NEWSLETTER ON ATMOSPHERIC ELECTRICITY

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AMS COMMITTEE ON ATMOSPHERIC ELECTRICITY

AGU COMMITTEE ON ATMOSPHERIC AND SPACE ELECTRICITY

INTERNATIONAL COMMISSION ON ATMOS. ELECTRICITY

Announcements

Future Newsletter Contributions. Two issues of this Newsletter are issued each year, in November and May. In efforts to save the expense of this mailing (now to approximately 440 recipients), we are requesting contributions for the spring Newsletter to be received by **April 30, 1995** . If you missed the deadline for this issue, you are probably not reading the Newsletter Announcements. MARK YOUR CALENDARS NOW!

AGU CASE NEWS (John Willett)

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

This year begins a new term for the Committee, which will continue through June, 1996. We welcome new members *Charlie Croskey, Dave Sentman,* and *Chuck Swenson,* who replace outgoing members *Mike Kelley* and *Conrad Ziegler. John Willett* will serve as chairman for another term. Please feel free to approach any member of the CASE about any issue related to the charter of the committee. The current membership is:

Charles L. Croskey, CSSL, 304 Electrical Engineering East, University Park, PA 19802. Phone: 814-865-2357. E-mail: csc@ecl.psu.edu

James E. Dye, Mesoscale and Microscale Meteorology, NCAR, P.O. Box 3000, Boulder, CO 80307. Phone: 303-497-8944. E-mail: dye@ash.mmm.ucar.edu

Richard A. Goldberg, NASA/GSFC, Code 690, Greenbelt, MD 20771. Phone: 301-286-8603. E-mail: goldberg@nssdca.span.nasa.gov

Robert H. Holzworth, II, Geophysics AK-50, University of Washington, Seattle, WA 98195. Phone: 206-685-7410. E-mail: vpi@atmos.albany.edu

Umran S. Inan, Star Laboratory, 321 Durland Bldg., Stanford University, Stanford, CA 94305. Phone: 415-723-4994. E-mail: inan@sierra.stanford.edu

E. Philip Krider, Institute of Atmospheric Physics, University of Arizona, Tucson, AZ 85721. Phone: 602-621-6831. E-mail: krider@atmol.atmo.arizona.edu

Donald R. MacGorman, CIMMS, Rm 1110, 100 East Boyd, University of Oklahoma, Norman, OK 73019. Phone: 405-325-5667. E-mail: macgorman@nssl.nssl.uoknor.edu.

Douglas M. Mach, Earth System Science Lab., Research Institute, Room A11, University of Alabama, Huntsville, AL 35899. Phone: 205-922-5830. E-mail: douglas.mach@msfc.nasa.gov

Thomas C. Marshall, Department of Physics and Astronomy, University of Mississippi, Mississippi 38677. Phone: 601-232-5325. E-mail: marshall@sparc.ncpa.olemiss.edu

Nelson C. Maynard, Mission Research Corporation, One Tara Blvd., Suite 302, Nashua, NH 03062-2801. Phone: 603-891-0079. E-mail: maynard@zircon.plh.af.mil

Davis D. Sentman, Geophysical Institute, University of Alaska, Fairbanks, AK 99775-0800. Phone: 907-474-6442. E-mail: dsentman@geewiz.gi.alaska.edu

Charles Swenson, Department of Electrical Engineering, Utah State University, UMC 4120, Logan, UT 84322-4100. Phone: 801-797-2958. E-mail: chuck@pippin.ee.usu.edu

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

Earle R. Williams, Room 54-1818, Department of Earth, Atmospheric and Planetary Sciences, MIT, Cambridge, MA 02139. Phone: 617-253-2459. FAX: 617-253-6308. E-mail: earlew@juliet.ll.mit.edu

To date, the agenda for the next CASE meeting, which will be held Monday night, December 5, at 8:00 P.M. in the Cathedral B Room of the Cathedral Hill Hotel, is as follows:

1. Results of the Los Alamos Workshop on the Physics of lightning--Joe Borovsky
2. Nominations for Awards and Fellows--Bob Holzworth
3. Updated listing of available funds and proposal deadlines -- John Willett. Please send any information you have on funding sources (aside from Ron Taylor at NSF and Jim Kroll at AFOSR) to John Willett ASAP.
4. Announcement of Upcoming Experiments -- Please be prepared to share any opportunities for collaboration with the community.
5. Session scheduling at the Fall Meeting -- John Willett

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

You will recall from previous issues of this Newsletter that the CASE is assembling a concise listing of new atmospheric/space electricity datasets of general interest, organized by category rather than by researcher, for publication annually in the Fall issue. The idea is to devote just a few lines to each such dataset in order to promote both intra- and inter-disciplinary collaboration. Over the past year we have received the following listings:

Annual CASE Database Listing -- 1994

- Spherics/Lightning Radiation
  - Schumann Resonance/ELF Radiation

    Parameters Measured: N-S and E-W components of magnetic field and vertical component of electric field in the band 3-120 Hz at West Greenwich, Rhode Island. Complete power spectra for each component every 12 min., continuously.

    Amount of Data: 10 MBytes per day

    Periods Covered: Magnetic field -- Dec. 93 to present

    Electric field -- May 94 to present

    PI: Earle R. Williams, Dept. of Earth, Atmospheric and Planetary Sciences, MIT, Cambridge, MA 02139.

    Phone: 617-253-2459, FAX: 617-253-6208.

  - VLF Radiation/Lightning Location

    Parameters Measured: Amplitude and phase of narrowband VLF signals at 20 to

    100 per second, at >15 locations throughout Canada, Alaska, CONUS, Puerto Rico and Antarctica. Typical frequencies are 21.4, 23.4, 24.0, 24.8, 28.5 and 48.5 kHz.

    Periods Covered: Various periods since 1987, typically ~2 years at a given location, measurements being logged daily during nighttime hours. Ongoing measurements at >6 locations.

    PI: Prof. Umran S. Inan, Dept. of Electrical Engineering, Stanford University, Phone: 415-723-4994 E-mail: inan@nova.stanford.edu

    Parameters Measured: Time, direction of arrival, and intensity of VLF radio atmospherics generated by lightning, measured at Palmer Station, Antarctica, and at Stanford, California, with time resolution better than 2 ms.

    Periods Covered:
    Palmer Station -- 3-9 hours between 0000 and 1200 UT since 1989
    Stanford -- daily for 3-6 hours between 000 and 1200 UT since 1993.

    PI: Same as above

- Global-Circuit Fields/Currents

- Stratospheric Measurements

  Parameters Measured: Vector DC electric field, positive and negative polar conductivity, magnetospheric HISS (4.5 kHz), air temperature. 10-minute averages plus 5 s sampling of E-field. Data from up to 4 ELBBO balloons simultaneously circling the globe between 28 deg. S and the South Pole at 26 km altitude, launched from Dunedin, New Zealand.

  Amount of Data: 30+ MB

  Periods Covered: Nov. 18, 1992 through Mar. 23, 1993
  Nighttime data are limited after 12/25/92.

  PI: R.H. Holzworth, Univ. of Washington, Seattle, WA 98195. Phone: 206-685-7410; Fax: 206-685-3815; E-mail: bobholz@geophys.washington.edu

Apologies to the authors for any confusion that may have been introduced by editing their contributions into a concise and uniform format. The CASE hopes that the voluntary submission of database listings from all of you will grow rapidly in the coming years, so that this can become a useful service to the community. Please follow the examples above to minimize the editing required of your chairman.

Those of you who have tried to contact our colleagues at the NASA Marshall Space Flight Center recently have discovered that all the phone numbers have been changed. Since there does not seem to be an easy way to determine the new numbers, some are provided below (all in area code 205, as before):

J. Bailey: 922-5976
H. Christian 922-5828
W. Koshak 922-5963
R. Blakeslee 922-5962
K. Driscoll 922-5826
D. Mach 922-5830
D. Buechler 922-5827
S. Goodman 922-5891
O. Vaughan 922-5893
FAX: 922-5723

Finally, there are two important notices about the schedule of the Fall Meeting. First, the two poster sessions A21C (Atmospheric Electricity II) and A21D (Lightning, Natural and Triggered II) have been moved from Tuesday morning, as shown in the 11 October EOS, to Tuesday Afternoon to avoid a conflict with A21G (Thunderstorm Electrical Effects in the Middle and Upper Atmospheres I). This change will not be reflected in the Abstract Issue of EOS, but it should be indicated both in the abstract-acceptance letters to affected authors and in the Final Program to be handed out at the meeting. Second, the VORTEX Poster Session, which will probably contain a few electricity papers and will certainly be of interest to some of our community, is scheduled for Friday morning--far removed from the remainder of the atmospheric-electricity papers! Your chairman will be working hard next year to make sure that such problems do not recur. You can help by bringing to his attention any special session relevant to the CASE or any other scheduling requirements.

AMS COMMITTEE ON ATMOSPHERIC ELECTRICITY REPORT (Dave Rust)

The AMS Committee on Atmospheric Electricity is presently composed of the members listed below. We will not have a formal meeting at the AGU meeting, based upon a poll indicating a lack of quorum attending. We will possibly arrange to meet informally. We will plan on a meeting during the 75th AMS Annual Meeting in Dallas. If you have any issues you would like the committee to consider, please contact any member or the Chair, Dave Rust (voice: **405-366-0404** ; FAX **405-366-0472** ; email address below).

Dr. William H. Beasley, wbeasley@geoadm.gen.uoknor.edu

Dr. Robert A. Black, rblack%3338.span@sdsc.edu

Dr. Kathy L. Giori, hewitt@crvax.sri.com

Mr. Ronald L. Holle, holle@nssl.uoknor.edu

Mr. Richard J. Kane, rkane@smtpgate.ssmc.noaa.gov

Dr. Thomas C. Marshall, marshall@ncpa.olemiss.edu

Dr. Richard E. Orville, orville@ariel.tamu.edu

Dr. W. David Rust, rust@nssl.uoknor.edu

Dr. Mark E. Weber, markw@juliet.ll.mit.edu

INTERNATIONAL CONFERENCE UPDATE (Zen Kawasaki)

The 10th International Conference on Atmospheric Electricity will be held in Osaka, Japan from June 10-14, 1996. The Chairman of conference is *Prof. K. Kikuchi* of Hokkaido University and the Secretary is *Dr. Zen Kawasaki* of Osaka University. The first call for papers was marked in November, 1994. Extended abstracts will be due before August 31, 1995.

This IUGG/IAMAS/IAGA Meeting (Bob Holzworth) will be held next summer in Boulder, Colorado. This is a unique opportunity for the atmospheric electricity community to find out about other research activity elsewhere in the world - without the expense of international travel. There will be a focussed IAMAS symposium on Atmosphere Electricity with sessions on lightning and related phenomena above the clouds, laboratory research related to thunderstorms (Clive Saunders), Global Circuit and Global Change (Earle Williams), return stroke optical and electrical, and more. Also note there will be a Joint Symposia sponsored by IAMAS on the Middle Atmosphere including solar terrestrial interactions. Please watch for the 3rd Circular due out soon. For more information contact R. Holzworth, IAMAS convenor for Atmospheric Electricity.

HANDBOOK ON ATMOSPHERIC ELECTRODYNAMICS (H. Volland)

A two-volume Handbook of Atmospheric Electrodynamics, edited by H. Volland and published by CRC Press, Boca Raton, FL, will appear in April 1995. This handbook is the extension of the well-known Handbook of Atmospherics, CRC Press, Boca Raton, FL, 1982. Its intention is to combine classical geoelectricity with low frequency electric and magnetic fields of upper atmospheric origin. Twenty-eight review articles written by experts in their fields cover a broad range of research in this area.

The first volume includes: Ion chemistry (Viggiano and Arnold), Thunderstorms (Williams), Thunderstorm electrification (Saunders), Lightning (Ogawa), Lightning detection (Orville), Triggered lightning (Horii and Nakano), Ball lightning (Kikuchi), Lightning and atmospheric chemistry (Lawrence et al.), Planetary lightning (Rinnert), Global electric circuit (Holzworth), Schumann resonances (Sentman), VLF radio noise (Fraser-Smith), HF radio noise (Proctor), Radio noise and telecommunication systems (Spaulding).

The second volume includes: Thunder (Few), Lightning protection (Wiesinger and Zischank), Radio wave propagation (Volland), Radio noise from earthquakes (Parrot), Biological effects of radio waves (Reiter), Nuclear EM pulses (Longmire), Whistlers (Hayakawa), Ionospheric storms (Proelss), Ionospheric dynamo (Richmond), Power line radiation (Bullough), Magnetospheric configuration (Voigt), Magnetospheric electric currents (Baumjohann), Magnetospheric radio noise (Sonwarkar), ULF pulsations (Glassmeier).

WORKSHOP ON ELECTRICAL PRECURSORS TO EARTHQUAKES (M. Hayakawa)

Monograph, "Electromagnetic Phenomena Related to Earthquake Prediction", edited by M. Hayakawa and Y. Fujinawa, is now available from TERRA Scientific Publishing Company, Tokyo.

About twenty candidate phenomena for precursors to earthquakes have been reported and in recent years electromagnetic phenomena, especially in the radio wave range, have been attracting keen interest in both earthquake and volcanic eruption prediction. International symposia or workshops have been devoted to anomalous electromagnetic phenomena, but there have so far been no well organized ones focussed on this particular subject. As a result we organized such an "International Workshop on Electromagnetic Phenomena Related to Earthquake Prediction", in Chofu (The University of Electro-Communications) during the period of 6-8 September, 1993.

The aim of the workshop was to assemble observational evidence of the precursory electric and magnetic phenomena in different frequency ranges (DC, ULF, ELF/VLF, LF and HF) presenting new experimental measurements. The generation mechanism of these electromagnetic phenomena with a propagation path to the observation point near the ground surface was another important subject in the workshop. We intended to promote interactions between researchers in electromagnetics and those in other areas including (1)

seismic patterns, seismic wave propagation and crustal deformation, (2) geochemical changes, and (3) ionospheric and magnetospheric effects to foster future collaboration.

This monograph includes the papers presented in the workshop and several additional papers. By including the latter papers, we intend to make the monograph more complete as a better reference book for people working in diverse disciplines. This monograph is concluded with a summary of the general discussion mainly based on session reports by the chairmen.

M. Hayakawa, Sugadaira Space Radio Observatory, The University of Electro-Communications, Chofu Tokyo 182, JAPAN

Summary of URSI Conference (Masahi Hayakawa)

JATP Special Issue, "Terrestrial and Planetary Electromagnetic Noise," (Guest Editors: M. Hayakawa, E.K. Smith and W.J. Borucki), The University of Electro-Communication, Chofu, Tokyo 182, Japan

This special issue is an outgrowth of presentations made at two Commission E (Electromagnetic Noise and Interference) sessions at the URSI XXIVth General Assembly in Kyoto, August 25-September 2, 1993. There were seven working groups in Commission E during the 1990-1993 period. One of them was titled "Terrestrial and Planetary EM Noise" and was chaired by *M. Hayakawa* and *E.K. Smith.* Two of the sessions of this Working Group at Kyoto were "Terrestrial Electromagnetic Environment" organized by M. Hayakawa, and "Planetary Lightning and Related Phenomena" organized by *W.J. Borucki.* Both sessions attracted a lot of interest so we proposed a special issue to *Prof. M.J. Rycroft,* editor of JATP and it was accepted. This issue contains reviews and original papers on the latest results of terrestrial and planetary electromagnetic noise and it will appear in the near future. The contents are given as follows:

1. Y. Goto and K. Naroita, Characteristics of winter lightning
2. D. Wang, T. Ushio, Z-I. Kawasaki, K. Matsuura, Y. Shimada, S. Uchida, Y. Izawa, C. Yamanaka, Y. Sonoi, and N. Shimokura, How to trigger lightning by high power laser
3. M. Hayakawa, K. Ohta, S. Shimakura and K. Baba, Recent findings on VLF/ELF sferics
4. M. Fullekrug, Schumann resonances in the magnetic field components
5. M. Hayakawa, K. Ohta and S. Shimakura, Recent findings on the propagation of low-latitude whistlers
6. A.J. Smith, VELOX: a new VLF/ELF receiver in Antarctica for the global geospace science mission
7. O.A. Molchanov and M. Parrot, PLHR emissions observed on satellites
8. M. Hayakawa, Association of whistlers with lightning discharges on the Earth and on Jupiter

9. R.J. Strangeway, The plasma wave evidence for lightning on Venus
10. V. Sonwalker and D.L. Carpenter, Notes on the diversity in the properties of radio bursts observed on the nightside of Venus
11. R. Grard, H. Soedhem, V. Brown, P. Falkner, and J. Hamelin, An experimental investigation of atmospheric electricity and lightning activity during the descent of the Huygens probe on Titan.

Newsletter Support

President *Richard Kithil* of Western Electrostatics (Louisville, Colorado) recently made a cash contribution to offset publication costs for this newsletter.

HAILSTORM ELECTRIFICATION STUDY (John Helsdon)

A field project is being planned for the summer of 1996 in the Greeley, CO region to investigate the electrical development of large, hail-bearing clouds. Preliminary plans call for measurements to be made by the CSU-CHILL radar, the SDSMT T-28, and possibly the NCAR Sailplane. One of the focusses of the proposed project will be to investigate the physics and meteorology behind the apparent tendency of hail-bearing storms to produce predominantly positive cloud-to-ground lightning. Many other aspects of thunderstorm electrification can be studied in such a project. *John Helsdon* and *Andy Detwiler* of the South Dakota School of Mines and Technology are working to organize this project and are seeking collaborators with additional instrumentation (balloons, interferometers, aircraft, radars, etc.) and ideas for investigation. If you would be interested in participating in such a project, please contact either John (helsdon@lightning.ias.sdsmt.edu) or Andy (andy@nimbus.ias.sdsmt.edu) at **(605) 394-2291** or write to:

Institute of Atmospheric Sciences
South Dakota School of Mines & Technology
501 E. St. Joseph St.
Rapid City, SD 57701-3995

If sufficient interest exists, we will organize a preliminary planning meeting, possibly at the Fall AGU Meeting.

RESEARCH CENTER FOR ATMOSPHERIC REMOTE SENSING (Y. Shvarts)

A Research Center for Atmospheric Remote Sensing (Voeikov MGO RC ARS) headed by Professor *Georgiy G. Shchukin* was set up by order of the Chief of the Russian Federal Service for Hydrometeorology and Natural Environment Monitoring. The Center is a branch of A.I. Voeikov MGO. The Voeikov MGO RC ARS has its own bank accounts. Beginning on October 1, 1994, the Center began its operations. The address of the center:

Voeikov MGO RC ARS, Voeikovo Vsevolozhskiy Rayon, Leningradskaya Oblast 188685, RF Phone: **(7)-812-247-8681, (7)-812-70-75142;** FAX: **(7)-812-247-0103** or **247-8661**.

The atmospheric electricity department is part of the Voeikov MGO RC ARS. The Center for collection, accumulation and distribution of regular atmospheric electric data (WDC/AE) is included in the Voeikov MGO RC ARS too.

Dr. Boris F. Evteev left the service of A.I. Voeikov MGO in September, 1994.

Dr. Gennadiy V. Kupovych left the service of the High Mountain Institute (Nalchik). His new address:

Department of Physics, Taganrog State University of Radio Engineering, GSP-17A, Nekrasovskiy str., 44, Taganrog, Rostov region 347928, RF

Phone: **(7)-863-44-65067, (7)-863-44-61665;** FAX: **(7)-863-44-65019;** TELEX: **298109** KVARC SU; E-mail: Bmike@tricnit.rostov-na-donu.SU.

ADDITIONAL CONFERENCES

The II International Symposium on Electromagnetic Compatibility and Electromagnetic Ecology (EMC-95) will be held in St. Petersburg, Russia on 26-30 June 1995. Please send contributions to Prof. M. Ianoz, LRE-DE, Ecole Polytechnique Federale de Lausanne, CH - 1015 Lausanne, Switzerland. For further information please call or FAX to: Prof. M. Ianoz, Tel. (**+4121**) **693 26 64,** FAX (**+4121**) **693 46 62.**

The 1995 International Aerospace and Ground Conference on Lightning and Static Electricity will be held in Colonial Williamsburg, Virginia from 26-28 September 1995. The chairman of the conference is *Anthony J. Iacono* fromthe U.S. Naval Air Systems Command. For further information the conference coordinator is Mr. Sam Frazier at **(301) 826-3868,** or FAX **(301) 826-3871.** If you are interested in attending or would like to add someone to the mailing list or change your current mailing address, please contact one of the above.

The Conference on Electrostatics organized by the Static Electrification Group of The Institute of Physics will be held from 2-5 April 1995 at the University of York.

Research Activity by Organization

RESEARCH CENTER ON REMOTE SENSING OF THE ATMOSPHERE OF THE A.I. VOEIKOV MAIN GEOPHYSICAL OBSERVATORY (St. Petersburg, Russia)

Simon Galperin, Valery Stasenko, Valery Frolov and *Georgy Shchukin* continue to investigate thunderstorms with unusually high lightning rates (40-60 discharges per minute) as compared to weaker rates (1-4 discharges per minute) in more common thunderstorms. Continuous (up to 30-40 min) radar reflection on two meter wavelength accompanies these events regularly. Our experimental data sets produced during previous experiments in the Crimea region were reanalyzed to find the origin of these reflections. It

seems that there is no certain relationship to latitudes or to hailbearing clouds. There were also some seasons in the St. Petersburg region with relatively low intensity thunderstorms when radar reflections were not detected. The 1993-1994 summer season yielded a dozen days with very intensive thunderstorms and radar reflections. These clouds revealed the following features: the cloud height is above 10 km, the reflectivity maximum exceeds 35 dBZ, the vertical reflectivity profile is well developed with the 30 dBZ echo reaching 7-9 km height level, elevated liquid water content occurs in the upper part of the cloud according to radiometric measurement. Detailed investigation of radar echoes based on simultaneous wide band thundercloud EM emission measurement will be conducted next year.

For further details, please contact *V. Stasenko* and *G. Shchukin* at FAX: **(812) 247-0103.**

A.I. VOIEKOV MAIN GEOPHYSICAL OBSERVATORY AND VOEIKOV MGO RC ARS (St. Petersburg, Russia)

Oleg P. Rulenko (RAN Far-Eastern Branch Volcanology Institute) successfully defended his thesis "Experimental study of volcanic cloud electrification" during the meeting of the MGO special academic board in May, 1994.

The subsection "Atmospheric electricity" (now "Electromagnetic fields of the atmosphere") of the Fourth sec. of the RAN council on the complex problem "Fundamentals of Electrical Engineering Physics and Electrical Power Engineering" have held the second meeting at MGO in June 1994. The theme was "A conception of the lightning direction finder network". The problem was presented by *Victor S. Snegurov* . A meeting on the problem of remote measurement of lightning discharge characteristics was adjourned til 1995.

Four Russian meteorological stations, one Ukraine station and one Uzbekistan station are continuing to carry out atmospheric electric measurements. Atmospheric electric field together with air conductivities are measured in most cases. Data are collected, processed and accumulated at WDC/AE.

Recently, *Drs. Elena I.Khlebnikova* and *Elena N. Rusina* from the Air Pollution Monitoring Department together with *Ya. M. Shvarts* correlated sets of turbidity monthly means at Voeikovo with the proper sets of polar and total air electric conductivities for the period 1970-1992. They found a significant negative correlation between the turbidity and conductivity. In the case that the turbidity was correlated with the "fair-weather" total conductivity, a correlation coefficient had the most absolute value. An effect of the seasonal variations of these quantities on the correlation relations was excluded.

Ya. M. Shvarts has included a brief summary of a study of long-term changes of atmospheric electric quantities based on network evidence in a cooperative paper which was submitted by MGO to the WMO Global Watch Conference in Peking, China, September 12-16, 1994.

ASTeR/MISSION RESEARCH CORP (Ft. Collins, Colorado)

The 1994 SPRITE Campaign was conducted from the Yucca Ridge site in Colorado during 75 days of the summer of 1994 with participants from several groups. Two dozen nights provided storms and viewing conditions for sprite observations with low-light video systems and a suite of concurrently recorded VLF signals. *Walt Lyons, Ian Baker* and *Tom Nelson* (ASTeR/MRC) operated twin XYBION ISS-255 imagers, GPS timing, data acquisition and logging facilities, and logistical support systems. *Robert Nemzek* (Los Alamos) developed the data D/A, archival and display sub-systems. A broad band VLF antenna and receiver and a pointing photometer were fabricated by *Jack Winckler* (University of Minnesota). A whistler receiver (1-10 kHz) and a third XYBION ISS-255 camera (for triangulation of sprite locations) were operated by *Perry Malcolm* (USAF Academy). *Earle Williams* and *Dennis Boccippio* (MIT) successfully provided coordinated Schumann resonance observations on several nights. *John Molitoris* and *Colin Price* (Lawrence Livermore National Lab) made initial tests of a new CCD imaging system that will be deployed in 1995 (see below). Some of the imaging experiments were conducted in tandem with *Dave Sentman* and *Gene Wescott's* (University of Alaska) jet flights.

Some initial results: on 5-6 August, over 30 large sprites, some >70 km height and >50 km wide, were imaged, along with a distinctive coincident VLF signature (1-10 kHz and 1-100 kHz receivers). These originated from a mesoscale convective system (30,000 km2) some 400 km distant. Over 90% of the sprites were time correlated to within 50 ms with positive CGs. The sprite-associated positive CG current amplitudes were generally 2 to 3 times more intense, some exceeding 150 kA, and were more likely to have multiple strokes. The associated cloud flash was often dramatically brighter than others, reminiscent of reports of lightning "superbolts". On this night, over a dozen sprites were visually observed. Several cases of sprites propagating in sync with extended horizontal flashes inside anvils were noted. Some events appeared as large horizontal glow discharges. On 11-12 July, over 40 large sprites were associated with intense cloud flashes, almost all reported as large positive CGs, some with amplitudes above 400 kA. There was also a very strong correlation between sprites and ELF Q-bursts detected by the MIT Schumann resonance station in Rhode Island. A large luminous region above the distant storm appearing on several nights is suspected to be enhanced OH emissions due to thunderstorm-excited gravity waves. Smaller, highly electrically active storms with few or no +CGs and absent significant stratiform precipitation region generally produced few or no sprites. During September, 1994, *Walt Lyons* and *Tom Nelson* conducted a ten day test at KSC of the low-light camera systems' performance in the high haze, high ambient light environment of the Florida east coast. Numerous excellent images of lightning were obtained, but persistent middle and high cloud cover precluded sprite detection.

Activities for 1995 are being planned. A follow up measurement program directed from the Colorado site will be conducted from mid-June through mid-July. In addition to repeating the various low-light imaging and ELF/VLF measurement programs, high temporal and spectral resolution CCD imagers will be deployed by *John Molitoris* and *Colin Price* of (LLNL) and *Russ Armstrong* and *Jeff Shorter* (Mission Research/Nashua, NH). A several week-long monitoring program during August 1995 is planned for KSC using the image intensified cameras to conduct a "sprite inventory" above east central Florida. Parties interested in making cooperative measurements in 1995 should contact Walt Lyons at ASTeR (**303-568-7664**).

CENTER FOR ATMOSPHERIC PHYSICS & LIGHTNING RESEARCH
(University of Colombo, Sri Lanka)

K.P.S.C. Jayaratne reports on developing research activities in Colombo. The first Colombo University - awarded PhD degree in Physics was bestowed in 1992 for the work 'On Fair-Weather and Thunderstorm Electricity - Basis for construction of an atmospheric electrical station in Sri Lanka'. At present a group of 8 members including two PhD students and two MPhil students are actively engaged in the following research projects: (1) Measurement of air-earth conduction current density and the study of its relationship to the global electric circuit. (2) Magnetic fields generated by tropical lightning with special attention to lightning localization. (3) Electrostatic and radiation fields of lightning discharges with special attention to the electrical structure of tropical thunderstorms. (4) Characteristic features of radiation field signatures from tropical cloud flashes. (5) Lightning flash-rate characteristics of tropical thunder clouds.

A paper on 'The lightning HF radiation at 3 MHz during leader and return stroke processes' was published in the January 1994 issue of *J. Atmos. Terr. Phys.,* 56(4), 493-501, and another on 'Characteristics of lightning flashes observed in Sri Lanka, in the tropics' has been submitted for publication in the JGR.

The group has collaborative link programs with the Institute of High Voltage Research and the Marsta Atmospheric Electricity Measuring Station of the Uppsala University, Sweden together with support from the International Science Programs of Uppsala University, Sweden.

CENTRAL AEROLOGICAL OBSERVATORY
(Dolgoprudny, Moscow Region, Russia)

Victor Ermakov reports that lightnings must pass along ionized tracks of galactic cosmic particles of very high energies, which generate extensive air showers. This hypothesis is a matter of principle when working out physical foundations of the origin of lightning and the creation of effective means for lightning defense. Theoretical calculations and also the work of spark chambers, which are intended for visual observation after elementary particles movement in high-voltage electrical fields, corroborate the truth of this hypothesis. A direct experiment is needed.

In September of 1993 *Ermakov* addressed the International Science Foundation (Soros Fund) with a request to issue a grant for carrying out the work for the period of 1994-1995. In this work we would carry out simultaneous registrations of cosmic particles of very high energies and lightnings at one and the same observation station. But I haven't received any financial support for carrying out this work from ISF.

During 1994 with small financial support from the Russian Fund of Fundamental Investigations we (employees of the Central Aerological Observatory of Roscomgidromet and Lebedev Physical Institute of the Russian Academy of Sciences) have conducted spade work for carrying out the foregoing experiments during 1995-1996 at Tien Shan Alpine scientific station of Lebedev Physical Institute. This station is at a height of 3330 m not far from Alma Ata (43 N, 77 E). This station makes continuous measurements of cosmic

particles of very high energies. Owing to carrying out of spade - work this station will make simultaneous measurements of both particles of very high energies and lightnings.

Taking into account the importance and complication of conducting the foregoing experimental work, we invite collaboration. Unfortunately, we haven't yet solved the question of financial support for this work for the period 1995-1996. We'll be glad if there are sponsors, who wish to give financial help in realizing this work. We will be very much obliged to AGU CASE if it can provide some advice for solving this problem.

GEODETIC AND GEOPHYSICAL RESEARCH INSTITUTE (Sopron, Hungary)

1. Schumann resonance observations

The vertical electric component of the ELF field in the Schumann-resonance (SR) frequency range has regularly been measured in the Nagycenk Observatory (47.6 N, 16.7 E) since May of 1993 using a very stable ball-antenna, a preamplifier with high input impedance and low noise, an amplifier and a personal computer with high speed AD-converter. (There are some gaps in the measurements because of the local bad weather conditions.) The complex demodulation as a spectral technique has been applied for the quasi-continuous determination of the actual frequencies of the first three SR modes and the amplitudes belonging to them. Using convolution filters the phase-variations of the complex wave vector relating to the central period of the filters are determined. By computing the phase changes versus time the frequency (and the amplitude) can also be monitored in time. An alternate sampling and computation process yields a quasi real-time technique.

The average daily frequency patterns are different for the three modes and each of them shows distinct seasonal variations. The recurrence in the daily frequency pattern in the two consecutive summer periods also supports the existence of seasonal variations. The average daily frequency pattern of the first mode shows a spring-autumn asymmetry. Considering the mean frequency level, the third mode exhibits a considerable seasonal variation. Namely, the mean frequency level is significantly higher in the summer months both in 1993 and 1994 as compared with the corresponding winter. The frequency range of each mode in which the actual frequencies are shifting is generally wider in the winter months than in summer. The differences between the mean frequency levels in summer 1993 and 1994 suggest the reality of a year to year variations in the SR frequencies.

It will be the subject of further studies how the daily and seasonal frequency variations relate to the changes in the position of the source region as well as to the inhomogeneities and the anisostropy in the Earth-ionosphere waveguide.

In several cases it has been found that the daily variations of the first resonance mode are influenced by geomagnetic activity. The actual daily frequency patterns measured at the end of July 1992 (between the 26th and 28th) and in the middle of September 1992 (between the 16th and 18th) were shifted toward the higher frequencies with increasing geomagnetic activity indicated by Kp-indices (Satori, 1993). It seems that these intervals were characterized by highly relativisitic electrons precipitating from the magnetosphere deeply into the atmosphere as shown by satellite measurements during of the SAMPEX project (Baker, 1993).

There are some indications that the mean frequency level of the third mode correlates with the global meteor activity.

For some days in 1994 experimental measurements of the NS and EW magnetic field components (using a provisional system with induction sounds) were carried out. The average daily amplitude distributions were different for the three field components indicating their different sensitivity to the conditions (source position, inhomogeneity, anisotropy) in the Earth-ionosphere waveguide.

References

Baker, D.D., Highly relativistic electrons: their morphology and effect of the middle atmosphere IAGA 7th Scientific Assembly, Buenos Aires (1993) 02.01.18.

Satori, G., Schumann-resonances and geomagnetic activity, IAGA 7th Scientific Assembly, Buenos Aires (1993) 02.01.15.

2. Atmospheric electricity measurements

Atmospheric electricity measurements have been carried out in the Nagycenk Observatory of the Geodetical and Geophysical Research Institute of the Hungarian Academy of Sciences for about three decades. The atmospheric electric potential gradient (PG) is determined at 1 m height above the ground. The measuring equipment using a radioactive collector is situated in a quite plain area with undisturbed conditions. The PG data (hourly means) have been published in the Geophysical Observatory Reports of the Institute since 1962. The last issue contains the data for the years 1988 and 1989.

At the observatory, the point-discharge current is measured by means of a steel-peak (mounted on a bar placed at the flat roof of a building) which is grounded via a highly sensitive galvanometer. Both the total positive and negative charge flowing to the earth is determined and hourly averaged for each month. These values have also been published in the Geophysical Observatory Reports since 1962.

The data series were occasionally interrupted because of reconstruction works at the observatory or due to equipment maintenance, however, they cover a rather long interval. Based on the atmospheric electric data of the Nagycenk Observatory, various investigations were carried out. The results of some studies have been published in well-known periodicals (e.g. Märcz F.: Links between atmospheric electricity and ionospheric absorption due to extraterrestrial influences, J. Geophys. Res., 81, 4566-4570, 1976; Märcz F.: Atmospheric electricity and the 11-year solar cycle associated with QBO, Annales Geophysicae, 8, 525-530, 1990.)

GLOBAL LIGHTNING TECHNOLOGIES (Hobart, Tasmania)

Rick Gumley and his group reestablished their test site at Loughman Lake, Florida in July 1994. Five air terminals at 15 meter height are being monitored for up leader emission currents in the final 3 milliseconds before a ground stroke.

A similar site at the meteorological radar location at the Darwin airport will be recommissioned to precede the monsoon in October 1994. Results from Darwin in the last

season saw several recordings of upward emission curents exponentially increasing to exceed 20 amperes.

INSTITUTE FOR HIGH TEMPERATURES
(Russian Academy of Sciences, Izhorskaya, 13/19, Moscow, 127412, Russia)

In the Yaroslavl State University, 6-8 of July, a conference was held devoted to problems of atmospheric electricity that include Ball Lightning (BL), St. Elmo's fire, aerometeors, electrically charged water drops and other long living plasma objects in the atmosphere. Participants from Russia, Ukraine, U.S.A., Belgium and Comores delivered 20 reports on these problems. Interesting results:

Emelin S.E., Semenov V.S. (Russia), *Hassani A.K.* (Co mores) (St. Petersburg University) delivered 3 reports on the formation of long lived (about 1-3 seconds) compact erosive plasma objects with the help of the erosion type plasma generator in PMMA. They managed to analyze the trace which persisted in these objects. The structure consisted of elastic composite thin threads (10-5 - 10-4 cm thick) that included chains of amorphous carbon and they came to the conclusion that a polymer BL model is applicable to this object.

Klimov A.I. (Russia, Moscow Radio-Technical Institute) delivered a report on the formation of a long lived (about 1 second) compact plasma object with the help of the erosive type plasma generator in wax. When these objects were directed onto a cell with liquid nitrogen the whole surface became covered with threads (10-5-10-3 cm thick) of polymer that resembled lint. These objects had hydrodynamic properties analogous to BLs.

Manykin E.A. (Russia, Kurchatov Institute of Nuclear Energy, Moscow) delivered a report on obtaining plasma fire balls in a magnetron arrangement in conditions analogous to those of a successful experiment in Ohtsuki. The elaborated theory of the plasma vortex in convection conditions explained the main properties of the phenomenon.

Yakovlenko S.I. (Russia, Institute of General Physics of Russian Academy of Sciences) delivered a report on the over-cooled plasma. This plasma of Coulombic particles in special conditions will recombine very slowly, and there is the principal possibility to create such a plasma.

Handel P.H. (University of Missouri, St. Louis, USA) delivered a report on the maser-caviton BL. It is based on the interpretation of BL as a plasma region, a caviton, fed by a large atmospheric maser - a large region of rotationally excited water molecules. The plasma caviton is a localized nonlinear quasi stationary electric field and plasma configuration in oscillation, also described as a soliton. The mechanism of transport of the maser energy to the caviton is under examination.

Gaidukov N.I. (Russia, Orekhovo-Zuevo, Pedagogical Institute) delivered a report on the interaction of BL with the one motor and two motor air plain and with the one motor helicopter. The main idea is that BL is a ball of ideal liquid with corresponding boundary conditions. It helps to describe the interaction reasonably.

Meseniashin A.I. (Russia, St. Petersburg, "Mekhanobr" Inst.) described a model according to which BL is a water bubble. He could explain several properties of BL such as the energy, ability to fly, the stability of form that make this theory worthy of special attention.

Bychkov V.L. (Russia) delivered a report (in cooperation with *Anvar Kh. Amirov*) on the statistical analysis of BL properties. A new approach was noted on the basis of the analysis of variance and parametric regression. A special report was devoted to polymer BL theory which, in its modern state, can explain many properties of BL and the results of the experiments with polymer structures that appear in gas discharges of different types of gas mixtures that contain polymer components or macro molecular organic additives. A connection was shown between this theory and the results of *Gaidukov* and *Meseniashin.*

During the conference a new group was formed "The Russian Committee on Ball Lightning and Long Lived Plasma Formations in the Atmosphere". Its purpose is to coordinate activity of all investigators in this field of science in the countries of the former USSR and to improve on information exchange. *Dr. V.L. Bychkov* was elected its president, and professor *A.I. Grigoriev* and *Dr. A.I. Klimov* were elected to be vice presidents. An edition commitee headed by *Anatoli I. Klimov* has prepared for publication a book of experimental works "Ball Lightning in the Laboratory", Chemistry Publishers, Moscow, 1994.

LAWRENCE LIVERMORE NATIONAL LABORATORY (Livermore, CA)

Colin Price and *Joyce Penner* of Lawrence Livermore National Lab (LLNL) are working with *Michael Prather* of UC Irvine to improve our understanding of the role of lightning on tropospheric chemistry. Lightning is a major source of nitrogen oxides (NOx) in the atmosphere (primarily NO and NO2), which play an important role in ozone chemistry. We are working on two papers dealing with this topic: one looking at global distributions of nitrogen oxides resulting from lightning discharges, and one dealing with the global contributions of lightning to the NOx budget. The global distribution of lightning-produced NOx uses lightning physics to bound the energies available in lightning discharges. We conclude that most of the energy for NOx production is found in the cloud-to-ground discharges and not in the intracloud discharges. The global budget paper uses the global electric circuit to analyze the integrated energies in the system resulting from cloud-to-ground lightning. Both methods give global estimates that agree with each other and present new constraints on the possible contribution of lightning to the global NOx budget.

John Molitoris and *Colin Price* of LLNL together with *Eric Arens* of UC Berkeley and *Mike Peck* of Berkeley Camera Engineering developed and fielded a fast optical imager this summer as pat of a field measurement program organized by *Walt Lyons* of Aster, Inc., to observe stratospheric discharges (sprites). The imager can read out up to 2000 frames/second (0.5 ms temporal resolution) and is set up to trigger a very high spatial resolution CCD array, which supplies a high spatial resolution snapshot of the stratospheric event. The system performed well in the field, however, nature was not cooperative, and no sprites were visible during the period of measurement. We plan to try again next summer.

As a result of a paper in Science by Fishman et al. in May, 1994, *Britton Chang* and *Colin Price* have submitted a paper to GRL discussing the possibilities of gamma radiation being

emitted from discharges above thunderstorms (sprites). Using very conservative numbers for electron density, electric field, etc., we have shown that at altitudes above 70 km it is possible to produce runaway electrons which can gain enough energy to produce gamma radiation. If this is true, there could be major implications for the chemistry of the stratosphere above these sprite-producing storms.

LLP/ARSI/GDS (Tucson, Arizona)

We have completed our first full year as a combined business. All three organizations have carried out a number of research and development activities, some of which are summarized below.

ARSI and GDS are carrying out a joint project with the NWS to detect lightning out to the Hawaiian islands using four modified LPATS sensors placed along the west coast between Washington state and Southern California. This long-range detection network will be commissioned this winter, and will be operated by GDS out of its Control Center in Tucson.

ARSI has completed the development of the Series IV LPATS network product which will employ DSP-based waveform analysis, GPS-based timing, and extremely fast (nominally 1 msec) stroke processing times. Field testing in Florida will be performed over the next six months. This same system will provide an extensive waveform archive and processing option.

LLP and ARSI networks are being installed internationally at a steady pace, providing lightning data for all corners of the world. Installations were recently completed in Malaysia, Thailand, Russia, Italy, and Israel. New installations in Colombia, Korea, and Indonesia are in process. Two new projects in Japan will allow us to study winter lightning waveforms, improving our ability to detect and classify lightning in unusual climates.

All three businesses have contributed to a major upgrade of the National Lightning Detection Network, the installation of which is 90% complete. The new network is comprised of 105 sensors, 63 of which are LPATS III time-of-arrival (TOA) sensors modified to include waveform discrimination. The remaining 42 sensors are LLP IMPACT sensors which have been modified for higher sensitivity and greater range. Since the IMPACT sensors provide both time and angle information, TOA/MDF-based location accuracies of 500 meters will be realized throughout the network. On average, more than five sensors will detect a stroke, resulting in a high level of redundancy with cloud-to-ground detection efficiency of 80-90 pecent throughout the network once the upgrade is complete. The network will be capable of computing all stroke locations in real time. In preparation for the design of this "hydrid" network, overlapping ARSI and LLP networks with co-located sensors were operated from January through April, 1994.

In an effort to verify our ability to predict network performance, a joint study with *Vince Idone* and *Ron Henderson* of SUNYA was carried out this summer using three video cameras and a remote electric field recording site. Data analysis is currently underway.

We remain committed to both the commercial and research applications of lightning information, and continue to support numerous studies which strive to advance the basic

understanding of atmospheric electricity. For further information, contact *Dr. Ken Cummins* or *Dr. Rodney Bent.*

MIT LINCOLN LABORATORY (Lexington, Massachusetts)

In association with Lincoln Laboratory's FAA sponsored weather radar field program in Albuquerque, N.M., ONERA deployed their 3-dimensional interferometric lightning mapping system from late July to early September. The data collected supplement previous Doppler-radar/total lightning mapper measurements in Orlando, FL in documenting the relation of lightning activity to thunderstorm convective state and associated aviation impact.

Lincoln Laboratory FAA-sponsored terminal weather system prototypes will be active during the summer of 1995 at the Albuquerque, Orlando, Memphis, and Dallas-Ft. Worth airports. National Network Lightning Detection Data (LLP) will be used to provide operational warnings of lightning hazard to ground operations, and as a qualitative indicator of the convective intensity of storms in terminal airspace. One long term development activity for the FAA focusses on the capability to predict thunderstorm impact on terminal area flight routes up to 30 minutes in advance. The role of CG and/or total lightning mapping systems in providing this forecast capability is under active investigation.

Under a NASA SSTR grant (in collaboration with *Ralph Markson* at Airborne Associates, Inc.) we will be quantifying the incremental skill for specific forecast problems (e.g., microburst onset, thunderstorm dissipation) associated with adding data on total lightning activity to a baseline forecast that uses only Doppler weather radar measurements.

MIT WEATHER RADAR LABORATORY (Cambridge, Massachusetts)

Further observation of thunderstorms in Albuquerque, New Mexico were carried out last summer in collaboration with Lincoln Laboratory, ONERA, and NASA Marshall Space Flight Center. Extensive comparisons were made among ONERA's 3D interferometer, the National Lightning Detection Network and the CGR3 lightning flash counter. Results continue to show intracloud lightning precursors to 'wet' thunderstorm outflows. These precursory events are detected by the 3D interferometer but not by the CGR3 detector, evidently because they produce field changes below the latter instrument's threshold. The NLDN and 3D interferometer often showed excellent agreement on the occurrence of ground flashes in both space and time. Extreme cases of 'dry' microbusts showed no lightning precursors. The only electrical effect associated with the latter events was the negative electrification of dust stirred up in the gust front boundary.

The Albquerque experiment also provided an opportunity for the comparison of conservative thermodynamic varibles at different altitudes. Hourly measurements of dry bulb and wet bulb temperature were made simultaneously at the base and top of the Sandia Crest tram (a vertical separation of 1164 meters). The largest potential temperatures were found at the top, whereas the largest wet bulb potential temperatures were found at

the base. No evidence was found for the undilute ascent of low level parcels over the mountain crest.

Nilton Renno, now at Cal Tech, returned to Albququerque in August to work on boundary layer observations with remotely-controlled model aircraft. A gasoline-powered Piper cub (1/4 scale) achieved altitudes considerably greater (~2000 m AGL) than the earlier electrically-powered sailplane carrying a Vaisala radiosonde. Thermodynamic observations from the earlier study were submitted to Monthly Weather Review. Electrical measurements are planned.

Dennis Boccippio spent several sleepless nights over the summer at MIT's Schumann resonance station in West Greenwich, Rhode Island, on the phone with *Walt Lyons* in Fort Collins, Colorado. These phone calls facilitated real-time comparisons between observations of sprites (transient patches of luminosity in the mesosphere) high above mesoscale convective complexes in Colorado and the occurrence of large electromagnetic transients (Q-bursts) in Rhode Island. On two nights for which extensive comparisons have been made, the sprites and Q-bursts are closely associated with positive CG's with extraordinarily large peak currents as identified by the National Lightning Detection Network. These observations suggest that large positive ground flashes cause dielectric breakdown in the mesosphere and simultaneously launch ELF transients.

When the Rhode Island field station is unmanned, the archival of Schumann resonance spectra continues, with the aim of understanding the global seasonal variation of planetary lightning and its relationship with temperature and deep convection. *Earle Williams* is collaborating with *Joel Susskind* of NASA's Goddard Space Flight Center on the use of TOVS satellite data to understand the spatial origins of the semiannual and annual signals evident in the Rhode Island and other long term records.

Stan Heckman has returned to MIT (from Phillips Laboratory where he worked with *John Willett*) as a post-doc to work on the difficult problem of determining regional lightning source characteristics based on Schumann resonance power spectrum measurements in the electric and magnetic field.

MARSHALL SPACE FLIGHT CENTER (Huntsville, Alabama)

The MSFC Atmospheric Electricity group is now part of the newly established Global Hydrology and Climate Center in Huntsville, Alabama. This center is formed under a cooperative agreement between NASA, the University of Alabama at Huntsville (UAH), Universities Space Research Association (USRA), and others to better promote scientific synergisms and advance Earth Systems Science research and education. As part of this reorganization we have moved to a new location. Our new mailing address is: *977 Explorer Blvd., Hunstville, AL 35806* . Our old address will still get mail to us as well. New phone numbers include: *H. Christian* (205-922-5828), *S. Goodman* (-5891), *R. Blakeslee* (-5962), *D Mach* (-5830), *J. Bailey* (-5976), *W. Koshak* (-5963), *M. Stewart* (-5843) and *D. Buechler* (-5827). The fax number is *205-922-5723.* E-mail addresses remain the same.

We continue to be interested in any lightning data sets that could contribute to a global lightning climatology (e.g. regional lightning detection networks, etc.). Any groups with

such data sets are encouraged to contact *S. Goodman* (E-mail: steven.goodman@msfc.nasa.gov) or *H. Christian.*

The NASA Lightning Imaging Sensor (LIS) engineering flight model, called the Optical Transient Detector, is still awaiting launch on an OSC Pegasus rocket into a 785 km, 70 inclination orbit with a planned lifetime of 2 years. The LIS for the Tropical Rainfall Measurement Mission (TRMM) satellite is currently scheduled for calibration (*H. Christian, W. Koshak, J. Bergstrom, M. Stewart, J. Hall*) in December of this year. A full radiometric calibration will be performed and includes: DC linearity analyses, AC response testing, FOV coverage, and narrow-band filter testing. In addition, performance tests of the sensor will be performed using an externally modulated laser light and conditioning optics.

A ground truth campaign (*R. Blakeslee, H. Christian, W. Koshak* and *J. Bailey*) involving MSFC, Kennedy Space Center (KSC), New Mexico Tech, DOE, and DOD was conducted in September at Kennedy Space Center, Florida. A second campaign is planned for Darwin, Australia in Nov.-Dec. 1995. Also plans continue for participation in the Maritime Continent Thunderstorm Experiment (MCTEX) planned for Melville Island. During MCTEX, in collaboration with many groups (e.g., NSF, NSSL, NOAA, several universities), MSFC will provide and deploy a 9 station field mill network, wideband E-field sensors, optical pulse detectors, and spectrometers. In addition, a 3 station Advanced Lightning Direction Finder (ALDF) will be installed in Darwin in 1995 to support long term Tropical Rainfall Measurement Mission (TRMM) ground truth studies.

National images of cloud-to-ground lightning frquency (derived from GDS network) and precipitation rate (derived from U.S. national radar network composite reflectivity data from WSI) are being generated every 15 min at 8 km spatial resolution. These images are available to the NASA Earth Observing System research community and participants in the Tropical Rain Measuring Mission (TRMM) through the EOS Data and Information System (EOSDIS) node for hydrologic cycle studies located at MSFC. For more information contact the Distributed Active Archive Center (DAAC) user services group at email: msfc@eos.nasa.gov (205-922-5813). A Mosaic home page describing the MSFC science and flight hardware programs is available on the World Wide Web at URL http://wwwdaac.msfc.nasa.gov. The images are produced in real-time (ready in about 10 minutes after the observations are taken). There is also a movie loop (mpeg) for both lightning and precipitation of the previous 24 hour period composed of the individual 15 min images. In addition, daily composite images of accumulated precipitation and lightning are available. The images are restricted to certain users. For more information contact *S. Goodman.*

NATIONAL SEVERE STORMS LABORATORY (Norman, Oklahoma)

Raúl López is studying the progression of cloud-to-ground lightning activity in an Oklahoma hailstorm on June 19, 1992 as a function of changes in the structure and microphysical characteristics of the storm inferred from polarimeric radar observations. Preliminary results indicate that bursts of CG lightning flash activity are *preceded* by the appearance, several minutes before, of regions of supercooled liquid water at high elevations topped by regions of high reflectivity which are mostly ice. The increased flash

activity which follows is *coincident* with the descent of high reflectivity cores containing mostly graupel and hail.

Don MacGorman and *Ron Holle* are planning again to use NSSL's RADS system to display and process lightning strike and radar data in real time for a test of operational applications of lightning strike data during 1995. Radar data from the NWS Doppler radar in Oklahoma City will be combined with ground strike data from GDS to produce histograms of lightning and radar-derived storm trends for individual cells. Histograms also will be produced in postanalysis for historical data and data from VORTEX'95 to use in a statistical study of relationships between lightning trends and other storm trends.

Raúl López, Irv Watson, and *Ron Holle* are studying the climatology and interannual variability of cloud-to-ground lightning activity in Arizona. This work has been sponsored by the Salt River Project. Preliminary results show the marked control that complex topography of the region exerts on the distribution of flashes. Year-to-year variability, however, is very large not only in the total number of flashes but also in their spatial distribution. Nevertheless, cohesive and recurrent patterns of lightning frequency appear in the regions that are of potential use for SRP in their fault analysis and line design, and for the National Weather Service by providing a climatological framework for forecasting thunderstorm activity in the region.

Data are being analyzed from electric field soundings made during the spring of 1994. As part of VORTEX-94, *Dave Rust, Maribeth Stolzenburg* (NSSL and Oklahoma University/Cooperative Institute for Mesoscale Meteorology Studies), and *Tom Marshall* (University of Mississippi) flew electric field meters and radiosondes. In addition, *Monte Bateman* (Langmuir Lab) flew his particle charge and size device on some flights, and *Ken Eack* and *Bill Beasley* (University of Oklahoma) did a test flight of an X-ray detector. We had eight successful electric field soundings through severe storms, another four that went to about 3 km altitude before the balloon was presumably destroyed by hail, and four soundings through the convective and stratiform regions of mesoscale convective systems.

Ron Holle and *Raúl López* of NSSL, with *Lowell Arnold* and *John Endres* of State Farm Fire and Casualty Company in Colorado, summarized State Farm lightning-caused insurance claims in Colorado, Utah, and Wyoming for several years. State Farm claims extrapolate to 6755 claims from all companies, for an annual loss of $5,000,000 a year in Colorado, and $650,000 a year each in the other states. Claims averaged $916 each. A national estimate assumes that the population and lightning risk in these states are representative of the whole country; extrapolated totals for the U.S. are 307,000 lightning claims at a cost of $332,000,000. Claims occurred mainly in summer months; monthly distributions were similar to property damage reports in NOAA's *Storm Data.* Maps of claims for the three states showed that largest numbers were always in counties with the largest populations. However, the claim rate per population and dollar loss per claims were not well related to population. The State Farm dataset had 367 times as many claim as insurable damage reports during the same years and states in *Storm Data.* Personal and commercial losses of the type insured by State Farm were extrapolated to be more than 10 times the *Storm Data* costs.

Don MacGorman has been working with an undergraduate student to begin analysis of a heavy-precipitation (HP) supercell storm whose lightning activity was dominated by positive ground flashes during several periods. This case, which occurred during VORTEX'94, is unique among those studied so far in two respects: (1) it is the first case in

which ground flash activity of HP supercell storms has been dominated by positive ground flashes, and (2) it is the first case in which the dominant polarity of ground flashes has changed more than twice.

Raúl López and *Ron Holle* examined long-term fluctuations in the number of lightning deaths and injuries from 1959-1990 for the contiguous United States. After taking into account the population increase, there was an overall trend amounting to a 30% reduction in casualties during the period. It is possible that this trend resulted from improved forecasts and warnings, increased education efforts of the public, and socio-economic changes. In addition, there was a 40% reduction in the number of deaths, but not of non-fatal injuries. This additional reduction in deaths was probably due to improved medical attention given to lightning victims and a wider knowledge of cardiopulmonary resuscitation techniques among the public. Superimposed on the overall downward trend were fluctuations of one or two decades in duration. It appears that these oscillations are climatologically related. Patterns of these fluctuations were parallel to nationwide changes in thunder-day frequencies, cyclone frequencies, and surface temperature values. A simple probabilistic model has been developed that shows the principal factors responsible for variations in the number of lightning casualties.

PHILLIPS LABORATORY (Hanscom AFB, Massachusetts)

An experiment was conducted during July and August, 1994, at NMIMT's Langmuir Laboratory to study the relationship between ambient electrostatic-field profiles and rocket-triggered lightning. Two re-designed sounding rockets were launched, and data were obtained from parts of both flights. Collaborators included *Bill Winn,* who provided rocket triggering, video, radar, surface fields, and site support, *Stan Heckman,* who measured currents in, and field changes near, the triggering wires, *Vince Idone,* who provided streak photography of the triggered lightning, and *Paul Krehbiel,* who operated his polarimetric radar and lightning interferometer.

PHYSICAL RESEARCH LABORATORY (Ahmedabad, India)

S.P. Gupta reports on balloon borne experiments for measurements of polar electrical conductivity and vertical electric field for the last ten years. The location for the balloon launch is Hyderabad (17.5 N, 78 E).

We have also been conducting rocket experiments for electron density and plasma irregularities from two rocket ranges, namely Thumba (mag. dip = 0 and Sriharikota (Mag. dip = 12).

We will also conduct future balloon experiment on the solar eclipse day, 24 October 1995 from Hyderabad. The eclipse will be about 75%, around 8:30 A.M. local time. We will study the effect of the lunar shadow on electric field and conductivity.

STANFORD UNIVERSITY (Stanford, California)

The Stanford University VLF Group, under the direction of *Dr. Umran S. Inan,* performs continuous measurements to investigate the global consequences of lightning. Broadband VLF measurements are conducted at Stanford, California, and at Palmer Station, Antarctica, for the long distance detection of lightning over the Pacific Ocean and the Americas. The new method of VLF Fourier Goniometry allows the precise determination of the direction of arrival of each sferic. Each station detects discharges up to 10,000 km from the receiver. The location of individual lightning flashes is determined to ~100 km accuracy by triangulation.

Another component of the Stanford research program is VLF remote sensing of lightning-induced ionospheric disturbances. Localized disturbances of the lower ionosphere are caused both by electron precipitation due to whistle waves originating in lightning, and by direct coupling of energy from lightning discharges to the mesosphere and lower ionosphere. An array of stations along the California coast from Stanford to San Diego measures the magnitude and dimensions of these disturbances, in order to estimate the global consequences of lightning. The Stanford group and *Dr. Phil Krider* (Univ. of Arizona) are making coordinated measurements of lightning and ionospheric disturbances in an area of high lightning activity near Flagstaff, Arizona. Continuous VLF remote sensing measurements are ongoing in Alabama, Alaska and at multiple sites in Antarctica.

TAGANROG STATE UNIVERSITY (Taganrog, Russia)

At present *Gennady Kupovykh* works for the Taganrog State University of Radio Engineering. Any correspondence after February 1, 1994 should be addressed to him in the Department of Physics, Taganrog State University of Radio Engineering, GSP-17A, Nekrasovsky str., 44, Taganrog, Rostov region, 347928, Russia. FAX: **[863-44]-65019,** TELEX:L 298109 KVARC SU, Phone: **[863-44]-65067** or **61665,** E-mail: bmike@tricnit.rostov-na-donu.su or rector@itl.rostov-na-donu.su.

TEXAS A&M UNIVERSITY (College Station, Texas)

The mesoscale research group remains active in areas relating lightning studies to meteorological phenomena. Approximately fifteen students are working on lightning and related meteorological studies under the faculty guidance of *Dick Orville, Ed Zipser, Mike Biggerstaff,* and *Lou Wicker.* Seven papers resulting from our research will be presented at the AMS Annual Meeting in Dallas, January 15-20, 1995. These papers are all first-authored by our graduate students and the papers will be presented by them. The authors and titles are the following:

Perez, Orville and Wicker, "Characteristics of cloud-to-ground lightning associated with violent-tornado producing cells." This is Tony Perez's masters' thesis. He analyzed all the F4-F5 tornadoes that occurred in 1989-1992 to determine if there is a unique lightning signature associated with the severe tornadoes.

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

patterns." In this study, *William Carle* examines all tornadoes in this storm system and finds little evidence in the lightning signature and ensuing tornadoes. At most, *Carle* indicates there is a warning time of 5-6 minutes, of little use to the forecaster. Perhaps of greatest interest are the combined maps of meteorological parameters, such as vertical speed shear and lightning bipolar patterns. *Carle* shows higher speed shears are correlated with the bipolar patterns of cloud-to-ground lightning.

Silver and Orville, "A climatology of cloud-to-ground lightning for the contiguous United States: 1992-1993." Silver's work reports on the increase of lightning in the United States by 43% in 1993, primarily in the midwestern States where the floods occurred in the summer.

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

Mohr, Toracinta, Orville and Zipser, "A comparison of WSR-88D reflectivities, SSM/I brightness temperatures and lightning for mesoscale convective systems in Texas." This is an exciting paper. It is an advance as much from the techniques developed for the research as for the conclusions. *Toracinta* has developed computer techniques to take the WSR-88D level II CAPPI's and map the cloud-to-ground lightning locations onto the CAPPI's at various altitudes. He has done this as a function of height and as a function of the lifetim of the storm.

McMillan and Orville, "A classification of Texas thunderstorms according to their cloud-to-ground lightning characteristics during the spring 1993." *Capt. McMillan* completed his masters' thesis on this topic and is now stationed at Eglin Air Force Base, Florida. He performed a detailed analysis of all storms in Texas for a three-month period.

McEver and Orville, "Summer lightning over southeast Texas and adjacent coastal waters." *McEver* has discoverd a maximum summer cloud-to-ground lightning flash density concentration on the northwest side of Galveston Bay. This concentration was predicted from numerical studies in 1970 by a young PhD student at the University of Texas named *Ronald McPherson,* now the Director of the NMC.

All papers will be available in the respective conference proceedings to be published in January by the AMS.

UMIST, UK (Manchester, England)

The visit of *Rohan Jayaratne* to UMIST this summer led to cloud chamber experiments that confirmed our earlier result that ice crystal interactions with a riming target do not necessarily produce ice splinters. The implication is that the charge transfer we measure is not associated with splinter production. In other experiments, positive rimer charging under low liquid water content conditions, as noted by *Takahashi* in 1978 and *Saunders et al.* in 1991 but not by *Jayaratne et al.* in 1983, was investigated. The results suggest that weakly riming targets that also have enhanced growth by vapor deposition, charge positively during crystal collisions. There are implications for some aspects of thunderstorm charging here. This Fall, *Rumjana Mitzeva* spent a month here remodeling some of our 1991 results, incorporating velocity dependence via a rime accretion rate rather than

effective liquid water content into her model. *Eldo Avila* from *Caranti's* group in Cordoba will be visiting us from November, for three months. We hope to reconcile the multiple crystal approach to the single particle interaction approach in rimer electrification studies. *Su Ling Peck* continues our traditional cloud chamber work - she has measured the velocity dependence of negative rimer charging during crystal interactions with both riming and non-riming targets and found them to be the same. This is consistent with a charging mechanism that depends on the thickness of a non-equilibrium layer on the ice surfaces.

UNIVERSITY OF ALBANY, STATE UNIVERSITY OF NEW YORK
(Albany, N.Y.)

The lightning research group at the University at Albany had a very active and productive season this past summer. We again operated a network of three video stations in the Albany area, each station being equipped with a "calibrated" video camera. We accurately located (to better than 1.5 km) over 100 flashes which were also seen by the NLDN. Analyses of these data will yield hard estimates of location accuracy and detection efficiency for the recently implemented partial uprade of the NLDN by GDS. In addition, *V. Idone* participated in the triggered lightning experiments at Langmuir Laboratory this past July in support of *J. Willett* and *P. Krehbiel.* Though the season there was relatively lightning poor, we were rewarded with a single triggered lightning flash that entailed 47 strokes! Data obtained on this event include high-speed near UV photography, inteferometric measurements, close slow and fast E-field waveforms, video from several sites, and still photography. In addition, *M. Brook,* from his residence ~30 km away, obtained fast E-field recordings for the first 45 strokes of this same flash. Analysis of this most interesting event is well underway. In fact, *Dan Davis,* a recent physics graduate of New Mexico Tech and now a master's student in the physics department at Albany, is already heavily involved with the analysis of the recordings from this flash along with those from our overall inventory of time-resolved triggered lightning photographs. At the time of this writing, *M. Brook* is visiting with us, working on the data from this flash and several other collaborative projects. We are thrilled to find him improving in health - and just as fiesty as ever!

Two other students are presently completing master's degrees in atmospheric science. *Yan Wang* has examined carefully our inventory of simultaneous video and fast E-field records of 132 natural lightning flashes obtained during the summer of 1993; she has confirmed the recent hypothesis of Rakov and Uman (1994) that two return strokes along the same channel can sometmes be separated by less than a millisecond. *Jeffrey Freedman* has completed a study of the occurrence of winter storms with high percentages of positive lightning; he finds strong evidence that these storms are often associated with regions of "symmetric" instability. Both of these studies will be written up and submitted for publication over the next few months.

J. Molinari, V. Idone, R. Henderson and *P. Moore* are continuing the examination of lightning in several major hurricanes of recent years. A proposal has been submitted to the NSF to continue and expand this particular lightning research venue. *R. Henderson* has recently made it possible for UNIDATA Members to access the NLDN lightning data over the Internet. Details on the access procedure can be found in the Winter 1994 UNIDATA Newsletter. *V. Idone* has had his recent submission to JGR entitled "The Microscale

Tortuosity of Lightning and Its Variation as Observed in Triggered Lightning Channels" accepted for publication pending minor revision. *V. Idone* will attend the IGPP Workshop on the Physics of Lightning this November 14 and 15 at Los Alamos National Laboratory, chairing the session "What is Known About Lightning Channels?"

In other news from Albany, *A. Seimon, J. Freedman,* and *E. Bracken* took a small field trip to the Midwest this past June in search of thunderstorms characterized by an anomalous dominance of positive cloud-to-ground (CG) lightning (see *Don MacGorman* and *Don Burgess's* paper and *Maribeth Stolzenberg's* paper on these storms in the August 1994 Monthly Weather Review). In their 5 days in the field, they were lucky to observe several such storms. All were supercells, producing large hail, wall clouds, and several produced tornadoes as well. A case from June 7th near St. Francis, Kansas is of particular interest as it exhibited an excellent example of a CG "polarity reversal", a rarely observed process tha occurs in some tornadic supercells. Most fortuitous is that the storm's entire life cycle took place well within range of the Goodland, KS Nexrad site, with the storm just 30 km distant when the dominant CG polarity reversed from positive to negative. They are presently analyzing this case using a rich variety of data sources that includes flash data from the NLDN, the Nexrad data, and video and still photography collected from several experienced observers.

A few days before the comet hit Jupiter, *Bernie Vonnegut* submitted this prediction to Geophysical Research Letters:

Effect of the Comet Collision on Jovian Lightning

It is not surprising that the articles in the GRL issue on the possible effects of the comet impact fail to consider how it might affect the lightning in Jupiter's atmosphere. Most investigators believe the old idea that the energy for lightning is provided by falling, electrified, precipitation particles (Vonnegut 1994), and it is unclear how the comet will affect precipitation.

According to recent theories (Grenet 1947), (Vonnegut 1955), (Phillips 1967) and (Wagner and Telford 1981), the updrafts and downdrafts of convection supply the energy for lightning. When the comet enters Jupiter's atmosphere, much of its energy will be released as heat, which, for a while, will produce strong convection. If the convective theories of cloud electrification are acting, it is to be expected that this will increase the frequency and inensity of Jovian lightning.

References

Grenet, G., Essai d'explication de la charge electrique des nuages d'orages, Ann. Geophys., 3, 306-307, 1947 (for English translation see Atmopspheric Research, 30, 176-179, 1993.)

Phillips, B.B., Convected charge in thunderstorms, Mon. Wea. Rev., 95, 863-870, 1967.

Wagner, P.B. and J.W. Telford, Cloud dynamics and an electric charge separation mechanism in convective clouds, J. Rech. Atmos., 15, 97-120, 1981.

Vonnegut, B., Possible mechanism for the formation of thunderstorm electricity, Geophys. Res. Paper No. 42, Proc. Conf. Atmos. Electr., AFCRC-TR-55-222, pp. 169-181, 1955.

Vonnegut, B., The Atmospheric Electricity Paradigm, Bull. Amer. Meteor. Soc. 75, 53-61, 1994.

A paper by *H.H. Jonsson* and *B. Vonnegut,* entitled, "Comment on 'Negatively Charged Precipitation in a New Mexico Thunderstorm' by Marshall and Marsh and 'Charged Precipitation Measurements Before the First Lightning Flash in a Thunderstorm' by Marsh and Marshall", has been accepted for publication in JGR. In addition, a paper entitled, "An Explanation for Anomalous Lightning From Forest Fire Clouds", by *B. Vonnegut, D.J. Latham, C.B. Moore* and *S.J. Hunyady* has been accepted for publication in JGR.

UNIVERSITY OF BOTSWANA (Dept. of Physics, Gaborone)

Rohan Jayaratne has two recent papers on the charge separation during ice-ice collisions (*Atmos. Res.,* 39, 247; *JAS* 50, 3185) that confirm that the sign of charge acquired by a riming graupel pellet subject to ice crystal interactions is controlled by a physical parameter affected by the surface states of the two particles. There remain some difficulties in explaining fully the charging under specific conditions, in particular the now accepted positive charging of graupel at relatively warmer temperatures and higher cloud water contents. *Rohan* is of the opinion that the Baker-Dash liquid-like layer hypothesis provides the best explanation, so far, for his observations.

Analysis of data from a CGR3 flash counter covering four complete lightning seasons in Gaborone obtained by *Rohan Jayaratne* and *V. Ramachandran* has provided some unexpected results. The measured cloud flash to ground flash ratio in Gaborone was 1.0+0.2. The expected value for this latitude from the empirical formulae of *Pierce* and *Prentice* and *Mackerras* is 3.0, although *Dave Mackerras* (Univ. of Queensland) has recently shown that there are marked variations at a given latitude. The most intense storms always had very low ratios; one storm with over 1000 flashes within a radius of 14 km of the antenna showed an overall ratio of 0.2. Two CGR3 counters, both recently upgraded and calibrated by Dave have been used with two antennae in various combinations at two locations 1.5 km apart, giving very similar results. The information is now being correlated with electric field change waveforms and visual observations. It is estimated that the possible counter error is 20% at the most.

UNIVERSITY OF FLORIDA (Gainesville, Florida)

The University of Florida is in the process of acquiring the lightning triggering facility at Camp Blanding, Florida constructed by Power Technologies, Inc. (PTI) under Electric Power Research Institute (EPRI) funding. The facility, operated by UF since September 1994, is primarily designed for studying the responses (voltages and currents) of a test underground power distribution system and a test overhead power line to lightning strikes. Lightning is triggered using the rocket-and-wire technique. Recording equipment includes 6 Nicolet Pro 90 digitizing oscilloscopes and about 50 Macrodyne Lightning Transient Recorders. Besides the measurements of voltages and currents at different points along the underground cables and on the overhead power line, video recording, still photography, electric and magnetic field observations, and current measurements at the rocket launcher

are made. Provisions for measurement of the physical properties of the triggered lightning will be an important part of any experiment at Camp Blanding. UF plans to distribute a memo regarding the facility status when final agreements are concluded with EPRI and Camp Blanding, including any conditions for the participation in the experiments and lightning protection communities, both from the U.S. and abroad. The present plan is to form an Advisory Committee to resolve issues of conflict that may arise between groups wishing to use the facility. Ideally, scientific experiments can be performed free of charge while commercial testing will be charged a reasonable fee to offset the cost of operating the facility. All correspondence regarding the use of the facility should be addressed to *Martin A. Uman,* 216 Larsen Hall, Department of Electrical Engineering, University of Florida, Gainesville, FL 32611; FAX **(904) 392-8671;** Tel. **(904) 392-0913.**

Preliminary results of a joint study of electric fields close to triggered lightning at Camp Blanding by UF, Centre d'Etudes Nucleaires de Grenoble, France (CENG), PTI, and EPRI were reported (invited paper) by *Vlad Rakov* at the International Symposium on Electromagnetic Compatibility in Rome, Italy, September 13-16, 1994 (EMC '94 ROMA).

Martin Uman, Dan Cordier, Bob Chandler (Florida Museum of Natural History), *Vlad Rakov, Ralph Bernstein* (EPRI), and *Phil Barker* (PTI) will present a paper at the 1994 Fall AGU Meeting on fulgurites produced by triggered lightning at Camp Blanding, Florida during the 1993 experiments. Five fulgurites of overall length 1 to 3 m were excavated between lightning ground-entry points and underground power cables. Besides the common tubular fulgurites, flat fulgurites were found beneath concrete slabs. The fulgurites were prone to form in disturbed zones of primary cross-bedded sands.

Vlad Rakov, Rajeev Thottappillil, and *Martin Uman,* in collaboration with *Phil Barker* of PTI have proposed, based on the results of the 1993 Camp Blanding measurements of channel-base currents and electric fields at 30 m, a new mechanism of the lightning M component that allows the reconciliation of previous, seemingly contradictory, views of this lightning process. According to the proposed mechanism, different from either a downward leader which is unable to produce a discernible upward return stroke (Malan and Schonland, 1947) or "a momentarily current increase without involving the leader process" (Kitigawa et al., 1962), an M component involves both a downward progressing incident wave (the analog of a leader) and an upward progressing reflected wave (the analog of a return stroke). However, as opposed to a "normal" leader-return stroke sequence in which the latter removes the charge deposited by the former, both the upward and downward processes contribute about equally to the total charge flowing from the bottom of the channel to ground at any instant of time. A paper containing a description of the new M component mechanism will be presented at the 1994 Fall AGU Meeting.

UNIVERSITY OF WASHINGTON (Seattle, Washington)

R.H. Holzworth and his students are planning to launch a rocket next May to study lightning phenomena in the upper atmosphere and ionosphere (*M.C. Kelley,* PI, Cornell University). A Workshop on ELBBO (Extended Life Balloon Borne Observatories) data is being held in November 1994. The optical photodiode on the Alexis/Blackbeard mission continues to operate with about 0.5 MB of data collected daily (*D. Holden,* PI, LANL). A test flight of a Kite Tram experiment to measure electrical profiles was flown spring 1994 (*B.*

Balsley, PI, Univ. of Colorado); a new high voltage, ultra high impedance electrometer that operates to +- 120 V has been developed for future kite flights. It is extremely small and light weight.