GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

Date: 1/10/81

Project Title: Development of Graduate Research Opportunities in Atmospheric and Terrestrial Sciences

Project No: G-35-679

Project Director: C. S. Kiang

Sponsor: *National Science Foundation*

Agreement Period: From 9/1/80 Until ~~1/30/83~~ 2/29/84 2/28/82
(Includes unfunded period of six months)

Type Agreement: *Grant No.* ATM-8009560 *, dated* 9/16/80

Amount: $100,000 *NSF* G-35-679 (Total funding estimated to be
76,797 *GIT* G-35-354 $574,900 for three years)
$176,797 *TOTAL**

* Partial funding for first five months only.

Reports Required: *Annual Progress Report ; Final Project Report*

Sponsor Contact Person (s):

Technical Matters

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Directorate for Administration
National Science Foundation
Washington, D. C. 20550
202/357-9602

Defense Priority Rating: *N/A*

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SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

Date 6/12/85

Project No. G-35-679 School/~~XXX~~ Geo Sci.

Includes Subproject No.(s) N/A

Project Director(s) C. S. Kiang (Chas S.) GTRC / ~~XXX~~

Sponsor National Science Foundation

Title Development of Graduate Research Opportunities in Atmospheric and Terrestrial Sciences

Effective Completion Date: 2/29/84 (Performance) 5/29/84 (Reports)

Grant/Contract Closeout Actions Remaining:

- [ ] None
- [ ] Final Invoice or Final Fiscal Report
- [ ] Closing Documents
- [X] Final Report of Inventions For our records
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G-35-619

School of Geophysical Sciences
Georgia Institute of Technology

Dr. C. S. Kiang, Principal Investigator

NSF Grant No.: ATM8009560

DEVELOPMENT OF GRADUATE RESEARCH OPPORTUNITIES IN ATMOSPHERIC AND TERRESTRIAL SCIENCES

PROGRESS REPORT

April 1982

Submitted to:

National Science Foundation

and

National Oceanic Atmospheric Administration

I. Introduction

The overall objective of our efforts is to provide for the development of graduate research opportunities in atmospheric and terrestrial sciences at Georgia Tech, with special emphasis on the development of cooperative research and educational programs with the Atlanta University and other selected regional minority universities.

Specifically, the program objectives for the first two years have been: (1) joint development of research capabilities; (2) seminars and short course arrangements; (3) joint development of research programs; and (4) joint development of educational programs. The progress toward each of these specific objectives will now be given.

II. Progress

1. Joint Development of Research Capabilities

The five projects chosen for the first two years of operation are illustrated in Table 1. Projects A through D were implemented the first year at Georgia Tech. Project E was implemented at Atlanta University Center this year. A status of the development of research capabilities is given in Table 2. Each of these research capabilities has been utilized for the development of joint research and educational programs involving faculty and students at Georgia Tech, the AUC, and other regional colleges (Jackson State University, the University of Tennessee at Chattanooga, Georgia Southern University and Savannah State College).

The opportunities for interactions of Georgia Tech faculty with the AUC and other regional colleges have been greatly increased with this grant.

Table 1. Development of Research Capabilities.

Project	Task	Scientist Involved	Technical Support	Remarks
A. Development of Mobile Atmoshperic Research Vehicle	Install aerosol optical counter, lidar, radiation, monitoring equipment, and recording system	G. W. Grams E. M. Patterson C. G. Justus L. Lewis	C. Wyman D. Rawlings	Boundary layer and air pollution studies
B. Development of Boundary Layer Measurement System	Develop and test tethered balloon, and 20 foot VAN MAST systems	C. G. Justus L. Lewis J. I. Metcalf	D. Rawlings	Measure wind speed, wind direction, temperature, humidity, and pressure
C. Study of Organic Compounds in the Environment	Develop analytic capabilities (GC/MS/DS) for organic compounds	H. Reuter L. Roland E. Chian	Provided by School of Civil Engrg.	GC/MS/DS system is located in the School of Civil Engineering
D. Improvement of Computer Facilities	Install expanded disk, memory, and terminal facilities	Faculty Computer Committee	W. Pace	Data processing capabilities for all of above systems plus other programs
E. DECSYSTEM-20 Computer Facility at Atlanta University Center	Installation and Operation	J. Hall	W. Pace B. Hardeman	Data processing cabilities for large-scale computations

Table 2. Status of the Development of Research Capabilities.

Project	Task	Status	Remarks
A. Development of Mobile Atmos. Research Vehicle	Install and test optical aerosol counter (Climet Particle Analyzer)	Installed and Tested: First year	Measure number of particles per unit volume in 6 size ranges from 0.3 to 10 radius
	Install radiation monitoring equipment	Installed: First Year Tested and Operational: Second Year	For direct beam solar radiation For global (all sky) radiation For global radiation on tilted surface For net radiation (IR and visible)
	Install lidar and data system	Installed: First Year Tested and Operational: Second Year	Measure aerosol concentration versus altitude
B. Development of Boundary Layer Measurement System	Development and test tethered balloon system	Tested and Operational: First Year	Measure profiles of wind speed, wind direction, temperature, humidity, and pressure to heights of 800 M
	Develop and test auxilliary sensors	Ordered: First Year Tested and Operational: Second Year	High resolution temperature measurement Will be tested against Dasibi ozone sensor Monitor temperature difference
	Install VAN MAST	Tested and Operational: 1981	Wind speed, wind direction, temperature, humidity, and pressure

Table 2. Continued

Project	Task	Status	Remarks
C. Study of Organic Compounds in the Environment	Develop analytic capabilities (GC/MS/DS) for organic compounds		
D. Improvement of Computer Facilities*	Install 300 Mb disk drive	Operational: First Year	Control Data Corporation
	Install 256 Kb memory board	Operational: First Year	Data General
	Tektronix 4025 graphics terminal	Operational: First Year	
	Install Z19 CRT terminal	Operational: First Year	
	Install 1200 baud originate modem	Operational: First Year	
	Install 1200 baud auto answer modem	Operational: First Year	
E. DECSYSTEM-20* Computer Facility (at Atlanta University Center)	Install	Tested and Operational: Second year	Digital Equipment Corporation

*The DECSYSTEM-20 installed at the Atlanta University Center provides computer services to the faculty and graduate students involved in this program at Georgia Tech and the Atlanta University Center. Therefore, while not a part of this grant, the system provides for the joint development of research capabilities between the two institutions.

2. Seminars and Short Courses

A. Seminars

1. Weekly Seminars at Georgia Tech: There is a weekly seminar at Georgia Tech for faculty and students at both Georgia Tech and the AUC. This seminar series is scheduled throughout the academic year. Seminar speakers include faculty and invited guests.

2. Special Seminars at Regional Colleges: Seminars have been given at the following regional colleges: Jackson State University, Georgia Southern University and Savannah State Colleges. The seminars at Jackson State were given in October, in preparation for the spring short course. The seminar topics were "Solar Radiation Collection Analysis Procedures" (Dr. C. G. Justus), and "Measurement and Data Interpretation of Atmospheric Laser Instruments" (Dr. G. W. Grams).

On November 9-11, 1981, several Atmospheric Sciences Program faculty and staff visited Georgia Southern College in Statesboro, GA. A seminar series on the topic of "Atmospheric Resources" was conducted on the evenings of November 9 and 10. Topics presented were "Water Resources" (Dr. George Chimonas), "Solar Radiation and Climatic Resources" (Dr. C. G. Justus), and "Our Atmosphere as a Resource" (Dr. C. S. Kiang). A panel discusion of these participants was conducted by local host Dr. Arthur Woodrum of the Physics Department, Georgia Southern College.

Demonstrations with the Mobile Atmospheric Research Vehicle (MARV) and the tethered balloon systems were conducted by Dr. Lonzy Lewis, Mr. Clyde Wyman, and Mr. John Lawther for several specific classes at the colleges, for "open-house" visitors, and for two groups of local high school science students (150 students total).

On November 11-13, a similar visit to Savannah State College, Savannah, Georgia was conducted. The seminar topics of "Atmospheric Resources" was presented by Dr. Kiang. The visit to Savannah State was hosted by Drs. Kailash Chandra and G. S. Ghoman of the School of Science and Technology. The MARV and tethered balloon demonstrations were attended by three School of Science classes and several "drop in visitors during the "open house" sessions (75 students total).

The visits to both colleges were well publici-ed by the local hosts. Coverage was given on both WPTB and WWNS local radio in Statesboro, and a feature video coverage was done by Patrick Prokop of WTOC television in Savannah. Copies of local announcements and campus newspaper coverage at the two colleges are attached, (Appendix C).

B. Short Courses

Short courses were given in March, 1982 at Atlanta University Center and Jackson State University. The short course at Atlanta University Center, "Urban and Regional View on Air Resources", was coordinated by Atlanta University, Atlanta University Center Science Research Institute, and Georgia Tech (Appendix D). The MARV provided support for the course through demonstrations of the tethered balloon and the lidar system. The AUC response was excellent. The average student attendance for the six lectures was 38, with a total of 229 students participating.

This year, the short course at Jackson State Universitv (Appendix E), "Atmospheric Instrumentation and Data Interpretation", concentrated on data acquisition and intrepretation. The lectures supported MARV laboratory demonstrations and

data interpretation demonstrations through dial-in communication lines to the Georgia Tech ECLIPSE system. Thus, while the short course offered at Jackson State University last year and the seminars given earlier this year prepared the students theoretically, this short course provided "hands-on" familarity of equipment and data analysis techniques.

3. Joint Development of Research Programs

Drs. John Hall, Lonzy Lewis, and Luther Roland have been involved in this phase of our program. First, the AUC has installed the DECSYSTEM-20 Computer which will serve to increase the interaction between Georgia Tech and the AUC faculty, thereby providing a mechanism for joint proposal development. The AUC has installed color graphics terminals at Georgia Tech, which are used to communicate via dial-in lines with the DECSYSTEM-20. We are currently planning more efficient means of communication using high-speed data transmission lines. Second, the AUC Science Research Institute has allocated two of the thirteen laboratories in the AUC Science Laboratory now under construction for Drs. Hall, Lewis, and Roland. The new facility, which will be completed August 1, 1982, will provide a terminal/remote job entry room for access to the DECSYSTEM-20, in addition to the laboratories. Each activity is designed to increase the interaction between Georgia Tech and the Atlanta University Center in order to promote cooperative research efforts.

4. Joint Development of Educational Programs

A. Atlanta University Center

We have made significant progress in this direction. First, Morehouse shall present to the Academic Program Committee in April, a proposal to offer minor degrees in atmospheric chemistry, meteorology, geophysics and geochemistry start-in the fall, 1982. The instructors for the added courses will come from Georgia

Tech, as well as the Atlanta University Center. Morehouse has also allocated space in the facility presently occupied by the Medical School for this program, and wishes to expand the scope to include biology. This space will consist of office, classroom, and laboratory facilities. Second, Atlanta University has added "Research in Atmospheric Chemistry" and "Introduction to Atmospheric Science" to its graduate curriculum. Atlanta University is strongly interested in developing cooperative research programs with Georgia Tech and the Atlanta University Center, Inc., in the atmospheric sciences.

B. Jackson State University

Jackson State University has made similar progress. In particular Jackson State University is expanding its meteorology program to include atmospheric chemistry. JSU will also have access to software on the DECSYSTEM-20, through this program.

Proposed Activities for Third Year

As in the first two years, we plan to concentrate on the four objectives listed above. The Seminar and Short Course schedule is essentially fixed as last year, and a major emphasis in the third year will be towards the development of joint research and educational programs. To meet these objectives, we are requesting that Dr. John Hall be made co-principal investigator of this grant. Dr. Hall has a joint appointment with Georgia Tech and the AUC, and therefore can be very effective in facilitating cooperation between the institutions. Drs. Lewis and Roland will assist Dr. Hall in these efforts. Both Dr. Lewis and Dr. Roland have been provided with office and laboratory space at the AUC.

The second major emphasis will be on the development of the joint educational programs. In particular, with Drs. Hall, Lewis, and Roland providing the

impetus, we will assist in the development of the undergraduate program in atmospheric sciences at Morehouse by providing instructional manpower, seminars, and short courses. Also, we will assist Atlanta University in the development of its graduate curriculum. Atlanta University has added a course in atmospheric sciences, which will be taught by Dr. Lewis and Dr. Hall. Additionally, a major objective of these efforts will be towards increasing the graduate and undergraduate student participation in our program.

Unexpended Funds

As of August 31, 1982; there will be no residual funds remaining in grant No. ATM80-09560.

APPENDIX VI

NATIONAL SCIENCE FOUNDATION
Washington, D.C. 20550

FINAL PROJECT REPORT
NSF FORM 98A

PLEASE READ INSTRUCTIONS ON REVERSE BEFORE COMPLETING

PART I–PROJECT IDENTIFICATION INFORMATION

1. Institution and Address	2. NSF Program	3. NSF Award Number
Georgia Institute of Technology School of Geophysical Sciences 225 North Avenue, NW Atlanta, Georgia 30332		
	4. Award Period From Jan., '84 To Dec., '86	5. Cumulative Award Amount $575,100

6. Project Title
A Proposal for the Development of Graduate Research Opportunities in Earth and Atmospheric Sciences.

PART II–SUMMARY OF COMPLETED PROJECT *(FOR PUBLIC USE)*

For the past three years, we have concentrated on the joint development of research capabilities and programs with the AUC. Specifically, our approach has been centered around the following activities:

(a) Joint development of research capabilities involving faculty at both Georgia Tech and AUC.

(b) Seminar and short course arrangements between Georgia Tech, AUC and other regional minority colleges.

(c) Joint development of research programs involving students and faculty at Georgia Tech, AUC, and other regional minority colleges.

As a result of our cooperative efforts, graduates of the AUC and Jackson State University (JSU) are participating in, or have participated in, our graduate program at Georgia Tech. The AUC and JSU are developing undergraduate and graduate programs in the atmospheric and earth sciences, and each institution has significantly increased its research capabilities.

(SEE ATTACHED MATERIALS)

PART III–TECHNICAL INFORMATION *(FOR PROGRAM MANAGEMENT USES)*

1. ITEM *(Check appropriate blocks)*	NONE	ATTACHED	PREVIOUSLY FURNISHED	TO BE FURNISHED SEPARATELY TO PROGRAM	
				Check (√)	Approx. Date
a. Abstracts of Theses	X				
b. Publication Citations	X				
c. Data on Scientific Collaborators	X				
d. Information on Inventions	X				
e. Technical Description of Project and Results					
f. Other *(specify)*					

2. Principal Investigator/Project Director Name *(Typed)*	3. Principal Investigator/Project Director Signature	4. Date
John H. Hall, Jr.		4/25/85

NSF Form 98A (5-78) Supersedes All Previous Editions

Form Approved OMB No. 99R0013

A PROPOSAL FOR THE DEVELOPMENT OF GRADUATE RESEARCH OPPORTUNITIES IN EARTH AND ATMOSPHERIC SCIENCES

I. Introduction

Three years ago, in our first request to NSF for the funding of this program, we began with the sentence "One of the significant trends of our time is the rising tide of concern over the limitations of the natural resources on earth and the degredation of man's surroundings." This statement is even more appropriate for today. It is recognized that government and industry can and will be primarily responsible for solutions to problems of the present, and that they must, in many instances, draw upon the resources from the educational institutions. It is therefore appropriate for universities, both high-tech and liberal arts, to take a vigorous and active part in the education and training of manpower to attack environmental problems, as well as provide for fundamental research in the environmental sciences. Three years ago, the Georgia Institute of Technology, in cooperation with the Atlanta University Center (AUC), initiated a program designed to increase the graduate research opportunities in the atmospheric and earth sciences. The initiation of this program coincided with the establishment of a graduate program in the atmospheric sciences at Georgia Tech within the School of Geophysical Sciences (Appendix A), leading to the Master of Science and Ph.D. degrees. Together with existing programs in Geochemistry, Geophysics, Engineering Geology and Oceanography, the School of Geophysical Sciences provides a comprehensive framework which includes the essential elements for the study of the earth's environment.

A specific motivation for our program in earth and atmospheric sciences stemmed from the recognition of the increasing importance of the impact of energy-related technology on the atmosphere, earth, and ocean. A second important aim of the program and a motivation during its conception and development was to meet the need of involving minority institutions in the field of geophysical sciences, at both the regional and national level. The recognition of this need by members of this program was due in part to an existing interaction between the Atlanta University Center (see Appendix B), other minority colleges, and Georgia Tech. This interaction has strengthened and has led to an increased participation by the AUC in the environmental sciences.

The AUC is a consortium of seven independent institutions: Morehouse, Clark, Spelman and Morris Brown Colleges (all undergraduate colleges), Atlanta University (a graduate university), the Interdenominational Theological Center, and Morehouse Medical College. Together, these institutions form the world's largest center of private black higher education (10,000 students and 700 faculty). Cooperative programs among the institutions are coordinated by the Atlanta University Center, Inc. (AUC, Inc.).

Both the Atlanta University Center and Georgia Tech realize that, traditionally, private minority colleges, as well as liberal arts colleges in general, have concentrated on developing curricula in the fundamental sciences: physics, chemistry, mathematics and biology. However, energy and environmental concerns in the seventies have led to the development of more interdisciplinary fields, such as atmospheric sciences, oceanography and geology.

For several reasons, it does not appear to be presently economically feasible or practical for small minority colleges to independently develop curricula and research programs in the atmospheric and terrestrial sciences. First, these colleges would have to compete for faculty and students with institutions that have established programs. Second, to establish a reputable program, a number of new personnel in the environmental sciences would be required. These people are few in number, and the strain on the budgets of most liberal arts colleges would be great. Third, specialized equipment is required which is beyond the financial capability of most minority colleges. Clearly, the assimilation of the atmospheric and terrestrial sciences into the curricula of minority colleges would be difficult at best, if done independently. Yet, the projected demand for personnel in the environmental sciences is great, and there is a distinct need for the minority colleges (who educate a significant portion of the nation's students) to participate in this education. A final incentive for the development of programs in the atmospheric and terrestrial sciences at the minority colleges is the prospect that they would be entering these fields in the developmental stages, and would not be facing the prospect of playing "catch-up" in existing, extensively developed fields.

A viable mechanism to increase the participation of minority or liberal arts colleges in the geophysical sciences is through joint programs involving research and educational curricula with institutions already established in these fields. This approach has been successful for our program.

It is important to understand that the efforts of this proposal fit into a comprehensive program. Figure 1 illustrates our program, consisting of three main components: Research, Instructional and Outreach. Under the Instructional component, Morehouse College has initiated a minor degree program in Earth and Atmospheric Sciences (Appendix D). The remaining undergraduate colleges in the AUC (Clark, Spelman and Morris Brown) are preparing proposals to be submitted to the AUC presidents so that their students may also participate in this program. Also, a great deal of effort has been directed towards developing a program for undergraduate research participation at Morehouse College. This program will enable an honor student to pursue a two-year research program, supplemented with summer courses in the geophysical sciences. Proposals have been submitted to NSF and ARCO Foundation for the funding of this program. The AUC, Inc. has set up an undergraduate scholarship fund for AUC students studying the earth and atmospheric sciences (funded by the ARCO Foundation). Here at Georgia Tech, we are preparing a proposal to be submitted to the Board of Regents for a B.S. degree in Geophysical Sciences. This proposal includes a Dual Degree component with the AUC member institutions.

In regard to the Research component, the AUC, Inc. has created and developed, through grants from NSF and Digital Equipment Corporation, a research computations center to provide support for researchers in the environmental sciences. This computer, the DECSYSTEM 20, has become an important part of the AUC research environment. Atlanta University has added atmospheric chemistry to its list of research offerings for graduate students and the AUC Science Research Institute has provided laboratory and office space for the Earth and Atmospheric Sciences program in a modern, newly constructed laboratory.

The Outreach component seeks to extend our efforts beyond the AUC. Short courses and seminars have been offered at several other minority institutions. Most notably, Jackson State University, through cooperative efforts with Georgia Tech and the AUC is developing a curriculum in the atmospheric sciences, as well as developing a research capability. Jackson State University has received funding from NSF and DEC to establish a research computer center for research in the atmospheric sciences, and is planning to expand its existing meteorology program to include atmospheric chemistry. Each accomplishment was achieved through cooperative efforts designed not only to strengthen the resources at Georgia Tech, but also those at the AUC and Jackson State University. Thus, our efforts are comprehensive and designed to have a lasting impact.

Our objective for the next three years is to strengthen the research interaction between Georgia Tech and the AUC, while increasing the depth of our existing efforts (research and educational programs, short courses, and seminars). Thus, this proposal concentrates on developing joint research and educational programs by strengthening the research capabilities of the faculty specifically interacting with the AUC and regional minority colleges. To this end, $615,992 are requested from NSF. With these funds, we propose to strengthen the GA Tech/AUC interaction by continuing our existing efforts through the seminars and short courses, and by developing the research programs of Drs. Lewis, Roland and Hall. These research projects, along with a new geophysics thrust, will serve as the nucleus for the long-term development and implementation of joint research programs with the Atlanta University Center. Dr. Hall, a co-principal investigator of the original proposal, has served as the coordinator of the activities between Georgia Tech and the AUC, and holds a joint appointment with Georgia Tech, Morehouse College and the AUC, Inc. Dr. Hall is responsible for the development of the undergraduate program at Morehouse College, teaches atmospheric chemistry at both the graduate and undergraduate levels in the AUC, and directs graduate students at both Georgia Tech and Atlanta University. Drs. Lewis and Roland play an instrumental role in the program. Both are beginning to develop their research programs, and both are presently holding adjunct appointments at Morehouse College. Drs. Lewis and Roland are spending the second part of this academic year teaching courses at both the AUC and Jackson State University. The success of this program depends largely on the continued development of their research capabilities.

Additionally, Drs. Tim Long, Anton Dainty, and Bob Lowell of Georgia Tech will aid in the development of joint research programs in geophysics. Presently, Dr. Lowell is teaching the geophysics course at Morehouse College. Dr. Lowell will continue in his present capacity, and Drs. Long and Dainty will assist in the upgrading of our present seismic network and the installation of a monitoring station in the AUC. Additional faculty involved in the research and development efforts are Drs. C. S. Kiang, William Chameides, and Fred Alyea.

II. Research Projects and Research Plans

This proposal concentrates on strengthening the research interaction between Georgia Tech and the AUC, as well as continue the successful elements

of our program presently in place. In order to achieve this goal, support is requested for the research of Drs. Lonzy Lewis, Luther Roland and John Hall, and for the expansion of the interaction with the AUC, Inc. to include geophysics and geochemistry. Thus, this section presents an overview of the proposed research projects of Drs. Hall, Lewis and Roland and the proposed research in geophysics.

(a) Solar Energy, Radiation and Climate-Related Aerosol Research

Dr. Lonzy Lewis

The Radiation and Atmospheric Optics Groups in the School of Geophysical Sciences at the Georgia Institute of Technology (of which Dr. Lewis is a member), carry out both laboratory and field measurement programs for determining the effects of suspended atmospheric particulates (aerosols) on the propagation of visible radiation in the atmosphere, as well as a wide variety of energy-related atmospheric research. As part of our Solar Energy Meteorological Research and Training Site program, one of eight such sites funded by the Department of Energy, extensive solar radiation monitoring equipment provides continuously monitored solar radiation data and information on atmospheric parameters related to solar energy.

The Radiation and Atmospheric Optics groups have developed a Mobile Atmospheric Research Vehicle (MARV) with instrumentation designed to provide data for regional climate studies and research on solar radiation parameters in addition to concentration, vertical distributions, and optical properties of aerosol particles. The mobile laboratory is also outfitted to record simultaneous data on standard meteorological parameters such as temperature, pressure, humidity and winds. MARV is based on a custom-designed atmospheric sampling vehicle that had previously been operated by the Environmental Protection Division of the State of Georgia's Department of Natural Resources. The initial instrument package included aerosol filter sampling equipment, a single-particle optical counter, and several sensors for monitoring direct beam, global, and net short-wave and long-wave radiation parameters. During the summer of 1980, a compact dye-laser radar (lidar) was installed in MARV to provide information on the vertical distribution of aerosol particles in the atmospheric boundary layer. The mobile lidar incorporates a minicomputer to analyze laser echoes in real time, and to provide graphic displays of the lidar data on a CRT terminal; the minicomputer is also used to process and record data from the other instruments. Power for operating the equipment in MARV can be an external power line or a built-in gasoline powered generator. MARV will be used in a variety of projects involving the interaction of atmospheric radiation with the atmospheric aerosol. In particular, we are planning to use the facility for studies related to the effect of aerosol particles on local and regional climate, for documenting turbidity variations in urban and rural areas, and for other radiation propagation problems such as the effects of atmospheric pollutants on visibility and on atmospheric heating rates. This mobile lab will be used in conjunction with the on-campus solar-radiation/meteorological monitoring site for local and regional climate studies.

Research activities of Dr. Lewis will revolve around solar radiation data measurements, interpretations and modeling, including analysis and measurement

of such atmospheric effects as attenuation by aerosol particles, clouds and water vapor. The research approach will utilize solar radiation measurements at the Georgia Tech campus, Shenandoah, Georgia site and other sites throughout the Southeast region, laboratory and field measurements of aerosol optical properties, and computer modeling for simulation of solar radiation, especially for solar energy applications and regional climate studies. Interactions will be sought with NCAR, SERI, and NOAA laboratories in Rockville, MD and Boulder, CO to develop mutual exchange of data and modeling results and interpretations.

To enhance Dr. Lewis' research capabilities in his studies of the propagation of radiation in the atmosphere, we wish to acquire a portable spectroradiometer system. To improve our observational capabilities in characterizing the atmospheric boundary layer, we wish to improve the performance of our Mobile Atmospheric Research Vehicle (MARV).

We plan to purchase a Li-Cor, Inc. LI-1800 Portable Spectroradiometric Research System. This portable spectroradiometer is a much needed observational tool for applications in Dr. Lewis' radiative transfer studies, regional climate studies, basic boundary layer research, and for our Solar Energy Research and Training Site Program. The LI-1800 System provides a fast, accurate method of obtaining spectral radiation data. With optical attachments, the system is converted to an integrating sphere based instrument for measurements of diffuse reflectance and transmittance in the field. It utilizes a holographic grating monochromator and a stable, high quantum efficiency silicon detector. Stray light is minimized through the use of filters and it contains a black target for zero referencing. Two wavelength ranges are available; 300-1100nm with 6nm or 12nm bandwidths, and 300-850nm with 4nm or 8nm bandwidths. At the heart of the LI-1800 system is an internal microcomputer which controls the optics, electronics, and data. Due to its small size, the spectroradiometer would serve as both a laboratory instrument and as a field instrument when placed in our mobile laboratory.

As part of our proposed research, we wish to take the proposed portable spectroradiometric system to SERI to thoroughly test it against an expensive and more accurate SERI instrument (Bird et al., 1983).

Our field measurement program of radiation and aerosol parameters, and our regional climate studies are largely dependent on the performance of our mobile laboratory. The present instrumentation package in MARV is described in Table 1-A. The small laser radar (lidar) referenced in Table 1-A is based on the flashlamp pumped dye laser system described by Grams et al. (1975). The lidar is used to observe the vertical distribution of aerosol particles in the atmospheric boundary layer. Dr. Lewis has been designated principal coordinator of our mobile atmospheric research program, and is the chief investigator using the lidar system.

To improve our ability to detect the presence and location of aerosol layers in the atmosphere, we wish to purchase a new pumped dye laser for the lidar system. The present system is almost ten years old, outdated, has low power output, and its down-time has been a major factor in delaying more frequent use of MARV as a true mobile research laboratory. We also wish to improve our data acquisition and display capabilities by upgrading our minicomputer system. In addition, we seek partial support for electronic and

TABLE 1A

GEORGIA TECH MOBILE
ATMOSPHERIC RESEARCH VEHICLE
(MARV)

INSTRUMENTATION:

AMBIENT INSTRUMENTATION RESEARCH TS-2A TETHERSONDE

A tethered balloon system to measure profiles of wind speed, wind direction, temperature, humidity, and pressure to heights of 800M (2,600 ft.). The system, with free balloon AIRSONDE package and theodolite, can measure atmospheric parameters to 10 km (30,000 ft.).

SOLAR RADIATION MONITORING INSTRUMENTS

Eppley normal incidence pyrheliometer (NIP) for direct beam solar radiation; Eppley precision spectral pyranometer (PSP) for global (all sky) radiation; Eppley PSP for global radiation on tilted surface; Swissteco (CSIRO) funk radiometer for net radiation (visible and IR); Li-Cor Solar Meter/Integrator (LI-175) for global radiation.

CLIMET METEROLOGICAL SYSTEM

On 20 ft. Van Mast: wind speed, wind direction, temperature, humidity and pressure instrumentation.

LIDAR

Compact flash lamp-pumped dye laser system with minicomputer to analyze laser echoes from atmospheric haze and cloud layers, display results on graphics terminals, and record data on magnetic-tape for more detailed analysis on larger computers. Measures aerosol concentration versus altitude.

CLIMET PARTICLE ANALYZER

Measures number of particles per unit volume in 6 size ranges varying from 0.3 to 10 m radius.

THE VEHICLE:

An 837 ft^3 custom-designed atmospheric sampling van with 126 sq. ft. of floor space. The laboratory space is environmentally controlled, and has flurorescent lightning. Power for operating the equipment can be either external powerline or a built-in gasoline powered generator.

computer technicians. Their time would be required to implement the following projects:

1) data analysis and archiving of the tethersonde measurements;

2) installation, testing, operation and analysis of data from the new lidar system and the solar spectroradiometric system;

3) assisting in the maintenance of the lidar, spectroradiometer and the other instrumentation in MARV and the operation of MARV.

4) installing and interfacing the array of sensors on MARV with the lidar's updated minicomputer-based data acquisition system, and;

5) developing software to interface remote data sensors with our centralized mainframe and minicomputer systems.

(b) The Isolation and Identification of Acid Rain

Precursors by Matrix-Isolation Infrared Spectroscopy

Dr. John H. Hall

Dr. Hall's research involves the detection and identification of transient species, and the products of photochemical reactions, with primary application to the chemistry of the atmosphere. Basically, the matrix-isolation method is used in conjunction with infrared and Raman spectroscopy to isolate and spectroscopically characterize transient intermediates in gas-phase reactions. Reactants are mixed in gas reaction cells similar in design to those used in gas-phase kinetics experiments. The subsequent products are trapped on a cold window at 10K for ir or Raman study. To date, we have studied the following reactions relevant to stratospheric and trophospheric chemistry:

$$Cl + O_3 \longrightarrow P$$

$$NO + O_3 \longrightarrow P$$

$$NO + O_2 \longrightarrow P$$

$$ClO + NO_2 \xrightarrow{M} ClONO_2 + ClOONO$$

$$Cl + NO_2 \longrightarrow ClONO + ClNO_2$$

$$I + O_3 \longrightarrow P$$

$$SO_2 + OH \longrightarrow P$$

and

$$CO_3SX + OH \longrightarrow P \ (X = H, CH_3)$$

where P = products. Consequently, we observed the following compounds as products of the above reactions: ClOO, ClOO*, OClO, OONO, $ClONO_2$, ClOONO, ClONO, $ClNO_2$ and I_2O_4, with tentative identification of HSO_3, H_2SO_3 and CH_3SOH. The determination of products and intermediates in reactions associated with atmospheric chemical processes is important in formulating atmospheric chemical reaction mechanisms.

A major advantage of our method is its ability to determine molecular structures, to trap reactive transients molecules for spectroscopic characterization, and to distinguish between isomeric forms of the same molecule. With the general experimental method and method for data presentation in mind, we shall now discuss the procedure specific to the proposed research.

The objective of this proposed research is to determine the chemical nature of acid rain precursors in order to establish the mechanism for conversion of sulfur dioxide to sulfuric acid. We will attempt to identify and characterize the products of the following gas-phase reactions by their infrared and Raman spectra:

$$SO_2 + OH \longrightarrow HSO_3$$

$$SO_2 + OH + O_2 \longrightarrow \text{Products}$$

$$SO_2 + OH + H_2O \longrightarrow \text{Products}$$

$$SO_2 + O_3 \longrightarrow SO_3 + O_3$$

$$SO_2 + O_3 + H_2O \longrightarrow \text{Products}$$

$$SO_2 + OH + NO \longrightarrow \text{Products}$$

$$SO_2 + OH + NO_2 \longrightarrow \text{Products}$$

The major components of the acid rain are shown to be sulfuric and nitric acids. The sulfuric acid is predominant in the Eastern United States and Canada, while the precipitation falling in Europe and Como Creek appears to be dominated by nitric acid. The effects of acid rain on the aquatic system, agricultural and plants are well documented, but the chemistry and physics of the acid precursors is not thoroughly understood. The attempt to explain the chemical precursors can be broadly divided into two categories; a) the photochemical model, b) the reactions of sulfur dioxide and nitrogen dioxide with hydroxyl radicals. The usual photochemical models do not explain the relative atmospheric concentrations of HNO_3 and H_2SO_4. Rodhe, et al., have suggested the inclusion of OH, H_2O_2 and ozone oxidizing species in order to explain the conversion of sulfur dioxide and nitrogen dioxide to their corresponding acids. The conversion of sulfur dioxide to the sulfuric acid has been proposed to go through the following mechanisms:

$$OH + SO_2 + M \longrightarrow HSO_3 + M \qquad R1$$

$$HSO_3 + OH \longrightarrow H_2SO_4 \qquad R2$$

$$HSO_3 + OH \longrightarrow H2O + SO_3 \qquad R3$$

$$HSO_3 + HSO_3 \longrightarrow H_2S_2O_6 \qquad R4$$

$$HSO_3 + H_2O \longrightarrow HSO_3 \cdot H_2O \qquad R5$$

The role of the reaction R1 in the sulfur dioxide chemistry is well established, but different groups have suggested other mechanisms for the conversion of the HSO_3 radical to the sulfuric acid (H_2SO_4), and the sulfate aerosol formation.

In order to propose mechanisms for such chemical systems it is necessary to identify and characterize the products of these reactions. The only direct experimental studies of acid rain precursors has been by Niki et al. These investigators studied the reaction of SO_2 with OH using an FTIR, coupled with a long-path reaction cell. The matrix-isolation method is well-suited for this kind of study. Transient and reactive constituents of a primary reaction may be trapped in the inert matrix before their subsequent reaction with other species. Once a species is trapped in the matrix, a variety of studies may be initiated: matrix warm-up and cool-down to qualitatively measure relative stabilities; photochemical studies; and infrared/laser-Raman studies. Thus, the detection of HSO_3 and SO_3 may be realized in our system, whereas the detection of these species may have eluded researchers in the gas-flow experiments.

Theoretical electronic structure studies will be carried out using both ab-initio self-consistent field and the approximate PRDDO methods. The primary quantities of interest are the relative energies of isomers and reaction products, optimized molecular geometries, charge distributions, one-electron properties, localized orbitals, potential energy surfaces, and in some cases, excited state wavefunctions. Dr. W. Chameides and F. N. Alyea will work jointly with Dr. Hall on this project in order to develop a numerical 2 D Model for global sulfur distribution.

(c) Gas-Phase Organic Analysis of Trace Pollutants

Dr. Luther Roland

During the past three years, Dr. Roland has been involved in the development of analytical techniques necessary to analyze for trace organic compounds in complex matrices. These techniques involved the isolation, concentration and identification of organics in aqueous phase. In addition to the organics present in the aqueous phase, vapor phase organics are also important, especially in tropospheric chemistry.

Organic compounds are important in trospospheric chemistry for several reasons. Halogenated species (including methylchloroform) are of major interest upon the stratospheric ozone layer. The possible importance of peroxy acetyl nitrate (PAN) and other nitrogen containing compounds in remote locations has not been sufficiently established, and requires further study. The photochemical reaction of ozone by iodine compounds requires further study. The oxidation of atmospheric hydrocarbons of both biogenic and anthropogenic origin should be delineated. The oxidation of reduced nitrogen species is potentially important to the nitrogen budget; hence, the chemistry of NH_3 and

amines must be studied. The free radical reaction involving the hydroxyl (OH) is not only important in destroying methane, but also in initiating a series of subsequent reactions that ultimately lead to the generation of carbon monoxide. These reactions include the OH initiated oxidation of non-methane hydrocarbons such as isoprenes and terpenes emitted by trees and other vegetations, the incomplete combustion of fossil fuels (principally automotives), and the burning of biomass, such as wood, agricultural wastes and forests. Dr. Roland's research efforts will be directed towards determining the role that vapor phase organic species play in tropospheric chemistry.

The major problems associated with vapor phase organic analysis are the low concentrations present in ambient samples, the losses and transformation the compounds undergo during transport from the sampling site to the laboratory, and instrumental adaptations in order to introduce the sample into the system and yet maintain the high resolution power of the capillary column. The presence of water vapor is also a major problem encountered when sampling vapor phase organic matter. Of these problems, the adaptation of our present system to accommodate vapor phase organic material represents the most severe limitation.

The multitude of organic compounds and their large concentration range prohibits an investigation of all the organics present in the troposphere. Dr. Roland's research effort will therefore concentrate only on vapor-phase organic material (VOM). Furthermore, this research effort will focus primarily on anthropogenic emission, aromatic compounds and the oxygenated compounds formed as products of hydrocarbon photooxidation reactions.

The intermediates and products of tropospheric chemical reactions are compounds of vastly differing chemical natures (aldehydes, ketones, acids, halogenated hydrocarbons, nitrogen containing compounds, sulfur containing compounds, amines). Depending on the chemical nature of the compound, different requirements are imposed upon the particular analytical system employed for their quantitation and identification. The highly complex composition of environmental samples requires the use of high resolution techniques.

For gas chromatographic analysis, we will utilize glass capillary columns coated with the appropriate stationary phases to resolve the vapor phase organic compounds of interest. These stationary phases will be chosen from ones representative of the non-polar, semi-polar and polar types. The particular ones selected will be based on the chemical properties of the vapor phase organic compounds of interest. The highly complex composition of vapor phase organic materials requires the use of high resolution glass capillary columns.

Selected detectors will be utilized to identify certain specific compounds. The NPD will be used for nitrogen-containing compounds and amines; the ECD will be used for halogenated compounds; the FPD for sulfur-containing compounds. However, the ultimate confirmation of the identity of each compound will be performed using a gas chromatography/mass spectrometry/data system (GC/MS/DS).

Many of the trace species that play key roles in atmospheric chemical system are the subject of ongoing research here at Georgia Tech. A Georgia

research team consisting of senior members, Drs. Douglas D. Davis, John Bradshaw and Mr. Mike Rodgers of the School of Geophysical Sciences, is developing a new apprach to detecting atmospheric trace gases through state-of-the-art laser technology. In particular, they are interested in the detection of NO and the hydroxyl radical. Dr. Roland's research will involve the identification and concentration of organic species simultaneously with the species investigated by Dr. Davis' group.

(d) Earth Science Component

Dr. L. T. Long, Dr. A. Dainty, Dr. W. Lowell

Georgia Tech is committed to the development of a comprehensive educational and research program in the earth science which, when coupled with our efforts in atmospheric science, will result in a regional and national resource for studying the environment. A major emphasis of the School of Geophysical Sciences is to increase the research capabilities in geophysics and geochemistry. In subsection (1), we give a synopsis of the research interests of the members of the geophysics and geochemistry programs at Georgia Tech, and in subsection (2), we give the particular research capability we wish to enhance, in cooperation with the Atlanta University Center.

(1) Research Interests of the Earth Sciences Division

Earthquake seismology and tectonics in the southeastern United States have been the underlying objective of several research projects. In seismicity, current projects are directed toward understanding induced seismicity by monitoring reservoir areas and performing detailed studies of earthquakes recorded by small arrays. The mechanisms of earthquakes in the Piedmont Province have been studied in recent projects in the Clarks Hill Reservoir area and the Sinclair Reservoir area. The spectral signature of induced earthquakes has been used to speculate on the conditions of faulting and to predict the size and extent of induced seismicity. Plans are underway to study the seismicity in Alabama and southeastern Tennessee using a new seismic array. Tectonic and crustal structure have been interpreted from combinations of gravity data and seismic refraction data. Inhomogeneties in crustal thickness and composition are evaluated as possible contributing factors in the seismicity in the southeastern United States. Other projects are underway in the areas of heat transfer and thermal convection in permeable media, the thermomechanical evolution of the continental lithosphere and the modelling of continental tectronics and a study of the optical properties of ash from the El Chicon volcano. In geochemistry, research is being conducted on clay-water chemical interactions, the interaction of refractory hydrophilic organic matter in natural waters with metals and hydrophobic organic compounds, and on the diagnetic and metamorphic changes that occur in shales and salt deposits during burial.

(2) Proposed Cooperative Research

A major part of our educational growth will be in coordination with the AUC. We are planning an expansion of our undergraduate program to a major degree program which will include a dual-degree component with the AUC member institutions. The AUC has implemented an undergraduate educational program,

which includes geology, geochemistry, and geophysics (see Appendix D). Our efforts will concentrate on providing support for this program and increasing the research efforts in the earth sciences program at AUC.

The implementation plan for the earth sciences component concentrates on developing a modern and strong research capability at Georgia Tech and the AUC, as well as the development of a competitive educational program. A most pressing need is for an earth scientist in the AUC to coordinate and develop the earth sciences component. This person will be partially supported by the AUC institutions. His responsibilities will be to teach and develop the research liasion between Georgia Tech and the AUC. Also involved will be Drs. Tim Long, Antion Dainty, and Bob Lowell. This faculty will provide teaching manpower, as well as assist in the development of a joint research capability. Presently, Dr. Lowell teaches the geophysics course in the AUC. Drs. Long and Dainty will assist in joint research efforts, seminars, and the short courses described below.

It is important that we develop a research link with the AUC in the beginning stages of this program. To achieve this objective, we are requesting funds for the installation of two seismic display stations. The School of Geophysical Sciences operates a telemetered seismic network of about 30 stations in Georgia, Alabama, Tennessee and South Carolina. This network is used to study seismicity and seismic hazard crystal structure induced seismicity and the scattering of seismic waves (funded by AFOSR). This network is a major research tool for students in geophysics. Ground motion at these seismometers is transmitted by modulated carrier tones over phone lines to Georgia Tech, where it is recorded on analog paper records. One seismic display station will be installed at the AUC. Eventually, we hope to install at the AUC, a demonstration intermediate-period (0.05 to 5 Hz) seismograph. This type of system has optimal response for obtaining exciting results in an urban environment. The system will consist of a long period seismometer, clock, amplifier, and visual seismograph in a display case. This system will also have the capability for digital analysis of selected events, as well as data storage.

The display station will also be used in the yearly short courses and seminars to be presented in cooperation with the AUC.

Given the above research capability and commitment to educational development, we have the opportunity to further develop and solidify our unique cooperative efforts with the AUC.

III. Proposed Plan for the Development of Graduate Research Opportunities

The close interaction between the AUC and Georgia Tech has been adequately described in Section I and Appendix C. It is important to note that several of our faculty have had a long history of direct involvement with the AUC. In 1971, Dr. Kiang and his colleagues established the Clark College Research Group for involving undergraduate students from the AUC in experimental and theoretical research activities related to atmospheric sciences. Dr. Hall, a graduate of Morehouse College, has been a faculty member in the AUC since 1974. Drs. Lewis and Roland are graduates of Morehouse and Clark Colleges, respectively.

The overall joint Georgia Tech and AUC research and educational program in earth and atmospheric science consists of three components: (1) the development of research programs, (2) the development of educational programs, and (3) outreach programs.

This proposal, in addressing the first component of the overall plan, seeks funding for a three-year continuation of our program. The second component emphasizes the development of an undergraduate curriculum leading to a degree in earth and atmospheric sciences. Substantial progress has been made in this direction. Morehouse College offers a minor degree in the earth and atmospheric sciences, and plans are underway to make this degree Center-wide, with eventual expansion to a full-scale major program. The third component has been submitted to ARCO Foundation and NSF for funding consideration. This component provides support to honor sutdents at the AUC who participate in a year-round research program offered at the AUC and Georgia Tech. During the summer, these students are exposed to research in various professor's laboratories and are offered courses designed to broaden their scope, as well as participate in a specific project.

In this proposal, we are requesting support from NSF to support faculty time devoted to this program, and to purchase additional instrumentation to provide further strengthening of our research capabilities and the interaction with the AUC. A detailed description and justification of faculty time, instrumentation, and technical staff are given in the following subsections. Subsection (a) will cover the continuation and further generation of research efforts between Georgia Tech, the AUC, Jackson State University, and other minority institutions. Subsection (b) will cover our continued efforts to develop research capabilities to attract interest in our program and solidify the joint research projects between the AUC, Georgia Tech, and other minority institutions.

For the first grant period (1980-1983), Dr. Kiang was the overall project director of the program. Dr. Kiang presently serves as Director of the School of Geophysical Sciences, and Dr. Hall will assume the responsibility as project director. Drs. J. Hall, L. Roland and L. Lewis will be supported half time by the grant, and hold joint appointments with the AUC. Dr. Kiang will serve as a faculty associate. Dr. Lowell will have three months support per year, while Drs. Long, Dainty, Chameides, Alyea, Graham and Justus will have one month's support per year, and will be involved in the research and educational aspects. It should be noted that Dr. Lowell has a commitment to teach a course at the AUC for one semester's time.

(a) Generation of Research Interactions

As outlined in our original proposal, we plan to provide opportunities for research interactions between Georgia Tech, the AUC, and other minority institutions which will allow minority students to participate in graduate research programs in atmospheric and earth sciences. Our plans include the following mechanisms which we have found to be successful:

1. To organize seminars and short courses in the fields of atmospheric and earth sciences for the faculty members at Georgia

Tech, AUC, and regional minority colleges.

We will continue to offer weekly seminars in the fields of earth and atmospheric sciences for faculty members and students from Georgia Tech and the AUC. The speakers, as before, will be from Georgia Tech, the AUC, other universities, national laboratories, and industry. We also will give a series of seminars at selected minority colleges each fall. Each spring quarter, we will continue to offer short courses, lasting two to three days at the AUC, JSU, and other selected minority colleges. These seminars and short courses are invaluable means for increasing the scientific interaction and promoting interest. $5,000-8,000 of the requested travel money will be used to support these activities.

2. To continue the development of joint research programs at Georgia Tech, the AUC and regional minority institutions.

Drs. Hall, Lewis and Roland will play an instrumental role here. Their roles will be the solidification of the joint research programs with the AUC and Jackson State University, as well as the initiation of new efforts with other institutions.

3. To continue the development of the undergraduate instructional program in the AUC, and to assist JSU in its efforts to expand its undergraduate program in meteorology.

We are requesting funding for 25% of Dr. Hall's time to coordinate the implementation of these above activities. Drs. L. Lewis and L. Roland will play instrumental roles in the joint proposal activities, as well as in the coordination of the short course and seminar programs. Additionally, Dr. Hall has the resonsibility of directing the development of the educational programs with the AUC, Inc., and Drs. Lewis and Roland will teach one course each semester at the AUC. Other faculty who will be closely involved are Drs. R. Lowell, T. Long, A. Dainty, F. Alyea, W. Chameides, C. Justus, G. Grams, and C. S. Kiang.

Dr. Lowell will aid in the implementation of joint research programs in geophysics, and will teach one course in the AUC, one semester in each year. Drs. Long and Dainty will be responsible for the implementation of the seismic network and the installation of a monitoring station at the AUC. Dr. Chameides and Dr. Alyea will work closely with Dr. Hall in developing models for the global distribution of sulfur, using experimental data obtained by Dr. Hall's laboratory as input data to modelling programs. Most of this computational work will be performed on the DECSYSTEM 20 computer at the AUC. Drs. Kiang, Grams, and Justus will provide assistance with the short courses, and participate in joint research development with Drs. Lewis and Roland. Drs. Lewis and Roland will devote most of their time to research in coordination with the AUC. Dr. Lewis will be involved in numerical modeling of the solar radiation and radiation transfer processes, as well as lidar instrumentation development for the MARV (Mobile Atmospheric Research Vehicle). The MARV is not only a valuable research tool, but it has proved to be a tremendous asset to our short courses, giving participants a first-hand view of atmospheric research instrumentation. Table 3 gives the allocation of time and responsibility to research for senior

personnel. The time allocations in the budget sections reflect this time from Table 3, plus the time devoted to the short course and seminar development. For example, in Table 3, three weeks are allocated for Dr. Grams' research participation, with the remaining one week for short course and seminar development.

(b) Development of Research Capabilities

We briefly describe in this section the items of equipment we propose to purchase in order to strengthen our capability and increase our research interaction with the AUC. In order to implement Dr. Lewis' research program, Georgia Tech is committing funds for a spectroradiometric research system at a cost of $20,000, and we are requesting from NSF a pumped dye laser at a cost of $8,500. The spectroradiometer system will be used for boundary-layer characterization (Section II (a)), and the pumped dye laser will be mounted on the MARV for lidar studies. Dr. Roland is interested in atmospheric chemistry, and in applications of high resolution gas chromatography for the qualitative and quantitative analysis of organic compounds in the environment. His present research capability includes a gas chromatograph/mass spectrograph, and we are requesting only supplies for Dr. Roland's research. Georgia Tech is committing $19,000 in the second year for necessary equipment for Dr. Roland's spectrometer. The materials and equipment requested for Drs. Lewis and Roland are important for their development as contributing scientists in our program, allowing them to begin the development of a research program of their own. Finally, the seismic equipment requested ($24,500) in the first year, will not only be an important addition to our research program at Georgia Tech, but will also provide the AUC with the capability for attracting new faculty and students to their program.

V. Summary

We are requesting $615,992 from NSF for the continued development of graduate research opportunities in earth and atmospheric sciences with the AUC. The funds requested will support the following components:

(1) Joint-development of specific research programs;

(2) expansion of the program to include research in the earth sciences; and

(3) short-courses and seminars for selected regional minority institutions.

Additionally, complementary efforts will go into assisting the AUC in the development of graduate and undergraduate educational programs, and in the development of outreach programs to involve high school science faculty and students in a high-technology field.