Norfolk State University

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Research Experience in Earth System Science

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Appendix A – Paper on REESS to be published in Proceedings of 90th Indian Science Congress, Bangalore, India, January 2003

1. INTRODUCTION

The truly interdisciplinary nature of Earth System Science lends itself to the creation of research teams comprised of people with different scientific and technical backgrounds. In the annals of Earth System Science (ESS) education, the lack of an academic major in the discipline might be seen as a barrier to the involvement of undergraduates in the overall ESS enterprise. This issue is further compounded at minority-serving institutions by the rarity of departments dedicated to Atmospheric Science, Oceanography or even the geosciences. At Norfolk State University, a Historically Black College, a six week, NASA-supported, summer undergraduate research program (**REESS** - Research Experience in Earth System Science) is creating a model that involves students with majors in diverse scientific disciplines in authentic ESS research coupled with a structured education program. The project is part of a wider effort at the University to enhance undergraduate education by identifying specific areas of student weaknesses regarding the content and process of science. A pre- and post-assessment test, which is focused on some fundamental topics in global climate change, is given to all participants as part of the evaluation of the program. Student attitudes towards the subject and the program's approach are also surveyed at the end of the research experience. In 2002, 11 undergraduates participated in REESS and were educated in the informed use of some of the vast remote sensing resources available through NASA's Earth Science Enterprise (ESE). The program ran from June 3rd through July 12, 2002. This was the final year of the project. The project web site has been maintained since 1998 and can be viewed in its final state at http://watson.nsu.edu/reess/.

2. OBJECTIVES

A. Introduce undergraduate MSET students to relevant aspects of ESE programs and encourage usage of on-line NASA resources.

B. Provide an enriching experience of scientific investigation in Earth System Science within a collaborative interdisciplinary group.
   (1) Exploit the Stratospheric Aerosol and Gas Experiment II (SAGE II) data for the determination and understanding of the global atmospheric water vapor variations from high to low tropical storm activity years and atmospheric aerosol concentrations influence in ozone depletion.
   (2) Enhance SAGE II data visualization techniques
   (3) Study the earth radiation budget using the Earth Radiation Budget Experiment (ERBE) satellite data.

C. Provide research opportunities and educational experiences to students from institutions that are underrepresented in the ESE programs. This includes Historically Black Colleges and Universities, Hispanic Serving Institutions, and Junior Colleges.

3. INSTITUTIONAL BACKGROUND

Founded in 1935, Norfolk State University is one of the largest historically black institutions in the nation with an enrollment in excess of 6,000 students. While Norfolk State offers a broad range of liberal arts programs, the university is particularly dedicated to quality education and research in the sciences, along with an extensive teacher-preparation program.

The 1986 establishment of the Dozoretz National Institute for Minorities in the Applied Sciences (DNIMAS) scholarship program is an example of Norfolk State University's commitment to providing increased educational opportunities for minority students in the sciences. The Dozoretz Institute provides full scholarships, housing in an honors dormitory and a required three-week summer transition program with intensive preparation in mathematics, physics and study skills. Partly due to the implementation of the DNIMAS program, NSU is now ranked tenth nationally among all institutions in the number of baccalaureate degrees in the physical sciences awarded to African Americans.

In order to maximize the opportunities provided to students in the summer through research internships, the BEST Lab (Bringing Education & Science Together) which operates REESS, works closely with the Center for Materials Research on campus. Thus, joint educational and social activities are offered for students in the summer programs funded by NASA and the National Science Foundation at these respective Centers. This strong collaboration in undergraduate research experiences has culminated in awards from the NASA PAIR program (2000) and NSF HBCU-UP program (2002) to continue these activities, built in part on the model developed and refined in REESS.

4. PROGRAM DESIGN

4.1 Students

One of the principal goals of REESS is to expose a large community of undergraduate science majors to the possibilities of research careers in Earth System Science. In addition, the professional NASA research teams we collaborate with are constituted of people with different academic backgrounds. Hence, student participants in REESS over the past two years have majored in biology, geology, geography, computer science, chemistry and physics. In addition, community college students were recruited. This part of the college population is often overlooked in the more established summer research programs for undergraduates. In building the pipeline of future minority scientists, an early research experience has been shown to be a positive catalyst [1]. REESS has therefore no restrictions on academic status for applying i.e., full time students from freshmen through seniors have been eligible to apply.

To increase diversity, in 2000 and 2002, a special attempt was made to recruit students from Puerto Rico, a strategy that was generally quite successful.

For 2002, the REESS participants were:

Name	Institution	Classification & Major
Digital Earth Group		
Nievita Hartness	University of Arizona	Sophomore/Geoscience Education
Martin Senica	Northeastern Illinois University	Junior/ Mathematics
Katie Nealiegh	Wright State University	Sophomore/Undecided
SunDIAL Group		
Pamela Majumdar	Old Dominion University	Sophomore/ Engineering
Wesley Cuffee	Norfolk State University	Senior/Computer Science
Devin Harper	Howard University	Sophomore/Undecided

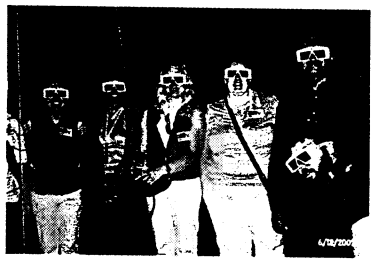
SunRISE Group		
Taina Cleveland	Norfolk State University	Sophomore/Chemistry
Evelyn Acevedo	University of Puerto Rico, Mayaguez	Senior/Physics
Maxim Noginov	Ocean Lakes High School, Va.	High School Senior (unpaid)
Virtual Reality Group		
Vladimir Oliveras	University of Puerto Rico, Mayaguez	Senior/Industrial Engineering
Kristin Hehe	College of William & Mary	Sophomore/Chemistry

Two other students – Jose Rivera (University of Puerto Rico at Rio Piedras) and Vanessa Michelou (University of South Carolina) started the program but had to withdraw due to illness.

4.2 Educational Activities

A series of structured **educational** activities were scheduled in the first two weeks of REESS to give students some of the necessary tools in the content area to effectively tackle their research topics. In addition to readings from a textbook [1], students were given training exercises in Microsoft Excel, Satellite Tool Kit [2], WorldWatcher [3] and as necessary, specialized tools such as vGEO (a virtual reality programming language). The whole mentor team delivered lectures on global climate change issues, with respect to the physics, chemistry, instrumentation or data collection/assimilation aspects.

Also included in the educational package were trips to local installations. At NASA Langley Research Center, the REESS students took at tour of the Distributed Active Archive Center's CAVE. They interacted with satellite data rendered in virtual reality by employees of VRCO, the company that markets the vGEO software used by one of the REESS groups (details below). The REESS group also took a trip to Old Dominion University to visit their Virtual Environments laboratory where they were hosted by Professor Bowen Loftin and his staff and shown a variety of applications of visualization for research and education.



In order to provide students hands-on experience with climate change protocols important to NASA, REESS students were provided training in GLOBE (GLobal Observations to Benefit the Environment). For most of the six weeks of the program, students collected and reported data on GLOBE atmosphere and hydrology protocols. Each group had an assigned responsibility for a measurement in a particular week. On the 2nd Saturday of the program, the REESS students participated in a MUC-A-THON with a group of local K-12 teachers at a site in Churchland, Portsmouth, VA. This experience was unique and educational for all the students involved.

A few joint sessions of Atmospheric Science research were held with Hampton University's Center for Lidar for Atmospheric Science Students (CLASS). Their Lidar instrument was transported to NSU for a week during late June and students from both institutions made presentations to their peers about their ongoing research. Dr. Wei Gong, a post-doctoral associate provided technical leadership for the Hampton University

students. Previous discussions between REESS co-Investigators and Dr. Doyle Temple, PI of the Hampton project facilitated the interfacing of the two groups.

Finally, a trip was arranged over July 4th weekend to take the students to Washington D.C., for exposure to the National Air and Space Museum and other educational sites. The PI, Dr. Chaudhury, personally drove the students to Washington. The students learned a lot and thoroughly enjoyed themselves at the various museums.

4.3 Research Activities

In the first week of REESS the students were divided into small groups. The groups were designed to have multiple academic majors represented and the project directors made initial personnel assignments. The breakdown of the groups is shown in the table below. Each summer several of Norfolk State students working on some of our other related projects join the REESS student activities during the period of the program. In 2002, other NSU students and staff acted as group liaisons to assist the faculty members with the REESS activities. Principal amongst them were Barbara Cooper-Pabis, formerly a REESS participant who now works as a staff member of the BEST Lab research team. Also serving as a liaison was Kerry Lee, NSU Biology graduate and BEST Lab Scholar, who had 12 months experience working with Drs. Chaudhury and Rodriguez.

Group	Mentor	Institution
Digital Earth	S. Raj Chaudhury	NSU
SunDIAL Group	Prathap Basappa	NSU
SunRISE Group	W. J. Rodriguez	NSU
Virtual Reality	Shanda Harper	NSU

The table to the right shows the assignment of mentors to groups. The project mentors suggest possible research topics since the students coming into REESS rarely have much appreciation of the types of topics that are of current interest to ESS researchers. In addition to the co-Investigators, Dr. Chaudhury and Dr. Rodriguez, the 2002 group mentors featured Dr. Prathap Basappa and Ms. Shanda Harper, Department of Computer Science at NSU as group mentors. Dr. Basappa had worked during the academic year with the BEST Lab faculty and brought expertise in instrumentation and computer-based data acquisition to the team, while Ms. Harper brought an extensive knowledge of Unix and an interest in exploring visualization in virtual worlds.

At the end of the first week, students made group presentations on their initial literature search/Internet search on the topics they selected. These weekly oral presentations helped provide focus for the group's work during the week. It also provides an opportunity for some students to become familiar with professional graphics and presentation tools. The format of typical national meetings of scientific societies is followed – 10 minute talk, followed by 2 minutes for questions. Each person in the group is required to speak. Ms. Cooper-Pabis provided individualized instruction to each group member that requested it, in PowerPoint and the basics of multimedia presentations. All groups were exhaustively critiqued during their presentations. The constructive feedback leads to steady improvement in the presentations over the six-week period of the program.

In addition to the weekly oral reports, students sequentially assemble the necessary parts of their final research paper starting the very first week.

- Week 1, involved an overview of the topic;
- Week 2, background information was presented along with more global issues connected to the topic e.g. societal or economic impact. Students began to address the methodology section of their research – i.e. start to identify which datasets to use, which visualization tools to use etc.
- Week 3 was a time when students further refined their methodology and began to generate some preliminary results for discussion with the group as a whole
- Week 4 students focused on the results section of their paper and generate a large number of plots and visualizations from which to draw their analysis
- Week 5 and part of week 6 were devoted to the analysis and conclusion sections
- At the end of Week 6 the final oral presentations are made, final completed papers were due, and the closing ceremony was held.

This particular model allows for the entire research paper to be completed in the short six-week program period. More importantly it (a) does not allow much room for student procrastination (b) breaks the writing task into short, manageable segments and (c) allows the mentors to provide ongoing constructive feedback. Of course some of the paper-writing steps are iterative and frequently, as in any research, students need to refine methodologies and re-generate data products in the final weeks to answer ambiguities in their analysis of the phenomenon.

4.4 Student Projects

4.4.1 **Digital Earth** Natural Disaster Readiness Activity
Mission Statement: To develop an interactive student module, utilizing inquiry based learning, demonstrating the link between the El Nino Southern Oscillation (ENSO) anomaly and its effects on certain natural disasters in the United States, specifically:

· Floods, Landslides, Drought and Fires

Methods include data mining, focusing on information found on government websites, primarily:

· National Oceanic and Atmospheric Administration (NOAA)
· National Climatic Data Center (NCDC)
· National Aeronautics and Space Administration (NASA)
· United States Geological Survey (USGS)

4.4.2 **SunRISE** : Sunphotometry for the Regional Investigation of Species in the Environment
Mission Statement: To have a better understanding of regional effects of aerosols, particularly their differences in ocean and land environments and their contribution to the Earth Radiation Budget.

Data will be collected from CIMEL SunPhotometers at two different sites – NSU and COVE, and compared to determine particle size distribution and sources. Modeling of trajectories of aerosols will be completed with HySplit software.

4.4.3 **Virtual Reality** Group - Modeling Concepts For SAGE-II Data Using VGEO

Mission Statement: To understand the trends that may be present in SAGE II data and to learn the usage of vGEO software on NSU's virtual reality system to visualize the data in a virtual world and discover the important trends in it.

VGEO is a virtual reality program that is ideal for modeling, interacting with, and displaying SAGE-II data. This software allows for representation of time-dependent and positional data in a way that accurately reflects the data's real world form.

4.4.4 **SUN DIAL**: Sun photometer Development for the Investigation of Atmospheres Locally

Mission Statement: To assemble an inexpensive, hand-held sun photometer to monitor haze in the atmosphere and to integrate this system with a computer-based data acquisition system and a motion-control system.

A sunphotometer was built following the TERC VHS model and a Virtual Instrument was created in LabView to calculate Aerosol Optical Thickness given the standard input parameters such as LED voltage, universal time, solar zenith angle etc.

5. PROGRAM OUTCOMES

5.1 Challenges

The short time period, the variety of projects and the diversity of students all pose challenges for us in the implementation of this program. We had anticipated problems with the highly specialized use of computers the program necessitated and possible student difficulties with the Earth System Science concepts they would encounter. These were addressed with hands-on dedicated tutoring and mentoring. It is worth observing here that two principal challenges that the REESS students faced which we had not anticipated were (a) lack of ability to work cooperatively in groups and (b) lack of creative problem solving skills.

Item (a) speaks to the nature of introductory college science courses, which promote individual achievement and rarely allow students to tackle meaningful problems in a group setting. Tobias [4] has identified this issue as one that often dissuades 'second tier' students from majoring in the hard sciences. 'Second tier' students typically have the academic preparation and aptitude to succeed in science disciplines but choose not to do so. Certain students, regardless of academic achievement, need assistance to productively work in groups. This has been the case in REESS. Item (b) above is also a byproduct of students learning problem solving strategies based around getting the "correct" answer to "end-of-chapter" questions. In a research environment the "proper question" needs to be identified before one can even address the issue of finding the "correct" answer. As a group, REESS students have demonstrated difficulty in applying problem solving skills to the technical and scientific barriers they encounter in their six-week stay at Norfolk State University. Whether it be a problem with a malfunctioning computer or a problem with the interpretation of remote sensing data, we have had to continuously monitor each group's progress and intervene almost daily to keep them on task.

5.2 Assessment and Evaluation

The pre- and post-assessments on fundamental topics in ESS that we administer each year have revealed that students leave REESS with a greater knowledge base than which they entered, including knowing the "reason for the seasons".

Over the duration of the project, independent observers from academia and NASA have praised the presentation skills and technological skills demonstrated by the students by the end of the program. They were invited to the Final Presentation session, which was held on July 12, 2002 in the final year of the program.

A number of students have applied to REESS in the past based on recommendations by former participants. Thus, overall student satisfaction with the program, as measured by recommendations to peers, is high. An evaluation form, based on a Likert Scale, was used to gauge student interest in the area of Earth System Science as a result of this program and a overall score of **3.75/5.0** was compiled. In a residential program, there are certain logistical problems, such as housing and meals that are outside the purview of the investigators. REESS did not score highly on those issues. On this portion of the survey, students gave the program a **2.5/5.0** rating. On the mentor interactions, the ratings have varied from year to year and mentor to mentor – however the principals Dr. Chaudhury and Dr. Rodriguez have always scored at about **4.0/5.0** in terms of student satisfaction with their roles.

In 2002, REESS Program Manager (supported by other funds), Ms. Cooper-Pabis acted as internal evaluator for the project – designing the questionnaire used, providing formative evaluation comments and feedback to the faculty and steering students towards successful outcomes from an attitudinal perspective.

5.3 Presentations and Publications

Several REESS-related presentations and publications have been completed by Drs. Chaudhury & Rodriguez. These have included national and international meetings of societies related to Earth Systems Science and Geoscience. A copy of the final paper on this project, to be presented at the Indian Science Congress 2003, is attached to this document.

a. W. J. Rodriguez & S. R. Chaudhury, "Research Experience in Earth System Science at Norfolk State University", Proceedings of the Eighth NASA MU-SPIN Users' Conference, Albuquerque, NM, 1998
b. S. R. Chaudhury & W. J. Rodriguez, "Diversifying Earth System Science Education – the Undergraduate Research Model," Proceedings of IEEE IGARSS 2000, Honolulu, 2000
c. S. R. Chaudhury & W. J. Rodriguez, "The BEST Lab – Fostering the Growth of Geoscience Education at an Historically Black University", American Geophysical Union, Spring Meeting, Boston, 2001
d. J. Isler, H. Rivera, W. J. Rodriguez, "Sun Photometer Development for Investigation of Atmospheres Locally," poster presented at American Association of Physics Teachers (AAPT) National Meeting, Rochester, July 2001

e. S. R. Chaudhury & W. J. Rodriguez, "Scientific Visualization & Modeling for Earth Systems Science Education," Proceedings

5.4 AWARDS

A few awards have been received by REESS program participants that can be directly related to the success of the program:

a. S. Raj Chaudhury - *Outstanding Faculty Service Award*, NASA Minority University Space Interdisciplinary Network, 2000
b. W. J. Rodriguez - *Outstanding Faculty Service Award*, NASA Minority University Space Interdisciplinary Network, 2000
c. J. Isler – *Best Student Paper*, Chesapeake Section of the American Association of Physics Teachers, Fall 2000 Meeting
d. S. Raj Chaudhury - *Millennium Award for Excellence in Teaching at Historically Black Colleges and Universities*, White House Initiative/U.S. Department of Education, 2001

6. BUDGET NARRATIVE FOR YEAR 3

Labor

For the time and effort that the PI, Dr. Chaudhury, spends in the preparation and implementation of REESS, he was compensated one-month summer salary. Dr. Rodriguez was also compensated 1.0 month salary for his role in recruiting and research mentoring. Ms. Shanda Harper was the third mentor for 2002 and she was supported from non-REESS funds, but contributed approximately 1.0 month effort to the project. These salaries were computed against the individuals' standard University contract rates.

Students

Stipends of $1,600 were granted to the students, and living expenses were provided for the six-week period. All students, including commuters were provided meals in the cafeteria.

Other Expenses

This research and educational program requires phones, faxes, and office supplies for everyday operation. Brochures and flyers are printed and widely distributed for REESS related announcements as well as for the final presentations. Twelve copies of *The Atmosphere* [1] and copies of *The Data Handbook,* B. Fortner, and several other reference books were purchased in Year 1 and distributed to students as needed. These introductory books cover topics essential to the education and research goals of the program. Software upgrades (Windows and Mac OS) as were purchased to assist student teams in completing their projects, as were supplies for the large format poster printer and desktop printers that were used by students to prepare their presentations.

Equipment

To replace aging hardware in support of REESS, two Macintosh G4 computers have been purchased. These are being used for rendering, IDL programming, digital video authoring and

driving the large format HP 500PS printer on which students created posters as lasting mementos of their experience.

Travel

REESS students traveling from out of state were provided reimbursement of travel expenses. Since students were recruited nationally, some students' costs exceeded the initial targeted $500/student, but the balance of commuters and out-of-towners enabled the project to stay within budget. For additional education and recreation, 3 group field trips were undertaken. One of these was to Portsmouth, VA for a GLOBE fieldwork event. One was to Washington D.C. to visit museums and the final one was to Busch Gardens.

Overhead

Indirect costs have been charged at the University's negotiated rate of 49.5% of salaries and wages only. The benefits have been charged at the University's negotiated rate of 7.65% for summer salaries and part time wages.

8. SUMMARY

Over its duration, the rigorous 6 week Research Experience in Earth System Science (REESS) program exceeded expectations in educating undergraduate science students in the manipulation, interpretation, and understanding of remote sensing data. This was achieved by the assignment of research projects relevant to ESE coupled with an educational program. Faculty mentors guided the students through the entire scientific process, from the initial literature search to the final report. Since research projects were very specific, an educational component was incorporated into the REESS in order to broaden the experience. This component exposed students to other topics relevant to ESE which may have not been covered by the research project alone. A lecture and seminar series provided a background on various topics of interest. The literature and World Wide Web searches exposed the students to data from other satellite platforms acquainted them to a variety of remote sensing data. At the end of REESS the students, had an understanding of the earth as a coupled system in which many interactions are critical to climate change, understood satellite data manipulation and image creation, were capable of accessing and interpreting satellite images via Internet, and some of them became inspired to pursue further work in atmospheric sciences.

REESS also provided research opportunities and educational experiences to students from institutions, which are underrepresented in the ESE programs. This included Historically Black Colleges and Universities, Hispanic Serving Institutions and Junior Colleges.

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[1] F.K. Lutgens and E.J. Tarbuck, "The Atmosphere", Seventh Edition, Prentice Hall, 1998
[2] Satellite Tool Kit, Analytical Graphics, Malvern, PA
[3] *WorldWatcher*, Northwestern University, Evanston, IL (http://worldwatcher.nwu.edu/)
[4] S. Tobias, "They're not dumb they're different: stalking the second tier", Research Corporation, Tucson, 1990