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University Instruction in Observational Techniques: Survey Responses



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ABSTRACT

A 1987 survey of the atmospheric and oceanic science community on university instruction in instrumentation and observations revealed that an apparent imbalance existed between observational and theoretical/numerical components of the atmospheric sciences. The committee analyzing the survey results identified several factors contributing to the perceived imbalance. From a follow-up survey conducted of the same community in 1997 to assess the level of change over 10 years, it is found that some progress has been achieved over this period, but that more can be done. Rather than try to implement all of the recommendations from analysis of the initial survey, it is suggested that attention be focused on seven items that build on partial successes over the last 10 years and that offer likelihood of success in the near future.

1. Introduction

In 1987, a Study on Observational Systems (SOS-I) Committee surveyed the atmospheric and oceanic science community on university instruction in instrumentation and observations. The SOS-I Committee consisted of B. Heikes, D. Sargeant, R. Serafin (chair), W. Smith, E. Takle, D. Thomson, and R. Wakimoto. Ninety-three surveys were sent out, and 48 colleges and universities responded. The committee then conducted personal interviews with scientists and educators from universities and scientists from national laboratories and offices having research and operational activities in the atmospheric and oceanic sciences.

Survey results, published in the *Bulletin of the American Meteorological Society* (BAMS; Serafin et al. 1991), indicated that lack of university resources was impeding needed development in curricula, laboratories, equipment, and educational materials. An overall conclusion of SOS-I was that

“a serious imbalance appears to have developed between observational and theoretical/numerical components of the atmospheric sciences” (Serafin et al. 1991).

The report also suggested several ways in which the deployment of national resources should advance opportunities for educating the next generation of scientists. At the time of the survey, NEXRAD, COMET, and new automated observing systems were just being launched, and the word “Internet” was known to only a handful of people in our community.

The committee went on to identify factors contributing to the perceived imbalance.

- Major observational systems are not upgraded/replaced as early in their useful life as computational systems.
- Only a very few universities have the necessary faculty and facilities to offer quality instruction on state-of-the-art measurement technology.
- Few students elect to focus on undergraduate or graduate studies that blend atmospheric science with special training in physics, chemistry, or engineering.
- There is a perception that the National Science Foundation (NSF) has not funded observation and instrumentation-oriented university research and development.

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- Academic expectations for faculty productivity and requirement for university promotion and tenure seem to discourage measurements-oriented/dependent research.
- Development of remote-sensing systems and processing and interpreting remotely sensed data are not meeting present and future needs.

The report goes on to list 30 recommendations for dealing with the problem.

The American Meteorological Society (AMS) Committee on Measurements meeting in Long Beach, California, in January 1997 raised the issue of revisiting the status of education in measurements. An ad hoc group (SOS-II: W. Cooper, W. Dabberdt, M. LeMone, R. Serafin, E. Takle) including some of the original SOS committee met informally in April 1997 to discuss the status of university educational programs in observational meteorology and oceanography.

SOS-II established a tentative schedule for revisiting the status of university instruction on instrumentation and observations. The plan called for a follow-up survey of the educational and scientific community to determine the level to which recommendations of the SOS-I as published in BAMS have been implemented and the current status of university instruction. A survey (appendix) was developed by E. Takle and sent to all colleges and universities listed in the AMS 1996 *Curricula in the Atmospheric, Oceanic, Hydrological and Related Sciences* (AMS, UCAR, 1996). The survey questions were constructed from issues raised in the SOS-I report. Fifty-three institutions have completed and returned the survey, the results of which are given in the following paragraphs.

2. Composite survey responses

Responses were overwhelmingly from Ph.D. granting institutions, with B.S. and M.S.-only institutions contributing two and four responses, respectively. Separate analysis of these responses would not be statistically significant, so all responses are lumped together in the following discussion. Results are summarized in Table A1. Respondents were first asked for their views on the six problems identified by SOS-I—whether the problems in their view 1) were worse than 10 years ago, 2) remain a serious problem, 3) have seen modest improvement over the last nine years, or 4) have seen major improvement over the last nine years. Questions in the second category of the present sur-

vey were formulated from the 30 recommendations listed by Serafin et al. (1991) in the summary report. For purposes of discussion of results, I have labeled responses as follows:

- *large majority*, if more than 80% of respondents agree or strongly agree;
- *majority*, if between 70% and 80% of respondents agree or strongly agree; and
- *weak majority*, if between 60% and 70% of respondents agree or strongly agree.

a. Eliminating problems raised by SOS-I

In evaluating problems raised by SOS-I, a majority agrees that two assertions raised are still serious compared with nine years ago: 1) major observational systems are not upgraded or replaced as early in their useful life as computational systems, and 2) only a very few universities have the necessary faculty and facilities to offer quality instruction on state-of-the-art measurement technology. However, a majority of respondents sees modest improvement in the perception that NSF has not funded observational and instrumentation-oriented university research and development, and major improvement in the assertion that development of remote sensing systems and processing and interpreting remotely sensed data are not meeting present and future needs. Responses were evenly divided on the remaining two items: 1) that few students elect to focus undergraduate and graduate studies that blend atmospheric science with special training in physics, chemistry, or engineering; and 2) that academic expectations for faculty productivity and requirements for university promotion and tenure seem to discourage measurements-oriented/dependent research.

b. Progress on recommendations from SOS-I

The survey indicated some progress has been made toward implementing recommendations listed in the 1991 BAMS article. A large majority sees more scientists from national centers and laboratories serving on Ph.D. dissertation committees at universities, and a majority sees observed datasets being more widely used for educational purposes. A weak majority concurs that the following recommendations have been implemented.

- A few universities should provide the breadth and depth of curricula and research in this area to educate the next generation of specialists.

- More emphasis needs to be placed on remote sensing systems and data derived therefrom.
- Electronic bulletin boards, newsletters, and other communication networks should be established to disseminate educational information regarding datasets and instrument design.
- NWS should collocate forecast offices with universities.
- Sponsors of national centers and laboratories should establish long-term plans for needed investments in observational equipment to meet future demand.

Some recommendations raised in 1991 continue to await implementation. Among these are urgent calls by a large majority of respondents for the University Corporation for Atmospheric Research (UCAR)/AMS to facilitate preparation and use of specialized texts that include instrumentation and observations and to prepare a video series on fabrication, calibration, and use of specific instruments or suites of instruments, together with raw datasets, for use by students. A large majority also recommends that leaders in the meteorological and oceanographic community evaluate the balance of investment in different segments of the community. A majority of respondents agree that providing basic support for measurements/observations courses at all universities remains to be implemented and that competitive graduate fellowships have yet to be established in observational research.

A weak majority agrees that there is yet a need to establish curriculum standards to ensure literacy in both observational and theoretical methods. By a weak majority, respondents also see the need to implement fellowships aimed at increasing student participation in major field campaigns and establishing cooperative programs with private industry. By the same weak majority, respondents encourage UCAR and AMS to work together to organize special journal issues to consolidate information on state-of-the-art instrumentation and that AMS should give an annual award recognizing excellence in observational research. [Presumably, respondents are not aware that the AMS offers the Robert Leviton Award for “the best student paper on the development or evaluation of atmospheric instrumentation or unique measurement techniques.” (AMS 1998b) and the more recently established Verner E. Soumi Award given “in recognition of highly significant technological achievements in the atmospheric or related oceanic and hydrologic sciences” (AMS 1998a). Also, the Cleveland Abbey Award “for Distinguished Service to Atmospheric

Sciences by an Individual” has been and could be granted for recognition of observational science. Conversations with past members of the AMS Committee on Measurements indicate very few nominations typically are submitted for the Robert Leviton Award.] Finally, a weak majority of respondents see that more scientists and engineers at national laboratories should be encouraged to participate in developing university educational and curricular materials.

Another approach to analyzing the data is to use an “ensemble” approach (suggested by W. Dabberdt) in which the number of responses “a” and “b” to problems 1–6 are added and compared with the number of responses “c” and “d” (“e” responses are ignored). From this we find that 63.6% of those responding with an opinion and/or information indicate that the problems remain serious or are worse than 10 years ago. Applying the same analysis to the list of 30 recommendations produces the result that 48.2% observe either modest or successful implementation and 52.8% contend that recommendations need to be implemented or are more urgent than 10 years ago. Thus, respondents are evenly divided on whether recommendations have been implemented, but a clear majority indicates that problems remain. One interpretation of these ensemble results is that the recommendations suggested by SOS-I did not exactly fit the problems.

3. Summary and proposed action plan

Some progress has been achieved over the last 10 years in giving attention to instrumentation and observations, particularly in the areas of involvement of scientists from national laboratories being involved at universities (although more can yet be done) and use of datasets, particularly remotely sensed data, in instruction programs. Rather than attempt to uniformly implement all recommendations of the Serafin et al. (1991) report, perhaps we can use the present survey to prioritize our efforts. University investment in meteorological equipment for instruction seems to be on a continuing decline, although there may be some isolated exceptions. On the basis of information collected from this survey and related information, I offer the following action items.

- 1) UCAR/NCAR should continue and perhaps even intensify its offering of opportunities for university faculty to take sabbatical leaves at the National Center for Atmospheric Research (NCAR), to par-

ticipate in development of instrumentation and observing strategies, and to bring students to UCAR/NCAR-supported field studies. University faculty and administrators should become more aware of such opportunities (UCAR, 1998a; UCAR, 1998b).

- 2) Efforts to consolidate materials for classroom use such as the many fine materials produced by COMET (Johnson and Spayd, 1996) and Unidata (Fulker et al. 1997) should be more widely publicized. A new UCAR effort under the Program for the Advancement of Geoscience Education (PAGE) has a mission to enhance teaching and learning in undergraduate geoscience education through the application of contemporary pedagogies and educational technologies.
- 3) Smaller atmospheric/oceanic science programs in universities should seek liaisons with other university departments and programs. Departmental realignments and mergers at major universities offer opportunities and obligations to realign traditional courses more accurately with new paradigms. Environmental science, environmental engineering, resource management, agriculture, forestry, geography, hydrology, ecology, and other natural and applied sciences are examining the boundaries of their traditional areas for new collaborations and have need to provide students with information on environmental measurements. Atmospheric and ocean science faculty should seek students and support from a wider audience within universities.
- 4) A small team of university faculty and NCAR or national laboratory scientists should prepare a set of videos or other electronic media on specialized instrumentation (e.g., airborne platforms, tower platforms, radar, satellites, lidar, profilers, and ship-borne systems). Expansion of past activities of COMET and Unidata offers one possible approach, and publishing notes from NCAR instrumentation colloquia would also be helpful.
- 5) Better use of electronic communication. Improved use of data has been documented, but there is a need for more metadata (online documentation of observing procedures, data limitations, irregularities, uncertainties, quality assurance, preprocessing procedures). Emergence of the Internet in the last 10 years provides unprecedented opportunities, and with the long-standing practice of being one of the first disciplines to use new communication technologies, atmospheric science should be a

leader in this area. Faculty members at universities with unique equipment should consider developing Web-based courses or course supplements that could be shared with other colleges and universities.

- 6) Fellowships and field opportunities should be expanded, particularly in conjunction with major national and international observing programs. There is need for students to experience first-hand the sensor limitations and sampling problems.
- 7) Involvement in university programs by scientists from national centers and laboratories is viewed as having improved, and this trend should be continued.

Leadership of the atmospheric and ocean sciences should continue to evaluate the overall deployment of resources in our field and actively seek opportunities to add accompanying educational components to funding allocation for major purchases and upgrades of observational equipment and systems. The Geosciences Directorate of NSF is in the process of preparing a strategic plan called GeoVision 2000 to be completed in late 1999 that includes facilities, science, and education, which may provide a timely response to this issue.

This list is more modest than the list of recommendations given in Serafin et al. (1991), but represents, in my estimation, a very achievable and realistic set of goals that will advance the status of student educational experiences with instrumentation and observation.

Acknowledgments. Comments on the survey results from SOS-II members, especially W. Dabberdt and M. LeMone, provided insight and improved the summary and conclusions.

Appendix: Instrumentation Survey: AMS and UCAR

In 1989 UCAR and AMS conducted a survey of colleges and universities having programs in the atmospheric and related sciences to assess the status of university instruction in observations and instrumentation. This survey, together with interviews of numerous scientists in national laboratories and operational offices, led to a summary article in the *Bulletin of the American Meteorological Society* (Serafin et al. 1991). The Serafin article identified six problems in this area and listed 30 recommendations on ways to meet fu-

TABLE A1. Responses to questionnaire.

Question Number	Response					Question Number	Response				
	a	b	c	d	e		a	b	c	d	e
Problems						12	1	14	23	5	15
1	8	36	13	0	2	13	4	35	11	5	2
2	8	33	11	2	5	14	6	32	10	3	6
3	6	22	19	3	8	15	1	18	20	2	16
4	6	11	20	8	13	16	1	6	27	7	15
5	4	22	12	9	11	17	0	12	27	10	8
6	3	14	16	21	4	18	4	8	16	5	23
Recommendations						19	7	21	12	12	4
1	0	23	23	9	3	20	4	20	14	7	11
2	3	21	10	3	18	21	4	10	18	7	14
3	6	31	8	11	3	22	0	5	22	7	22
4	1	19	24	12	1	23	2	23	17	4	7
5	3	22	17	6	10	24	4	23	7	5	15
6	1	21	24	7	4	25	5	35	6	2	5
7	2	12	27	12	3	26	3	28	16	7	3
8	3	22	23	7	3	27	1	22	11	4	18
9	0	18	23	5	11	28	2	19	9	6	18
10	1	17	22	8	10	29	2	29	11	10	4
11	1	7	22	12	16	30	1	24	9	10	11

ture community needs in observations and instrumentation. The present survey seeks information to document improvement and continuing needs for improvement in this area some nine years later. Responses to the survey can be found in Table A1.

1. Problems

The 1989 survey identified several problems facing the fields of meteorology and oceanography relating to education in observational science. For each of

the following problems identified in the BAMS summary, give your opinion as to whether the problem

- a) is worse than 10 years ago,
- b) remains as a serious problem,
- c) has seen modest improvement over the last nine years,
- d) has seen major improvement over the last nine years, or
- e) is one which you have no opinion or no information.

- _____ 1) Major observational systems are not upgraded/replaced as early in their useful life as computational systems.
- _____ 2) Only a very few universities have the necessary faculty and facilities to offer quality instruction on state-of-the-art measurement technology.
- _____ 3) Few students elect to focus undergraduate or graduate studies that blend atmospheric science with special training in physics, chemistry, or engineering.
- _____ 4) There is a perception that NSF has not funded observation and instrumentation-oriented university research and development.
- _____ 5) Academic expectations for faculty productivity and requirements for university promotion and tenure seem to discourage measurements-oriented/dependent research.
- _____ 6) Development of remote sensing systems and processing and interpreting remotely sensed data are not meeting present and future needs.
- _____ 4) Curriculum standards need to be established to ensure literacy in both observational and theoretical methods.
- _____ 5) Faculty and students should take advantage of short courses and other such opportunities at national laboratories or other universities.
- _____ 6) Cooperative arrangements between and among universities should be promoted to better take advantage of centers of expertise.
- _____ 7) All universities should provide basic support for measurements/observations courses.
- _____ 8) Universities and national laboratories and operational branches should work together to give students hands-on experiences with modern observational equipment and data.
- _____ 9) Fellowships should be offered to increase student participation in major field campaigns.
- _____ 10) Cooperative educational programs with private industry should be established.
- _____ 11) UCAR/AMS should facilitate preparation and use of specialized texts that include instrumentation and observations.
- _____ 12) UCAR and AMS should work together to organize special journal issues to consolidate information on state-of-the-art instrumentation.
- _____ 13) Use of datasets for educational learning modules should be promoted.
- _____ 14) Electronic bulletin boards, newsletters, and other communication networks should be established to disseminate educational information regarding datasets and instrument design.
- _____ 15) National laboratories and operational offices should identify an educational contact person.
- _____ 16) UCAR/AMS should prepare a video series on fabrication, calibration, and use of specific instruments or suites of instruments, together with raw datasets, for use by students.
- _____ 17) Competitive graduate fellowships should be established in observational research.
- _____ 18) AMS should give an annual award recognizing excellence in observational research.
- _____ 19) National centers and laboratories should establish collaborative programs for university faculty.
- _____ 20) Specific arrangements for student and faculty involvement should be made by sponsors and participating laboratories that organize large field programs.
- _____ 21) Scientists and engineers at national laboratories should be encouraged to participate in

2. Additional comments

Please attach a separate sheet if you have additional comments.

3. Recommendations

For each of the following 30 recommendations proposed in the BAMS summary, give your opinion as to whether the recommendation

- a) has been implemented successfully,
- b) has seen modest implementation,
- c) remains to be implemented,
- d) is now more urgent than nine years ago, or
- e) is one for which you have no opinion or no information.

- _____ 1) All universities need to provide more comprehensive curricula on observations systems and experimental methods that are more fully integrated with theoretical courses.
- _____ 2) A few universities should provide the breadth and depth of curricula and research in this area to educate the next generation of specialists.
- _____ 3) More emphasis needs to be placed on remote sensing systems and data derived therefrom.

developing university educational and curricular materials.

- _____ 22) Leaders in the meteorological and oceanographic community should evaluate the balance of community investment in different segments of the community.
- _____ 23) Operational branches should provide adequate information on existing and planned observing systems.
- _____ 24) NWS should collocate forecast offices with universities.
- _____ 25) Scientists at national centers and laboratories should serve on Ph.D. dissertation committees at universities.
- _____ 26) National laboratories should place greater emphasis on making facilities, equipment, and datasets available for educational purposes.
- _____ 27) Sponsors of national centers and laboratories should establish long-term plans for needed investments in observational equipment to meet future demand.
- _____ 28) COMET should play a large role in addressing the need for measurement-oriented educational programs at universities.
- _____ 29) Funding agencies should provide easy access to and support for analysis of large datasets.
- _____ 30) Advance plans should be made to ensure that data from NEXRAD and other new observing systems are suitable for educational and research purposes.

4. Additional comments

Please attach a separate sheet if you have additional comments.

5. Representation

I represent (check one):

- _____ a university with M.S. and Ph.D. programs in atmospheric, oceanic, or related sciences.
- _____ a university with M.S. programs in atmospheric, oceanic, or related sciences.

_____ a university with B.S./B.A. as highest program in atmospheric, oceanic, or related sciences.

_____ a national laboratory.

_____ a National Weather Service office.

_____ the military.

_____ the private sector.

_____ other.

(specify) _____

If you choose to identify yourself and (or) your institution, please do so here:

We thank you for taking the time to help inventory national needs in instruction in observations and instrumentation.

Please return this survey to Eugene S. Takle, 3013 Agronomy Hall, Iowa State University, Ames, IA 50011, or fax to 515-294-2619. Communication by e-mail: gstakle@iastate.edu.

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