

# COLLABORATION BETWEEN FORECASTERS AND RESEARCH SCIENTISTS AT THE NSSL AND SPC

## The Spring Program

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In the right setting, mutual interests between motivated forecasters and researchers can blossom into a productive and rewarding collaboration.

Collaboration between forecasters and researchers advances meteorology by promoting better understanding and improved prediction of atmospheric processes, yet sustained collaboration between these two groups is relatively rare. Forecasters analyze atmospheric conditions nearly every day and often observe poorly understood processes or phenomena that are critically important to predicting threats to life and property. Many forecasters have a keen insight into the weather and an interest in doing applied atmospheric research, but too often they are not

provided adequate time, diagnostic tools, guidance, or mentoring for independent research projects (Doswell 1986; Auciello and Lavoie 1993). On the other hand, many researchers have at their disposal a vast array of diagnostic tools, numerical models, theoretical knowledge, and experience in formal research. Yet, most meteorological research does not have direct implications for improving weather forecasts, despite the obvious societal benefits of applied research (Serafin et al. 2002). The failure of meteorological researchers and forecasters to collaborate on

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DOI: 10.1175/BAMS-84-12-1797

In final form 9 July 2003  
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a consistent and widespread basis appears to be a serious impediment to solving many of the science's most accessible problems (Doswell et al. 1981).

One way to promote collaboration between the two groups is to make their physical environment and proximity conducive to interaction. In early 1997 the National Weather Service relocated the Storm Prediction Center (SPC) to Norman, Oklahoma, where facilities are shared with the National Severe Storms Laboratory (NSSL). This move combined the scientific staffs of NSSL and the University of Oklahoma's Cooperative Institute for Mesoscale Meteorological Studies (CIMMS) with the forecasting expertise of the SPC. A small group of applied researchers from NSSL and CIMMS worked with the SPC to pursue operationally relevant research and to facilitate interaction between the SPC, NSSL, and the larger meteorological community. The SPC operational forecasting area was mirrored in an adjacent "Science Support Area" (SSA; see below) so that the forecasting environment could be simulated in research activities without interfering in time-critical daily forecasting responsibilities. Daily map discussions were initiated, and complementary interests began to draw forecasters and researchers together to cultivate collaborative research.

This environment fostered a productive interaction at the NSSL/SPC facility. Numerous collaborative studies were spawned and brought to fruition (e.g., Evans and Doswell 2001; Craven et al. 2002; Baldwin et al. 2002; Schultz et al. 2002; Stensrud and Weiss 2002; Thompson et al. 2002; Kain et al. 2000, 2003a,b) and others are under way. Organized interactions on a larger scale matured as well. In recent years, annual "Spring Programs," intensive multiweek research efforts during the peak severe convective weather season, became the cornerstone of the collaboration.

These programs are designed to be mutually beneficial to the participating operational and research organizations. For example, the 2001 Spring Program focused on improving forecasts of thunderstorm initiation, revolving around experimental forecast products and innovative use and verification of numerical models from the research community.

Local support for organized collaborations has been strong because managers at SPC, CIMMS, and NSSL recognize the numerous benefits to their respective programs. Forecasters learn to address operational challenges from a more scientific perspective, while researchers become better equipped to pursue projects that have operational relevance. A look at the growing NSSL-CIMMS-SPC collaboration, with particular emphasis on the 2001 Spring

Program, will reveal some of the key ingredients in this successful collaboration.

**HISTORICAL PERSPECTIVE.** Interest in collaboration between research scientists at NSSL and operational forecasters in the Oklahoma Weather Center (OWC) dates back to the 1980s. During 1984–85, forecasters and researchers collaborating at the Norman National Weather Service Forecast Office (WFO/OUN) participated in data collection and forecasting for mesoscale convective systems (MCSs) during the Preliminary Regional Experiment for STORM-Central (PRE-STORM; see Cuning 1986) program. The experience gained through exchange of ideas, support of field operations, and real-time data collection in this experiment was paramount to the success of future collaborative programs (Doswell et al. 1986). NSSL and the Norman WFO participated in real-time operational testing and evaluation of Doppler radar during the Doppler and lightning exercise of 1987 (DOPLIGHT '87; Doswell and Flueck 1989). The fundamental success of this effort contributed to the nationwide implementation of the Next Generation Weather Radar (NEXRAD) Weather Surveillance Radar-1988 Doppler (WSR-88D) radar network. Other successful collaborative exercises during this time included the Mesoscale Applications Project (MAP) 1988–89 (Jincai et al. 1992) and STORMTIPE (Brooks et al. 1993; Wicker et al. 1997), which helped introduce forecasters to high-resolution mesoscale and storm-scale prediction models.

Inspired by these early successes, the National Oceanic and Atmospheric Administration (NOAA) created a collaborative research and forecast facility in Norman, Oklahoma, known as the Experimental Forecast Facility (EFF; see Howard et al. 1986; Subcommittee on Atmospheric Research 1992; Auciello and Lavoie 1993). This facility, adjacent to the operational forecast floor in the Norman WFO, was supported/staffed by NSSL, the WFO, and the WSR-88D Radar Operations Center (formerly known as the Operational Support Facility). The EFF focused on applications of new operational datasets, interrogation of numerical model guidance, and technology transfer from research into forecast operations (Janish et al. 1995).

SPC forecasters (then in Kansas City, Missouri) became involved in OWC activities during 1994 and 1995, providing forecast support for the 1994–95 Verification of the Origin of Rotation in Tornadoes Experiment (VORTEX-94/95) at the EFF and NSSL (Brooks et al. 1996). The forecasters were able to explore new data analysis software, use experimental

numerical model output in the forecast process, and discuss the daily operational forecasts with leading scientists in an informal setting—the first experience of its kind for most SPC forecasters. This interaction benefited both researchers and forecasters, but post-event data analysis was left in the hands of researchers. Desire for more participation in the scientific analysis process helped spur the SPC's move from Kansas City to Norman in early 1997 (McPherson 1994).

In anticipation of the SPC's arrival, NSSL created the Mesoscale Applications Group (MAG), staffed by both NSSL and CIMMS employees, including a cross section of numerical modelers, observational specialists, and mesoscale meteorologists, all interested in operational issues. The goal of the MAG was to build on the collaborations with the Norman WFO in the 1980s and early 1990s and create synergy between local researchers and the SPC's mesoscale forecasting experts.

**THE SCIENCE SUPPORT AREA.** NSSL facilities were modified to accommodate the SPC relocation. A key development was the creation of the SSA, an area in which the operational forecasting equipment, data feed, and physical environment were duplicated to provide an operational forecasting test bed. The Spring Program takes place in the SSA each year.

The SSA (Fig. 1) has flexibility to support field research, testing of experimental products/techniques, and other collaborative efforts. Ample computer networking, telephone connections, and electrical power supplies (including generator backup) ensure continuous accessibility of systems during real-time operations. The SSA contains workspace for up to five meteorologists during operations or 15–20 people in map discussions and/or briefings. The facility contains multiple National Center Advanced Weather Interactive Processing System (N-AWIPS) Unix/Linux workstations similar to those used in SPC operations and an AWIPS workstation that duplicates the data feed and display used by WFOs. These workstations access the full operational data stream in addition to experimental data. Other equipment includes more PCs, a flash-by-flash National Lightning Detection Network (NLDN) display, large monitors to facilitate



**FIG. 1.** A scene from the 2001 Spring Program in the SSA. Pictured from left to right are Don Burgess (NSSL), Lou Wicker (NSSL), Greg Carbin (partially hidden; SPC), Paul Janish (SPC), and Mike Foster (Norman WFO). Note that the SPC operational forecasting area can be seen through the doorway.

discussions and briefings, and additional test equipment for NSSL and SPC collaborative projects.

A key to the success of collaborative programs in the SSA is the similarity in workstation design, data flow, and display capability to that of the SPC operations area. Local forecasters and researchers who participate in SSA activities are familiar with equipment; with predistributed documentation and simple training, visitors quickly adapt to technical procedures.

**ESTABLISHING WORKING PARTNERSHIPS IN THE SSA.** Agreement on mutually beneficial goals and objectives has been a fundamental part of each program since VORTEX. This philosophy has inspired mutual respect and enthusiasm among participants.

The first organized effort involving NSSL–CIMMS–MAG and SPC focused on winter weather [Winter Weather Experiment (WINWEX)] during the cold season of 1996/97. This effort resulted in a more systematic and scientific approach to evaluating mesoscale conditions and the creation of an ingredients-based approach toward winter forecasting (Janish et al. 1996). Feedback from selected WFOs about the experimental forecast product was instrumental in developing a winter weather mesoscale discussion product that became operational at the SPC in 1997. This activity prompted more operationally relevant research on mesoscale aspects of winter

weather (Cortinas 2000; Kain et al. 2000; Robbins and Cortinas 2002).

The focus shifted from winter weather to convective weather in 1998 as NSSL hosted the MCS Electrification and Polarimetric Radar Study (MEaPRS) field project (Jorgensen et al. 2000). All forecasting and nowcasting operations for MEaPRS were conducted in the SSA with NSSL–CIMMS–MAG and SPC forecasters. Forecast teams prepared probabilistic outlooks of MCS activity and the forecast position of the low-level jet across the MEaPRS operations domain.

**SPRING PROGRAM 2000.** After a year with no organized program (1999), NSSL, CIMMS, and SPC organizers decided to develop a program that was inspired by the mutual scientific and strategic interests of participants rather than imposed by the external demands of field programs or new forecasting responsibilities. The Spring Program 2000 was designed to evaluate operational and experimental numerical models, as well as various diagnostic tools used in SPC operations, such as objective analysis routines and hail forecasting algorithms. Each component of the program had a local “sponsor,” a scientist or forecaster who developed and/or promoted one of the tools and helped design the specific evaluation procedures used during the program. This framework was designed to endow each contributor with a vested interest in the success of the program. In addition, numerical modelers from both the Environmental Modeling Center (EMC) and the Forecast Systems Laboratory (FSL) participated and provided input for the design of numerical model evaluation procedures.

The interaction between forecasters and numerical modelers was the most rewarding part of Spring Program 2000. As a direct result of this interaction, participating forecasters improved their skill at interpreting model output and modelers developed new insights into the ways that models were being used at the SPC. For example, forecasters began to learn how model convective parameterizations can impart misleading changes to model output soundings (Baldwin et al. 2002), and modelers responded to forecaster requests for nontraditional output fields (Kain et al. 2003a). On the basis of feedback from all participants and the strategic goals of the organizations involved, a decision was made to focus on numerical modeling and specific SPC forecast problems for 2001.

**SPRING PROGRAM 2001.** Organizers capitalized on the momentum gained and lessons learned in 2000 to plan more refined and focused activities for spring

2001. The primary goal was to investigate whether mesoscale numerical models could be used more effectively to enhance the accuracy of convective initiation, intensity, and evolution predictions. For short-term convective prediction (e.g., issuing severe weather watches) SPC forecasters have traditionally relied much more heavily on observations than numerical guidance. Although models do *sometimes* provide very accurate predictions of convective initiation and evolution, forecasters do not know *in advance* how much confidence to place in a particular model solution. A working hypothesis of the 2001 program was that bringing modeling experts into the forecast preparation process would allow forecasters to make more skillful judgments about model reliability and accuracy, ultimately leading to improved forecasts of convective initiation and evolution. The research objectives were to develop a better understanding of how forecasters use numerical weather prediction (NWP) model output and to gather subjective impressions of model forecasts for comparison with current objective verification metrics.

Two programmatic changes were introduced in 2001. First, experimental forecast products became a major part of the daily activities. These products were a main attraction for operational forecasters and helped produce tangible benefits for the SPC in their quest to optimize the lead time for severe weather watches. Second, model evaluation forms were designed to elicit quantitative information (Kain et al. 2003b) for the subjective verification of model parameters. Analogous forms for the 2000 program had focused on descriptive feedback, a format that is poorly suited for statistical analysis.

The 2001 Spring Program was conducted from 16 April to 8 June. Program activities are highlighted below. Additional details can be found online at [www.spc.noaa.gov/exper/ Spring\\_2001/](http://www.spc.noaa.gov/exper/Spring_2001/).

**Personnel, equipment, and data.** Full-time participants were required to spend an entire week (Monday–Friday) in the program. (A complete list of participants and affiliations is given in appendix A.) Bringing in a new “team” at least once a week introduces diversity of experience, perspective, and sense of continuing enthusiasm to the program, which is essential. On the other hand, requiring team members to stay for a full week is quite important for several reasons. It helps to ensure that participants become comfortable and confident with their required tasks, limits the orientation and training sessions that organizers must conduct to a tolerable number, and promotes a sense of day-to-day continuity.



Each three-member team had expertise in forecasting *and* numerical model interpretation, including at least one SPC forecaster; one modeling expert from NSSL, CIMMS, EMC, or FSL; and a third forecaster or researcher with expertise in related areas. In addition, a number of other scientists participated as observers on a “part-time” basis (generally for less than a week). All visitors were encouraged to incorporate their interests into the evaluation portion of the program and to present a seminar on their current research activities.

Full-time participants had access to fully configured N-AWIPS workstations in the SSA, including the full operational data stream used by SPC forecasters. This also included output from several experimental forecast models typically *not* available in routine operations.

*Daily schedule.* Complete daily operations were conducted from 8 A.M. to 4 P.M. (1300–2100 UTC) Mon-

day through Thursday. The 8-h day allowed sufficient time for verification of the previous day’s model guidance and experimental forecasts, evaluation of current model data, and preparation of two experimental forecasts.

*Forecast product.* The forecast product (e.g., Fig. 2) was designed to assess forecaster skill in predicting initiation of severe and nonsevere convection with up to a 4-h lead time. The forecast domain was limited to an area approximately 10° lat x 10° long so that forecasters would have sufficient time to examine multiple sets of NWP guidance. Domain placement was established early in the day based on expected locations of severe convective development, determined in consultation with both the outlook and lead forecasters working the operational SPC day shift.

Experimental forecasts were issued twice daily. The 1700 UTC forecast was valid during 1800–2100 UTC; the 2000 UTC forecast was valid during 2100–0000

## MODELS UTILIZED DURING THE PROGRAM

Table SBI summarizes the model output examined during the Spring Program 2001. Forecasts from the operational Eta (Black 1994), the regional high-resolution Eta threats (now called HiRes Window; G. DiMego 2001, personal communication), the Rapid Update Cycle, version 2 (RUC-2; Benjamin et al. 1999), and a version of the Eta configured and run at NSSL known as the EtaKF (Kain et al. 2003a), were available as part of the normal real-time data stream at the SPC. Output from other models was imported especially for the program. The RUC-20 was a “beta” version of the modified, higher-resolution configuration of the RUC that evolved into the new operational RUC in the spring of 2002 (Benjamin et al. 2001). The EMC mesoscale ensemble was a 10-member system composed of five members from the Eta and five from EMC’s regional spectral model (RSM; Du and Tracton 2001). The NSSL ensemble was a multimodel ensemble created at

TABLE SBI. Model output examined during Spring Program 2001.

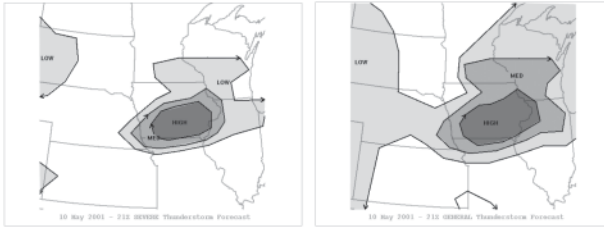
Model	Initialization times (UTC)	Native grid spacing (km)	Output grid spacing (km)
Eta	0000, 1200	22	40
EtaKF*	0000, 1200	22	20/40
Eta threats run*	1200	10	10
RUC-2	1200, 1500, 1800	40	40
RUC-20*	1200, 1500	20	20
EMC mesoscale ensemble*	0000	48	48
NSSL ensemble*	0000, 1200 combined	Various	40
WRF*	0000	34	34

\* Indicates experimental models.

NSSL by M. Baldwin by combining all available (operational and experimental) mesoscale models. A beta version of the Weather Research and Forecasting (WRF) model (Skamarock et al. 2001), was also available. All model output was presented in a common format on NAWIPS workstations, with the exception of the WRF forecasts, which were only available online.

A Spring Program data archive including surface and upper-air analyses, local storm reports, radar, lightning, and selected model output was produced daily to assist in model verification and postevent analysis. These data remain online for continued study (see [www.spc.noaa.gov/exper/Spring\\_2001](http://www.spc.noaa.gov/exper/Spring_2001)).

SPC/NSSL Experimental Forecast for 20010510 Valid 2100-0000 UTC  
Severe Thunderstorm Forecast      General Thunderstorm Forecast



Forecast Issue Date: 20010510  
Forecast Period: 2100-0000 UTC  
Forecast Team: Corfidi/Gallus/Smith  
Visiting Scientist(s): STENSRUD

Forecast Area: WESTERN PLAINS THROUGH THE WESTERN GREAT LAKES

..Synopsis..

A COLD FRONT ASSOCIATED WITH A LOW AMPLITUDE DISTURBANCE IN FAST ZONAL FLOW ACROSS THE NRN TIER OF STATES WILL CONTINUE TO MOVE SLOWLY ESE ACROSS THE LWR MO/MID MS VLYS THIS PERIOD. THUNDERSTORMS NOW FORMING ON THIS BOUNDARY...AND ON A WEAK OUTFLOW BOUNDARY ASSOCIATED WITH AN EARLIER CLUSTER OF CONVECTION...EXPECTED TO INCREASE IN COVERAGE AND INTENSITY DURING THE NEXT SEVERAL HOURS. INCREASING DEEP LAYER SHEAR ASSOCIATED WITH THE APPROACHING UPPER IMPULSE, COUPLED WITH CONTINUED SURFACE HEATING AND BOUNDARY LAYER MOISTURE INFLUX, SUGGEST GOOD LIKELIHOOD FOR A FEW SUPERCELLS WITH LARGE HAIL AND PERHAPS SMALL SCALE BOWS.

..Discussion..

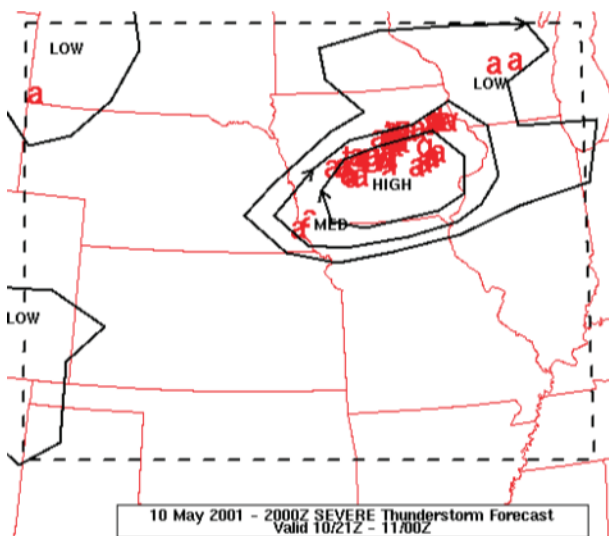
N/S BAND OF THUNDERSTORMS DEVELOPING ATTM OVER CNTRL IA APPEARS TO BE ASSOCIATED WITH WEAK WARM ADVECTION ON THE BACK SIDE OF RETREATING COOL POOL ASSOCIATED WITH DISSIPATED OVERNIGHT MCS. THESE STORMS APPEAR TO BE SLIGHTLY ELEVATED PER RADAR AND VISIBLE SATELLITE DATA. OTHER SHOWERS/WEAK THUNDERSTORMS HAVE DEVELOPED IN THE PAST 90 MINUTES ALONG E/W OUTFLOW BOUNDARY ASSOCIATED WITH MID MORNING CONVECTIVE CLUSTER IN THE NORTH CENTRAL PART OF THE STATE.

THE LOWER TROPOSPHERIC FLOW HAS VEERED TO WEST SOUTHWESTERLY ACROSS MOST OF IA IN THE PAST 2-3 HOURS. THIS APPEARS TO BE AT LEAST PARTIALLY RESPONSIBLE FOR THE DEVELOPMENT OF THE N/S CONVECTIVE BAND NEAR DSM. THE VEERING HAS, HOWEVER, LIMITED THE DEGREE OF LOW LEVEL CONVERGENCE ALONG THE COLD FRONT IN EASTERN NEBRASKA AND FAR WESTERN IA. POSSIBLY AS A RESULT, THE BOUNDARY LAYER CU/SC FIELD OVER THIS REGION APPEARS TO STILL BE RATHER STRONGLY CAPPED. COMBINATION OF CONTINUED SURFACE HEATING, BOUNDARY LAYER MOISTURE INFLUX, FRONTAL/OUTFLOW BOUNDARY ASCENT AND INCREASING UPPER DIVERGENCE ASSOCIATED WITH APPROACHING TROUGH EXPECTED TO RESULT IN INCREASED CONVECTIVE COVERAGE AND INTENSITY OVER TARGET AREA IN THE NEXT HOUR. LARGELY UNIDIRECTIONAL DEEP LAYER WESTERLY SHEAR, ON THE ORDER OF 50 KTS/ ROUGHLY PARALLEL TO COLD FRONT/OUTFLOW BOUNDARY SUGGESTS POTENTIAL FOR A FEW EMBEDDED SUPERCELLS WITHIN DEVELOPING MCS. THE MAIN SEVERE THREATS SHOULD BE LARGE HAIL AND LOCALLY DAMAGING WINDS.

ELSEWHERE, MORE ISOLATED WIND/HAIL POTENTIAL MAY EXTEND EWD INTO ENVIRONMENT OF MODERATE WLY SHEAR AND INSTABILITY ACROSS WI/NRN IL. OTHER LOCALLY SEVERE STORMS MAY DEVELOP IN "INVERTED-VEE" ENVIRONMENT OVER THE SOUTHERN HIGH PLAINS, AND IN REGION OF STRONG /40-50 KT/ DEEP LAYER SHEAR, BUT LIMITED INSTABILITY/CONVERGENCE OVER SOUTHEAST MT/NORTHEAST WY/WRN SD.

Expected Hour of First Report: 2100 UTC  
Expected Primary Report Type: HAIL  
Probability of Convection Within Forecast Area: 99  
Probability of Severe Convection Within Forecast Area: 90  
Possible Watch Type: SEVERE THUNDERSTORM

**Fig. 2. Experimental forecast product from the 2001 Spring Program, issued 2000 UTC 10 May 2001, valid for the time period 2100-0000 UTC 11 May.**



based form (not shown) was used to compile a brief overview of the broadscale flow regime and to quantify the dynamic forcing, convective available potential energy (CAPE), and 0-6-km wind shear over the area of interest.

*Model evaluation.* While the SPC forecaster prepared the experimental forecast product, other members of the team began a formal *evaluation* of the models used to make the forecast. For each model, they recorded

**Fig. 3. Verification data for the experimental forecast shown in Fig. 2. Severe weather reports are marked on the map according to hail diameter  $\geq 0.75$  in. (a), wind gusts =  $58 \text{ mi h}^{-1}$  (g), and tornado (t).**

UTC. Within the prescribed domain, the forecast team had a choice of up to three contours (low, medium, and high) representing forecaster confidence of convective initiation and development of severe convection during each 3-h period. For severe convection, this level of confidence is a key part of the convective watch decision-making process. Detailed evaluation of these experimental products is expected to help identify situations when watches can be issued successfully with extended lead times.

For the forecast issued at 2000 UTC on 10 May 2001 (Fig. 2), forecasters expressed a "medium" level of confidence that thunderstorms would develop over a large area including parts of Minnesota, Wisconsin, Illinois, Iowa, Nebraska, and Missouri. Within this area, they expressed high confidence that development would occur over the southeastern half of Iowa and that convection would be severe over south-central and southeastern Iowa. The discussion provides a broad synoptic overview and details about specific concerns. Specific information regarding the timing, character, and probability of activity is also provided since it is particularly relevant to the SPC convective watch program. In addition, a separate Web-

forecaster impressions of how favorable individual model solutions were for the development of severe weather, forecaster confidence in various model solutions, and forecaster impressions of the overall utility of individual models.

**Forecast verification.** Participants verified experimental forecasts of thunderstorms (without regard to severity) using NLDN cloud-to-ground lightning data, while severe convection was verified by local storm reports (LSRs). In addition, radar and satellite data were used to corroborate the NLDN and LSR data and to provide additional information on the timing and character of convection. Forecast errors in timing, areal coverage, and displacement were measured separately. A graphic display of LSRs from 10 May (Fig. 3)—the day discussed above—shows that the experimental forecast was quite good on this day. Almost all of the LSRs were within the “medium confidence” area, and most were within the “high confidence” region. Areal coverage corresponded well with the area of highest confidence, although the center of activity was displaced slightly to the north.

**Model verification.** The team that subjectively *evaluated* model output during forecast preparation sub-

jectively *verified* the same output the next morning. Comparison between the model evaluation and subsequent verification statistics showed that, averaged over many forecast periods, forecast teams generally expressed a higher degree of confidence in models that verified better. However, confidence and verification were poorly correlated for individual models and forecast periods. No single model consistently provided the “best” forecast, and forecast teams showed little or no skill in picking a “model of the day” in advance. Results from the model evaluation and verification component of the program are discussed in detail in Kain et al. (2003b).

**FUTURE PROGRAMS.** We intend to host organized collaborative programs nearly every year. During some years, the program will occur in conjunction with larger externally driven projects, such as observational field programs. When this happens, the goals of the larger program will dictate the objectives of the Spring Program to some extent. For example, in 2002, the Spring Program was conducted in collaboration with the International H<sub>2</sub>O Project (IHOP; Weckwerth and Parsons 2002). Consequently, significant effort went into providing forecasting support for IHOP field operations. Nonethe-

## SPC/NSSL SPRING PROGRAM 2003

The SPC and NSSL hosted another Spring Program in 2003, exploring two promising applications of numerical models in forecasting severe weather:

1) short-range ensemble forecast (SREF) prediction systems, and 2) high-resolution deterministic models. As in previous years, forecast/research teams were anchored by SPC forecasters and NSSL-CIMMS researchers. The teams were rounded out with visiting scientists from numerous institutions, including EMC; FSL; the Norman, Oklahoma, and White Lake, Michigan, WFOs; the University of Arizona; the University of Oklahoma; the University of Washington; Iowa State University; the Massachusetts Institute of Technology; the UK Met Office; and the Meteorological Service of Canada. In addition, observers from the Cooperative Program

for Meteorology, Education and Training (COMET) and the U.S. Weather Research Program (USWRP) participated.

The SREF systems used in the program included two separate ensembles, one from EMC and one from NSSL. The EMC ensemble was an upgraded version of the one (Du and Tracton 2001) used in the 2001 program, with five EtaKF members added to the original 10 Eta and RSM members. It used an automated “regional breeding” method to perturb initial conditions for individual model runs. The NSSL ensemble was a newly developed system with a unique method for perturbing initial conditions. It utilized forecaster input to identify regions and parameters of meteorological sensitivity, ingesting this information in an adjoint model as part of

a forecaster-based system of perturbing the initial environment.

In the second area of focus, participants compared mesoscale model forecasts using parameterized convection to cloud-resolving forecasts (i.e., without parameterized convection) from the WRF model. The goal was to provide a preliminary assessment of the forecast value of high-resolution models compared to the current generation of operational and experimental forecast models, including the WRF, Eta, EtaKF, RUC, and EMC’s new Nonhydrostatic Mesoscale Model. The program ran weekdays from 14 April to 6 June 2003. (More information on Spring Program 2003 is available online at [www.spc.noaa.gov/exper/Spring\\_2003/](http://www.spc.noaa.gov/exper/Spring_2003/).)

less, Spring Program organizers still managed to incorporate a subjective verification component for both numerical guidance and experimental IHOP forecasts in their daily routine in 2002. We expect to scale back *internal* research objectives when Spring Programs are entrained into larger programs, but in other years local applied research can take precedence.

**CONCLUDING REMARKS.** Numerous tangible benefits emerged from the 2001 Spring Program. For example, the program confirmed that it is wise to consider multiple model solutions as guidance when predicting convective initiation and evolution; forecast teams showed little or no skill in picking the best model forecast ahead of time. The program also demonstrated that systematic subjective verification procedures can provide valuable information for both forecasters and model developers. Subjective impressions of model-forecast skill often paint a picture that is quite different from summaries of objective measures. These results are discussed in Kain et al. (2003b).

The program also catalyzed research projects that were not directly related to the stated objectives. For example, examination and interrogation of model-forecast soundings from the Eta Model allowed us to document common irregularities in sounding structure associated with the model's convective parameterization scheme. This documentation was recently compiled in a paper designed to provide forecasters with guidance in interpreting Eta Model soundings (Baldwin et al. 2002). Parameterized updraft mass flux, a unique predictor of convective intensity from the Kain-Fritsch convective scheme (KF; Kain and Fritsch 1993), earned the confidence of forecasters during the program. This output parameter, now available on a routine basis, is described in Kain et al. (2003a). In addition, sounding analysis programs in SPC operations have recently been modified to include diagnostic versions of the Betts-Miller-Janjic (Janjic 1994) and KF convective parameterizations. This software infusion came about because significant differences between Eta and EtaKF model soundings were documented during Spring Programs and daily map discussions. The diagnostic versions of the schemes have proven to be very helpful in facilitating educated interpretations of model soundings and the behavior of the two convective schemes.

The Spring Program also produced numerous intangible benefits that are more difficult to measure. Model developers worked side by side with the end users of their product—operational forecasters. Developers gained valuable insight into how their prod-

ucts are being used and how they might be improved to meet the needs of forecasters more effectively. At the same time, forecasters were given a rare opportunity to discuss various applications and interpretations of NWP models with their developers in the context of a simulated operational forecasting environment. Thus, participating forecasters became more confident and educated users about one of their primary guidance tools (e.g., see Baldwin et al. 2002). Perhaps most importantly, the organizational environment of the program promoted solid working relationships between the operational and research communities. These relationships will form the foundation for expanding collaborative efforts in coming years.

**ACKNOWLEDGMENTS.** Special thanks and appreciation is extended to all participants and staff for assisting in preparations/planning, programming, and data flow issues for the 2001 Spring Program. Without the combined efforts of many SPC, NSSL, and CIMMS staff members, the Spring Program could not be conducted. In particular, special thanks to Mike Kay (CIMMS) and Greg Carbin (SPC) for their work on Web page development, evaluation forms, and the archive; John Hart (SPC) for software support and development; Phillip Bothwell (SPC) and Gregg Grosshans (SPC) for providing access to model and verification data; Dave Stensrud (NSSL) for experimental MM5 data access; Kim Elmore (CIMMS) for providing experimental cloud model ensemble data; Jay Liang (CIMMS), Gary Petroski (SPC), Doug Rhue (SPC), Steve Fletcher (CIMMS), and Brett Morrow (CIMMS) for assistance in configuring hardware/software in the Science Support Area; and Charlie Crisp (NSSL) for his expert meteorological analysis and contributions to the Web page. We further wish to recognize the full support of SPC, NSSL, and CIMMS management and enthusiasm by participants from Forecast Systems Lab, Environmental Modeling Center (NCEP/EMC), National Weather Service Forecast Office, Norman, Oklahoma; and Iowa State University, who provided motivation for making such an undertaking a positive experience for everyone. This work was partially funded by COMET Cooperative Project 099-15805 and NOAA-OU Cooperative Agreement NA17RJ1227.

#### **APPENDIX: LIST OF PARTICIPANTS FOR SPRING PROGRAM 2001 BY AFFILIATION.**

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John Hart  
Paul Janish



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FSL:	Barry Schwartz	
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	Steve Weygandt	
	Stan Benjamin (part-time participant)	
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	Dave Floyd	
	Mike Foster (part-time participant)	
	Doug Speheger	
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