**Final Technical Report**

**NASA GISS Cooperative Agreement NCC 5-549**

**The Institute on Climate and Planets (ICP): A Research Education Program**

**Performance Period: June 1, 2002 to December 30, 2003**

## 1. Introduction

Giving students a fair start to become productive and responsible contributors in the 21st century workforce and society depends on our ability to help them develop: 1) A global view of the world, 2) Problem-solving and reasoning abilities, 3) Basic scientific and technical literacy and 4) A multi-disciplinary understanding of how humans and nature interact with the earth system.

The Institute on Climate and Planets (ICP) in New York City is NASA Goddard Institute for Space Studies' (GISS) response to the national challenge to give students a fair start to become productive in America's workforce and society. GISS is part of the Earth Science Director at NASA Goddard Space Flight Center in Maryland and a component of Columbia University's Earth Institute, a university-wide initiative whose mission is to understand our planet so as to enhance its sustainability.

In 1994 Jim Hansen, several of his GISS and Columbia University colleagues and Fitzgerald Bramwell, the former Director of the New York City Alliance for Minority Participation at City University of New York, launched the ICP. ICP contributes to NASA education and minority outreach goals by directly involving underrepresented college, high school and junior high school students and their educators in research. ICP takes advantage of the interest of many civil servants and Columbia University research scientists at GISS to involve students and educators on multi-level research teams working on problems at the core of NASA's Earth Science Enterprise - advancing our understanding of Earth's climate, climate variability, and climate impacts. ICP aims to:

1) Work with pre-college and undergraduate educators to address real research problems and science standards in curriculum and instruction and provide professional development that connects them with current practices in science, math and technology,

2) Open advanced science learning opportunities for urban and underrepresented minority students and provide internship and leadership experiences that prepare them for college and the workforce.

3) Collaborate with museums on public education about climate change.

By offering internships, fellowships and research projects to educators and students they become active contributors in NASA's earth and space science research program with world-class scientists. We call this approach to teaching and learning and workforce preparation - Research Education. Students and educators are integrated into the GISS research community and help scientists advance what we know about the effect of humans and nature on Earth's climate, using NASA satellite and ground-based measurements as well as other earth data sets. The combination of GISS' earth science mission, demonstrated research education approach and location in New York City establishes it as a unique NASA facility to address national education, workforce and minority outreach goals "As only NASA Can."

In 1998, ICP research projects began to evolve connections between earth science and the applications of science results to socially relevant problems concerning such issues as health, energy, water resources, urban ecosystems and development. More than a program, ICP is a community of individuals and institutions dedicated to the idea research education to develop the scientific and technology talent of urban and minority students and educators in one of the nation's largest urban areas. School involved in our research education community represent a range of academic competitiveness, with the aim of helping educators address national and state science standards through real science problems and process and opening advanced science learning opportunities for students under-represented in the science and engineering.

The research education program is comprised of six main activities:

- Student and Educator Research Summer Institutes
- School-based Research Education Projects (classroom-based and after –school programs)
- Research Education Curriculum Project – The Earth Climate Course
- Electronic Classroom Project on the ICP Web
- Earth Quest Youth Community Service Project
- Research Education Conferences

The full cycle of a research project is divided in four connected phases: 1) Measurment/Analysis, 2) Significance, 3) Applications and 4) Classroom Impact

## 2. Research Driving the 2002/03 Program

Each year several science questions and research projects guide all the program activities. Below is a summary of these research projects developed by GISS researchers to contribute to their current interests.

**Urban Measurement of Aerosol and Asthma Project (UrbanMAAP)**

***What is the radiative forcing of aerosols and how are these particulates influencing atmospheric composition and human health?***

The main science question for UrbanMAAP is how do concentrations and spatial distribution of atmospheric particulates (aerosols) or pollutants (aerosol precursors) affect the climate and asthma burden? Millions of people of all ages around the world suffer from asthma. Asthma is a complex disease, influenced by multiple factors or triggers. One asthma trigger is pollution, in particular, concentration of atmospheric particles in our atmosphere called aerosols. NASA's unique contribution to the study of human health and the environment is the observation, measurement, analysis and modeling of Earth's atmospheric and surface properties on regional to global scales.

UrbanMAAP was created for students to help quantify the potential relationship between the alarming increase in the prevalence of asthma and global and decadal scale changes in atmospheric composition and climate due to human activity. One dimension of the research focuses on what relationships can be found between asthma, environmental and socioeconomic factors from the UrbanMAAP Survey data collected from students attending high schools in four cities: New York City, NY; Camden, NJ; Washington, DC; and Fillmore, CA? A second study area attempts to determine the spatial distribution of aerosols in New York City and the main aerosol sources using a combination of NASA and EPA data supplemented with their own measurements.

The instrumentation used to collect aerosol measurements are Multi-Filter Rotating Shadowband Radiometers (MFRSR) located at GISS, CCNY, Medgar Evers College, Lamont Earth Observatory, as well as hand-held sunphotometers that are used by students to enhance the spatial coverage. Measurements from the MFRSR are processed to obtain atmospheric optical depth in six spectral channels (wavelengths). These total optical depths can then be analyzed to obtain aerosol optical depth providing an indication as to the concentration of aerosols in the atmosphere, i.e. column loading of the aerosols. The measurements from all of the sunphotometers will be combined to investigate the spatial variability of aerosol with EPA measurements used to constrain the concentrations of aerosol precursors. A third study conducted by a team at City College will characterize the spectral response of the LED that is used to measure sunlight in the handheld sunphotometer and will use that information in conjunction with the MFRSR measurements to refine the analysis methods and recommend and implement improved measurement and analysis protocols.

Collectively, the team will use their results to evaluate how the scientific instruments and survey data employed in UrbanMAAP, as well as their research findings might help produce more informed policy decisions if it were applied on a broader scale?

**Tracks and Cloud Structures in Midlatitude Storms**

***What is the relationship between cloud and storm properties, what are the economic trends for storm damage and how might weather conditions and economic trends change in a warmer climate?***

This project deals with the question of how weather conditions will be different in a possible future warmer climate. In the middle latitudes, where most of the world's population lives, the major weather-makers are midlatitude storms that mix cold and warm air masses and produce high winds and precipitation. In order to explore how different the midlatitude weather of a warmer world will be from the weather that we experience today, it is important to understand how the properties of midlatitude storms may change as climate warms.

What will midlatitude storms in the future look like in terms of their intensity, frequency, severity, tracks and cloud properties? How well does the GISS General Circulation model reproduce these storm characteristics and what is the assessment of its capability to predict future storms? Can we apply research findings to study the potential economic risks of the storms that we may expect in a future warmer climate?

Midlatitude storms are disturbances that form along the jet stream (the river of air that circumnavigates the globe in the Northern and Southern midlatitudes) and travel with it in an eastward direction. The jet stream owns its existence and draws its energy from the large temperature differences that exist between the Earth's equator and poles. In a warmer climate, the temperature difference between those two regions will be smaller and this may result in a slower, less energetic jet stream. Does this mean that a warmer world will experience fewer or weaker midlatitude storms?

In our attempt to profile the storm of the future and it's effect on the economy, our group will build on the knowledge that can be gained from studying the storms of the past and on predictions made using the GISS climate model. We have developed tools that scan weather data to locate and track midlatitude storms as well as tools that collocate and correlate storm and cloud properties from weather and satellite observations, and we have developed a thirty-year climatology of storms. We also have datasets that describe economic damages from storms over that thirty-year period. Combining the different parts of our analysis we will attempt to resolve how the frequency and strength of midlatitude storms will change in a warmer climate and what such changes will mean in terms of the everyday weather conditions and their economic effects in the midlatitude regions.

**Climate Impacts**

***What are the potential regional impacts of climate variability and change on natural systems and human activities?***

Large cities are at the forefront of both vulnerability and adaptation to climate impacts. These cities are commonly located on the coastlines and are home to a rapidly growing percentage of the earth's people. The need for understanding potential climate impacts in urban areas is growing, as urban dwellers and decision-makers are being challenged to devise new types of adaptations and adjustments.

This summer's project addresses two important research topics of the recently conducted Metropolitan East Coast Regional Assessment of the Potential Consequences of Climate Variability and Change â€" Sea-level Rise and Coasts and Water Supply. The project team will study regional trends and identify scenarios for future trends. One important challenge to the team will be to evaluate the potential impacts these trends and scenarios might have on human and natural systems. They will also work with the Clouds team in a comparative study to evaluate economic storm damage for Midwestern and Northeastern states, 1950 to the present.

Some of the guiding science questions include: What is the likelihood of droughts and floods in the Metro East Region? What are the costs of these extreme weather events? How can citizens and policy-makers adapt and mitigate these potential climate impacts.

**The Alternative Climate Scenario**

***How do trends in energy consumption influence emission of carbon dioxide and what would need to be done to reduce CO2 emissions called for in the Alternative Scenario suggested by James Hansen of NASA GISS?***

It is suggested that human activities since the Industrial Revolution have magnified the normal warming trend of the earth's climate. The natural greenhouse effect is largely responsible for the habitable conditions here on earth and it is caused by the presence of an atmosphere containing greenhouse gases, which trap heat given off by the Earth. Without a natural greenhouse effect, the average temperature of the Earth would be about 0°F instead of 57°F.

Since the industrial revolution humans have become a factor in climate by consuming large quantities of fossil fuels; such as petroleum, coal, and natural gas. Burning fossil fuels release additional greenhouse gases, such as nitrous oxide, methane and carbon dioxide (CO2) into the atmosphere. These gases trap more heat than would otherwise leave the planet, therefore causing average global temperature to increase. This rise in the earth's average temperature further induces evaporation and therefore increases the presence of water vapor, which is another greenhouse gas, in the atmosphere.

Many scientists believe that all these factors lead to what is known as the "global warming". We are doing climate simulations for the period 2000-2050 for an IPCC "business-as-usual" (BAU) scenario and for a specific "alternative" scenario.

There are three key elements in the A scenario: a. the CO2 growth rate levels out and begins to decline slightly during the 50 year period, b. the CH4 growth rate, which has been declining in the past 20 years, declines further and becomes negative, such that CH4 in 2050 is actually less than it is today and c. black carbon (BC) aerosols, which cause warming, will decrease, or at least their growth rate will slow down enough that the net aerosol forcing will not increase (sulfates, which cause cooling, may decrease in amount, at least in many regions).

The goal of this project is to break down energy numbers into component parts (sources) that relate more to what people are doing, and to ask questions about what would need to be done to achieve the alternative scenario. Is it practical to achieve the growth rate of CO2 (or CH4) that is assumed in the Alternative Scenario? How much of assumed energy demand would need to be taken up by a fuel source that does not produce CO2 (such as solar power or wind power)? Is that practical?

**Global Methane Inventory**

***How are terrestrial emissions and atmospheric sinks of methane changing in relation to observed trends in methane concentrations in the atmosphere?***

Atmospheric concentrations of greenhouse gases have increased substantially in the last two centuries. Increases in these gases, including methane (CH4), carbon dioxide (CO2) and nitrous oxide (N2O), are most likely due, in part, to anthropogenic (human) activities.

The overall scientific objectives of our research are to understand the global methane cycle, including how its sources and sinks have changed over the last 20 years, how they might change in future decades, and what the implications are for climate. The objective of this ICP project is to estimate global methane emissions for all sources, all countries and every year from 1980 onward. These estimates rely on internationally recognized methods for estimating sources, as well as on new approaches to estimating emissions. These data contribute to interpreting, understanding, and predicting changes in atmospheric constituents and their impact on climate.

This research project is an interdisciplinary study of global and regional methane sources where students study historical changes in methane emissions in order to understand their potential role in climate change. This is done by first investigating the potential contribution of a suite of anthropogenic and natural methane sources to interannual

variations and decadal trends in atmospheric methane concentrations. We are investigating the following sources: animals, irrigated rice cultivation, landfills, and production and consumption of fossil fuels (natural gas, oil, and coal) (anthropogenic), and wetlands (natural) for the period 1980 to the present.

The team has produced initial series of emission estimates for all of these sources, and is now focusing on addressing several known weaknesses in several sources. For example, new information on specifics of cattle populations for many countries will allow revision of the current estimate of emissions from this source; the new estimates will probably lower the earlier values for these animals. In addition, potential availability of energy data on management of natural gas at wells may improve the current estimate of emissions from that fossil fuel.

**Carbon Initiative**

**What is the role of wetland ecosystems in the carbon cycle and what do they reveal about Earth's past climate and the potential for future climate change?**

Humans alter Earth's land-surface through various activities, impacting the vegetation, soils, and wetlands where carbon is stored. These carbon reservoirs have an influence on changing atmospheric composition and can even contribute to climate warming or cooling.

Exciting results of the last five years have placed a fundamental science question concerning carbon storage squarely in the lap of terrestrial ecologists. How much carbon is being stored on the terrestrial part of the Earth? How much is in the trees versus in the soils? How does this carbon sequestering vary over time?

At GISS, we have a chance to make a real contribution to this question by using our combined carbon and pollen/climate research in the Hudson Watershed. Black Rock Forest is a representative oak forest where research scientist Bill Schuster is now studying carbon storage in the trees. We can study this forest carbon as well, with land use variations (fire) as we began to do last year.

But in addition, we can measure the carbon in the soils, and use Black Rock Forest wetlands such as Sutherland Bog and Glycerin Hollow, where we have some ongoing pollen/climate research. Then we can add to the carbon soil sequestration measurements by adding Hudson River marsh sites such as Croton Marsh and Jamaica Bay wetlands. The advantage of using both wetland pollen/climate and carbon studies in connection with the forest landscape carbon study is that when the pollen shows changes in trees over time due to climate change, the carbon storage in the wetland will provide a measure of the influence that vegetation change makes.

Thus we will be able to make estimates of present carbon storage in forests (dry soils, wetland soils) with present vegetation, and past and future carbon estimates in soils when a different vegetation (and climate) are present. It is an ideal combination and together we can begin to answer questions about the northeastern US "missing sink", which is about one-third of current US emissions.

**Ocean-Atmosphere Connections**

***How well do ocean-atmosphere models simulate general features of the ocean circulation?***

In order to advance our understanding of the Earth's climate system and predict future climate change, atmospheric and ocean processes are mathematically simulated in computer modeling programs called General Circulation Models (GCMs). There is a great deal of uncertainty in using this scientific tool to predict future climate.

Scientists at GISS are actively involved in studies to test the capability of the GISS GCM and using the results of their analysis to make improvements. Simulating the ocean and atmosphere requires understanding dynamic fluid processes influenced by the complex characteristics of nature and human activities. The difference in climate between fully coupled ocean-atmosphere models and models run with fixed sea surface forcing demonstrate the importance of ocean processes in determining climate.
The new GISS GCM has been coupled to various ocean GCMs. These "coupled" models will be used to predict ocean uptake of heat captured by anthropogenic greenhouse gases, along with the resulting regional patterns of the ocean response.

As a prerequisite to these calculations, the project team will evaluate the coupled model's ability to simulate general features of the ocean circulation, such as the Gulf Stream, thermohaline circulation, El Nino, and water mass trajectories. Specifically, the project team will examine the output from climate simulations using fully coupled ocean-atmosphere models and models run with fixed sea surface forcings to a) determine how accurate the simulated ocean processes are, and b) determine whether the atmospheric variability with an fully coupled ocean is more or less realistic than the fixed forcing run. In particular, the team will examine the processes of water mass formation in the simulated ocean since these are very effective diagnostics of the reality of the ocean simulation. A more general aim will be to examine how climate variability is connected across the globe.

## Student and Educator Research Summer Institutes

The ICP program hosts an intensive Summer Institute where students and educators compete for research internships at the NASA GISS lab. This year's program was held from June 27th to August 2nd. Undergraduate

students began on June 20th along with high school students funded by NASA SHARP. A total of 58 students and educators participated on seven research teams contributing to the 2002 Summer Institute at GISS and Black Rock Forest. Two spin-off summer institutes took place at City College of New York and Medgar Evers College, each involved in related environmental research, primarily contributing to studies of aerosols and climate.

***Recruitment:*** ICP annually recruits from our network of 20-25 New York City metro area schools where current or alumni ICP faculty teach. Each year we add 1-2 new schools to recruit from. This year these schools included: Newtown High School and John F. Kennedy. The program involves alumni and new recruits. The majority of funded internships are available for underrepresented minorities in science/engineering (Women, Latinos, Hispanics, African-Americans, Native Americans, Pacific Islanders) or students with disabilities. However, all interested students are encouraged to apply. The combination of an application essay, in-person interview, school transcripts and faculty recommendation should demonstrate both interest and accomplishment in one or more of the following subjects: physics, chemistry, earth science, biology, computer science or mathematics. At least a B grade point average is preferred, but not required. ICP's emphasis is on recruiting highly motivated students who can provide thoughtful responses to essays questions that ask them to discuss why they would like to have a research internship experience, what skills and knowledge they possess that are relevant to this experience and to explain their thinking about a current science problem. A selection committee comprised of scientists, current faculty and students and the ICP Director will review applications and interview candidates. Considerable weight is placed on application essays (35%), recommendations (20%) and interviews (35%). Transcripts and resumes are also evaluated (10%). A list of the faculty and students selected as research interns will be made available on the ICP web site. All applicants receive notification letters. Acceptance packages are sent, including letters of agreement and parental permissions to return with required materials.

**Education and Research Schedule:** Monday through Thursday is primarily research days and Friday is dedicated to an all day writing workshop to help students develop the skills to prepare the different sections of a research paper, and to provide milestones for submitting drafts of each section. These workshops are led by a scientist and an educator, and involve tutorials, self and group critique and presentations. Other education activities are also held to help students develop the science skills and knowledge to understand and make progress in their research. Weekly sports and social events were also provided, including a evening in Central Park to see the New York Philharmonic and a Poetry Reading, trip to Fire Island, Soccer, Volleyball and Basketball. The summer program concludes with a research conference.

The summer began with an intensive orientation designed to develop common basic understandings concerning: scientific observation, human and natural climate variables, the earth system, the climate debate, evidence of climate change, team research goals and their significance and computer skills. On two Mondays during the summer a lunchtime book discussion was held among students, teachers and scientists on e=MC2, exploring the scientific process, the development and critique of theories and influences on scientific discoveries and applications of knowledge.

A Science and Society Seminar Series introduced participants to the connection between their climate research and public policy, journalism, the economy and international relations. This seminar series brought students and teachers together with experts from different fields to explore the interplay that takes place between science and society. It is widely recognized now that science and technology are connected to our daily lives. Arguably, it has become a civic responsibility to obtain a level of scientific literacy that enables us to appreciate the connections between current scientific understanding and public life. Students prepared for these seminars in a Student Working Group where they critically read and discussed articles relevant to the seminar and prepared questions. The working Group was led by 2 students. The speakers included:

Gordon Albrecht, Ohio State University. Author of Energy
*Climate Change, Human Activity and World Population*

Jim Hartz, former NBC Anchor
*Worlds Apart: How the Distance Between Science and Journalism Threatens America's Future*

Mr. G, WPIX-TV, Channel WB11 and Jim Witt, former head of Fleet Weather Service
*Reporting the Weather: The Making of a Weather Report*

## School-based Research Education Projects

Annually, ICP Faculty Fellows implement research education curriculum based on ICP summer research projects. The education modules have been created by ICP Faculty Fellows in collaboration with GISS science advisors. This addresses one of the key benchmarks for ICP – to translate educator research experiences into innovative curriculum that represents the nature of research and current science problems in the teaching and learning of science. Below is a summary of the projected curriculum impact this year (based on previous years).

| School | Curriculum Impact | Student Involvement |
|---|---|---|
| A. Phillip Randolph High School | Energy Lessons/AP Physics | 15 |
| Bayside High School | El Nino Lab/Marine Science and Living Environment<br>Inventory of Climate Variables/Earth Science | 50<br>25 |
| Bronx High School of Science | Sea-Level Rise Lessons/Geoscience | 80 |
| Central Park East High School | Carbon Cycle Lessons/Biology | 60 |
| City College of New York | Remote Sensing Course | 12 |
| Ernie Davis Middle School | Pollen, Plants and Climate Guide/Biology | 25 |
| Frederick Douglass Academy | Aerosol, Climate and Health/Physics | 20 |
| HS for Environmental Studies | Energy Use and CO2 Study/Earth Science | 25 |
| LaGuardia Community College | Polarimeter Modules/Electronics and Computer Science | 15 |
| Medgar Evers College | Clouds Data Study/Computer Neural Networks | 15 |
| Middle School 8 | Carbon Study/Computer Projects Lab | 20 |
| Mott Hall Middle School | Methane Inventory and Greenhouse Lessons | 30 |
| New Rochelle High School | Carbon and Plant Experiments | 25 |
| New York University | Global Warming Debate/Curriculum Development Education Course | 15 |
| PACE University | Global Warming Lessons/Science Education Course | 25 |
| Plainedge High School | Research Projects Course | 25 |
| School of the Future | Water Cycle Lessons/Environmental Science | 25 |
| York College | Meaning of Energy and Physics Courseware/Physics and Meteorology | 15 |

## School-based UrbanMAAP

UrbanMAAP was created as means for students and teachers to get involved in studying the connections between urban environments, Earth's climate and human health. There are two parts to UrbanMAAP. The first is an asthma survey conducted of a high school's population and the second is a study where student collect measurements of atmospheric particulates, aerosols, using a hand held sunphotometer instrument. During the 2002 Spring Term data was collected and analyzed. In June schools reported their results.

The guiding science question for this investigation is: How do concentrations and spatial distribution of atmospheric particulates or pollutants (aerosols) affect the climate and asthma burden? By collecting asthma survey data of their school's student population, students helped build a valuable new data set to help us better understand the prevalence of asthma among urban high school students, as well as the social and environmental triggers of this illness. Aerosol measurements taken with the hand-held subnphotometer instruments helped to understand potential relationships between asthma prevalence and pollution.

Five schools participated in the UrbanMAAP in New York, California, New Jersey and California. New York City: Newtown High School in Queens, California: Fillmore High School in Fillmore, Washington, DC: Eastern High School and Dunbar High School and New Jersey: Brimm Medical Arts High School in Camden. This school-based research project was facilitated via the OCP web pages found at http://icp.giss.nasa.gov/research/urbanmaap/. All the materials a school needs to conduct the project are provided on this web site, including: background, protocols, asthma surveys, data collection and reporting tools, and research projects and questions.

At each participating school a 1-2 educators serve as the project leaders for a team of 10 students. These school teams administer 300-500 surveys at their school. In total, 5260 asthma surveys were collected. All schools, except Fillmore participated in the second phase of the project collecting hand-held sunphotometer measurements from their localities. The asthma data reported to the ICP web site can be found at http://icp.giss.nasa.gov/research/urbanmaap/asthma.html and the aerosol data was entered at http://icp.giss.nasa.gov/research/urbanmaap/aerosols_form.html.

As the pilot for a multi-city Intensive Observation Period (IOP), many problems were encountered that need to be addressed, namely: training for schools teams, mechanism for delivering hand-held instruments to schools and protocols, communication protocols between the participating schools and ICP and a streamlining the ICP web site so it is more user-friendly.

## Research Education Curriculum Project – The Earth Climate Course

The final version of the Earth Climate Course (ECC), a semester-long investigation into What Determines A Planet's Temperature, will be completed this year and submitted to the NASA Earth Science Product Review. During the Summer and Fall of 2002, the ECC has mostly been in the production and editing stage. In addition, the assessment questions and educator answers were revised for each section of the module, the modeling programs were improved, and the problem scenario for the four and final topic was developed.

## Electronic Classroom Project on the ICP Web

The ICP web is undergoing a major design. Several projects are involved in the redesign. 1) An electronic archive of more than hundred student, educator, and team posters and research papers is being developed. 2) A reference for student and educator research, academic competitions and scholarships is partially completed on the following web page: http://icp.giss.nasa.gov/about/programs.html. 3) A second on-research project was developed over the summer for the Methane Project, modeled after UrbanMAAP. 4) The ECC is being prepared for integration on the web. 5) Participant bios are being prepared for the web along with updated information for the "about" section. Web statistics reflect the traffic for the ICP web pages that reside in the NASA GISS web site. Only outside traffic is used to compute the number of hits and KB. The annual KB transferred for the ICP web pages is 9044741.

## Earth Quest Youth Community Service Project

The Earth Quest Community Service Project is a way for ICP student researchers to "give back" to their community. They do this by conducting a science enrichment program that introduces elementary and middle school students to their research, the process of science inquiry and to topics of climate and weather. This year's instructional guides can be downloaded at http://www.bxscience.edu/~mcgrawm/icp/index.html. In the midst of this experiential learning process, the younger students see a connection between science and their lives, and engage in an investigation that not only motivates them about science but gives the deeper understanding about science concepts. For the older students leading the Earth Quest, they appreciate the rewards of making service part of their lives, gain valuable leadership skills and acquire the kind of deep scientific understandings gained when you have to teach others. Earth Quest typically takes place in the Spring or Fall, with students developing the program 2-3 months in advance during after-school sessions advised by scientists, staff and teachers. Targeted schools in the GISS neighborhood or nearby ICP partner schools are invited to send 10-20 students and 2-4 teachers. We typically have 3-6 schools participate. All the ICP student researchers received 50 hours of community service for their contributions.

***Spring 2002 – Earth Day Earth Quest Program:*** Student researchers in high school and college working at NASA GISS planned an Earth Day Community Service Project for middle school science educators and. The aim of the program is to involve students in an exciting study about Earth's weather and climate, as well as to introduce their research about Earth's climate. The education activity was held after-school on Friday, May 10th and was called: A Student Exploration of Our Planet and the Technologies Used to Study. It centered on three core activities for students to explore the following topics: 1) Viewing Earth to Understand our Planet, 2) Visualizing Earth Data 3) Climate Variability. Teams of students received Earth data in many different formats that scientists use to investigate Earth's atmosphere, land surface and oceans (e.g., images, graphs, weather maps, storm tracks maps, satellite images, urbanization satellite image, hurricane images etc). In the process they develop perspectives about Earth's unique characteristics that influence our weather, climate and life. The main focus was on using computers to access data and information and on performing various basic statistical analyses of two climate variables, temperature and precipitation, to understand the average climate and variability in regions throughout the U.S. ICP student researchers developed all the activities and materials with the guidance of staff, scientists and teachers, as well as served as the program instructors. Students prepared and presentations of their findings and their teachers received classroom guides. Schools: Middle School 8, Middle School 54 Delta Program, and Booker T. Learning Center.

**Fall 2002 Earth Quest.** This program was the first one coordinated by an ICP faculty member, Teresa Smith from Middle School 8 in Queens. It was also done in collaboration with the National 4-H Youth Development Program and Agilent Technologies. An ICP student research, Marquise McGraw, assisted Ms. Smith in the coordination of the program via the Cornell University Cooperative Extension's 4-H Program. He recruited student volunteers during the 2002 Summer Institute and facilitated the planning process via email. Agilent Technologies contributed education activity kits called "The Deep Sea Diver" that were used to help students understand a key science concept of pressure. This activity was used to introduce the influence of the Hadley Cell on weather and other concepts such as sea breeze, jet stream and coriolis effect. A company represented provided training to the student volunteers in using the science kits. This year's session presented students with a problem scenario to determine why forecasting the weather in New York is different than Los Angeles. Students developed various activities to develop and test a hypothesis. By analyzing climate data such as sea surface temperature, they investigated differences of temperature over land and ocean. They calculated the average temperature for a July in Central Park to begin to appreciate the difference between weather and climate. The concept of Earth's energy budget was introduced, as was the distribution of energy around the global. Storm tracks over the U.S. were also analyzed. It was an excellent activity that exposed students to use and value of various types of data to solve a problem, as well as the process of developing, depending and testing a scientific hypothesis. The schools and educational participating included: Girls, Inc., Harlem Children's Zone, Middle School 54 Delta Program, PS 86Q, St. Johns Academy and The Family Academy.

## Research Education Conferences

ICP holds two research education conferences, one in the Spring for students to present the research they have been involved in during the academic year and the other in the Summer as the final event for the Summer Institute. The Conferences are organized as professional science meetings with opportunities for presentation and Q&A. Attendees included: parents, students, educators, scientists, education specialists at community organizations, journalists, industry representatives and staff from government offices involved in science and education.

**Spring 2002 Conference.** Thirty students and educators from 12 partner schools presented their academic year research projects. Scientists and faculty judged the research poster presentations and awarded recognition is several categories. The spring conference was also attended by the new recruits for the 2002 Summer Institute.

**Summer 2002 Conference.** As the culminating event for the summer institute this serves as an opportunity for researchers to share their findings and knowledge with the public. This was our 9th Annual Conference and the theme was: *Preparing Tomorrows Leaders By Involving them in Scientific Discovery Today.* The conference was held at Columbia University. In the morning a plenary session was held where each team had 2 student representatives contribute a Power-Point presentation in *Two-minute Madness.* This session introduced the attendees to the full scope of the research presented at the conference. Our Keynote Science and Society Address followed, with a presentation on Jeffrey Sachs, the Director of the Columbia Earth Institute. As one of the world's leading economist and experts on global development, Dr. Sachs provided insights into how ICP climate research contributes to current global problems dealing with such topics as hunger, poverty, energy, environment and health. In the afternoon concurrent seminars were held dealing with ICP research, as well as research conducted by five CUNY college partners: Hunter, City College, Medgar Evers, LaGuardia Community College and York College. In total 102 students and educators gave research presentations. Later in the day a luncheon was held where "Mr. G", the WB11 weather forecaster, announced a partnership between the television station and ICP that would integrate ICP research findings into newscasts and the WB11 web site. The day concluded with a ceremony recognizing 8 ICP alumni students for their academic and professional achievements. Each student gave a presentation on where they are today and the influence of the ICP in his/her life.

## Student and Educator Program Participation

| Activity | Students | Educators | Scientists | Others | Total |
|---|---|---|---|---|---|
| Summer Institute | 40 | 18 | 13 | 4 | 74 |
| School-based Research Education Projects | 522 | | | | 457 |
| UrbanMAAP (NJ, NY, DC) | 50 | 10 | 2 | | 62 |
| Earth Quest – Fall 2002 | 65 | 10 | 3 | 4 | 82 |
| Earth Quest/Earth Day - Spring 2002 | 39 | 3 | | | 41 |
| Spring Conference | 57 | 14 | 14 | 10 | 95 |
| Summer Conference | 80 | 41 | 22 | 64 | 207 |

## Student Research Presentations in Academic Competitions and Scholarship Awards

The following is a partial list of student participation in academic competitions and scholarship awards

***Academic Competitions***

1) Seimans Science Competition: Leon Abbo and Adam Greenbaum, Bronx Science - National Semi-Finalists, and Anna Ruvinskya, Brooklyn Tech

2) Intel Science Talent Search: Leon Abbo - National Semi-Finalist, Autumn Anderson, Bronx Science, Shaynah Brown, AP Randolph

3) NASA Student Involvement Competition: Ayesha Anwar, Al-Noor

4) New York City Science Fair: Shaynah Brown, Leon Abbo, Adam Greenbaum, Ali Mirza (AP Randolph), Ankita Patel (Newtown High School)

***Scholarships***

1) Ron Brown Scholars: Marquise McGraw at Cornell and Crissaris Sarnelli at Yale

2) Gates Millennium Scholarship: Marquise McGraw and Crissaris Sarnelli

3) United Federation of Teachers Scholarship: Crissaris Sarnelli

4) New York Times Essay Competition: Gloria Bonsu, HS for Environmental Studies

5) Full College Scholarship: Amelia Adams at Babson College

6) Franklin Williams Scholarship: DeVoia Stewart at Georgetown University

## Institutional Participation

| Pre-College | Higher Education | Industry | Non-Profit | Government |
|---|---|---|---|---|
| Al-Noor Academy | City College of New York | SGT, Inc. | American | NASA |
| A. Philip Randolph HS | Columbia University | TRW, Inc. | Museum of | |
| Bayside HS | Hunter College | WB 11 TV | Natural History | |
| Bronx HS of Science | LaGuardia Community College | Agilent, Inc. | | |
| Brooklyn Technical HS | Medgar Evers College | | Black Rock | |
| Byram Hills HS | New School University | | Forest | |
| Central Park East HS | PACE University | | | |
| DeWitt Clinton HS | Southern Connecticut State U. | | National 4-H | |
| Ernie Davis Middle School | York College | | | |
| Fieldston School | | | | |
| Frederick Douglass Academy | | | | |
| John F. Kennedy HS | | | | |
| Junior High #8 | | | | |
| HS for Environmental Studies | | | | |
| Mott Hall Junior High | | | | |
| New Rochelle HS | | | | |
| Newtown HS | | | | |
| Plainedge HS | | | | |
| School of the Future | | | | |
| South Shore HS | | | | |
| St. Regis HS | | | | |

## Evaluation Activities

A major report is being prepared to provide a history of the ICP from 1994-Present. This includes collecting and updating biographical information concerning academic and professional progress on 183 students and educators who have participated in the program. Contact was made with 80% of all ICP participants for this project. One of the major aims of the report is to benchmark the ICP program and define the ICP research education model for replication.

***Sampling of Tracking Data Collected***

*Summer Institute 2002 Participation.* 8 Colleges, 16 Jr./Sr. High Schools. Student Research Interns: 1 graduate, 10 undergraduates, 30 high school students, 14 high school teachers, 4 college faculty. Demographics (Total Students-41): Male: 41%, Female: 59%, Black: 46%, Hispanic: 23%, Asian/Multi-Ethnic: 15%, White: 15%. 12 of the educators teach in urban schools with primarily minority student populations.

Participation from 1994-Present - A total of 181 students (133) & teachers (48) have participated in ICP. Annual tracking is maintained with 80% of participants. Student Demographics: Male: 39%, Female: 61%, Black: 50%, Hispanic: 28%, Asian/Multi-Ethnic: 13%, White: 9%. 59% of the students and 73% of the teachers participate for 2 years or more. 58% of the student alumni are employed in science, engineering or technology careers or are SMET majors.

**Sampling of Qualitative Data Collected**

Student quotes that put ICP in perspective

"Doing scientific research helps you look at the world more seriously... you become aware and understand the chain of effects that your actions have and how it comes back to you." Ayesha Anwar, Al Noor Academy, Carbon Team

"I was better able to communicate my ideas and findings and ideas to others", Ben Lewis, CCNY graduate and now works in the development of fuels cell technology for an engineering company, Aerosol Team

I realized at ICP that one must be able to think unconventionally...Many times in high school you learn a formula or format and try to apply it to every problem...I learned from attempting problems that sometimes you can not solve every problem with an equation...it takes building on what you know to reach a conclusion" Carlyle Ann Francis, graduate of School of the Future and Senior at Stonybrook College (chemistry major), Impacts Team

"Because I wasn't treated like just a high school student, I was able to grow in ability and knowledge... after doing my project I felt more capable to evaluate what politicians say." Christine Felming, DeWitt Clinton HS graduate and junior at MIT (chemistry major). Aerosols Team

"I learned how to think about problems scientifically and how to deal with people with different opinions than mine with respect to a scientific issue...I discovered that I can take a leadership role in a group especially when it comes to motivating team members..." Crissaris Sarnelli, HS for Environmental Studies graduate, freshman at Yale. Alternative Scenario Team

"ICP taught me to think critically and not expect a single right answer, but rather to make sure you are asking the right questions." Dorothy Louis, Bronx Science graduate and senior at Stanford (pre-med), Oceans Team

"Reflecting back on my experiences at the ICP, I realize that becoming a scientist is an attainable goal." Ely Duenas, graduate of LaGuardia Community College and Queens College (physics major) and currently working at GISS on the Clouds Team.