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COMET'S INFLUENCE ON METEOROLOGICAL EDUCATION AND RESEARCH WITHIN UNIVERSITIES: THE SAINT LOUIS UNIVERSITY EXPERIENCE

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1. INTRODUCTION

Since its inception in 1989, the Cooperative Program for Operational Meteorology, Education and Training (COMET) has developed numerous ways for students, educators, and operational meteorologists to upgrade their skills and keep abreast of rapid developments in the field. Saint Louis University (SLU) has been involved in many COMET programs including residence courses, distance-learning education, and outreach programs that team university faculty with National Weather Service (NWS) forecasters. Like many universities, SLU has benefited greatly from COMET's various programs through enhanced teaching aids, research grants, and invaluable collaborations with NWS forecasters. In kind, SLU has contributed to COMET's efforts by offering subject-matter expertise on various mesoscale meteorological topics, teaching at residence courses, and serving on COMET committees. This paper will focus upon the numerous ways in which SLU and other universities have been involved with COMET and describe how this relationship has proven to be mutually beneficial.

2. RESIDENCE CLASSES

Although the paradigm has changed in recent years due to monetary constraints, residence courses have been at the core of the COMET program. Residence courses are mostly offered for NWS forecasters, however special courses have been created for forecasters from the Meteorological Service of Canada (MSC) and university faculty. SLU professors have been involved in residence courses as students and as subject matter experts (SMEs) in several instances. Courses for faculty are offered during the summer approximately every other year, and are designed to bring faculty "up-to-date" on select topics including: numerical weather prediction, hydrometeorology, and utilizing new technology in the classroom. These courses not only offer excellent content but also provide a collegial atmosphere in which faculty can discuss pedagogical issues and compare notes on what techniques and approaches work and don't work in the classroom. This kind of forum for faculty is uncommon, except perhaps during brief discussions at national conferences.

Another way in which residence courses provide enrichment for faculty is when they are asked to serve as a SME for a course designed for forecasters. The primary author has been fortunate to be involved in a number of COMET residence courses including the Hydrometeorology Course, the COMET Mesoscale Analysis and Prediction (COMAP) course for Science and Operations Officers (SOOs), and the Winter Weather Course for the MSC. Often the instructor learns at least as much from the "students" as he/she teaches them. Although residence courses can be expensive to run they offer many intangibles that do not come with either web-based instruction or CD lessons. The collegial experience of interacting with experienced forecasters who tackle real-world problems during their shifts is a great "reality check" for the SMEs. Also, it gives them a chance to explore new ways to approach old problems through improved visualization tools and conceptual models. Many times life-long friendships are made during lunch or break times that facilitate research and the exchange of ideas. This is the stuff of science!

3. DISTANCE LEARNING EDUCATION

SLU has used many of COMET's distance learning materials, including laserdiscs, CD-ROMs, and, more recently, web-based lessons. These resources have grown in popularity and usage over the last decade in both undergraduate and graduate coursework. We developed a "COMET Modules" course for undergraduates for which students sign up for 1-3 credits of COMET CD-ROM or web-based coursework. Generally,

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we only allow juniors or seniors to take this course as an elective. Students like the self-paced learning and the ability to go over the material several times until they understand the subject. In recent years we have moved more to material posted on the **meted.ucar.edu** web site since students are able to access the material in their residence halls or at home. Faculty members then question students on material relevant to the module studied while going over sections of the module with them. It turns out to be a good learning experience for the faculty member as well! Table 1 lists some of the more popular courses chosen by students over the last decade. In addition to the COMET Modules course some students are exposed to the modules through a standard SLU course, e.g., Remote Sensing and Instrumentation, which requires them to complete a module on satellite imagery as part of the course.

Graduate students have found the **meted.ucar.edu** web site to be a valuable resource as they research topics relevant to their thesis or dissertation. Most recently, one of our doctoral candidates was able to create several presentations on the basics of Numerical Weather Prediction, Data Assimilation Techniques, and Ensemble Model Forecasting using information obtained from the **meted.ucar.edu** web site. He presented this material to students in our Synoptic Meteorology II course to assist the lead professor. In the same way, professors can use this site as a resource to upgrade their own knowledge on a certain topic or obtain fresh graphics to amplify older, more staid material (e.g., illustration of atmospheric conveyor belts). In many ways, the **meted.ucar.edu** web site has grown from being a "handy" resource to being invaluable for both education and research. In the past, collecting such technical information took hours or days; today it takes minutes, thanks to the diligence of the COMET staff and the financial support of the program by numerous governmental agencies.

In the last few years COMET has introduced "webcasts" in which a lecture is taped, typically during a residence course presentation. The webcast presents the slides and broadcasts the voice of the lecturer. The author has been fortunate to have three of his lectures made into webcasts, including "Isentropic Meteorology", "Heavy Banded Snow", and, most recently, "Jet Streak Circulations." This format is engaging since it brings the full flavor of the lecture to the web, which can be more interesting to the student. Additionally, it allows for more effective learning through an auditory component, thereby accommodating different learning styles.

Table 1. Popular COMET Modules Used At SLU

- Hydrology for the Meteorologist: The Headwater Forecast Process
- Isentropic Analysis
- A Convective Storm Matrix: Buoyancy/Shear Dependencies
- Ensemble Forecasting Explained
- Quantitative Precipitation Forecasting Overview
- How Mesoscale Models Work
- Heavy Banded Snow
- Jet Streak Circulations
- Model Fundamentals
- Ten Common NWP Misconceptions
- How Models Produce Precipitation and Clouds
- Inverted Troughs and Their Associated Precipitation Regimes
- Impact of Model Structure and Dynamics
- Influence of Model Physics on NWP Forecasts
- Intelligent Use of Model-Derived Products
- Operational Models Matrix: Characteristics of Operational NWP Models
- Understanding Data Assimilation: How Models Create Their Initial Conditions
- The Use and Misuse of Conditional Symmetric Instability
- Freezing and Melting, Precipitation Types, and Numerical Weather Prediction
- Mesoscale Convective Systems: Squall Lines and Bow Echoes
- Satellite Meteorology: GOES Channel Selection

4. THE COMET OUTREACH PROGRAM

Another significant way in which the COMET program has impacted teaching and research at SLU and many other universities is through its Outreach Program. Over the last decade COMET has offered both **partners grants** and **cooperative grants** to universities who have collaborated with NWS forecast offices on research projects. Partners grants generally cover a one-year period, are highly focused, and involve a university and one NWS forecast office. Cooperative grants typically cover a two or three-year period and partner one university with several

NWS forecast offices and/or national centers (e.g., the Storm Prediction Center). Although the funding for these grants is relatively small compared to that from standard granting agencies, e.g., NSF, the outreach program is very cost effective. This breakthrough program has helped to bring the research and operational sectors closer together by connecting university research scientists with NWS forecasters. It should be remembered that when this program started these meteorological communities rarely communicated! COMET is to be congratulated for funding operationally-oriented research. Unfortunately, in recent years, due to budget cuts, the Outreach Program has fallen on hard times. It is our hope that this program can be funded again in the near future!

SLU has had the good fortune of being funded through the Outreach Program on many occasions. Table 2 lists the various partners and cooperative projects completed by SLU investigators over the last thirteen years and the NWS partners involved.

Table 2. SLU-NWS COMET OUTREACH PROJECTS FROM 1991-PRESENT

1 July 1991 – 31 December 1992: Partners Project: A Study of the Initiation and Propagation of Mesoscale Precipitation Systems. **SLU**: James Moore. **NWS FO**: St. Louis, MO: Fred Glass and Guy Tucker.

1 May 1993 – 1 November 1994: Partners Project: Propagation and Evolution of Mesoscale Convective Systems Producing Flash Floods. **SLU**: James Moore. **NWS FO**: St. Louis, MO: Fred Glass and Dan Ferry.

1 January 1993 – 1 May 1997: Cooperative Project: Cooperative Research on Midwestern Severe Convective Storms. **SLU**: James Moore and Y.J. Lin. **NWS FO**: St. Louis, MO: Fred Glass, Dan Ferry, Gary Schmocker, Todd Shea, and Ron Przybylinski. **NWS FO**: Louisville, KY: Kevin Darmofal, Don Kirkpatrick, and Ted Funk.

1 January 1994 - 30 November 1997: Cooperative Project: Fog Prediction using a Simple Numerical Model. **SLU**: G.V Rao. **Headquarters USAF** (Offitt, Nebraska) and **Scott Air Force Base**, IL (XTX) with the **Air Force Weather Agency (AFWA)**.

1 January 1996 – 31 December 1999: Cooperative Project: Research on Severe Mesoscale Convective Systems and Quantitative Precipitation Forecasting across the Middle Mississippi and Ohio River Valleys. **SLU**: James Moore and Y.J. Lin, **NWS FO**: St. Louis, MO: Ron Przybylinski, Fred Glass, Gary Schmocker, Greg Lewis, Tom Spriggs, and Dave Metze. **NWS FO**: Louisville, KY: Ted Funk, Don Kirkpatrick, Van DeWald, Rob Cox, Larry Dattilo, and Marty Trexler. **NWS FO**: Paducah, KY: Pat Spoden, Jim Keysor, Chris Jones, Mike York, and Jeff Hovis. **NWS FO**: Slidell, LA: Alan Johnson and Jim Moser.

1 September 1999 – 30 August 2000: Partners Project: Case Studies of Tornadoes Associated with Tropical Cyclones. **SLU**: G.V. Rao, Joshua Scheck, and Krishnaraj Santhanam. **NWS Storm Prediction Center (SPC)**: Roger Edwards.

1 January 2002 – 31 December 2002: Partners Project: Analysis and Forecasting of Tornadoes Associated with Tropical Cyclones. **SLU**: G.V. Rao, Joshua Scheck, and Krishnaraj Santhanam. **NWS SPC**: Roger Edwards. **NWS FO**: Jacksonville, FL: David Sharp and Bart Hagemeyer.

1 January 2003 – 31 December 2003: Using MM5 Short-term Integrated Kinematic Fields to Distinguish TC Gabrielle's (2001) Mesocyclones Which Produced Tornadoes From Those Which Did Not in Florida. **SLU**: G.V. Rao, Joshua Scheck, and Krishnaraj Santhanam. **NWS SPC**: Roger Edwards. **NWS FO**: Jacksonville, FL: David Sharp and Bart Hagemeyer.

1 October 2003 - 31 December 2004: Partners Project: A Diagnostic and Prognostic Examination of a Major Flash Flood in Eastern Iowa and Northwest Illinois: 3-4 June 2002. **SLU**: James Moore and Charles Graves. **NWS FO**: Davenport, IA: Ray Wolf and Jeff Zogg.

These seven Partners Projects and two Cooperative Projects resulted in seventeen M.S. theses and five doctoral dissertations on topics ranging from forecasting radiation fog, bow echoes, and heavy convective rainfall to understanding how tornadoes develop from land-falling tropical cyclones. Many of these graduates now work for the NWS, bringing their COMET research experience to the operational field. Several of our doctoral students accepted teaching positions at universities, carrying this rich

operational experience into their teaching and research.

Another result of this collaborative research has been the publication of dozens of preprint articles and at least six peer-reviewed manuscripts published in American Meteorological Society journals (e.g., *Weather and Forecasting*) and the *National Weather Digest.* It is important to realize that this operationally-based research has fostered friendships and facilitated continued collaboration well past the period of the grant. Also, it is the authors' belief that doing research together leads to a respect for each other's position in the meteorological community. Prior to the COMET Outreach Program there was a distinct disconnect between the operational and research communities; now there is renewed enthusiasm to work together to overcome the difficulties in forecasting winter storms, mesoscale precipitation systems, fog, and a myriad of other weather challenges. Most importantly, this was done at a fraction of the cost of conventional grants. Furthermore, our experience at SLU has been mirrored at numerous other universities that have benefited from the Outreach Program (e.g., Florida State University, University of Oklahoma, North Carolina State University, and the State University of New York at Albany),

One other program that is no longer available at COMET is the Dissertation Fellowship Program. One of our doctoral students, Dr. James O'Sullivan received a COMET Dissertation Fellowship from 1 September 1996 – 31 August 1999. He worked with Dr. Y.J. Lin on research related to severe squall lines and their attendant straight-line winds and tornadoes. Numerous Dissertation Fellowships were awarded by COMET during this time period. Unfortunately, this program was cut a few years ago due to budgetary constraints, which is unfortunate.

5. COMET CASE STUDIES

Yet another area where COMET expertise has impacted teaching and research at universities is through GARP (GEMPAK Analysis and Rendering Program) case studies. In addition to developing the GARP software, the talented crew at COMET has meticulously collected observational and numerical data sets on winter storms, severe convective storms, tropical cyclones, etc. to distribute as case studies. At SLU and elsewhere around the nation, these case studies have been instrumental in teaching important concepts from Quasi-Geostrophic (Q-G) theory, jet streak circulations, skew-t log-P analysis, isentropic analysis, etc. in the synoptic laboratory using real-world events, not numerical simulations or idealized models. For most instructors the time and effort required to complete a data set for a case study can be overwhelming. The GARP case studies are now used across the nation for instruction to help students analyze weather data and compare numerical model data. In addition, critical concepts of radar and satellite meteorology can be taught using actual examples from historical storms. Table 3 lists just some of the GARP case studies that have been used at SLU in Synoptic Meteorology I and II. Students enjoy working on cases in which they can overlay data and animate imagery to better understand the physical processes critical to the production of heavy precipitation, severe convection, or winter weather.

Table 3. GARP CASE STUDIES USED AT SLU

- 11-13 March 1993: Storm of the Century
- 3 May 1993: Oklahoma City Tornado
- 31 October 1998: Wichita Halloween Flood
- 5 May 1996: Bow Echo over Paducah, KY
- 17-19 July 1996: Chicago Flood
- 24-26 January 2000: East Coast Cyclogenesis
- 9-11 November 1998: Heavy Snow in Sioux Falls, SD and Winter Severe Weather
- 4 October 1998: Kansas City Flash Flood

More recently, the NWS has moved toward the creation of case studies by archiving data on the Weather Event Simulator (WES). The WES allows the user to relive a weather event in the Advanced Weather Interactive Processing System (AWIPS) environment. NWS forecasters currently are required to complete two WES cases for training on station. COMET has provided the software to create a WES workstation within a PC-LINUX environment for universities. In this way universities can use WES case studies in the classroom or as a laboratory exercise. More importantly, students are now able to learn the functionality of an AWIPS workstation to better understand how current NWS forecasters diagnose and predict weather systems. This helps universities to offer training on a system used by NWS meteorologists, thereby bridging the gap between the university and the "real world" environment.

6. CONCLUSIONS

Over the last seventeen years COMET has revolutionized the manner in which professional meteorologists obtain training. COMET has provided this training, education, and research experience through:

- Residence Classes,
- Distance Learning Education,
- Outreach Program, and
- GARP and WES Case Studies.

Although these efforts were originally designed for the NWS, other agencies including the U.S. Navy, the U.S. Air Force, the MSC, and the National Environmental Satellite, Data, Information Service (NESDIS), have funded COMET to produce material that is available for the entire meteorological community. In this way, broadcasters, university students, professors, and private meteorologists all benefit from COMET's expertise. Thus, the SLU experience is typical of what many other universities, agencies, and companies can get from COMET. For this and more, we and the rest of the meteorological community are very grateful.

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