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The LBL/AGMEF/JSU El Yunque Environmental Research Initiative

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The LBL/AGMEF/JSU El Yunque Environmental Research Initiative#

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Abstract:

The LBL/AGMEF/JSU Environmental Research Initiative has had several noteworthy successes. Faculty and student development is apparent. A research project involving atmospheric aerosol sampling was established at Universidad Metropolitana under Prof. Fernando Diaz. A National Science Foundation grant received to expand upon that project. Review of analyses carried out since 1986 supports the original view that El Yunque peak on the eastern end of Puerto Rico offers a unique site to study atmospheric processes relevant to current national and international concerns regarding global climate modification. Based on this review, a Puerto Rico El Yunque Intensive Summer Research Campaign is proposed.

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Introduction:

The Anna G. Mendez Educational Foundation (AGMEF) wants to develop graduate studies in the physical sciences at Universidad Metropolitana (UMet) and Universidad del Turabo (UT). As an integral part of such studies, a research program needs to be instituted. Projects in this research program need to be of a quality which would be accepted by the scientific community, and also need to fit faculty time, budget, and space constraints. Additionally, the projects should be interesting to students and suitable for substantial involvement on their part. The JSU/LBL/AGMEF Consortium[1], established to improve science teaching and research at the member minority institutions, was the obvious choice for instituting this new program.

Lawrence Berkeley Laboratory has had ongoing collaboration with Jackson State University (JSU) in aerosol particle research. Dr. Cass Parker, of the JSU chemistry department, studied with the LBL's Atmospheric Aerosols Group (AAG). Two graduate students from that department have also completed part of their thesis research at LBL studying aerosol particles; and Dr. Parker's group has an ongoing project to characterize the atmospheric aerosol particles in Jackson, MS. In addition to LBL's resources, a strong related research effort at the nearby Rio Piedras campus of the University of Puerto Rico provided the potential for support and collaboration for an atmospheric research program at UMet. It was proposed that the AAG extend their existing collaboration with JSU to include AGMEF. Dr. T. Novakov, leader of the AAG, and Dr. Fernando Diaz, physics professor at UMet, are the principals in this collaboration. An initial goal was to collect filter samples of ambient aerosol particles on or near the UMet campus and to analyze them at LBL. This exploratory investigation of the particulate content of the air helped to identify fruitful areas of research, and the operation of such a collection program established the capabilities of the UMet students and staff to provide the manpower support for the project. Student and faculty participation in chemical and physical analyses at LBL served as training for later work at UMet.

Development:

Puerto Rico was judged to be a very desirable site to study the atmospheric chemistry of local emissions because it is located in prevailing winds blowing from the east off the Atlantic Ocean, with no large anthropogenic sources of air pollutants within 5000 kilometers in that direction. The island has a population of 3.3 million, with approximately 1 million automobiles, but lacks the diversity of pollutant source types that serve to confuse atmospheric chemistry in many other locations. The trade

winds through much of the year assure that urban air pollution in Puerto Rico is local and freshly emitted.

During late winter and early spring of 1986, the necessary equipment was assembled at LBL from the Atmospheric Aerosols Group and from purchases made with funds from the Office of Minority Outreach Programs. Mr. Dick Schmidt, a technician in AAG with extensive experience in constructing and maintaining aerosol research equipment, travelled to UMet to assemble and test the equipment and to provide training in its operation to the staff. Two separate filter samplers and a meteorological package were installed adjacent to UMet on the roof of WTMJ-TV, an educational station operated by AGMEF. Dr. Diaz and Ms. Wallis Medina, a chemistry instructor, were trained to operate the equipment, with Ms. Medina overseeing the routine operations. Filter samples were collected for the atmospheric project under the direction of Dr. Diaz, and for archives for future use in a biological science research project.

The initial work in the spring of 1986 established the capabilities of the collaborators to collect and analyze aerosol particle samples. The analyses were broadly based elemental surveys, encompassing as many of the possible pollutants as practicable. The analyses were also selected to be readily transferable from LBL to UMet, and to be of types that could be effectively used by the undergraduate students. The sample collection protocol was designed to provide material and information that could be used by physical and biological sciences. Basic meteorological data were collected, providing a basis for sample evaluation as well as for transport modeling. Particle samples were collected on both high- and low-volume filters. The daily sample collection was performed by a student team. Depending on their intended use, the filters were either archived at UMet or sent on a frequent basis to LBL for analysis and archiving.

During the summer of 1986, Dr. Diaz, Ms. Medina and Ms. Wanda Reyes, a student from UT, came to LBL to analyze the samples collected during the previous spring. Each was analyzed for trace elements by x-ray fluorescence spectroscopy (XRF), for total carbon (TC) and black carbon (BIC) by combustion and optical attenuation, and for soluble ions by ion chromatography (IC). The visitors were responsible for all phases of the analyses, with the exception of the XRF analysis. Assistance and direction was provided as needed by AAG staff scientists Dr. Henry Benner, Dr. Tony Hansen, Dr. Lara Gundel and Dr. Ray Dod. The data from these

analyses were collated and entered into a p.c.-based spreadsheet for reduction and analysis.

The results of this initial season of sampling[2] were used to help define the program for the coming year. The carbon combustion analysis, as well as some supporting combustion thermal analyses, indicated the presence of large quantities of biogenic carbon, rendering the measurement of limited use. Sulfate was present in amounts consistent with a source other than sea salt and fuel oil combustion, the two expected contributors. High levels of particulate mercury were also observed during the March-May sampling period, with temporal patterns indicating that local anthropogenic activities were the source.

The focus therefore became the continuation of sample collection at the Rio Piedras site, as well as planning for a project to look at the "excess" sulfate, using a site in a remote area upwind of the San Juan metropolitan area. Concurrent research at LBL had indicated that significant production of sulfate can occur in cloud and fog droplets[3]. The very humid air that predominates in the Caribbean during much of the year can easily form clouds, thus providing conditions appropriate to the study of aerosol sulfate production. The central spine of Puerto Rico is a mountain range, typically 800-1400 m. in elevation, the top of which is frequently in convective or orographic cloud. The remote site selected was on El Yunque, a 1050 m. mountain in the Caribbean National Forest on the eastern end of the island, at an antenna complex operated by Puerto Rico Telephone Company.

The most appropriate agency to support the research project on El Yunque is the National Science Foundation (NSF), through their Minority Research Initiation Program. Dr. Novakov of LBL made inquiries of NSF to determine their level of interest in the proposed project, and to refine the focus of the work. Using this information, and with substantial assistance from LBL and Dr. Novakov, a proposal was prepared and submitted by Dr. Diaz of UMet, for funds to carry out a research project on cloud and aerosol particle chemistry, primarily based on the proposed El Yunque site.

To facilitate prompt initiation of research when the project was funded, either from NSF or other sources, it was decided to establish and instrument the mountaintop location. In January 1987, Mr. Dick Schmidt, using LBL support, constructed a platform on the site and installed an automatic filter sampler which had

been built at LBL and modified for this purpose, together with a fog (cloud) detection system and an automatic cloud water collector, also of LBL manufacture. For a variety of reasons, the equipment was not immediately placed in service, but rather was maintained in a stand-by condition. At the same time, a dichotomous sampler capable of fractionating aerosol particles by size and collecting them on filters was installed at UMet, on loan from the LBL Atmospheric Aerosol Group. Particle size, in addition to composition, is useful in elucidating the chemical reactions which may have played a part in the formation and/or transformation of the particles. The necessity for manual changes of filters with this sampler made it unsuitable for use at the mountaintop location.

During the summer of 1987, Dr. Diaz, Ms. Reyes and another student, Ms. Deborah Rivera, were brought to LBL for training in sample collection and analysis in a program designed to closely parallel the proposed El Yunque project. This training was under the supervision of the Atmospheric Aerosol Group staff, with Dr. Diaz the designated leader. The value of the summer training was compromised by the uncharacteristic lack of summer fog (marine stratus) in Berkeley. At the conclusion of the summer, however, the group was felt to be adequately trained to commence an episodic sampling regime using the El Yunque site. The team was unfortunately immediately broken up, with Ms. Reyes staying at LBL for the fall semester co-op program, and Ms. Rivera transferring her studies from UMet to UT.

In August, Mr. Dick Schmidt was again sent to Puerto Rico to repair and refurbish the equipment, both at UMet and on El Yunque. No individual had been identified at the AGMEF institutions capable of performing routine maintenance on the equipment, an obvious significant impediment to research progress. The equipment at UMet was restored to operation, while the station on El Yunque was held in a standby state, pending availability of personnel to service the site.

In the fall of 1987, Dr. Dod travelled to Puerto Rico in order to assist in starting a sampling period at the El Yunque site. The equipment was checked out and placed in operation, and a limited number of cloud water samples were collected, but operational problems with the heated-inlet sampler caused particle sampling to be unsuccessful. The recorder for meteorological data failed during this period, and particle sampling was discontinued to avoid expending supplies on samples which could not be fully supported as to source. The fall semester closed prior to the

recorder being restored to service, consequently, while some cloud water was collected, the corresponding particle samples were not taken.

During the spring semester, additional problems with the equipment and personnel were sufficient to preclude collection of further samples at the El Yunque site. It became apparent at this time that although the electric power at the site was protected by an emergency generator, the time required for the automatic changeover of power source was sufficient to cause a reset of the electronic controls of the automatic filter sampler.

The JSU/LBL/AGMEF Consortium environmental workshop, held in San Juan in the spring of 1988, developed interest in collaborative environmental research among several AGMEF faculty members who had not previously been involved. Chemistry professor Dr. Luis Feliu of UMet spent the summer with the Atmospheric Aerosol Group, working with Dr. Dod and Dr. Lara Gundel of the Indoor Environment Program's Organic Chemistry Group (and formerly with the Atmospheric Aerosol Group), learning new analytical techniques and investigating the concentrations of certain classes of organic compounds in ambient aerosol particles collected on the UMet campus. Chemistry professor Dr. Guillermo Martinez and mathematics professor Dr. Jorge Sarmiento of UT were also involved in other facets of environmental research with actual or potential application to the atmospheric projects. Ms. Lourdes Valentin, a chemistry student at UT, worked in the Atmospheric Aerosol Research Group on the analysis of particle samples collected at UMet, investigating in particular samples collected during episodes of high concentrations of African dust, a periodic occurrence in the Caribbean. The choice of Ms. Valentin was particularly appropriate for this task as she had been involved in the Atmospheric Project at UMet prior to her transfer to UT.

The atmospheric research proposal, "Aerosol and Cloud Chemistry at El Yunque Peak in Puerto Rico" submitted by Dr. Diaz, was funded by the National Science Foundation for a period of 1.5 years starting in September of 1988, at a level of $30K. This provided the impetus to commence more active work on the El Yunque project. Dr. Dod spent several weeks in Puerto Rico during September and October, first refurbishing and repairing malfunctioning equipment, installing a power supply to assure uninterrupted power to the electronic controls of the sequential sampler and assisting in bringing the facility to full operation. Collection of cloud water and corresponding particle samples was carried out continuously from late September

until late November, with only minor equipment malfunctions. The basic operating protocol for the El Yunque station was at last established.

Analysis in Puerto Rico of the collected samples has been limited to pH measurements on the water samples, and the remainder of the water together with the particle samples were sent to LBL for analysis. An ion chromatograph and data acquisition systems have recently been installed at UMet to allow more significant analyses to be carried out in a more timely fashion, and to more completely involve faculty and students in the entire chain. As data becomes available it will be necessary to reduce, analyze and correlate it in order to meet the immediate and long-term needs of the project. The current project will provide some insight into sources of airborne sulfate in the tropical background air, and produce a solid database on which to formulate further hypotheses and identify fruitful and substantive avenues of research. In the two years since the proposal to NSF was first written, additional hypotheses have been proposed regarding marine sources of global background sulfate, hypotheses which could be tested using the site on El Yunque, with only minor modifications to the equipment in place. Sulfate derived from dimethylsulfide emitted from marine phytoplankton may be a substantial contributor to the global atmospheric sulfate[4], with significant effects on cloud formation and persistence. In addition, the Gaia hypothesis advanced by Lovelock[5,6] can be applied to evaluate the feedback mechanisms based on this biogenic sulfur which could have effects on global warming comparable to those expected from the expected doubling of CO_2 concentrations[4]. The mountaintop observatory established as part of this initial study has the potential to be a platform for a wide variety of future studies of these effects.

Following the spring environmental workshop, UMet chemistry professor Dr. Luis Feliu expressed interest in joining the research program. During the following summer, he participated as a visiting faculty member with the LBL Atmospheric Aerosol Group, receiving training in organic analytical chemistry from RD and Dr. Lara Gundel of the Indoor Air Quality Group. Two professors from UT, Dr. Guillermo Martinez (chemistry) and Dr. Jorge Sarmiento (mathematics), who had previously participated as summer visiting faculty at LBL were also incorporated into the overall atmospheric (or environmental) research program. All of these professors have since been granted seed funding by AGMEF to provide release time, student assistants and equipment to further develop their research projects. It is expected that these

projects will provide interaction and support for each other, strengthening the entire program.

The involvement of faculty and students from AGMEF is shown schematically in Fig. 1. Productivity, measured in terms of samples collected or analyzed, shows little correlation with the number of people involved in the project, at least through Spring 1988. This is at least in part due to the lack of an established equipment maintenance and repair capability within the AGMEF institutions. The importance of technical support can be clearly seen in the sample collection map (Fig.2), where it is apparent that after a period of approximately two years the decreased equipment reliability causes sample collection to become sporadic and halting. (The collection of high-volume filters was stopped at an earlier date due to lack of perceived need for additional samples.) Similarly, it can be seen that the equipment installed on El Yunque, being automated and in a more hostile environment, has been slow in becoming productive.

Recommendations:

The history of the atmospheric project shows that a clear goal must be in view in order to maintain progress. During the interim period when the goals of the project were changing from a survey of urban particulate content to a cloud chemistry project at a remote site, progress tended to stagnate. Lack of assurance of funding for future work caused the project to enter a holding pattern, with little apparent activity. There was minimal direct contact between the researchers at LBL and UMet during this period, which could be interpreted by those involved as a lack of interest in the project. The activities of 1988, starting with the Environmental Workshop in April, regenerated interest in the project, with a corresponding increase in participation and output.

Further and accelerated research progress will require continued institutional support, both at LBL and AGMEF, of the LBL scientists. Progress to date has been in part dependent on a significant amount of mentorship from LBL scientists, usually advising on a continuing basis the AGMEF researchers, and at times directing the research while local leadership is being sought and established. This is to be expected in this phase of the project since AGMEF faculty and students have significant academic demands for their time. However, the importance of the research to the central issue of climate change will ensure continued interest and commitment from researchers at LBL. When combined with direct participation by

faculty and staff and support for the Project's AGMEF Director, an ongoing and self-sustaining research activity will be established.

The development of research capabilities at the AGMEF institutions requires not only the development of laboratory space, but also the establishment of a support infrastructure, including technical support. Summer research opportunities at LBL for AGMEF faculty are effective introductions to current research interests, but the translation from the National Laboratory to the academic environment of their home institutions needs to be made more apparent. To those without recent experience, it is frequently not apparent that quality research can be carried out using less than optimum equipment and facilities, or with limited time availability.

LBL and JSU could assist in this transition by helping to organize and staff an intensive summer research campaign in Puerto Rico. This is a time not committed to normal instruction, provides an excellent opportunity for LBL scientists and JSU faculty to collaborate with AGMEF faculty and students in the present and proposed research projects in atmospheric and other environmental sciences. Such a program should involve several of the AGMEF faculty members who currently have funded research proposals, and a significant number of students and support personnel. One or more scientists or graduate students from LBL and JSU would be directly involved, assisting with the projects. Among the benefits of the program would be the set up and utilization of a significant number of different analytical instruments and sampling equipment. This campaign should accelerate the process of research initiation at AGMEF and shorten the time to establish a significant atmospheric research capability. Figure 3 shows the historical and proposed timelines for analytical capabilities which would be utilized for the summer campaign. It can be seen from this chart that ongoing complementary analytical capability would be established at AGMEF and JSU to supplement or supplant work that is currently being done at LBL.

The National Science Foundation funding of the Atmospheric Project, with the attendant timelines for performance, establishes the optimum projected schedule for this research program - as soon as possible. The summer of 1989 is the closest period during which faculty and students would be available for the work. Ideally, any faculty from the AGMEF institutions with research projects at least tentatively defined and some of the necessary laboratory equipment available could, and probably should, participate in the program. Participation from LBL should include a

representative of the Atmospheric Aerosol Group, with experience in both laboratory and field research, since so much of the work is related to that field. Related atmospheric aerosol work is in progress at JSU, under Prof. Cass Parker in chemistry. One of the graduate students from that group could enhance the summer program.

The Puerto Rico-El Yunque Intensive Summer Research Campaign should involve as nearly as possible a comprehensive sampling and analysis or the air, rain and clouds at the El Yunque site. A preliminary sampling and analysis plan is given in appendix A. A matrix is included showing the site and location (LBL, UMet, UT, JSU) of sample types and instrumentation required. Weekly conferences of the researchers will be held in Rio Piedras at UMet to assess progress, report results and make mid-course corrections. Academic year follow-on activities will include data analysis and reports. A wintertime conference in Puerto Rico would include invited atmospheric researchers from the larger international community to build on the base which is established by this campaign.

References and Notes

1. The Lawrence Berkeley Laboratory/Jackson State University/Anna G. Mendez Educational Foundation Consortium was established with the signing of a Memorandum of Understanding and Intent in September 1983.
2. W. Reyes, W. Medina, F. Diaz, W.H. Benner, R.L. Dod and T. Novakov, "Chemical Composition of Aerosol in San Juan, Puerto Rico," Lawrence Berkeley Laboratory report LBL-22154, 4-5 (1987).
3. M. Bizjak, V. Hudnik, A.D.A. Hansen and T. Novakov, "Evidence for Heterogeneous SO_2 Oxidation in Ljubljana, Yugoslavia," *Atmos. Environ.* **20**, 2199-2204 (1986).
4. R. Charlson, J. Lovelock, M. Andrae and S. Warren, "Oceanic Phytoplankton, Atmospheric Sulfur, Cloud Albedo and Climate," *Nature* **326**, 655-661 (1987).
5. L. Lovelock, *Gaia: A New Look at Life on Earth*, Oxford University Press, 1979.
6. The current Lovelock-Margulis version of the Gaia hypothesis is reported to be "devoid of purposefulness but still powerful" (R.A. Kerr, *Science* **240**, 393-395, 1988).

Appendix A: Preliminary sampling and analysis plan.

The primary goal of the summer research campaign is the furtherance of the "Aerosol and Cloud Chemistry at El Yunque Peak in Puerto Rico" project. The summer period has not previously been studied as part of the Research Initiative, and climate patterns are reported to be significantly different during the summer than at other periods of the year, especially with regard to long range transport of aerosol particles, reflected in the increased frequency of occurrence of African dust episodes.

The regular availability of increased staffing will allow the El Yunque site to be attended regularly, permitting the acquisition of data and samples which currently need to be done on a manual basis if they are to be done at all. In this category would be collection of time-resolved size-segregated particle samples using the manual dichotomous sampler, and the collection and preservation of rainwater samples for each precipitation event. If analysts and facilities can be found, possibly in conjunction with the University of Puerto Rico, grab samples of air could be collected and analyzed for trace gases, such as dimethylsulfide.

The Campaign should also include the acquisition of pollutant gas data at the El Yunque site, as well as in the San Juan metropolitan area. Monitoring stations operated by the Environmental Quality Board can offer some information regarding gas concentrations in San Juan and other urban areas on the island. Installation of an ozone monitor on El Yunque would be planned to add information regarding the oxidizing nature and the altitude and transport history of the individual air parcels. Other common pollutant gases, sulfur dioxide and nitrogen oxides, are expected to be at or below the lower limit of the operating range of commercial analyzers.

The work proposed by Dr. Feliu in characterization of polycyclic aromatic hydrocarbon content of the particles could be pursued both at the current site in Rio Piedras and also at the El Yunque site. Operation of the Rio Piedras samplers concurrently with those on El Yunque should provide a wealth of information regarding the contributions of aerosol particle sources between the mountain and the university. This information would be very useful to the source apportionment or factor analysis statistical studies proposed by Dr. Sarmiento. It would be expected that the information gathered during the summer would clearly identify a factor corresponding to the trans-Atlantic African dust aerosol, enabling the Evironmental

Quality Board to correctly assign the source for this frequent cause of violation of U.S. clean air standards.

We would also expect Dr. Martinez to continue with some studies of surface waters and pollutant transport, as well a providing facilities and expertise in analytical chemistry to support the El Yunque aerosol project. Dr. Parker of JSU could provide analytical support from Mississippi, with on-site collaboration in Puerto Rico through one of his graduate students. The experience at JSU in field operations and carbon analysis would provide a substantial asset to the Campaign.

Appendix B: Current and former personnel.

Environmental research at the AGMEF institutions has to date involved several faculty members and students at both Foundation universities. Those currently involved, and their specialties are:

Dr. Fernando Diaz, professor of physics at UMet. Principal investigator on the NSF-funded Atmospheric Project with active field stations at the UMet campus and at El Yunque. Present laboratory capabilities at UMet include analyses anions by ion chromatography, black carbon by light absorption and solution acidity. Collaborative analyses have been through LBL, but could be expanded to include JSU. As part of the summer faculty program, worked in the Atmospheric Aerosol Group at LBL during 1986 and 1987.

Dr. Luis Feliu, professor of chemistry and assistant dean of science at UMet. Interests in analysis of organic constituents of ambient aerosol particles. Currently has seed funding from AGMEF for this project. Worked during the summer of 1988 with the Atmospheric Aerosol Group at LBL as part of the summer faculty program.

Dr. Guillermo Martinez, professor of chemistry at UT. Has interests in the chemistry of surface waters, especially their heavy metal content. Has instrumental capabilities in High Performance Liquid Chromatography, atomic absorption, gas chromatography and other common techniques. Worked with Dr. Andy Yee of Earth Sciences at LBL during the summers of 1987 and 1988 as part of the summer faculty program.

Ms. Wallis Medina, instructor in chemistry at UMet. Has been involved in the Atmospheric Project since its inception, with responsibilities for UMet field station operation, and laboratory support. Worked in the Atmospheric Aerosol Group at LBL during the summer of 1986 as part of the summer faculty program.

Dr. Jorge Sarmiento, professor of mathematics at UT. Has interests in applied mathematics. Has seed funding from AGMEF to work on the application of statistics to environmental research using the established computational capabilities of AGMEF. Worked during the summer of 1988 at LBL in conjunction with the Atmospheric Aerosol and Indoor Air Quality Groups.

AGMEF students involved in environmental research, either in Puerto Rico or LBL are:

Ms. Agnes Ortega, major in biology at UMet. Student assistant in the Atmospheric Project under Dr. Diaz and Ms. Medina (1987/1988, 1988/1989). Worked during the summer of 1988 in Cell and Molecular Biology at LBL.

Ms. Wanda Reyes, major in chemistry at UT. Worked during the summers of 1986 and 1987, and Fall semester 1987 with the Atmospheric Aerosol Group, with emphasis on laboratory analyses and field collection of samples. Currently a student at UT.

Ms. Deborah Rivera, major in chemistry at UMet and UT. Student assistant at UMet in the Atmospheric Project under Dr. Diaz and Ms. Medina. Worked during the summer of 1987 with the Atmospheric Aerosol Group at LBL, primarily in field collection of samples. Currently taking postgraduate courses in Puerto Rico.

Ms. Lourdes Valentin, major in chemistry at UMet and UT. Student assistant at UMet in the Atmospheric Project under Dr. Diaz and Ms. Medina. Worked during the summer of 1987 in Molecular Biology at LBL, during the summer of 1988 with the Atmospheric Aerosol Group, with primary emphasis on laboratory analyses. Currently student teaching assistant with Dr. Martinez at UT.

LBL scientists and staff who have been involved in environmental research with the AGMEF faculty and students include:

Dr. W. Henry Benner, staff chemist in the Atmospheric Aerosol Group.

Dr. Joan Daisey, senior staff chemist, leader of the Indoor Environment Program and group leader in the Organic Chemistry Group.

Dr. Raymond Dod, staff chemist in the Atmospheric Aerosol Group and Center for Science and Engineering Education.

Dr. Lara Gundel, staff chemist in the Organic Chemistry Group, formerly with the Atmospheric Aerosol Group.

Dr. Tihomir Novakov, senior staff physicist, leader of the Environmental Research Program and group leader of the Atmospheric Aerosol Group.

Dr. Dale L. Perry, senior staff scientist, leader of the Geochemistry Program and group leader of the Analytical Geochemistry Group.

Mr. Richard C. Schmidt, senior technician in the Atmospheric Aerosol Group.

Dr. Andrew W. Yee, staff chemist in the Analytical Geochemistry Group.

Jackson State University faculty who have been involved in collaborative work with the Atmospheric Aerosol Group at LBL or who have indicated an interest in collaborating on the El Yunque project are:

Dr. Sonny Bolls, professor of technology. Interests in hazardous waste management in Puerto Rico.

Dr. Lonzy Lewis, professor of physics and meteorology. Interests in micro- and meso-scale meteorological phenomena.

Dr. Cass D. Parker, professor of analytical chemistry. Current research includes a project to characterize the atmospheric aerosol in Jackson, MS. Worked with the Atmospheric Aerosol Group conducting a project to characterize dust in coal mines (2 year contract with the U.S. Bureau of Mines).

Dr. Charles Rhyne, professor of biology. Interests in development of plant tissue culture techniques for tropical species.

JSU students directly involved in related research activities at JSU and LBL include:

Mr. Dewitt Partee, graduate student in chemistry. MS degree research in characterization of the atmospheric aerosol in Jackson, MS. Research conducted in part with the LBL Atmospheric Aerosol Group. Currently with the U.S. Food and Drug Administration.

Ms. Carolyn Pryor, graduate student in chemistry. MS degree granted in 1985, with research conducted at LBL in the characterization of coal mine dusts. Currently in medical school.

Mr. Louis Tobias, graduate student in physics. Postgraduate research with the LBL Atmospheric Aerosol Group. Currently in graduate school at the State University of New York at Albany, Atmospheric Sciences Research Center.

Figure captions:

Figure 1. Direct participants in the Atmospheric Project or the Atmospheric/Environmental Program at AGMEF.

Figure 2. Map of particle and cloud water samples collected 1986-1988. Samples collected at UMet in Rio Piedras are shown by type, those at El Yunque by site, including both cloud water and particle samples.

Figure 3. Solid lines represent analytical capabilities being actively applied to the Puerto Rico Environmental Program. Dashed lines represent periods of phase-in, phase-out or tentative planned application.

XRF is x-ray induced x-ray fluoresence analysis, which provides information about the elemental content of the samples, especially the trace metals.

IC is ion chromatography for either anions or cations. Capability of analyzing for both classes exists at LBL and JSU, with anion analysis currently coming on line at UMet.

Total C is combustion analysis for total carbon content. This capability exists at both LBL and JSU.

Black C is optical analysis for the soot content of aerosol particles. This capability currently exists at all three institutions, with LBL providing the reference standard method which will be used to maintain quality assurance.

HPLC is high performance liquid chromatography, used in this instance to analyze for combustion-generated organic compounds which have been shown to be hazardous to human health.

AA is atomic absorption spectroscopy for metals and metal ions. This has been applied at LBL to both surface waters and aerosol particles.

O_3 is ozone gas analysis. This is a real-time measurement which must be carried out on site.

ATMOSPHERIC/ENVIRONMENTAL PROGRAM

AGMEF Participants

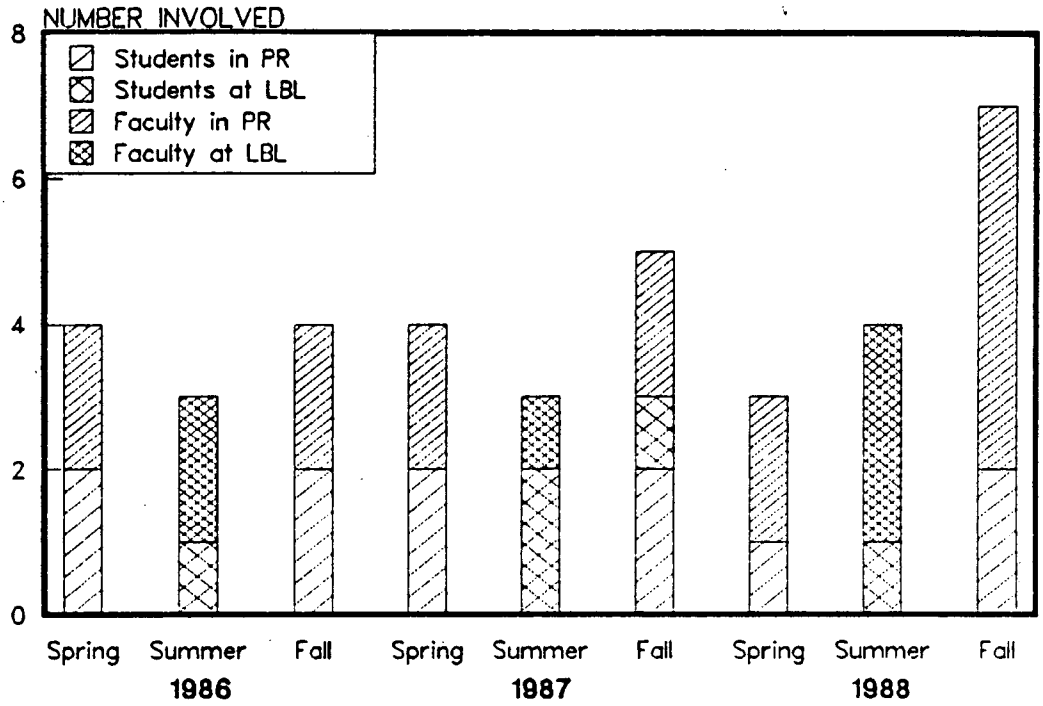

Figure 1.

SAMPLE COLLECTION IN PUERTO RICO

Atmospheric Program

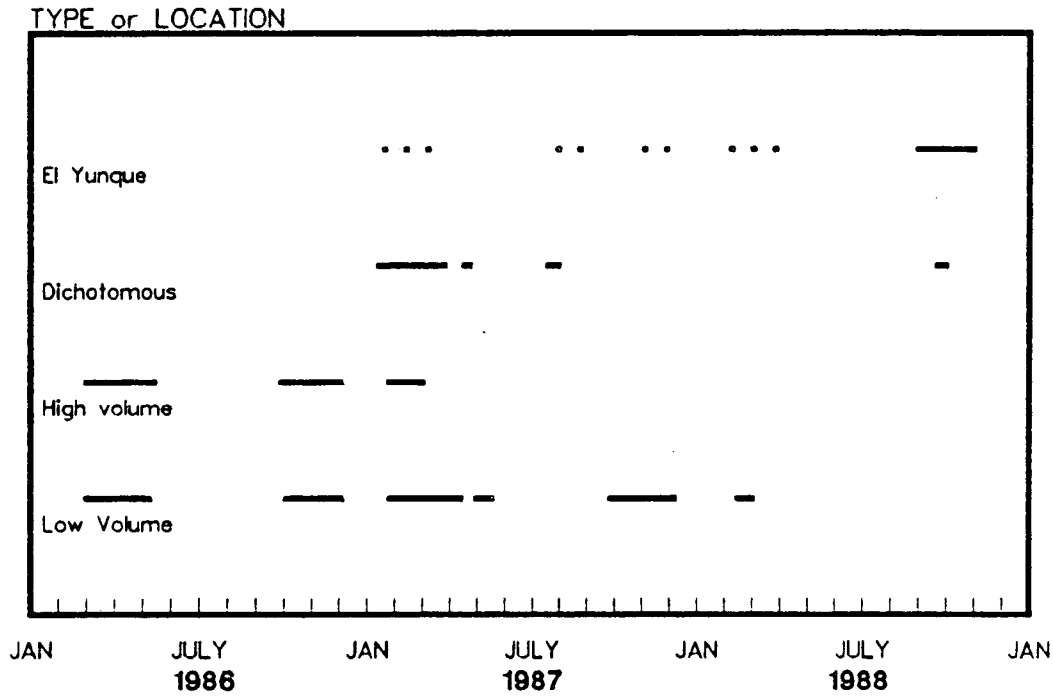

Figure 2.

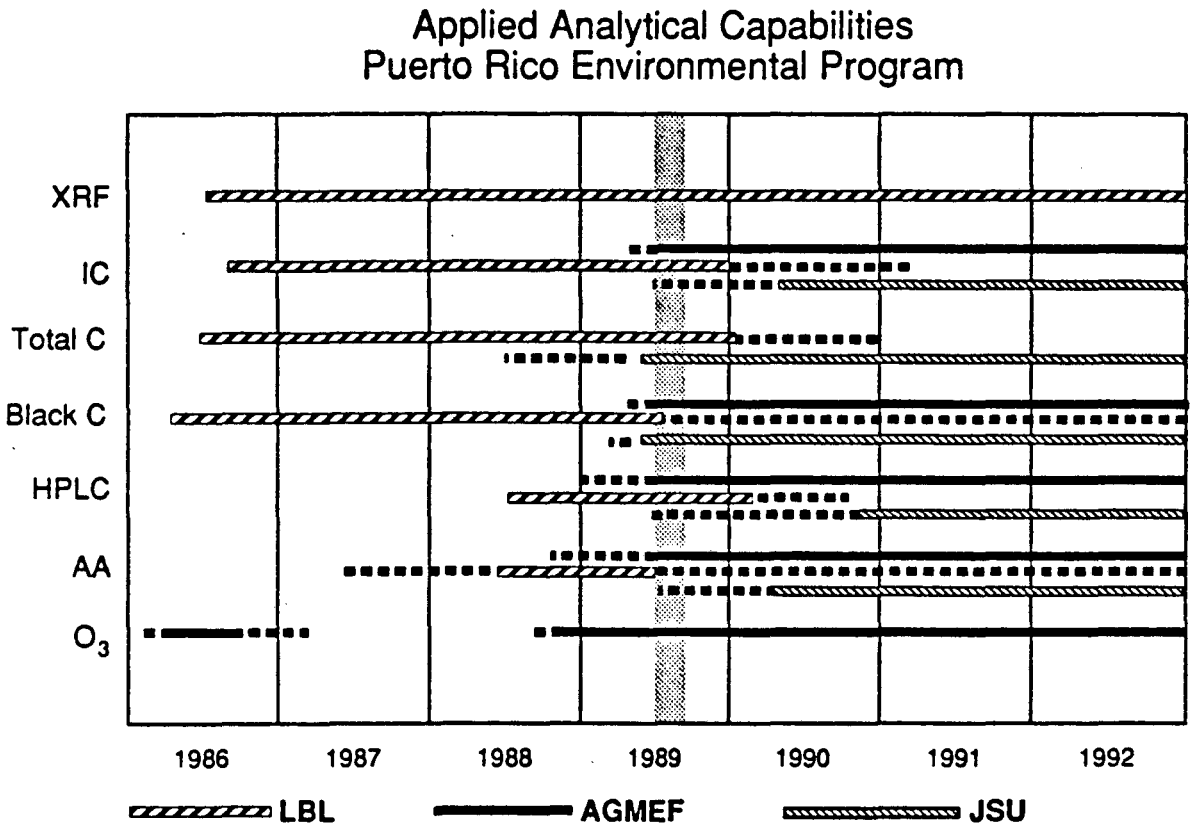

Figure 3.

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