INTEGRATION OF A FIELD COMPONENT AND INQUIRY-BASED LEARNING IN AN INSTRUMENTATION METEOROLOGY COURSE

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Background:

In Feb 2002, a project was initiated at North Carolina State University, Department of Marine, Earth and Atmospheric Sciences under the NSF Awards for Geoscience Education (AFGE) grant. Project objectives are to: (i) Educate and Train undergraduate students with practical applications of field instrumentation, measurements and observations; (ii) Introduce students to the synthesis of heterogeneous instrumentation output, with human observations, for data assurance and interpretation, and multidisciplinary applications, and (iii) Promote and Emphasize student - community interactions for understanding the microvariability in climatological observations, and its feedback on regional perceptions.

In this project we proposed to design, implement, and evaluate the development of an innovative, active–learning based undergraduate level course. The course focused on meteorological instrumentation and observations of climate variables, along with the analysis and interpretation of climate data, and community interactions to develop cause – effect associations.

Project Activities and Findings:

As a direct result of the AFGE grant, a new course titled ‘Instrumentation Meteorology’ was designed, implemented and successfully offered at Department of Marine, Earth, and Atmospheric Sciences at North Carolina State University in the Spring since 2002 in the Spring semester. The intent of this write-up is to share the experiences associated with the development sand subsequent implementation of the project and course contents for a meteorology curriculum.

The Instrumentation Meteorology course was jointly attended by undergraduate and even graduate students in Meteorology major. In Spring 2002 at total of 14 students signed for this special topics course (which is significantly larger than other special topics courses offered for the first time). In the following year, there were 7 students (6 undergraduates). The lower number was largely due to a coinciding Satellite Meteorology course that is offered as a regular course every alternate year and was included in the students’ plan of work. Subsequent discussions were conducted at the Department to review how the course can be included in the students plan of work, and it was concluded that after the third year a proposal will be made to the graduate school to include a regular course number for the course in place of the special topic status currently available.

In designing the course, discussions and input was sought through number of sources and individuals. These included: (i) recent graduate students who had opinions about what they should have learnt more when in school; (ii) National Weather Service meteorologists both at Raleigh WFO, National Climatic Data Center, Southeast Regional Climate Center, and NCEP, who maintain and use the different meteorological sensors; (iii) media and community service individuals regarding what observations are needed and the knowledge students should have regarding uncertainty in the observations; (iv) stake holders such as agricultural superintendents through the North Carolina Agricultural Research Services who help with the NWS cooperative observing network and also review the differences in the forecast and local observations; (v) from faculty members within the department and across US who teach or have taught instrumentation meteorology (University of Oklahoma, Utah State, University of Nebraska, Colorado State University, University of Missouri, Penn State, University of Wisconsin – Milwaukee and Madison, and the American Association of State Climatologists- which comprises of a combination of academics, federal and state government, and outreach personnel, were all active in the discussion); and (vi) field experiment participants in a major field experiment sponsored by NSF- International H2O Project : IHOP in which number of instrumentation platforms were used. All these inputs ranging from broad philosophical perspectives to vision statements, to specific laboratory routines and textbook chapters that could be important were identified in a series of communications. These input were synthesized and then through series of meetings with the NCSU Provost Office’s Faculty Center for Teaching and Learning a course design and evaluation module was developed. This module was discussed again formally and informally with the meteorology faculty within and beyond the department. In the course content then a focused outline on the issue of educating students on climate analysis both as a monitoring and outlook problem, along with a cause and effect based policy problem through community partnerships and feedback was evolved. The course involves hands - on training with meteorological instrumentation and analysis of climate variables using real - time and archived data, and web-based models. A typical course layout for the different weeks of the semester is shown in Table 1.

Several experiences can be summarized from the course activity. First, the students needed to be reoriented from the strictly academic / class room outlook to a field and operational viewpoint. For example, it was necessary to continuously emphasize that there is no need to memorize formulae, or techniques, or procedures, and to refer to vendor websites and manuals for information. Similarly, it was necessary to take the students to field sites and the site technicians were asked to give their perspectives on how they use, maintain, and operate the instruments. It was noted that the students needed to see the sensors in the actual environment to get an impression of the actual size and its utility. Second, despite the availability of existing and even recently published textbooks on this topic; our experience is that the course content could not be evolved following any particular text. This was largely because of the diverse background of the students attending the course, the need to integrate field component in to classroom activity, and the frequent changes in the operational or research instrumentation, satellite launches, and analyses. Therefore a combination of introductory material from some textbooks, and the reference manual from different manufacturer sensor manuals and NWS ASOS handbook provided a good setup for the course content.

Educational, Human Resources, and Diversity Achievements:

(i) The students provided a dynamic input in the course structure and was constantly improved depending on their background and interests after a core series of lectures were developed. A syllabus for the course is attached.

(ii) The proposed project is (i) in congruence, and in response to prepare undergraduate students for the National Research Council's eight ‘Grand Challenges’ identified for Environmental related projects; and (ii) an important, and often missing, component of the undergraduate geophysical and meteorological education in most educational institutes today.

(iii) The broader impact of the project will be to: (i) provide a dialogue between the community and the classroom activities, (ii) develop "better teaching practices" for meteorological and geoscience education, and (iii) understand community perceptions that can be used by the researchers in improving the dissemination of climatological information.

Students from the Instrumentation Meteorology course installing a 30-ft tower at a field site in Cherry Farm Agricultural Research Station, Goldsboro,NC

Students from the Instrumentation Meteorology course have a hands-on training on the instrumentation and data formats at the Chapel Hill AWOS station, through the National Weather Service.

Students from the Instrumentation Meteorology course installed a 30-ft tower at a field site in Cherry Farm Agricultural Research Station, Goldsboro, NC.
The concepts for data logger programming, site selection, instrumentation characteristics, and communication and data retrieval were discussed in the class while the actual implementation of the class room teaching was made in the field setup.

Datalogger exercise at a field site as part of class tour.

Students studying spatial heterogeneity in observations and geo-referencing the observations for a microclimatological analysis.

Active and Enquiry Based Learning
Students developed independent and team research projects. They developed literature review, presented the initial proposal for a study, (and then as required were mentored with an outside agency such as the WRAL/TV; NWS; Division of Air Quality; North Carolina Supercomputing Center; NC Agricultural Research Services, were some prominent examples).

1. The role of a land-atmosphere scheme and convective parameteriztion on seabreeze induced convection over central Florida
Compared MM5 model run results with observations (including non standard observations such as human reports) for assessing the performance with a statistical – dynamical technique for a hail storm event in central Florida. A peer reviewed paper is under preparation.

2. The effects of land-atmospheric interactions on the evolution and structure of hurricane Fran over North CarolinaStudied the model and observed features of a Category 3 hurricane (Fran) which impacted central North Carolina in 1996. The Bulletin of American Meteorological Society highlighted part of these results in meetings highlight.

3. An Investigation of Extreme Prolonged Summertime Heat Events in the United States
Using data from the National Climatic Data Center the frequency of extreme heat events across US. The data was then correlated with the electrical utility loads from a local power company and the value of such forecasts for the utility company was made. The need for localized observations was also studied to make user specific decisions.

4. A Multi-Sensor Model Evaluation of an Eroding Appalachian Cold Air Damming Event
A cold air damming event was investigated using different sensor platforms and a comprehensive assessment of the erosion was developed using two specific cases over North Carolina

5. ASOS observations at RDU International Airport Compared to Weather and climate observations from surrounding Stations
The question about how representative are the airport observations of the city and regions weather and climate was investigated using observations from a number of sources (coop data, non federal sensors, landuse, and concurrent analysis)
6. Climate observations in support of hydrometeorological and agricultural analysis in Africa

A comprehensive synthesis of the observations available for developing policy decisions related to hydrological and agricultural aspects in Africa were taken by reviewing the CLIVAR, UNCEP and WMO datasets

7. Assessment of a snow algorithm for remote sensing applications with surface observations
Following an internship with NASA two undergraduates developed a followup validation of a snow detection algorithm with observations from North Carolina

Publications and Products- Dissemination, Publications and Broader Impacts:

As a direct result of this project a new Instrumentation Meteorology course was developed and is being offered in Department of Marine, Earth and Atmospheric Sciences at North Carolina State University.

The progress and findings from this project have been disseminated via discussions with peers, by presentations in professional meetings and conference proceedings. A course website is also maintained and has provided efficient means of disseminating the information (www4.ncsu.edu/~dsniyogi). Two undergraduate students have participated in this project and one graduate student has benefited via course and peer reviewed paper development.

As a broader impact the project offered one of the investigator (Niyogi) to participate in a field experiment IHOP – International H2O Project to review the instrumentation available and used and the IHOP field experiment will be used as an example in future classes for training undergraduate and graduate students on the instrumentation, data accesses and science inter-relations.

Syllabus and course layout used in the course:

Instrumentation Meteorology MEA 493J 008/ 593Y			
Course Schedule, T/H 9:50 - 11:05 pm			
Lecture	**Date**	**Topic]**	
1	9-Jan	Introduction/ Overview/ Survey	
2	14-Jan	Temperature (sensor review)	
3	16-Jan	World Trade Center – EPA's onsite monitoring	
3	15-Jan	Data logger program overview /Temp. sensor programming exercise	
		Humidity (overview)	
4	23-Jan	DL program with Humidity; Winds	
5	28-Jan	DL program with Winds	
6	30-Jan	Soil measurements	
7	4-Feb	Soil and Environment	
8	6-Feb	Radiation measurements	
9	11-Feb	Radiation surface and remote sensing	
10	13-Feb	Cloud, Visibility and air quality measurements	
11	18-Feb	Radiation – Cloud Visibility	
12	20-Feb	NWS Lecture ASOS/ abstract submission	
13	25-Feb	Siting and Calibration, Uncertainty	
14	27-Feb	Preview of Topics for Presentation (5 minute presentations)	
15	4-Mar	QAQC representativity of observations	
16	6-Mar	EXAM	
17	18-Mar	Guest Lecture – ASOS field visit	
18	20-Mar	Integrated Datalogger Programming Exercise	
19	25-Mar	Integrated Programming 2	
20	27-Mar	Progress on Topics for Presentation (5 minute presentations)	
21	1-Apr	Assimilating Observations into models	
22	3-Apr	Air Quality monitoring – guest lecture	
23	8-Apr	Soil biophysical field measurement exercise	
24	15-Apr	Porometery, biophysical observations	
25	22-Apr	Applications/ Community Interface-	
26	24-Apr	Field Expts / Project Submission	
27	29-Apr	Guest Lecture on weather derivative industry	
28	1-May	Last Class / Lecture	
29	6-May	Student Presentation (10 + 5 minutes)	
30	8-May	Student Presentation (10 + 5 minutes)	
31	13-May	Final Exam	

Instrumentation Meteorology MEA 493J 008/ 593Y
Course Schedule, T/H 9:50- 11:05 pm, JOR

Course Instructors:
Dr. Dev Niyogi ; dev_niyogi@ncsu.edu Tel: 515 7912.
Course Website: www4.ncsu.edu/~dsniyogi

Generic Topics to be covered
Different measurement systems, their operations, characteristics, and applications. Monitoring of meteorological /environmental variables with particular emphasis on tower measurements, field experiments, and application of different observational datasets for meteorological problems. In class lectures, field projects, site visits.
Measurement systems
Temperature Measurements
Humidity Measurements
Wind Measurements
Data Acquisition and Datalogger Programming
Soil and Environmental Sensors
Radiation Measurements
Footprint analysis, source area representation
Siting, Calibration, Representativity and QA QC
Applications (Assimilation, GIS, Field Experiments)
Guest Lectures (air quality measurements, remote sensing, NWS operations,
Important Dates:
February 20 Abstract submission for Project topics
February 27 Project topics preview presentations (5 mins/ person; revised abstract)
March 6 Mid term Exam/Test
March 27 Progress on Project presentations (5 mins/ person; 2 to 3 page writeup)
April 22 Project report / paper submission (about 10 page writeup excluding figures)
April 29 Four Project Presentations (10 mins presentation/person + 5 minutes QA)
May 1 Project Presentations (10 mins presentation/person + 5 min QA)
Dates for guest lectures, site visits will be announced ahead of time.
Grade Distribution
Homeworks 15%
2 Exams 10% each
Field Project /Site visits 15%
Project 50% (10% abstract; 10% project topic presentation; 10% progress presentation; 40% paper /project; 25% presentation; 5% peer review)
For 593: 96 and above A+; 92-95 A; 89 –91 A-; 85 – 88 B+; 82 – 84 B; 79-81 B-; 75 – 78 C+; 72 – 74 C; 69 – 71 C-; Below 68 D
and below C
For 493: 92 and above A+; 89 –91 A; 85 – 88 A-; 82 – 84 B+; 79-81 B; 75 – 78 B-; 72 – 74 C+; 69 – 71 C; 65 –68 C-; Below 65 D
Top students could be given A+ depending on their overall performance
Office Hours: 1 hr after every class; Feel free to email/call to set up a meeting as needed.