J 4.11 CURRICULUM DEVELOPMENT IN ATMOSPHERIC INSTRUMENTATION FOR UNDERGRADUATES

Melanie A. Wetzel*[1] and W. Patrick Arnott[2]
[1]Desert Research Institute, Reno, Nevada
[2]Department of Physics, University of Nevada, Reno

1. INTRODUCTION

Modern observational techniques for atmospheric monitoring and research incorporate a growing variety and complexity of optical, acoustical, chemical and other sensing technologies. In-depth training with atmospheric instrumentation provides undergraduates with the skills to succeed in a variety of careers that rely on environmental measurements, as well as to pursue graduate study in a wide range of atmospheric research topics. There is a need to expand these types of instructional opportunities in Atmospheric Sciences degree programs (Takle, 2000). A course in atmospheric instrumentation is being developed as part of a new B.S. degree program in Atmospheric Sciences at the University of Nevada, Reno (UNR). The undergraduate program is a partnership between the UNR Department of Physics and the Division of Atmospheric Sciences of the Desert Research Institute (DRI).

The B.S. curriculum complements the UNR DRI graduate (M.S. and Ph.D) Atmospheric Sciences degree program and builds on the research expertise in atmospheric instrumentation of faculty members at both institutions (Arnott *et al*., 1995 ; Borys and Wetzel, 1997). The curriculum includes a strong focus on atmospheric physics and observational meteorology. The new course on Atmospheric Instrumentation will incorporate activities in atmospheric sensor design principles, signal processing, use of computers for instrument control, as well as creation and use of real-time web accessible measurement datasets.

The students will also develop and utilize instrument systems and on-line datasets that are accessed, queried and controlled via radio and web portals, to provide real-time analysis and experience within the scope of atmospheric research opportunities and monitoring programs. The on-line information access will include archived and current measurement databases with tailored graphical, statistical and climatological analysis tools, instrument documentation, training materials and metadata.

The course draws on faculty experience in existing graduate courses such as Radiation Transfer (Figure 1), Mountain Meteorology (Wetzel *et al*., 2003) (Figure 2), Measurement in the Atmosphere (Hallett *et al*., 1993), and prior development of three computer based training modules on meteorological measurement techniques (Wetzel *et al*., 1998; Wetzel and Jenrow, 2001) (Figure 3).

Figure 1. UNR/DRI faculty member Dr. Pat Arnott (foreground) and UNR students study the spectral characteristics of downward atmospheric infrared radiation from clear sky and cirrus cloud with a Bomem spectroradiometer.

2. COURSE OBJECTIVES

The undergraduate course structure for Atmospheric Instrumentation (ATMS 360) will address five key themes:

(1) Sensors: Physics and Engineering Principles

(2) Design: Construction, Calibration, Testing

Corresponding author address: Dr. Melanie A. Wetzel, Atmospheric Sciences, Desert Research Institute, Reno, NV 89512, Email: wetzel@dri.edu

(3) Data Collection: Instrument Control, Operational Measurement Acquisition, Signal Processing

(4) Implementation: Network and Field Program Design, Remote Monitoring, Computer-based Data Distribution

(5) Analysis: Multi-parameter Display, Statistics, Interpretation

Figure 2. A University of Nevada, Reno student (left) and UNR/DRI faculty member (Dr. Randy Borys, right) conducting a calibration procedure for a vane-mounted cloud optical probe at DRI Storm Peak Laboratory in northern Colorado.

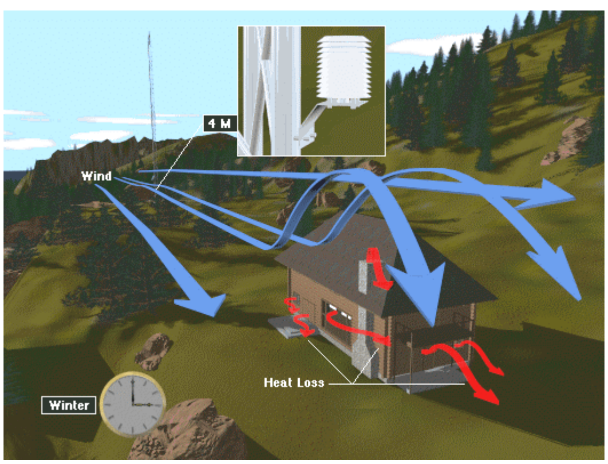

Figure 3. Schematic diagram indicating choice of height for tower position of temperature and wind sensors to be used in evaluating thermal gain and loss for a building (graphic from a computer-based training module developed by DRI and COMET).

Priority will be given to thorough treatment of the first three themes (Sensors; Design; Data Collection), while theme 4 (Implementation) and theme 5 (Analysis) will build a strong foundation for follow-on coursework taken in our graduate program.

Hands-on training will introduce the students to a wide variety of instruments such as a direct-beam spectral radiometer, acoustic wind sensor, sodar, Fourier Transform infrared spectrometer, optical particle counters and gas concentration monitors.

Lecture and practicum activities will include instruction on detector components, physical principles of operation (both *in situ* instrumentation and remote sensing systems), sensor response functions, sources and treatment of error, calibration procedures, field network design, data collection programming, ambient air sample collection techniques, sampling protocol, software for analysis and presentation of results, and statistical treatment of datasets. Student teams will carry out research projects that emphasize instrument design, detector characterization, and field measurement strategy.

3. FOCUS ON INSTRUMENT DESIGN

In order to develop the confidence and creativity of the individual students so that they can design and successfully utilize instruments to suit their own research interests, the class participants will build and test instruments that utilize the most important physical methods for atmospheric instrument design, such as optical extinction and aerosol backscattering, acoustic signal generation and measurement, transducer components, and gas/particulate sample collection. Examples of instrument design projects will include a particle sampler (with controlled flow inlet, impaction and photomultiplier detector), short-range lidar, and multi-wavelength sunphotometer.

Students will benefit from use of computer-aid mechanical and electrical circuit board design software, and lecture contributions from mechanical engineers and computer/electronics control system engineers who are part of the UNR/DRI atmospheric sciences group.

The instrument design and deployment projects will lead to utilization and evaluation of more advanced instruments such as commercial systems for aerosol extinction monitoring (Figure 4), a Fourier Transform Infrared Spectrometer, multispectral shadowband radiometers, 1-D and 2-D optical probes for cloud and aerosol microphysics, gas concentration monitors, acoustic wind sensors, sodar units, wind profilers, radar and multispectral satellite platforms.

Figure 4. An aerosol sampler used for determination of particulate optical extinction characteristics.

4. IMPLEMENTATION AND ANALYSIS

One of the most important aspects of atmospheric measurement is proper implementation, which includes appropriate selection from among many similar types of sensors, establishment of sampling protocol (Figure 5), integration of data from multiple sensors for research or monitoring analysis, knowledge of instrument limitations, and effective dissemination methods for multiple users.

The faculty members in our program have extensive experience in designing and implementing measurement systems for a variety of purposes, and they have utilized remote control methods for sensor operation, web-based dataset archival, statistical and graphical analysis, and development of instrument inter-calibration processes.

Class participants will be given hands-on experience with instrument control software including Campbell Scientific datalogger programming methods and use of LabView. Students will gain experience evaluating trends and other statistical characteristics of long-term archived measurements from the DRI Western Regional Climate Center's large network of atmospheric monitoring sites. The students will also be encouraged to take advantage of multi-platform datasets obtained from large field research projects for course topics on sensor installation, communications and validation.

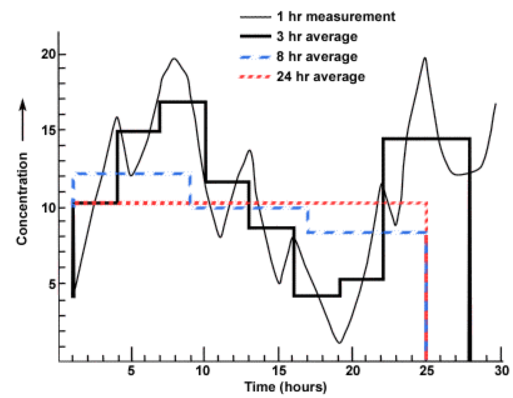

Figure 5. Schematic diagram showing the effect of measurement averaging period on recorded concentration (graphic from a computer-based training module developed by DRI and COMET).

Acknowledgements

Equipment and support for course development is provided by the University of Nevada, Reno and the Desert Research Institute, including equipment grant funds to DRI from the Hawkins Foundation. Research and academic initiatives at DRI in conjunction with the NSF Geoscience Education Program, the NSF Advanced Technological Education Program, and equipment design and procurement projects funded at DRI and UNR by the NSF Major Research Instrumentation program have also furthered the ability of the faculty members to teach in the area of atmospheric instrumentation.

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