COMET Partners Project for Visiting Scientist Support: The Storm Prediction Center/National Severe Storms Laboratory Spring Program
Partners Project S03-38671 Six Month and Final Report

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1. PROJECT OBJECTIVES AND ACCOMPLISHMENTS

1.1 Each year during the active spring severe weather season, the Storm Prediction Center and the National Severe Storms Laboratory conduct a collaborative, multi-agency experiment designed to explore operationally relevant research and forecasting activities. The 2003 Spring Program was conducted in the SPC/NSSL Science Support Area (SSA) adjacent to the SPC Operations Room from April 14 through June 6, 2003, and focused on two areas of current NWP model development: 1) a primary component (60%) explored the use of Short-Range Ensemble Forecast (SREF) systems in support of severe thunderstorm forecasting, and 2) a secondary component (40%) evaluated operational and experimental high resolution model forecasts of convective initiation and evolution. Spring Program participants included SPC forecasters and support scientists, NSSL/CIMMS researchers, forecasters/SOOs from other NWS offices, and a wide range of visiting scientists and forecasters from a variety of organizations, including USWRP, COMET, Meteorological Service of Canada, UK Meteorological Office, and a number of academic institutions (Universities of Oklahoma, Arizona, and Washington, Massachusetts Institute of Technology, the Pennsylvania State University, and Iowa State University). Travel expenses for visiting scientists from Iowa State (Prof. William Gallus), Penn State (Prof. Nelson Seaman), and MIT (Prof. James Hansen) were provided by the COMET partners grant.

The SREF component of the program provided a framework to test the utility of new ensemble display concepts and statistical output from the 15 member NCEP

SREF, leading directly to science and technology infusion into SPC forecast operations. Each day as part of the SREF experiment, two probabilistic severe weather outlooks for the day 2 period were made by an operational SPC forecaster participant: 1) an initial outlook in the morning based on deterministic model output emulating current operational practices, and 2): an updated outlook in the afternoon incorporating additional information from the SREF output. This methodology allowed us to evaluate the impact of SREF guidance as value-added information, and to determine if the additional information was useful to experienced severe weather forecasters well-versed in the use and interpretation of deterministic model guidance. The experimental outlooks were verified using objective (Brier and ROC scores) and subjective methods. It was found that our initial use of SREF output in this experiment contributed to a small positive improvement in the skill of the experimental outlooks over the course of the program.

The development of numerous specialized display fields for thunderstorm and severe weather forecasting was a major part of the program. Approximately 300 SREF fields were developed prior to and during the program, ranging from standard synoptic fields (500 mb height, PMSL pressure, dew points, etc.) to specialized convective parameters used for severe thunderstorm prediction (vertical shear, helicity, CAPE, lapse rates, and combination multi-parameter fields developed at SPC). A variety of chart formats were produced to take advantage of the statistical attributes of ensemble systems, including spaghetti, mean/spread, median-max/min, and probability maps. In addition, application of more advanced concepts of determining central tendency such as probability matching and the formulation of joint probabilities were explored during the program, which ultimately proved to be very useful for operational forecasting purposes. In addition to pre-computed fields, an interactive GUI was developed that allowed participants to quickly create specific GEMPAK SREF displays on a one-time basis, thus enhancing applied research opportunities. All displays were created in NAWIPS workstations located in the SSA that were identical to those used in SPC operations, which facilitated transfer of Spring Program results directly to SPC operations.

A major part of the program's collaborative design enabled forecasters to work side-by-side with researchers so they can learn about various research tools and products that are being tested for operational use; similarly, researchers benefited by working closely with forecasters and developing an appreciation and understanding of operational constraints and the strengths and limitations of current NWP systems. As a result, forecasters are better suited to address forecasting challenges from a more scientific perspective, and researchers are better prepared to conduct applied research that will have direct operational benefits.

As part of the program, all participants completed a comprehensive survey form to provide feedback about their experiences at the conclusion of their weekly

participation. They were asked to provide numerical ratings on a scale from 0 to 10 (10 being the best) that reflected their perceptions about whether or not the Spring Program met specific stated goals. Here are results from a sample of questions and mean ratings from the participants:

A. How useful was the Spring Program in contributing to unique/new perspectives applicable to your current work and professional development?
Mean Rating 8.58 out of 10

B. Do you feel that you have a better understanding of SREF concepts/utility in forecasting severe convection as a result of your participation in Spring Program 2003? (forecasters only)
Mean Rating 6.94 out of 10

C. Did your participation in Spring Program 2003 have an impact on your understanding of SREF concepts and their potential utility in your research activities? (researchers only)
Mean Rating 7.64 out of 10

D. How well did Spring Program 2003 activities enhance interactions between operational and research groups by focusing on topics important to both segments?
Mean rating 8.56 out of 10

E. Would you be interested in participating in any follow-up activities resulting from this Spring Program?
Mean Rating 8.32 out of 10

From these responses it can be seen that most participants gained valuable experience from this unique scientific and forecasting collaboration.

Each visiting scientist funded by the COMET grant presented a one hour seminar directly related to issues of ensemble forecasting (see section 2). The seminars were well attended by a variety of operational forecasters and research scientists. These were part of a larger training program designed to educate and familiarize SPC forecasters about basic SREF concepts, initial condition and model physics uncertainty, issues of predictability, statistical interpretation of model output, and the role of SREF and deterministic NWP systems in operational forecasting. As a result, SPC forecasters are better prepared to incorporate SREF output into their operational forecasting regimen during the fall of 2003, when the SREF tools were implemented in the operational NAWIPS workstations at SPC.

Findings from the program also allowed us to identify issues for further study and research, including:

- The need to develop advanced tools to "mine" relevant information from what can seem to be an overwhelming amount of SREF data output

- Methods to enhance the statistical nature of the output in an operational decision-making sense since experienced forecasters already apply "poor-mans" ensemble approaches

- Current SREF systems tend to be underdispersive, and often do not span the range of forecast possibilities

- Frequent "clustering by model" is apparent, especially for fields such as CAPE and convective precipitation in the warm season

2. RELATED ACCOMPLISHMENTS

2.1 Substantial work was also completed on the development and testing of the MM5 adjoint SREF system that allows forecaster interaction in the creation of initial condition perturbations (Xu et. al., 2001). This "feature-based" interactive approach allows forecasters to use their insights in identifying synoptic features (such as short wave troughs, jet streaks, surface fronts, moisture fields) that will play a role in determining severe weather potential; through an interactive GUI, they were able to subjectively select fields of interest at various mandatory levels and forecast times for input into the MM5 adjoint, which then worked "backwards" to create properly scaled initial condition perturbations for the MM5 SREF. The MM5 adjoint and the MM5 forward model were executed on a Linux supercomputing cluster maintained by the Oklahoma Supercomputing Center for Education and Research (OSCER), through a grant provided by OSCER. Additional pre- and post-processing of the MM5 model results were conducted on SPC workstations and NSSL Linux clusters, resulting in a partnership of computational resources between the SPC, NSSL, and CIMMS/OU. The results of this component of the Spring Program are currently being analyzed and evaluated by NSSL/CIMMS/OU/SPC staff, and will be shared with other researchers and students.

2.2 An undergraduate meteorology student (Marc Dahmer, University of Missouri-Columbia) working at SPC during the summer under the auspices of the Oak Ridge Institute of Science and Education (ORISE) assisted in the evaluation of the Spring Program data. He analyzed daily participant feedback, experimental outlook evaluations, and SREF/deterministic model evaluation data collected in real-time during the program. He also assisted in the analysis of the weekly participant survey forms. At the conclusion of his summer experience, he wrote a brief paper summarizing his statistical findings, and presented a seminar as part of the Oklahoma Weather Center summer student program. This experience enabled him to better understand how applied collaborative research activities contribute to advancing forecast improvements, and directly contributed

to his decision to apply to graduate schools this semester to continue his own academic research experiences.

3. SUMMARY OF BENEFITS

3.1 The Spring Program provided a structured framework for additional interactions between the academic and government research/forecasting communities. Faculty members returned to their campuses and shared their first hand experiences of applying SREF concepts to operational severe weather forecasting needs with students and colleagues. This science/service application of meteorology will enhance the "real-world" perspective in the education of meteorology students, and will serve to motivate additional research efforts that address operational forecasting needs. At this time, there are continuing collaborations on SREF development between OU faculty/researchers and SPC staff addressing issues of the stability of "best SREF members" during the model run, the viability of "thinning" members from the ensemble that perform poorly early in the run, and application of clustering techniques. All of these activities are a direct result of the Spring Program.

3.2 SPC forecasters are directly benefiting from the SREF development and testing that occurred during the Spring Program. The NCEP SREF output and display systems that were developed, tested, and evaluated during the program are now used by SPC forecasters on a daily basis in the prediction of severe convective weather. New SREF tools based on the experience gained in the Spring Program are now being developed to support the SPC Fire Weather and Winter Weather Programs. Other NWS forecasters and model developers from EMC, as well as COMET staff, benefited from their participation in the real-time forecasting and evaluation component of the Spring Program. SPC staff have been working closely with model developers at the NCEP/Environmental Modeling Center on the formulation and implementation of a new SREF system that incorporates enhanced physics diversity. This new SREF system is being evaluated in a test mode at this time, and scheduled to become operational in the NWS in late January 2004.

4. PRESENTATIONS AND PUBLICATIONS

The following three seminars were presented by visiting faculty funded by the COMET grant:

William Gallus –Seminar, "Warm Season Predictability Issues", SPC/NSSL, May 2, 2003.

James Hansen – Seminar, "Model Bending: Towards Dealing with Model Inadequacies in Data Assimilation and Forecasting Using a Single Model Structure", SPC/NSSL, May 23, 2002.

Nelson Seaman – Seminar, "WRF Ensemble Modeling: A Redirection Strategy for IOC and Beyond", SPC/NSSL, June 3, 2003.

Additional publications and presentations resulting from Spring Program 2003:

Bright, David R., S. J. Weiss, J. J. Levit, and D. J. Stensrud, 2003: The utility of short-range ensemble forecasts in the real-time prediction of severe convective weather at the Storm Prediction Center. Preprints, 10th Conference on Mesoscale Conferences, Amer. Meteor. Soc., Portland, OR.

Bright, David R. and P. A. Nutter, 2004: On the challenges of identifying the "best" ensemble member in operational forecasting. Preprints, 20th Conference of Weather Analysis and Forecasting/16th Conference on Numerical Weather Prediction, Amer. Meteor. Soc., Seattle, WA.

Levit, Jason J., 2003: "The Storm Prediction Center 2003 Spring Program: Evaluation of short-range ensembles for severe weather forecasting." Presented to the 2003 Pacific Northwest Weather Workshop, Seattle, WA, March 1st, 2003.

Levit, Jason J. 2003: "Using OSCER for a real-time experiment...and other projects." Presented to the 2003 Oklahoma Supercomputing Symposium, Norman, OK, September 25th, 2003.

Levit, Jason J., D. J. Stensrud, D. R. Bright, and S. J. Weiss, 2004: Evaluation of short-range ensemble forecasts during the SPC/NSSL 2003 Spring Program. Preprints, 20th Conference of Weather Analysis and Forecasting/16th Conference on Numerical Weather Prediction, Amer. Meteor. Soc., Seattle, WA.

Kain, John S., S. J. Weiss, D. R. Bright, M. E. Baldwin, M. Dahmer, and J. J. Levit, 2004: Subjective verification of deterministic models during the 2003 SPC/NSSL Spring Program. Preprints, 20th Conference of Weather Analysis and Forecasting/16th Conference on Numerical Weather Prediction, Amer. Meteor. Soc., Seattle, WA.

Dahmer, Marc, S. J. Weiss, D. R. Bright, and J. S. Kain, 2003: Reviewing the SPC/NSSL Spring Program: An evaluation of the use of short-range ensemble forecasting systems and new high resolution deterministic models in the prediction of severe thunderstorms. Oklahoma Weather Center Summer REU/ORISE research papers. (Available at http://www.caps.ou.edu/reu/reu03/projects.html)

Weiss, Steven J., D. R. Bright, J. J. Levit, D. J. Stensrud, J. S. Kain, and M. Dahmer, 2003: The SPC/NSSL Spring Program 2003: Exploration of Short-Range Ensemble Prediction Systems and High Resolution Deterministic Numerical Models for Use in Operational Severe Storm Forecasting. Presented at National Weather Association Annual Meeting, Jacksonville, FL, October 15, 2003.

Bright, David R., 2003: Ensemble Modeling: Theory and Operational Application. Presented at COMET COMAP Course, Boulder, CO, October 22, 2003.

Weiss, Steven J., D. R. Bright, and J. J. Levit, 2004: Short Range Ensemble Forecasts During the 4-10 May 2003 Tornado Outbreak Week. Invited presentation at the Third Southeast Severe Storms Symposium, Mississippi State University, January 16-18, 2004.

5. SUMMARY OF PROBLEMS ENCOUNTERED

One visiting academic scientist who was initially scheduled to participate (Prof. Steven Mullen of the University of Arizona) was unable to come to Norman due to personal health and family issues. We were fortunate to have Prof. Nelson Seaman from the Pennsylvania State University (on assignment to NWS Office of Science and Technology) serve as a visiting academic scientist in place of Prof. Mullen. Prof. Seaman is working closely on WRF model ensemble development plans for the NWS, and his insights and experience at the Spring Program contributed to advancing WRF ensemble plans and delivery of relevant SREF products to NWS forecasters.

For more information about the 2003 Spring Program, see:
www.spc.noaa.gov/exper/Spring_2003

6. FUTURE WORK

Planning is underway for Spring Program 2004. SPC/NSSL staff and visiting scientists and forecasters will investigate several versions of the WRF model (NCAR core and NCEP core), including a high resolution version with explicit precipitation physics, and a small mesoscale WRF ensemble with varied initial conditions and physics. In addition, the new NCEP SREF with enhanced physics diversity will be evaluated more thoroughly during the program. We anticipate inviting a number of visiting forecasters, SOOs, researchers, and university faculty again this next year. We plan to submit a proposal in early 2004 for a small COMET grant to provide travel funding for several academic visitors whose participation will enhance the likelihood for a successful outcome.

7. REFERENCES

Xu, Mei, Stensrud, David J., Bao, Jian-Wen, Warner, Thomas T. 2001: Applications of the Adjoint Technique to Short-Range Ensemble Forecasting of Mesoscale Convective Systems. *Mon. Wea. Rev.*, 129, 1395-1418.