The Summer Employment Program at NOAA's National Severe Storms Laboratory: An Experiment in the Scientific Mentorship of Undergraduates

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Abstract

In an effort to encourage college students to consider careers in scientific research, NOAA's National Severe Storms Laboratory has instituted a Summer Employment Program. The program is centered around a scientific mentorship experience that matches each student with a laboratory scientist. During the nominal 12 weeks of the program, the scientist leads and directs a research project that is designed to be commensurate with the student's background. Along with the research experience, there is an educational component that encompasses both classroom work and experimentation. Additionally, students are introduced to a variety of research efforts in the laboratory through a continuing series of guest lectures by lab scientists.

The program has operated in 1987, 1989, and 1990, and has included 17 students, 12 of whom have come from under-represented groups in our society. We report on the evolution of the program and scrutinize the results after these three years of effort.

1. Introduction

During the fall and winter of 1986, a series of discussions took place at the National Severe Storms Laboratory (NSSL) to address problems related to: 1) the relative dearth of young researchers in meteorology in general and severe-storm meteorology in particular, 2) the lack of domestic females and ethnic minorities in meteorology, especially at the Ph.D. level, and 3) the inability of our current educational system to introduce undergraduates to the business of scientific research. As a result of these discussions, we felt it imperative that the NSSL make an effort to ameliorate some of these problems. A summer institute or summer employment program was considered a good candidate to address the issues in items 2 and 3. The satisfaction of needs in item 1, however, is a more difficult goal and the connection between a summer employment program and the ultimate generation of quality researchers is tenuous at best. Nevertheless, we set out to design a summer program that would encourage young people to consider careers in research and give them experiences that complemented the academic approach to their vocation.

The problems we identified are not endemic to meteorology; they are pervasive in the entire scientific community. As stated by Kenneth Green (1989) in his recent article in *American Scientist,* "The largest and oldest empirical study of higher education in the United States [American Council on Education and UCLA's Cooperative Institute Research Program (CIRP)] indicates that the nation's science resources, as represented by the students who are planning undergraduate work in the sciences, have suffered serious erosion over the past two decades. . . . Given this broad picture, the declines in science capacity reflected in the CIRP data raise serious questions about the ability of the nation's labor market to respond to the scientific, technological, and economic challenges of the 1990s and the twenty-first century." Figure 1, from Green's article, shows that between 1966 and 1988 the proportion of college freshman planning to major in the sciences and mathematics fell by half, from 11.5% to 5.8%. Only the biological sciences have retained freshman interest; this interest, however, reflects aspirations for medical careers rather than intrinsic interests in life science (as per Green 1989). The statistics also show that women's interest in the sciences actually declined by more than two-fifths during this period (8.8% to 5.1%). This result is surprising, since women have been encouraged to pursue majors and careers traditionally dominated by men in these past three decades.

Green points out that declining interest in the sciences has been paralleled by a bull market in business (Fig. 2). Between 1972 and 1988, the proportion of freshmen planning to pursue business careers more than doubled (10.5% to 23.6%). Figure 2 also highlights the particularly dramatic changes in women's career preferences in business over the past two decades. The dramatic increase in women planning

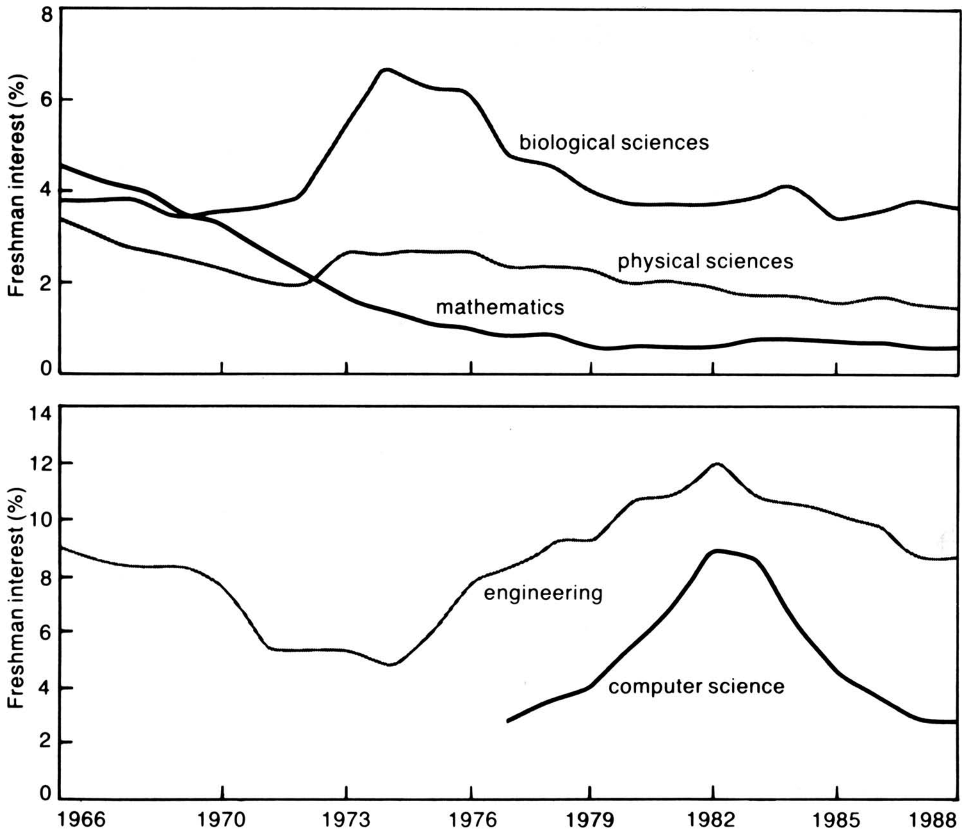

FIG. 1. The annual CIRP survey of college freshmen indicates that interest in science and engineering (top) and technology (bottom) careers has dropped precipitously over the past two decades. (After Green 1989.)

business careers is particularly disturbing during a period in which the number of women entering the sciences has declined despite extensive efforts at recruitment. More encouraging are the CIRP data on interest in sciences among ethnic minority students. Preferences for engineering, physical science, and life science majors among black and hispanic freshmen have all increased over the past decade.

Federal efforts to lure minority talent into the science and engineering pipelines stretch back at least to 1962 when the Atomic Energy Commission launched a summer institute program for middle and high school students (McIntosh 1990). A plethora of programs followed, but according to McIntosh they have done little to increase the number of students who received doctoral degrees in science. One attempt that has received high marks is the National Institute of Health's (NIH) Minority Access to Research Careers (MARC) program. Begun in 1972 as a way to help minority faculty, it was broadened in 1977 to support honor students from their undergraduate years until they reach the end of the pipeline. Currently, the National Science Foundation (NSF) has a $10 million initiative planned for fiscal year 1991 called Alliance for Minority Participation (AMP). A goal of this new minority education program would be production of 50 000 baccalaureates and 2000 Ph.D.'s by the year 2000. The NSF would like industry to invest approximately $100 million in the program, but this private sector partnership has yet to be finalized (Morgan 1990).

Notable programs in meteorology that have achieved success in attracting minorities are: 1) the Experimental Meteorology Laboratory (EML) of NOAA that operated during the '60s and '70s, and 2) the National Center for Atmospheric Research (NCAR) Summer Employment Program, which was begun in 1980 and is still in existence. The program at EML is noteworthy because of its use of federally and municipally funded programs: the Junior Fellowship Program and the Dade County (Florida) Public Schools Gifted and Talented Program, respectively. An interesting summary of the program between 1967–1974 is found in the article by Arnhols and Woodley (1975). The program at NCAR was established to encourage greater participation of minority students in the atmospheric sciences and to encourage them to consider careers in this field. They

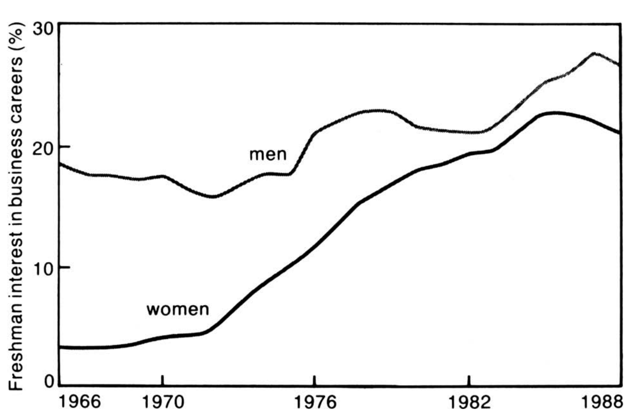

FIG. 2. Interest among college freshmen over the last 20 years in business careers. (After Green 1989.)

have vigorously worked to establish a national communication network including former students and a host of universities. The number on the list of contacts now totals over 700. Quoting from a document prepared for us by Rebecca Campbell–Howe of NCAR's Human Resources Service, "Students work one on one with volunteering supervisors throughout the summer. Each completes a project or part of a larger endeavor, writes a paper, and does a presentation on the results of his/her investigation." In the ten summers since its inception, NCAR has hosted 76 students.

At the NSSL, we would like to make a small, but hopefully significant, contribution to the development of talent in the sciences. We also feel that a continuing laboratory program can be used as a meaningful way to attract underrepresented groups into scientific research careers. We are aware of the many pitfalls that hinder achievement of these lofty goals, and plan to take advantage of our past experience and lessons learned by organizations such as MARC. We have instituted a summer program and now have three years of experience, starting with one student in 1987, six in 1989, and ten in 1990. This article describes the evolution of the NSSL summer program.

2. Structure of the program

a. Philosophy

The essential ingredient in the program has always been mentorship projects between the student(s) and the scientist(s) at the laboratory. By mentorship, we mean the identification of a project that fits the student's background and interests, followed by a continuing guidance of the student by the cognizant scientist. The critical element in this process is the pairing of students with scientists on the basis of pedagogical skill of the scientist and the student's natural interests, maturity, and skills.

Since we don't limit the program to students majoring in meteorology, it is especially important to have an educational component to the program. In this regard, our philosophy has been to introduce students to background materials essential to understanding the thrusts of the summer research topics. However, we have refrained from attempting to give a survey course such as those available in most colleges.

As the program evolved, we decided to set aside three hours each morning for education. Since the program is nominally three months in duration, this amounts to roughly 180 hours of instruction. This is considerably more than the typical three-credit course in college, which provides about 50 hours of classroom instruction; but with the 2 to 1 ratio of outside work to classroom work/lecture in college, the hours are comparable. In our education component, however, we also schedule work outside the morning lectures, so there is a significant increase in work over the typical college science elective.

In addition to the individual mentorship project and the group educational component, each student is given a library project. This project is expected to take roughly 40–60 hours of work on topics of wide-ranging interest in science. The students have access to the NSSL library and the library at the University of Oklahoma, which includes the DeGolyer Collection in the History of Science, one of the most celebrated collections of its type in the world. A written report is expected, and the students present the results of their study before peers and the program coordinator near the end of the summer program. This project is intended to give the student experience in preparing arguments to defend his/her position on difficult and often controversial questions in geophysical science.

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b. Administration of the program

During the second year of the program (1989), the laboratory worked closely with NCAR's Human Resources staff, who were kind enough to share "nonselected" applications from their summer student solicitation. This package of applications, plus those resulting from several visits to local high schools, led to a substantial pool of candidates. This procedure, along with substantial "word of mouth," led to even more applications in 1990. A laboratory selection committee of three, along with the administrative officer, carefully reviewed the applications to select the final candidates. In 1990, we required the students to provide a statement of up to two pages of their interests in science or mathematics and their reasons for wanting to participate in the program. The interaction with NCAR has provided, to date, a de facto outreach to minority and underprivileged candidates; however, a more formal outreach and advertising are planned for future years.

The students who were selected were hired as temporary student employees of the NSSL. This provided them with an income during the summer that was better than typical summertime, minimum-wage service jobs that are widely available to students.

However, this type of student appointment does not permit transportation to or from the job location, and the participants had to arrange their own travel to Oklahoma. Several students shared apartments during the summer and enough had vehicles so that transportation was not a problem. We hope, as the program expands somewhat, to be able to provide both transportation and a coordinated housing arrangement for future attendees. Not surprisingly, the largest challenge in administration of the program involves keeping its size reasonably under control; the interest and demand are great, and the resources available are very limited.

c. Historical perspective on program structure

The information presented above represents the culmination of three years of effort to find an equilibrium structure to our program. The program is continuing to evolve, but it is important to summarize our efforts to achieve an equilibrium. We feel that a hallowed steady state has not been achieved, but we also see significant advancement toward it. As suspected, a key ingredient in the program's success depends on attracting talented and highly motivated applicants. As mentioned in the introduction, the MARC program of NIH has achieved spectacular success and this appears to be keyed to their selection process (McIntosh 1990). Before a program has built a record of accomplishment, the ability to get a relatively large number of applicants is difficult but essential. To date, we have relied on somewhat random inquiries from undergraduates that are received at the lab, opportunities that allowed our scientists to discuss the program with student groups, and most importantly on the Human Resources Department at NCAR. As mentioned earlier, NCAR has had a summer program in place for nearly two decades and has drawn on a network of academic institutions that guide applicants to their program. The NCAR officials have been supportive and have worked with us to make the NSSL program known to their applicants.

We started the program, somewhat cautiously, when we attracted a young woman, Stephanie Leifer, to it in 1987. She had applied to the NCAR program and, although a strong applicant, was unable to secure one of their positions. Leifer had just completed her junior year in physics at the University of Pennsylvania in Philadelphia. With her background in physics and interest in electromagnetic theory, it became apparent that a mentorship under the direction of Dave Rust, a severe storm electrician, was a natural choice. Rust outlined a project that concentrated on work with instrumentation designed for the storm electricity group's field work. With Leifer's lab background in physics, a significant amount of the work involved

FIG. 3. Stephanie Leifer, our first summer employee in the mentorship program, preparing for the launch of a Cross-Chain LORAN Atmospheric Sounding System (CLASS).

electric-field mill calibration and data processing of the electric-field measurements. To get experience in the field, Leifer also accompanied the storm-intercept crew when they used the mobile lab to launch instruments in the vicinity of storms. A picture of Leifer, holding an upper-air sounding balloon prior to launch, is shown in Fig. 3. Our educational component was ill-defined during this first year, but John Lewis and Rust gave Leifer reading assignments from standard texts that complemented the research project. Rust was extremely pleased with Leifer efforts and felt that she not only learned about applied electromagnetic theory but made a meaningful contribution to the summer field program. What thrilled us most and led us to consider an expanded effort was Leifer's unexpected consideration of a career in research meteorology upon graduation from the University of Pennsylvania. We lost out, however, when she opted to take a position in basic physics at the Jet Propulsion Laboratory in Pasadena, California.

Having accomplished one of our major goals, viz., successful mentorship on a well-defined scientific project, we were encouraged to take some bolder steps. Since the coordinator of the summer program

FIG.4a. The 1989 summer students and one of the lecturers, John Pflaum. Bottom row: Fred Mah, Trevor Carson, and Leslie Nye. Top row: John Pflaum, Karen Winston, Weston Hill, and Sonia Lasher.

FIG. 4b. The 1990 summer students and the teaching assistant, Sonia Lasher. Bottom row: Daphne Fontenot, Pamela Heinzelman, Radha Masalamani, Kelly McNerney, and Connie Haag. Top row: Sonia Lasher, David Babb, Anita Choudhary and David Montroy. Absent from the picture were Christine Goins and Gabe Mares.

(J. Lewis) was involved in the planning and execution of a field program in late 1987 and early 1988, we thought it best to wait until the summer of 1989 to hold an expanded, second edition of the program. We also decided at this time to allow high school students to apply for the program.

To date, we have had 11 undergraduates and 6 high school students (4 graduating seniors and 2 juniors) complete the summer program successfully. Of these 17 students, 11 have been women. Two of the women and one of the men were members of ethnic minority groups. Figure 4 shows a group picture of the 1989 and 1990 classes (remember that the *entire* 1987 class is shown in Fig. 3).

3. Components of the 1990 program

a. The lectures

As mentioned earlier, a series of lectures was given throughout the summer by the scientific staff of the laboratory. These lectures fell into two main categories: 1) extended presentations over a one- to three-week period that were intended to introduce students to fundamental concepts in meteorology such as the analysis of synoptic charts and principles of storm generation, and 2) the presentation of capsulized views of an individual scientist's research. The second category of lectures would typically take two days, with three hours of lecture on each day. To introduce students to the research area of a particular scientist, it was incumbent on the scientists to give sufficient background material on their subjects, e.g., cloud physics, before they got into details of their personal,

An effort was made to introduce the students to scientists at all professional levels: post-doctoral fellows, junior-level researchers on up through the senior scientists, and scientific managers. In short, it was hoped that students could identify with some of the various vantage points provided by this collection of scientists and also get an idea of the research interconnections in a laboratory such as NSSL.

specialized research. Accordingly, each lecturer was expected to spend considerable time in preparation for the two lectures. In addition to presentation of research results, the speakers were admonished to give the students an idea of what motivated their work, as well as a feel for the support and collaborations necessary to accomplish the work. Additionally, the speakers were asked to discuss their own careers introspectively and give the students an idea of the factors that attracted them into scientific research.

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To provide an intermediary between the lecturers and the students, we employed a teaching assistant in

TABLE 1. Lecturers - 1990 NSSL Summer Student Program (with parenthetical notes by one of the students, Anita Choudhary)

Time	
3 wks	Charlie Crisp (with help from Sonia Lasher) — synoptics and thermodynamics. Very useful set of lectures.
2 days	DeWayne Mitchell and Brian Curran — tour of NSSL and familiarization with upper-air observations at NWS Norman Forecast Office.
1 day	Bob Maddox — greenhouse effect and paleoclimatology. It was interesting to learn about the greenhouse effect without all the media hype.
3 days	Sherman Fredrickson — instrumentation. He taught us a lot about asking questions and not taking things for granted.
1 day	Library skills at University of Oklahoma.
1 day	Jim Vavrek — spotter's guide film and tornado films.
2 days	Brad Smull — taxonomy of heavy precipitation events.
1 day	Dave Jorgensen — hurricanes.
1 wk	Rodger Brown and Don Burgess — Doppler radar.
1 day	Charles Doswell — field of science. Thought-provoking lecture.
1 day	John Lewis — Dr. Richard Feynman. It was fascinating to learn about Richard Feynman.
1 wk	Dave Rust — storm electricity. Very good lectures.
1 day	Don MacGorman — lightning detection.
2 days	Conrad Ziegler—cloud physics.
1 day	Harold Brooks — computer graphics and cloud modeling.
3 wks	Bill Martin — 5 laboratory experiments and 6 films.

1990. This assistant, Sonia Lasher, had just obtained her B.S. degree in meteorology from St. Louis University and was a graduate of the 1989 summer program. We found that the assistant is an invaluable member of the summer program team. Her responsibilities for securing reading materials from lecturers in a timely fashion, coordinating the use of visual aids during lectures, and collecting and distributing homework were certainly important; but the more subtle task of detecting mismatches between lecture material and students' academic background was found to be essential. The actual working requirements proved more strenuous than those of the usual "TA" in academia, because the assistant was with the students continuously for 12 weeks and the material covered was both concentrated and diverse.

Table 1 provides a summary of the lectures in the 1990 program. Parenthetical comments by one of the students, Anita Choudhary, a biochemistry student at Rice University, are also included.

b. The laboratory experiments

In 1990, we instituted a series of five lab experiments in atmospheric science and six films on fluid dynamics. This supplemented the lecture material in much the same way that a physics lab in college is often associated with its lecture counterpart. The lab instructor was a fluid dynamicist, Bill Martin, who joined our staff in 1989 after receiving an M.S. degree in mechanical engineering at University of California–Berkeley. Martin has had a wealth of experience as a lab instructor at Berkeley and designed a set of experiments that drew heavily upon the very successful book by Professor Craig Bohren at Pennsylvania State University, titled, *Clouds in a Glass of Beer* (Bohren 1987). Martin designed each experiment to last about 2-1/2 hours and broke the group into a set of five teams, two members to a team. The experiments that were conducted are briefly described below:

1) NUCLEATION

Students conducted the experiments described in chapters 1, 2, and 6 in Bohren's book. These examined processes such as the action of salt nuclei in saturated air; the relations between saturation vapor pressure and atmospheric pressure; and the nucleations of carbon-dioxide bubbles when salt grains are added to a carbonated beverage. Incidentally, the students used bottled, carbonated water, rather than beer.

2) SUPERCOOLING WATER

Chapter 22 of Bohren's book was used for background reading. The actual lab work closely followed that described by Ira Geer in *Weatherwise* (1979). The students partially immersed a cup of water, with a thermometer, into a larger container filled with salt water and ice to demonstrate the degree to which water can be supercooled. They also explored the effects of coating the thermometer and/or cups with oil prior to the experiment.

3) HEAT TRANSFER

Students read chapters 8, 9, and 10 in Bohren's book prior to the lab session. They used cups of equally heated coffee and measured the time rate of the cooling processes. One cup had a measure of cream added initially, while the measure was added to the second during the cooling process. The cooling curves were then compared for the two cups.

4) Surface tension

This experiment was inspired by chapter 7 in Bohren's book, but most of the material was ultimately drawn from a number of other sources, namely: a film on surface tension from the National Committee for Fluid Mechanics Films (NCFMF), John Cassidy's *The Unbelievable Bubble Book* (1987) (a good source of practical information on how to make soap bubbles), and various textbooks on physical chemistry. The students used soap bubble equipment to observe the shape of the interface between two bubbles as a function of relative size. They also examined the way the soap concentration in the solution affected the bubbles and were asked to speculate on factors that limit maximum bubble size.

5) Cold cloud precipitation process

An ice chest with shaved dry ice was used to simulate precipitation processes at temperatures below freezing. The paper by Schaeffer (1946) was used as a guide. Figure 5 shows two of the students conducting one phase of this experiment.

In addition to the lab experiments, Martin obtained a group of films on fluid dynamics from the NCFMF. Six films were shown and each was followed by a question/answer period. The titles of the films were: Low Reynolds Number Flows, Vorticity, Secondary Flow, Turbulence, Flow Instabilities, and Rotating Flows.

c. The library project

During the second week of the 1990 program, students were taken to the Oklahoma University library and spent one afternoon being briefed on how to access source materials for their library project. Special emphasis was placed on using PC (personal computer) software to locate library books and journals. The students were then allowed to choose a research topic from a list of 20 prepared by Lewis and Maddox. Roughly half the questions related to vigorously contested issues that had appeared in the news media. An effort was made, however, to isolate smaller components of the large issues and make them challenging for the students. For example, the following question was posed:

> Assume you are a scientist employed by one of our largest and most successful chemical companies. Your task is to present a case to the U.S. Congress that casts suspicion on the argument that chloroflourocarbons (CFCs) are the culprit in the ozone depletion that has been observed over the South Pole.

Students were given roughly 40–60 hours to do this research. A written report and an oral presentation were required of all participants.

Students were given some latitude to either augment or modify their project slightly. In all cases, the students were encouraged to communicate directly (in personal interview, by telephone, or letter) with scientists working at the forefront of research related to their project. Nearly every student took advantage of this approach, which generally strengthened the projects.

David Babb, a meteorology student from the University of Kansas, addressed the following question:

> Jetstreams are recognized to be an important aspect of the atmospheric circulation. These "jets" are so linked to daily and weekly weather that we frequently see their position animated, and hear them discussed, on media weather segments. Document the discovery of both the polar and low-level jet streams and discuss the important relations of these to weather processes and conditions, particularly in the southern Plains. If you have time, also discuss the "subtropical" jet stream.

Babb's initial reading brought him in contact with Professor Dave Fultz's classic lab work on hemispheric circulation (Fultz et al. 1959). He approached the lab instructor, Martin, and sought advice on replicating the work. The following appendix from Babb's report summarizes this effort.

> In order to make the presentation which accompanied this paper more interesting, it was decided to simulate the experiment done by Fultz (1959). This experiment used a rotating pan of water with a heat source at the edge and a cold source at the center to produce a circulation which resembled a jet stream. The following description highlights the efforts to achieve similar results using as minimal funds as possible.

Fig. 5. One of the student lab teams forming ice crystals in a freezer chest by sprinkling shaved dry ice into the chest. (Kelly McNerney is on the left and Daphne Fontenot is on the right.)

> The first necessary items that were needed were some cake pans of various sizes. A 10-inch and an 8-inch pan were purchased for about $4 and a tin can was used for the innermost container. It was decided that three containers were needed because the outer ring would hold hot water and the inner can, ice water. The middle ring was where the circulation would take place—I hoped. That was the easy part. The hard part was how was I going to get this collection of pans to rotate at a constant speed, and at a speed which would be slow enough so that circulation patterns could be seen. The first attempt was to mount the pans on the blades of my fan with rubber-bands. A variack kept the apparatus from becoming a sprinkler system, which occurred when the rotation became too fast and the water was thrown out of the pans. The problem was that the speed did not remain constant.
>
> The decision was made to upgrade the experiment so I bought an old record-player for $5 and borrowed a blow-torch to replace the outer ring of hot water. After many days of frustration trying to find the right speed of the record-player/variack combination, a four-wave circulation pattern was established—much to the joy of myself and others who were assisting the project. One more note, due to the lack of aluminum powder, it was found that pepper works just as well for marking the pattern of flows at the surface of the water.

Figure 6 shows the laboratory apparatus constructed by Babb and Martin and a view of a simulated wave pattern.

d. The science mentorship project

After a series of discussions between each student and the program coordinator and between each student and the teaching assistant during the first week of the program, a pairing of students and mentors was made. This is an extremely important decision and involves many variables as mentioned earlier. Essential to the success of the relationship is the willingness of scientists to participate in the program out of genuine concern for its goals rather than because of perceived pressure from supervisors or the Director of the Laboratory. Each mentor is given at least a month to consider possible projects, and, when students arrive, the job of the program coordinator and the teaching assistant is to pair projects and associated mentors with the students.

Table 2 itemizes the mentor–student teams and the topics of research in 1987, 1989, and 1990. Each mentor is expected to acquaint the student with the process of doing research. In particular, he/she is expected to make sure the student understands the context in which the research question is posed. This necessitates a reference to earlier work and concurrent work: "How does this work mesh with other efforts in the laboratory; who are the collaborators both inside the lab and outside? What are the realistic goals of the work in the 3-month time frame of the summer program?" Finally, near the end of the summer, the students are required to write a report on their research efforts.

It is noteworthy to mention that some of these research projects have been atypical and designed to accommodate both the strength of a student's background or special concerns of the student. Two such projects took place in 1989 with Weston Hill and Leslie Nye. First, Hill had entered the Westinghouse National Science Fair and wanted to work on a project that could contribute to this competition. He was allowed to work on the subject of microbursts and the hazards to aviation, under the supervision of Lewis and Mike Eilts. This was somewhat difficult because every effort had to be made to insure independence of Hill's work and yet make him aware of lab resources. On the other hand, Nye was interested in both the history of science and literature, and requested the opportunity to investigate the use of weather in poetry, as well as a historical project. She wrote an anthology of literary works that relied on weather and also examined the life of one of meteorology's pioneers in upper-air observations, Leroy Meisinger.

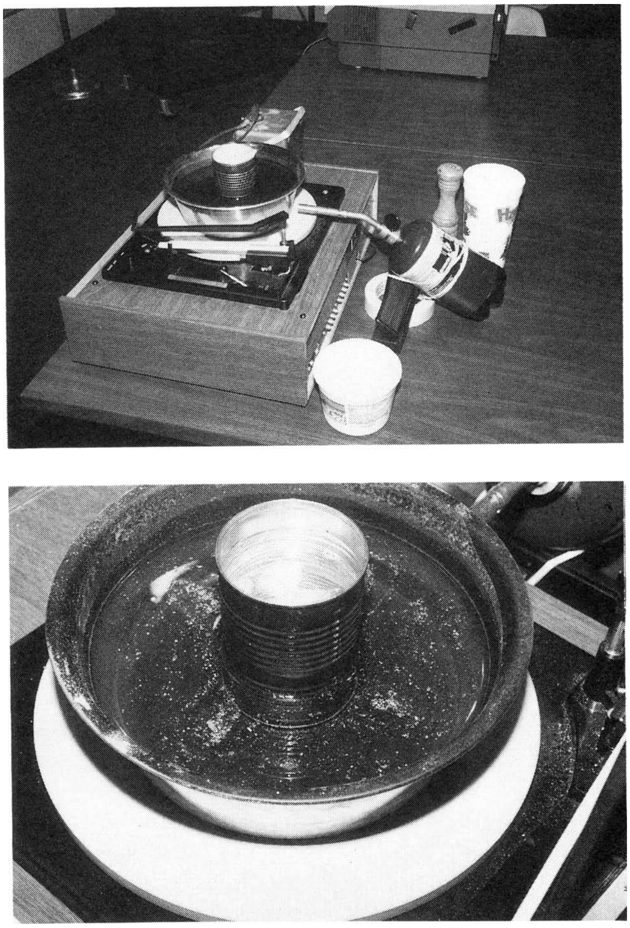

FIG. 6. The laboratory simulation of large-scale atmospheric motion following the work of Fultz et al. (1959).

Table 2. List of students and mentors in NSSL summer program.

Student	Completed School/Level/Major	Mentor/Year	Research Topic
Stephanie Leifer	Univ.Penn./Jr./Physics	Rust/1987	Storm electrification (field mill calibration)
Trevor Carson	Calif.State (Fresno)/Jr./Math.	Lewis/1989	Variational data assimilation
Weston Hill	Norman H.S./Jr.	Eilts/Lewis/1989	Microbursts (Review paper)
Sonia Lasher	St. Louis Univ./Jr./Meteor.	Zrnic/Eilts/1989	Study of low-level jets using Doppler radar
Fred Mah	Norman H.S./Grad.Sr.	Forsyth/1989	Mobile lab instrumentation design
Leslie Nye	Norman H.S./Grad.Sr.	Maddox/1989	History of science (Leroy Meisinger) and anthology of literature related to weather
Karen Winston	Okla.Univ./Fr./Meteor.	Maddox/1989	Analysis of synoptic data related to Derechos
David Babb	Univ.Kansas/So./Meteor.	Brandes/1990	Reflectivity signature in tornadic storms
Anita Choudhary	Rice Univ./Fr./Biochemistry	Forsyth/1990	Engineering design using ORCAD and C
Daphne Fontenot	Bartlesville H.S./Grad.Sr.	Burgess/1990	Climatology of mesocyclone paths
Christine Goins	Norman H.S./Jr.	Beasley/1990[1]	Checking and documenting graphics software
Connie Haag	Univ.Denver/So./Geography	Maddox/1990	Synoptic studies of nighttime rain
Pamela Heinselman	St. Louis Univ./Jr./Meteor.	Rust/1990	Electric-field meter calibration
Gabe Mares	Norman H.S./Grad.Sr.	Lakshmivarahan/1990[2]	Numerical analysis (splines) using computers
Radha Masilamani	Norman H.S./Grad.Sr.	Zrnic/1990	Analysis of cloud-drop distributions
David Montroy	Okla.Univ./So./Meteor.	MacGorman/1990	Forecast verification of lightning-mapper data
Kelly McNerney	St. Louis Univ./Jr./Meteor.	Stumpf/Hermes/1990	A comparison of gust-front forecasting techniques

[1]William Beasley, Assoc. Prof. of Meteor., Okla. Univ.
[2]S. Lakshmivarahan, Prof. of Computer Science, Okla.Univ.

One of the most satisfying experiences of these mentor–apprentice relationships resulted when Ed Brandes and David Babb worked on wave-like signatures in the reflectivity field derived from Doppler radar. They concentrated on studying the Edmond, Oklahoma, storm of May 1986. Babb will continue to work on the project as time permits during the academic year, and they plan to present results at the Tornado Symposium III in Norman (April 1991).

The usefulness of the research efforts is exemplified by the work of Daphne Fontenot, who worked with Don Burgess. Fontenot, who grew up in Texas and was always fascinated with severe weather, was given the task of documenting the paths of mesocyclones from the 20-year history of Doppler radar records at the lab. Burgess has had this project in mind for several years but couldn't devote enough time to it. Fontenot eagerly learned how to use the lab's graphics software, accessed and stratified the data, and produced a series of plots for the tracks of these mesocyclones. One such plot is displayed in Fig. 7. Once the tracks were plotted, a host of questions arose that have generated wide interest among NSSL staff. Fontenot will pursue this work as a part-time employee at the lab while she attends the University of Oklahoma.

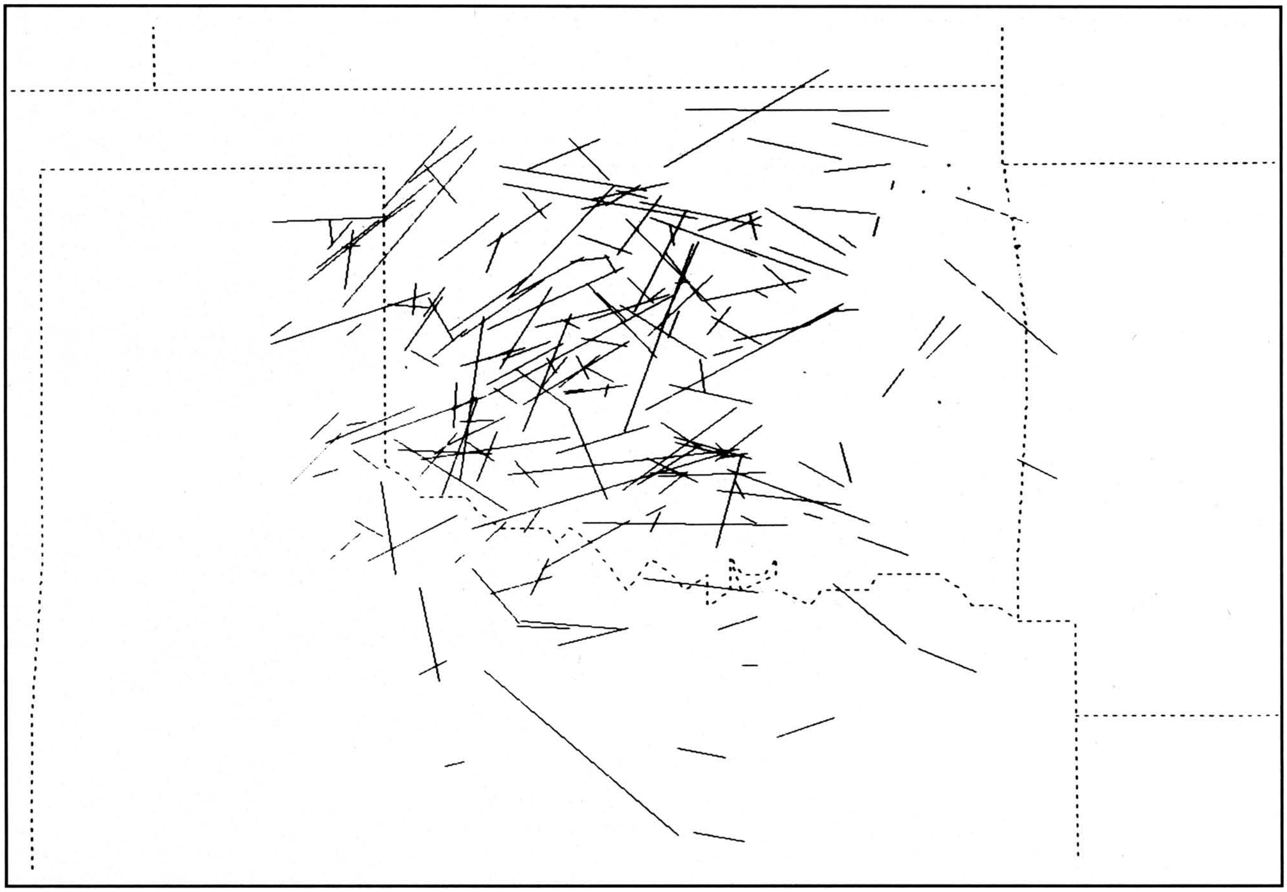

FIG. 7. A scatterplot generated by a student using NSSL's graphics software to track paths of mesocyclones.

4. Scrutiny of the program and prospects for its future

There are two salient features of the program that have been gleaned from student evaluations: 1) The students have unanimously appreciated the opportunity to work with scientific researchers in the mentor–apprentice mode. This has helped the students to more clearly define their career options and define personal goals. 2) The educational component continues to be a challenge. This is due, in part, to the combination of lengthier 1- to 2-week presentations on basic material with the 1–2-day lecture material by an individual scientist. Additionally, the amalgamation of diverse backgrounds of the students along with their wide-range of maturity exacerbates the problem of preparing appropriate lectures.

To alleviate some of the problems in 2), we have decided to recruit primarily college students and to allow only those high school students with exceptional backgrounds and motivation to enter the program. Although each of the six high school students had sterling grades, only one had gone beyond the school curriculum to nourish her interest in meteorology. She was able to assimilate most of the lecture material, and when it was beyond her, she minimized her frustrations by vigorously seeking help from the lecturers and the TA.

We have been pleased that 11 of our 17 students have been from underrepresented groups of our society. We feel this program gives each student an advantage, but it is likely to provide the most opportunities for special groups. Jonathan Cole, in his book on women in science, stresses the point that scientific success can be viewed as a process of accumulation of advantage and minimization of disadvantage (Cole 1979). Women, the group studied by Cole, and members of other underrepresented groups are especially in need of special opportunities, such as the mentorship experience, to improve their motivation and desire to attend graduate schools. An example of this process is discussed in a recent article in Research Sampler, a University of Wisconsin–Madison annual report, published by its graduate school (Swanson 1990). One of UW–Madison's most distinguished professors, Sau Wan Wu, credits an experience at the summer institute of Brookhaven National Lab as a major stimulus to her pursuit of a career in theoretical particle physics.

Our program was reviewed in 1990 by Jim Vavrek, a middle-school earth science teacher in the Hammond, Indiana, school system. Vavrek was the recipient of a Lilly Fellowship (Eli Lilly Pharmaceutical Co.) and as part of his summer program, spent one week at our laboratory. He wrote a formal review that contained several valuable suggestions. Among them was a plea to offer students university credit for the educational component. We will pursue this possibility and couple it with efforts to coordinate the program with the University of Oklahoma. The Cooperative Institute for Mesoscale Meteorology Studies (CIMMS), a joint NOAA/OU institute, and the Center for the Analysis and Prediction of Storms (CAPS), an NSF Science and Technology Center, are organizations whose missions encompass meteorological education and training. The NSSL is working with these two institutes to expand the sponsorship and backing of the summer program. This type of association will increase the pool of mentors, as well as the breadth of topics that could be considered in both the research and educational components. As we strive to broaden our program, we are also aware of the need to advertise it more effectively. We are currently planning to distribute an announcement of the program to all institutions with meteorology programs, as well as special interest groups represented by organizations such as AISES (American Indians in Science and Engineering Society) and Equal Opportunity Publications (EOP). The EOP has quarterly periodicals such as *Black Collegian* and *Woman Engineer* that are widely distributed to undergraduates.

In our summer program, we feel that significant strides have been made to address the major concerns highlighted in the introduction. There are some rather obvious improvements that need to be made. We have not allowed this to discourage us and are allowing our plans for 1991 to evolve in ways that will hopefully strengthen the program. The real inspiration to continue the program, however, comes from the students who have participated. They have left the National Severe Storms Laboratory at the end of summer with new or renewed enthusiasm for science and a better idea of where they fit into its future.

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