

Universities Space Research Association
139-A McMurtrie Drive
Huntsville, AL 35806
(205) 895-0582

December 23, 1987

TRANSMITTAL LETTER

Please find enclosed a copy of the final report fulfilling the reporting requirements for Contract NAS8-34748, "Atmospheric Electricity."

Respectfully submitted,



Maurice G. Estes, Jr.
Contracts Manager

(NASA-CR-179239) ATMOSPHERIC ELECTRICITY
Final Report, 28 May 1982 - 21 Oct. 1987
(Universities Space Research Association)

7 p

CSCI 04B

N88-14575

Unclass

G3/47 0115088

Final Report Contract NAS8-34748

Distribution

- 0 **NASA/MSFC**
Code: AP29-F
Marshall Space Flight Center, AL 35812
- 5 **NASA/MSFC**
Code: AS24-D
Marshall Space Flight Center, AL 35812
- 1 **NASA/MSFC**
Code: AT01
Marshall Space Flight Center, AL 35812
- 1 **NASA/MSFC**
Code: EM13A-15
Marshall Space Flight Center, AL 35812
- 2 **NASA/MSFC**
Code: ED43/Christian
Marshall Space Flight Center, AL 35812
- 2 **USRA Headquarters**
Attn: Contract Administrator
The American City Building, Suite 212
Columbia, MD 21044

FINAL REPORT

**RESEARCH STUDY:
ATMOSPHERIC ELECTRICITY**

CONTRACT NO. NAS8-34748

REPORTING PERIOD: May 28, 1982 to October 21, 1987

Program Director: Dr. Michael W. Kalb

PREPARED FOR:

**THE GEORGE C. MARSHALL SPACE FLIGHT CENTER
MARSHALL SPACE FLIGHT CENTER,
ALABAMA 35812**

**UNIVERSITIES SPACE RESEARCH ASSOCIATION
139-A McMurtrie Drive
Huntsville, AL 35806**

December 8, 1987

Introduction

Universities Space Research Association (USRA) under Contract NAS8-34748 has utilized a team of Visiting Scientists and consultants to undertake research activities. The following final report documents and summarizes the results of research efforts including conclusions and recommendations based on experience and results obtained as well as suggested applications for research products.

The Visiting Scientists conducting research under this Contract were Dr. Philip Gillaspy, Dr. Richard Blakeslee, Dr. Steve Goodman and Mr. Dennis Beuchler. Mr. Robert A. Garst also performed research for a three month term as a research specialist. The research activities of Visiting Scientists and Consultants are summarized below.

Summary of Research Efforts and Results

During the contract period (1983-1987) USRA Research Associates published five journal articles and at the present time have three others in revision or review. Eighteen nonrefereed preprint papers or abstracts have also been published. The articles appear in journals or collections of papers published by the American Meteorological Society, the American Geophysical Union, the American Institute Aeronautics and Astronautics, and the Institute of Electrical and Electronics Engineers. These studies support the design and eventual scientific use of NASA's proposed lightning mapper sensor.

In the last three years, USRA Research Associates have primarily focused on the unique information contained in the lightning measurement, which is independent of other meteorological measurements that can be made from space. Mr. Goodman published the first paper that quantified the characteristics of lightning activity in mesoscale convective systems (squall lines and mesoscale convective complexes) and found a strong relationship between lightning activity and surface rainfall. Goodman's most recent paper shows that lightning provides a precursor signature for wet microbursts (the strong downdrafts that produce windshears hazardous to aircraft) and that the lightning signature is a direct consequence of storm evolution.

USRA collaborated with NASA scientists in the preliminary analysis and scientific justification for the design and deployment of an optical instrument which can detect lightning from geostationary orbit, now entering its preliminary design phase for launch on GOES-NEXT in the mid-1990's.

During the contract period USRA personnel (Goodman) were called on to review science proposals for the NASA mesoscale science program (Code E) and for NASA's Tethered Satellite System and to review NASA's weather forecasting research and support programs associated with the processing, launch, and landing of manned and unmanned space vehicles (Code M). During the last year, Steve Goodman provided a weather analysis of the events leading up to the AC-67 accident at Kennedy Space Center in March, 1987 and the Wallops Island accident in June of the same Year.

USRA installed, maintained, and operated the NASA lightning detection and location network during the contract period and developed a real-time lightning display system for operational and scientific use. An IBM-PC AT lightning display system is now in use by scientists in the MSFC Earth Science and Applications Division and by the Neutral Buoyancy Simulation Facility and test areas at NASA/MSFC. Software was written to ingest and analyze the lightning ground strike data on the MSFC McIDAS system. In addition, radar processing software has been written or modified to perform a NEXRAD (NEXt Generation weather RADar) analysis on the MSFC Perkin Elmer computer and radar data processing on the MSFC VAX or McIDAS systems. The lightning location system and McIDAS Processing System both are unique observing and data analysis systems with applications for correlating individual lightning events with other meteorological phenomena over a wide range of spatial and temporal scales. The capabilities which were developed here have a wide application to a number of problems associated with the operational impacts of electrical discharge within the atmosphere.

Dr. Mike Stewart, Dr. John Latham, Mr. Rod Shelton, and Mr. Doug Forsyth have served the contract as consultants. They assisted in the design, checkout, and analysis of data from airborne and groundbased instrumentation used for scientific investigation (U2 optical sensors, atmospheric electricity instrumentation, and a charged-particle imaging spectrometer (CPIS); and provided scientific and programming consultation and assistance.

Financial

Total Contract Value: \$620,989
Total Cumulative Costs: \$620,989
Cost to Complete: 0
Percentage of Physical
completion of Contract: 100%

The Contract is 100% complete and all funds have been expended.

Refereed Publications

Christian, H. J., R. L. Frost, P. H. Gillaspy, S. J. Goodman, O. H. Vaughan, Jr., M. Brook, B. Vonnegut, and R. E. Orville. Observations of optical lightning emissions from above thunderstorms using U-2 Aircraft, Bull. Am. Met. Soc., 64, 120-123, 1983.

Robertson, F. R., G. S. Wilson, H. J. Christian, S. J. Goodman, G. H. Fichtl, and W. W. Vaughan. Atmospheric science experiments applicable to space shuttle spacelab missions, Bull. Am. Met. Soc., 65, 692-700, 1984.

Rust, W. D., W. L. Taylor, D. R. MacGorman, E. Brandes, V. Mazur, R. Arnold, T. Marshall, H. J. Christian, and S. J. Goodman. Lightning and related phenomena in thunderstorms and squall lines, J. of Aircraft, 22, 449-454, 1985.

Goodman, S. J., and D. R. MacGorman. Cloud-to-ground lightning activity in mesoscale convective complexes, Mon. Wea. Rev., 114, 2320-2328, 1986.

Christian, H. J., and S. J. Goodman. Optical observations of lightning from a high altitude airplane, J. Atmos. Ocean. Tech., in press, December, 1987.

Goodman, S. J., H. J. Christian, and W. D. Rust. Optical pulse characteristics of intracloud and cloud-to ground lightning observed from above clouds, J. Clim. Appl. Met., in revision, 1987.

Goodman, S. J., D. E. Buechler, and M. E. Weber. Cloud-to-ground lightning activity associated with microburst producing storms, IEEE Trans. Aero. Elec., to be submitted, 1987.

Goodman, S. J., D. E. Buechler, and P. J. Meyer. Convective tendency images derived from a combination of lightning and satellite data, Weather and Forecasting, to be submitted, 1987.

Nonrefereed Publications and Abstracts

Goodman, S. J., and H. J. Christian. Airborne measurements of lightning generated optical emissions, EOS, 63, 889, 1982.

Goodman, S. J., R. J. Doviak, and D. R. MacGorman. Lightning location in a severe Oklahoma thunderstorm, Preprints, 12th Conf. on Severe Local Storms, Am. Met. Soc., Boston, MA, 326-329, 1982.

Goodman, S. J., and H. J. Christian. Simultaneous observations of lightning from above and below thunderstorms, EOS, 64, 660, 1983.

Goodman, S. J., Lightning activity associated with severe storms embedded within a mesoscale convective storm complex, Preprints, 13th Conf. on Severe Local Storms, Am. Met. Soc., 29-32, 1983.

Rust, W. D., W. L. Taylor, D. R. MacGorman, R. T. Arnold, S. J. Goodman, and V. Mazur. Storm electricity research in Oklahoma: an overview, Preprints, 8th International Aerospace and Ground Conf. on Lightning and Static Electricity, DOT/FAA/CT-83/25, 1-8, 1983.

Goodman, S. J., H. J. Christian, W. D. Rust, D. R. MacGorman, and R. T. Arnold. Simultaneous observations of cloud-to-ground lightning above and below cloud tops, Preprints, VIIth International Conf. on Atmospheric Electricity, Am. Met. Soc., Boston, MA, 1984.

Johnson, R. L., and S. J. Goodman. Atmospheric electrical activity associated with Hurricane Alicia, Preprints, VIIth International Conf. on Atmospheric Electricity, Am. Met. Soc., Boston, MA, 295-298, 1984.

Christian, H. J., R. L. Frost, S. J. Goodman, The optical characteristics of lightning as measured from above cloud tops, Preprints, VIIth International Conf. on Atmospheric Electricity, Am. Met. Soc., Boston, MA, 468-471, 1984.

Rust, W. D., W. L. Taylor, D. R. MacGorman, E. Brandes, V. Mazur, R. T. Arnold, T. Marshall, H. Christian, and S. J. Goodman, Lightning and related phenomena in thunderstorms and squall lines, AIAA 22nd Aerospace Sciences Meeting, Reno, NV, 1984.

Goodman, S. J., and D. R. MacGorman, A composite picture of lightning activity in mesoscale convective complexes, EOS, 65, 849, 1984.

Goodman, S. J., and D. E. Buechler, Buoyant energy and the production of lightning in convective storms, EOS, 66, 841, 1985.

Mobilia, J., H. D. Voss, W. L. Imhoff, and S. J. Goodman, Lightning observations from the SEEP/S81-1 satellite, EOS, 66, 1001, 1985.

Goodman, S. J., Real-time applications from remotely sensed lightning observations, Preprints, Conf. on Aerospace and Range Meteorology, Am. Met. Soc., Boston, MA, 11-16, 1985.

Goodman, S. J., and D. R. MacGorman, Lightning Activity in mesoscale convective systems, Preprints, 14th Conf. on Severe Local Storms, Am. Met. Soc., Boston, MA, 368-371, 1985.

Rust, W. D., D. L. MacGorman, and S. J. Goodman, Unusual positive cloud-to-ground lightning in Oklahoma storms, Preprints, 14th Conf. on Severe Local Storms, Am. Met. Soc., Boston, MA, 372-375, 1985.

Buechler, D. E., and S. J. Goodman, Lightning measurements during the COHMEX field experiment, EOS, 67, 886, 1986.

Goodman, S. J., J. E. Arnold, and S. E. Williams, An overview of the Satellite Precipitation and Cloud Experiment (SPACE), EOS, 67, 881, 1986.

Weber, M., E. Williams, and S. Goodman, 1987. Rapid update Doppler radar and electrical measurements of a microburst-producing thunderstorm, EOS, 68, 1987.

Buechler, D. E., S. J. Goodman, and M. E. Weber. Cloud-to-ground lightning activity in microburst producing storms, Preprints, 15th Conf. on Severe Local Storms, Baltimore, MD, Am. Meteor. Soc., 1988.

Goodman, S. J., D. E. Buechler, and P. J. Meyer. Storm diagnostic/predictive imagery derived from a combination of lightning and satellite imagery, Preprints, 3rd Conf. on Satellite Meteorology and Oceanography, Anaheim, CA, 1988.