of Mines and Technology (SDSMT) T-28 aircraft, GOES-8 satellite, rain gauge, chase-van surface hail observations are also available for many of the storms. The preliminary analyses of Larry Carey and Steve Rutledge have focused on the predominate +CG producing supercell storms which occurred on 7 June 1995 within 40 km of the CSU-CHILL radar. These storms, which exhibited classic supercell characteristics such as a bounded weak echo region (BWER), a forward overhang, and a large (10-20 km) and persistent mesocyclone, produced over 150 +CG flashes (68% of total CG activity) within 40 km of the radar during a 6 hour period. This anomalous lightning behavior was accompanied by radar observed and surface confirmed reports of severe weather such as large hail (up to 5 cm in diameter) and tornadoes (a tornado vortex signature, or TVS, was observed with the CSU-CHILL radar for one of these). An initial goal of this research was to investigate the temporal and spatial relationships between large hail (> 2 cm) and +CG lightning occurrence that have been previously reported in the literature. Using multiparameter radar data (supplemented by surface reports) to identify large hail, we were able to investigate these apparent relationships at unprecedented temporal (4-5 minutes) and spatial (few kilometers) scales. Although the initial production of large hail in one of these supercells just preceded the first +CG lightning flash, the actual peak in the +CG lightning flash rate occurred after the majority of the large hail had fallen out of the storm. The majority of the +CG ground strike locations were found downshear but within 20 km of the main precipitation shaft. Future research will attempt to confirm these initial findings with other +CG producing storms and to investigate the kinematic structure of these storms with single Doppler data. This work formed the thrust of a presentation by Larry Carey at the recent AMS Conference on Radar Meteorology which earned Larry the Spiros Geotis Prize for the best student paper at the Conference.

Steve Rutledge and Larry Carey will travel to the Tiwi Islands just north of Darwin to take part in the Maritime Continent Thunderstorm Experiment (MCTEX) from mid-November to early December. The center piece of this experiment will be a 5 cm, Doppler, polarimetric radar developed by the Bureau of Meteorology Research Centre. Steve and Larry will utilize the polarimetric data from this radar to study the couplings between storm microphysics and electrification. Various electrical measurements will be made by a four station ALDF network (operated by NASA/MSFC), a field mill, flat plate antenna, a videosonde (T. Takahashi) and 2-D interferometer (Z. Kawasaki).

University of Florida (Gainesville, FL)

During Summer 1995, researchers from several countries carried out a variety of experiments at the International Center for Lightning Research and Testing at Camp Blanding, Florida. The following researchers participated in the program.

M. A. Uman, V. A. Rakov, K. J. Rambo, T. W. Vaught, M. I. Fernandez, J. A. Bach, Y. Su; University of Florida (UF), USA

A. Eybert-Berard, J. P. Berlandis, B. Bador; Centre d'Etudes Nucleaires de Grenoble (CENG), France

P. Lalande, A. Bonamy, F. Audran, F. Morillon; Electricite de France (EDF), France

P. Laroche, A. Bondiou-Clergerie; Office National d'Etudes et de Recherches Aerospatiales (ONERA), France

S. Chauzy, S. Soula; Universite Paul Sabatier, Toulouse (UPST), France

C. D. Weidman; University of Arizona (UA), USA

F. Rachidi, M. Rubinstein; Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland

C. A. Nucci, S. Guerrieri; Universita di Bologna (UB), Italy

H. K. Hoidalen; University of Trondheim (UT), Norway (on leave from Norwegian Electric Power Research Institute (EFI))

V. Cooray; Uppsala Universitat (UU), Sweden

The Center is a unique facility, particularly in view of the recent termination of the triggered-lightning programs in France and in Japan, for studying simultaneously and synergistically various aspects of atmospheric electricity, lightning, and lightning protection. Presented below is a list of the 1995 projects, many of which are collaborative between different groups and some of which will continue in the following years.

1. Effects of direct and nearby lightning strikes on a full-scale power distribution system (UF, EPFOL, UB). Additionally, induced lightning effects on specially designed systems were studied by EPFOL and by UT/EFI.
2. Study of the electromagnetic environment close to the lightning channel (UF, CENG, EDF, EPFOL, UB). Electric and magnetic fields were measured using a network of 10

sensors placed from tens to hundreds of meters from the lightning triggering facilities.

3. Study of the connection of the downward negative leader to ground (EDF, ONERA, CENG). This experiment involved so-called altitude triggered lightning, discharges initiated using rockets with 400 m of attached copper wire followed by 400 m of kevlar cable below followed by an additional 50 m of copper wire that is connected to ground.
4. Testing of the effectiveness of two types of lightning protection devices: conventional Franklin rods and non-conventional early-streamer-emission rods (CENG).
5. Study of slow charge exchange between ground and thundercloud (UPST). In this experiment a number of aerological quantities were measured, as well as the electric fields at the ground and about 90 m above it using a tethered balloon. Electric fields measured aloft were also used to help in making a decision when to launch triggering rockets.
6. Study of lightning channel temperature from measurements of the relative intensities of the NI(1) and NI(18) spectral lines (UA). A four-channel near-IR radiometer was used in this experiment.
7. Measurement of the return stroke velocities in the bottom 200 m of the channel. In this experiment two photoelectric instruments were used, one operated by the UA and the other by UU.

In spite of relatively unfavorable meteorological conditions at the site during the summer, including one hurricane, one tropical depression, long periods of high pressure, and record high temperatures, the 1995 campaign was a success. There were 13 classical triggers, 2 altitude triggers, and 2 naturally occurring lightning flashes on site. Data obtained will significantly improve our knowledge of the physics of the lightning discharge, of atmospheric electricity, and of the interaction of lightning with various systems.

The 1995 campaign was primarily supported by the Electric Power Research Institute (EPRI), Duquesne Light, the National Science Foundation, the Florida Power Corporation, the National Aeronautics and Space Administration, the Camp Blanding Army National Guard Base, the Office National d'Etudes et de Recherches Aerospatiales (France), Electricite de France, INDELEC (France), and Hydro-Quebec (Canada). The International Center for Lightning Research and Testing is administered by an Advisory Committee composed of two representatives of UF, two representatives of EPRI, and one representative of the Camp Blanding Florida Army National Guard Base.

Various results of the 1995 triggered lightning campaign in Florida are scheduled to be reported at the 1995 Fall AGU Meeting in San Francisco (December 11-15, 1995), the 10th International Conference on Atmospheric Electricity in Osaka, Japan (June 10-14, 1996), and the 23rd International Conference on Lightning Protection in Florence, Italy (September 23-27, 1996).

Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences (Sopron, Hungary)

The regular observation of the vertical electric field component (Ez) in the Schumann resonance frequency range will be completed by the measurements of the two horizontal magnetic field components (Hx, Hy) in the Nagycenk Observatory (47.6 N, 16.7 E). These field components will be measured by two perpendicular induction coils with 100000 turns of wire on permalloy cores put them in a concrete hole. The regular observation will be started at the end of 1995.

Spectral characteristics of the vertical electric field component were presented on the basis of quasi-continuous measurements of two years (Gabriella Satori, 1995; Boulder, IUGG, M7). The actual peak frequencies and the amplitudes belonging to them were determined for the first three modes. Each mode has own character and they show distinct daily and seasonal variations. The recurrence tendency of these variations from year to year was also presented. The significant annual and semiannual variations of the amplitudes support the suggestion (Earle Williams), that the Schumann resonance as a global phenomenon is sensitive to small temperature variations in the tropical atmosphere.

Lightning Location and Protection (Tucson, AZ)

During the past year, LLP, GDS and ARSI merged into a single corporation now known as Global Atmospherics, Inc. (GAI), a wholly owned subsidiary of Sankosha Corporation. Global Atmospherics has continued with the research and development efforts of its comprising companies, and this year completed its joint project with the Electric Power Research Institute (EPRI) which included an upgrade to the U.S. National Lightning Detection Network (NLDN) during summer/fall of 1994. The NLDN is now a combined MDF/TOA network which records and reports cloud-to-ground lighting in both flash and stroke formats, and has achieved an average location accuracy of 500 meters. This project will be summarized in papers to be presented at the upcoming AGU and AMS meetings. As part of the NLDN EPRI project, GAI has developed a GIS-based lightning analysis workstation which is being used for detailed flash density analysis and for the assessment of electric utility line reliability. This workstation also has applications in meteorological research for the analysis of storm dynamics. It also utilizes a relational database to facilitate comparative analysis with other phenomena.

The NLDN has provided important data for basic scientific studies and for meteorological analyses, and will continue to do so in the future. GAI has now accumulated 7 years of national data, resulting in a statistically meaningful national database of lightning. Commencing January 1, 1995, the company began archiving the time, latitude, longitude, estimated peak current, and location quality information for all detected cloud-to-ground strokes (previously just first strokes were reported). An estimated fifty million strokes will be recorded over the contiguous USA in calendar 1995. A spatial and temporal analysis of stroke and flash information is being carried out in collaboration with E. Philip Krider of the University of Arizona.

The Pacific Coast Long Range Lightning Detection Network, a joint project with the NWS (Drs. Jalickee and Mosher) has been fully operational since June, 1994, and has been employed to detect thunderstorms in southern Mexico and the Pacific Ocean. Storms in Colombia and to the west of Hawaii have been observed. Research is continuing in order to determine the detection efficiency and location accuracy of this 8-sensor network.

For further details, please contact Ken Cummins or Burt Pifer.

M.I.T. Parson's Laboratory (Cambridge, MA)

The investigation of Schumann resonances continues on two fronts: the continuous background problem and the transient problem.

On the background problem, Stan Heckman, now at Phillips Laboratory, has succeeded in inverting calibrated measurements of electric and magnetic power (from the West Greenwich, RI site) to obtain the global vertical charge moment squared. In a day's worth of observations, we can see "the sun go around the earth" and resolve the temporal variation of the lightning source in Asia, Africa, and America. This method is now being extended to evaluate the seasonal variation of the lightning source term. Observations by Dave Sentman, at the University of Alaska, at other locations (California and Australia) are being compared with these results.

On the transient problem, graduate student Charles Wong is building on the earlier result (Boccippio et al., Science, August 1995) that sprites, Schumann resonance transients and positive ground flashes are closely interrelated. A semi-automated method has been developed for global location of large events from the Rhode Island site, based on the impedance method. The use of LLP data provided by Ken Cummins for the U.S. and by Masaru Ishii for Japan, has been very valuable in ground-truthing these events. Analysis of ELF spectra for many events has shown that single stroke negative flashes exhibit flat (i.e., TwhiteU) spectra, whereas single stroke positives exhibit declining power (i.e., TredU) spectra with increasing frequency. The former results support the idea that an impulsive source is capable of ringing the earth-ionospheric cavity without the need for a long continuing current. The latter phenomenon is probably responsible for TredU spectra of positive CG's and may be essential for the occurrence of sprites in the mesosphere over mesoscale convective systems.

Further comparisons of sprite events from Rhode Island and Fort Collins, Colorado with Walt Lyons suggest that airglow events are associated with the positive LLP events with the largest peak currents. The ELF spectra for these events tend to be TpinkUQnot as TwhiteU as the single stroke negatives but not as TredU as the sprite-producing positives.

Dennis Boccippio, on leave from MIT at the NASA Marshall Space Flight Center, has assembled a collection of large radiance events form the OTD (Optical Transient Detector) for comparison with transient events detected from Rhode Island.

Further comparisons between the global circuit and deep tropical convection continues through collaboration with Ebby Anyamba and Joel Susskind at the NASA Goddard Space Flight Center. Regional analysis of deep convection on the tropics with TOVS satellite data for five consecutive years indicates that Africa is dominant, followed by South America and the Maritime Continent. This general ranking is consistent with the inversions of Schumann resonance observations. The satellite observations also show indications of a semi-annual signal in Africa and South America, but not obviously in the Maritime Continent, probably due to the small fractional land mass there.

Earle Williams has been working informally with Steve Clodman of the Atmospheric Environment Service in Canada to gain a better understanding of the origin and behavior of positive ground flashes in extraordinarily vigorous thunderstorms.

This laboratory recently received a windfall of surplus geophysical exploration equipment. Magnetometer coils well suited to Schumann resonance measurements have been supplied to Walt Lyons, Carl Lennon at Kennedy Space Center, Masashi Hayakawa and Zen Kawasaki in Japan and Colin Price in Israel.

NASA / Marshall Space Flight Center (Huntsville, AL)

The Optical Transient Detector (OTD) continues to provide observations of global lightning from space after being launched on 3 April 1995 into a 785 km, 70 degree inclination orbit. The sensor detects lightning events during both day and night with a time resolution of 2 ms to within 8 km over a 1300 x 1300 km region. OTD is the engineering flight model of the NASA Lightning Imaging Sensor (LIS) which is included on the Tropical Rainfall Measurement Mission (TRMM) planned for launch in 1997. Significant progress has been made by the LIS science team (H. Christian, K. Driscoll, D. Boccippio, D. Mach, J. Hall, W. Boeck, D. Buechler, J. Fennelly, W. Koshak, S. Goodman, R. Blakeslee) in the processing, analysis and validation of the OTD data. We have also initiated the building and archiving of a global lightning data base using OTD data. Initial OTD results will be presented at the Fall meeting of the AGU in San Francisco.

A World Wide Web home page has been established at URL http://wwwghcc.msfc.nasa.gov:5678 to disseminate OTD results and developments. This home page will be updated regularly to keep the science community abreast of our progress. It was recently updated to include the OTD global lightning distributions for May and July 1995. Also, OTD observations of several recent hurricanes have been placed on the home page. Other information about the MSFC electricity program can be found at this Web site.

A subset of May and July 1995 OTD data coincident with the DMSP F11 and F13 satellites (100 orbits) has been provided by the LIS Science Team to E. Zipser of Texas A&M University. His laboratory will perform analysis of global mesoscale weather systems as observed by the SSM/I sensor and results will be presented at the Fall Meeting of the AGU.

The LIS for the TRMM satellite is now undergoing final laboratory calibration (H. Christian, W. Koshak, J. Bergtrom, M. Stewart, J. Hall). A full radiometric calibration is being performed and includes: DC linearity analyses, AC response testing, FOV coverage, and narrow-band filter testing. In addition, performance tests of the sensor are being performed using an externally modulated laser light and conditioning optics.

We are presently participating in the international Maritime Continent Thunderstorm Experiment (MCTEX) field campaign being conducted in the Tiwi Islands of Northern Australia during November and December 1995 (R. Blakeslee, H. Christian, J. Bailey, S. Goodman, M. Stewart). A four station Advanced Lightning Direction Finder (ALDF) network was installed in October (includes one island and three mainland sites). In addition, a field mill and a wideband E-field sensor are also being operated during MCTEX in collaboration with CSU (S. Rutledge). Following MCTEX the mainland ALDF sites will remain deployed for several years to support TRMM ground truth.

A review of OTD results was made at the AFOSR Sprites Workshop by D. Boccippio and W. Boeck (Niagara U.) Plans for participation in a summer Sprites 96 field campaign with OTD and high altitude aircraft are being formulated (H. Christian, R. Blakeslee).

We continue to have an interest in lightning data sets that could contribute to a global lightning climatology and/or to our ground truth activities for OTD (e.g., regional lightning detection networks, etc.). Any individual or group interested in such a collaboration is encouraged to contact S. Goodman (e-mail: steven.goodman@msfc.nasa.gov), H. Christian (hugh.christian@msfc.nasa.gov).

The MSFC Atmospheric Electricity group is located at the Global Hydrology and Climate Center in Huntsville, Alabama. The mailing address is: 977 Explorer Blvd., Huntsville, AL 35806. The fax number is 205-922-5723.

National Center for Atmospheric Research (Boulder, CO)

Dan Breed and Wolf Herold, a scientific visitor from Paul Scherrer Institute in Switzerland, participated in a small field project this past summer involving the NCAR sailplane and the CSU-CHILL radar. Originally designed as an extended test program for a new sailplane data system, moderate success was realized in obtaining coordinated data sets in weak to moderate convection on about 5 days. Anyone interested in a more detailed summary of the summer's flights can contact Dan Breed at breed@ncar.ucar.edu or 303-497-8933.

Dan Breed is also completing a manuscript describing the electrification of Florida cumuli, using data from the 1991 CaPE. Associated with these analyses, a separate paper by Tom Marshall and colleagues describes results of particle charge data obtained by the sailplane.

Plans are underway for an experiment to be conducted in NE Colorado during June and July of 1996 to examine the effect of deep convection on the chemical composition of the upper troposphere and lower stratosphere (UT/LS) including studies of NOx production by lightning. The STERAO (Stratosphere - Troposphere Experiment -- Radiation, Aerosols and Ozone)/ Deep Convection Experiment will use the NCAR WB57F and the NOAA P3 aircraft, the CSU-CHILL multiparameter radar and surface observations in a cooperative program including NCAR, NOAA Aeronomy Lab, NOAA NSSL Boulder, Colorado State University, NASA Marshall and other Universities and organizations. Jim Dye of NCAR, Adrian Tuck of the NOAA Aeronomy Lab and Steve Rutledge of CSU are co-chairs for the scientific steering committee.

The WB57F will be instrumented to be able to examine the chemical composition including water vapor of the UT/LS and electrical instrumentation for examining electric fields and electric field and optical transients caused by lightning. Many of the chemical instruments will be from NCAR or the NOAA Aeronomy Lab. Six electric field mills built by Bill Winn of New Mexico Tech and used previously on the NCAR King Air will be modified for cold temperature operation and field change and optical transient detectors of Hugh Christian and colleagues at NASA Marshall will be flown on the B57. The NOAA P3 will carry an extensive array of chemical instrumentation from the NOAA Aeronomy Lab and also the tail Doppler radar, which will be coordinated by Tom Matejka of NSSL Boulder. The CSU-CHILL multi-parameter Doppler radar, lead by Steve Rutledge, will provide both air motion and microphysical information on the storms.

An important part of the study will be to try to characterize both intra-cloud and cloud-to-ground discharges occurring in the storms of interest. The National Lightning Network will be used for information on frequency and location of CG lightning. For identifying both IC and CG lightning, the CSU corona point network will be supplemented with a time resolved field change meter near the radar and also a mobile field change meter to pursue distant storms.

Although approval of use of the WB57F and CSU-CHILL radar by the NSF Facilities Allocation Committee are pending as of this date, 1 November, the outlook is good. A request was also made as a piggy back on the STERAO/Deep Convection Experiment to make a few flights above mesoscale convective complexes to investigate electrical conditions above storms producing Sprites and Blue Jets. However, it is uncertain at this time if the NCAR Research Aviation Facility will be able to complete the pressure suit work necessary for flights above 50,000 ft.

Individuals or groups interested in participating in this effort should contact either Jim Dye via email at dye@ucar.edu or Steve Rutledge at rutledge@olympic.atmos.colostate.edu

National Severe Storms Laboratory (Norman, OK)

Irv Watson has placed the Olympic lightning climatology on the web site for the Atlanta National Weather Service office. Check http://www.nws.noaa.gov/olympics/Olympics.html then Forecaster Training...and New Studies for these results.

NSSL staff have co-authored two articles in the journal Seminars in Neurology. The September 1995 issue has "Demographics of Lightning Casualties" by Raúl López and Ron Holle. The December 1995 issue will include "Safety in the Presence of Lightning" by Holle and López, together with Ken Howard of NSSL, Jim Vavrek of Spohn Middle School in Hammond, Indiana, and Jim Allsopp of the National Weather Service in Romeoville, Illinois. Both issues are devoted to lightning, particularly its medical effects.

Fresh from the press is the paper by Vlad Mazur, Lothar Ruhnke, and Pierre Laroche (ONERA) in GRL, Vol. 22, October 1, 2613-2616, that addresses the unique relationship between the leader and return stroke in CG flashes and the ambient cloud potential distribution. Vlad and Lothar Ruhnke are working on a computer simulation of bi-directional leader development within the simplified model of a thunderstorm at its mature stage. Also in print at JGR is the paper by Vlad Mazur, Paul Krehbiel and Xuan-Min Shao "Correlated high-speed video and radio interferometric observations of a cloud-to-ground lightning flash" that sheds light on the nature of M-components and other hot issues, e.g., continuing currents.

We obtained three soundings of electric field and atmospheric state variables in supercell thuderstorms and six in mesoscale convective systems. Some MCS flights included measurements of rays. Investigators participating were Tom Marshall (University of Missisippi), Maribeth Stolzenburg (NSSL/CIMMS), Monte Bateman (New Mexico Tech.), Bill Beasley (University of Oklahoma, School of Meteorology), Ken Eack (University of Oklahoma), and Dave Rust (NSSL). Several reports of initial results will be given at upcoming conferences.

Don MacGorman and Curtis Marshall at the University of Oklahoma completed preliminary analysis of the Kaw Lake supercell storm that occurred during VORTEX-94. From radar estimates of large hail probability and hail size, there seems to be an association between large hail and +CG flash occurrence, as inferred from hail reports in an earlier study. During VORTEX-95, data were obtained on two new supercell cases in which +CG flashes dominated ground flash activity. In one of the VORTEX-95 cases, data were obtained from

NSSL's 10-cm multiparameter radar, as well as from an airborne Doppler radar and a National Weather Service WSR-88D radar.

Langmuir Laboratory (Socorro, NM)

Monte Bateman reports: We are currently working on a new version of the balloon-borne particle charge and size instrument. Our goal is to capture and transmit images of precipitation particles. Next summer, we will have our next ballooning program, with help from Tom Marshall and Dave Rust. Our plan is to make serial soundings to better understand the time evolution of New Mexico thunderstorms.

Pennsylvania State University (State College, PA)

NOTE: This material was not considered sufficiently "new" to be published as a letter by a couple of journals, but may be of interest to some people not intimately familiar with the literature in this "field." Comments, including violent disagreement, are welcomed with enthusiasm. (L.H.)

On the coupling of fields, currents, and energy from lightning to the upper atmosphere and ionosphere: A "current" statement

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Stimulated by the "red-sprites" phenomenon, there has been a resurgence of interest in the coupling of E & M fields from tropospheric lightning to the "ionosphere." Many workers have concluded that the fields calculated using free space dipole moments (or, using superposition, multipole moments), e.g. radiation, induction or intermediate, and electrostatic, are inadequate to explain the mesospheric phenomenon of "red sprites." This communication is intended to collect some ideas which, while generally not new, may be relevant to the problem. While there appear to be some good theoretical treatments, for example the recent work of Sukorukov, such work tends to be somewhat mathematical, which is avoided in this discussion.

Free space dipole moments are not generally valid for lightning fields which are confined between the conducting earth and the generally more "fuzzy" ionospheric boundary. However, for a lightning return stroke current iL(t) which flows in less than about a millisecond, the "induction" and "radiation" fields incident on the upper atmosphere, due to iL and diL/dt, are valid as long as ground reflection is considered. This is not true for the "electrostatic" component, which is quite different from the free-space case. In the case of cloud-to-earth strokes this is usually handled by considering the effects of "Wilson monopoles," which are charge centers created by the time integral of the lightning currents. ("Dipoles"and more complex situations can be considered using the superposed fields of two or more such monopoles.) At large distances the monopoles can generally be considered to be point charges, persisting for the tens of seconds "relaxation time" of their tropospheric deposition altitude. They provide sources for calculating the time dependent "quasi-static" fields associated with the lightning. Although this is a very complex problem in an atmosphere with continuously varying conductivity, generally requiring a computer solution of the complete Maxwell's equations, in some cases simplifying assumptions may enable estimation of the fields and currents. In particular, in the "quiet" nighttime mesosphere, there are essentially zero free electrons and the electrical conductivity s remains as low as 10-10 to 10-9 S/m up to a "ledge" at 80 to 85 km, which defines the effective height of the transient solution which persists for a time eo/s of up to tens of milliseconds after a lightning stroke. This gives rise to a virtually free-space "electrostatic" solution for the fields involving upper and lower conducting boundaries and a Wilson monopole following a cloud-to-earth return stroke. The solution of this electrostatic problem is well known, and involves an infinite Bessel series. A result of interest in the sprites problem is that the electric field just below the "ledge" directly above the monopole is nearly double that calculated without considering the presence of the ionospheric boundary. Thus whatever lightning charge would be necessary to initiate "breakdown" just below the ledge (generally estimated at over 200 C using the "free-space-monopole-plus-earth-image" model) can be reduced by about half.

Although sufficient to create the electric fields that initiate breakdown, a purely "electrostatic" solution couples little energy and cannot sustain the discharge for the observed duration of several milliseconds. This requires substantial current in the discharge region, which can be generated in different ways. The first is direct excitation by a portion of the source lightning current iL(t). Although the electric fields are complex, the ratio of the electric flux is given by a fraction f (typically ~0.1) equal to the simple distance ratio hm/hi, where hm is the altitude of the monopole and hi is the effective height of the ionosphere. This means that for current pulses of milliseconds or longer, for which a quasi-static solution is valid, a current of fiL(t) is coupled directly to the ionosphere. As the width of the current pulse is decreased to the millisecond range and below, it is found by a computer solution of the complete Maxwell's equation that the current pulse to the ionosphere does not continue to decrease accordingly, but remains about a millisecond. This is interpreted as the time required to establish the initial "quasi-static" solution, which is controlled by the round-trip propagation delay between the lightning and the upper boundary. In this limit the peak current is found to be several hundred amperes per coulomb of lightning-separated charge [Hale and Baginski, Nature 329, 814, 1987], and the writer believes that this is the most likely candidate for producing the brightest portion of the sprite discharge (which may be what is currently being called an elf).

Another mechanism which produces a current to the ionosphere is due to the conductivity gradient Qs. This mechanism was suggested by C. and P. Greifinger [JGR 81, 2237, 1976], who also gave an interesting physical interpretation, a post-stroke downward moving boundary between regions dominated by conduction current (above) and displacement current (below), which has been termed a "variable capacitor" model by Sukorukov. This mechanism dominates at ULF frequencies, but is much weaker than the "millisecond" ELF pulse, which has been shown by computer modelling to be dominant even in situations where the conductivity varies continuously, with no obvious "ledge." This mechanism could be important to the sprites situation if the discharge originated at or more likely propagated rapidly to very much lower altitudes (with a velocity of 107 m/sec or greater), causing a substantial change in the ionospheric boundary height on the millisecond time scale.

These post-stroke currents to the ionosphere give rise to radial TEM (zero mode) wavelets which are easily observed at a distance of thousands of kilometers as "slow tails," although their waveshape will appear modified, both by local effects of the earth's magnetic field [Hale, JGR 99, 21089, 1994] and dispersion and attenuation, which will be much greater in the daytime than nighttime. The best diagnostics will probably be done by E & M measurements extending from about 5 Hz to 50 kHz to pass all of the highest energy parts of the E & M signal. The principal unknown quantity continues to be the actual pre-existing conductivity profile associated with "red sprites."

Phillips Laboratory (Bedford, MA)

A major field experiment is being planned for July and August, 1996, to study the relationship between ambient electrostatic-field profiles and the development of the initial upward "leaders" in rocket-triggered lightning. The location of the experiment is expected to be Camp Blanding, Florida (at a site not far from that operated by Martin Uman of U. Florida). Twenty electric-field-sounding rockets will be available to profile the ambient field immediately prior to triggering attempts. French scientists from ONERA and CENG plan to trigger the lightning and measure the "precursor" and leader currents. Vince Idone (SUNY Albany) proposes to obtain video and UV streak photographs of the developing leaders. Other collaborators are welcome; please contact John Willett at the above address.

At the Geophysics Directorate of the Phillips Laboratory, a new program has been initiated under sponsorship by the Air Force Office of Scientific Research (AFOSR) to investigate the infrared and optical emissions of high-altitude atmospheric discharges. These large luminous glow discharge events include at least three types: "sprites", "blue jets", and recently identified bright precursor flashes referred to as "elves". The results of several investigators also indicate that sprites at altitudes between 50 and 90 km are associated with energetic, positive cloud-to-ground lightning strokes.

The first major activity under this program was a Workshop on Sprites, Blue Jets, and Elves which was held on October 18-19 at the Phillips Laboratory, Hanscom Air Force Base, MA. The formal talks given by most of the key research groups in the US working in this field presented results of the Summer '95 Campaign conducted at Yucca Ridge, CO and new insights gained from theoretical modeling. Key technical gaps which need to be addressed and measurement plans for a coordinated Summer '96 Campaign were also discussed.

The overall objective of the Air Force program is to characterize enhancements in atmospheric radiance due to transient, high-altitude atmospheric discharges. In addition to understanding the spectral, spatial, and temporal characteristics of emissions in the ultraviolet, visible, and infrared, the program will investigate the origin and dynamics of discharge events. Ground-based, aircraft, and satellite data collections are planned to obtain radiometric and spectral data. These measurements will be supplemented by radar and VLF data to determine the ionization in the discharge-perturbed atmosphere. Correlative data of lightning strokes and Q-bursts to understand the origin and occurrence of high-altitude atmospheric discharges will also be obtained. Some of these measurements are planned as part of a coordinated Summer '96 Campaign. The observational data base will be used to develop a "Sprites" Atmospheric Radiance Code (SPARC) to model discharge-induced atmospheric radiance backgrounds for arbitrary wavelengths and viewing geometries.

The Phillips Laboratory staff who will be conducting research under this program are William Blumberg, Edmund Dewan, Laila Jeong, Richard Picard, and Jeremy Winick of the Optical Environment Division and Keith Groves of the Ionospheric Effects Division. The AFOSR Program Manager is Maj. James Kroll.

Polish Academy of Sciences, Institute of Geophysics (Warsaw, Poland) Atmopspheric Electricity Research Group (AERG)

Comparative analysis of the Maxwell current measured at the Polish Polar Station Hornsund, Spitsbergen and Jozefoslaw observatory in Poland has been continued (A. C. Losakiewicz). Some of the data sets display significant values of the cross-correlation function. According to the theory of current response to ionospheric potential variations, the Jozefoslaw current precedes in phase the Hornsund current for these data sets. The phase delay (up to 90 s) indicates that changes in ionospheric potential are the origin of the observed global Maxwell current fluctuations. Hence, these fluctuations are connected with the processes occurring in the extraterrestrial (magnetospheric, interplanetary) space. Theoretical studies of spectral densities of noises generated by turbulent charge advection in vertical electric field and Maxwell current measured on the ground have been carried out. In comparison with point sensors for long antennae, electric noises are considerably damped, especially at high frequencies. The calculated slope of spectral densities of short-period noises was confirmed experimentally. P. Baranski is investigating the use of the electric field and current measurements near the earth surface for distinguishing the convective component of the Maxwell current density from other components. He is also studying the use of electical methods for detection of severe weather phenomena (e.g., downburst events) accompanying the observed thundercloud. Some recent results of a field experiment carried out during rainfalls and downdrafts associated with nearby thunderstorms in Warsaw have given support for such expectation. We have begun studies on fast electric field changes generated by lightning discharges. Our research is within the CESAR (Central European Satellite Advanced Research) satellite experiment programme. Now we are in the laboratory phase aimed at designing a satellite detector of fast changes of the electric field and a suitable digital data aquisition system.

Coworkers:

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The suggestion that the discharge processes between precipitation particles are essentially in the initiation of lightning discharge in the cloud is studied in greater detail. A possible role of precipitation particles in the development of the lightning discharge is considered (Nguyen Manh Duc).

Atmospheric electricity recordings are carried out at the polar station Hornsund in Spitsbergen (M. Kubicki and M. Chrobak). The observed response of the ground electric field on magnetosphericPionospheric influences, observed in periods coinciding with strong geomagnetic activity and fair-weather conditions are being examined (S. Michnowski, N. Nikiforowa, M. Kubicki).

Atmospheric electricity recordings at the Swider station have been continued (M. Kubicki). The errors of the measurements of the ion mobility spectra and electrical conductivity of the air have been analysed (J. Berlinski). Some results of the research group will be presented at the 10th ICAE in Osaka, Japan.

South Dakota School of Mines & Technology (Rapid City, SD)

Two modeling studies are being prepared for publication. One is based on a case from the 9 August 1991 Convection and Precipitation/Electricity (CaPE) experiment discussed below. The model used noninductive charge separation based on the work of Takahashi (1978) and showed good agreement with the observations of in situ aircraft and multiparameter radar measurements with respect to electric field direction and location of charge regions. The model did not predict the electric fields to grow as rapidly as was observed, however. The second study, based on the Master's thesis of Bill Wojcik, involves the comparison of the noninductive schemes of Takahashi and Saunders and colleagues at UMIST. The results show that the Takahashi scheme produces a positive electric main dipole within the cloud, while the Saunders scheme is very sensitive to the effective liquid water content in the charge interaction region. The level of charge reversal in the two schemes is markedly different. The Saunders scheme is highly sensitive to the collection efficiency of ice for cloud water resulting in positive or negative dipoles depending on the value of this efficiency. Other work in progress involves the analysis of model-produced Maxwell currents under different charging schemes that are being compared with observations from Florida storms. This work is being done by Master's student Lin Sheng. In addition, the lightning parameterization scheme is being adapted for inclusion in the 3D electrification model by Master's student Chris Waits who is currently grappling with the charge redistribution of a tortuous channel in three dimensions.

We continue with the analysis and publication of studies based on observations from CaPE experiment in Florida in 1991. A case study of electrification in two thunderstorm systems on 29 July 1991 is in press. This case study is based on the Master's thesis of Rahul Ramachandran, now in the Ph.D. program at University of Alabama at Hunstville. A second case study, concerning a storm on 9 August, was completed by Jeff French as part of his Master of Science program. Jeff is now in the Ph.D. program at the University of Wyoming. A paper based on his analysis of aircraft and radar observations is now under review. Further publications, derived from his cloud electrification modeling work with John Helsdon, are in preparation. A collaborative case study of another CaPE 9 August thunderstorm, spearheaded by V. N. Bringi at CSU, has been submitted for publication. A common thread running through these studies is the appearance of ice via the freezing of raindrops, followed by development of electric fields of 10's of kV/m, sensed by aircraft in the 5 to 6 km altitude range, within 5 to 10 minutes.

St. Petersburg State University (St. Petersburg, Russia)

Denis Dovzhenko, Igor Kononov and Igor Petrenko completed analysis of lightning electromagnetic field data recorded during previous years. The primary objective of this investigation was to improve the accuracy of a single-station VLF lightning ranging system. The estimation of the effective inclination of the discharge channel by digital decomposition of the EM field waveshapes allows the calculation of the distance with accuracy of 10-15 percent in the 100 km zone. Further improvement of ranging accuracy can be obtained by statistical analysis of several discharges in a lightning flash and between flashes. The errors of the middle-zone ranging algorithm (100-1500 km), being conditioned by variations of the atmospherics waveforms, attain 10-15% and can be decreased by means of estimation of some waveform parameters.

Victor Borisov and Igor Kononov continued their theoretical investigations of the space and temporal dependence of electromagnetic fields produced by lightning discharges and analyzed the possible conditions for the formation of localized fields. For some discharge current wave parameters one can see significant field concentration near the direction of wave propagation. The variations of the geometrical parameters of lightning channels can lead to appreciable field changes compared with ones caused by current wave variations.

Sergey Emelin and Vladimir Semenov continue experimental investigations of artificial plasma objects which resemble Ball Lightnings. The metastable plasma activated in cold metallic or dielectric (polymers) media is used for the formation of these objects. Their dimensions are about 1cm, the lifetimes up to 5 sec. They have a distinctive structure with a dense core and a brightly shining envelope.

Tel Aviv University (Tel Aviv, Israel)

Zev Levin and Yoav Yair, from the Cloud Physics Lab in the Department of Geophysics and Planetary Sciences at Tel-Aviv University, have recently begun analyzing data obtained from the LPATS system which is being operated by the Israel Electrical Company since 1994. The lightning data is combined with radar images, which are obtained from the Enterprize WR-100 weather radar operated by our group. The cases which were analyzed thus far show that lightning activity in winter-time storms in Israel occurs in clouds with radar reflectivities > 30-35 dBZ . The horizontal scan shows isolated, vertically developed cumulonimbus clouds which are embedded in a matrix of lower lying, precipitating clouds. We plan to create a time-lapse series of combined lightning positions/radar images, which will help determine the evolution of the thunderstorms.

Yoav Yair, Zev Levin and Shalva Tzivion have evaluated the probability of the Galileo entry probe, which will be passing through Jupiter's atmosphere on December 7th, to encounter lightning activity. They used a numerical model, which includes detailed microphysics and a formulation of the non-inductive ice-ice charge separation process (see: Icarus 114, 278-299, 115, 421-434, 1995). The results showed that the probability of lightning activity in the equatorial region of Jupiter (the penetration is located at latitude 7N) is low, due to the fact that clouds there are shallower, with lower concentrations of ice particles, compared to clouds in midlatitudes (where lightning has been already observed by Voyager 1 and 2). These tropical clouds separate enough charge to reach the breakdown electric field of Jovian air in the corresponding pressure level, but lightning frequency is lower by 35% compared to midlatitudes. The results have been submitted to Nature.

Colin Price recently joined the faculty of the Geophysics and Planetary Sciences department at TAU. He will be continuing his research into lightning- and atmospheric electricity-related topics. His new address is: Dept. of Geophysics and Planetary Sciences, Tel Aviv University, Ramat Aviv 69978, ISRAEL. His new e-mail address is: cprice@flash.tau.ac.il and his tel/fax numbers are 972-3-6408644 (tel) and 972-3-6409282 (fax).

Colin Price and Joyce Penner of Lawrence Livermore National Lab (LLNL) and Michael Prather of UC Irvine have recently submitted a two-part paper to J. Geophys. Res. dealing with the role of lightning in the production of nitrogen oxides (NOx) in the atmosphere (primarily NO and NO2), which play an important role in ozone chemistry.

Colin Price together with John Molitoris of LLNL and Eric Arens of UC Berkeley fielded fast optical and infrared imagers this summer as part of a field measurement program organized by Walt Lyons of Aster, Inc., to observe stratospheric discharges (sprites). The results of this field experiment are still being analyzed.

A paper by Britton Chang of LLNL and Colin Price recently appeared in Geophys. Res. Lett. (22, 1117-1120, May 1, 1995) discussing the possibilities of gamma radiation being emitted from discharges above thunderstorms (sprites). Using very conservative numbers for electron density, electric field, etc., we have shown that at altitudes above 70km it is possible to produce runaway electrons which can gain enough energy to produce gamma radiation. However, it has been pointed out to us that by neglecting the effect of the earth's magnetic field in our calculations, we underestimated the electric fields that would be needed to cause runaway electrons to occur.

Texas A&M University (College Station, TX)

The following research projects related to atmospheric electricity have been completed or published in the past year. Most of the studies represent master's thesis research. Some have been published and some are in the manuscript preparation stage. The student's advisor, listed in parentheses, should be contacted for further information. The advisors include Ed Zipser, Lou Wicker, Mike Biggerstaff, John Griffiths, and Dick Orville.

TOGA COARE Studies

Luis Rios (Orville), "Analysis and comparison of lightning data gathered by three magnetic direction finders in the tropical western Pacific Ocean during TOGA COARE"

Christopher Lucas (Zipser and Orville), "TOGA COARE: Oceanic lightning"

Steve Barnaby (Orville), "Meteorological characteristics of thunderstorms in TOGA COARE"

Tornadoes

Antony Perez (Wicker), "Characteristics of cloud-to-ground lightning associated with violent-tornado producing supercells"

William Carle (Orville), "The 21-23 November 1992 severe weather outbreak: Correlation between lightning flash rate tendencies and tornadic activity, and shear versus bipolar patterns"

Mid-Latitude Storms

Aaron Studwell (Orville), "Characteristics of cloud-to-ground lightning in a severe winter storm, 9-12 February 1994"

Eric Livingston (Orville), "Meteorological conditions associated with severe lightning storms in northeast Georgia-July and August"

Alan Silver (Orville), "A climatology of cloud-to-ground lightning for the contiguous United States, 1989-1994"

Jon Zeitler (Griffiths, Orville), "Precipitation and lightning studies"

Scott Sheridan (Griffiths, Orville), "Precipitation and lightning

studies"

Southern Plains Storms

David Billingsley (Biggerstaff), "Evolution of cloud-to-ground lightning characteristics within the convective region of a mid-latitude squall line"

Scott Saul (Biggerstaff, MacGorman), "Lightning characteristics in a PRE-STORM case, June 2-4, 1985"

Steve McMillan (Orville), "A classification of Texas thunderstorms according to their cloud-to-ground lightning characteristics during spring 1993"

Karen Mohr (Zipser), "A comparison of WSR-88D reflectivities, SSM/I brightness temperatures and lightning for mesoscale convective systems in Texas-Part 1: SSM/I brightness temperatures and lightning"

Richard Toracinta (Zipser, Orville), "A comparison of WSR-88D reflectivities, SSM/I brightness temperatures and lightning for mesoscale convective systems in Texas-Part II: Radar reflectivity and lightning"

Arturo Valdez (Biggerstaff) "The structure and evolution of a multiple convective bands in an MCS"

David McEver (Orville), "Summer lightning over southeast Texas and adjacent coastal waters"

Keith Aclin (Orville), "The use of Doppler radar to predict cloud-to-ground lightning occurrences"

Randall Bass (Orville), "Analysis of the meteorological characteristics associated with the east Texas floods of October 16-18,1994"

Magda Hashem (Biggerstaff) "A ten-year (1985-1994) springtime radar climatology of mesoscale convective systems over southeast Texas."

Hurricanes

Christopher Samsury (Orville), "The relationship of cloud-to-ground lightning with radar reflectivity and vertical velocity in hurricanes Bob (1991) and Emily (1993)"

William George (Orville), "Analysis of cloud-to-ground lightning in hurricane Andrew"

University of Toronto Lightning Studies Group (Toronto, ONT, Canada)

The Lightning Studies Group at the University of Toronto (U of T) has been engaged in collection of lightning data since 1978, soon after the completion of the Canadian National Tower (CNT) in Toronto. During the 1995 lightning season the Group comprised W. Janischewskyj (U of T) as its Chair, Associates A.M. Hussein of Ryerson Polytechnic University in Toronto (RPU), J.-S. Chang of McMaster University in Hamilton, Ontario (McU), W.A. Chisholm of Ontario Hydro Technologies (OHT), P. Joe of Atmospheric Environment Services of Canada (AES), the Visiting Scientist V. Shostak of Kyiv Polytechnic Institute in Ukraine (KPI) as well as graduate and undergraduate students. At this time, the Group pursues activities in two main areas: simultaneous recording of lightning events at CNT, and measurement of lightning ground flash density throughout Canada.

Since 1990, the Lightning Studies Group has been engaged by the Canadian Electrical Association (Association of Canadian Power Utilities) to collect data on Lightning Group Flash Density in Canada. The Program involved adjusting the CIGRE 10-kHz Lightning Ground Flash Density Counter (LFC) to Canadian climatic conditions and producing the adopted version for installation throughout Canada. At this time, a total of 78 sites is operated within territories of all Canadian provinces except Prince Edward Island. Data is collected with the assistance of provincial utilities and is utilized for yearly updating of the Canadian Lightning Ground Flash Density Map.

Measurement of lightning characteristics at the tallest free-standing structure in the world, the 553 m tall CN Tower in Toronto, Canada, includes digital recording (Tektronix 710A digitizers) of the return-stroke current derivative (40 MHz Rogowski coil) and of the electric and magnetic fields 2 km away from the tower (sensors with more than 100 MHz bandwidth), it also includes capturing of the 3-D lightning trajectory using two video cameras located nearly perpendicularly to each other (Hitachi), and measuring of the return-stroke velocity by a special camera developed and loaned by Z.-I. Kawasaki of Osaka University. Details of these instruments are described in the paper "Simultaneous Measurement of Lightning Parameters for Strokes to the Toronto Canadian National Tower", published in JGR, Vol. 100, No. D5, May 1995.

A graduate student Radu Rusan uses collected data to check models for computation of electromagnetic fields from the simultaneous information on the lightning channel. First attempts, which indicate difficulties in simulating the first peak in the rather complex measured magnetic field waveform, were shared with colleagues at the Meeting of the Electrostatics Society of America in Rochester, NY in June 1995. These attempts indicate a need for a more concise account of current travels down the CN Tower, and also for a more rigorous description of the return-stroke process.

During the 1995/96 academic session, a B.A.Sc. thesis is being prepared to determine the details of reflections and refractions in the CN Tower. The goal is to derive from measurements of current, reflection coefficients at the bottom and top of the tower and use these values for finding the wave impedances of the tower itself, of the grounding system and of the incident lightning channel. The information will be subsequently adapted in Radu Rusan's graduate thesis mentioned above.

Another undergraduate thesis is designed to produce a computer program that will take observations of the two video cameras and produce a 3D trajectory of the lightning channel. This information will be combined with the 2D information on return-stroke velocity to determine the 3D velocity of the return stroke. The same information on the 3D trajectory will also be used to assess the effect of the lightning channel orientation upon the two components (orthogonal and radial) of the magnetic field. In addition, the 3D trajectory will be utilized by Radu Rusan in his computing of the electromagnetic field from instantaneous values of lightning current and its location.

Another graduate student, Ying Chen is working in the area of signal processing. Present current records include distortions caused by noise. While removal of noise at the front of the current wave can be achieved comparatively easily, undistorted variation of current at the tail of the wave is much more difficult to retrieve.

A third graduate student, Ileana Rusan, has been working with the Scientific Visitors of the last two years (J.X. Li of Xi'an Jiaotong University in China and V. Shostak of the Kyiv Polytechnic Institute in Ukraine) to analyze 17 years of video data on CN Tower flashes and develop statistical information on monthly and diurnal occurrence of lightning, on flash duration, multiplicity of strokes and on interstroke intervals. On this topic, a paper was prepared by the Group and was presented by V. Shostak to the International Aerospace and Ground Conference on Lightning and Static Electricity in Williamsburg, Virginia in September 1995. One of the findings relates to the fact that occurrences of lightning at the CN Tower, although predominantly upward initiated, seem to represent well the occurrences of the generally downward-dominated thunderstorms in the Toronto area. The other finding relates specifically to the CN Tower flashes and indicates a nonlinear correlation between flash duration and multiplicity of strokes in a flash, and between multiplicity and the interstroke interval.

There is an intention to use the 17-year videodata also for a discrimination between and for a closer analysis of intensive and non-intensive thunderstorms. An initial paper on this topic was presented in 1992 at the International Aerospace and Ground Conference on Lightning and Static Electricity in Atlantic City, NJ under the title "Lightning Environment at the Toronto 553m AGL CN Telecommunications Tower under Severe Weather Conditions."

An analysis has been started on the correlation between information collected by Lightning Location and Protection (LLP) Systems and that observed at the CN Tower with the aim of developing a procedure for calibration of LLP Systems. On that basis, in the future, time-tagged lightning strikes to any tall structure may be used for such calibration. In the case studied, the analysis will include investigation of the influence, exerted by the tall structure itself and by the inclination of the lower portion in the lightning trajectory, upon the amplitude and locations errors of the LLP System.

Uppsala University (Uppsala, Sweden)

Institute of High Voltage Research, Uppsala University, Sweden: The institute has a multi-disciplinary program with research related to lightning, electromagnetic compatibility (EMC), discharge and atmospheric physics. The scientific staff at the Institute consist of Viktor Scuka (director), Vernon Cooray, Rajeev Thottappillil, Sven Issraelsson (Dept. of Meteorology) and seven Ph.D students. The research work that may be of interest to those in the area of atmospheric electricity is reported here.

Water drop initiate discharges in air (WIDA): The development of discharge from water drops in high electric field in atmospheric air is studied experimentally. One of the methods employed is to place water droplets on a hydrophobic insulating surface and study the electrodynamic behaviour of the drops and the discharge development from the drops.

NOx and Ozone production by lightning: This research is being done in co-operation with the Department of Meteorology, Stockholm University. Laboratory experiments were performed to estimate the production of NOx and Ozone in streamer discharges. The results show that the efficiency of streamer discharges in forming NOx and Ozone is

2.7x1016 mole/J and 2.0x1017 mole/J, respectively. When this result is extrapolated to lightning, it appears that the events like step leaders and incloud streamers are as important as return strokes in the role they play in the production of NOx. The theoretical work done by us shows that cloud flashes produce as much, if not more, energy as ground flashes. Moreover, the leader stage of a ground flash or a cloud flash produces as much energy as a return stroke. From these results it appears that the cloud flashes and ground flashes may be equally effective per discharge as NOx producers. Two papers on this subject are now under review with JGR.

Return stroke models: The discharge type of models that describe the return stroke as the discharging of the charge deposited by the leader to the ground can be specified by four parameters-the channelbase current, the return stroke speed that varies with height, the discharge time constant that varies with height, and the charge distribution on the channel. A method is developed in which the variation with height of the return-stroke speed and time constant can be calculated from the channel base current and charge distribution as the only input parameters.

A.I. Voeikov Main Geophysical Observatory (st. Petersburg, Russia)

In a joint scientific effort with the CIAMS of Texas A & M University, a 1995 summer thunderstorm experiment at the Turgosh field site was carried out during the period of July-August. Due to the dry and relatively cold summer months, only a few thunderstorms were explored during this time. It seems that low total water vapor content of the atmosphere measured by a set of radiometers yields low lightning rates in thunderclouds. The data from the recent season will be compared to the same from previous years, when thunderstorms were more intensive, to find out the respective correlation.

Low thunderstorm activity in the above-mentioned period also did not facilitate the running of a subsatellite lightning detection experiment. However, respective arrangements were adopted and we hope to be more lucky next summer.

Valery Stasenko, Simon Galperin, Georgy Shchukin and Dima Karavaev will continue to investigate thunderstorms next year, using a mutual technique developed together with Richard Orville. For further details, please contact V. Stasenko and G. Shchukin at: fax: 812-247-8661 and email: valery@rcars.spb.su.

Three Russian meteorological stations are continuing to carry out atmospheric electric measurements. Atmospheric electric fields, together with polar air conductivites, are measured. Data are collected, processed and accumulated at the Data Center of the MGO RC ARS.

University of Washington (Seattle, WA)

The Thunderstorm III rocket was launched Sept 2, 1995 from Wallops Island over an active thunderstorm. Good data were received from all instruments which included vector electric field, energetic particles, magnetic field, optical imager, and multicolor filtered photodiodes. Hundreds of lightning events were detected from an altitude range between 100 and 350 km. This payload included a high speed sampling capability up to the MHz range of the electric waveform. The latest results will be presented at the Fall AGU meeting. [M. C. Kelley (PI), S. Baker, Cornell University, R. H. Holzworth, B. Barnum, Univ. of

Washington, Craig Kletzing, Eric Dors (Univ. of New Hampshire), Fritz Primdahl, DSRI, John Jorgensen, Tech. Univ. Denmark.]

Yaroslavl State University (Yaroslavl, Russia)

On September 15 of 1994 Grigor'eva Irene successfully defended her PhD thesis entitled "Capillary electrostatic instabilities and the physical nature of St. Elmo's lights and ball lightning as forms of thunderstorm activity." Supervisors: PhD A.S. Rudy and PhD S. O. Shiraeva.

Alexander I. Grigor'ev, Svetlana O. Shiraeva, and Alexander S. Rudy are investigating capillary electrostatic instabilities in liquid-drop aerosol systems and the part they play in atmospheric electrical phenomena. Yaroslavl State University, Sovetskaya Street, 14, Yaroslavl, 150000, Russia. Fax: (0852) 225-232; e-mail: abc@iman.yaroslavl.su.