USING OPERATIONAL AND EXPERIMENTAL OBSERVATIONS IN GEOSCIENCE EDUCATION

BY BRIAN J. ETHERTON, SEAN C. ARMS, LARRY D. OOLMAN, GARY M. LACKMANN, AND MOHAN K. RAMAMURTHY

The Unidata Users Committee organizes summer workshops every three years on topics of interest to the Unidata community. Seven such workshops have been held over the past two decades on wide-ranging topics, and the collaboration between the Unidata Users Committee and the Unidata program office is crucial for its success. In addition to providing forums for addressing contemporary issues to enhance teaching in the atmospheric and related sciences, the workshops provide a venue for sharing ideas and materials, engaging in in-depth discussion on curricular matters, and devising ways to improve student learning.

AFFILIATIONS: ETHERTON*—Renaissance Computing Institute, University of North Carolina, Chapel Hill, North Carolina; ARMS—School of Meteorology, University of Oklahoma, Norman, Oklahoma; OOLMAN—Department of Atmospheric Science, University of Wyoming, Laramie, Wyoming; LACKMANN—Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, Raleigh, North Carolina; RAMAMURTHY—University Corporation for Atmospheric Research/Unidata, Boulder, Colorado
***CURRENT AFFILIATION**: Forecast Applications Branch, NOAA/OAR/ESRL/GSD, Boulder, Colorado
CORRESPONDING AUTHOR: Brian Etherton, Forecast Applications Branch, NOAA/OAR/ESRL/GSD, 325 Broadway, R/GSD7, Boulder, CO 80305
E-mail: Brian.Etherton@noaa.gov

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THE 2009 UNIDATA TRIENNIAL USERS WORKSHOP

WHAT: Through education and instruction, this summertime event helped attendees to expand the interactive use of instrumentation and observations in their geoscience classrooms.
WHEN: 8–12 June 2009
WHERE: Boulder, Colorado

Building on techniques employed in the 2006 Unidata Users Workshop (Orf et al. 2007), which emphasized the use of models in education, the 2009 workshop, "Using operational and experimental observations in geoscience education," emphasized observations. Although recognizing that models are excellent tools for demonstrating physical processes and testing hypotheses, observational data represent something closer to physical reality. In addition, observations and their analyses are critically important in model evaluation and development and are vital to model initial conditions.

Increasing enrollment in undergraduate meteorology programs around the nation (e.g., Knox 2008) can be attributed to a number of factors. Among them is the fact that students are drawn to atmospheric and related sciences through fascinating real-world experiences during high-impact and societally relevant meteorological events. These personal observations and connections to nature often provide inspiration for careers in the atmospheric sciences. However, students who begin study in undergraduate meteorology programs are sometimes discouraged by the

challenging mathematical and theoretical nature of the field. Interactive, hands-on learning techniques provide opportunities to reignite passion for the science in students. In particular, working with observational data can allow students to reconnect with the inspirational experiences that originally led them to study the atmosphere. If faculty can successfully integrate observations and bridge the gap between theory, models, and observations, then students will better understand the basic physical processes occurring in the atmosphere.

The overarching goal of the workshop was to expand the use of instrumentation and observations in geoscience education. Toward that goal and through a series of interactive sessions with educators, the workshop had the following specific objectives:

1) Instill the view that classroom engagement between students and faculty can be enhanced through the use of instrumentation and observations.
2) Make the case that, in addition to graduate students, participation of undergraduate students in geoscience research in a classroom setting can complement course-specific goals.
3) Demonstrate that fundamental concepts in several of the geosciences can be taught through the interrogation of observational data.
4) Provide a venue for educators to discuss, collaborate, and share teaching techniques and materials.
5) Highlight the community service and broader impact opportunities that observational data collection activities provide.
6) Facilitate the development and dissemination of educational materials in emerging areas such as data assimilation, remote sensing, and unmanned in situ observing platforms.

The 2009 workshop attracted 81 participants, from 32 universities, four foreign institutions, and three U.S. government labs. A total of 11 students participated, and they helped to energize the workshop. During the workshop, academic faculty, researchers, Unidata staff, and graduate students presented an array of educational and instructional sessions showcasing real-world application of observations, software, and instruments for use in the classroom.

WORKSHOP SYNOPSIS. The first day of the workshop was devoted to the topics of remote sensing and educational tools. Welcoming remarks by Unidata Director Mohan Ramamurthy were followed by talks on GPS radio occultation observations (Anthes et al. 2008), multifunction radar, the Colorado State University–University of Chicago–Illinois State Water Survey (CSU–CHILL) radar (Chandrasekar et al. 2005), and National Oceanic and Atmospheric Administration (NOAA) satellite products. In addition to increasing participants' knowledge of the data, subsequent exercises focused on their use in the classroom. Later were talks on products from the Cooperative Program for Operational Meteorology, Education and Training (COMET); the fusion of weather data into Google Earth; Unidata tools Repository for Archiving, Managing, and Accessing Diverse Data (RAMADDA) and Integrated Data Viewer (IDV); and how to build one's own web-based applets. Most of these sessions included a laboratory component, where attendees built keyhole markup language (KML) files for use in Google Earth, captured an image in IDV and published it to a RAMADDA repository, and built the hypertext markup language (HTML)/extensible markup language (XML) tools for making a Web-based applet. A student-led poster session concluded the day, the first time such a session has taken place at a Unidata users workshop.

The theme for the second day of the workshop was data assimilation, the means by which observational data are incorporated into the analyses used by numerical forecast models. Given the growth of this field, there is wide recognition that the utility of assimilation is not limited to constructing the most accurate initial condition for numerical models. Rather, advanced data assimilation students and researchers have demonstrated utility in a new direction for synoptic analysis. At the workshop, four different data assimilation presentations were given, to span techniques for teaching the fundamentals of data assimilation at both the undergraduate and graduate levels. Simple examples, such as the use of the Barnes analysis package in the IDV, demonstrated the value and power of data assimilation as a means for linking new observational sources to the power of numerical modeling. Workshop attendees were also exposed to the more advanced analysis systems, including the MesoWest observational network (Horel et al. 2002) and the Data Assimilation Research Testbed (DART; Anderson et al. 2009).

The third day of the workshop was dedicated to field experiments and instrumentation. The field experiments discussed on this day conscientiously involved students at both the undergraduate and graduate levels. University students who participated in observation-based research performed better in the classroom because of insights gained in the field. In

addition, students who participated in fieldwork were more excited about meteorology. The presenters also offered advice on how to obtain the equipment for such fieldwork, including locating donated or borrowed equipment from local state and federal state agencies. Attendees launched a rawinsonde and toured Radiometrics, a manufacturer and developer of microwave remote sensing equipment. Both of these experiences provided attendees with the hands-on experience advocated in prior talks.

Attendees at the 2009 Unidata Triennial Users Workshop assist in launching a GPS Advanced Upper-Air Sounding System (GAUS) balloon-borne rawinsonde.

The fourth day of the workshop offered exercises on science education, climate observations, air quality data, climate change data, and tools to facilitate explorations of data. The day started with two talks focused on how to engage students in research, be it air quality observations in the urban environment (Powell et al. 2009) or fieldwork in meteorology. Emphasis was placed on knowing your students and their abilities, recognizing your own resources and limitations, and focusing on goals first and content last in designing a course. The point was made that those students who do science will think of themselves as scientists. Following these talks, participants performed a number of exercises, in which downscaled climate forecasts were used to demonstrate the potential impacts of climate change on their own hometowns. Also, the use of data showing the melting glaciers in Greenland gave attendees a means for visualizing climate change in a very tangible way. These talks were followed by a final presentation of educational tools—in this case, the deliberate use of laptop computers by students in large lecture classes (Samson 2010). In contrast to such tools as "clickers," laptop computers allow for information flow in two directions: students to professor and back again. This back and forth allows for a great deal more engagement with students. The "Weather in a tank" (Illari et al. 2009) presentation provided an exciting illustration of how basic principles of geophysical fluid dynamics can be conveyed through rotating fluid tank experiments, providing a means for students to make connections between real-world atmospheric phenomena, simple physical laboratory models, and theory.

The final day of the workshop consisted of two panel sessions. The first was on emerging technology, giving workshop attendees a peek at the future. The second panel focused on lessons learned from the workshop as well as reflections on Unidata at age 25.

BENEFITS AND OUTCOMES OF THE WORKSHOP. Benefits of the 2009 Unidata Triennial Workshop included the sharing of tools developed within the community, along with the inspiration and synergy that results from the exchange of ideas with other educators. Indeed, the use of RAMADDA at the workshop greatly facilitated the sharing of data, software, and educational materials. Finally, the workshop succeeded in establishing a lasting discussion and a close network to improve the sharing of both materials and pedagogical ideas on how to most effectively educate students in the geosciences.

To inform subsequent workshop offerings, participants completed online evaluations and also provided candid suggestions during the final panel discussion. The responses were overwhelmingly positive. That said, there were requests for more hands-on work and classroom emulation in the presentations, the opportunity for off-site participation, and expanded breakout discussion opportunities at several points

during the workshop. To make our vision of an open, robust collection of curricular material involving observations a reality, we have established and encourage you to visit the online RAMADDA repository of the workshop materials (http://motherlode.ucar.edu/repository/alias/2009_user_workshop). Here you can share your views, utilize the workshop materials, and perhaps contribute some of your own materials to the community.

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