NEWSLETTER ON ATMOSPHERIC ELECTRICITY

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INTERNATIONAL COMMISSION ON ATMOSPHERIC ELECTRICITY
(IAMAS/IUGG)

AMS COMMITTEE ON ATMOSPHERIC ELECTRICITY

AGU COMMITTEE ON ATMOSPHERIC AND SPACE ELECTRICITY

EUROPEAN GEOPHYSICAL SOCIETY

SOCIETY OF ATMOSPHERIC ELECTRICITY OF JAPAN

ANNOUNCEMENTS

We remind all our colleagues that the Newsletter is now routinely provided on the web, thanks to Monte Bateman's help. Those individuals needing the mail version should contact Serge Chauzy: (chas@aero.obs-mip.fr) or Pierre Laroche: (laroche@onera.fr). They will receive the Newsletter in its paper version. Those knowing anybody who needs such a paper version are also welcome to contact us. On the other hand, the easiest way to communicate being now electronic mail, we would be grateful to all of those who help us complete the "atmospheric electricity" list of email addresses already available.

Contributions to the next edition of this Newsletter (November 2001) are welcome and should be submitted to Serge Chauzy or Pierre Laroche before October 15, 2001, preferably under word attached documents.

NEW EDITORS FOR JGR-ATMOSPHERES.

Dick Orville reports: The AGU Search Committee for JGR-Atmospheres Editors has completed its assignment. Out of 25-30 candidates, 12 were interviewed and 4 names were recommended to the President of AGU. All four have accepted. Their names, preceded by their area of responsibility are as follows:

Chemistry and Composition: Darin Toohey, University of Colorado
Aerosols/Physics of Atmospheres: Colin O'Dowd, University of Helsinki
Transport Processes: Steven Pawson, Univ. Space Research Associates, NASA (GSFC)
Climate and Dynamics: Alan Robock, Rutgers University

These new editors will begin phasing in this year and the transition should be complete by December. Your first question may be, "Who should receive the AE papers?" Answer: I'm not sure. It may be Alan Robock, but the Editors will have to decide among themselves the division of papers. The categories above are just approximate. When I discussed atmospheric electricity with "candidate" Alan Robock, I know that he said he would depend heavily upon his associate editors. So I suspect this will be his procedure. I know that when Bill Chameides was Editor, he sent most, if not all, of the AE manuscripts to me as I was an associate editor at the time. If you have any questions, I will try to answer them. Your can reach me at: rorville@tamu.edu.

C. T. R. WILSON'S NOTEBOOKS

Earle Williams reports: The original scientific notebooks of C.T.R. Wilson are currently archived in the library of the Royal Society in London. These notebooks contain a wealth of fascinating material on the seasonal variation of the global circuit, illustrations of positive ground flashes in stratiform clouds, illustrations of the convective and electrical structure of thunderstorms, and numerous calculations on runaway electrons. Living relatives of Wilson (his daughter Jessie and his grandson Andrew) have graciously requested that this material be made available for researchers in atmospheric electricity. Negotiations are underway with the Royal Society library to allow for this access.

9th INTERNATIONAL SYMPOSIUM ON GASEOUS DIELECTRICS

The 9th International Symposium on Gaseous Dielectrics will be held May 21-25 2001, at Turf Valley Resort & Conference Center, Ellicott City, Maryland, USA. The purpose of this symposium is to provide a forum for review and discussion of the progress and problems of current interest in gaseous dielectrics and their use, especially as insulators in high-voltage equipment and substation. The symposium also will stress the use of SF_6, fluorocarbons and other dielectric gases in plasma processing. For technical and general conference information, please contact the local organizing committee: National Institute of Standards and Technology, 100 Bureau Drive, Stop 8113, Gaithersburg, MD 20899-8113, USA, Fax: (301) 948-5796. Conference web site: www.eeel.nist.gov/dielectrics_ix.

26th INTERNATIONAL CONFERENCE ON ALPINE METEOROLOGY (ICAM 2000)

Attendees are expected from the meteorological and hydrological community and all related interdisciplinary branches. This conference will be held Monday, 11th to Friday, 15th of September 2000 in Innsbruck, Austria. More information available on the web site of the conference: http://www.zamg.ac.at/~ICAM2000/.

13TH INTERNATIONAL ZURICH SYMPOSIUM AND TECHNICAL EXHIBITION ON ELECTROMAGNETIC COMPATIBILITY (EMC ZURICH '01)

This conference will be held in Zürich, Switzerland on February 20-22, 2001. The program will include a session on lightning. Preliminary manuscripts (up to 6 pages) should be sent by July 1, 2000 to the Technical Program Committee EMC Zurich '01, ETH Zentrum; IKT-ETF, CH-8092 Zurich, Switzerland. Financial support for authors is available. Further information is found at http://www.nari.ee.ethz.ch/emc/.

AMS CONFERENCES

24th Conference on Hurricanes and Tropical Meteorology, 29 May—2 June 2000, Ft. Lauderdale, Florida.
29th Conference on Broadcast Meteorology, 20—24 June 2000, San Francisco, California.
14th Symposium on Boundary Layers and Turbulence, 7—11 August 2000, Aspen, Colorado.
9th Conference on Mountain Meteorology, 7—11 August 2000, Aspen, Colorado.
14th Conference on Biometeorology and Aerobiology, 14—18 August 2000, Davis, California.
24th Conference on Agricultural and Forest Meteorology, 14—18 August 2000, Davis, California.
3rd Symposium on the Urban Environment, 14—18 August 2000, Davis, California.
20th Conference on Severe Local Storms, 11—15 September 2000, Orlando, Florida.
9th Conference on Aviation, Range, and Aerospace Meteorology, 11—15 September 2000, Orlando, Florida.
More details on the AMS web site: http://www.ametsoc.org/AMS/.

5th INTERNATIONAL CLOUD MODELING WORKSHOP

This workshop, sponsored by the World Meteorological Organization (WMO) Executive Council/Commission on Atmospheric Sciences Working Group on the Physics and Chemistry of Clouds and Weather Modification Research, will be held at Breckenridge, Colorado, USA from the 7th through the 11th of August 2000. Available information on the web site: http://misty.sws.uiuc.edu/wmoworkshop/.

13th INTERNATIONAL CONFERENCE ON CLOUDS AND PRECIPITATION

The conference, sponsored by the International Commission on Clouds and Precipitation (ICCP) of the International Association of Meteorology and Atmospheric Sciences (IAMAS) is to be held at the John Ascuaga's Nugget Hotel near the Reno-Tahoe International Airport, Nevada, 14-18 August 2000. Papers on all research topics related to clouds and precipitation will be presented, including papers on i.) microphysics of clouds and precipitation, ii.) cloud dynamics and structure, iii.) cloud-climate interactions, iv.) modeling of cloud-scale processes, v.) cloud processes and the mesoscale, vi) interactions between clouds and atmospheric chemistry, vii.) instrumentation for cloud physics research, and viii.) applications of cloud physics and cloud parameterization. Papers are also welcome on the electrification process and the nucleation of water in the atmosphere as they specifically relate to cloud physics. The deadline for abstracts was 1 December 1999. More on the web site:
http://www.tor.ec.gc.ca/armp/CP_Conf/CP_Conf.html

15th INTERNATIONAL CONFERENCE ON NUCLEATION AND ATMOSPHERIC AEROSOLS

Hosted by the Cloud and Aerosol Sciences Laboratory (CASL) and the Physics Department University of Missouri-Rolla, this conference will be held August 6-11, 2000 in Rolla , Missouri 65409 USA. More on the web site: http://www.umr.edu/~icnaa/

1st EUROPEAN CONFERENCE ON RADAR METEOROLOGY (ERAD)

This conference, co-sponsored by the European Meteorological Society and the Consiglio Nationale delle Ricerche, will be held at the CNR Congress Center in Bologna, Italy, the European Cultural Capital of the year 2000. Posters and oral communications will be presented on all aspects of radar meteorology and its applications including improvements to the quantitative estimation of precipitation, microphysics, cloud remote sensing, mesoscale dynamics, technical developments, networking and compositing, nowcasting and short-period weather forecasting, assimilation into meteorological and hydrological models, complementary use of radar with other remote sensing technologies, hydrological applications and applications of radar products by others users. The deadline for abstract was 30 April. More information on the web site: http://www.copernicus.org/erad/index.html.

ICLP 2000

The 25th International Conference on Lightning Protection (ICLP 2000) will be held from 18 to 22 September 2000 at Rhodos in Greece. It will be hosted by the High Voltage Laboratory of the University of Patras. Check the web site of the conference at: http://www.iclp2000.gr.

RESEARCH ACTIVITY BY ORGANIZATION

*** THE UNIVERSITY OF ARIZONA (Tucson, Arizona)**

E. P. Krider and W. J. Koshak are continuing to study the response of the NASA Lightning Imaging Sensor (LIS) when lightning flashes occur over or near the KSC-ER and are within the LIS field of view. Scott Handel is studying the behavior of the surface electric field during the onset of isolated thunderstorms and also the surface field just before large, horizontal flashes propagate into the KSC-ER area from distant storms. We are finding that during the onset of electrification, a lower positive charge center (LPCC) usually appears first at field mill sites that are close to or under the storm, before negative charge at higher altitudes dominates the pattern. In the future, an effort will be made to determine if the total light output from CG and/or IC flashes, as measured from the ground and/or satellites, is proportional to the total charge deposited by the flash.

*** ATMOSPHERIC ENVIRONMENT RESEARCH GROUP, OFFICE NATIONAL D'ETUDES ET DE RECHERCHES AEROSPATIALES (Paris, France)** www.onera.fr

Anne Bondiou-Clergerie (bondiou@onera.fr), Philippe Lalande (lalande@onera.fr) and Patrice Blanchet (blanchet@onera.fr) proceed with the definition of the payload of the future ORAGES mission. ORAGES consists in the location of lightning flashes from a microsatellite, using interferometer in VHF band. The project widely benefits from collaboration with the FORTE team in Los Alamos National Laboratory. The access to FORTE database, together with discussions with Abe Jacobson (ajacobson@lanl.gov) and his colleagues have provided very important information about lightning and anthropogenic noise signal levels; these information are currently used to define the different sub-systems of the instrument. A prototype close to what could be an Engineering Model of the payload is under development.

Analyzes of the total lightning activity mapped by Onera's 3D VHF interferometric system around Munich, South of Germany, during the Eulinox campaign (1998) had been achieved by Claire Thery (thery@onera.fr) for the most active events. Eulinox was a European experiment which objective is to evaluate the transport and production of NOx by storms. It was coordinated by Harmut Hoeller (Hartmut.Hoeller@dlr.de) at DLR and included participation of Onera, KNMI (Netherlands Weather Service Research Center) and NILU (Norvegian Institute for Air Research). The method is to evaluate the length of the discharge. We found, for one active day, a mean flash length of about 30 km (without considering the length of negative stepped leader discharges). The mean length per flash increased during the storm life (more than 6 hours) from 10 km to 50 km. We noticed a large number of low altitude intra-cloud negative leaders around the freezing level, which might be attributed to the existence of a large LPCC. We checked the total flash rates for the 22 Eulinox stormy days, and we found that they were much higher than what could be expected from the Price and Rind (1992)'s parameterization.
Pierre Laroche (Laroche@onera.fr), Anne Bondiou-Clergerie Philippe Lalande and Alain Delannoy (Alain.Delannoy@onera.fr) are involved in studies of aircraft and helicopter interaction with lightning. This work is performed under the frame of the European program EM_HAZ (Electromagnetic Hazard to Aviation). The program started in March 2000 and will last 3 years. In EM_HAZ, a collaboration with Anders Larsson of Lund Institute of Technology in Sweden (Anders.Larsson@fysik.lth.se) is setup for the modeling of the sweeping of a lightning channel on the fuselage of an airliner. ESD experiment, lightning attachment modeling and airborne lightning detection instrumentation development will be performed during EM_HAZ.

*** CENTRE NATIONAL DE RECHERCHES MÉTÉOROLOGIQUES, MÉTÉO-FRANCE/CNRM/GMME (Toulouse, France)**

Since March 1999, E.N. Koffi, S. Sénési, and C. Morel from the nowcasting team of the CNRM in Toulouse have initiated a study of European Mesoscale Convective Systems (MCS) through a combined use of the METEOSAT infrared images and the Météo-France/Météorage Cloud-to-Ground (CG) lightning data. The main purpose of the project is to objectively check, on a large data base and for Europe some findings related to electrical life-cycle of MCSs. This adresses i) the conceptual model of dominant CG flash polarity switching from negative to positive at the dissipating stage of the MCS, ii) the time-lag between the CG flashes peak rate and the MCS decay start, and iii) the unusual cases of early dominating CG positive flashes, associated with tall and rapidly growing MCS, producing severe weather. All these results may provide useful hints for MCS nowcasting.
The MCS cloud shields are automatically identified and tracked using the METEOSAT satellite infrared channel images. The tracking method allows to correctly track cloud systems which are as small as one satellite pixel (i.e. ~ 35 km^2) and from their warmer stage (i.e. cloud top at ~0°C or even warmer). Thanks to this tracking system, the "satellite" life-cycle of a large number of MCSs has been documented over 1993-1997 warm seasons, for the whole Europe. The Météo-France/Météorage CG lightning detection network, based on IMPACT technology and providing high detection efficiency and a good location accuracy, allows to integrate the CG flashes over the area of each cloud shield.
Because the proportion of CG flashes that occur out of the diagnosed MCS cloud shields (called "orphan" flashes) is significant, and especially to ensure that the diagnosed MCSs depict their earlier flashes, a refined methodology of CG flashes association to convective systems has been developed. It is first a matter of the correction of parallax error on the METEOSAT pixel location when one considers its altitude to be zero. The method also takes

into account the motion of the convective system during the time between the CG flash date and the date at which the satellite radiometer scans the cloud system. These corrections made, the remaining orphan flashes were found to be in their majority located upwind of their possible "parent" convective system. This could be related to the slope driven by the wind shear between the cloud top and its base. Thus, the maximum shift between the cloud top and its base generated by the wind shear is parameterized as the displacement of the convective system top during the ascent of a parcel from the cloud base assumed to be motionless. The algorithm has been tested on 48 convective days over the 5 warm seasons of the 1993-1997 period. This allows to use a spatial tolerance of only 12 km in a physically meaningful match of flashes and clouds.

Some statistical results on the electrical life of the MCS for the entire month of August 1997 have been derived. The tracking method allows an early detection of the MCS (i.e. before the first CG flash). The MCS cloud top temperature at CG flash start is colder than –10°C with a mode at –25°C. It was also found that 90% of the MCSs studied have lowered less than 1500 CG flashes and 80% of them exhibit their peak electrical activity ½ hour prior to the maximum area of their cloud shield.

* COLORADO STATE UNIVERSITY (Fort Collins, Colorado)

Cooperative Institute for Research in the Atmosphere

NWS/VISIT Lightning Training. The U.S. National Weather Service (NWS) is offering forecasters training on lightning through the Virtual Institute for Satellite Integration Training (VISIT). Training sessions are delivered in a teletraining format, using interactive Internet software that allows graphics, text, and animations to be viewed by multiple remote participants. A conference phone call provides a voice link. A comprehensive list of lightning links is also maintained (web site listed below). The first VISIT lightning teletraining session, entitled CONUS CG Lightning Activity, was delivered to 61 of the 114 NWS Weather Forecast Offices (WFOs) from July 1999 - January 2000. This session, based on Zajac and Rutledge (2000), discusses: 1) climatological lightning studies over the contiguous U.S. (CONUS), 2) the operation and performance of the National Lightning Detection Network (NLDN), and 3) the spatial, annual, and diurnal distributions of cloud-to-ground (CG) lightning over the CONUS and over the forecast areas of participating WFOs. The second VISIT lightning teletraining session, scheduled for released in May 2000, will discuss 1) specifics of lightning detection by the NLDN, 2) the spatial, annual, and diurnal distributions of positive and negative polarity CG lightning, and 3) forecast applications of lightning data. Magnetic direction finding and time-of-arrival techniques will be reviewed in Section 1. Section 2 will include interpretation of lightning distributions in terms of theories of electrification. And Section 3 will discuss forecast applications of NLDN CG lightning data as well as applications of total lightning data from both ground- and spaced-based systems.

The VISIT home page is located at: www.cira.colostate.edu/visit. Point-of-contact for VISIT lightning training is Bard Zajac (zajac@cira.colostate.edu)

Severe Thunderstorm Electrification and Precipitation Study (STEPS) 2000. The forecast utility of NLDN CG lightning data will be examined by members of CSU/CIRA, CSU/Department of Atmospheric Science, NWS WFO Goodland, KS, and NOAA/Technique Development Laboratory. The goal of the study is to develop verification statistics correlating positive CG lightning production and large hail and tornado production during STEPS, a field program scheduled for May-July 2000 over eastern Colorado and western Kansas. A growing number of case studies over the central U.S. have found that thunderstorms which produce dominant fractions of positive polarity CG lightning also produce large hail and, sometimes, tornadoes. During STEPS, lightning data will be documented objectively on a cell-by-cell

basis using SCAN 2.0 (System for Convective Analysis and Nowcasting) developed at NOAA/TDL. A comprehensive spotter network organized by WFO Goodland will collect large hail and tornado reports. Verification statistics will be analyzed at CSU using these two data sets.
The STEPS home page is located at: www.mmm.ucar.edu/community/steps.html Point-of-contact for +CG/severe study is Bard Zajac (zajac@cira.colostate.edu)

Department of Atmospheric Science.
Timothy Lang and Steven Rutledge are continuing to examine how convective storm microphysics and dynamics affect lightning production. They have investigated five cases using multiparameter and Doppler data from the CSU-CHILL and CSU-Pawnee radars. The two strongest storms, a supercell and a small squall line, featured the highest reflectivities, the strongest updrafts and downdrafts, strongest hail production, and the highest average vertical air mass fluxes. They also presented significantly lower negative cloud-to-ground lightning production, especially compared to more moderate storms that were studied. Where data were available, the stronger storms also displayed higher total flash rates. The squall line exhibited enhanced production of positive CGs. But based on the microphysical and dynamical variables examined, the squall line appears to not be significantly different in intensity than the supercell, which did not show significant positive CG production.
These results are consistent with the elevated charge mechanism of MacGorman et al. (1989). However, it remains unclear what fundamental microphysical and dynamical differences, if any, exist between low negative CG producing storms and positive CG producing storms. We hope to add to this work using tropical cases from TRMM/LBA (January-February 1999) and possibly more mid-latitude cases from STEPS (summer 2000).
STEPS Field Project. The study of both severe convection and Mesoscale Convective Systems (MCS) will be conducted this summer in western Kansas-eastern Colorado, during the Severe Thunderstorm Electrification and Precipitation Study (STEPS). The goal of this project is to advance our understanding of the dynamical, microphysical, and electrical behavior of these two classes of storms. Specifically, we will investigate 1) why some storms produce copious amounts of positive cloud-to-ground lightning during particular stages of their lifetime; 2) the role that large hail may have in the electrification of severe convection; and 3) the electrical structures and lightning associated with MCSs, particularly the causes of bipolar lightning patterns.
Along with Colorado State University personnel, researchers from the National Weather Service (NWS), NOAA's National Severe Storms Laboratory, NCAR, the New Mexico Institute of Mining and Technology (NMIMT), and the South Dakota School of Mines and Technology (SDSMT) will be involved in the 8-week study. A unique combination of field instrumentation will be implemented to support this project, including a triple-Doppler radar network (the CSU-CHILL deployed to Burlington, CO; NCAR's S-Pol installed near Idalia, CO, and the NWS Doppler radar based in Goodland, KS), a Lightning Mapping Array (LMA) from NMIMT, and in-situ observations provided by SDSMT's armored T-28 instrumented aircraft.

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

Triggered-lightning experiments will continue in Summer 2000 (for the eighth year) at the International Center for Lightning Research and Testing (ICLRT) at Camp Blanding, Florida. A number of experiments are planned including (1) continued multiple-station measurements of electric and magnetic fields, (2) continued studies of the interaction of lightning with power distribution lines of different design, (3) continued studies of the close lightning

electromagnetic environment using an underground rocket-launching facility surrounded by a 70 m by 70 m buried metallic grid, and (4) initiation of positive lightning discharges. Note that one positive discharge and one bipolar discharge were initiated in 1997 – 1999, although neither contained a positive return stroke. The total number of flashes triggered in the three years was 112.

Mirela Bejleri defended her Masters Thesis titled "Triggered-Lightning Testing of an Airport Runway Lighting System." A paper based on this work has been submitted to the International Conference on Lightning Protection (ICLP) to be held in Rhodos, Greece in September 2000 (http://www.iclp2000.gr).

Vlad Rakov and Martin Uman are collaborating on a monograph "Lightning: Physics and Effects" for Cambridge University Press (under contract; 600 p.). The authors plan to finish the monograph before the end of the year. A Table of Contents for the monograph is presented below, with principal author's name for each chapter being given in the parentheses.

Lightning: Physics and Effects (Encyclopedia of Lightning) by V. A. Rakov and M. A. Uman
Introduction (Rakov)
Incidence of lightning (Rakov)
Electrical structure of lightning-producing clouds (Rakov)
Downward negative lightning discharge to ground (Rakov)
Positive and bipolar lightning discharges to ground (Rakov)
Upward lightning initiated by ground-based objects (Rakov)
Artificial initiation (triggering) of lightning by ground-based activity (Rakov)
Winter lightning in Japan (Rakov)
Cloud discharges (Rakov)
Lightning and airborne vehicles (Uman)
Thunder (Uman/Rakov)
Modeling of lightning processes (Rakov)
The distant lightning electromagnetic environment: Atmospherics, Schumann resonances, and whistlers (Uman)
Lightning effects in the middle and upper atmosphere (Uman)
Lightning effects on the chemistry of the atmosphere (Uman)
Extraterrestrial lightning (Uman/Rakov)
Lightning locating (Uman/Rakov)
Deleterious effects of lightning and protective techniques (Uman)
Rare and unusual-looking discharges in the atmosphere (Uman)
Suggestions for future lightning research (Uman)
A more detailed Table of Contents is found at http://plaza.ufl.edu/rakov.

*** FMA RESEARCH INC. (Fort Collins, Colorado)**

The Severe Thunderstorms Electrification and Precipitation Study (STEPS) will be held from 22 May through 16 July 2000 over the High Plains some 200 to 400 km east of the Yucca Ridge Field Station (see web site: www.mmm.ucar.edu/community/steps.html). This large, multi-agency program will deploy a variety of observing systems to characterize the co-evolving dynamical, microphysical and electrical features of convective storms, with a special emphasis on those generating significant positive cloud-to-ground lightning. Of particular interest will be the first full-scale deployment of the New Mexico Tech 3-D Lighting Mapping Array (LMA) and numerous electric field sensors. FMA Research (Walt Lyons) will provide support to STEPS including monitoring with Xybion ISS255 cameras, color CCD

digital cameras, and photometers for sprites, blue jets and elves above storms near the STEPS domain. The lightning discharges will be recorded both on GPS-time stamped tape (with VLF audio) and sampled using a photodiode system constructed by Tom Nelson. Lightning video data will be combined with that from a special waveform recorder set up by Global Atmospherics Corp. (Ken Cummins) on the Colorado State University Campus. One goal is to better understand the possible contribution of intracloud discharges to small amplitude +CG flashes identified by the NLDN. In conjunction with Earle Williams, MIT, we will record near-field ELF signals at Yucca Ridge.

Additional ELF transient monitoring will be conducted in Rhode Island, by MIT at 2.7 Mm range and is Israel (Colin Price, Tel Aviv University) at 12 M. during STEPS, a team from Stanford University (Elizabeth Gerken) will operate a telescopic imaging system to obtain extreme close up views of sprites. Utah State University (Mike Taylor) will also operate narrow band intensified video imaging systems, for sprite monitoring, as well as documented storm generated gravity wave modulates of the airglow layer. Russ Armstrong (Mission Research Corp) contributed a data acquisition system and Dave Suszcynsky (Los Alamos National Lab) contributed a Xybion camera and tracking unit to the effort. FMA's primary goal during STEPS is to define the distinguishing characteristics of those +CGs which do and do not generate sprites or elves. An undergraduate meteorology study (Judy Fossum) from the University of Northern Colorado will participate in data acquisition and analysis activities.

Of particular interest will be verifying the hypothesis that the prime generators of sprites are +CGs with large charge moments and unusual continuing current characteristics, perhaps associated with horizontally extensive "spider" lightning near the freezing level in the MCS trailing stratiform region. During STEPS, daily sprite forecasts and nowcasts (during actual observing periods) will be posted on the Yucca Ridge web site (www.FMA-Research.com).

*** GLOBAL ATMOSPHERICS, INC. (Tucson, Arizona)**

GAI is in the process of installing the first prototype commercial version of its VHF time-of-arrival lightning mapping system, based on the Lightning Detection and Ranging (LDAR) system at the NASA Kennedy Space Center and the Lightning Mapping Array developed at New Mexico Tech. The seven antennas of the system have recently been installed, and electronics will be installed in May. The system is centered around the Dallas-Fort Worth International Airport and is in the middle of a test network of LPATS-IV LF time-of-arrival sensors, which in turn are embedded within the National Lightning Detection Network. Data from the test networks will be used in a joint study by GAI, MIT Lincoln Laboratory (Earle Williams, Mark Weber), and NSSL (Don MacGorman).

An initial study of advance warning of cloud-to-ground (CG) lightning activity at a point of interest was presented in January (see M. Murphy and K. Cummins “Early Detection and Warning of Cloud-to-ground Lightning at a Point of Interest,” paper 6.11, 2nd Symposium on Environmental Applications, 80th AMS Annual Meeting, Long Beach, CA). The addition of cloud flash data improves lead time over CG data alone as long as the cloud flash detection efficiency of the network is at least 10%, but the additional lead time is limited to the time from first cloud flash to first CG flash in new storms (typically 3-8 minutes in Florida). The Canadian Lightning Detection Network was used for a second study (N. Demetriades and M. Murphy) whose results were presented at the Northern Plains Convective Workshop in Winnipeg in late April. The second study included examining (1) the effect of producing estimates of cloud flash locations with an absolute minimum of three time-of-arrival measurements, and (2) lead time distributions and false alarm rates as a function of the azimuth with respect to the point of interest. The inclusion of cloud flashes significantly increased the false alarm rate.

GAI is continuing its long range lightning detection experiment, comprised of sensors from the U.S., Canada, France, Germany, Japan, and the Benelux countries. CG lightning flash data from this network is overlaid on hourly IR global satellite images at the National Weather Service's Aviation Weather Center (AWC) in Kansas City (Fred Mosher). This network is estimated to have a nighttime flash detection efficiency (DE) of about 10% within 3500 km of the participating countries (Boccippio et al., 1999 AGU Conference). This DE reduces significantly when the paths between the lightning and all participating sensors are in complete daylight. A preliminary evaluation of the use of these data for oceanic convective forecasting for aviation is covered in a paper by Nierow et al. (80^{th} AMS).

As noted in Cummins et al. (JGR, 1998, pp 9035-9044), the upgrade of the NLDN resulted in the detection of a previously undetected population of small positive discharges. Some fraction of these discharges are known to be NPBB intra-cloud discharges. In an effort to determine the nature of these events, Ken Cummins and John Cramer (GAI) along with Walt Lyons and Tom Nelson (FMA Research), carried out simultaneous audio, video and electric field recordings at Yucca Ridge during the summer of 1999. To date, we have six positively identified cases with both video and E-field data (millisecond-level time correlation), and 2 of the six events appear to be CG discharges. We will repeat this experiment during the summer of 2000.

* INDIAN INSTITUTE OF TROPICAL METEOROLOGY (IITM) (Pune, India)

The Indian Institute of Tropical Meteorology (IITM) functions as a national centre for basic and applied research in monsoon meteorology of the tropics in general with special reference to monsoon meteorology of India and neighbourhood. Its primary functions are to promote, guide and conduct research in the field of meteorology in all its aspects. IITM has made significant contributions in the challenging areas of the Meteorology and Atmospheric Sciences like Weather Forecasting, Climatology and Global Change, Hydrometeorology, Monsoon, Climate Modelling, Cloud Physics, Weather Modification, Atmospheric Chemistry, Atmospheric Electricity.

Studies in Atmospheric Electricity is one of the projects of Physical Meteorology and Aerology Division of the IITM. Under this project the continuous observations of different electrical parameters such as electric field, point discharge current, drop charge etc. were taken since the 1970 at this station (Pune) and also in different environmental conditions. The present study deals with the behavior of one of the above mentioned electrical parameters.

Dr G.K. Manohar, Dr S.S. Kandalgaonkar and Dr M.I.R. Tinmaker studied the **Diurnal Variation of Point Discharge Current during thunderstorms at a Tropical Inland Station:**

The data of point discharge current (PDC) measurements during a total of 65 thunderstorms at Pune (18°32´N, 73°51´E; 559 m asl) are analysed to study the PDC local diurnal variation and some issues related with the current. Our analysis showed that about 83% of the total quarter hours occupied by PDC are localised between 1400 hrs to 2300 hrs local time and the remaining 17% are sparsely distributed over midnight to early hours in the morning. The local diurnal variation of PDC and charge received by the earth showed an early morning minimum and an afternoon maximum. It is inferred that the diurnal features of currents and charges are closely associated with the time of the activity of the thunderstorms over this part of the Indian subcontinent. The net result of this study showed that PDC is the dominant agent for the negative charging of the earth's surface and should be identified as an active element participating in global electric circuit. The phase relationship between the positive and negative current during the diurnal period suggested that the active period of current of one polarity has a preferred time of occurrence over the other and by the late night hours the

charge of positive sign showed its sustained occurrence over the negative one. The seasonal relationship between storm averaged PDC and surface monthly mean maximum air temperature was examined. Our comparison of seasonal average amplitude of PDC suggested a strong positive correlation with the surface monthly mean maximum air temperature, and the average amplitude of the PDC during the premonsoon season thunderstorms is about three times higher than those during the monsoon season. An examination of association between duration and amplitude variation of PDC showed that storms that are closer to the station within about 4 km have longer duration and stronger current amplitude than when they are few km away.

*** INSTITUTE OF ENVIRONMENTAL PHYSICS, UNIVERSITY OF TARTU, (Estonia)**

The atmospheric electricity research group of the Air Electricity Laboratory (AEL, web site: http://ael.physic.ut.ee/) at the University of Tartu, Estonia, continued measurements of natural air ion mobility spectra at the Tahkuse Observatory (U. Hõrrak, H. Iher, J. Salm and H. Tammet, see more on the web site:
http://ael.physic.ut.ee/KF.public/Teadus/Tahkuse/Tahkuse-eng.htm).
The main research topics are: (1) the classification of air ions and correlation between air ion classes, relationship with boundary layer meteorology; (2) the evolution of mobility spectra during photochemical nucleation bursts; (3) correlation of air ion mobility spectra and aerosol particle size spectra. Some results are presented in the paper:
http://ael.physic.ut.ee/tammet/www/TahkuseStatistics.htm.
Tahkuse Observatory is located in a sparsely populated rural region, 27 km northeast of the city of Pärnu, Estonia (58°31'N 24°56'E). The mobility spectrum of small natural air ions at Tahkuse was routinely measured by an original spectrometer during 1985–1986. An extended instrumentation for measurements of the air ion spectra in a wide mobility range of 0.00041–3.14 $cm^2\ V^{-1}\ s^{-1}$ was installed in 1988. The complex consists of three original multichannel aspiration spectrometers designed according to the principle of second–order differential mobility analyzer. In addition to the air ion mobility spectrum, the system records basic meteorological parameters, and NO_2 concentration. Various measurement campaigns in 1994–2000 applied also an Electrical Aerosol Spectrometer (EAS) of the University of Tartu installed side-by-side with the ion spectrometer. The EAS measures the size distribution of particle concentration in a diameter range of 3 nm – 10 μm.
Other activities of AEL are measurement of ions and aerosols in town (A. Mirme and J. Salm, see: http://ael.physic.ut.ee/KF.Public/Teadus/Fyswin.pdf), air ion chemistry (T. Parts and A. Luts, http://ael.physic.ut.ee/KF.Public/Teadus/Tiia_Artikkel.pdf) and effect of atmospheric electricity on the deposition of air pollutants (H. Tammet, V. Kimmel and S. Israelsson, see more on the web site:
http://ael.physic.ut.ee/tammet/Dublin2000TKI/TammetKimmelIsraelsson.htm).
The University of Tartu (J. Salm) is participating in air ion measurements carried out at a Finnish boreal forest site since 1999 according to an international project BIOFOR (http://mist.helsinki.fi/Biofor/index.html). Aerosol particle number size distribution was measured in a diameter range of 3-800 nm using electrical mobility analysis. Fraction concentrations of small and intermediate air ions were measured by four integral air ion counters designed at the University of Tartu. On certain days, intense bursts of intermediate ions with subsequent generation of aerosol particles were detected.

*** LABORATOIRE D'AEROLOGIE, UNIVERSITE PAUL SABATIER (Toulouse, France)**

The data gathered during the MAP (Mesoscale Alpine Programme) field experiment in Northern Italy (fall 1999) are being processed and studied by the group of Atmospheric Electricity of the Laboratoire d'Aérologie (Serge Chauzy, chas@aero.obs-mip.fr, Sylvain Coquillat, coqs@aero.obs-mip.fr and Serge Soula, sous@aero.obs-mip.fr). Serge Soula compares the evolution of the surface precipitation current to the electric field variation during the storms lifetime. The physical interpretation of the mirror image effect systematically observed between both parameters leads to consider that the surface field evolution partially results from the electric charge transferred to the ground by the precipitation. The precipitation current evolution provides a surprisingly faithful picture of the typical vertical bipolar structure of the thundercloud. The microphysical analysis of the rain performed by Sylvain Coquillat and Olivier Pace (paco@aero.obs-mip.fr, DEA student) helps interpret the current data. The net charges on the raindrops produced by convective clouds appear to be mostly unipolar at a given instant, indicating the succession of rather homogeneous rainshafts.
The correlation between lightning and precipitation activities is performed by Serge Soula as a preliminary work related to the ORAGES project (electromagnetic lightning detection from space) developed by ONERA (Anne Bondiou-Clergerie) in collaboration with the Laboratoire d'Aérologie (Serge Chauzy, Serge Soula, and Franck Roux rouf@aero.obs-mip.fr). A recent investigation on several events observed using the Météorage and the SAFIR detection systems shows that positive CG flashes are associated to much larger rain volumes than negative ones. The comparison of the results obtained over land and over sea is presently studied by Serge Soula, Henri Sauvageot (sauh@aero.obs-mip.fr) and Yann Seity (seiy@aero.obs-mip.fr, student from the Ecole Nationale de Météorologie). The same kind of work is performed on the MAP data by Serge Soula and Jean-François Georgis (geojf@aero.obs-mip.fr) comparing lightning activities and radar characteristics.
Also in relation to the ORAGES project, Gilles Molinié (molg@aero.obs-mip.fr), Jean Pierre Pinty (pinjp@aero.obs-mip.fr) and Frank Roux have developed an electrical module in the French 3D non-hydrostatic mesoscale model MésoNH. The parameterization is grounded on a bulk description of mixed-phase clouds (5 types of particles) with an explicit computation of charge transfer rates associated to each microphysical process and charge separation rates produced by ice-ice collisions. The Poisson equation is solved to get the three components of the electric field. Finally, lightning flashes are triggered when the electric field exceeds locally a threshold value. The lightning channels are then calculated in the model grid and a simple neutralization budget is applied. Preliminary tests of the parameterization are underway to simulate the intense electrical activity of a super-cellular storm.
Sylvain Coquillat starts developing a video sensor devoted to in situ microphysics detection associated to electric field and net charge sensors. Both systems carried by free balloons are planned to be eventually tested under radar coverage.

*** LABORATORY OF CONVECTIVE STORM AND LIGHTNING PHYSICS, COLD AND ARID REGIONS ENVIRONMENTAL AND ENGINEERING RESEARCH INSTITUTE, CHINESE ACADEMY OF SCIENCES** (Lanzhou, China) – (former filiation: Lanzhou Institute of Plateau Atmospheric Physics, Chinese Academy of Sciences)

Professor Xiushu Qie (qiex@ns.lzb.ac.cn) reports:
The lightning research group in Lanzhou, China, now belongs to Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences. It is actively engaged in experimental and theoretical works targeted at understanding the lightning

physics, artificially triggering lightning, lightning and precipitation, thunderstorm electrification and other related topics.

The artificially lightning triggering experiment using small rockets has been carried out in China since 1989. More than 40 lightning discharges have been triggered under both positive and negative electric field in northern and southern China. In addition to the aim of understanding lightning physics, altitude lightning triggering technique now has been used to evaluate the efficiency of lightning rod and lightning eliminator in collaboration with the Chinese Electrical Power Company.

The unusual charge structure of thunderstorms in Chinese inland plateau, located in the verge of Qinghai-Tibetan Plateau, has been widely noticed in China since 1980's. A positive charge region is widely distributed at the base of the thundercloud. To better understand the charge structure of thunderstorms and discharge features in Chinese Inland Plateau, scientists from China and Japan jointly conducted multi-station simultaneous observations of natural lightning in the summer of 1996 and 1997. Because of the limited data, the preliminary results need to be further verified. We are planning to organize a big project staring next year. Any kind of collaboration is welcome, especially for electric field sounding by rocket and other lightning measurements.

A new lightning radiation location system, broadband interferometer, has been developed to investigate the spatial and temporal development of lightning radiation sources. The linear relationship between phase differences of radiation sources arriving at spaced antennas and their frequency has been used to effectively locate the radiation sources even in the condition of more than one radiation sources simultaneously arriving at the station. The radiation from positive and bi-directional leader was observed for the first time with the system.

The interaction between microphysics and thunderstorm electrification is continuously studied within the group. A new three-dimensional dynamics-electrification cloud model, modified from a two-dimensional, axisymmetric, dynamic-electrification cloud model and a three dimensional dual-parameters hail cloud model, has been developed to investigate the spatial and temporal development of electric structure within a thunderstorm, the influence of electrical environment on growth of hail particles. As a result of thermal disturbance in the middle and lower part of the thundercloud produced by stronger electrical activity, convection in the thundercloud will be reinforced. It is, therefore, obvious that electrification activity could influence dynamics in thundercloud, especially in stronger electric field areas.

Correlation studies between lightning and precipitation activities have been carried out recently. Based on the observation data of the Lightning Location System, radar and sounding data since 1997, we have developed a technique using CG lightning to estimate the rainfall in convective weather systems. The potential uses of this method include correction of radar-estimated rainfall and characterizing the specific lightning activities in strong thunderstorms for applications in real time forecasting.

*** LIGHTNING RESEARCH GROUP, OSAKA UNIVERSITY (Osaka, Japan)**

The Lightning Research Group of Osaka University (LRGOU) conducted a winter thunderstorm observations at Hokuriku district in Japan as a cooperative project with Gifu University. They operated both wide band and narrow interferometers to have 3D images of positive cloud-to-ground lightning strikes. The main objective of these observations is to confirm the Bi-directional leader concept by means of filed observations. The additional objective is the evaluation of system performance of their wide band interferometer as a lightning mapper system for the Total Lightning Activity. They captured a few tens of data sets during the last two-month campaign, which was held from December 1999 through January 2000. The data processing is on going, and results will be presented in the related

international and domestic conferences. One of the interesting results at this moment is the success to have a channel image of a positive leader progression. This is an upward initiated leader from a 200-meter chimney top, and that is why LRGOU could see the positive upward leader. LRGOU also operated SAFIR system as a cooperative project with Kansai Electric Power Corporation, and they accomplished excellent observations. This success may influence the project of National Wide Lightning Monitoring Network by Japan Meteorological Agency (JMA), and they installed a SAFIR National Wide Network in March 2000. LRGOU contributes to the Tropical Rainfall Measuring Mission (TRMM) from the aspects of Lightning Imaging Sensor (LIS) data analysis. LRGOU conducted the filed campaign in Northern Territory of Australia in November 1999, and measured lightning activity by means of a wideband interferometer in this area. They also observed Red Sprite in Northern Territory with Image Intensifier as the cooperation with Dick Dowden.

*** LOS ALAMOS NATIONAL LABORATORY. SPACE AND ATMOSPHERIC SCIENCES GROUP (Los Alamos, New Mexico)**

LIGHTNING RESEARCH WITH THE FORTE SATELLITE (Abe Jacobson FORTE project leader)

(1) The FORTE satellite has been configured recently to help delineate the relationship between optical and radio-frequency lightning emissions seen from space. Toward this end, the LLS lightning imager (whose front-end design was provided by NASA Marshall Space Flight Center's Dr. Hugh Christian and colleagues) has been used to trigger both the non-imaging photometer (PDD instrument) and the radio-frequency receiver. During this coupled mode of operation, the latter two instruments are currently using approximately 8-millisecond records, so as to capture the temporally extended emission history (in both the optical and rf) accompanying the imager's geolocated "hit". The PDD and rf instruments' records are time-aligned to within microseconds, while the LLS frame has millisecond (or slightly worse) time definition. For this reason, the detailed rf/optical comparisons are being done with the PDD and rf, while the LLS provides geolocation and emission geometry (number and shape multi-pixel hit).

The salient issues in optical/rf joint phenomenology include: (a) the extent to which the rf pulses serve as proxies for the onset of optical emissions; (b) the extent to which the optical emissions are distorted (delayed, broadened) by photon scattering in the clouds before reaching the satellite; and (c) the systematic relationships between rf pulse-shapes and optical pulse-shapes/stroke type.

In order to better recognize and interpret systematic trends in item (b) above, we are using the Monte Carlo photon-transport simulation tool recently developed by Dr. Tess (Lavezzi) Light.

(2) The Los Alamos sferic-waveform array, consisting of eleven fast vertical E-field sensors, is being partially relocated to support the STEPS campaign in the eastern Colorado plains. The subarray previously in New Mexico has been used for this, while the Florida subarray remains in place.

The latter will be used increasingly in coordination with KSC LDAR data to resolve the relationship between ground-truth (i.e., LDAR) VHF parameters and either sferic-based or space-based observations. The STEPS subarray, in a similar manner, will be used to provide comparisons with the LMS (NM Tech's VHF system) dataset to be gathered there.

*** MIT LINCOLN LABORATORY (Lexington, Massachusetts)**

Mark Weber, Earle Williams, Bob Boldi and Anne Matlin continue their collaboration with Steve Goodman, Dennis Buechler and their colleagues at NASA MSFC on the analysis of

LISDAD (Lightning Imaging Sensor Data Application Display) archive and the development of another real time system in the northern Alabama area. The analysis effort is presently focussed on tornadic thunderstorms documented with radar and the LDAR system in Florida. The use of a vertical angular momentum (A.M.) variable (the product of the Doppler velocity couplet and the couplet diameter) is revealing a systematic evolution of features, with strong A.M. in midlevels in association with vigorous intracloud lightning, followed by pronounced diminishment of both lightning and A.M. aloft at the time of the tornado.
Earle Williams, Bob Boldi and Anne Matlin are working with Ken Cummins and Martin Murphy of Global Atmospherics on a reanalysis of 30 severe storm cases documented with LISDAD in an earlier benefits study for NOAA NESDIS (Weber at el, 1998). This analysis involves the study of the vertical component of LDAR radiation and the comparison of flash rate estimates using several different source-to-flash grouping algorithms. One clear cut result shows that the radiation in the lightning 'jumps' (that have been shown to provide the occurrence of severe weather on the ground) is emanating from the upper mixed phase region in the great majority of cases.

*** MIT PARSONS LABORATORY (Cambridge, Massachussetts)**

Danny Castro completed his M. Eng. thesis in February. This study explored the relationship between the background and the transient signals in the Earth's Schumann resonances using observations from West Greenwich, Rhode Island. The three major tropical source regions are peaking at tradtional GMT times (8, 15, 21 GMT) in the background data. The large positive transients are delayed by 3-6 hours in the respective regimes, consistent with an important role of mesoscale convective systems late in the diurnal cycle. Castro has also explored the relationship between lightning transients and continental scale rainfall for Africa where correlated behavior on a 5 day time scale is a prominent feature. Present efforts are aimed at distinguishing the role of African easterly waves and the global 5-day planetary wave (with wavenumber one structure) as explanation for these observations. Dave Sentman and Colin Price have independently identified a 5-day periodicity in Schumann resonance observations from other measurement sites.
Bob Boldi and Earle Williams examined the Rhode Island data archive for lightning flashes in the trailing stratiform region of an MCS in Oklahoma in which Tom Marshall , Maribeth Stolzenberg and Dave Rust have balloon soundings of the electric field. The ELF analysis of the vertical dipole moments for these events coupled with the balloon measurements of the heights of the positive charge regions enable estimates of the total positive charge carried to ground by the energetic ground flashes. Values of 100-200 C were inferred and are larger by an order of magnitude than typical values in ordinary thunderstorms.
Vadim Mushtak is examining a wide range of theoretical models of the Earth -ionosphere cavity to understand the observed frequency dependence of the waveguide quality factor Q. A model treating the day-night asymmetry of the ionosphere is being used to improve on the accuracy of single station locations of large transients also detected (and ground-truthed) by NASA's Optical Transient Detector (OTD) and Lightning Imaging Sensor (LIS) in space (currently under study by Karen Rothkin). This work was carried out in collaboration with Mission Research Corporation (Russ Armstrong).
Earle Williams, Karen Rothkin, Dan Stevenson and Dennis Boccippio (NASA MSFC) have completed a paper focussed on LIS and OTD observations for the TRMM Special Issue in the Journal of Applied Meteorology entitled: "Variations in global lightning caused by changes in the number of storms and by changes in the flash rate per storm".
A study led by Ebby Anyamba at NASA GSFC concerned with the manifestation of the tropical Madden-Julian oscillation in the Earth's Schumann resonances appeared in the April

15, 2000 issue of the Journal of the Atmospheric Sciences. Coauthors are Joel Susskind, Earle Williams, Martin Fullekrug, and Tony Fraser Smith.
Earle Williams returned to Rondonia, Brazil for the 'premonsoon' season in October-December, 1999 where he worked with John Gerlach's NASA Wallops radar crew, with Mauricio Antonio's radar group in Bauru , with Paulo Artaxo (USP) and Greg Roberts (Cal Tech) on the measurement of cloud condensation nuclei (CCN), and with Rich Blakeslee and Jeff Bailey (NASA MSFC) and Nilton Renno (U. Arizona) on the four-station lightning network. The lightning flash rates in the premonsoon were notably higher than during the regular wet season in January- March, 1999. Work in progress is focussed on sorting out the effects of updraft speed and CCN on the first radar echo heights and lightning flash rates. These field observations are being examined in cloud modelling efforts by Danny Rosenfeld and Alexander Khain (Hebrew University) and by Vicki Schroader and Marcia Baker (University of Washington).

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

(NLSI is a non-profit, no-products organization providing objective information about lightning safety issues.)
An anthology called *Lightning Safety Handbook* is in the final stages of preparation. Edited by NLSI, some 75 authors have contributed papers relating to their fields of lightning study. The Handbook addresses lightning hazard mitigation measures in a variety of circumstances. The publisher, Academic Press, expects to release the 700+ page book in late 2000.
NLSI Founder & CEO Richard Kithil addressed the National Inter-Agency Coordinating Group's (NOAA, DoD, FAA, NASA) Conference on Lightning and Static Electricity, Orlando FL. His paper was "NFPA-780: Transitioning from An Outdated Concept to Approved Alternatives." NLSI suggests that NFPA-780 is a lightning protection document with many errors and omissions.
Kithil was invited to address the Department of Defense Explosive Safety Board at a recent meeting in Washington DC, also on the subject of NFPA-780.
NLSI was an invited reviewer of the Federal Aviation Administration STD-019d, "Lightning Protection, Grounding, Bonding, and Shielding Requirements for Facilities." This updated document is a revision of the existing FAA-STD-019c. Readers following the subject of lightning protection codes will be interested to compare FAA-019d with NFPA-780.
NLSI provided guidance for a major national utility company on lightning hazard mitigation for a new wind turbine farm in upstate New York. NLSI was consulted by a Texas minerals processing company regarding costly electrical outages. Here it was determined that lightning was not a cause of their problems. NLSI was retained by the owner of a large livestock feed lot to investigate a lightning event which caused the deaths of 84 animals. NLSI was retained by SpaceNet Inc. to consult on lightning protection for their VSAT (Very Small Aperature Terminal) communications system.
Bill Jafferis, formerly project manager for NASA's rocket triggered lightning program, is developing magnetic tape lightning current sensors for NLSI's Research Site in the Colorado mountains. The NLSI experiment is described at :
http://www.lightningsafety.com/nlsi_info/research/exp1design.html

*** NASA/MSFC (Huntsville, Alabama)**

OTD End-of-Mission: Hugh Christian is pleased to announce that the Optical Transient Detector successfully completed its 5-year mission in April 2000. Over the course of its deployment, OTD has observed over 4 million flashes, compiling a nearly unbiased global

lightning climatology. OTD orbit data continue to be available through the GHRC (http://thunder.msfc.nasa.gov). We are planning to produce a reprocessed, quality-controlled dataset sometime after the updated LIS dataset is released. A cross-sensor validation paper appeared in the JAOT (17, 441-458), and an instrument calibration paper is in press to JAOT.

LIS Update: The TRMM-based Lightning Imaging Sensor continues to operate in an outstanding manner. Rich Blakeslee and Doug Mach have revised the Algorithm Theoretical Basis Document (ATBD) and Validation Plan; both are now publicly available. Preliminary LIS validation is underway, and a revised production code (which implements software filters to eliminate radiation and optical noise) is currently being tested by Doug Mach and Kevin Driscoll. A reprocessed dataset may be released to the community pending review of the new production code.

LMS Update: Hugh Christian reports that the design and development of the geostationary Lightning Mapping Sensor (LMS) is now complete. The MSFC team continues to seek flight opportunities for this sensor, building on renewed interest from NOAA. Recent demonstrations of total lightning usefulness in severe storm identification (building on earlier results by Don MacGorman and others) from Steve Goodman's LISDAD project with the Melbourne NWS office have been instrumental in re-engaging NOAA interest. The team is pleased to announce that the LMS was one of the proposals under the University Earth System Science (UnESS) project selected for concept design.

Brazilian Lightning Detection Network: Rich Blakeslee and Jeff Bailey continue to monitor the 4-sensor ALDF network deployed in February 1999 under TRMM-LBA. The network will be operational for at least two years. Site corrections for the network have been derived, and a full dataset reprocessing is now underway. Analytic-based algorithms developed for analyzing the magnetic bearing and arrival time data are described in detail in upcoming issues of JAOT [Koshak et al, 2000]. Rich Blakeslee, Jeff Bailey, Abe Jacobson and Matt Heavner plan to intercompare BLDN with FORTE observations using the reprocessed data. Earlier, encouraging results were obtained when a few select days were compared. Careful analysis of the positive discharges from the BLDN is also underway. It appears that a large number of low amplitude IC flashes are masquerading as positive CGs, as has been observed by other ALDF systems.

Lightning Mapping Array: An 11-station VHF/TOA total lightning mapping is being deployed in the Tennessee Valley region, and is undergoing shakedown by Rich Blakeslee and Monte Bateman. Built for MSFC by Paul Krehbiel and Bill Rison, the "LMA" will be a permanent long-baseline installation used for both LIS validation and continuation of Steve Goodman's LISDAD demonstration project, now with the Birmingham, AL NWS office. Several Doppler radars will be permanently co-located with the network. A LISDAD/COMET review (attended by Mark Weber, Earle Williams and Bob Boldi) was held in February to help plan the new demonstration project and bring Birmingham forecasters up-to-speed on total lightning data products.

VHF/TOA network validation: On a related note, Dennis Boccippio, Stan Heckman and Steve Goodman have completed diagnostic studies of the KSC LDAR network (prior to GAI upgrades) (JGR, in review). Both source and flash detection efficiency vs range have been established, as well as revised estimates of network location errors vs range. Working with Ron Thomas and Martin Murphy, we have determined that at medium-far ranges, "$1/r^2$" type losses are only a small component of VHF signal loss. This has the practical implication that system performance must be bootstrapped using observed data from each new VHF/TOA network, rather than being predictable from nominal network sensitivity and geometry. This diagnostic methodology will be applied to the Alabama LMA once it is fully operational.

GAI Long-Range Network validation: Continuing on the validation theme, Dennis Boccippio, Bill Boeck and Steve Goodman, in collaboration with Ken Cummins and John Cramer of

GAI, have completed an OTD- and LIS-based estimate of GAI Long Range network detection efficiency vs range and signal transit path characteristics (day/night, land/ocean). Sensitivity appears to fall off exponentially past a fixed range-to-network, with different decay rates for the various transit path characteristics described above. This calibration is of use to researchers in NOx field programs as well as the aviation forecast community.

LDAR "Bubbles": Tomoo Ushio and Stan Heckman have compiled a year's worth of observations of rising "bubbles" of LDAR upper level VHF source clusters in individual storm cells, similar to patterns previously documented by Paul Krehbiel. They have derived a spectrum of bubble rise-rates with a mean near 15 m/s. Continuing analysis (also using new LMA data) will help empirically demonstrate the connection between lightning and storm updrafts.

Flash rate and storm height: In a separate project, Tomoo Ushio and Stan Heckman have revisited the "z^5" empirical correlation between storm flash rate and storm height, now using LIS and TRMM precipitation radar observations to extend the earlier results by Earle Williams to tropical, subtropical and oceanic regions. They find relationships similar to earlier studies, in which z^5 is consistent with, but not demanded by, the observations.

Global per-storm flash rates: Following a suggestion by Earle Williams, Dennis Boccippio, Stan Heckman and Steve Goodman have confirmed that the bulk of the variability in *regional* flash rates observed by OTD and LIS is driven by variability in the number of flashing storm cells (factor of 10 regional differences), rather than by variability in the per-storm flash rate (factor of 2 regional differences *among flashing storms*) (JAM, in review). This result is corroborated by an independent study by Earle and Karen Rothkin, using a different cell-counting technique.

LDAR/EFM: William Koshak continues upgrading the NASA Field Mill Analysis Package (NAFMAP). This package consists of a 30 file library written in IDL. It reads KSC field mill data, plots strip-chart type records of *E(t)* for fast data quality checking, automatically detects flashes in the records (with user adjustable flash detection criteria), computes the values of lightning delta-Es, plots delta-E contour maps, inverts the delta-Es, and plots the resulting charge solutions in space and in time. Simulated annealing and new "dimensional reduction" methods have been explored for attempting to improve the accuracy of delta-E inversions. [A lightning charge source simulator was recently built directly into the NAFMAP so that user-specified charge sources can be easily selected and inverted, thereby allowing for quick assessment of delta-E inversion accuracy.] The NAFMAP also allows one to plot LDAR, NLDN and LIS data for intercomparisons. Several LDAR plots have recently been forwarded to Philip Krider and Scott Handel for further analysis.

Lightning and meteorology: Dennis Buechler and Kevin Driscoll have documented OTD and LIS overpasses of two tornadic storms, noting in one case a time evolution similar to that observed in the LISDAD project, and in both cases very high IC:CG ratios. (GRL, in review). Steve Goodman, Dennis Buechler and Kevin Driscoll have also documented wintertime lightning anomalies related to the 1997-1998 El Nino event (GRL 27, 541-544).

CONUS IC:CG ratio: Dennis Boccippio and Steve Goodman, in collaboration with Ken Cummins, have generated the first-ever map of mean IC:CG ratio over the continental U.S. by merging OTD and NLDN data (MWR, in review). A U.S. mean of 2.64 is found, with values in the range of 0.5-1.5 over mountains, and very high anomalies (8-9) in the upper Great Plains (coincident in high anomalies in %+CG and large peak current +CGs seen by the NLDN, as well as severe storms with predominantly positive +CGs documented by Larry Carey).

*NATIONAL SEVERE STORMS LABORATORY, NOAA (Norman, Oklahoma)

Dave Rust participated with a small adjunct project in the Intermountain Precipitation Experiment (IPEX) based in Salt Lake City, Utah, during February. Six balloon flights were made to obtain electric field soundings in winter storms. The data include clouds that produced no lightning. Data are yet to be analyzed, but all clouds sampled had internal electric fields of at least a few kilovolts per meter. For further information about IPEX, see: http://www.nssl.noaa.gov/~schultz/ipex.

Ted Mansell has defended his dissertation entitled "Electrification and Lightning in Simulated Supercell and Non-supercell Thunderstorms" and will receive his Ph.D. from the University of Oklahoma (OU) in May 2000. Working with Don MacGorman (NSSL), Jerry Straka (OU), and Conrad Ziegler (NSSL), Mansell performed simulation experiments for three types of supercell storms and one severe storm that was not a supercell. The cloud model he used was the three-dimensional dynamic model developed by Straka to which Ziegler, Straka, and MacGorman added a parameterization of the noninductive graupel-ice mechanism, the inductive graupel-droplet charging mechanism, and lightning. Mansell added two additional parameterizations of the noninductive graupel-ice mechanism (each for a different set of laboratory measurements), a new bidirectional dielectric breakdown parameterization of lightning, and various refinements. Examples of the simulations can be seen on the internet at http://www.nssl.noaa.gov/%7Emansell.

*** PENN STATE UNIVERSITY, DEPARTMENT OF ELECTRICAL ENGINEERING, COMMUNICATIONS AND SPACE SCIENCES LAB, (University Park, Pennsylvania)**

Les Hale has moved to New Mexico but is continuing the work he started at Penn State.

He is reviewing several decades of work, and thinks he is making progress. He thinks he has an explanation for the large (V/m) electric fields in the mesosphere which were first observed by the Russian group of Bragin from Novosibirsk and later confirmed by Hale's Penn State group and Maynard from NASA. He believes they are created by the global ensemble of unipolar "slow tails" launched by lightning. The key part of this argument, which he hopes to report to the COSPAR meeting in Warsaw in July, is that as the wavelets travel, they continually "polarize" the ionospheric "conductor," producing charge separation which lasts at least as long as the "relaxation time" in the mesosphere where the "big fields" are observed. This mechanism produces an effective amplification of the initial charge associated with the wavelets, sufficient to sustain the "big fields."

A secondary question is whether the separated charge reaches the magnetically conjugate hemisphere, and on what time scale. This could be determined by simple observations of the ELF electric field at the conjugate region from lightning, looking for "patterns" such as those due to multiple strokes, with constant time delay. This could be done from a number of different conjugate regions, such as S. Africa to locations in Europe and various locations in Australia conjugate to places in NE Asia, including Japan, Korea, Mongolia, and Russia. Hale sent out an earlier e-mail to the AE group with the hope that this might be done this summer by people in appropriate locations, and has received some encouraging replies.

Another question is whether the large lightning events that produce "red sprites" could produce sprites in the conjugate region. This elicited replies from people who had been doing related calculations, using other mechanisms, particularly the acceleration of electrons to relativistic velocities. It is reiterated here that Hale is not disputing the possible validity of such calculations, but suggesting a possible additional mechanism, based on simple polarization of the ionosphere along closed magnetic field lines. The good news is that this should all be settled by observations within the foreseeable future, if the AE community is on the ball. Lift thine eyes (and photometers) and observe (and measure the fields, please).

Realizing that the magnetically conjugate fields may already be in someones data, or planned for this summer, Hale volunteers to correlate any work submitted to him at LesW3LH@aol.com. However, if it appears necessary he will pack the small suitcase needed for equipment to record the fields and travel to wherever is most promising, and accessible, and conjugate to a region with located lightning. But he prefers the Tom Sawyer approach, and would be glad to help someone else do it.

***SOUTH DAKOTA SCHOOL OF MINE AND TECHNOLOGY (Rapid City, South Dakota)**

Preparations are well underway for participation in the STEPS (Severe Thunderstorm Electrification and Precipitation Studies) project in Goodland, KS from 22 May through 14 July 2000. Andy Detwiler, John Helsdon, and Qixu Mo will be accompanying the SDSM&T armored T-28 aircraft into the field. The main purpose of the T-28 component of STEPS is to obtain data on state parameters as well as microphysical and electrical measurements in severe, supercell storms. These data will be used in conjunction with multiparameter and triple Doppler radar data, balloon-borne electric field soundings, and 3D lightning mapping data to investigate the electrical characteristics of severe storms, and, in particular, such storms that produce a high percentage of positive cloud-to-ground lightning. The T-28 will carry the pod electric field mills designed by Bill Winn (New Mexico Tech), allowing for resolution of all three components of the ambient electric field. In addition, a High Volume Particle Sampler will be flown that has been modified by Winn to not only image precipitation particles, but also to detect the charge that they carry. Winn will be collaborating with SDSM&T scientists in the acquisition and interpretation of the particle charge data. Also to be flown on the T-28 will be an X-ray detector, to support the investigations of Bill Beasley (U. of Oklahoma).

*** TEL-AVIV UNIVERSITY, DEPARTMENT OF GEOPHYSICS AND PLANETARY SCIENCES, (Tel-Aviv, Israel)**

Prof. Zev Levin is collaborating with Dr. Yoav Yair, (presently at the Open University of Israel) to perform sprite measurements from the shuttle during the Mediterranean Israeli Dust Experiment, scheduled for spring 2001. MEIDEX involves remote sensing of dust plumes in the atmosphere from a NASA space-shuttle, together with airborne and ground measurements. The astronauts will be using a Xybion IMC-201 camera, equipped with six narrow-band filters at 340nm, 380nm, 470nm, 555nm, 665nm and 860nm (a camera of similar make was used for ground measurements of sprites by W. Lyons). The sprites will be imaged whenever the shuttle is in a limb-viewing attitude, but opportunities may be constrained by other experiments on-board. Preference was given to observations over south-east Asia, Australia and tropical America. The space imaging will be combined with ELF/VLF measurements from the 2 Negev-Desert stations operated by Dr. Colin Price. This campaign welcomes additional partners who wish to add optical/electrical measurements during the shuttle mission.

Ms. Orit Altaratz is continuing her research on the properties of winter thunderstorms in Israel, with special emphasis on the differences between the coastal areas near Tel-Aviv and Mt. Carmel, further north. The RAMS model is used to simulate the evolution of clouds as they develop and move from the Mediterranean Sea toward land. Results are combined with weather radar, lightning location systems and satellite data.

Dr. Colin Price, Dr. Yoav Yair and Prof. Zev Levin began a project designed to combine lightning measurements from space and from ground stations (LIS, OTD, FORTE, LPATS,

CGR3 and VLF antennas) together with radar recording of cloud echoes, to better parameterize the connection of precipitation and lightning in the eastern Mediterranean. This parameterization will then be used to improve forecasts of precipitation, primarily in areas where meteorological data is scarce.
Dr. Colin Price and student Mustafa Asfur have been analyzing the ELF signatures received in Israel during the SPRITES '99 campaign. In collaboration with Walt Lyons and Tom Nelson, we find that we are able to locate, from our Negev desert station, most of the optically-observed sprites to within 15% of the location of the positive ground flash that produced the sprites. Dr. Price is also working with Mike Taylor of Utah State University to co-locate the sprites they observed visibly over southern Europe during the Leonid-MAC '99 campaign during November 1999. During that campaign to study meteors a number of Sprites and Elves were observed. In addition, Dr. Price and student Moshe Blum detected ELF/VLF pulses produced by the meteors themselves. This finding confirms the existence of radio waves produced by the incoming meteors.

* UNIVERSITY OF TEXAS AT DALLAS (Texas)

Dr. Brian Tinsley (Tinsley@UTDallas.edu) continues to study the effect of atmospheric electricity on cloud microphysics. In a paper in press in JAS Tinsley et al. show that the previous view that atmospheric electricity effects are negligible for non-thunderstorm clouds is not true. Most previous treatments have neglected image charge forces in the interaction between charged aerosol particles and cloud droplets. Also, they have not considered the effects of the relatively high aerosol particle charges (~10^2 elementary charges) that are retained for periods of ~ 10^3 s on the residual nuclei from evaporated droplets. In such circumstances the electrically enhanced collection (electroscavenging) of evaporation nuclei by nearby droplets can increase the collection efficiencies by one or two orders of magnitude over phoretic collection efficiencies.
A further property of evaporation nuclei is that they temporarily retain coatings of sulfate and organic materials that droplets absorb before evaporation. This is believed to make them good ice-forming nuclei. Calculations presented in extended abstracts for the ICNAA and ICCP meetings this August show that in clouds with broad or bimodal droplet size distributions and high liquid water content the electroscavenging of evaporation nuclei could be the dominant ice-forming process. This mechanism provides a link between variations of the global electric circuit (solar activity induced and internal) and changes in weather and climate.
Tinsley's work is funded by NSF. He is participating in the European Science Foundation's SPECIAL (Space Processes and Electrical Processes Influencing Atmospheric Layers , http://sgo.fi/SPECIAL/) and in a NASA study on Sun-Climate Connections.

* TOMSK POLYTECHNICAL UNIVERSITY (Russia)

Prof. E. T. Protasevitch reports on the possibilities of modeling ball lightning:
For modeling the ball lightning, we have proposed: a) to cool the plasma by water vapor, paying special attention to electrodeless HF- and UHF- discharges; b) high efficiency of such a cooling of a stationary plasma HF-discharge has been experimentally shown; c) energy stored in ball lightning is small, so it would be incorrect to define it by the damages the lightning produces, since the main part of the energy causing the damages is electrostatic energy of discharges on protruding objects struck by the ball lightning; d) on the basis of the model under investigation we are able to explain some properties of ball lightning, which could be verified under laboratory conditions.

*** YORK UNIVERSITY (Toronto, Canada)**

Stephen Clodman (sclodman@yorku.ca) has (with Wayne Evans of Trent University, Canada) submitted to the Canadian Space Agency a proposal for a concept study called SNOOP (Sprites and Nitric Oxide Observed Production). It would measure sprites, jets, and elves above thunderstorms with a limb view using imagers and photometers at various wavelengths. It would also use Dr. Evans' method to estimate middle atmosphere nitric oxide, which destroys ozone (and so can affect climate). SNOOP, combined with other data, would give the first measurement of sprite production of nitric oxide to compare with model estimates which show that this production may be important. SNOOP would also collect important data on sprites, jets, and elves. A satellite can measure their light at wavelengths not well seen from the ground, and thus can provide better data on ionized (N2+) emission. Although its sprite-finding is in some ways similar to that of the planned Taiwanese ISUAL satellite, SNOOP would have specific features allowing it to collect unique sprite data.