5.11 The Benefits of a Nine Year Partnership between the National Weather Service and The Pennsylvania State University

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1. INTRODUCTION

The National Weather Service Forecast Office (NWS) in State College, Pennsylvania opened in January 1993 when the Middle Atlantic River Forecast Center (MARFC) moved from Harrisburg to State College. The Weather Forecast Office (WFO) staff began arriving in May of 1993. The newly established office was intentionally located in State College to foster a relationship between the NWS and the Pennsylvania State University's Department of Meteorology (PSU). Initially a small group of meteorologists, including one professor and two graduate students were collocated in the Rider-II Building. This initial collocation fostered a rapid growth in scientific exchanges between the NWS and the PSU. The PSU Meteorology Department, located in the Walker Building, is about two blocks from the NWS office in the Rider-II Building.

The PSU provided data connectivity to the NWS on the Internet in the autumn of 1993. This benefited both organizations research and forecast opportunities. The early access to the Internet and data connectivity issues played a significant role in the relationship between the two organizations.

The PSU also provided classroom space one floor below the NWS operations area. This space has been used for a wide range of activities over the past nine years. Additionally, this facility has been refurbished and modernized by the PSU to provide excellent instructional space for PSU meteorology classes. In addition to instructional activities, this space has been widely used for meetings and NWS seasonal workshops.

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This paper will summarize some of the key activities related to the nine-year association between the PSU and the NWS. The focus is primarily on the WFO activities, including research and data exchanges, instructional activities, and COMET projects.

2. RESEARCH

Research activities between the PSU and the WFO date back to September of 1993 and the arrival of the first jointly shared Hewlett-Packard workstation called *supercel*. Upon arrival, the graduate students in the Rider-II Building connected the machine to the PSU network. By October 1993, ***supercel*** was used to obtain PCGRIDDS data for operational use in the WFO. The machine was also used as an access point to allow the PSU weather display system to be used operationally at the WFO.

The Internet connectivity fostered data sharing and led to the rapid development of case studies and experimental data on the web. Past web servers (***supercel, bookend***, and ***hail)*** provided post-event summaries and real-time data related to several COMET projects. This data connectivity also led to the use of GEMPAK in operations (1994) and selection of the NWS State College, Pennsylvania as a Regional and Mesoscale Meteorology Team Advanced Meteorological Satellite Demonstration and Interpretation System (RAMSDIS; Molenar et al 2000) test site in 1994 for experimental digital GOES data display.

The data availability led to the first joint map discussions in the winter of 1994. From 1994-1998 GEMPAK training was provided for students involved in the Map Discussion class. Additionally, the data access also provided the framework for the first research project, related to the banded snowfall event of 31 October 1993

(Grumm and Forbes 1994; Grumm and Nicosia 1997).

In the period 1993-1999, research efforts focused on radar and model applications. This led to several publications on banded precipitation, culminating in a paper summarizing winter storms published in 1999 (Nicosia and Grumm 1999). A unique banded precipitation event in September 1996 occurred while two WFO forecasters were attending a mesoscale meteorology class. The event became a class project, which was eventually published (Nicosia et al. 1999). This led to the course METEO 579 "Significant Weather Events" discussed in section 3.

In the period from the summer of 1999 through the summer of 2002, the research efforts shifted more toward mesoscale modeling and advanced forecast techniques. With the assistance of graduate students from the PSU, the PSU-NCAR MM5 was set-up and made operationally available in the spring of 1999. The model is still in use. The MM5 has been used to conduct sensitivity studies and for student projects in a jointly taught course on Quantitative Precipitation Forecasting (autumn 1999). Several model simulations were conducted of East Coast snowstorms. The results were presented at the 18th Conference on Weather Analysis and Forecasting (Grumm and Bryan 2001).

Advanced forecasting techniques included the development of a Climatic Anomalies Database in the autumn of 1999. These data were quickly applied to operational model forecasts and showed great utility in identifying potentially large and significant weather events. This research produced several conference papers and two formal publications (Hart and Grumm 2001 and Grumm and Hart 2001).

The WFO and the PSU jointly entered the realm of model blending (ensembling) in October 1999. The initial ensembles included the National Centers for Environmental Prediction (NCEP) models. Local model data were included in ensemble suite in December of 1999. This resulted in a conference paper (Grumm, Knight, and Gadomski 1999) and fostered increased model ensembling efforts. In the winter of 1999-2000, access was obtained to the National Center for Environmental Prediction's Medium Range Ensemble Forecast (MREF) system output files. This led to the jointly hosted website at http://eyewall.met.psu.edu/ensembles/ . This site was expanded to include a model blend of ensembles or super ensembles early in the winter of 1999. The ensembles and other model output were also displayed using the departures of the forecast fields from the climatic anomalies. The data displayed on these pages precipitated several jointly taught courses from 2000-2002.

A more recent effort, began in the early autumn of 2001, was the production and display of ensemble model output statistics. This and other experimental forecast products were rapidly integrated into operations and used in courses taught in Rider II Building.

3. INSTRUCTION

Instruction covers a wide range of activities from formal classroom instruction to an independent study approach best characterized by the PSU METEO 418W course, entitled *Topics in Mesoscale Meteorology*. Through a computer based learning course (METEO 418W), undergraduate students completed COMET modules and conducted studies, often using WSR-88D archive II data. Several of these studies were made available on the web over the years. This effort, begun in 1995, has continued for the past seven years. It provides students an exposure to WSR-88D data, and in some instances, mentoring by a WFO meteorologist during the case study phase of the course. The PSU and WFO invested considerable resources to this effort. The PSU purchased a series of SUN-SPARC workstations, through a National Science Foundation grant, to facilitate data display and case playback. These workstations were placed in the PSU classroom on the fourth floor of the Rider II Building. The WFO provided real-time archiving of cases of interest for use in METEO 418W. Many METEO 418W projects are hosted at http://www.ems.psu.edu/~diercks/meteo418w.html.

Several courses have been offered in the collocated space over the years including mesoscale meteorology, radar meteorology, and a wide range of seminars and short courses. Jointly taught courses on precipitation forecasting, long-range forecasting, and extended long range forecasting have been taught every semester since the autumn of 1999. NWS employees attend and participate in these courses.

METEO 579 “Significant Weather Events” was taught in the Rider II Building in the autumn of 1997 and 1998. In this course, recent papers or recent significant weather events were discussed. Students and NWS attendees selected the topics.

In addition to PSU classes in the Rider-II Building, open to all NWS employees, the NWS conducts a winter and a severe weather workshop every year. Since the 1994 Severe Weather Workshop, a guest speaker from the PSU has made a presentation at each workshop. From 1995-1998, Dr.Greg Forbes provided lectures on forecasting severe weather and radar interpretation. Dr. Forbes, as part of a COMET project, spent three years conducting storm surveys with the NWS, providing training and guidance on storm surveying too many NWS employees.

In addition to the classroom instruction, the WFO has maintained an active student trainee program. On average, 1 to 3 students per semester gain experience by working in the WFO several hours each week during the semester. At the end of the semester, a short paper is written on the experience and student gets credit for the METEO 496, Independent Studies course. Often, a paid position is set-up for one student. This program has been very effective and many former trainees have become NWS employees (see Acknowledgements).

4. COMET

The WFO and the PSU have shared in many COMET projects over the years. Dr Forbes served on the COMET advisory board (1989-1993) and was the instructor of the second COMET Mesoscale Analysis and Prediction Course (COMAP II) in 1993.

a) Cooperative and graduate student fellows

A list of cooperative and graduate Fellows projects is provided in Table 1. The first COMET Cooperative project was funded from 1996-1998. The project title was “Studies to Improve the Forecasting and Warning of Weakly Forced and Non-Classic Severe Convective Events". The project helped improve severe weather forecasting and warning procedures at the WFO and resulted in numerous conference papers related to severe convection. This study led to a study on pulse storms. Additionally, the PSU primary investigator, Dr. Forbes, provided survey training to NWS staff during and after the project.

The second COMET project, from 1996-1998 was a Graduate Fellow project on "Forecasting Studies Using Hourly Model-Generated Soundings”. This project led to several publications (Hart et al. 1998 and Hart and Forbes 1999). The overall success of this project was demonstrated by a lasting relationship between the student and the WFO, which has now spanned over six years. Additionally, the resulting model soundings page is still a widely accessed site.

An investigation of banded precipitation was conducted under the project entitled “The Use of Equivalent Potential Vorticity Diagnostics in Quantitative Precipitation Forecasting”. The study was conducted from 1999-2002. The results were presented at two seasonal workshops and the final results will appear in Monthly Weather Review in late 2002.

The COMET project on the Pennsylvania Mesonet project is on going. This project has provided for real-time observational data and will provide a basis for future mesoscale climatology over Pennsylvania. The first year of the project included efforts to routinely obtain and decode Roadway Weather Information System (RWIS) data. These data were then made available on AWIPS and put into a MySQL database. These data provide the basis for an operational mesonet, and have potential climatological applications.

b) Partners projects

The list of COMET partner’s projects is shown in Table 2. These projects covered a wide range of topics and a large number of individuals. Individuals primarily involved in work related to the project are listed in the table.

The ensembles project resulted in numerous conference papers and a more recent paper in review for an AMS journal. The results of this project have been used in other studies and provided course materials for several PSU courses, the COMET Numerical Weather Prediction (NWP) course, and the WDTB Winter Weather Workshop.

5. CONCLUSIONS

The nine year long partnership between the PSU and the NWS in State College has been a time of

considerable collaboration. In addition to the examples cited, the list of references, and individuals acknowledged below reflect an impact on a large number of meteorologists. The case studies and classroom courses impacted even more people. These considerable activities clearly indicate that the concept of collocating an NWS office with a university can have a wide range of positive impacts.

The partnership is continuing through several ongoing efforts. Recent impacts of the ensembling effort and the climatic anomalies studies show great promise for continued research and collaboration into the future. The RWIS project offers great potential to establishing a viable mesonet in Pennsylvania.

With the evolution of the Weather Research Forecast (WRF) model, and its eventual inclusion in the NCEP production suite, a new opportunity is now available. The NWS and the PSU mesoscale-modeling group have a unique opportunity to use the detailed MM5 runs and compare these with runs of the WRF. This should facilitate the implementation of the WRF while providing a good medium of exchange. Additionally, these data should be useful ensemble members.

Finally, the climatic anomalies database offers incredible potential for long range and seasonal forecasting through anomaly analogs. One method to improve this and the viability of anomaly analogs would be to move toward a 6-hour database rather then the current 12-hour database. With these data, individual 6-hour climatology's could be built, eliminating the diurnal impacts when these data are applied to operational models and ensemble forecast fields.

6. ACKNOWLEDGEMENTS

Many PSU and NWS individuals contributed the successes of the cooperative efforts over the past nine years. Notable individuals include undergraduate students, graduate students, professors, and network personnel. Italics denote former student trainees who have become NWS employees.

Graduate students Mathew Pearce and Steve Hoffert helped develop the NWS web presence in 1994. Both were active in radar studies and radar display capabilities from 1994-1998. Robert Hart was instrumental in developing model soundings data access, network support, MM5 setup, and an incredible range of computer and experimental forecast support. George Bryan set-up and maintains the MM5 model. Richard James and Neil McGillis conducted case studies.

Undergraduate students were many, several standouts from 1993 to 2002 including present NWS affiliation; include *David Michaud* (NCEP), *Diane Innes* (KCHO), Joel Widener, Tommy Owens, *Evan Bookbinder* (KSGF), Jana Sielhiemer, *Steve Rogowski* (KORD), Bryan Ayers, and Justin Brolley.

Past NWS staff members who played significant roles include *David Michaud* (1994-1997), David Nicosia (1994-1999), Ernest Ostuno (1994-1999), Michael Evans (01/1998-01/2002), and current employees David Ondrejik and Peter Jung.

PSU professors who have made contributions in course work and participation in seasonal workshops over the years include Dr. Michael Fritsch, Dr. John Clark, Dr. Hans Verlinde, and Dr. Gregory Forbes. Dr Forbes was the key player in the early successes and whose assistance paved the way to success.

Other individuals of note include Gary Carter and Paul Stokols for the vision and early support of this office during their tenure and the NWS Eastern Region Headquarters. Finally, Jeff Wolfe (PSU) for network and computer support over the past nine years.

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COMET Cooperative and Fellowships				
Title	**Years**	**PSU**	**NWS**	**Notes**
Studies to Improve the Forecasting and Warning of Weakly Forced and Non-classic Severe Convective Events	1996-1998	Dr. Forbes Mathew Pearce	Grumm Dunham	Final Report January 1998
Forecasting Studies Using Hourly Model-Generated Soundings	1996-1998	Dr. Forbes Robert Hart	Grumm	Hart and Forbes (1999) Hart et al. (1998) Evans and Grumm (2000)
Meteorological Analysis of the Madison County Flood	1996-1998	Dr Fritsch Michael Pontrelli	Zubrick	Sterling WFO project with some State College participation. Pontrelli et al (1999)
The Use of Equivalent Potential Vorticity Diagnostics in Quantitative Precipitation Forecasting	1999-2002	Dr. Clark Richard James	Grumm	Clark et al. (2002)
Developing an Interactive Mesonet for Penn DOT	2001-2002	Mr. Knight Bryan Ayers	Ondrejik Grumm	Real-time web and AWIPS data
Bow Echo Development Associated with the Interaction of Complex Terrain: Blending Observations and Idealized Simulations	2002-2003	Dr. Markowski	Grumm	Began summer 2002

Table 1 A list of COMET Cooperative projects and fellowships conducted by title and approximate year. Data also include the primary Pennsylvania State University investigators and National Weather Service employees involved in the project. Shading denotes COMET Fellowships.

COMET PARTNERS PROJECTS				
Title	**Years**	**PSU**	**NWS**	**Notes**
A Study of Lake-Effect Rain Event Downwind of Lake Erie	1995	Dr. Fritsch Todd Miner	Grumm	Final Report January 1996 With Buffalo NWS office. Miner and Fritsch (1997)
Improved QPF Using Artificial Neural Networks	1995-96	Dr. Forbes	Ostuno	
An Investigation of Mesoscale Band Formation in Extratropical Cyclones and Implications for Quantitative Precipitation Forecasting	1997-98	Dr. Clark	Nicosia Grumm	Nicosia et al. (1999) Grumm (2000)
Mean Arial Precipitation (MAP) Forecast Project	1998-1999	Mr. Knight	MARFC Grumm	Web pages QPF Class
An Investigation of Pulse-Type Thunderstorms: Implications for Developing a Local Warning and Forecast Strategy	2000	Dr. Verlinde	Gartner Ostuno	Web
Operational Ensembling, Forecasting and Data Display Techniques	2000-2001	Robert Hart Dr. Fritsch	Grumm	Real-time WebPages Ensemble Training Grumm and Hart (2001) Hart and Grumm (2001)
A Method for Predicting Heavy Rainfall Events in the MARFC Domain Using Mesoscale Model QPF Biases and Climatology	2000-2001	Mr. Knight	Grumm Evans	MM5 and WS-ETA studies
An Early Alert Flash Flood Warning System	2001-2002	Mr. Knight Justin Brolley	Grumm Ondrejik	QPF class 2002 Numerous studies

Table 2 As in Table 1 except a list of COMET Partners projects.