# NEWSLETTER ON ATMOSPHERIC ELECTRICITY

**Vol. 8, No. 2 November 1997**

**AMS COMMITTEE ON ATMOSPHERIC ELECTRICITY**

**AGU COMMITTEE ON ATMOSPHERIC AND SPACE ELECTRICITY**

**INTERNATIONAL COMMISSION ON ATMOSPHERIC ELECTRICITY**

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***A N N O U N C E M E N T S***

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) any time before **April 15, 1998.** Mark your calendars!

This newsletter is now routinely provided on the World Wide Web (http://ae.atmos.uah.edu). Those individuals not needing the mailed version should contact Earle Williams toward reducing distribution expenses.

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## AGU Fall Meeting

The American Geophysical Union's annual fall meeting is once again approaching. The program will include four special sessions requested by the AGU Committee on Atmospheric and Space Electricity (CASE): (1) Thunderstorm Electrical Effects on the Middle and Upper Atmosphere and Ionosphere (Dec. 8-9: all day Monday and Tuesday afternoon), (2) Global Electrical Circuit (Tuesday afternoon), (3) Lightning and Thunderstorm Electrification (all day Tuesday), and (4) Deep Convection and Atmospheric Chemistry: The STERAO-A Project (Dec. 11-12, Thursday afternoon and Friday morning). The sessions on Tuesday afternoon and Friday morning are poster sessions.

CASE will have its annual evening committee meeting on Monday, December 8, at 5:30 pm in Room 125 of Moscone Center. The meeting is open to all conference attendees. As most of you know, CASE is chartered by AGU to promote interdisciplinary collaboration among meteorologists, atmospheric electricians, middle- and upper-atmospheric electrodynamicists, space physicists, and others interested in electrical processes in atmospheres. All who are involved in any aspect of research on this topic are encouraged to attend the CASE meeting.

You are invited to submit agenda items for the meeting. In the interest of time, particularly because of the evening setting, we will not include brief reports of past field and research programs which should be reserved for the sessions and for this newsletter, as in recent years. The one exception is a report from NASA/MSFC, since their papers were prevented from being in a session, through no fault of their own. If you have other suggestions, please send them to me at the address below.

In June, we will come to the end of another two year term for CASE membership. Please let me know if you would like to serve on CASE or would like to suggest someone new to serve. Thanks to all current CASE members for their participation and help these past two years.

Below is a list of the names, addresses, and telephone numbers of current CASE members. If you have concerns that you would like brought to CASE's attention, please feel free to contact any of us.

Thanks to the AGU for continuing to share the printing and mailing costs of this Newsletter with the ICAE and the AMS.

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## Atmospheric Electricity Address Changes

The Atmospheric Electricity (AE) mailing list has moved. The new address is:

ae-list@updraft.msfc.nasa.gov

*and* the Atmospheric Electricity HomePage has moved. Its new address is:

http://ae.atmos.uah.edu

Please update your bookmarks. (Thanks to the Earth System Science Lab at the University of Alabama in Huntsville for hosting the AE HomePage by providing us disk space and a network address.)

## International Conference on Grounding and Earthing

The GROUND `98 Conference to be held in Belo Horizonte, Minas Gerais Brazil 12-16 April 1998, tracts the latest sicientific results and practical experience in the field of grounding and earthing.

For further information contact GROUND98@novell.cpdee.ufing.br

## 1998 International Conference on Mathematical Methods in Electromagnetic Theory June 2-5, 1998, Kharkov, Ukraine

### First Announcement and Call for Abstracts

The 7th International Conference on Mathematical Methods in Electromagnetic Theory (MMET*98) will be held in Kharkov, Ukraine on June 2 - 5, 1998. The MMET series of conferences began in 1988 and since 1990 it has been the only regular symposium in the Former Soviet Union (FSU) in electromagnetics that has English as a medium of presentation and discussion. Information on the previous MMET meetings can be found in the Antennas and Propagation Magazine: no 2, 1992, no 5, 1995, and no 6, 1996. The conference has established itself as a true interface between the Western and FSU electromagnetics scientists and engineers. A characteristic feature of the conference is a stronger emphasis on the analytical and mathematical aspects of research, together with detailed physical analyses of wave phenomena.

There will be a `low frequency' session at this Conference, that includes ELF, VLF propagation topics (natural and man-made signals), trimpi, sprites, etc. Professor Hayakawa and Alexander Nickolaenko will be co-convenors of the session.

VENUE AND LOCATION: MMET*98 will be held at the Kharkov State University, the third oldest (since 1805) and highly respected university in mathematical and physical sciences in the FSU. Kharkov is the second largest city in Ukraine with a population of about 2 million.

TRANSPORTATION CONNECTIONS: MMET*98 is scheduled the week following the 1998 URSI Commission "B" Symposium on Electromagnetic Theory in Thessalonika, Greece. There are convenient Air Ukraine flights of between Thessalonika or Athens and Kiev, followed by a one-hour flight or an overnight train to Kharkov. Other international connections are available to Kiev, with daily flights from Amsterdam, Budapest, Frankfurt, Istanbul, London, Paris, Prague, Tel Aviv, Vienna, and Zurich. For interested participants the organizers can book a charter flight from Istanbul directly to Kharkov. Train tickets from

Kiev to Kharkov and back can be booked by the organizers, and those who choose this route will be accompanied by English-speaking volunteers. It is possible to reach Kharkov via Moscow, but in such a case a Russian double-transit visa should be obtained. Every possible assistance will be given in case of problems.

YOUNG SCIENTIST TRAVEL GRANTS: as with the previous MMET conferences, travel grants are expected to help young scientists from FSU and developing countries to attend the Kharkov meeting. The number and amount of grants will depend on the success of the on-going search for sponsors.

SUGGESTED TOPICS: antenna theory, asymptotic methods, beam electronics, complex media, computational techniques, electromagnetic theory, fiber optics, function-theoretic methods, gratings and FSS, inverse problems, linear accelerator problems, nonlinear phenomena, plasma science, propagation, RCS, radomes, random media, regularization techniques, remote sensing models, rough surfaces, scattering and diffraction, time-domain methods, waveguide circuits, and others.

ORGANIZERS: IEEE AP/MTT/ED/AES-SS East Ukraine Joint Chapter, Ukrainian URSI Commission "B", Kharkov State University, Institute of Radiophysics and Electronics of the National Academy of Sciences (IRE NAS), Institute of Radio Astronomy of NAS (IRA NAS), under expected co-sponsorship of IEEE AP, MTT, and ED Societies, URSI Commission "B" and IAGA.

Chairman of the Organizing Committee: Prof. Eldar I. Veliev, IRE NAS, Ukraine Co-Chairmen of the Technical Program Committee: Dr. W. Ross Stone, IEEE Antennas and Propagation Society & URSI, and Prof. Alexander I. Nosich, IRE NAS, Ukraine

OC ADDRESS: MMET*98, c/o Dept. Computational Electromagnetics, IRE NAS, Ulitsa Proskury 12, Kharkov 310085, Ukraine. Tel: +38-(0572)-448595; -377380; Fax: +38-(0572)-441105; -377380; -365968; E-mail: veliev@dut.kharkov.ua, alex@emt.kharkov.ua

DEADLINE for submission of 1-page English-written abstract is February 15, 1998, and for the 3-page camera-ready paper it is March 25, 1998. Invited paper authors will be given special instructions. Visa invitation letters will be sent together with the acceptance notifications.

## IUGG MEETING in Birmingham, England

The next meeting of the IUGG (the last one was held in August in Uppsala, Sweden with good attendance on atmospheric electricity) will be held in Birmingham, England July 19-30, 1999. Clive Saunders (cpsaus@mh1.mcc.ac.uk) is organizing a session on Thunderstorm Electrification and Dick Goldberg (goldberg@nssdca.gsfc.nasa.gov) will convene a session on Middle Atmospheric Electrodynamics.

## NSF RACES (Radar and Aircraft Cloud Electrification Studies) Not Funded

We have received word that the core NSF proposals for RACES will not be funded. RACES hopefuls who have submitted proposals will receive copies of reviews. We have been invited to consider revising the overview document and to submit it to NSF for review as a "large project." Following review of the overview at NSF, if such a review is encouraging, individual PIs might then submit revised proposals and facility requests by June, 1998, for a field effort in 1999.

We thank all who have invested their efforts in trying to get RACES into the field in 1998. We ask each of you to sit back and think about the above suggested course of action, and how it might fit into your future plans.

Andy Detwiler and John Helsdon
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## RESEARCH ACTIVITY BY ORGANIZATION



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### COLORADO STATE UNIVERSITY (Ft. Collins, CO)

Walt Petersen, Steve Rutledge and Earle Williams (MIT), have been analyzing 1989 lightning flash count data (SAFIR) and other meteorological variables for the tropical location of French Guyana. The data have been partitioned into two distinct climate regimes, monsoon (Dec-May) and continental (Jul-Oct), as a function of electrical activity and rainfall (monsoon: heavy rain, less lightning; continental: less rain, more lightning). Thus far, analyses of flash counts, Outgoing Longwave Radiation (OLR), vertical motion, and wet-bulb (WB) temperatures, all suggest the presence of intra-seasonal oscillations (ISO) with periods of approximately 30-50 days. The oscillations, as observed in the lightning and meteorological data, appear to occur as a result of interfering westward and eastward propagating wave disturbances. Minimum values of OLR and peaks in lightning activity occurred in phase. However, peaks in the monsoon-regime maximum daily WB's lagged peaks in both the lightning and OLR signals by 5 to 10 days. Hence, there was apparently little correlation at zero-lag between the daily maximum WB and lightning activity during the monsoon-regime. In the electrically-active continental--regime, estward propagating disturbances originating over tropical western Africa dominated both the OLR and the lightning activity, which varied in phase with OLR minima. In contrast to the monsoon-regime, continental-regime daily maximum WB's varied approximately in phase with both the lightning and the OLR, and were positively (albeit weakly) correlated to flash counts. The analysis suggests that care must be taken when relating single parameters such as the wet-bulb temperature to lightning activity in French Guyana due to climatological, seasonal and intra-seasonal influences on the occurrence of deep convection. This same behavior is suspected in other regions of the tropics as well.

Bard Zajac and Steve Rutledge have examined characteristics of cloud-to-ground (CG) lightning activity in the United States using data from the National Lightning Detection Network and from National Weather Service radars (i.e. 15-minute 8-km national radar summaries). We observed regional-scale maxima of annual percent positive cloud-to-ground (CG) lighting located over the northern Great Plains (NGP) for the years 1994-96; regional-scale maxima have been observed over the NGP since 1989. In addition, we found that 1) regional-scale maxima of annual mean positive CG peak current were located over the NGP for the years 1994-96 and 2) hourly positive CG strike count peaked 0-6 hours BEFORE hourly negative CG strike count over the NGP from June-August 1994-96 (hourly positive CG strike count peaked 0-2 hours AFTER hourly negative CG strike count over the rest of the U.S.). We examined these signals in greater detail by comparing national radar summaries with plots of strike location for 15-minute periods over a 200-km radius area centered on the WSR-88D radar at Sioux Falls, South Dakota (KFSD). We compared these two time series on 19 days in 1996; these 19 days produced 75% of positive CG lightning over the KFSD area in 1996. We found that two thunderstorm types tend to occur over the KFSD area: late-afternoon and evening, developing mesoscale convective systems (MCSs) and nocturnal, mature MCSs. These thunderstorm types have distinct electrical properties at the time of maximum positive CG production: developing (mature) MCSs are characterized by percent positive CG lightning values greater than (less than) 50% and mean positive CG peak current values greater than (less than) 40 kA. We observed developing MCSs more frequently over the KFSD area than mature MCSs. Despite these differences, the overwhelming majority of positive CG lightning produced by both thunderstorm types was collocated with reflectivity values > 45 dBZ and was spatially clustered. We believe that the signals observed over the northern Great Plains are a result of the greater frequency of occurrence of developing MCSs relative to mature MCSs over this area.

Using severe storm reports of large hail and tornadoes as compiled by the National Weather Service and cloud-to-ground (CG) lightning ground strike location, polarity, and peak current from the National Lightning Detection Network (NLDN) for the contiguous United States during the 1994 and 1995 warm seasons (April-September), Larry Carey and Steve Rutledge have addressed the two following fundamental questions: 1) What are the percentages of severe storms that are characterized by predominately positive CG (PPCG) lightning?, and 2) What is the geographical distribution of these severe, PPCG lightning storms. Nationally, only 14% (4%) of the 13,577 severe storm reports were accompanied by greater than 50% positive CG lightning (and by a positive flash density > 0.01 $km^{-2}$ $h^{-1}$). There was great variability in these statistics by region. Only 3% (0.3%) of the 3861 severe storm reports in the eastern third of the country satisfy the above constraints. On the other hand, 24% (7%) of the 6,686 severe storm reports in the Great Plains region east of the Rocky Mountains meet the same criteria. In addition to this pronounced east-west difference in the percentage of severe storms associated with PPCG lightning, there is also a noticeable north-south gradient over the Great Plains. In the Southern Plains, only 12% (3%) of the 3633 severe storm reports meet the criteria given above. Similar percentages for the Central and Northern Plains are 37% (9%) and 45% (21%) respectively. Interestingly, these last two regions are collocated with the regional-scale maxima of percent positive CG lightning documented in annual maps from 1989 to the present.

Larry Carey and Steve Rutledge are also comparing C-band polarization radar (C-pol) and ALDF (Advanced Lightning Direction Finder, provided by NASA/MSFC) CG lightning data from the Maritime Continent Thunderstorm Experiment (MCTEX). Preliminary results have revealed a strong temporal and spatial correlation between mixed phased ice mass and the production of cloud-to-ground lightning, consistent with the non-inductive charging (NIC) theory of cloud electrification. Analysis of the differential reflectivity (Zdr) and specific differential phase (Kdp) suggest that the lofting of supercooled raindrops above the -10C level is a prerequisite for the production of CG lightning. In storm complexes with strong flash rates (> 3 per min), supercooled raindrops were inferred from the radar data at environmental temperatures as cold as -20°C. The freezing of these drops is hypothesized to enhance cloud electrification in three ways: 1) by providing "instant" precipitation sized (> 1 mm) ice which can rime and collide with ice crystals to separate charge, 2) through the production of secondary ice crystals which can enhance the separation of charge, and 3) through the intensification of the updraft via the release of the latent heat of fusion.

In addition to tropical and mid-latitude severe-storm analyses, Larry Carey, Walt Petersen and Steve Rutledge have been examining CSU-CHILL radar data, NEXRAD radar data and NLDN lightning data collected during a recent flash flood event that occurred in the city of Fort Collins on July 28, 1997. The flood caused five fatalities and extensive damage to the western side of the city. Preliminary rainfall estimates computed using the CSU-CHILL polarimetric data indicate that nearly 10 inches of rain fell in a 5-hour period during the evening of 28 July, consistent with values measured by rain gauges, but a factor of two larger than values computed with conventional reflectivity-based methods (e.g., the WSR-88D Z-R relationship). Interestingly, the heavy rainfall was not accompanied by significant lightning activity. Over the 5-hour period, approximately 20 CG flashes were detected by the NLDN in the storm vicinity (consistent with a noticeable lack of thunder during this period). Peak CG flash rates averaged approximately 0.5 flashes/minute for a single 30 minute period between 1930 and 2000 MDT, even though 50% of the total rainfall occurred between 2030 and 2230 MDT when only 5 flashes were detected! Analysis of the storm vertical structure revealed a morphology similar to that observed in tropical convection. Relatively weak reflectivities (e.g., < 40 dBZ) were observed above the -10°C level in the clouds even though the echo-tops often exceeded 14 km. During periods that lightning occurred, 40-45 dBZ echoes extended to elevations approaching -20°C. Vertical cross-sections of radar reflectivity, Zdr, LDR, and Kdp, suggest that warm-rain processes lead to the development of raindrops at temperatures near +5°C. In one lightning producing cell, CHILL radar data suggests that rainwater was being lofted through the 0°C level and subsequently frozen between -5°C and -10°C. The lofting of supercooled raindrops followed by freezing and the production of lightning in these cells seems consistent with more recent studies of tropical convection over Florida and the Maritime Continent Region.

Walt Petersen and Steve Rutledge both made presentations at the 2nd International Conference on the Physics of Lightning held in September 1997 in St. Jean de Luz, France.

Timothy Lang and Steve Rutledge are examining concurrent measurements from the CSU-CHILL multiparameter Doppler radar, the ONERA VHF lightning interferometer, and the National Lightning Detection Network, obtained during Phase A of the Stratosphere Troposphere Experiments: Radiation, Aerosols, Ozone (STERAO-A) field project. These measurements provided a unique data set with which to study the relationships between convective storm microphysics and lightning. Two events have been examined in detail: storms of 10 and 12 July 1996. Both storms underwent major organizational transitions during their lifetimes, identified by sharp changes in total lightning flash rates, dominant cloud-to-ground (CG) flash polarity, or dominant flash type (cloud-to-ground vs.intra-cloud). Both storms also featured relatively high intra-cloud (IC) flash rates. The 10 July 1996 storm evolved from a multicellular line to an intense unicellular storm. The unicellular stage was marked by a sharp peak in IC flash rate as identified by the interferometer. Cloud-to-ground flash rates were low throughout the storm's lifetime. Small hail was produced during the entire period of observation, suggesting storm updraft speeds were significant. The storm of 12 July evolved from an intense multicellular, hail-producing storm to a weaker rainstorm. Before this transition, hail was being produced and the CG flash rates were low. After the transition, hail was no longer being produced and negative CG flash rates were significantly larger. Storm updraft speeds likely weakened during the transition. These observations are consistent with the elevated-dipole hypothesis to explain low CG production in convective storms, especially if the observed high IC flash rates mostly neutralized any charged core before it descended toward the ground. Alternatively, if significant charging does not occur during wet growth of hail and graupel, both these storms might have produced enough wet-growth ice to prevent the generation of a lower positive charge center that could act to stimulate CG production. However, the radar data, in particular the linear depolarization ratio (LDR) data, suggest that dry growth was more prevalent than wet growth.

**FMA RESEACH Inc. (Fort Collins, CO)**

**THE SPRITES'97 CAMPAIGN**

The SPRITES'97 Campaign was conducted at the Yucca Ridge Field Station (YRFS), operated by FMA Research, Inc., during July and August 1997. As in past years, Walt Lyons provided forecasts and coordinated observations. Tom Nelson contributed technical support and managed data acquisition functions. This year's measurement campaign was somewhat smaller but also more focused than those of the past several years. On site for the program were the staff from Tohoku University, Sendai, Japan (Yukihiro Takahashi, Hirioshi Fukunishi), Mission Research Corporation (Russ Armstrong) and Penn State (Lee Marshall, Morgan David, Less Hale). Equipment was also provided by several organizations to complement the existing low-light TV and RF systems at YRFS. These included a blue sensitive low-light TV (LLTV) from Los Alamos National Laboratory (David Suszcynsky), and broad band photometers from MIT (Earle Williams) and the University of Otago (James Brundell, John Bahr, Richard Dowden).

Off site experiments with which coordination was maintained included a radar system from SRI International (Roland Tsunoda, Rick Doe) at Platteville, CO, the MIT Schuman Resonance site in Rhode Island (Earle Williams), and a similar ELF system operated by the Hungarian Geodetic and Geophysical Research Institute (Gabriella Satori). Coordinated measurements were conducted on several evenings with personnel from Stanford University (Chris Barrington-Leigh) and New Mexico Tech (Mark Stanley, Paul Krehbiel). Additional analyses of data taken from Yucca Ridge and Socorro on 24 July 1996 (along with Marx Brook) are suggesting that some sprite events may be associated with horizontal spider lightning discharges almost 200 km long.

Weather conditions were less favorable than in past years, probably due to the effects of the developing El Nino. While storms were frequent, they tended to be smaller in size. Also enhanced low-level cloudiness precluded viewing many systems. Even so, approximately 500 sprites and elves were recorded on the optical imagers. While the larger storm systems clearly tended to produce more sprites, there were some observations of sprites from storms of less than 15,000 sq. km, especially during their late mature and early dissipation stages. The last sprites of the season were logged on the night of 12 October above a tornadic squall line in Nebraska and Kansas ahead of an Arctic cold front.

The key focus of SPRITES'97 was to obtain coordinated LLTV video imagery and high temporal resolution photometry (broad band red, and narrow band blue at 4278 and 3998 nm) in the sprite region along with broad band photometry data from the region of the lightning discharge itself. Useful data were obtained suggesting that blue emissions may proceed the onset of the red emissions (Russ Armstrong). The blue sensitive LANL imager also recorded additional examples of blue sprites. Both the tendril and body region of some sprites showed blue emissions.

The Penn State group (Lee Marshall) reported possible emissions from sprites at VHF frequencies on several nights. Attempts to correlate the nature of ELF signatures, including Q-bursts, with the optical characteristics of the parent CGs is ongoing (Earle Williams). Stroke level lightning data from the NLDN will be employed in our analyses for the first time this season with the assistance of Global Atmospherics, Inc. (Ken Cummins). SPRITES'97 activities will be summarized in several papers presented at the Fall AGU Meeting in San Francisco.

Plans are currently underway for a substantial SPRITES'98 effort, including taking lightning video coordinated with NLDN (Ken Cummins) and LDAR lightning observations during the RACES program (Paul Krehbiel). The major thrust will involve coordinating ground photometry measurements (with MRC, LANL, MIT) in support of as many as a half dozen stratospheric balloon missions above potentially sprite-generating mesoscale convective systems being flown by the University of Houston (Gar Bering).

A climatological summary of the distribution of large peak current (>75 kA) CG flashes stratified by polarity was prepared by Walt Lyons, Marek Uliasz and Tom Nelson and was accepted for publication in the Monthly Weather Review. FMA maintains a web site for information on its sprite-related activities (www.fma-research.com).

**GEODETIC AND GEOPHYSICAL RESEARCH INSTITUTE OF THE HUNGARIAN ACADEMY OF SCIENCES (Sopron, Hungary)**

A monitoring system for Schumann resonances was completed with the inclusion of measurements of the horizontal magnetic field in November 1996. The vertical electric field has been recorded since May 1993. Earle Williams visited the Institute and the Nagycenk Observatory in February 1997. Due to his assistance the same software was adopted as used for recording SR transients near West Greenwich, Rhode Island. In this way we could join the Sprite Campaign 1997 in July.

Collaborative work was performed with A.P. Nickolaenko (Institute of Radiophysics and Electronics, Ukrainian Academy of Sciences) for parameters of global thunderstorm activity deduced from Schumann resonance records (JASTP, in print).

Trade wind speeds in the Pacific were deduced from the anomalous behavior of Schumann resonances observed in winter 1995/1996 at Nagycenk (JGR, in print).

Long-term records of potential gradient (DC component of global electric circuit)and Schumann resonances (AC component) at the same measuring site (Nagycenk) yielded a unique possibility for several comparisons (F. Marcz, G. Satori and B. Zieger).(Annales Geophysicae, in print)

Gabriella Satori had a productive and enjoyable visit with Earle Williams at M.I.T.in the Parsons Laboratory and in the SR observation site, Rhode Island in October 1997. Collaborative work was discussed for comparisons of background and transient SR records observed simultaneously in Rhode Island and at Nagycenk. A half-day workshop on Schumann resonances gave a good possibility to meet other SR enthusiasts: Vadim Musthak from St.Petersburg, Bob Boldi, Stan Heckman, and Everest Huang.

**GLOBAL ATMOSPHERICS, INC.**

Global Atmospherics (GAI) is currently involved in a number of product development and applied research projects. We are midway through a Dual-use development project with NASA to commercialize the LDAR technology developed at Kennedy Space Center. A prototype Time-Interval Unit (TIU) developed by GAI will be operated in parallel with the NASA system through the Winter and Spring of 1998. The new TIU is designed to locate significantly more sources per flash than the current LDAR system. As part of this Dual-use project, GAI is utilizing waveform and source location data from the NASA LDAR system to help characterize the cloud discharge detection capabilities of GAIs new LPATS IV Time-of-Arrival lightnng sensor. In order to accomplish this objective, GAI is characterizing the LF vertical electric field source strength distribution for events occurring during cloud flashes.

As was reported in a previous issue of this Newsletter, the 1995 upgrade of the U.S. National Lightning Detection Network (NLDN) has resulted in the detection and reporting of a large population of small amplitude positive discharges. A collaborative effort with Paul Krehbiel and Mark Stanley of New Mexico Tech has clearly demonstrated that some fraction of these events are actually isolated bipolar positive cloud discharges. An additional sub-population of these small positive events could not be unambiguously classified based on their electric field waveshapes. We will try to resolve the question during the summer of 1997 as an adjunct to the RACES project. GAI will be working with New Mexico Tech, along with Walt Lyons and Tom Nelson of FMA Research, to record simultaneous video recordings and LF electric fields which will be correlated with small positive discharges located by the NLDN.

In a recent agreement with Environment Canada's Atmospheric Environment Service, GAI will supply, install, and operate 81 lightning detection sensors (LPATS IV and IMPACT) which will comprise the Canadian Lighting Detection Network (CLDN). The CLDN will be seamlessly integrated with the NLDN, creating a North American Lightning Detection Network which will cover the coast-to-coast land mass from the northern border of Mexico up to 60: North Latitude. This 187-sensor network is the largest lightning detection network ever deployed, and will provide tremendous information for research on regional climatology, lightning, and severe weather.

The research community has long requested that a description of the NLDN and its performance be published in the refereed scientific literature. GAI has recently submitted a paper to the JGR which describes the NLDN and discusses the lightning parameters provided by the NLDN. Two companion papers by Vince Idone and coworkers at the State University of New York at Albany were submitted at the same time. These papers describe the detection efficiency and location accuracy of the NLDN based on multi-camera studies in the Albany area over a two year period. This collection of papers should provide sufficient information to allow the research community to understand and properly employ data provided by the NLDN.

**LOS ALAMOS NATIONAL LABORATORY (Los Alamos, NM)**

The FORTE (Fast On-orbit Recording of Transient Events) satellite was successfully launched into a 70 degree inclination, 800 km orbit on August 29, 1997. Since that time, FORTE has operated nominally, returning several hundred Mbytes of optical and RF data per day. The satellite radio instrument suite includes a pair of 20 MHz bandwidth radio receivers which are independently tunable to VHF bands between 20 and 300 MHz, and a third 100 MHz bandwidth radio receiver which is also tunable throughout the VHF. Dual multiple-channel trigger systems give the RF payloads a high sensitivity to transient radio signals, like those produced by lightning processes. An important milestone was passed on October 28 with the successful deployment of the primary VHF radio antenna, a 12 m crossed log-periodic dipole array designed for operation from 30 to 300 MHz. The primary antenna has a smaller beam width and higher sensitivity than the backup active monopole antennas which had been used for RF data collection prior to primary antenna deployment. FORTE 92s opticalinstruments include a fast (15 microseconds per sample) photodiode detector and an optical lightning imager. Cross-triggering between the RF and optical payloads is possible, presenting us with the unique opportunity to perform ground-breaking research into the mechanisms and correlates of lightning on regional, synoptic, and global scales.

A Los Alamos FORTE science team has spearheaded data analysis efforts and worked closely with Spacecraft Operations to perform a number of studies in parallel. As one of its primary objectives, the science team (whose members include Abe Jacobsen, Joe Fitzgerald, Bob Franz, Matt Kirkland and Bob Massey) has been studying radio and optical data returned by the satellite to learn more about emissions from thunderstorms as recorded from space. FORTE has recorded large numbers of VHF radio emissions including emissions similar to Transionospheric Pulse Pair (TIPP) events recorded by the Blackbeard instrument.

Xuan-Min Shao has been working on the design and layout of a multiple-station ground-based fast electric field change array to support FORTE science observations during 1998. The array will have at least six stations with baselines of a few hundred kilometers, and will be centered in northern New Mexico. The field change array will be used to locate and identify the sources of lightning field change emissions. The insight provided by the ground-based data will be a great asset to the FORTE science team, as we correlate emissions recorded by ground-based and space-based sensors.

Charley Rhodes has been collaborating with the New Mexico Institute of Mining and Technology to develop a portable, 2-D, adjustable baseline, VHF lightning interferometer for use in field campaigns. The interferometer is close to completion and will be ready to travel in 1998.

Dave Smith continues to analyze field change and HF emissions from positive bipolar pulses. The highly energetic emissions produce the strongest high frequency radio emissions from thunderstorms and have a number of intriguing characteristics.

Ken Eack, Dave Suszcynsky and Bob Roussel-Dupre are working on the second year of a three year ballooning project to look for the presence of gamma (x-ray) emissions in the thunderstorm environment. Last summer's ballooning effort took place at Langmuir Laboratory in collaboration with Bill Winn and was restricted to testing of the balloon flight hardware (no science packages were flown). This year's ballooning will have two observational objectives. The first is to look for runaway breakdown in lightning by using high time-resolution x-ray detectors. These flights will take place at Langmuir Lab in July and August. The second objective is to look for x-ray emissions in Sprites, also using high time resolution instruments. A possible collaboration is with he MEAPRS field program to make these measurements in May and June of 1998. Bill Beasley and Heidi Morris of the University of Oklahoma plan to provide electric field change measurements in support of the x-ray observations. In addition LANL will also field intensified cameras and high time-resolution filtered photometers at Yucca Ridge (Ft. Collins, CO) to provide ground truth for the Sprite ballooning efforts, as well as to provide new optical data on Sprites. Ken Eack also plans continue to work with Bill Beasley (OU), Dave Rust (NSSL), Tom Marshall and Maribeth Stolzenburg (University of Mississippi) on simultaneous measurements of x-ray production and electric field inside thunderstorms.

The Space and Atmospheric Sciences Group (NIS-1) at LANL has an immediate opening for a postdoctoral researcher to join an ongoing optical and radio-frequency study of lightning, associated with the FORTE satellite. Highly qualified candidates should, as soon as possible, contact Dr. Abram Jacobson, (505) 667-9656, ajacobson@lanl.gov, Mail Stop D466, LANL, Los Alamos, NM 87545.

We also continue our ongoing need for graduate and undergraduate researchers. Interested candidates can contact Dr. Abram Jacobson or Dr. Dan Holden, (505) 667-3406, dholden@lanl.gov.

**M.I.T. LINCOLN LABORATORY (Lexington, MA)**

Under NOAA sponsorship, Lincoln Laboratory and Marshall Space Flight Center conducted a study to evaluate the operational benefits that could be realized through deployment of a total Lightning Mapping Sensor (LMS) on a future GOES. We attempted to delineate incremental capabilities -- above and beyond those realizable with current operational sensors such as the NEXRAD network and National Lightning Detection network -- and to quantify the value of these in terms of reduced human casualty, property damage or economic disruption. Areas considered in detail include:

(i) NWS responsibilities for issuance of tornado and severe weather warnings to the public;
(ii) thunderstorm ("flash") flood warnings;
(iii) impacts of convective weather on aviation, particularly outside the CONUS where current remote sensing capability is limited;
(iv) human casualty and economic disruption potentially reducible through more accurate warnings of the onset and cessation of cloud-to-ground lightning hazard.

The analysis indicates that on a nationwide basis, the economic "value" of the LMS may significantly exceed its costs. The study will be published as a Lincoln Laboratory Project Report late in 1997, available through the National Technical Information Service.

The currently operational LISDAD (Lightning Imaging System Data Application and Display) system continues to provide total iightning information in severe weather cases in Florida --a valuable source of information for the NOAA study described above.

**M.I.T. PARSONS LABORATORY (Cambridge, MA)**

As a result of discussions with Vadim Mushtak on an analytical model for the day-night asymmetry in the Earth-ionosphere waveguide and suggestions by Martin Fullekrug (at the IUGG meeting in Uppsala) for bearing deviations in ELF observations in Germany, Everest Huang has examined a year's worth of transient events from Africa detected in Rhode Island. Systematic diurnal variations in source bearing have been found (of the order of 5-10 degrees) which are more reasonably attributed to asymmetry of the waveguide than to changes in source location.

Gabriella Satori, Everest Huang and Earle Williams are examining comparisons between Schumann resonance intensity measurements in Hungary and Rhode Island. A strong annual signal is seen in both data sets, but the semiannual signal is notably stronger in the Hungary observations. We have hypothesized that this difference is attributable to a difference in the seasonal signals from the tropical zones that most strongly impact the signals at the two locations: Africa and South America. A recent examination of the seasonal discharge records for the Congo and the Amazon basins (giant raingages for the respective zones) supports the hypothesis: a substantial semiannual component is present in the Congo record which is evident in the Amazon. (The river records were examined in a recent paper with Fatih Eltahir in the Journal of Hydrology.)

Emily Mitchell, Russ Armstrong, Walt Lyons, Marx Brook and Earle Williams have been making comparisons on mesoscale lightning flashes observed from space with the M46 satellite, from Yucca Ridge with video cameras and from New Mexico and Rhode Island with ELF sensors and with the National Lightning Detection Network. The results provide further support for Wait's (1960) theory for 'slow tails' and show evidence that continuing currents in the positive flashes (with which sprites are associated) are of the order of kiloamperes and that long continuing currents are essential for Schumann resonance Q-bursts.

Everest Huang, Bob Boldi and Earle Williams have developed a method using calibrated ELF magnetic field data to measure the charge transfer to ground for flashes with ELF spectra that are approximately 'white' (ie., impulsive sources). Ground flashes associated with elves are often in this category and the measured charge transfers are of the order of 100 C. Positive flashes associated with sprites tend to show larger charge transfers but the impulsive assumption is less accurate. Comparisons with the traditional electrostatic method for charge transfer are needed to validate the electromagnetic method.

Earle Williams traveled to the (deforested) rainforest in tropical Brazil in October with Nilton Renno, John Gerlach and Jim Wilson, to scout out possible radar sites for the LBA experiment planned for January/February 1999. This field team met later with Steve Rutledge, Ramesh Kakar, Otto Thiele and Oswaldo Massambani in Sao Paolo to report their findings.

**NASA / MARSHALL SPACE FLIGHT CENTER (Huntsville, AL)**

The Lightning Imaging Sensor (LIS) is scheduled for a November, 1997 launch as a scientific payload on the Tropical Rainfall Measuring Mission (TRMM-1). The LIS is a calibrated optical sensor operating at 0.7774 μ that will observe the distribution and variability of total lightning (intracloud and cloud-to-ground flashes, day and night) occurring over the Earth in the tropics and subtropics. The LIS will detect, locate, and measure the radiant energy produced by lightning from a 350 km altitude, 35$^{o}$ inclination orbit with high detection efficiency (>90%), total field of view of 600 km x 600 km, storm scale (5-10 km) spatial and 2 ms temporal resolution.

The Optical Transient Detector (OTD), developed in-house at MSFC and launched in April 1995 as an early prototype of the Lightning Imaging Sensor (LIS), continues to provide measurements of global lightning activity from its 735 km altitude, 70$^{o}$ inclination orbit. Global lightning data observations from the OTD experiment are now available to the general science community and can be obtained from the Global Hydrology Resource Center (GHRC). You can learn more about this data from http://ghrc.msfc.nasa.gov/. More information about both OTD and LIS can be found on the NASA/GHCC homepage http://www.ghcc.msfc.nasa.gov. Additional information about the MSFC electricity program and how to order data can be found at this site.

We continue to have an interest in lightning data sets that could contribute to a global lightning climatology and to on-going ground truth activities for OTD (e.g. regional lightning detection networks, etc.) and LIS. 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).

Three MSFC Tropical Rainfall Measuring Mission (TRMM) lightning validation investigations were selected in response to the Satellite Remote Sensing Measurement Accuracy, Variability, and Validation Studies NASA Research Announcement (NRA-97-MTPE-03). The investigators and titles are 1) S. Goodman (MSFC), R. Raghavan (USRA), E. Williams (MIT), and M. Weber (MIT), Interpretation of Lightning Observations for Understanding the Meteorological Properties of Clouds; 2) D. Boccippio (MSFC), M. Bateman (USRA), and N. Renno (Univ. of Arizona), Cross-Sensor Validation of the Lightning Imaging Sensor; and 3) E. Krider (Univ. Arizona) and W. Koshak (MSFC), LIS Validation Studies Using Lightning at the KSC-ER. As part of these studies we expect to provide daily browse data for the KSC Lightning Detection and Ranging (LDAR) and field mill network for interested scientists at the GHCC home page. Preparations (R. Blakeslee, M. Bateman, J. Bailey and M. Stewart) are underway to support a 3 to 4 week aircraft campaign this spring called the TExas FLorida UNderflight (TEFLUN) experiment in support of validation of the TRMM sensors, data products, and retrieval (e.g., multi-sensor precipitation retrieval) algorithms. This field campaign, which is viewed as having low risk, high payoff scientific return, will focus on the U.S. Gulf Coast and especially on the priority TRMM ground validation sites in Texas and Florida. In the summer, we will participate in the Convection and Moisture Experiment (CAMEX3) and a concurrent USWRP supported effort to study lightning relationships in Hurricanes and tropical cyclones.

NESDIS has tasked Lincoln Labs (M. Weber, E. Williams, M. Wolfson) and MSFC (S. Goodman, H. Christian) to conduct a Lightning Mapper Benefits Study. The Lightning Mapper is a proposed geostationary version of the NASA developed lightning sensors in low earth orbit (OTD, TRMM_LIS). S. Goodman and H. Christian attended the kick-off meeting in May, 1997 at NESDIS and the draft report review in October at Lincoln Labs. This team addressed a possible set of topics and applications that might benefit from total lightning observations. These categories were reduced to approximately ten study areas for further analysis. The data gathering consisted of telephone and personal interviews, literature surveys, and data analysis. The initial results were presented during the NESDIS briefing at Lincoln Labs. The final report is due out by the end of the year.

An Advanced Geosynchronous Studies (AGS) program was jointly initiated in the Spring of 1997 by the NASA Mission to Planet Earth (MTPE) program and the NOAA Geostationary Operational Environmental Satellite (GOES) program to develop technologies and system concepts for Earth observation from geosynchronous orbit for the benefit of both MTPE science and the operational GOES program. The AGS is currently engaged in four studies related to specific types of observations from geosynchronous orbit: visible-infrared imaging, infrared (IR) sounding, microwave sounding and imaging, and lightning mapping. H. Christian is leading the study for lightning mapping. The scope of this study includes scientific analysis, requirements development, instrument and mission concept development, technology and breadboard development, performance analysis, advocacy development, and pursuit of flight opportunities.

**NATIONAL CENTER FOR ATMOSPHERE RESEARCH (Boulder, Colorado)**

Processing and analysis of data collected during the STERAO/Deep Convection experiment is now well underway and being coordinated by James Dye in close collaboration with Steve Rutledge at Colo. State Univ., Jeff Stith, Univ. of No. Dakota, Brian Ridley, NCAR/ACD Pierre Laroche at ONERA in France, Gerd Hubler at the NOAA Aeronomy Lab, Tom Matejka at NOAA NSSL Boulder and others. The STERAO-A experiment (Stratospheric Tropospheric Experiment: Radiation, Aerosols and Ozone), Part A. Deep Convection and the Chemical Composition of the Upper Troposphere and Lower Stratosphere) was conducted in northeastern Colorado during June through August 1996. The project had major goals of investigating the transport of chemical constituents by deep convection and the production of NOx (comprised of NO and NO2) by lightning. It was unique in combining and coordinating extensive chemistry, air motion and electrical measurements in and around thunderstorms, and included participants from several universities and national laboratories. The major research facilities in the experiment included: (1) the NOAA P3 aircraft to make chemistry and Doppler radar measurements below and at mid-cloud levels; (2) the University of North Dakota Citation jet aircraft to make chemical, microphysical and air motion measurements around and in the anvils; (3) the CSU/CHILL

[Colorado State University/University of Chicago/Illinois State Water Survey] multiparameter Doppler radar to remotely investigate microphysical properties of storms and to coordinate with the P3 in Doppler radar studies; (4) the French Office National d'Etudes et de Recherches Aerospatiales (ONERA) lightning interferometer to determine the structure of lightning inside storms; (5) the National Lightning Detection Network for cloud-to-ground lightning; (6) CLASS soundings to characterize the environment in the project area.

Many of the early analysis efforts have been focussed on the storms of 10 and 12 July. The 10 July storm was a multicell storm which late in its life evolved to a quasi-supercell storm. Although the areal extent was small it had cloud tops to almost 17 km which is very high for NE Colorado. During the quasi-supercell stage work by Tim Lang of Colo. State Univ., Laroche and Dye showed that the lightning was almost all intra-cloud with very few cloud-to-ground flashes. Early Doppler synthesis by Matejka suggest that there was not an organized downdraft in this storm, thus most transport would have been from the boundary layer to the upper troposphere. In contrast the 12 July storm covered a much larger area with tops to roughly 12 km and lots of both CG and IC lightning. The Doppler analysis suggests that this storm did have an organized downdraft and might be expected to transport constituents from mid-levels down into the boundary layer.

**NATIONAL LIGHTNING SAFETY INSTITUTE (NLSI) (Louisville, CO)**

1. A *Lightning Risk Abatement Review* was conducted in Oct. by western USA optical and radio observatories at Sunspot, NM. Some 25 participants from Fermilabs, Kitt Peak, Apache Point, NRO, US Naval Observatory, LANL, VLA, and the universities of Michigan, NM State, Princeton, Washington, and Tokyo attended the two day session.

   At high altitude scientific sites, lightning threatens expensive equipment, interrupts operating schedules and presents personal dangers to researchers and visitors. NLSI presented a risk management overview to the group, and examined the Apache Point (NM) site grounding, bonding, TVSS, and shielding. Bill Rison of New Mexico Tech. discussed a systematic approach to lightning safety.

2. NLSI's second NASA's Johnson Space Center assignment investigated personnel lightning safety issues to the overall facility. The site contains some 100+ buildings, with 3000+ employees in a campus-like environment. The Final Report was submitted, with recommendations including:

   a) Improvements to lightning protection systems (LPS).
   b) Adoption of widespread signage and signaling devices.
   c) Regular inspection and maintenance of LPS.

3. NLSI's monthly Newsletter will appear regularly at NLSI's website effective Dec. 1997.

4. The National Collegiate Athletic Association (NCAA) has adopted the first-ever Lightning Safety Policy, printed in the *1997-98 NCAA Sports Medicine Handbook*. This guideline is available to all colleges and universities. It is expected to "trickle-down" to the secondary school sports venue. The principle authors were Brian Bennett of College of William and Mary and Ron Holle/Raul Lopez of the National Severe Storms Laboratory. Some 20% of all lightning injuries occur in recreation settings.

5. NLSI's 1997 activities were concentrated in the following areas:

a) Conducted 7 two-day intensive workshops for 110 students.
b) Presented 23 two-hour safety seminars to diverse interest groups.
c) Completed six site survey/consulting assignments.
d) Participated in 20+ lightning safety articles in the general media.
e) Retained as expert witness in four litigation matters.
f) Our website was accessed by readers more than 12,500 times this year.

**NATIONAL SEVERE STORMS LABORATORY (Norman, OK)**

This fall Don MacGorman and Dave Rust finished proof reading the last revision of page proofs for their book *The Electrical Nature of Storms.* It is to be available from Oxford Press in January.

The large drop in the number of lightning deaths during the 20th century has been documented by Raúl López and Ron Holle in an article accepted for the *Journal of Climate*. The exponential drop is shown to be linked to a similar reduction in the rural population of the U.S. Modulating this secular trend are decadal fluctuations in the number of lightning deaths that are closely associated with similar secular fluctuations in thunderstorm days and surface temperature.

An extensive summary of lightning-caused deaths, injuries, and damages in the U.S. has been published by Brian Curran of the National Weather Service in Fort Worth, and Ron Holle and Raúl López of NSSL. The NOAA Technical Memorandum shows maps and tables for the 3239 deaths, 9818 injuries, and 19,814 property damage reports in the U.S. from 1959 to 1994 in NOAA's Storm Data. It includes frequencies with and without population weighting by state; seasonal, monthly, day of week, and hourly summaries; and the number of people per event, gender, location, and damage amounts.

The National Severe Storms Laboratory will host the MCS Electrification and Polarization Radar Study (MEaPRS) project from May 15 through June 15, 1998. The two primary objectives of MEaPRS are to investigate MCS electrification processes and improve understanding of polarimetric radar measurands. In the MCS electrification component, kinematic and microphysical data collected by a NOAA P-3 aircraft will be combined with balloon-borne electric field meter measurements to refine currently existing conceptual models. Several coinvestigators plan to participate in the mobile ballooning with instruments to record lightning field changes, particle charge, x-rays, and replicas of hydrometeor habits. In the polarization radar component, emphasis will be placed on collecting high quality microphysical data with which to compare polarimetric measurements by the NSSL Cimarron radar. Anyone interested in participating in MEaPRS should contact either Dave Rust (dave.rust@nssl.noaa.gov) or Terry Schuur (terry.schuur@nssl.noaa.gov) at NSSL.

After MEaPRS, Don MacGorman, Dave Rust and Bill Beasley of the University of Oklahoma hope to take one of NSSL's mobile laboratories to the RACES field program to provide balloon soundings of the electric field in storms that produce high densities of positive ground flashes.

A guideline for lightning safety was published in the 1997-98 Sports Medicine Handbook of the National Collegiate Athletic Association (NCAA) by Brian Bennett of the College of

William and Mary, and Ron Holle and Raúl López of NSSL. This is the first guideline on lightning published by the NCAA, and is designed for practices, competitions, and intramural sports at NCAA colleges and universities.

Raúl López and Ron Holle presented two papers at the Second International Conference on Lightning and Mountains from June 1-5, 1997 at Chamonix Mont-Blanc, France. One paper, given at the conference's Medical Symposium, described secular changes and made a synthesis of our knowledge on the epidemiology of lightning deaths and injuries and changes due to demographic, societal, and climatic factors. The other paper described the location, time, and amounts of lightning damage found with insurance data in three western U.S. states that was published in the *Journal of Applied Meteorology.*

Ron Holle made two presentations on lightning damages and casualties during a special lightning session at the Summer Meeting of the American Association of Physics Teachers in Denver in August. The session was organized by Michael Cherington of the Lightning Data Center at St. Anthony's Hospital in Denver, and included presentations by others from the Center.

**NEW MEXICO TECH (Socorro, NM)**

Ph.D. student Mark Stanley conducted two field programs this summer, first at Kennedy Space Center, where he obtained additional measurements of lightning discharges with Tech's lightning interferometer in conjunction with KSC's LDAR system. A good dataset is now in hand for comparing the simultaneous observations from the two systems, and for further studying positive bipolar pulses. (Joint studies with Xuan-Min Shao and Dave Smith of Los Alamos in the summer of 1996 showed that the latter are the likely source of trans-ionospheric pulse pairs, or TIPPs, observed at radio frequencies by satellites.) Mark also obtained the first observations of sprites in Florida, including some at less than 100 km distance above a relatively small storm (1500-2000 $km^2$ area) whose parent lightning discharges were observed by the LDAR and interferometer systems.

Additional sprite and elve observations were subsequently obtained at Langmuir Laboratory in New Mexico, including a) observations of a number of elves produced by negative CG strokes (in conjunction with Chris Barrington-Leigh from the Stanford group), b) photometer and magnetic field confirmation that `slow' unipolar electric field signals at the time of sprites are indeed associated with charge transfer within the sprite itself (in conjunction with Barrington-Leigh and Dave Suszcynski of Los Alamos National Laboratory), and c) high speed video observations of both sprites and elves. The latter were obtained at rates of 1000-3000 frames/second using an image-intensified Kodak Ektapro system from Bill Abrahms of Speedvision, Inc., and show the ring-like nature and expansion of elves and the upward and downward development of sprites.

Good progress has been made on the development of a deployable LDAR-type system. The system, being designed by Bill Rison, Paul Krehbiel and Ron Thomas, is PC based and utilizes a specially-designed PC card to digitize and accurately time the lightning signals (either VHF radiation or sferics from the lightning) independently at each station. Relatively low-cost GPS receivers are used to achieve the timing accuracy, and high speed wireless modems are used to transmit the relatively low-rate time-of-arrival information to a central site for real time processing. Four stations have been constructed for testing in the Socorro area this winter. A complete system of 10-11 stations is planned for operation in the proposed RACES field program next summer.

**PHILLIPS LABORATORY (Hanscom AFB, MA)**

Dr. John Willett (Geophysics Directorate, Phillips Laboratory -- soon to undergo yet another name change, as the Air Force reorganizes its laboratories again!) is working with Dan Davis (State University of New York at Albany) to analyze data from the Rocket Electric-Field Sounding experiment that was conducted at Camp Blanding during the summer of 1996. First results were presented at the 3rd International Workshop on Physics of Lightning and indicate that lightning can be triggered with the rocket-and-grounded-wire technique when the field aloft is less than 15 kV/m. Collaboration is beginning with Anne Bondiou-Clergerie and Pierre Laroche (Office National d'Etudes et de Recherches Aerospatiales) to compare the experimental results with a theoretical model of positive-leader propagation that was developed by Bondiou and Gallimberti.

**ST. PETERSBURG STATE UNIVERSITY (St. Petersburg, Russia)**

Victor Borisov, D. Dovjenko, Igor Kononov, Irina Simonenko and Andrei Utkin (ILF of Vavilov State Optics Institute) are elaborating on the description of electromagnetic fields due to high-current components of the lightning stroke. We are investigating both cloud-to-ground and cloud-to-cloud strokes for arbitrary observation points (at and over the ground). We are considering variations of lightning-current waveforms, current-pulse velocity, and different channel structure (inclination, tortuosity, and branching). Further examination of possible directionality of electromagnetic waves due to lightning discharge and conditions for its manifestation is continued.

Mikhail Kostenko reported on the results of his continuing researches of lightning return stroke equivalent impedance at the XII Intern. Conference on Gas Discharges and their Applications in Greifswald, Germany. They were taken by means of the mathematical simulation of the wave processes arising by lightning strikes to overhead lines taking into account: 1) Nonlinear Volt-ampere and Volt-column characteristics of the heating and expanding lightning channel; 2) Impedance and wave processes in the stricken line; and 3) Current and Voltage both in the Downward Leader Wave and in the Upward Return stroke Wave. The lack of field measurements of lightning was overcome by considering them in laboratory conditions. The empirical approximated formula for equivalent impedance of the return-stroke is equal to $Z_{eq}=140*(1+240/i)$,if $i<I_{max}, t<t_f$; $i=i_0-u_s/Z_{eq}$; or $Z_{eq}=140*(1+240/I_{max})$, if $t>t_f$. Here i is the actual total (in leader and in return-stroke) current in the lightning channel, $i_0$ is "Calculated lightning current" according to R.B. Andersen and A.T. Eriksson (*Electra*, **69**, 65-102, 1980), $u_s$ is the voltage on the struck node of the line. The more precise values of $Z_{eq}$(in Ohms) will be obtained after 1-2 iterations according to formula for $Z_{eq}$. This solution is more precise as compared with the solution published in *J. Geophys. Res.* (**100**, 2739-2747, 1995)

**STANFORD UNIVERSITY: STARLAB (Stanford, CA)**

The VLF Group at STAR Laboratory of Stanford University continues experimental and theoretical work on upward coupling of tropospheric thunderstorms to the mesospheric and lower ionospheric regions.

During the 1997 Sprite campaign, Stanford University performed measurements of the ELF/VLF horizontal magnetic field using two orthogonal antennas at Yucca Ridge, Colorado; Stanford, California; and Palmer Station, Antarctica. Tim Bell, Steve Reising and Umran Inan analyzed continuous wideband ELF/VLF measurements from summer 1996 and demonstrated that ELF radio atmospheric can be used as a proxy measurement for sprite occurrence. In addition, these measurements allow assessment of the vertical component of currents in lightning discharges which lead to the production of sprites and elves. Clear evidence of electrical current in the sprites themselves was recently reported at the Uppsala conference in August 1997 by Umran Inan.

This summer Stanford's "Fly's Eye" optical array was again deployed to observe sprites and elves above distant thunderstorms. With assistance from the Langmuir Lab for Atmospheric Research and from Lockheed-Martin Palo Alto Research Lab, the array was fielded by Chris Barrington-Leigh for six weeks in July and August on South Baldy mountain in central New Mexico. Hundreds of upper atmospheric flashes were recorded from Mexico, Arizona, New Mexico, Texas, Oklahoma, Kansas, and Colorado. This year the photometric time resolution was improved to about 16 microseconds, and the use of optical filters improved the signal to noise ratio. Results from last summer's campaign were recently published by Umran Inan, Chris Barrington-Leigh, Sean Hansen, Slava Glukhov, Tim Bell and Rick Rairden (Lockheed-Martin Palo Alto Research Lab) (*Geophys. Res. Lett.*, **24**, p. 583, 1997).

During the summer of 1997, the Holographic Array for Ionospheric Lightning research (HAIL) team (Mike Johnson, Hemanth Sampath, Michael Lau and Frank Kolor) upgraded its VLF receivers by replacing the analog amplitude and phase receivers with new high resolution digital systems. Four of the five receivers in the Colorado and New Mexico array were previously deployed during the summer of 1996. The new receiver scheme uses a high resolution, digital data acquisition system to improve the sensitivity of the receiver. In addition, a new real-time algorithm takes advantage of GPS phase stability and computes the phase perturbations due to propagation and scattering by comparing the received phase with a reconstruction of the original transmitted signal. The resulting data shows that Trimpi events occur with a much higher rate than previously observed, and the five element array is now being used to determine the size and profile of the disturbed D-region ionosphere. In addition, three of the five instruments have been deployed at high schools with automated Internet transmission of the data, allowing the scientific community daily access to high resolution data. A new Java Data Browser allows simple data viewing using a web browser. Please visit http://star.stanford.edu/~hail/.

Nikolai Lehtinen, Tim Bell, Victor Pasko and Umran Inan developed a new two-dimensional runaway model of sprites (*Geophys. Res. Lett.*, Nov. 1, 1997) incorporating previously reported one-dimensional runaway (Bell et al., *Geophys. Res. Lett.*, **22**, p. 2127, 1995) and two-dimensional quasi-electrostatic heating (Pasko et al., *J. Geophys. Res.*, **102**, p. 4529, 1997) models. Optical and gamma-ray emissions are calculated and compared to experimental observations of sprites and terrestrial gamma-ray flashes.

Dick Picard (Air Force Phillips Laboratory), Umran Inan, Victor Pasko, Jeremy Winick (Air Force Phillips Laboratory), and Peter Wintersteiner (ARCON Corporation) reported results of studies (*Geophys. Res. Lett.*, Nov. 1, 1997) indicating that sustained heating of lower ionospheric electrons by thundercloud fields as recently suggested by Inan et al., (*Geophys. Res. Lett.*, **23**, p. 1067, 1996) may lead to the production of enhanced infrared emissions, in particular the 4.3µ $C0_2$ emission. Predicted infrared enhancements should be observable to an orbiting infrared sensor.

Steve Cummer completed his Ph.D. dissertation entitled "Lightning and Ionospheric Remote Sensing using VLF/ELF Radio Atmospherics" aimed at the development and implementation of techniques to use sferic observations to determine the characteristics of the ionosphere and lightning. The developed models allow, in particular, to measure lower ionospheric electron density profiles as well as vertical charge moments of sprite producing lightning discharges (see Steve Cummer and Umran Inan, *Geophys. Res. Lett.*, **24**, p. 1731, 1997).

Victor Pasko, Umran Inan and Timothy Bell investigated possible association of sprites and gravity waves launched upward by convective activity in thunderstorms (*Geophys. Res. Lett.*, **24**, p. 1735, 1997). It was shown that large area multicell thunderstorms may lead to the formation of vertically oriented cylindrical structures of gravity waves at mesospheric altitudes closely resembling those observed in optical emissions associated with sprites.

**STATE UNIVERSITY OF NEW YORK (Albany, NY)**

The last six months have been both very busy and very sad. In the Spring, Bernie Vonnegut passed away, leaving a void that certainly can never be filled. We miss him profoundly. Hopefully, his spirit will remain with us as we attempt to carry on. Though his demise was certainly sad, it should be noted that Bernie's legendary humor was manifest frequently right up to the very end. He was truly an extraordinary individual and scientist!

Another mainstay in the department, Ron Henderson, left to take a position in the private sector this past June. Ron was here for seventeen years, initially as a grad student and later as a staff member. Needless to say, his efforts in realizing the NLDN were nothing short of phenomenal. We wish him the very best in his new career.

This past June, we submitted two papers to JGR summarizing our evaluation of NLDN performance in the Albany area for two summer seasons of lightning observation. We used video cameras and fast electric-field recordings to document local lightning characteristics in comparison with that observed by the NLDN for common events. These two papers are presently under revision and will likely be published early next year. A third paper submitted by Ken Cummins and associates at Global Atmospherics Inc. should accompany our two evaluation papers. The Cummins et al. paper provides an overview of the operational principles and techniques employed in the recent upgrade of the NLDN to the IMPACT configuration. We believe this trio of papers will provide the lightning research community with very relevant information on the use and interpretation of NLDN data.

Using NLDN data from several years ago, John Molinari, Paul Moore and Vince Idone recently submitted a paper to MWR summarizing the general character of lightning and convective activity observed in eight Atlantic basin hurricanes.

As far as field work goes, Vince Idone and Dan Davis participated in the triggered lightning studies at Camp Blanding this past summer. Various measurements were made by Dan directed at documenting the attachment process. Vince was successful in obtaining channel cross-section recordings of triggered channels with improved spatial and temporal resolution relative to earlier measurements. We hope to coordinate our analyses with that of Martin Uman and Vlad Rakov as well as continue our ongoing studies with John Willett in examining data from several earlier triggered lightning campaigns.

**TEL AVIV UNIVERSITY Dept. of Geophysics and Planetary Sciences (Tel Aviv, Israel)**

Zev Levin and Yoav Yair have begun a 3-year project to study the relationship between lightning flashes and meteorological conditions in Israel, using lightning location systems, weather radar and satellite images. The project is funded by The Israel Academy for Sciences andHumanities. They plan to use the LPATS data of the Israel Electrical Company. The 2 existing CGR3 lightning detectors will provide lightning data in the Tel-Aviv and Haifa areas. Radar images of clouds will be obtained from the Tel-Aviv weather radar and from an air-force radar in the Negev highland. AVHRR images and meteorological data will be used to determine the synoptic setting for the development of thunderstorms in our region. This will enable an analysis of seasonal and geographical trends in lightning characteristics, and an identification of the influence of meteorological conditions on the observed lightning patterns.

Colin Price continues working on setting up a Schumann Resonance monitoring station in the Negev Desert in Israel in collaboration with Earle Williams of MIT. As part of this project Colin Price also visited the Schumann Resonace site in Rhode Island operated by Earle during the summer.

Colin Price, together with Sven Israelsson (Sweden), Sasha Nickolaenko (Ukraine), and Sasha Schekotov (Russia) succeeded in obtaining funding from the European Union (INTAS) to start a collaboration looking at the possibilities of using the global electric circuit to monitor climate change. This collaboration will continue for 3 years and will supply badly needed funds to support scientists in the Former Soviet Union (FSU).

**TEXAS A&M UNIVERSITY (College Station, Texas)**

Titles and abstracts of recent publications are shown below:

LIGHTNING IN THE REGION OF THE TOGA COARE

Richard E. Orville, Edward J. Zipser, Marx Brook, C. Weidman, Graydon Aulich, E. P. Krider, H. Christian, S. Goodman, R. Blakeslee and K.Cummins

(Bulletin of the American Meteorological Society, June 1997)

A lightning direction finder network was deployed in the western Pacific Ocean in the area of Papua, New Guinea. Direction finders were installed on Kapingamarangi Atoll and near the towns of Rabaul and Kavieng, Papua New Guinea. The instruments were modified to detect cloud-to-ground lightning out to a distance of 1,000 km. Data were collected from cloud-to-ground lightning flashes for the period 26 November 1992 to 15 January 1994. We present the analyses for the period 1 January 1993 through 31 December 1993. In addition, a waveform recorder was located at Kavieng to record both cloud-to-ground lightning and intracloud lightning in order to provide an estimate of the complete lightning activity. The data from these instruments is to be analyzed in conjunction with the data from ship and airborne radars, in-cloud microphysics, and electrical measurements from both the ER-2 and DC-8.

During the year, January through December 1993, the cloud-to-ground lightning location network recorded 857,000 first strokes of which 5.6% were of positive polarity. During the same period 437,000 subsequent strokes were recorded. The waveform instrumentation operated from approximately mid-January through February 1993. Over 150,000 waveforms were recorded. The peak annual flash density was 2.6 flashes/km$^2$ centered on the western coastline of New Britain, just southwest of Rabaul. The diurnal lightning frequency peaked at 1600 UTC (0200 LT), perhaps in coincidence with the nighttime land-breeze convergence along the coast of New Britain. Median monthly negative peak currents are in the 20-30 kA range, with first stroke peak currents typically exceeding subsequent peak currents. Median monthly positive peak currents are typically 30 kA with one month (June) having a value of 60 kA.

Positive polar conductivity was measured by an ER-2 flight from 40$^o$ north geomagnetic latitude to 28$^o$ south geomagnetic latitude. The measurements show that the air conductivity is about a factor of 0.6 lower in the tropics than in the mid-latitudes. Consequently, a tropical storm will produce higher field values aloft for the same rate of electrical current generation. An ER-2 overflight of tropical cyclone Oliver on February 7, 1993, measured electric fields and 85 GHz brightness temperatures. The measurements reveal electrification in the eyewall cloud region with ice, but no lightning was observed.

CHARACTERISTICS OF CLOUD-TO-GROUND LIGHTNING ASSOCIATED WITH VIOLENT TORNADOES

Antony Perez, Louis J. Wicker and Richard E. Orville

(Weather and Forecasting, September 1997 issue)

Cloud-to-ground lightning patterns were analyzed in forty two violent tornado-producing (F4-F5) supercells that occurred between January 1989 and November 1992. The purpose of this analysis was to identify potential correlations between cloud-to-ground lightning patterns and tornadogenesis. Thirty one of the storms were characterized by a peak in CG flash rate preceding tornado formation; twenty two storms displayed a decrease in CG activity coincident with tornado touchdown. Six of the forty two storms exhibited a polarity reversal, from positive to negative, in the sign of the charge lowered to ground. Storms exhibiting a majority of positive flashes were generally associated with long-track tornadoes, F-5 damage ratings or severe weather outbreak conditions. The total number of flashes associated with each storm had no correlation with tornadogenesis (total number of flashes ranged from 16 to approximately 4000). Based on this analysis, it appears that cloud-to-ground lightning flash patterns will not be useful in identifying tornadogenesis. Total lightning counts, both cloud-to-ground and intracloud flashes, may be useful. This study should be repeated when total flash counts become available from lightning detection networks.

A TEN-YEAR MONTHLY LIGHTNING CLIMATOLOGY OF FLORIDA: 1986 THROUGH 1995

Stephen Hodanish, David Sharp, Waylon Collins, Charles Paxton and Richard E. Orville

(Weather and Forecasting, September 1997)

Average cloud-to-ground lightning flash density values for Florida have been calculated for the ten-year period 1986 through 1995. An annual mean map and monthly mean maps were constructed from a data base exceeding 25 million flashes. These maps represent a 10-year climatology of the geographic distribution of detected cloud-to-ground lightning flashes and provide an insight into the thunderstorm distribution in Florida. The locations of relative areas of lightning maxima and minima are strongly affected by the various combinations of synoptic and mesoscale contributions and are discussed. During the cool season, November through February, the greatest flash densities occur over the panhandle from storms mostly associated with mid-latitude synoptic scale systems. During the spring transitional period of March through May, flash densities increase over the entire state as synoptic contributions transition to mesoscale. Flash density totals in the warm season, June through August, exceed 10 flashes/km$^2$ in the central part of Florida. Flash density maxima in the summer are locally enhanced by mesoscale convergence and convection, especially along the west and east coasts of the central peninsula. Neither the panhandle nor the south peninsula show these impressive maxima. During the autumn transition period, September and October, flash densities decrease sharply across the state except for an area maximum that does remain over the eastern part of the peninsula.

WARM SEASON CLOUD-TO-GROUND LIGHTNING-PRECIPITATION RELATIONSHIPS IN THE SOUTH CENTRAL UNITED STATES

Scott C. Sheridan, John F. Griffiths and Richard E. Orville

(Weather and Forecasting, September 1997)

This study examines the relationship between cloud-to-ground (CG) lightning and surface precipitation taken from observations from six regions (each on the order of 10 000 km2), April through October (1989-93), in the South Central United States. The relationship is evaluated using two different methods. First, regression equations are fit to the data, first for only the CG lightning flash density and precipitation, and then with additional atmospheric and lightning parameters. Second, days are categorized according to differences in the precipitation-to-CG lightning ratio; the same additional parameters are then examined for differences occurring within each category.

Results show that the relationship between CG lightning and surface precipitation is highly variable; $r^2$ coefficients range from 0.121 in Baton Rouge to 0.601 in Dallas. A measure of the positive CG lightning flash density is the best addition to the model, statistically significant in all regions. When days are categorized, the percentage of lightning which is positive shows the most significant differences between categories, ranging from < 4 % on days with a "low" precipitation-to-CG lightning ratio, to 12-36% on days with a "high" ratio. Other lightning parameters give less significant results; however, three atmospheric parameters (CAPE, Lifted Index, and Showalter Index) do show a significant trend suggesting that there is much less instability in the atmosphere on "high" ratio days than on "low" ratiodays.

LIGHTNING GROUND FLASH DENSITY IN THE CONTIGUOUS UNITED STATES: 1992-1995

Richard E. Orville and Alan C. Silver

(Monthly Weather Review, April 1997, 631-638)

Cloud-to-ground lightning data for the years 1992-95 have beenanalyzed for geographical distribution of total flashes, positive flashes, and the percentage of flashes that lower positive charge to ground. In the contiguous United States the measured total cloud-to-ground lightning flash counts were 16.3 million (1992), 24.2 million (in both 1993 and 1994) and 22.3 million in 1995. The maximum flash densities occurred in Florida in 1992 (9-11 flashes $km^{-2}$) and in the Midwest in 1993 (11-13 flashes $km^{-2}$), coinciding with the storms and floods that dominated the summer of 1993 in the Midwest. In 1994, the area of maximum flash density was again in Florida (11-13 flashes $km^{-2}$). In 1995, the flash density maxima (9-11 $km^{-2}$) were in southern Louisiana and near the Kentucky-Illinois border. Positive flash densities had maxima in the Midwest in all four years with values of 0.4 flashes $km^{-2}$ (1992), 1.0 flashes $km^{-2}$ (1993), 0.7 flashes $km^{-2}$ (1994), and 1.8 flashes $km^{-2}$ (1995). The annual mean percentage of flashes that lowered positive charge to ground was between 4% and 5% for the three years, 1992-94, but increased to 9.3% in 1995. The monthly values of the percentage of positive flashes ranged from 3% (August 1992) to 25% (December 1993). The positive flash maxima in the Midwest appear to be near the geographical areas in which cloud-ionosphere discharges (sprites) have been reported.

Additional note for the newsletter: Dick Orville, Vlad Rakov, Steve Goodman and Bob Holzworth attended the Brazilian Geophysical Society meeting in Sao Paolo, Brazil, September 28-October 2. They were guests of the Brazilian Geophysical Society and presented papers on their recent research. In turn, we heard approximately 20 papers given by Brazilian scientists on their research covering many areas of atmospheric electricity. It is their hope to develop a lightning detection network covering the populated areas of Brazil.

**UNIVERSITY OF ARIZONA (Tucson, AZ)**

Electric field and lightning data obtained at the NASA Kennedy Space Center are being analyzed by Scott Handel and E. P. Krider, in order to check and improve the current Lightning Launch Commit Criteria that are used by NASA and the USAF for space flight operations. As a by-product of this work, W. J. Koshak of the Marshall Space Flight Center and E. P. Krider have developed a multipole method for analyzing complex field changes, and we expect to use this algorithm to provide "ground-truth" for the upcoming Lightning Imaging Sensor (LIS) that will be launched in November.

**UNIVERSITY OF FLORIDA (Gainesville, FL)**

During the 1997 triggered-lightning campaign at Camp Blanding, Florida, Dave Crawford, George Schnetzer, Martin Uman, Vlad Rakov, Keith Rambo and Mike Stapleton simultaneously measured electric and magnetic fields at seven distances (5, 10, 20, 30, 50, 110 and 500 m) from the triggered-lightning channel. Identical antenna systems were used at each station. Complete data were obtained for 3 flashes and partial data for several more. Field changes produced by dart leaders, return strokes, M components, and the initial processes associated with classical triggered lightning are being analyzed. Analysis includes an examination of the shape and magnitude of the recorded field waveforms and their dependence on channel current and distance from the channel with a view toward studying charge and current distributions along the channel. Preliminary results will be presented at the 1997 Fall AGU Meeting in San Francisco.

Daohong Wang, Nobuyuki Takagi, Teiji Watanabe (Gifu University, Japan), Dave Crawford, Keith Rambo, Vlad Rakov, Martin Uman, George Schnetzer, Dick Fisher and Zen Kawasaki (Osaka University, Japan), using the high speed (100-ns interframe interval) digital imaging system ALPS, studied the attachment process in rocket-triggered lightning strokes. A total of three dart leader/return stroke sequences, simultaneously recorded by ALPS and by electric field and current measuring systems during 1997 triggered lightning experiment at Camp Blanding, Florida, are suitable for examining the lightning attachment process. The following tentative conclusions have beenmade: (1) an upward leader may occur in the dart leader/return stroke sequence; (2) the larger the leader electric field change and the larger the following return-stroke current, the longer the upward connecting leader; (3) the upward connecting leader is characterized by a light intensity about one order of magnitude lower than that of the corresponding downward leader and by a duration of only several hundreds of nanoseconds; (4) the following return stroke starts at the junction point of the downward and upward leaders and then travels in both upward and downward directions. The results of this study will be presented at the 24$^{th}$ International Conference on Lightning Protection (ICLP) in Birmingham, UK, September 14-18, 1998.

Daohong Wang, Mark Fernandez, Keith Rambo, Vlad Rakov, Martin Uman, George Schnetzer and Dick Fisher have studied characteristics of the current pulses in the initial continuous current (ICC) stage of rocket-triggered lightning. The initial stage of a classical rocket-and-wire triggered lightning is characterized by a continuous current (ICC) with a duration of several hundred milliseconds and an amplitude of several hundred amperes that effectively lowers to ground several tens of Coulombs of charge. The ICC stage in all current recordings obtained during the rocket-triggered lightning experiments at Fort McClellan, Alabama in the Summer of 1994, and at Camp Blanding, Florida in the Summers of 1996 and 1997 has been examined. In most cases the ICC stage contained M-component-like current pulses (ICC pulses) superimposed on the slowly varying continuous current. A statistical comparison between these pulses and the M-component pulses following return strokes in triggered lightning have been made. Additionally, the optical measurement of the ICC stage, obtained with the high-speed (100-ns interframe interval) digital imaging system ALPS provided by Gifu University, Japan, have been examined. The results will be presented at the 1997 Fall AGU Meeting in San Francisco.

Vlad Rakov has completed a study in which inferences regarding the propagation mechanisms of dart leaders and return strokes are made from a comparison of the behavior of traveling waves on a lossy transmission line and the observed characteristics of these two lightning processes, in particular, their observed light profiles [*Jordan and Uman*, 1983; *Jordan et al.,* 1997]. It appears that the return stroke is similar to a "classical" (linear) traveling wave that suffers appreciable attenuation and dispersion and whose advancement can be visualized as being due to progressive discharging of elemental capacitors (previously charged by the leader process) of the equivalent R-L-C transmission line. Ionization does occur during the return-stroke process, but has a relatively small effect on the wave propagation characteristics which are primarily determined by the transmission-line parameters ahead of the front, as opposed to being determined by the wave magnitude. On the other hand, the progression of the dart leader is apparently facilitated by sustained electrical breakdown at its front, so that the downward propagation characteristics of the dart-leader wave are primarily determined by the wave magnitude, which largely determines the front electric field, as opposed to the transmission-line parameters of the channel ahead of the front. Thus the dart leader may be best described as a downward-moving ionizing front which generates current waves that propagate upward along the dart-leader channel. Finally, it is argued that the subsequent return stroke can possibly be viewed as a ground "reflection" of the dart leader.

**UNIVERSITY OF OTAGO (Otago, New Zealand)**

Dick Dowden reports: My team is about to leave for Darwin for a 6-week Sprites campaign. Zen Kawasaki will be there getting precision CG structure using wide band interferometry. My team will seek VLF sprites and measure ELF/VLF (CID?) emission on 3-components at spaced stations with GPS timing for location. Both of us have LLTV for optical images. With luck, we'll have something to show at the AGU Fall meeting.

**UNIVERSITY OF WASHINGTON (Seattle, WA)**

We have new results in our experimental test of the Baker/Dash model of thunderstorm electrification (*J. Cryst. Growth*, **97**, 770-776, 1989; *J. Geophys. Res.,* **99,** 10,621-10,626, 1994). The model describes surface melting of ice as a mechanism for charge transfer in ice/ice collisions in storms. This work constitutes Brian Mason's Ph.D. thesis, under the supervision of Prof. Greg Dash, at the University of Washington.

We have repeated in more detail previously reported results of charge transfer measurements for single ice/ice collisions (1996 Proceedings Int. Conf. Atmospheric Electricity, pp. 30-3) particularly the dependence of charging on differential growth rates of the two ice surfaces. Typical charge transfers are of the order of hundreds of femtocoulombs per collision, the growing surface charging positively with respect to the sublimating surface.

Also, we have measured mass transfer during such collisions (tens of mono-molecular layers for a contact area of approximately one hundredth of a square millimeter). On average, the colder, growing surface tends to gain mass at the expense of the warmer surface during the collisions.

Vicki Schroeder and Marcia Baker are working on a modelling study of corona emission from hydrometeors. The model is based on the Bondiou-Gallimberti streamer model. The values of electric field required for initiation of positive corona from idealized hydrometeors are compared to - and supplement - Crabb & Latham's (1974) experimental threshold values. We have also calculated the fields necessary for positive streamer propagation, electrohydrodynamic bursting of drops and negative corona initiation. We find that negative corona initiates from the opposite end of the hydrometeor when modest amounts of charge (Q \approx $10^{-9}$ - $10^{-10}$ C) are deposited on the drop by the positive streamer. Results from this work will be presented at the AGU Fall meeting and in a paper soon to be submitted for publication.

Using a 1.5 dimensional thunderstorm model with explicit microphysics and lightning paramaterization Baker, Robert Solomon and Schroeder have shown that the magnitude of upward water flux through the zero degree isotherm is correlated with the lightning activity in continental convective storms. Funding has been secured - via the Global Energy and Water Cycle Experiment project - to use a global, satellite based, lightning dataset (NASA's Optical Transient Detector) to explore the upper tropospheric water budget utilizing this correlation.