NOAA HAZARDOUS WEATHER TESTBED

EXPERIMENTAL FORECAST PROGRAM
SPRING EXPERIMENT 2007

http://hwt.nssl.noaa.gov/Spring_2007/

HWT Facility – National Weather Center
23 April - 8 June 2007

Program Overview
and
Operations Plan

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I. The NOAA Hazardous Weather Testbed

NOAA's Hazardous Weather Testbed (HWT) is a joint facility managed by the National Severe Storms Laboratory (NSSL), the Storm Prediction Center (SPC), and the NWS Oklahoma City/Norman Weather Forecast Office (OUN) within the National Weather Center building on the University of Oklahoma South Research Campus. The HWT is designed to accelerate the transition of promising new meteorological insights and technologies into advances in forecasting and warning for hazardous mesoscale weather events throughout the United States. The HWT facilities include a combined forecast and research area situated between the operations areas of the SPC and OUN, and a development laboratory also located nearby on the second floor. The facilities support enhanced collaboration between research scientists and operational weather forecasters on specific topics that are of mutual interest.

The HWT organizational structure is composed of two primary overlapping program areas (Fig. 1). The first program area focuses on forecast-scale activities under the auspices of the Experimental Forecast Program (EFP), and the second program tests research concepts and technology specifically aimed at short-fused warnings of severe convective weather under auspices of the Experimental Warning Program (EWP). A key NWS strategic goal is to extend warning lead times under the concept of "Warn-on-Forecast" through the development and application of convection-allowing numerical models to extend short-term predictability of hazardous convective weather. This provides a natural overlap between the EFP and EWP activities as the distinction between warnings and short-term forecasts of convective weather gradually diminishes. Both programs reside beneath the over arching HWT organization and facility with a focus on national hazardous weather needs.

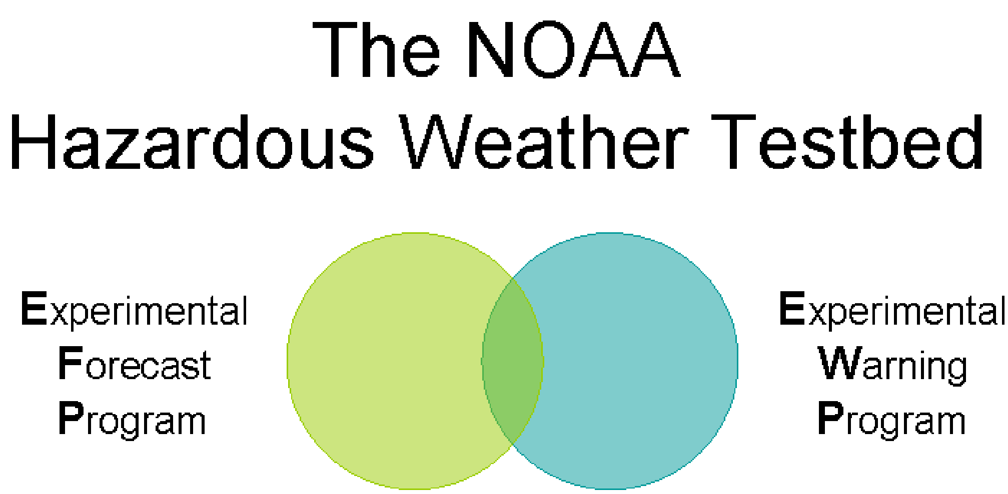

Figure 1: The umbrella of the NOAA Hazardous Weather Testbed (HWT) encompasses two program areas: The Experimental Forecast Program (EFP) and the Experimental Warning Program (EWP).

The specific mission of each HWT program branch is:

The Experimental Forecast Program - EFP

The EFP branch of the HWT is focused on predicting hazardous mesoscale weather events on time scales ranging from a few hours to a week in advance, and on spatial domains ranging from several counties to the CONUS. The EFP embodies the collaborative experiments and activities previously undertaken by the SPC and NSSL Spring Experiments.

The Experimental Warning Program – EWP

The EWP branch of the HWT is concerned with detecting and predicting mesoscale and smaller weather hazards on time scales of minutes to a few hours, and on spatial domains from several counties to fractions of counties. The EWP embodies the collaborative warning-scale experiments and technology activities previously undertaken by the OUN and NSSL.

Rapid science and technology infusion for the advancement of operational forecasting requires direct, focused interactions between research scientists, numerical model developers, information technology specialists, and operational forecasters. The HWT provides a unique setting to facilitate such interactions and allows participants to better understand the scientific, technical, and operational challenges associated with the prediction and detection of hazardous weather events. The HWT allows participating organizations to:

- Refine and optimize emerging operational forecast and warning tools for rapid integration into operations
- Educate forecasters on the scientifically correct use of newly emerging tools and to familiarize them with the latest research related to forecasting and warning operations
- Educate research scientists on the operational needs and constraints that must be met by any new tools (e.g., robustness, timeliness, accuracy, and universality)
- Motivate other collaborative and individual research projects that are directly relevant to forecast and warning improvement

For more information about the HWT, see www.nssl.noaa.gov/hwt

II. Historical Perspective

Co-location of the Storm Prediction Center (SPC) with the National Severe Storms Laboratory (NSSL), the Oklahoma City/Norman Weather Forecast Office, and many University of Oklahoma meteorological organizations in the National Weather Center in Norman provides a unique opportunity to enhance long-standing community interactions and collaboration on a variety of experimental forecast and other operationally relevant research programs. Since the re-location of the SPC to the previous NSSL facility Norman in early 1997, a wide cross section of local and visiting forecasters, research scientists, and model developers has participated in a number of experimental programs since the late 1990s. These include forecasting support for field programs such as the International H2O Project (IHOP), establishing the SPC winter weather mesoscale discussion product, evaluating operational and experimental NWP models for application in convective forecasting including Short Range Ensemble Forecast (SREF) systems and convection-allowing Weather Research and Forecasting (WRF) models, and integrating new observational data, objectives analyses and display tools into forecast operations. A key goal of these programs is to improve forecasts of meteorological phenomena by accelerating the transfer of new technology and research ideas into forecast operations at the SPC, and by sharing new techniques, skills, and results of applied research more freely with others in the operational forecasting community. Typical issues addressed in these activities include, but are not limited to: optimizing use of vast and ever increasing quantities of observational and model data in operational forecasting, testing and evaluation of new analysis or predictive (NWP) models, better understanding of operational forecast problems, development and evaluation of diagnostic conceptual models, and new product development and display strategies utilizing operational workstations.

Each spring during the climatologically most active severe weather periods, multi-agency collaborative forecasting experiments known as the HWT Spring Experiment (formerly called the SPC/NSSL Spring Program) have occurred since 2000. The only exception was in 2006 when the move to the new National Weather Center building precluded a large collaborative experiment. During that spring SPC conducted a focused internal pre-implementation evaluation of the NCEP NAM-WRF model.

Details about earlier Spring Experiments are available at:
www.spc.noaa.gov/exper/Spring_2000
www.spc.noaa.gov/exper/Spring_2001
www.spc.noaa.gov/exper/Spring_2002
www.spc.noaa.gov/exper/Spring_2003
www.spc.noaa.gov/exper/Spring_2004
www.spc.noaa.gov/exper/Spring_2005

The following sections will provide an overview of the scientific goals and relevance to severe weather forecasting, schedule of daily forecasting and evaluation activities, and list of weekly participants for the 2007 Spring Experiment.

II. Experiment Motivation, Goals and Objectives

The prediction of convective weather is important from both meteorological and public service/societal impact perspectives. Since a primary mission of the National Weather Service is the protection of life and property from hazardous weather phenomena, applied research aimed at improving the forecasting of impact weather such as severe thunderstorms and tornadoes is a critical responsibility at the SPC, NSSL, and OUN.

The SPC is responsible for the prediction of severe convective weather over the contiguous United States on time scales ranging from several hours to eight days. To meet these responsibilities, the SPC issues Convective Outlooks for the Day 1, Day 2, Day 3, and Day 4-8 periods to highlight regions with enhanced potential for severe thunderstorms (defined as thunderstorms producing hail $\geq$ 3/4 inch in diameter, wind gusts $\geq$ 50 kt or thunderstorm induced wind damage, or tornadoes). These outlooks are issued in both categorical (slight, moderate, or high risk) and probabilistic formats, and are issued with increasing frequency as the severe weather time frame draws nearer. In addition to the scheduled Outlooks, Severe Thunderstorm and Tornado Watches are issued on an as-needed basis to provide a higher level of alert over smaller regions in time and space when atmospheric conditions are favorable for severe thunderstorms and/or tornadoes to develop. The SPC also issues

Mesoscale Discussion products that emphasize hazardous weather on the mesoscale and often serve to fill the gap between the larger scale Outlooks and smaller scale Watches. These specialized forecast products depend on the ability of SPC forecasters to assess the current state and evolution of the environment over varied time frames, and to synthesize a wide variety of observational and numerical model data sources. In general, observational data play a larger role in the shorter time frames for diagnostic purposes, however, the development of more accurate and higher resolution models in recent years has allowed model information to play an increasing role in the short-term prediction of convection as well.

An effective NWS severe weather forecast and warning program is dependent on providing the public and others with critical weather information needs with sufficient advance notice of impending hazardous weather. Human response studies have shown that when a severe thunderstorm or tornado warning is issued, people are more likely to seek shelter if they have been made aware of the severe weather threat prior to the issuance of the warning. However, if they have not been "pre-conditioned" to the threat prior to hearing a warning, their first response is often to seek confirmation of the threat, rather than to seek shelter. This can result in the loss of precious time when life and property are at immediate risk. Thus, there is a substantial need for SPC to issue severe weather watches prior to the issuance of warnings by local NWS Weather Forecast Offices (WFOs), in order to allow WFO staffs, emergency managers, broadcast media, etc. sufficient time to implement contingency plans prior to the onset of severe weather. In recent years SPC has embarked on a program to increase the lead time of convective watches while continuing to improve forecast accuracy.

This ambitious goal places additional requirements on SPC forecasters to determine in advance the characteristics of potential severe thunderstorm activity. Operational experience and research studies suggest that the type of severe weather that occurs (tornadoes, hail, or damaging winds) is often closely related to the convective mode (or morphology) that storms exhibit, such as discrete cells, squall lines (or quasi-linear convective systems (QLCS)), and multicellular convective systems. A disproportionate number of tornado and widespread straight-line wind damage events appear to be associated with two dynamically unique classes of thunderstorms: supercells and bow echoes. Thus, accurate severe weather watches are dependent on forecasters being able to properly predict not only where and when severe thunderstorms will develop and how they will evolve over the next 4 – 8 hours, but also the convective mode(s) that are most likely to occur.

Given our primary mission of mesoscale forecast responsibility, it is not only prudent but necessary to place a strong emphasis on diagnostic analysis using real-time observational data for short-term thunderstorm prediction. However, owing to insufficient sampling of the mesoscale environment (especially when the horizontal and vertical distribution of water vapor is considered) coupled with limited scientific knowledge of important mesoscale and storm-scale processes, considerable uncertainty still exists in the short-term prediction of convection. While traditional mesoscale models such as the NAM and GFS often can predict broader regions of precipitation associated with parameterized convective processes, they are not capable of resolving important details of the smaller scale convective structure that is critical to severe weather forecasters. Furthermore, various proximity sounding studies using observed radiosondes and RUC model analyses indicate that the relationship between environmental characteristics (such as CAPE and shear) and storm mode is not unique; rather it is found that similar storm types occur within different parts of the CAPE-shear parameter space, and different storm types occur within similar parts of parameter space.

Earlier research studies using idealized cloud resolving models to simulate convective storms at the National Center for Atmospheric Research (NCAR) and the University of Oklahoma Center for Analysis and Prediction of Storms (CAPS), among others, indicated that in some cases the models could replicate severe storm structures including supercells and bow echoes. However, it was not until recently that sufficient computer resources, network bandwidth, and workstations were available that permitted the testing of large domain, convection-allowing WRF models in a semi-operational forecasting environment in order to assess their potential utility for operational forecastering. It has been demonstrated over the last four years in Spring Experiments, field programs such as BAMEX, and daily operational use at SPC of experimental 4 km WRF models from the NCEP Environmental Modeling Center (EMC) and NSSL that near-cloud resolving configurations of the WRF model can predict convective storms that, at times, appear remarkably similar to actual storms as seen on radar. Experiments with different WRF model configurations also indicate that it is not uncommon for the models to produce a variety of convective solutions regarding initiation, mode, and evolution, especially within more weakly forced environments. In some ways, the models appear to reflect various uncertainties associated with real-world convective forecasting. These include the need to better sample and predict the pre-convective and near-storm environment, as convection can be sensitive to small variations in the environment, and limits in our understanding of smaller scale physical processes relevant to convection, which are modulated by mesoscale and stormscale forcing that are difficult to assess in the actual atmosphere.

Consequently, we have found that variations in WRF model convective storm predictions are at times difficult for operational forecasters to reconcile, because all solutions may appear to be plausible for a given mesoscale environment. Thus, the forecaster is faced with the dilemma of knowing when to believe specific model solutions and when to discount them, but there is little guidance about WRF model performance that is available, in part because of the experimental and evolving configuration of the models. The uncertainty in predicting convection that is apparent when multiple WRF solutions are generated suggests at least several possible research approaches to explore: 1) development of appropriate data assimilation systems for convection-allowing models, and 2) improvement in the model with more realistic physics and increased resolution. However, inherent limits to the predictability of thunderstorms further suggest that application of ensemble forecasting concepts, currently used operationally for synoptic scale and mesoscale forecasting, may also be applicable to address challenges of convective-scale forecasting.

The Spring Experiment in 2007 will continue and enhance existing partnerships with CAPS, EMC, and NCAR to test and evaluate a number of daily, real-time WRF models over domains covering two-thirds to three-fourths of the CONUS. The unique component of the experiment is a 10 member, 4 km WRF ensemble (Storm Scale Ensemble Forecast or SSEF) run once daily at 21z by CAPS with forecasts to 33 hr. The SSEF represents an unprecedented real-time computational achievement, and it is part of a three year project that will test and refine a convection-allowing ensemble to provide probabilistic guidance on high impact convective weather events by quantifying aspects of uncertainty and offering insights about a possible range of solutions. The initial SSEF is a collaborative effort between CAPS, EMC, NCAR, the Pittsburgh Supercomputing Center (PSC), SPC, and NSSL. It consists of 10 WRF-ARW members, five having microphysics and PBL parameterization diversity and five having mixed physics-initial condition perturbations. The initial conditions (ICs) for the SSEF come directly from the operational EMC Short-Range Ensemble Forecast (SREF) system. Like most ensemble prediction systems, this configuration of the SSEF is likely to be underdispersive. However, this simplified structure was chosen to permit examination of fundamental statistical attributes of a convection-allowing ensemble, including the relative effects of IC versus physics diversity on ensemble performance. In addition, since the WRF models are still in their development stage, this SSEF configuration permits a direct comparison of various PBL and microphysics schemes, which previously have been found to impact both the pre-convective environment and subsequent characteristics of model generated convection. More information about the SSEF configuration is provided in Table 1 and Fig. 1.

Table 1. SSEF member configuration.

member	IC	BC	mp_phy	pbl_phy	**Status**
Cntl	21Z NAMa	18Z NAMf	WSM 6-class	MYJ	Tested
n1	Cntl – em_pert	21Z SREF em-n1	Ferrier	MYJ	Tested
p1	Cntl + em_pert	21Z SREF em-p1	Thompson	MYJ	Tested
n2	Cntl – nmm_pert	21Z SREF nmm-n1	Thompson	YSU	Tested
p2	Cntl + nmm_pert	21Z SREF nmm-p1	WSM 6-class	YSU	Tested
Ph1	21Z NAMa	18Z NAMf	Thompson	MYJ	Tested
Ph2	21Z NAMa	18Z NAMf	Ferrier	MYJ	Tested
Ph3	21Z NAMa	18Z NAMf	WSM 6-class	YSU	Tested
Ph4	21Z NAMa	18Z NAMf	Thompson	YSU	Tested
Ph5	21Z NAMa	18Z NAMf	Ferrier	YSU	Tested

NOTE:
2 km deterministic forecast uses the same IC/BC and physics as the 4 km Cntl member.

NAMa – 12km NAM analysis
NAMf – 12km NAM forecast

For all members:

- ra_lw_physics = RRTM scheme (1)
- ra_sw_physics = Goddard (2)
- sf_surface_physics = Noah (2)
- cu_physics = none (0)

In addition to the SSEF, CAPS will produce a single WRF-ARW at 2 km grid length that is identical to the SSEF control member except it is run at higher resolution. At the synoptic scale and mesoscale, ensemble systems have been shown to provide statistically improved verification scores when compared to a higher resolution deterministic model. But will this relationship hold near the stormscale? It is anticipated that this part of the experiment will establish a framework to compare the costs and benefits of running a coarser resolution 4 km convection-allowing ensemble versus a higher resolution deterministic 2 km WRF run. In addition, a number of studies have indicated that ~4 km grid length is at the upper range of where models without parameterized convection should be run, and as model resolution increases below 4 km more realistic model generated storms are possible. Comparison of the SSEF control run with the 2 km run permits examination of the resolution sensitivity of the WRF-ARW, especially as it relates to model storm initiation and storm structure.

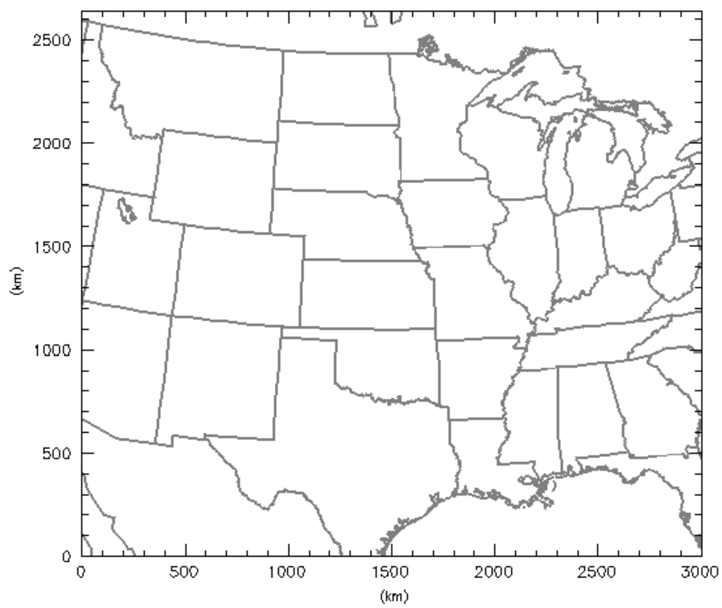

Fig. 1. Domain of SSEF and WRF-ARW2 provided by CAPS

EMC and NCAR will also contribute real-time forecasts to the experiment, providing once daily 3 km runs of the WRF-NMM and WRF-ARW, respectively. These runs will start at 00z and run through 36 hours. These forecasts are designed to test various upgrades to the pre-processing, physics, and numerics while also permitting examination of resolution sensitivity. All modeling systems will again use a cold start with initial conditions coming from the operational NAM model. Table 2 contains information about the deterministic WRF forecasts. Guidelines for changing experimental models during the experiment are found in Attachment I.

	NMM3 (NMM4)	**WRF-ARW3**	**WRF-ARW4**	**WRF-ARW2**
Horiz. Grid (km)	3.0 (4.0)	3.0	4.0	2.0
Vertical Levels	35	35	35	51
PBL/Turb. Param.	MYJ	MYJ	MYJ	MYJ
Microphysical Param.	Ferrier	Thompson	WSM6	WSM6
Radiation (SW/LW)	GFDL/GFDL	Dudhia/RRTM	Dudhia/RRTM	Dudhia/RRTM
Initial Conditions	32 km NAM	40 km NAM	40 km NAM	12 km NAM

Table 2. Configurations of deterministic WRF models. EMC NMM's, NSSL ARW4, and NCAR ARW3 start at 00z and run through 36 hrs; ARW2 starts at 21z and runs through 33 hours.

In addition to the convection-allowing WRF models, NSSL will be testing mesoscale EnKF WRF ensemble that assimilates hourly surface data starting at 12z each day. Since a key aspect in forecasting convective initiation is the specification and prediction of the mesoscale environment, accurate hour-by-hour analyses are an important component of the forecast process. A final experiment activity will be the evaluation of the EnKF ensemble mean basic surface fields and comparison with the hourly SPC automated mesoscale analyses.

A key component of the program is the participation of operational forecasters from SPC, other NCEP Centers, NWS WFOs, and several private sector companies. Their insights and experience provide a real-world severe weather forecasting perspective when assessing the usefulness of convection-allowing WRF modeling systems, increasing the likelihood that WRF development activities will result in improved severe weather forecasts and better public service. Their interactions with model developers, research scientists, and university faculty create a unique forum where a diverse mix of scientific backgrounds and insights work together to advance operationally relevant research and improve severe weather forecasts.

The primary objectives of Spring Experiment 2007 are to:

- Determine the technical feasibility of running for the first time a real-time, large domain convection-allowing ensemble prediction system (SSEF) during the prime severe weather season to gauge high performance computing, networking, data transfer and processing, product creation, and workstation display requirements for future high impact weather forecasting initiatives associated with the Warn-on-Forecast concept.
- Explore the relative impact of initial condition uncertainty and physics uncertainty in a convection-allowing ensemble as determined by statistical performance properties.
- From selected SSEF ensemble members assess the comparative ability of different PBL schemes to predict the evolution of the boundary layer and its subsequent impact on convective initiation.
- From real-time and post analyses of the SSEF, determine strengths and limitations of the ensemble configuration and consider appropriate modifications that will lead to improved ensemble performance in subsequent years.
- Identify and test ways to extract useful information from the SSEF and develop innovative product display techniques that will provide forecasters with meaningful probabilistic guidance on high impact convective weather events.
- Explore the possibility of “model overload” for severe weather forecast decision-making when guidance is available from multiple convection-allowing WRF models, especially if model performance characteristics are unknown.
- Assess the utility of higher resolution convection-allowing deterministic WRF models to provide more detailed and useful forecast guidance to forecasters on the initiation, mode and evolution of severe thunderstorms, including supercells.
- Identify new WRF applications most suitable for transfer to SPC operations.
- Evaluate ensemble mean surface analyses produced from a mesoscale WRF ensemble that utilizes an hourly EnKF surface data assimilation technique.
- Provide focused feedback to model developers on the performance of the experimental WRF ensemble and deterministic models during severe thunderstorm episodes.

The experiment expected outcomes include:

- Documentation of statistical verification properties of the convection-resolving WRF ensemble, leading to improvements in the configuration of the 2008 ensemble.
- Documentation of the potential utility of a convection-allowing ensemble to quantify uncertainty and provide probabilistic guidance for high impact severe weather events.
- Documentation of the relative operational severe weather forecasting utility of the latest experimental versions of the WRF-NMM and WRF-ARW for severe weather forecasting.
- Confirmation and clarification of the ability of convection-allowing WRF models to provide unique information on convective mode and how operational severe weather forecasters utilize this guidance in daily forecasting.
- Documentation of the evolving complimentary relationship between operational mesoscale deterministic models, the current mesoscale SREF, and convection-allowing WRF models including the SSEF in quantifying uncertainty in severe weather forecasts.
- Internal NWS documentation of challenges to the real-time display and utilization of very high resolution NWP output in an operational forecast setting.
- Enhanced communication and collaboration between model developers in the research and operational communities
- Continued effective collaboration between research scientists, model developers, and forecasters during the Spring Experiment with high participant satisfaction (greater than 70% very good to excellent collaboration assessment) as measured by responses to a survey form given to all participants.

III. Program Focus Areas

Spring Experiment 2007 will have eight (8) focus areas:

1. Determine if operational severe weather forecasters find added utility and value from the convection-allowing WRF ensemble that provides probabilistic information about high impact convective weather, including a range of possible convective storm solutions, when used to supplement output from mesoscale and convection-allowing deterministic models and the mesoscale SREF.

2. Examine several measures of central tendency (mean, median, maximum, probability matching, etc.) from the convection-allowing WRF ensemble to assess their ability to depict useful statistical properties of very high resolution convective weather fields such as simulated reflectivity and QPF when compared to observed fields.

3. Examine several approaches to compute exceedance probability values (traditional grid point ratio, distance weighted step function ratio, Gaussian weighted function ratio) from the convection-allowing WRF ensemble valid at a single time and over multiple hours to determine appropriate probability displays for guidance in operational severe forecasting products.

4. Determine the 4-D evolution of soundings from two members of the SSEF that will explore the sensitivity of PBL evolution in the pre-convective environment near boundaries and in the warm sector to different PBL parameterizations. Focus will be on comparison of low level thermal, moisture and wind profiles, lapse rates, and CIN layers.

6. Using simulated reflectivity fields from deterministic WRF models and the SSEF products, compare the initiation and evolution of model generated thunderstorms with actual storms as seen by observed radar reflectivity.

7. Evaluate the ability of diagnostic methods to identify supercell thunderstorms in deterministic WRF models and SSEF products, and determine the correspondence between model predicted supercells and observed supercells.

8. Examine hourly ensemble mean surface analyses from a mesoscale WRF ensemble that utilizes EnKF data assimilation of surface data, and compare it with the SPC hourly "sfcoa" fields that blend observed METAR data with hourly RUC analyses.

IV. Spring Experiment Web Site

A full description of all program objectives, types of model output, forecast products, evaluation and verification forms, a data archive, and other related links are available at the Spring Experiment web site:

http://hwt.nssl.noaa.gov/Spring_2007/

This web site is intended to support real time activities as well as additional research and reference after the conclusion of the program.

V. Dates and Participants

Spring Experiment 2007 will run Monday-Friday 8 am – 4 pm from April 23 through June 8, 2007. During the first week, final spin-up activities will be tested with in-house participants only. Beginning April 30, a full range of in-house and external participants will staff the program. Full time participants will work shifts of one week, with part-time visiting scientists and forecasters participating on a 2-3 day basis (schedule permitting). Program operations will be conducted in the Hazardous Weather Testbed facility (Room 2380) located on the second floor of the NWC between the SPC and WFO Norman operations areas. The full time forecast team will complete daily experimental forecasts and participate in evaluation and verification activities; part-time visitors can participate in daily activities at levels appropriate with their interest and expertise. Staffing typically will include one SPC forecaster, one or more NSSL scientists, and a number of visiting scientists, model developers, forecasters, and university faculty. Visitors come from a variety of locations – **See Attachment A for a list of participants and their affiliations.** A brief orientation/training session will be provided to all participants on the morning of their first scheduled shift.

VI. Daily Operations Schedule

Participants in the experiment will create experimental forecast products, conduct subjective evaluation activities and participate in a daily map discussion in the HWT from 8 am - 4 pm on Monday-Friday. Occasional seminars by visiting scientists will be scheduled for 4 pm in the David L. Boren Auditorium on the first floor of the NWC upon completion of daily experimental activities.

Participants are expected to perform evaluation activities in a collaborative manner, such that results reflect a consensus decision. Participants may eat lunch while conducting program activities or at their discretion any time during the day.   Visitors may purchase lunch at a food court located on the south side of the first floor of the NWC. Below is an outline of the daily schedule for activities during the experiment:

<u>Monday-Friday</u>:

7:30 a.m.	-	8:00 a.m.	-	Orientation (Monday only)
8:00 a.m.	-	8:45 a.m.	-	Complete online forms for subjective verification of yesterday's experimental severe weather forecasts
8:45 a.m.	-	9:45 a.m.	-	Select today's 6-hour valid period and forecast/evaluation domain based on 13z SPC Outlook and initial look at observational/model data and complete online domain selection form
8:45 a.m.	-	10:45 a.m.	-	Using traditional analysis techniques and assessment of operational models (e.g., NAM, RUC, SREF) and deterministic WRF models, prepare and issue *preliminary* graphical severe weather forecast and complete online forms
10:45 a.m.	-	Noon	-	Examine and assess SSEF output, issue *final* graphical severe weather forecast and complete final online forms
11:30 a.m.	-	Noon	-	Sounding analysis - initial selection of previous day soundings for more in-depth early afternoon evaluations
Noon	-	1:00 p.m.	-	Lunch, informal exploration and discussions
1:00 p.m.	-	1:30 p.m.	-	Briefing of today's experimental forecast and other issues of interest (HWT Map Discussion)
1:30 p.m.	-	2:00 p.m.	-	Completion of sounding evaluation activities
2:00 p.m.	-	3:30 p.m.	-	Evaluate yesterday's SSEF and deterministic WRF model forecasts and complete online evaluation forms
3:30 p.m.	-	3:45 p.m.	-	Evaluate EnKF mesoscale ensemble mean surface analyses and complete online evaluation forms
3:45 p.m.	-	4:00 p.m.	-	Informal wrap-up discussion of "what did we learn" today

VII.   Forecast Products

An experimental forecast component is a key part of the program, and it consists of formulating two short-term probabilistic severe weather forecast products valid for the current day from 18-00z. *(If deep convection is unlikely to develop before 00z and primary development is delayed until near or after 00z, the forecast period can be changed to 21-03z or 00-06z if appropriate. It is anticipated that this change will occur only on a small number of days during the program.)* A **preliminary forecast will be issued by ~10:45 am.** This product is prepared in a simulated operational forecasting environment, with access to the full suite of observations and model data currently available to SPC forecasters, including high resolution deterministic model output.   After the preliminary forecast is completed, the forecast team will assess output from the SSEF and issue a **final forecast by noon** incorporating information from the experimental convection-allowing ensemble. The intent of the forecast component is to examine the ability of experienced severe weather forecasters to issue detailed severe weather forecasts for the afternoon and early evening with emphasis on the timing and location of initial convective initiation, subsequent convective evolution, and aspects of convective mode. A key goal will be to assess the value-added impact of the SSEF guidance in the forecast process. A secondary goal is to assess the impact of multiple WRF models in addition to operational model guidance on the overall forecast decision-making process.

The preliminary/final severe weather forecasts will be formulated by 10:45 am/noon including completion of the online discussion forms. It is expected that the forecasters will need to make their primary decisions 20-30 minutes prior to the forecast deadlines in order to complete forecast graphics and online discussion forms on time.

The severe weather forecasts will be similar to operational severe weather outlooks except they are valid for a shorter period of time. They will show the probability of all severe weather (large hail, damaging wind, and tornadoes) occurring during the 6-hour valid period, and areas where there is a 10% or greater probability of significant severe weather (defined as tornadoes $\geq$ F2, hail diameter $\geq$ 2 inches, or winds gusts $\geq$ 65 kt) on the same graphic.

The severe weather probability contours for the severe storm forecasts will be chosen from the same contour values as used in SPC operational severe outlooks: 5, 15, 30, 45, and 60%. These represent the coverage of expected severe weather reports, and can also represent a measure of forecast uncertainty. The severe weather probability forecasts will be verified using an 80 km grid, so they are approximately equivalent to the probability of a severe weather event occurring within 25 miles of a point. The severe weather forecasts will be verified using both subjective and objective methods, based on severe storm reports collected by SPC from local storm report (LSR) products issued by NWS WFOs across the country. The subjective verification will be supplemented by radar imagery and NWS warnings to account for possible population biases in the severe report data base.

The convection-allowing WRF output and derived measures of updraft rotation such as Updraft Helicity (UH) and Supercell Detection Index (SDI) (see Attachment I) facilitates extraction of information about model generated supercell storms. Currently, operational SPC forecast products do not explicitly delineate areas of supercell threat although a general discussion of supercell potential is often contained in accompanying text products. Since supercell storms are often associated with more significant severe weather events, an important step in forecast improvement is to determine if output from the WRF modeling systems can provide forecasters with useful information about the timing, location, coverage, and longevity of supercell storms. This will be subjectively considered during the forecast preparation period.

In order to limit the size of the geographic area the forecasts are valid for, the experimental products will roughly focus on severe risk area(s) delineated in the 13 UTC SPC Day 1 Outlook, covering regions of 8 deg latitude by 14 deg longitude (480 nm by 840 nm / 890 km by 1555 km). If more than one severe risk area is included in the 13 UTC Day 1 outlook, the forecast team will choose one of the risk areas to concentrate on the area with the highest or most significant severe threat during the afternoon or early evening hours. Since we are most interested in timing/location of the ***initiation*** of convection and severe storms, rather than the ***continuation*** of existing convection and severe storms, these considerations will affect the choice of outlook areas. Also, areas of potential nocturnal convection developing after sunset should be avoided as the primary life cycle of these events will most likely take place outside of our required time window.

As part of the online documentation forms for the preliminary and final forecasts, the forecast team (usually the SPC forecaster) will: 1) categorize the ongoing thunderstorm activity at the time of the forecast issuance, 2) classify the mesoscale environment expected during the immediate pre-convective period using basic CAPE/shear parameters, and 3) write a narrative discussion product similar to operational outlook discussions that explains the scientific rationale for the forecast, including the impact of the WRF models (preliminary) and SSEF (final) in the decision-making process.

Instructions for creation of the experimental forecast products are in Attachments B, D and E.

VIII. Evaluation and Verification Activities

A. Morning Forecast Evaluation

Every morning, evaluation of the severe weather forecasts valid for the previous day will be conducted at the beginning of daily activities. (On Monday morning, the forecasts valid for Friday will be evaluated).

The evaluation of the severe weather forecasts will be over the domain selected for the previous day. The subjective verification of the severe weather forecast will utilize two different datasets. First, a static plot of the forecast probabilities overlaid on the severe reports occurring during the 6-hour forecast period will be used to directly assess the accuracy and usefulness of the forecasts. It is important to make sure the team members assess the forecast using the following criteria: 1) how well it delineated regions where severe reports and significant severe reports occurred (spatial accuracy), and 2) how well it exhibited a sense of reliability (more reports occurred in regions with higher probabilities). Second, a loop of radar reflectivity and county warnings issued by WFOs during the valid period will be used to provide additional information about potentially severe thunderstorms because the actual severe report listing can reflect inadequacies in spotter networks, low population bias, delayed reports, etc. These multiple sources of verifying information are used to assess the “goodness” of the severe weather forecast. The verification will include numerical ratings from 0-10 and space for a brief written discussion explaining the rating decision. Objective statistical verification of the severe weather forecast will also be conducted after the conclusion of the Spring Experiment, as we view these two methods as being complementary.

More information about the forecast verification forms is found in Attachment C.

B. Late Morning and Afternoon Model Evaluation

During the late morning and afternoon, several of the deterministic WRF models and the SSEF forecasts valid for the previous day are evaluated to assess the accuracy of: 1) predicted environmental conditions using forecast soundings, and 2) predicted storm evolution as seen in simulated reflectivity fields and diagnostic supercell indicators. The subjective assessment will include the available deterministic convection-allowing WRF models and the SSEF.

- Model Sounding Evaluation

The sounding assessment domain will be identical to the forecast domain selected for the previous day. To identify appropriate sounding locations, it is necessary to first examine the pre-convective environmental conditions in close proximity to the primary convective initiation, near significant boundaries, in the warm sector, and modifications associated with MCS development, so knowledge of model predicted and actual atmospheric convection will be incorporated in the process of selecting sounding points for examination. To assist in this process, model forecasts of low level thermodynamic properties and boundary locations will be compared with SPC hourly Surface Objective Analysis (sfcoa) fields. The sfcoa procedure uses a 2-Pass Barnes analysis to blend observed surface data with 3-D background fields provided by the RUC model 1-hour forecast. Web pages including time-matched images of WRF forecasts and verifying data are expected to provide much of the information needed to select appropriate sounding points.

Although the density of raob sites is far from optimal, one or two sites near important boundaries and in the warm sector that are not contaminated by ongoing convection will be used to assess the ability of the models to predict the general thermodynamic and kinematic structure, with close attention paid to PBL structure, any capping inversions, and low level temperature and dewpoint profiles. Similar comparisons between model soundings at one or two PFC (point forecast) locations will also be made, in order to determine how the evolution of model sounding profiles compare to each other. This comparison may reflect different physical parameterizations incorporated in the different WRF and SSEF member configurations. More information about the sounding evaluation is found in Attachment F.

- Convective Initiation, Evolution and Supercell Evaluation

Over the last four years we have gained experience in exploring the use of convective-allowing WRF models for operational forecasting applications, in large part due to their ability to provide more detailed information about convective structure compared to operational mesoscale models. Evaluation efforts during recent Spring Experiments and in SPC operations have focused on determining if the WRF simulated reflectivity forecasts provide useful guidance to severe weather forecasters in predicting the “where”, the “when”, and the spatial pattern of thunderstorm development, including information about convective mode. Convective mode refers to the thunderstorm organization or morphology into discrete cells, Quasi-Linear Convective Systems (QLCSs), and other multicellular systems. Our working concept is this: if we have a good idea how the timing, location, and evolution of afternoon convection will unfold, the ability of SPC forecasters to issue high quality severe weather outlooks and watches will increase. Accordingly, a continuing part of the model evaluation will consist of subjective comparisons of the model predicted simulated reflectivity with corresponding radar reflectivity within the forecast domain. For the deterministic WRF models, we want to specifically focus on the mesoscale evolution of convection during the forecast period, which encompasses initiation, direction and speed of system movement, areal coverage, configuration, orientation of mesoscale features, and perceived mode.

We will also examine the prediction and occurrence of supercell thunderstorms. Current operational forecasting techniques examine basic CAPE, helicity, and deep layer shear fields to determine if the environment can potentially support supercells. However, the occurrence or non-occurrence of supercells is dependent on a number of other mesoscale factors, such as the strength and orientation of the lifting mechanism and the strength of any cap, both of which will impact the number of storms that develop (if any). The longevity and intensity of storms is also impacted by subsequent interactions between existing storms. As such, the accurate prediction of convective mode is often a very important factor in the prediction of supercells, and current techniques allow only a simple approximation of many complex processes. With the high resolution output from the WRF models, however, we can use gridded vertical velocity and horizontal vorticity data as input and test several experimental supercell parameters designed to identify model storms with rotating updrafts. These model outputs will be compared with storms containing mesocyclones using output from the Mesocyclone Detection Algorithm (MDA) to subjectively assess the correspondence between model predicted supercells and radar detected supercells. **See Attachment G for information about the model evaluation details, and Attachment I for information about supercell detection approaches used with the WRF model output.**

Finally, the SSEF output raises new challenges in terms of creating useful probabilistic and other statistical products that provide forecasters with unique and meaningful information quantifying forecast uncertainty on the convective scale and offering insights about possible ranges of solutions. Evaluation of experimental new SSEF products and display formats will help determine how well they transfer information to forecasters and how forecasters might incorporate this additional information into the already complex decision-making process.

IX. Daily Map Discussion

A daily forecast discussion is held from 1:00-1:30 pm to summarize the Spring Experiment forecasting and evaluation activities. The discussion will typically be lead by the SPC forecaster with other comments by program participants as time allows. The map discussion is scheduled to end promptly by 1:30 pm so there is sufficient time to conduct model assessment activities during the remainder of the afternoon.

X. Forecaster/Participant Duties and Responsibilities

All new participants will participate in an orientation session on the morning of their first scheduled shift. However, to become familiar with program goals and objectives, participants are asked to read the operations plan prior to their first day in the HWT.

The forecast team will be made up of 5-9 full-week members on all days, with shorter-term visitors present on many of the days (see schedule, **Attachment A**). **<u>There are two critical tasks that must be achieved.</u>**

1) The morning forecasts, including generation of graphical and text products, should be created and issued in a timely manner, because this helps simulate a real-world forecasting environment where time deadlines must be met.

2) The subjective evaluation of the severe weather/supercell forecasts and model predictions will require a diligent and conscientious effort by all team members, because these findings will play a role in both future model development activities and the application of model output by operational forecasters. It is very important that we maintain our focus during the afternoon model evaluation task and strive to form consensus opinions in the evaluation process.

The order and responsibilities for completing scheduled activities should depend on individual skills and areas of interest. Since the SPC forecaster has the most familiarity with N-AWIPS workstations, data flow, and SPC severe weather forecasting techniques, they will be assigned as the lead of the forecast team. All participants are encouraged to contribute to the morning forecast process, especially if they have experience in severe weather forecasting. However, others without a forecasting background should find it very informative to observe the process of creating a severe weather forecast, including the complementary roles of observational and model data, as well as the incorporation of experimental WRF and SSEF output into the forecasting process. The increasing volume of observational and model data introduces new challenges in the extraction of meaningful information from the myriad of potential data sources, as the time available for forecasters to analyze and interpret data before creating and transmitting forecasts decreases in a relative sense. Studies have shown that simply adding more data to the human forecast process does not by itself result in improved forecasts; rather, improvements come from better use of existing and new data.

While it is recommended the entire forecast team work together and interact on morning evaluation and forecast activities, we will likely start the sounding evaluation tasks during the time that the final experimental forecast online forms are being completed. This will enable the sounding evaluation to begin before lunch. After the map discussion, the evaluation team will complete the sounding evaluation and then conduct the model evaluation activities. Short-term visitors are invited to participate in the forecast and evaluation activities and provide insight as their time and interests permit.

XI. Experimental Displays and Model Data

In order to incorporate new analysis displays and model data into the forecast process, a number of non-operational data sets will be available for use during the Spring Experiment. It is hoped that through a proof-of-concept testing, data sets, analysis tools, and new models which provide useful information during the experiment will be rapidly integrated into SPC operational data flow and workstations.

Model data for the Spring Experiment includes the following (model run resolution / model display grid / name / source / initial times):

12km/80km NAM (EMC - 12, 18, 00, 06z)
12km/40km NAM (EMC - 12, 18, 00, 06z)
12km/12km NAM (selected fields; EMC - 12, 18, 00, 06z)
13km/40km RUC (EMC - Hourly)
13km/20km RUC (EMC - Hourly)
32km/40km SREF-EtaKF Control Run (EMC - 09, 15, 21, 03z)
32-45km/40km SREF (21 members; EMC - 09, 15, 21, 03z)
~40km/40km GFS (EMC – 12, 18, 00, 06z)
4 km/4 km WRF-NMM4 (EMC - 00z)
3 km/3 km WRF-NMM3 (EMC - 00z)#
4 km/4 km WRF-NSSL4 (00z)
3 km/3 km WRF-ARW3 (NCAR - 00z)#
2 km/2 km WRF-ARW2 (CAPS - 21z)#
4 km/4 km WRF-SSEF (CAPS - 21z)#

Italics denotes non-operational models
# Denotes experimental models not available to operational SPC forecasters

XII. Operations Center Hardware and Software

Spring Experiment forecast and evaluation activities will take place in the HWT located between the SPC and WFO OUN operational forecast areas. Equipment available include:

1. Five dual monitor Linux Workstations running N-AWIPS with Mozilla Firefox available for Internet access
2. Raised monitors (including 42 inch plasma screen) and drop-down screens to show multiple images for group discussions and daily map discussion
3. Two laser printers for color and b/w hard copy output
4. OU wireless network for personal laptop internet connection*

* US Government IT security rules prohibit connecting any non-government computer or electronic device to the HWT network or any other NOAA computer system.

XIII. Data Archive (under construction 5/4/07)

Two special online web pages will contain selected images from WRF and SSEF model fields and corresponding observational fields from mosaic radar reflectivity, WDSS-II rotational tracks and objectively analyzed surface and upper air fields.

1) Daily hourly loops will contain data from each program displaying daily overviews, model forecasts, and verifying data including:

   Radar Reflectivity
   2m Temperature
   2m Dewpoint
   MUCAPE
   SBCAPE
   Low Level Winds/Convergence
   Deep Layer Vertical Shear
   0-3 km Helicity
   Precipitation/PMSL

   Radar and Storm Reports Overview
   Satellite/Radar Overview

2) The following special Spring Program 2-D data grids (grib and/or GEMPAK format) from the ARW2, ARW3, NSSL4, NMM3, NMM4 and SSEF output will be archived:

SURFACE/VERTICALLY INTEGRATED QUANTITIES:

2-m temperature (TMP)
2-m dewpoint temperature (DPT)
2-m specific humidity (SPFH)
10-m u wind (UGRD)
10-m v wind (VGRD)
Surface pressure (PRES)
Sea-level pressure
Surface Geopotential height (HGT)
Hourly Total Precipitation
Precipitable Water
1 km Reflectivity
4 km Reflectivity
Maximum Vertical Column Composite Reflectivity
SB CAPE
SB CIN
SB LCL
MU CAPE
MU CIN
0-6 km bulk shear
0-1 km bulk shear
0-3 km storm-relative helicity

0-1 km storm-relative helicity

UPPER AIR QUANTITIES AT 850, 700, 600, 500, 250 mb:

Geopotential height (HGT)
Temperature (TMP)
Specific humidity (SPFH)
Vertical velocity (W)
Wind (UGRD, VGRD)

WIND COMPONENTS (u, v, w) at 1, 2, 3, 4, 5, and 6 km AGL

4) These special datasets are complimented by the routine SPC "sparse" data archive

a) Observations: hourly METAR, NLDN CG lightning, wind profiler, upper air, WSR-88D VAD winds, national watch/warning products
b) RUC data: hourly point forecasts, ruc2a, sfcOA
c) Images: 5-minute national BREF radar, GOES-East and GOES West hourly visible satellite and three-hourly IR/WV

X. Acknowledgments

Special thanks and appreciation is extended to many people for their creative insights and assistance in Spring Experiment preparations, planning, and execution of numerous complex and ground-breaking technical and scientific activities. Without the combined efforts of many SPC and NSSL staff, the Spring Program could not be conducted. In particular, special thanks go to SPC's Phillip Bothwell for providing access to severe storm report verification data; Gregg Grosshans for establishing model data flow and configuring the experimental forecasts for transmission and archival, and for helping to organize model display files, and Jay Liang and Joe Byerly for assistance in configuring and upgrading hardware/software, network and workstations in the HWT. Expert NSSL technical support was provide by Doug Kennedy, Brett Morrow, Jeff Horn, Steve Fletcher and Brad Sagowitz to address networking, data flow and archive requirements. Linda Crank (SPC), Peggy Stogsdill (SPC), and Linda Foster (NSSL) ably assisted with logistical and budget support activities. J. J. Gourley's assistance in organizing the NSSL Seminar Series for visiting scientists during the experiment is also greatly appreciated.

The experimental activities could not take place without the dedicated collaborative efforts of many people at CAPS, EMC, and NCAR who are working to enhance community efforts to improve severe weather forecasting. We acknowledge the expertise of CAPS scientists Ming Xue, Kelvin Droegemeier, Dan Weber, Kevin Thomas, Yunheng Wang and Keith Brewster for outstanding efforts to develop and run the convection-allowing WRF ensemble and WRF-ARW2 runs; the Pittsburgh Supercomputing Center and David O'Neal in particular for providing technical support and computer facilities for the CAPS model runs; NCAR scientists Morris Weisman, Greg Thompson, Jimy Dudhia, and Wei Wang for developing the WRF-ARW3 runs and offering technical support and advice on the ARW system and configuration of the WRF ensemble; EMC scientists Matt Pyle, Zavisa Janjic, Brad Ferrier, Jun Du, Zoltan Toth, and Geoff DiMego for developing and contributing the WRF-NMM models and for scientific input and infrastructure support for the WRF ensemble. We further wish to recognize the full support of SPC and NSSL management; and the numerous contributions and insights provided by the many participants who clearly demonstrated the

value of collaborative experiments involving the research, academic, and forecasting communities, and whose presence and enthusiasm resulted in a positive learning experience for everyone.

Attachment A

Spring Experiment 2007 Participant Schedule (5/4/07)

OPERATIONS SCHEDULE FOR HWT SPRING EXPERIMENT 2007
23 APRIL - 8 JUNE 2007

ALL SHIFTS MON-FRI WILL BE FROM 8AM-4PM. SCHEDULES MAY BE CHANGED OR TRADED THROUGH INDIVIDUAL AGREEMENT **AND** COORDINATION WITH STEVEN WEISS OR JACK KAIN.

New Participants in the experiment are strongly encouraged to read the Operations Plan prior to working their first shift. A list of all participants by affiliation is provided at the end of this document.

(#) – Shorter-term visitor
(*) - Initial spin-up week

MON*	**TUE***	**WED***	**THU***	**FRI***
4/23	**4/24**	**4/25**	**4/26**	**4/27**
Weiss	Weiss	Weiss	Weiss	Weiss
Kain	Kain	Kain	Kain	Kain
Goss	Goss	Goss	Goss	Goss
Bright	Bright	Bright	Bright	Bright
Coniglio	Coniglio	Coniglio	Coniglio	Coniglio

Week 1

MON	**TUE**	**WED**	**THU**	**FRI**
4/30	**5/1**	**5/2**	**5/3**	**5/4**
Dial	Dial	Dial	Dial	Dial
Wandishin	Wandishin	Wandishin	Wandishin	Wandishin
Anderson	Anderson	Anderson	Anderson	Anderson
Brown	Brown	Brown	Brown	Brown
Weisman	Weisman	Weisman	Weisman	Weisman
Johns#	Johns#	Johns#		

Week 2

MON	**TUE**	**WED**	**THU**	**FRI**
5/7	**5/8**	**5/9**	**5/10**	**5/11**
Peters	Peters	Peters	Peters	Weiss
Pyle	Pyle	Pyle	Pyle	Pyle
Graham	Graham	Graham	Graham	Graham
Seaman	Seaman	Seaman	Seaman	Seaman
Taylor	Taylor	Taylor	Taylor	Taylor
Dudhia	Dudhia	Dudhia	Dudhia	Dudhia
Brill#	Brill#	Brill#		
Hirschberg#		Milbrandt#	Milbrandt#	Milbrandt#
		Manousos#	Johns#	

Week 3

MON	**TUE**	**WED**	**THU**	**FRI**
5/14	**5/15**	**5/16**	**5/17**	**5/18**
Carbin	Carbin	Carbin	Carbin	Carbin
Bunkers	Bunkers	Bunkers	Bunkers	Bunkers
Platt	Platt	Platt	Platt	Platt
Mullen	Mullen	Mullen	Mullen	Mullen
Manikin	Manikin	Manikin	Manikin	Manikin
Bryan	Bryan	Bryan	Bryan	Bryan
Meisner	Meisner	Meisner	Meisner	Meisner
Mylne	Mylne	Mylne	Mylne	Mylne
Gallus#	Gallus#	Gallus#		
	Ashton#	Ashton#	Ashton#	
	Uccellini#			

Week 4

MON	**TUE**	**WED**	**THU**	**FRI**
5/21	**5/22**	**5/23**	**5/24**	**5/25**
Darrow	Darrow	Darrow	Bright	Bright
Brooks	Brooks	Brooks	Brooks	Brooks
Entwistle	Entwistle	Entwistle	Entwistle	Entwistle
Fischer	Fischer	Fischer	Fischer	Fischer
Bosart	Bosart	Bosart	Bosart	Bosart
Galarneau	Galarneau	Galarneau	Galarneau	Galarneau
Hamill	Hamill	Hamill	Hamill	Hamill
Trapp #	Trapp#	Trapp#	Trapp#	
Stensrud#	Stensrud#	Stensrud#		
Mylne#	James#	James#	James#	James#

Week 5

MON	**TUE**	**WED**	**THU**	**FRI**
5/28	**5/29**	**5/30**	**5/31**	**6/1**
Holiday	Weiss	Weiss	Weiss	Weiss
	McCaul	McCaul	McCaul	McCaul
	Baldwin	Baldwin	Baldwin	Baldwin
	Janish	Janish	Janish	Janish
	Lackmann	Lackmann	Lackmann	Lackmann
	Mahoney	Mahoney	Mahoney	Mahoney
	Crawford	Crawford	Crawford	Crawford
	Arndt	Arndt	Arndt	Arndt
	Zubrick	Zubrick	Zubrick	Zubrick
	Carr#	Carr#		

Week 6

MON	**TUE**	**WED**	**THU**	**FRI**
6/4	**6/5**	**6/6**	**6/7**	**6/8**
Mead	Mead	Mead	Mead	Mead
Coniglio	Coniglio	Coniglio	Coniglio	Coniglio
French	French	French	French	French
Sisson	Sisson	Sisson	Sisson	Sisson
Flagg	Flagg	Flagg	Flagg	Flagg
Etherton	Etherton	Etherton	Etherton	Etherton
Schumacher	Schumacher	Schumacher	Schumacher	Schumacher
Goosen	Goosen	Goosen	Goosen	Goosen
Sun#	Sun#	Sun#		
Schultz#	Schultz#	Schultz#		

External Visitors to the NOAA HWT Spring Experiment (EFP)

Full-week visitors denoted by *italics*

Week of April 30

Chris Anderson (NOAA ESRL/GSD Boulder) April 30-May 4
John Brown (NOAA ESRL/GSD Boulder) April 30-May 4
Morris Weisman (NCAR Boulder) April 30-May 4
Stan Trier (NCAR Boulder) April 30-May 1
Bob Johns (retired SPC) April 30-May 2

Week of May 7

Randy Graham (NOAA NWS Salt Lake City) May 7-11
Jimy Dudhia (NCAR Boulder) May 7-11
Nelson Seaman (Penn State Univ.) May 7-11
Neil Taylor (Environment Canada Edmonton) May 7-11
Keith Brill (NOAA NWS NCEP/HPC Washington DC) May 7-9
Matthew Pyle (NOAA NCEP/EMC Washington DC) May 7-9
Paul Hirschberg (NOAA NWS OCWWS Silver Spring MD) May 7
Jason Milbrandt (Environment Canada Dorval QB) May 9-11
Peter Manousos (First Energy Corp. Akron, OH) May 9

Week of May 14

Matthew Bunkers (NOAA NWS Rapid City SD) May 14-18
Eric Platt (NOAA NWS Midland TX) May 14-18
Geoffrey Manikin (NOAA NCEP/EMC Washington DC) May 14-18
Bernard Meisner (NOAA NWS SRH Ft. Worth TX) May 14-18
George Bryan (NCAR Boulder) May 14-18
Steven Mullen (Univ. of Arizona Tucson) May 14-18
Ken Mylne (United Kingdom Meteorological Office Exeter) May 14-18
Louis Uccellini (NOAA NCEP Washington DC) May 15
Arnold Ashton (Environment Canada Toronto) May 15-17
William Gallus (Iowa State Univ. Ames) May 14-16

Week of May 21

Bruce Entwistle (NOAA NCEP/AWC Kansas City) May 21-25
Andy Fischer (NOAA NCEP/AWC Kansas City) May 21-25
Thomas Hamill (NOAA ESRL/PSD Boulder) May 21-25
Lance Bosart (Univ. at Albany SUNY) May 21-25
Thomas Galarneau (Univ. At Albany SUNY) May 21-25
Jeffrey Trapp (Purdue Univ. West Lafayette IN) May 21-24
Ken Mylne (United Kingdom Meteorological Office Exeter) May 21

Week of May 29 (No operations on May 28 Memorial Day Holiday)

Steven Zubrick (NOAA NWS Sterling, VA) May 29-June 1
William McCaul (USRA Huntsville AL) May 29-June 1
Michael Baldwin (Purdue Univ. West Lafayette IN) May 29-June 1
Paul Janish (Merrill Lynch Houston) May 29-June 1
Gary Lackmann (North Carolina St. Univ. Raleigh) May 29-June 1
Kelly Mahoney (North Carolina St. Univ. Raleigh) May 29-June 1

Week of June 4

Paul Sisson (NOAA NWS Burlington VT) June 4-8
Adam French (North Carolina St. Univ. Raleigh) June 4-8
David Flagg (York University Toronto) June 4-8
Brian Etherton (Univ. of North Carolina-Charlotte) June 4-8
Russell Schumacher (Colorado St. Univ. Fort Collins CO) June 4-8
Jim Goosen (Environment Canada Vancouver) June 4-8
Paul Schultz (NOAA ESRL/GSD Boulder) June 4-6
Jenny Sun (NCAR Boulder) June 4-6

Attachment B

Spring Experiment 2007
Experimental Severe Weather Forecast Product Instructions

Experimental Forecast Product Instructions
Spring Experiment 2007

1. Introduction

Two experimental severe weather forecasts valid for 6 hour periods during the afternoon and evening will be issued daily Monday-Friday. On most occasions the forecast period will be 18-00z, but when initial convective development is expected to be delayed until the late afternoon or evening the valid period can be adjusted to 21-03z or 00-06z.)

A **preliminary forecast will be issued by ~10:45 am** based on observational data and model output currently available in SPC operations, which is intended to simulate an operational forecasting environment. **After the preliminary forecast is completed, the forecast team will assess output from the SSEF and issue a final forecast by noon** incorporating information from the experimental convection-allowing ensemble. The intent of the forecast component is to examine the ability of experienced severe weather forecasters to issue detailed severe weather forecasts for the afternoon and early evening with emphasis on the timing and location of initial convective initiation, subsequent convective evolution, and aspects of convective mode. A key goal will be to assess the value-added impact of the SSEF guidance in the forecast process, which will be used to supplement operational mesoscale model guidance from the NAM, RUC, and SREF systems as well as deterministic convection-allowing WRF models. A secondary goal is to assess the impact of multiple WRF models in addition to operational model guidance on the overall forecast decision-making process.

2. Forecast Graphics

The **severe weather forecast** graphics will be very similar to operational SPC outlooks, except only total severe storm probability contours will be formulated (no categorical outlook, and no general thunderstorms will be forecast). The same probability contours used in the operational outlooks will be used for the severe forecasts (5, 15, 30, 45, and 60 %); an area delineating potential for significant severe storms will be included when the probability for significant severe is 10% or greater.

3. Saving the Forecasts in NMAP

For the Preliminary and Final Severe Weather Forecasts
a. The forecaster will draw/save probability contours in NMAP2, and save the forecast in the same manner as for operational outlooks. The time period will default to 18-00z.

1) in the format outlook box, ***manually change the valid time if the time period is 21-03z or 00-06z***
2) in the product save box, ***manually change "outlook" to "prelim" or "final"***.

b. Enter command in xterm window: sp07bg STN prelim # or
sp07bg STN final #

(STN is the METAR centerpoint site ID and # is NAWIPS workstation number). This is necessary to archive the severe weather forecast, attach a date/time to the graphics file, and send the graphics to the web page.

Next, on the preliminary forecast online web pages (below the forecast graphic), the forecaster will answer three questions related to: 1) whether thunderstorms and severe thunderstorms are ongoing within or immediately upstream from the forecast area at the issuance time, 2) classifying the environment in terms of expected CAPE and shear during the afternoon, and 3) determining the usefulness of the WRF models in preparing the severe weather and supercell forecasts. Finally, a written forecast discussion similar to an operational outlook discussion is prepared that will include the role of the WRF output in the forecast process.

For the final forecast, the online page requests only information about the perceived value of the SSEF guidance in formulating the product, focusing on any changes that were made to the severe weather forecast.

Attachment C

Spring Experiment 2007
Next-Day Experimental Forecast Evaluation
(Web Based Form)

WELCOME TO THE HWT 2007 SPRING EXPERIMENT
PRODUCT GENERATION/EVALUATION
SELECT ONE OF THE FOLLOWING:

Next-Day Forecast Verification

Continue

I. Subjective Verification of Yesterday's Severe Weather Forecasts

Evaluation Team Names: NAME1/NAME2/NAME3/NAME4

Overall Rating of Preliminary Severe Weather Forecast: In NMAP2 window1 overlay the forecast with the vgf file of severe reports for the 6 hour valid period. In another window, display a loop of radar reflectivity and NWS county warnings that is used to supplement the severe report information. Rate the accuracy of the forecast on a scale from 0-10, with 0 being a very poor forecast, and 10 being a nearly perfect forecast. Since the forecast covers a regional domain, some forecast regions may be more accurate than others - formulate an overall rating by averaging the accuracy of different forecast areas when necessary. Areas with greater severe storm occurrence, higher forecast probabilities, and the forecast or occurrence of significant reports should be given more weight in the rating process.

If the severe weather forecast was not available, click on the checkbox labeled N/A.

Forecast rating: N/A 0 1 2 3 4 5 6 7 8 9 10

Add additional comments related to reasons for your rating - e.g., regions where the forecast was good, and where it was not. Include aspects of predicted and observed coverage, and any displacement errors that were factors in your rating, e.g., the primary axis of severe weather was east of the forecast location.

...DISCUSSION...

Overall Rating of Final Severe Weather Forecast: In NMAP2 window1 overlay the forecast with the vgf file of severe reports for the 6 hour valid period. In another window, display a loop of radar reflectivity and NWS county warnings that is used to supplement the severe report information. Rate the accuracy of the forecast on a scale from 0-10, with 0 being a very poor forecast, and 10 being a nearly perfect forecast. Since the forecast covers a regional domain, some forecast regions may be more accurate than others - formulate an overall rating by averaging the accuracy of different forecast areas when necessary. Areas with greater severe storm occurrence, higher forecast probabilities, and the forecast or occurrence of significant reports should be given more weight in the rating process.

If the final forecast was different from the preliminary forecast, determine if the changes resulted in a better forecast, worse forecast, or no change in perceived accuracy/usefulness to the product user. Make sure your rating reflects this relative comparison - for example, if the final forecast improved the preliminary forecast, the final forecast rating should be higher than the preliminary forecast rating.

If the severe weather forecast was not available, click on the checkbox labeled N/A.

Forecast rating: N/A 0 1 2 3 4 5 6 7 8 9 10

Add additional comments related to reasons for your rating -be sure to consider the rating of the final forecast relative to the preliminary forecast. If the final forecast showed changes from the preliminary forecast discuss the relative impact of the changes on forecast accuracy (e.g, did the changes help or hurt the forecast?

...DISCUSSION...

Submit

Attachment D

Spring Experiment 2007
Preliminary Experimental Forecast Generation
(Web Based Forms)

WELCOME TO THE HWT 2007 SPRING EXPERIMENT:
PRODUCT GENERATION/EVALUATION
SELECT ONE OF THE FOLLOWING:

Preliminary Day1 Forecast

Continue

FORECAST GRAPHICS:

TEXT DATA AND EVALUATION QUESTIONS:

A) Categorize the type of thunderstorms ongoing or immediately upstream from the forecast area at issuance time:

No thunderstorms Non-severe thunderstorms Severe thunderstorms

B) Classify the instability and vertical shear in the afternoon pre-convective environment associated with the primary area of expected severe storm activity.

MLCAPE (J/kg):	<1500	1500-3000	>=3000
0-6 km Bulk Shear (kt):	<30	30-39	>=40

C) Please evaluate the usefulness and perceived value of the convection-allowing WRF output in preparing the severe weather forecast, where 0 indicates not useful and 10 indicates very useful.

◉ N/A ○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

...DISCUSSION...

D) Write the daily forecast discussion in the space below. This is similar to operational outlook discussions but also include your use of convection-allowing WRF output as a part of the forecast process.

FORECAST DISCUSSION:

SPRING EXPERIMENT 2007 PRELIMINARY FORECAST dISCUSSION
DAY1 FORECAST

VALID

...SYNOPSIS...

...AREA 1...

...... 04/20/2007

Submit

Attachment E

Spring Experiment 2007
Final Experimental Forecast Generation
(Web Based Forms)

WELCOME TO THE HWT 2007 SPRING EXPERIMENT:
PRODUCT GENERATION/EVALUATION
SELECT ONE OF THE FOLLOWING:

Final Day1 Forecast

Continue

FORECAST GRAPHICS:

TEXT DATA AND EVALUATION QUESTIONS:

A) Categorize the type of thunderstorms ongoing or immediately upstream from the forecast area at issuance time:

No thunderstorms Non-severe thunderstorms Severe thunderstorms

B) Please evaluate the usefulness and perceived value of the convection-allowing **WRF ensemble output** in preparing the final severe weather forecast, where 0 indicates not useful and 10 indicates very useful. If specific fields and/or graphical displays were particularly useful, identify the displays and how they were used. Finally, indicate the changes, if any, that were made to the preliminary forecast.

N/A 0 1 2 3 4 5 6 7 8 9 10

...DISCUSSION...

Submit

Attachment F

Spring Experiment 2007
Sounding Analysis Evaluation Forms
(Web Based Forms)

WELCOME TO THE HWT 2007 SPRING EXPERIMENT:
PRODUCT GENERATION/EVALUATION
SELECT ONE OF THE FOLLOWING:

Sounding Analysis

Continue

Sounding Analysis

Model soundings from SSEF Control and PH3 forecasts (differing only in PBL parameterization) will be compared first. If time permits, similar comparisons from the WRF-ARW3 and WRF-NMM3 will follow.

NOTE: PFC = Point ForeCast sounding from model forecasts

General: Examine the evolution of convective activity and the pre-convective mesoscale environment in output from the selected models and in objective analyses of observations (SFCOA). Identify locations where PFC soundings are available and relevant to convective activity, based on the following priorities: 1) proximity/inflow to convective initiation, 2) proximity to a 00Z RAOB, 3) not contaminated by ongoing or recent deep convection.

Part I: 4 km SSEF-Control and SSEF-PH3 Sounding Comparisons

Identification of interesting/relevant RAOB and/or PFC locations for comparative evaluation of SSEF-Control and SSEF-PH3 forecast soundings in the pre-convective environment (using web-based sounding analysis program and/or NSHARP)

A) Examine 00Z RAOBs and corresponding 27h PFCs from SSEF-Control and SSEF-PH3 runs at selected RAOB sites within domain. Focus on locations where none is contaminated by convection. Select up to 2 interesting RAOB sites for subjective comparisons. Include a brief notation of the relevance of each RAOB site to the meteorological scenario (e.g., near dryline, near instability maximum, etc.) If no 00z RAOB sites are appropriate because of convective contamination, write N/A in site #1.

RAOB Site #1:

Relevance:

Qualitatively compare PFCs to RAOB, focusing on specific differences in 1) general thermodynamic structure, 2) general kinematic structure, 3) estimated PBL depth, and 4) PBL structure, T, Td, CAP strength.

SSEF-Control to RAOB #1:

...DISCUSSION...

SSEF-PH3 to RAOB #1:

...DISCUSSION...

RAOB Site #2:

Relevance:

Qualitatively compare PFC to RAOB, focusing on specific differences in 1) general thermodynamic structure, 2) general kinematic structure, 3) estimated PBL depth, and 4) PBL structure, T, Td, CAP strength.

SSEF-Control to RAOB #2:

...DISCUSSION...

SSEF-PH3 to RAOB #2:

...DISCUSSION...

B) Identify mesoscale areas where RAOBS are not available but comparison of PFCs from SSEF-Control and SSEF-PH3 runs would be of interest. Preferred locations include 1) close proximity to convective initiation, 2) along/just ahead of dryline, 3) along/just ahead of other significant boundary, and 4) in warm sector near maximum instability. Select up to 2 such locations for later subjective comparisons.

PFC Site #1:

Relevance:

Qualitatively compare the PFC from the SSEF-Control to the PFC from the SSEF-PH3,
focusing on specific differences in 1) general thermodynamic structure,
2) general kinematic structure, 3) estimated PBL depth, and 4) PBL structure, T, Td, CAP strength.

...DISCUSSION...

PFC Site #2:

Relevance:

...DISCUSSION...

Part II: WRF-ARW3 and WRF-NMM3 Sounding Comparisons (time permitting)

A) Examine 00Z RAOBs and corresponding 24h PFCs from WRF-ARW3 and WRF-NMM3 runs at selected RAOB sites within domain. Focus on locations where none is contaminated by convection. Select up to 2 interesting

RAOB sites for subjective comparisons. Include a brief notation of the relevance of each RAOB site to the meteorological scenario (e.g., near dryline, near instability maximum, etc.) If no 00z RAOB sites are appropriate because of convective contamination, write N/A in site #1.

RAOB Site #1:

Relevance:

Qualitatively compare PFCs to RAOB, focusing on specific differences in 1) general thermodynamic structure, 2) general kinematic structure, 3) estimated PBL depth, and 4) PBL structure, T, Td, CAP strength.

WRF-ARW3 to RAOB #1:

...DISCUSSION...

WRF-NMM3 to RAOB #1:

...DISCUSSION...

RAOB Site #2:

Relevance:

Qualitatively compare PFC to RAOB, focusing on specific differences in 1) general thermodynamic structure, 2) general kinematic structure, 3) estimated PBL depth, and 4) PBL structure, T, Td, CAP strength.

WRF-ARW3 to RAOB #2:

...DISCUSSION...

WRF-NMM3 to RAOB #2:

...DISCUSSION...

B) Identify mesoscale areas where RAOBS are not available but comparison of PFCs from WRF-ARW3 and WRF-NMM3 runs would be of interest. Preferred locations include 1) close proximity to convective initiation, 2) along/just ahead of dryline, 3) along/just ahead of other significant boundary, and 4) in warm sector near maximum instability. Select up to 2 such locations for later subjective comparisons.

PFC Site #1:

Relevance:

Qualitatively compare the PFC from the WRF-ARW3 to the PFC from the WRF-NMM3, focusing on specific differences in 1) general thermodynamic structure, 2) general kinematic structure, 3) estimated PBL depth, and 4) PBL structure, T, Td, CAP strength.

...DISCUSSION...

PFC Site #2:

Relevance:

...DISCUSSION...

Submit

Attachment G

Spring Experiment 2007
Deterministic WRF and SSEF Evaluation
(Web Based Forms)

WELCOME TO THE HWT 2007 SPRING EXPERIMENT:
PRODUCT GENERATION/EVALUATION
SELECT ONE OF THE FOLLOWING:

Next-Day Model Verification

Continue

I. Next-Day Model Verification: Deterministic WRFs and SSEF-Control Member

Instructions:
A) For each of the models listed below, provide a subjective assessment of the correspondence between observations and model forecasts of convective evolution. This assessment should be based on model simulated reflectivity forecasts compared to corresponding radar data.

Please refer to the scale below in completing your subjective evaluation:

0	5	10
No Correspondence	Moderate Correspondence	Excellent Correspondence

No Correspondence: Model missed primary features and/or erroneously predicted features that did not occur and would have provided very poor guidance to a severe weather forecaster.

Moderate Correspondence: Model captured some primary features and would have provided some useful guidance to a severe weather forecaster.

Excellent Correspondence: Model captured all important features, and would have provided excellent guidance to a severe weather forecaster.

Make sure that subjective numerical ratings are consistent in a relative sense. For example, if you believe that model A provided significantly more accurate and useful guidance than model B, make sure that model A has a higher rating than model B.

Evaluation Team Names: NAME1/NAME2/NAME3/NAME4

A) Description of Yesterday's Convective Evolution

Discuss the primary convective evolution that occurred during the valid time and domain of yesterday's forecast based on observed reflectivity, including initiation?.

How would you characterize the relevant convective initiation as depicted by observed radar?

Please choose one:

...DISCUSSION...

B) Evaluation of Convective Evolution

Convective evolution: How well did the model reflectivity forecast correspond to the mesoscale evolution of convection within the evaluation domain, including initiation, direction and speed of system movement, areal coverage, configuration and orientation of mesoscale features, and perceived convective mode?

WRF-NMM4:	N/A	0	1	2	3	4	5	6	7	8	9	10
WRF-NMM3:	N/A	0	1	2	3	4	5	6	7	8	9	10
WRF-NSSL4:	N/A	0	1	2	3	4	5	6	7	8	9	10
WRF-ARW3:	N/A	0	1	2	3	4	5	6	7	8	9	10
WRF-ARW2:	N/A	0	1	2	3	4	5	6	7	8	9	10
SSEF-Control:	N/A	0	1	2	3	4	5	6	7	8	9	10

...DISCUSSION...

C) Descriptive Assessment of Model Supercell Forecasts

For the models evaluated above for convective evolution, subjectively assess and comment on the correspondence between supercell observations and model forecasts of supercells. A numerical rating is not requested, as the ability to predict supercell storms is partially dependent on the evolution assessed in B. Information about observed supercells can be obtained from MDA output, radar reflectivity signatures, and severe reports. In particular, please discuss the relative frequency of storms with rotating updrafts from various models, and the perceived value of these fields to operational forecasters.

...DISCUSSION...

C) Overall Comparison between 21z models (SSEF-Control and ARW2) and 00z models (NMM4, NMM3, NSSL4, and ARW3).

After comparing reflectivity from models initialized at 21z and those initialized at 00z, comment on perceived differences in performance that might be related to initial conditions. For example, is there a subjective appearance of clustering between the 00z models forecasts and the 21z model forecasts?

...DISCUSSION...

II. Next-Day Model Verification: SSEF

Instructions:
A key focus of the experiment is to provide an initial evaluation of the ability of SSEF output to provide severe weather forecasters with quantitative information about the likelihood of severe thunderstorm and supercell occurrence. This includes probabilistic information about locations and timing of strong/severe convection as well as examination of various measures of the central tendency of the ensemble such as mean, median, and probability matching fields.

A) For each of the model fields listed below, provide a subjective assessment of the correspondence between model forecasts and observations of 1) convective evolution, 2) supercell thunderstorms, and 3) maximum surface winds. For SSEF fields, we are interested in the relative usefulness of different statistical outputs as well as the perceived utility of specific ensemble-based fields.

Convective Evolution:

Please refer to the scale below in completing your subjective evaluation:

0 5 10

No Correspondence   Moderate Correspondence   Excellent Correspondence

No Correspondence: Model field missed primary features and/or erroneously predicted features that did not occur and would have provided very poor guidance to a severe weather forecaster.

Moderate Correspondence: Model field captured some primary features and would have provided some useful guidance to a severe weather forecaster.

Excellent Correspondence: Model field captured all important features, and would have provided excellent guidance to a severe weather forecaster.

Make sure that subjective numerical ratings are consistent in a relative sense. For example, if you believe that field A provided significantly more accurate and useful guidance than field B, make sure that filed A has a higher rating than field B.

Evaluation Team Names: NAME1/NAME2/NAME3/NAME4

Convective evolution: How well did the following SSEF forecast fields provide useful information about the mesoscale evolution of convection within the evaluation domain, including initiation, direction and speed of system movement, areal coverage, intensity, and configuration and orientation of mesoscale features? Please note if a specific reflectivity exceedance threshold has more utility for predicting strong/severe thunderstorms, and if the probability values appear reliable in a statistical sense.

Prob. Match. Reflectivity	N/A	0	1	2	3	4	5	6	7	8	9	10
Refl. Exceedance Prob.	N/A	0	1	2	3	4	5	6	7	8	9	10

...DISCUSSION...

Supercell and Maximum Surface Wind Evaluation: How well did the SSEF exceedance probabilities of Updraft Helicity and Maximum Lowest Level Wind Speed correspond to observed supercell occurrence based on radar reflectivity/MDA output and severe wind reports, respectively? Please note if a specific exceedance threshold has more utility for predicting specific phenomena, and if the probability values appear reliable in a statistical sense.

UH Exceedance Prob.	N/A	0	1	2	3	4	5	6	7	8	9	10
Wind Exceedance Prob.	N/A	0	1	2	3	4	5	6	7	8	9	10

...DISCUSSION...

C) Other comments about SSEF

Please include other comments about the performance of the SSEF, such as perceived contribution to ensemble spread or perfromance from physics versus mixed ICs-physics members. Comments can be based on single field displays or multiple displays such as postage stamps.

...DISCUSSION...

Submit

Attachment H

Spring Experiment 2007
EnKF Surface Analysis Evaluation Forms

WELCOME TO THE HWT 2007 SPRING EXPERIMENT:
PRODUCT GENERATION/EVALUATION
SELECT ONE OF THE FOLLOWING:

Surface Analysis

Continue

Estimating mesoscale surface conditions by comparing NSSL Mesoscale EnKF Analysis and SPC hourly sfcoa fields.

Evaluation Team Names: NAME1/NAME2/NAME3/NAME4

Using knowledge of yesterday's convective development and evolution within the evaluation domain, determine the time of primary convective initiation. Evaluate hourly analyses of EnKF ensemble mean fields of surface temperature, surface dew point, and surface winds beginning at 18Z and continuing up to the time of initiation.

When evaluating surface fields also document important differences in *location or character of key boundaries* such as fronts, dry lines, and larger outflow boundaries when apparent (e.g., dry line too far east, EnKF temperature gradient is stronger along cold front). Also include in the assessment information about *time consistency of the fields from hour-to-hour.*

Part I:
Assessing differences in warm sector (undisturbed) thermodynamic fields.

A: From sfcoa identify the region of maximum CAPE in the undisturbed (no convection or pre-convection) environment. Examine the following fields in this region and assess EnKF ensemble mean fields **relative to corresponding SFCOA fields.**
(-5: Much lower, 0: About same, 5: Much higher than SFCOA, or N/A if the EnKF ensemble is not available.)

Temperature:
EnKF Mean -5 -4 -3 -2 -1 0 1 2 3 4 5 N/A

...DISCUSSION...

Dew Point:

EnKF Mean -5 -4 -3 -2 -1 0 1 2 3 4 5 N/A

...DISCUSSION...

Include any other comments about **potential operational utility** of the EnKF mean surface analyses

...DISCUSSION...

Submit

Attachment I

Spring Experiment 2007
Model Updraft Helicity (UH) and Supercell Detection Index (SDI)
Background and Formulation

A Brief Description of the Supercell Detection Index

Louis Wicker and Jack Kain, National Severe Storms Laboratory[1]
Steve Weiss and Dave Bright, Storm Prediction Center

The supercell detection index (hereafter, SDI) was devised to help forecasters in the 2005 NSSL-SPC spring forecast experiment with dealing with the large amount of information available from high resolution forecast models. Some participants in the program may not be familiar with the structures of modeled supercell from cloud-resolving simulations. SDI was developed to help identify storms within the model forecasts that have the dynamical character of supercells. SDI is based on the Doswell and Burgess (1993) that the primary dynamical property of a supercell updraft is a persistent, deep mesocyclone. We also use concepts from Droegemeier et al. (1993) that attempts to measure the "supercell-ness" of a storm by computing the correlation between the storm's updraft and vertical vorticity. We use their computational methodology here, with some slight modifications, to detect supercells within the storm-scale forecast model output.

We wish to measure two things. To measure the dynamical character, we compute a layer-averaged correlation between vertical velocity and vertical vorticity (which is the relative vorticity, excluding the earth's rotation and hereafter ζ). Second, we are trying to categorize the "significance" of the storm rotation by scaling the correlation coefficient by the local value of ζ. Therefore small values of the SDI mean low correlation and/or low values of ζ, high values indicate large correlation values ($r > 0.6$) of correlation and/or large values of ζ. Importantly, values of ζ are resolution dependent. From cloud modeling studies on a 2 km horizontal mesh significant values of ζ are ~ $|0.01\ s^{-1}|$.

The correlation coefficient is computed via Droegemeier et al. (1993),

$$\rho = \frac{\langle w'\zeta' \rangle}{\left(\langle w' \rangle^2 \langle \zeta' \rangle^2\right)^{1/2}} \tag{1}$$

This requires knowing what the mean values of w and are in some region in order to create the perturbations. Experimentation with cloud model output indicates that choosing a local 3-D "slab" centered on the grid point that is 20 km on each side and 4 km deep yields an acceptable parameter. The calculation is centered on z = 3.5 km in the vertical. The mean of w and ζ is computed from the series of points, perturbations calculated, and then the correlation is obtained from (1). The final calculation is obtained via,

$$SDI^1{}_{i,j} = \left[\frac{\langle w'\zeta' \rangle}{\left(\langle w' \rangle^2 \langle \zeta' \rangle^2\right)^{1/2}}\right]_{i,j} \times \ \bar{\zeta}_{i,j} \tag{2}$$

The overbar on ζ indicates a vertical average in the column centered on the point. Rough estimates from the cloud model tests are that a minimal threshold for supercells is ~ $|0.0003\ s^{-1}|$, and that values greater than $|0.003\ s^{-1}|$ are significant. This quantity, called $\mathbf{SDI^1}$ actually indicates regions of updraft and downdraft (given by the sign of $\mathbf{SDI^1}$) because the quantity is scaled by ζ, which is of the same sign as the mean value of ζ in the 3D slab. Therefore regions of updraft correlated with either positive or negative ζ show positive, and regions of downdraft correlated with either positive or negative ζ show as negative.

To help highlight regions of rotating updrafts, it was decided to generate a second SDI field computed only where there is updraft. This second index, $\mathbf{SDI^2}$ is computed in a similar manner as $\mathbf{SDI^1}$ except that it is only non-zero in regions where $w > 0$, and it is scaled by the magnitude of ζ. This means that regions of positive $\mathbf{SDI^2}$ are regions of cyclonic updrafts, and regions of negative $\mathbf{SDI^2}$ are regions of anticyclonic updrafts.

[1] Dave Dowell and Kim Elmore also contributed to this work.

Updraft Helicity

1. Storm Relative Environmental Helicity

Helicity, H, is a scalar measure of the potential for helical flow (i.e., the pattern of a corkscrew) to develop in a moving fluid defined by

$$H = \vec{V} \bullet \nabla \times \vec{V} \, . \qquad (1)$$

Expressed in its component form,

$$H = u(\frac{\partial w}{\partial y} - \frac{\partial v}{\partial z}) + v(\frac{\partial u}{\partial z} - \frac{\partial w}{\partial x}) + w(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}) \, . \qquad (2)$$

The portion of helicity associated with the *storm relative streamwise component* is that along the ambient horizontal velocity vector, or

$$H_s = -(u - c_u)(\frac{\partial v}{\partial z}) + (v - c_v)(\frac{\partial u}{\partial z}) \, , \qquad (3)$$

where $\vec{c} = c_u + c_v$ is the storm motion and terms involving w neglected. Integrating H_s vertically through the thunderstorm inflow layer, z, yields the *storm relative environmental helicity*, SREH,

$$SREH = -\int_{z_o}^{z} [(u - c_u)(\frac{\partial v}{\partial z}) - (v - c_v)(\frac{\partial u}{\partial z})] dz \, . \qquad (4)$$

SREH is a commonly used parameter to assess the severe thunderstorm potential of the environment and is often integrated from the surface to 1 - 3 km AGL. Order of magnitude values of SREH are ~ O(50) to O(300) m^2/s^2 in environments that tornadic storms.

2. Updraft Helicity

With the availability of numerical models containing sufficient resolution to resolve convective processes explicitly, it is now possible to calculate a *vertical component of helicity* associated with the convective updraft. This is the vertical integral of the third term in equation (2) and referred to as *updraft helicity*, U_H. Thus,

$$U_H = \int_{z_o}^{z} [w(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y})] dz = \int_{z_o}^{z} [w\zeta] dz \qquad (5)$$

where ζ is the vertical component of the relative vorticity at grid points where w > 0. In post processing the WRF members for the SPC/NSSL Spring Program, equation (5) is integrated vertically from z_o = 2 km to z = 5 km AGL using a midpoint approximation. Data are available every 1000 meters AGL, so equation (5) is computed as

$$U_H = \int_{z_o}^{z} [w\zeta] dz \approx \sum_{z=2000m}^{z=5000m} (\overline{w\zeta}\Delta Z) = (\overline{w\zeta}_{2,3} + \overline{w\zeta}_{3,4} + \overline{w\zeta}_{4,5}) \times 1000 \, , \qquad (6)$$

where the over bar indicates a layer average and the subscripts indicate the bottom and top of the layer in kilometers. Early experience indicates that typical values of U_H associated with WRF predicted supercell thunderstorms are have U_H of at least ~O (50) m^2/s^2 and that significant supercells have U_H ~O (150) m^2/s^2.

Attachment J

Spring Experiment 2007
Model Configuration Change Guidelines

Experimental Model Configuration Change Guidelines

1. Introduction

The NOAA Hazardous Weather Testbed 2007 Spring Experiment will focus on the evaluation of several high-resolution WRF-model deterministic and ensemble systems during the peak severe convective weather season. Because these systems are experimental, it is inevitable that they will have deficiencies, and some of these deficiencies are likely to be revealed during the program. Yet, it is important to realize that are compelling reasons to "freeze" model and ensemble configurations at the start of the experiment. These reasons are highlighted below in the context of the the multi-agency scientific and operational forecasting goals of the experiment.

a) Research scientists are interested in understanding the behavior characteristics of a high resolution ensemble system and the physical parameterizations that provide diversity within the system. In both of these areas, detection of systematic biases is favored by the largest possible sample size. Changes in model configuration during the relatively short Spring Experiment would reduce the sample size, jeopardizing the detection of systematic errors and biases while making other statistical analyses less meaningful.

b) Model developers would also like to test stable configurations containing very few if any coding errors, but occasionally major coding errors are discovered during a testing period. If such errors are serious enough to invalidate results, model developers are encouraged to correct the errors and notify experiment coordinators. With less serious errors, such as non-optimal parameter settings, developers are encouraged to **make no changes**. If changes are made, they must be documented to preserve the integrity of the experiment

c) Forecasters are most interested in the potential utility of the experimental models and ensemble systems to provide improved guidance for operational forecasting. They also prefer a stable configuration during the experiment in order to test a consistent formulation over a variety of weather regimes and synoptic/mesoscale situations. However, if a major coding bug is present that seriously degrades model performance, forecasters would favor having the error fixed to improve model performance so a more meaningful evaluation can be conducted.

2. Guidelines

Since all participants benefit when the models are unchanged during the experiment, model contributors are asked to conduct thorough tests prior to the start of the Spring Experiment in order to increase the likelihood that their model can be run in a stable configuration throughout the Program. However**, if a major coding error that substantially affects forecasts is discovered during the Experiment, the developer will be encouraged to fix the code as soon as possible. Note that any model changes after the start of the Program should be limited to fixing major errors in code; changes should not be made to incrementally "fine tune" parameterizations or other physical processes, nor will major model upgrades occur during the testing period.**

We hope that these guidelines will offer a reasonable solution that allows all participants to satisfy many of their goals. We thank all contributors for their efforts to abide by these guidelines.