NOAA HAZARDOUS WEATHER TESTBED

SPC/NSSL SPRING PROGRAM 2005

http://www.spc.noaa.gov/exper/Spring_2005
SPC/NSSL Science Support Area
18 April - 3 June 2005

Program Overview and Operations Plan

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I. The NOAA Hazardous Weather Testbed

NOAA's Hazardous Weather Testbed (HWT) in Norman, OK transitions promising new meteorological insights and technologies into advances in forecasting hazardous mesoscale weather events. This is accomplished via a disciplined synergy between operations and research that is focused on real-time forecasting and evaluation activities conducted during active severe weather events.

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

II. Historical Perspective

Co-location of the Storm Prediction Center (SPC) with the National Severe Storms Laboratory (NSSL) and other agencies in the Norman, OK Weather Center has facilitated considerable interaction and collaboration on a variety of experimental forecast and other operationally relevant research programs. A wide cross section of local and visiting forecasters and researchers has participated in a number of 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 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 speeding up the transfer of new technology and research ideas into forecast operations at the SPC, and sharing new techniques, skills, and results of applied research more freely. Typical issues addressed in these activities include, but are not limited to: optimizing use of vast 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.

During the climatologically most active severe weather periods each spring, collaborative forecasting experiments known as the Spring Program have occurred since 2000.

Details about earlier Spring Programs 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

This document 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 2005 Spring Program.

III. Program 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 severe thunderstorms and tornadoes is a critical responsibility at the Storm Prediction Center (SPC) and the National Severe Storms Laboratory (NSSL).

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 and Day 3 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. Issuance of experimental severe weather outlooks covering the day 4-8 period began in late 2004. 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 near-term 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, synthesizing 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 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. Accordingly, over the last several 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. In recent years, it has become especially evident 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 forming in 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 – 7 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 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. One hypothesis suggests that it may be possible to reduce this forecasting uncertainty through the use of new numerical models. In particular, it has been demonstrated over the last two years that near-cloud resolving configurations of the Weather Research and Forecasting (WRF) model have generated convective storms that, at times, appear remarkably similar to actual storms. Consequently, it is important to further explore daily forecasts from the WRF model to assess its skill level in predicting important characteristics of the evolution of the pre-convective environment, and to determine if information from the new WRF model can help us more confidently predict not only when and where convection will develop, but also provide details about convective intensity, evolution and mode that are typically not evident from current operational modeling systems.

Through partnerships with the National Centers for Environmental Prediction Environmental Modeling Center (NCEP-EMC), the National Center for Atmospheric Research (NCAR), and the University of Oklahoma Center for Analysis and Prediction of Storms (OU—CAPS), the experiment will focus on three versions of the WRF model during Spring Program 2005: 1) the Advanced Research WRF (ARW) from NCAR with 4 km grid length, or WRF-ARW4, 2) the ARW from CAPS (run at Pittsburgh Supercomputing Center) with 2 km grid length, or WRF-ARW2, and 3) the Non-hydrostatic Mesoscale Model (NMM) WRF from EMC with 4.5 km grid length, or WRF-NMM4. The ARW4 and NMM4 domains cover the eastern three-fourths of the contiguous United States, whereas the ARW2 domain covers about two-thirds of the U. S. (Fig. 1). Each WRF will start at 00 UTC using initial fields from the 00 UTC operational NAM model, producing a 30 hour (ARW2) or 36 hour (ARW4, NMM4) forecast. More information about the WRF configurations is found in Table 1. Guidelines for experimental model configuration changes during the program are found in Attachment I.

	WRF-NMM4	**WRF-ARW4**	**WRF-ARW2**
Horiz. Grid Spacing (km)	4.5	4.0	2.0
Vertical Levels	35	35	51
PBL/Turb. Param.	MYJ	YSU	YSU
Microphysical Param.	Ferrier	WSM6	WSM6
Radiation Param. (SW/LW)	GFDL/GFDL	Dudhia/RRTM	Dudhia/RRTM
Initial Conditions	32 km NAM	40 km NAM	40 km NAM

Table 1: Model configurations used for the high resolution forecasts runs, daily at 0000 UTC. MYJ: Mellor-Yamada-Janjic (Janjic 2001); YSU: Yonsei University (Noh et al. 2003); Ferrier: Ferrier et al. (2002); WSM6: WRF single moment, 6 class microphysics; GFDL: Geophysical Fluid Dynamics Laboratory (Tuleya 1994); Dudhia: Dudhia (1989); RRTM: Rapid Radiative Transfer Model (Mlawer et al. 1997; Iacono et al. 2000).

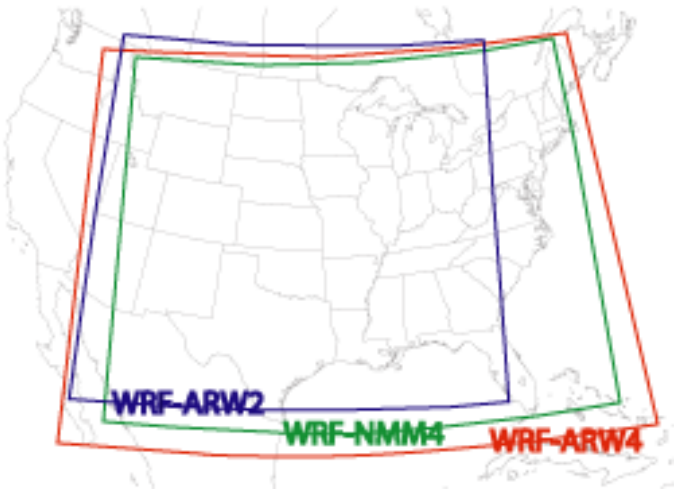

Figure 1: Geographic domains of high-resolution WRF models.

The use of different WRF configurations allows us to explore the impact of different model numerics, physics packages and grid resolution on model predictions, and to better test the high performance computing and communications resources required to produce large domain model guidance at 2-4 km grid spacing in a simulated operational setting. A key component of the program is the participation of operational SPC forecasters, whose insights and experience provide a real-world severe weather forecasting perspective when assessing the usefulness of high resolution WRF models, and the resultant likelihood that output from these models will result in improved severe weather forecasts. Their interactions with other forecasters, 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.

We will also examine output from three mesoscale WRF models with 8-10 km grid length and parameterized convection and compare their ability to predict short-term precipitation areas associated with severe convection with corresponding radar reflectivity patterns. Two of the three mesoscale WRF models, the WRF-NMM8 and WRF-ARW10, will form the basis of a six member short-range ensemble (SREF) system scheduled for operational implementation this summer. The third mesoscale WRF uses a mix of NMM and Global Forecast System (GFS) physics. These models are run once daily at 12 UTC over a central U.S. domain (Fig. 2), nested within a larger North American domain. Configurations of these mesoscale WRF models are found in Table 2. These models will arrive too late to be incorporated into the experimental forecast component, but they will be part of the next day model evaluation activities.

	WRF-NMM8	**WRF-ARW10**	**WRF-GFS8**
Horiz. Grid Spacing (km)	8	10	8
Vertical Levels	60	50	60
Convective Param.	BMJ	KF	SAS
PBL/Turb. Param.	MYJ	YSU	MRF
Microphysical Param.	Ferrier	Ferrier	Ferrier
Radiation Param. (SW/LW)	GFDL/GFDL	Dudhia/RRTM	GFDL/GFDL
Initial Conditions	40 km NAM	40 km NAM	32 km NAM

Table 2: Model configurations used for the mesoscale WRF forecasts, run daily at 1200 UTC by EMC. BMJ: Betts-Miller-Janjic 1994, Baldwin et al. 2002); KF: Kain-Fritsch: (Kain 2004); SAS: Simplified Arakawa-Schubert (Pan and Wu 1995); MRF: Medium Range Forecast non-local diffusion scheme (Hong and Pan 1996)

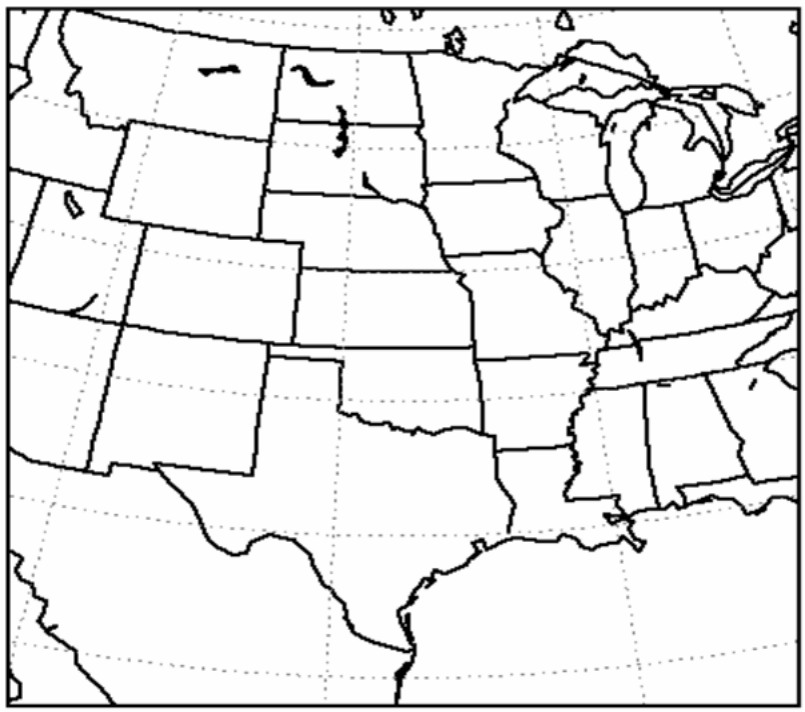

Figure 2: Geographic domain of mesoscale WRF models.

The primary objectives of Spring Program 2005 are to:

- Assess the utility of near-cloud resolving WRF models to provide more detailed and useful guidance to forecasters on environmental conditions and subsequent thunderstorm development and evolution
- Evaluate the ability of new methods to identify WRF model predicted supercell thunderstorms and determine the correspondence between model supercells and observed supercells
- Identify specific WRF applications most suitable for transfer to SPC operations
- Provide focused feedback to model developers on the performance of the experimental WRF models during severe thunderstorm episodes.

The program expected outcomes include:

- Documentation of the relative operational forecasting utility of current formulations of high-resolution 4km (both NCAR ARW & EMC NMM) WRF compared to ultra-high resolution (2km) WRF forecasts, especially related to severe thunderstorm prediction.
- Documentation of the importance of current formulations of high resolution WRF information relative to current deterministic NWP and short-range ensemble guidance.
- Documentation of the complimentary relationship between SREF and high resolution deterministic NWP in quantifying uncertainty in severe weather forecasts.
- Internal NWS documentation of challenges to the real-time display and utilization of ultra-high resolution NWP output in an operational forecast environment.
- Continued effective collaboration between researchers, modelers and forecasters 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.

IV. Program Focus Areas

Spring Program 2005 will have eight (8) focus areas:

1. Examine the ability of the near-cloud resolving WRF models to accurately predict primary pre-convective low level boundaries (e.g., fronts, drylines, larger-scale outflow boundaries) by comparing the predictions with corresponding observed boundaries.

2. Examine the relationship between pre-existing low level boundaries and the location of subsequent convective development in both WRF model forecasts and the real atmosphere.

3. Examine the ability of the near-cloud resolving WRF models to predict basic environmental fields of surface temperature, surface dewpoint, and surface-based CAPE prior to and during severe thunderstorm episodes by comparing model output to corresponding observed fields. This will focus on areas near boundaries and within the primary warm sector.

4. Determine the 4-D evolution of WRF model environment by examining model soundings near boundaries and in the warm sector, focusing on low level thermal, moisture and wind profiles, lapse rates, and CIN layers. At selected radiosonde sites, subjectively and objectively compare model soundings with observed soundings to determine vertical difference fields of basic parameters (temperature, dewpoint, wind) and key derived thermodynamic and kinematic parameters.

5. Using simulated instantaneous reflectivity fields from the WRF model, compare the initiation and evolution of model generated thunderstorms with actual storms as seen by observed radar reflectivity.

6. Evaluate the ability of new diagnostic methods to identify supercell thunderstorms in near-cloud resolving WRF model output, and determine the correspondence between model- predicted supercells and observed supercells.

7. Examine 1-hour precipitation output from three mesoscale WRF models and compare the implied thunderstorm evolution with 1-hour radar reflectivity fields.

8. Determine if operational severe weather forecasters find added utility and value in near-cloud resolving WRF models producing more detailed convective structures, including model generated supercells, when used in conjunction with output from operational mesoscale and SREF modeling systems.

V. Spring Program 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 Program web site:

http://www.spc.noaa.gov/exper/Spring_2005

This web site will be fully operational by 23 April 2005. The site is intended to support real time activities as well as additional research and reference after the conclusion of the program.

VI. Dates and Participants

Spring Program 2005 will run Monday-Friday 8 am – 4 pm from 18 April through 3 June 2005. During the first week, final spin-up activities will be tested with in-house participants only. Beginning April 25, 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 Science Support Area (SSA) located adjacent to the SPC Operations area. The full time forecast team will complete daily experimental forecasts and participate in evaluation and verification activities. Staffing typically will include one SPC forecaster, one NSSL scientist and a number of visiting scientists, model developers, forecasters, and university faculty. Visitors come from a variety of locations, including NCEP-Environmental Modeling Center, NCEP-Hydrometeorological Prediction Center, forecasters from NWS Central, Southern, and Western Regions, NWS Headquarters, NOAA-Forecast Systems Laboratory, NOAA-National Environmental Data and Satellite Service, NASA-Marshall Space Flight Center, National Center for Atmospheric Research, CIMMS/University of Oklahoma, University at Albany-SUNY, University of Nebraska-Lincoln, Millersville University, Lyndon State College, St. Louis University, Purdue University, North Carolina State University, UCLA, University of Miami, CIRA-Colorado State University, University of North Carolina-Charlotte, Meteorological Service of Canada, National Administration of Meteorology-Romania, and private industry. ***Visiting participants are invited to present a seminar related to Spring Program goals; interested visitors should contact Steven Weiss (steven.j.weiss@noaa.gov).***

A brief orientation/training session will be provided to all participants on the morning of their first scheduled shift. **A schedule of participants is provided in Attachment A.**

VII. Daily Operations Schedule

SPC, NSSL, and visiting staff will create forecast products, conduct evaluation activities and participate in a daily map discussion in the Science Support Area from 8 am - 4 pm on Monday-Friday. Occasional seminars by visiting scientists will be scheduled to occur at 4 pm in the NSSL Conference Room upon completion of daily program 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. Here is an outline of the daily schedule for activities during the Spring Program:

Monday-Friday:

7:30 a.m.	- 8:00 a.m.	- Orientation (Monday only)
8:00 a.m.	- 8:30 a.m.	- Complete online forms for subjective verification of yesterday's experimental severe weather forecast and supercell forecast
8:30 a.m.	- 8:45 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 - Create WRF-ARW2 domain for grid display in NAWIPS
8:45 a.m.	- 11:00 a.m.	- Using traditional analysis techniques and assessment of deterministic, SREF, and WRF models, prepare and issue daily graphical severe weather forecasts
11:00 a.m.	- 11:30 a.m.	- Break into forecast, sounding analysis, and surface analysis teams. - Forecast team will complete online discussion form for today's forecast. - Sounding and surface teams conduct initial analysis of yesterday's forecast domain and complete initial online analysis forms
11:30 a.m.	- 11:45 a.m.	- Sounding and analysis teams provide briefing of initial findings in preparation for more in-depth afternoon evaluations
11:45 a.m.	- 12:45 p.m.	- Lunch, informal exploration and discussions
12:45 p.m.	- 1:00 p.m.	- Forecast team provides briefing of today's forecast (SPC/NSSL Map Discussion)
1:00 p.m.	- 2:15 p.m.	- - Forecast team members move to sounding analysis and surface analysis teams - Sounding and surface teams work collaboratively to conduct more thorough examination of WRF environment forecasts for yesterday's domain and complete online forms
2:15 p.m.	- 2:30 p.m.	- Sounding and surface teams provide short briefing of results, findings, and their documentation
2:30 p.m.	- 3:30 p.m.	- All members evaluate HiRes WRF model reflectivity and supercell forecasts and complete online evaluation forms
3:30 p.m.	- 4:00 p.m.	- All members evaluate mesoscale WRF and WRF-NMM4 model precipitation forecasts and complete online evaluation forms

VIII. 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.)* 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 experimental near-cloud resolving WRF model output, which will be used to supplement operational mesoscale model guidance from the NAM, RUC, and SREF systems.

The severe weather forecasts will be formulated by 11 am CDT with online discussion forms completed by 11:30 am CDT. It is expected that the forecasters will need to make their primary decisions no later than 10:40 am CDT in order to complete forecast graphics by 11:00 am CDT. The forecast products will consist of a "standard forecast" and a "supercell forecast":

> The *standard forecast* will be similar to operational severe weather outlooks. It 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 *supercell forecast* will be a separate graphic that delineates the probability of supercell thunderstorms.

The severe weather probability contours for the severe storm and supercell forecasts will be chosen from the same contour values as used in SPC operational severe outlooks: 5, 15, 25, 35, and 45%. These represent the coverage of expected severe weather or supercells, 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 supercell forecasts will be evaluated by comparing the forecast with observed rotational tracks from the Warning Decision Support System-Integrated Information (WDSS-II) multi-radar analysis system, and from multi-radar output from the WSR-88D Mesocyclone Detection Algorithm (MDA).

The use of near-cloud resolving WRF model output allows us to explore our ability to predict more organized convective scale structures such as supercell thunderstorms. 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 models can provide forecasters with useful information about the timing, location, coverage, and longevity of supercell storms. This will be examined by issuing experimental supercell forecasts as part of the forecast component.

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 forecast documentation forms, 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, 3) assess the operational usefulness of the near-cloud resolving WRF guidance, and 4) 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.

Instructions for creation of the experimental forecast product are in Attachments B and C.

IX. Evaluation and Verification Activities

A. Morning Forecast Evaluation

Every morning, evaluation of the severe weather forecast and supercell forecast 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 forecast and supercell forecast 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 is 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 provides 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 Program, as we view these two methods as being complementary.

The experimental supercell forecasts are subjectively compared with rotational track output from WDSS-II showing location of actual supercells, and displays of radar reflectivity overlaid with locations of mesocyclones from the WSR-88D Mesocyclone Detection Algorithm (MDA). Again, it is important to evaluate the supercell forecast using the following criteria: 1) how well it delineated

regions where supercells reports occurred (spatial accuracy), and 2) how well it exhibited a sense of reliability (more supercells occurred in regions with higher probabilities).

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

B. Late Morning and Afternoon Model Evaluation

During the late morning and afternoon, the three near-cloud resolving WRF model forecasts valid for the previous day are evaluated to assess the accuracy of: 1) predicted environmental conditions using selected surface fields and forecast soundings, and 2) predicted storm initiation and evolution as seen in simulated reflectivity fields and diagnostic supercell indicators. The subjective assessment will include the following 00z models: ARW4, ARW2, and NMM4.

The verification domain will be identical to the forecast domain selected for the previous day. Assessment of the environmental conditions will focus on regions 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 focus regions. Separate surface analysis and sounding teams will be set up daily in the late morning to simultaneously examine selected surface conditions (such as boundaries, temperature, dewpoint, and SBCAPE) and sounding structures predicted by the WRF models. Although the two teams will conduct their work at separate NAWIPS workstations (surface analysis team at the northeast corner workstation and sounding analysis team at southeast corner workstation), they will need to share information during the evaluations to ensure there is agreement on which boundaries and locations are studied. The pre-lunch initial analysis will define the focus areas for the in-depth afternoon evaluations.

Surface Analysis Evaluation

The surface analysis team will assess the accuracy and relative characteristics of WRF forecasts of low level thermodynamic properties and boundary locations by comparing model forecasts 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. A web page containing time-matched images of WRF forecasts and verifying data is expected to provide much of the information needed for the surface analysis portion of the evaluation, and is found at:

http://www.spc.noaa.gov/exper/Spring_2005/archive/

Visual comparison of fields and objectively computed grid differences available in NMAP will also be used in the assessment process.

The presence of persistent low-level convergence along many boundaries has long been thought to provide a focus for subsequent thunderstorm development, and helps explains why SPC forecasters spend time identifying boundaries in their routine analysis activities. However, it is not clear how often severe thunderstorms develop near large-scale, identifiable pre-existing boundaries, and whether this conceptual model of thunderstorm development can be successfully applied to convective initiation in near-cloud resolving WRF models. Accordingly, the surface analysis team will identify key boundaries from the previous day, compare the location of model boundaries with observed boundaries, and determine the degree of association, if any, between pre-existing boundaries and subsequent primary convective development. In addition, in the pre-convective undisturbed warm sector, predicted environmental characteristics of temperature, dewpoint, SBCAPE, 0-6 km AGL shear, and 0-3 km AGL storm-relative helicity will be compared with

corresponding sfcoa fields. This will allow determination of the accuracy of model forecasts of basic severe weather ingredients.

Sounding Analysis Evaluation

The sounding analysis team will assess the accuracy of model forecast soundings by comparing model point soundings with co-located verifying radiosondes at 12 and 00 UTC.

A web page containing time-matched images of WRF forecast soundings and observed raobs, vertical difference profiles for temperature, dewpoint, and wind, and listings of many derived convective parameters from model and observed soundings is found at:

http://www.spc.noaa.gov/exper/Spring_2005/sndgcomp/

Although the density of RAOB sites is far from optimal, several 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. A web-based program has been developed that will automatically overlay model and observed soundings, showing vertical difference displays of temperature, dewpoint, and wind speed, and listing difference fields of a variety of key convective parameters. Similar comparisons between the ARW4 and NMM4 model soundings at key 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 two WRF configurations.

Convective Initiation, Evolution and Supercell Evaluation

A promising aspect of the near-cloud resolving WRF models is their ability to provide more detailed information about convective structure compared to current mesoscale models. A primary goal is to determine the ability of the high resolution WRF simulated reflectivity forecasts to provide useful guidance to severe weather forecasters interested 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, one part of the model convection evaluation will consist of subjective comparisons of model predicted simulated reflectivity with corresponding radar reflectivity within the forecast domain, focusing on specific topics of initiation of the previous day’s primary storms, and the mesoscale evolution of convection during the forecast period, encompassing 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 the specific convective mode 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 observed rotational track information from the WDSS-II system, and with mesocyclone information from the WSR-88D Mesocyclone Detection Algorithm (MDA) to subjectively assess the correspondence between model- predicted supercells and radar detected supercells. **See Attachment H for information about supercell detection approaches used with the WRF model output.**

Finally, we will examine convective evolution using 1-hour precipitation fields from the three mesoscale WRF models (NMM8, GFS8, and ARW10) and subjectively comparing these forecasts with corresponding 1-hr radar reflectivity. As a benchmark, we will also include 1-hour precipitation from the NMM4 in this evaluation. Precipitation forecasts are used from the mesoscale WRF models in this evaluation because the combination of parameterized convection and relatively coarse grid resolution make it difficult to produce realistic simulated reflectivity. The intent is not to perform a QPF verification, because storm severity is not necessarily correlated with precipitation amounts. It has been shown that subjective verification of mesoscale model precipitation fields provides important information about human perception of model performance, since traditional measures such as Equitable Threat Score can provide misleading information when small scale features are considered.

See Attachments E, F, and G for more information about the model forecast verification forms for Sounding Analysis, Surface Analysis, and High Resolution WRF Convection Initiation/ Evolution and Mesoscale WRF Convective Evolution, respectively.

X. Daily Forecast Briefing

A brief daily forecast summary is held from 12:45-1:00 pm to summarize the Spring Program forecasting activities, and to highlight contributions of the WRF models in the experimental forecasting process. The discussion will typically be lead by the SPC forecaster with other comments by program participants as times allows. The map discussion is scheduled to end promptly at 1:00 pm, in order for team members to have sufficient time to conduct important model verification activities during the remainder of the afternoon.

XI. 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, all participants are asked to read the operations plan prior to their first day in the SSA.

The forecast team will be made up of 5-7 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 WRF 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 computer equipment, data flow, and SPC-style severe weather forecasting, 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, and we will all be interested to see how the experimental WRF output is utilized as the forecasts are created.

While it is recommended the entire forecast team work together and interact on morning forecast issuance and evaluation activities, we will subsequently break into smaller groups to conduct the WRF surface and sounding evaluations during the late morning and first part of the afternoon. Participants will alternate between the two groups during the course of the week so everyone has an opportunity to explore different aspects of WRF model performance. During the afternoon activities, the SPC forecaster and NSSL scientist will be asked to primarily control the display of graphics in the NAWIPS workstations as they are most familiar with their operation. During the latter half of the afternoon, participants will again work together as a large group to conduct the model reflectivity evaluations. Short-term visitors are invited to participate in the forecast and evaluation activities and provide insight as their time and interests permit.

XII. Experimental Displays and Model Data

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

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

12km/80km Operational NAM Model (12, 18, 00, 06z)
12km/40km Operational NAM Model (12, 18, 00, 06z)
12km/12km Operational NAM Model (12, 00z)
20km/40km Operational RUC Model (Hourly)
32km/40km EMC SREF-EtaKF Control Run (09, 21z)
32-38km/40km EMC SREF (Eta/RSM/EtaKF) (09, 21z)
8 km/8 km WRF-NMM8 (EMC-12z; central U.S. domain)
10 km/10 km WRF-ARW10 (EMC-12z: central U.S. domain)
8km/8km WRF-GFS8 (EMC12z; central U.S. domain)
2 km/2 km WRF-ARW2 (CAPS-00z)
4 km/4 km WRF-ARW4 (NCAR-00z)
4.5 km/4.5 km WRF-NMM4 (EMC-00z)

* Italicized fields are experimental data not typically available to SPC forecasters *

XIII. Operations Center Hardware and Software

Spring Program forecast and evaluation exercises will take place in the Science Support Area (SSA), immediately adjacent to SPC operational forecast area. Equipment available to spring program participants includes:

1. Four dual monitor Linux Workstations running NAWIPS with Netscape available for Internet access
2. Three single monitor PCs with Windows XP applications (Internet, e-mail, etc.)
3. Automated Report Logging System (ARLS) for real time visual and audible alerts of any convective watches or warnings (or issuance of SPC operational products).
4. Raised monitors (including 42 inch plasma screen) to show images for group discussions and daily forecast briefing.
5. National Lightning Data Network display (for CG lightning info)
6. Two laser printers for color and b/w hard copy output.

XIV. Data Archive

Two special online web pages will contain selected images from WRF model fields and corresponding observational fields from mosaic radar reflectivity and objectively analyzed surface and upper air fields.

1) Daily hourly loops will contain data from 15-09 UTC from each program day 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

These loops are found at http://www.spc.noaa.gov/exper/Spring_2005/archive/

2) Observed radiosondes and corresponding 00, 12, and 24 hour WRF model forecast soundings for all radiosonde sites within each model domain, including sounding overlays, vertical difference plots of temperature, dewpoint, and windspeed, and listings of convective parameters from radiosondes, model soundings, and difference fields is found at http://www.spc.noaa.gov/exper/Spring_2005/sndgcomp/

Both sites are linked to the main Spring Program page.

3) The following special Spring Program grib 2-D data files from the ARW2, ARW4, and NMM4 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
1 km equivalent Reflectivity
4 km equivalent Reflectivity
vertical composite equivalent Reflectivity
SB CAPE
SB CIN
SB LCL
MU CAPE
MU CIN
0-6 km shear
0-1 km shear
0-3 km helicity
0-1 km helicity
Surface sensible heat flux (SHTFL)
Surface latent heat flux (LHTFL)
Ground heat flux (GFLUX)
Ground temperature (TSOIL)
Downward solar radiation flux (DSWRF)
Downward long wave radiation flux (DLWRF)
Upward solar radiation flux (USWRF)
Upward long wave radiation flux (ULWRF)

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

geopotential height (HGT)
temperature (TMP)
specific humidity (SPFH)
vertical velocity (W)
wind (UGRD)
wind (VGRD)

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

4) These special datasets are complimented by the routine SPC 45-day “sparse” data archive

a) Observations: hourly sfc obs, lightning, profiler, raws, ship, upper air, vad, watch/warn products
b) RUC data: hourly point forecasts, ruc2a, sfcOA
c) Images: 5-minute national BREF radar, hourly visible satellite, GOES-10 and GOES-12 IR/WV (GOES-10/12 saved every three hours)

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XVI. Acknowledgments

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Attachment A

Spring Program 2005
Participant Schedule
(4/21/05)

OPERATIONS SCHEDULE FOR SPC/NSSL SPRING PROGRAM 2005
18 APRIL - 3 JUNE 2005

ALL SHIFTS MON-FRI WILL BE FROM 8AM-4PM. SCHEDULES MAY BE CHANGED OR TRADED THROUGH INDIVIDUAL AGREEMENT **AND** COORDINATION WITH STEVEN WEISS (x705) OR JACK KAIN (x776).

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.

Updates to this document are available at: http://www.spc.noaa.gov/exper/Spring_2005/

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

MON*	**TUE***	**WED***	**THU***	**FRI***
4/18	**4/19**	**4/20**	**4/21**	**4/22**
Weiss	Weiss	Weiss	Weiss	Weiss
Kain	Kain	Kain	Kain	Kain
Goss	Goss	Goss	Goss	Goss
Burgess	Burgess	Burgess	Burgess	Burgess
Dowell	Dowell	Wicker	Wicker	Wicker

Week 1

MON	**TUE**	**WED**	**THU**	**FRI**
4/25	**4/26**	**4/27**	**4/28**	**4/29**
Dial	Dial	Dial	Dial	Dial
Brooks	Brooks	Brooks	Brooks	Brooks
Foster	Foster	Foster	Foster	Foster
Dudhia	Dudhia	Dudhia	Dudhia	Dudhia
Seaman	Seaman	Seaman	Seaman	Seaman
Shaw	Shaw	Shaw	Shaw	Shaw
Black#	Black#			
Bradshaw#	Bradshaw#			

Week 2

MON	**TUE**	**WED**	**THU**	**FRI**
5/2	**5/3**	**5/4**	**5/5**	**5/6**
Peters	Peters	Peters	Peters	Peters
Wandishin	Wandishin	Wandishin	Wandishin	Wandishin
James	James	James	James	James
Davies	Davies	Davies	Davies	Davies
LaCasse	LaCasse	LaCasse	LaCasse	LaCasse
Parker#	Parker#	Parker#		
Pryor#	Pryor#	Pryor#		
LaPenta#	LaPenta#	Modica#	Modica#	

Week 3

MON	TUE	WED	THU	FRI
5/9	**5/10**	**5/11**	**5/12**	**5/13**
Carbin	Carbin	Carbin	Carbin	Carbin
Schultz	Schultz	Schultz	Schultz	Schultz
Thoren	Thoren	Thoren	Thoren	Thoren
D.Moore	D.Moore	D.Moore	D.Moore	D.Moore
Manikin	Manikin	Manikin	Manikin	Manikin
Bryan	Bryan	Bryan	Bryan	Bryan
Stansion	Stansion	Stansion	Stansion	Stansion
			Robinson#	Robinson#

Week 4

MON	TUE	WED	THU	FRI
5/16	**5/17**	**5/18**	**5/19**	**5/20**
Racy	Racy	Racy	Racy	Racy
Coniglio	Coniglio	Coniglio	Coniglio	Coniglio
Branick	Branick	Branick	Branick	Branick
Scala	Scala	Scala	Scala	Scala
Szoke	Szoke	Szoke	Szoke	Szoke
Atkins#	Atkins#	Manousos#	Manousos#	Manousos#
	J.Moore#	J.Moore#	J.Moore#	
	Graves#	Graves#	Graves#	

Week 5

MON	TUE	WED	THU	FRI
5/23	**5/24**	**5/25**	**5/26**	**5/27**
Johns	Johns	Johns	Johns	Johns
Stensrud		Stensrud	Stensrud	Stensrud
Jungbluth	Jungbluth	Jungbluth	Jungbluth	Jungbluth
Trapp	Trapp	Trapp	Trapp	Trapp
Bosart	Bosart	Bosart	Bosart	Bosart
Galarneau	Galarneau	Galarneau	Galarneau	Galarneau
Lackmann	Lackmann	Lackmann	Lackmann	Lackmann
Weisman	Weisman	Weisman	Weisman	Weisman
Carr#	Carr#			

Week 6

MON	TUE	WED	THU	FRI
5/30	**5/31**	**6/1**	**6/2**	**6/3**
Weiss	Weiss	Weiss	Weiss	Weiss
Kain	Kain	Kain	Kain	Kain
Brown	Brown	Brown	Brown	Brown
Fovell	Fovell	Fovell	Fovell	Fovell
Janish	Janish	Janish	Janish	Janish
Etherton#	Etherton#	Etherton#		
	Lindsey#	Lindsey#	Lindsey#	Lindsey#
	Edman#	Edman#	Edman#	
		Mapes#	Mapes#	Mapes#
		Crook#	Crook#	Crook#

Full-Time Participating Scientists and Forecasters

SPC: S. Weiss, G. Dial, G. Carbin, S. Goss, J. Peters, J. Racy, R. Johns
NSSL: J. Kain, M. Wandishin, D. Burgess, M. Coniglio, H. Brooks, D. Stensrud, D. Schultz
NWSH/Penn State: N. Seaman
NCEP/EMC: G. Manikin
NWS/OUN: M. Foster, K. James, B. Thoren, M. Branick
NWS/DMX: K. Jungbluth
NWS/BIL: D. Moore
Forecast Systems Laboratory: J. Brown, E. Szoke
NASA-MSFC: K. LaCasse
NCAR: J. Dudhia, G. Bryan, M. Weisman
National Administration of Meteorology-Romania: A. Stansion
Millersville University: J. Scala
Purdue University: J. Trapp
University at Albany-SUNY: L. Bosart, T. Galarneau
North Carolina State University: G. Lackmann
UCLA: R. Fovell
Merrill/Lynch Corp: P. Janish
WeatherNews International: B. Shaw
Private Meteorologist: J. Davies

Part-Time Scientists and Forecasters (days in program)

SPC: R. Schneider, J. Schaefer, D. Bright, J. Levit
NSSL: D. Dowell(2), L. Wicker(3), Baldwin
NCEP: L. Uccellini(1)
NCEP/EMC: T. Black(2)
NCEP/HPC: P. Manousos(3)
Met. Service of Canada: R. Kuhn(1), D. Kania(1)
NWS/SRH: T. Bradshaw(2)
NWS/WRH: A. Edman(3)
Forecast Systems Laboratory: S. Benjamin(1)
NESDIS: K. Pryor(3)
NASA-MSFC: W. LaPenta(2)
NCAR: A. Crook(3)
University of Miami: B. Mapes(3)
University of Nebraska: M. Parker(3)
Colorado State University-CIRA: D. Lindsey(4)
Saint Louis University: J. Moore(3), C. Graves(3)
Lyndon State College: N. Atkins(3)
University of Oklahoma: A. Robinson(2), F. Carr(2)
University of North Carolina-Charlotte: B. Etherton(3)
Atmospheric and Environmental Research, Inc.: G. Modica (2)

Attachment B

Spring Program 2005
Experimental Severe Weather Forecast Product Instructions

Experimental Severe Weather Forecast Product Instructions
Spring Program 2005

Experimental 6-hour severe weather and supercell forecasts for the 18-00z period will be issued daily Monday-Friday. (On occasions when initial convective development is expected to be delayed until near or shortly after 00z, the valid period can be adjusted to 21-03z or even 00-06z.) The severe weather and supercell forecasts will be on separate graphics.

The severe weather forecast graphic 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, 25, 35, and 45 %); an area delineating potential for significant severe storms will be included when the probability for significant severe is 10% or greater.

The supercell forecast graphic will use the same probability contours (5, 15, 25, 35, 45%) to outline areas with potential for persistent supercell development, defined as supercells lasting for at least 30 minutes as identified through WDSS-II rotational displays or Mesoscyclone Detection Algorithm output.

Both graphical forecasts will be issued by 11 am CDT, and the associated online forecast form will be completed by 11:30 am CDT. Forecasters will utilize traditional forecasting methods based on a full-suite of observational data and operational models, supplemented by high resolution WRF output. The experimental supercell forecast asks forecasters to assess traditional environmental information (various measures of CAPE/shear, derived composite parameters such as SCP), conceptual models related to convective mode (such as orientation of mean wind/shear vectors to boundaries), and explicit storm and supercell information from WRF models to produce the supercell forecast. The overall goal is to explore the utility of cloud-resolving model guidance in severe weather forecasting, including indicators to denote generation of WRF supercell thunderstorms, and to determine if it provides value-added information over and above that provided by traditional deterministic and SREF models, especially relating to aspects of convective initiation, evolution, and mode.

For the **Severe Weather Forecast**, the forecaster will draw/save the probability contours in NMAP2 in the same manner as operational outlooks, except:

1) in the format outlook box, ***manually change the valid time to the 6-hr period of the forecast***

2) in the product save box, ***manually change the word "outlook" to "severe"***

After saving the severe forecast, enter the command: sp05bg STN severe # in an xterm window (STN is the three character 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.

For the **Supercell Forecast**, the forecaster will draw/save probability contours in a new graphic NMAP2, and save the forecast in the same manner as for operational outlooks except:

1) in the format outlook box, ***manually change the valid time to the 6-hr period of the forecast***

2) in the product save box, ***manually change the word "outlook" to "supercell"***

After saving the supercell forecast, enter the command: sp05bg STN supercell # in an xterm window (STN is the three character METAR centerpoint site ID and # is NAWIPS workstation number). Again, this is necessary to archive the supercell forecast, attach a date/time to the graphics file, and send the graphics to the web page.

Next, on the forecast web page (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 operational outlook discussions is prepared that will include the role of the WRF output in the forecast process.

Attachment C

Spring Program 2005
Daily Morning Forecast
(Web Based Form)

Daily Morning Severe Forecast
Spring Program 2005

In the online severe weather forecast web page, the following questions are asked once the forecast graphic is transferred from NAWIPS to the web page:

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, shear, and forcing of the afternoon pre-convective environment associated with the primary area of expected severe storm activity:

	Weak	Moderate	Strong
SBCAPE (J/kg)	<1500 ☐	1500-2999 ☐	≥3000 ☐
0-6 km Bulk Shear (kt)	<30 ☐	30-39 ☐	≥40 ☐
12hr 500 mb hgt falls(m)	<30 ☐	30-59 ☐	≥60 ☐

C. Please evaluate the usefulness and perceived value of the WRF output in preparing the severe weather and supercell forecasts, where 0 indicates not useful and 10 indicates very useful.

NA	0	1	2	3	4	5	6	7	8	9	10
O	O	O	O	O	O	O	O	O	O	O	O

Comments:

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

Forecast Discussion:

Attachment D

Spring Program 2005
Subjective Verification of Severe Weather Forecast
and Supercell Forecast
(Web Based Forms)

Severe Weather Forecast and Supercell Forecast Subjective Verification Form Spring Program 2005

I. Subjective Verification of Yesterday's Severe Weather Forecast:

Overall Rating of Severe Weather Forecast

In NMAP2 window 1 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 NA.

Severe Weather Forecast Rating:

NA	0	1	2	3	4	5	6	7	8	9	10
O	O	O	O	O	O	O	O	O	O	O	O

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.)

Comments:

II. Subjective Verification of Yesterday's Supercell Forecast:

Overall Rating of Supercell Forecast

In a separate NMAP2 window overlay the supercell forecast with a loop of radar reflectivity and the mesotvs.vgf file during the 6 hour forecast period. In addition, display the rotational tracks on the WDSS-II monitor over the time period and domain of the supercell forecast, and visually compare the occurrence of supercells with the forecast. Rate the accuracy of the forecast on a scale from 0-10, with 0 being an extremely poor forecast, and 10 being a nearly perfect forecast. Areas with greater supercell occurrence or higher forecast probabilities should be given more weight in the rating process.

If the supercell forecast was not available, **click on the checkbox labeled NA.**

Supercell Forecast Rating:

NA	0	1	2	3	4	5	6	7	8	9	10
O	O	O	O	O	O	O	O	O	O	O	O

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 supercell coverage, and any displacement errors that were factors in your rating, e.g., the primary location of supercells were east of the forecast location.)

Comments:

Attachment E

Spring Program 2005
Sounding Analysis Evaluation Forms
(Web Based Forms)

Sounding Analysis web form

While the SPC forecaster is completing the discussion portion of the human forecast, some participants may choose to work with him, but most will break off into two different groups: the Surface Analysis Team and the Sounding Analysis Team.

The Surface Analysis Team will gather at the NAWIPS terminal in the NE corner of the SSA

The Sounding Analysis Team will gather at the NAWIPS terminal in the SE corner of the SSA

These instructions are for the **Sounding Analysis Team**. Parts I and II will take place before lunch. We will resume with part III after lunch.

I. Overview of mesoscale environmental conditions and convective evolution in models and real atmosphere.

A) Examine the yesterday's meteorological scenario, including the evolution of convection and the pre-existing environmental conditions. Identify the most important forcing mechanisms (boundaries, etc.)and discuss your assessment with the Surface Analysis team.

II. Preliminary identification of interesting/relevant comparisons between raobs and model soundings in the preconvective environment (using web-based sounding analysis program and/or NSHARP).

A) Examine 00Z RAOBs and corresponding 24h PFCs (from WRF-NMM4 and WRF-ARW4 runs) at all RAOB sites within domain. Focus on locations where neither is contaminated by convection. Select up to 3 interesting RAOB sites for later 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.).

Selected RAOB sites (3 or 4 letter ID)	Meteorological relevance:

B) Identify mesoscale areas where RAOBS are not available but comparison of PFCs from WRF-NMM4 and WRF-ARW4 runs would be of interest. Preferred locations:

- close proximity to convective initiation
- along/just ahead of dry line
- along/just ahead of other significant boundary
- in warm sector, preferably near location of maximum SBCAPE *(consult with surface analysis team to ensure consistency of location of maximum SBCAPE)*

Select up to 4 such locations for later subjective comparisons.

Selected PFC sites (3 or 4 letter ID):	Meteorological relevance:

Save this form before breaking for lunch!

III. Quantification/classification of sounding comparisons (using web-based sounding analysis program).

A) Compare PFCs from WRF-NMM4 and WRF-ARW4 runs to RAOBs at previously identified RAOB sites.

RAOB Site 1 ID:

Describe the proximity of this location to relevant meteorological features (Is proximity information valid in observations as well as both model forecasts?):

Qualitatively compare PFC to RAOB, focusing on specific differences in

1) general thermodynamic structure
2) general kinematic structure
3) estimated PBL depth
4) PBL structure, T, T_d, CAP strength.

WRF-ARW4 to RAOB:

WRF-NMM4 to RAOB:

RAOB Site 2 ID:

Describe the proximity of this location to relevant meteorological features (is proximity information valid in observations as well as both model forecasts?):

Qualitatively compare PFC to RAOB, focusing on specific differences in

1) general thermodynamic structure
2) general kinematic structure
3) estimated PBL depth
4) PBL structure, T, T_d, CAP strength.

WRF-ARW4 to RAOB:

WRF-NMM4 to RAOB:

RAOB Site 3 ID:

Describe the proximity of this location to relevant meteorological features (Is proximity information valid in observations as well as both model forecasts?):

Qualitatively compare PFC to RAOB, focusing on specific differences in

1) general thermodynamic structure
2) general kinematic structure
3) estimated PBL depth
4) PBL structure, T, T_d, CAP strength.

WRF-ARW4 to RAOB:

WRF-NMM4 to RAOB:

B) Compare PFCs from WRF-NMM4 and WRF-ARW4 runs to each other at previously identified PFC sites.

PFC Site 1 ID:

Describe the proximity of this location to relevant meteorological features (Is proximity information valid for both model forecasts?):

Qualitatively compare the two PFCs, focusing on specific differences in

1) general thermodynamic structure
2) general kinematic structure
3) estimated PBL depth
4) PBL structure, T, T_d, CAP strength

PFC Site 2 ID:

Describe the proximity of this location to relevant meteorological features (Is proximity information valid for both model forecasts?):

Qualitatively compare the two PFCs, focusing on specific differences in

1) general thermodynamic structure
2) general kinematic structure
3) estimated PBL depth
4) PBL structure, T, T_d, CAP strength:

PFC Site 3 ID:

Describe the proximity of this location to relevant meteorological features (Is proximity information valid in for both model forecasts?):

Qualitatively compare PFCs, focusing on specific differences in

1) general thermodynamic structure
2) general kinematic structure
3) estimated PBL depth
4) PBL structure, T, T_d, CAP strength.

PFC Site 4 ID:

Describe the proximity of this location to relevant meteorological features (Is proximity information valid in for both model forecasts?):

Qualitatively compare PFCs, focusing on specific differences in

1) general thermodynamic structure
2) general kinematic structure
3) estimated PBL depth
4) PBL structure, T, T_d, CAP Strength.

General Comments:

Attachment F

Spring Program 2005
Surface Analysis Evaluation Forms
(Web Based Forms)

Surface Analysis web form

While the SPC forecaster is completing the discussion portion of the human forecast, some participants may choose to work with him, but most will break off into two different groups: the Surface Analysis Team and the Sounding Analysis Team.

The Surface Analysis Team will gather at the NAWIPS terminal in the NE corner of the SSA

The Sounding Analysis Team will gather at the NAWIPS terminal in SE corner of the SSA

These instructions are for the **Surface Analysis Team**. Parts I and II will take place before lunch. We will resume with part III after lunch.

I. Overview of mesoscale environmental conditions and convective evolution in models and real atmosphere.

A) Examine yesterday's meteorological scenario, including the evolution of convection and the pre-existing environmental conditions. Identify the most important forcing mechanisms (boundaries, etc.) and discuss your assessment with the Sounding Analysis team.

II. Preliminary identification and labeling of boundaries at the beginning of forecast period; estimation of cold-pool strength (end of forecast period).

A) Locate and label (analyze electronically) major large-scale boundaries (warm and cold fronts; dryline; prominent residual boundaries related to previous convective activity) in each WRF model forecast and in the SFCOA objective analysis at the beginning of the experimental forecast period. Provide general comments about configuration of boundaries and correspondence between different model forecasts.

Comments:

B) Choose one primary area of observed convective activity on which to focus. Is there a clearly corresponding area of activity in each of the model forecasts?

WRF-ARW4: ☐ Yes ☐ No

WRF-NMM4: ☐ Yes ☐ No

WRF-ARW2: ☐ Yes ☐ No

Comments:

SAVE THIS FORM BEFORE BREAKING FOR LUNCH!

III. Evaluating the association between convective development and low-level boundaries; assessment of boundary location errors.

A) Assess the association between the selected primary convective development and pre-existing large-scale boundaries:

How clearly were pre-existing large-scale boundaries in the SFCOA and each WRF configuration associated with the location of subsequent primary convective development during the forecast period? (check N/A if model configuration did not produce corresponding convective activity)

	No Apparent Association					Possible Association				Very Clear Association		
SFCOA:	-5	-4	-3	-2	-1	0	1	2	3	4	5	N/A
WRF-ARW4:	-5	-4	-3	-2	-1	0	1	2	3	4	5	N/A
WRF-NMM4:	-5	-4	-3	-2	-1	0	1	2	3	4	5	N/A
WRF-ARW2:	-5	-4	-3	-2	-1	0	1	2	3	4	5	N/A

What type of low-level boundary provided the focus for convective development? **[pull down menu]**

1) cold front
2) warm front
3) stationary front
4) dryline
5) cold front/dryline intersection
6) pre-existing convectively-induced boundary
7) no discernible low-level boundary
8) other

Comments:

B) Compare positions of two prominent boundaries in all WRF forecasts to corresponding positions in SFCOA. One boundary should always be the dryline (if it exists within domain) and one should always be the focus for convective development (if applicable).

Dryline: Compared to SFCOA, assess the position error of the dryline (if any) in each of the WRF forecasts (choose N/A is there is no dryline within domain):

	Shifted Towards Drier air					Just Right				Shifted Towards Moister air		
WRF-ARW4:	-5	-4	-3	-2	-1	0	1	2	3	4	5	N/A
WRF-NMM4:	-5	-4	-3	-2	-1	0	1	2	3	4	5	N/A
WRF-ARW2:	-5	-4	-3	-2	-1	0	1	2	3	4	5	N/A

Comments:

Second boundary: [PULL DOWN MENU]:

Compared to SFCOA, assess the position error of this boundary in all model forecasts

1) cold front
2) warm front
3) stationary front
4) cold front/dryline intersection
5) pre-existing convectively-induced boundary

	Shifted Towards Colder air					Just Right					Shifted Towards Warmer air	
WRF-ARW4:	-5	-4	-3	-2	-1	0	1	2	3	4	5	N/A
WRF-NMM4:	-5	-4	-3	-2	-1	0	1	2	3	4	5	N/A
WRF-ARW2:	-5	-4	-3	-2	-1	0	1	2	3	4	5	N/A

Comments:

IV. Assessing differences in warm sector (undisturbed) thermodynamic and kinematic fields.

For each set of WRF output, identify the region of maximum CAPE in the undisturbed (no convection or pre-convection) environment. Examine the following fields in this region and assess values relative to corresponding SFCOA fields. Consult with sounding analysis team to relate soundings to these 2-D parameters.

CAPE:

	Much Lower					About Same					Much Higher	
WRF-ARW4:	-5	-4	-3	-2	-1	0	1	2	3	4	5	N/A
WRF-NMM4:	-5	-4	-3	-2	-1	0	1	2	3	4	5	N/A
WRF-ARW2:	-5	-4	-3	-2	-1	0	1	2	3	4	5	N/A

Comments:

Temperature:

	Much Lower					About Same					Much Higher	
WRF-ARW4:	-5	-4	-3	-2	-1	0	1	2	3	4	5	N/A
WRF-NMM4:	-5	-4	-3	-2	-1	0	1	2	3	4	5	N/A
WRF-ARW2:	-5	-4	-3	-2	-1	0	1	2	3	4	5	N/A

Comments:

Dew-point temperature:

	Much Lower					About Same					Much Higher	
WRF-ARW4:	-5	-4	-3	-2	-1	0	1	2	3	4	5	N/A
WRF-NMM4:	-5	-4	-3	-2	-1	0	1	2	3	4	5	N/A
WRF-ARW2:	-5	-4	-3	-2	-1	0	1	2	3	4	5	N/A

Comments:

Deep-layer (0-6 km) shear:

	Much Lower					About Same					Much Higher	
WRF-ARW4:	-5	-4	-3	-2	-1	0	1	2	3	4	5	N/A
WRF-NMM4:	-5	-4	-3	-2	-1	0	1	2	3	4	5	N/A
WRF-ARW2:	-5	-4	-3	-2	-1	0	1	2	3	4	5	N/A

Comments:

0-3 km Storm-relative helicity:

	Much Lower					About Same					Much Higher	
WRF-ARW4:	-5	-4	-3	-2	-1	0	1	2	3	4	5	N/A
WRF-NMM4:	-5	-4	-3	-2	-1	0	1	2	3	4	5	N/A
WRF-ARW2:	-5	-4	-3	-2	-1	0	1	2	3	4	5	N/A

Comments:

Attachment G

Spring Program 2005
Model Reflectivity, Supercell, and Precipitation
Subjective Evaluation Forms
(Web Based Forms)

I. Next-Day Model Verification Instructions: High Resolution WRFs

A) Convective Initiation and Evolution

For each of the models listed below, provide a subjective assessment of the correspondence between observations and model forecasts of 1) convective initiation and 2) convective evolution. All assessments should be based on model equivalent-reflectivity forecasts compared to corresponding radar data, in the context of the mesoscale and sounding analyses already performed.

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 would have provided misleading 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.

Convective initiation: How well did the model reflectivity forecast correspond to the timing and location of convective initiation within the evaluation domain?

	NA	0	1	2	3	4	5	6	7	8	9	10
WRF-ARW4	O	O	O	O	O	O	O	O	O	O	O	O
WRF-NMM4	O	O	O	O	O	O	O	O	O	O	O	O
WRF-ARW2	O	O	O	O	O	O	O	O	O	O	O	O

Question: How would you characterize the relevant observed convective initiation?

- O Continuation of ongoing organized convection within evaluation domain
- O Movement of ongoing organized convection into evaluation domain
- O New convective development, not associated with ongoing local convection
- O Other (please explain below)

Comments:

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

	NA	0	1	2	3	4	5	6	7	8	9	10
WRF-ARW4	O	O	O	O	O	O	O	O	O	O	O	O
WRF-NMM4	O	O	O	O	O	O	O	O	O	O	O	O
WRF-ARW2	O	O	O	O	O	O	O	O	O	O	O	O

Comments:

B) WRF Supercell Forecasts

For each of the models listed below, provide a subjective assessment of the correspondence between supercell observations and model forecasts of supercells. Information about observed supercells can be obtained from from WDSS-II rotational tracks on the WDSS-II monitor and the Mesocyclone Detection Algorithm (MDA) loops on the Archive Web Page.

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

0	**5**	**10**
No Correspondence	**Moderate Correspondence**	**Excellent Correspondence**

No Correspondence: Model missed supercell features (false alarm and/or missed prediction) and would have provided misleading guidance to a severe weather forecaster.

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

Excellent Correspondence: Model captured all important supercell 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 supercell guidance than model B, make sure that model A has a higher rating than model B.

Supercell Forecasts: How well did the model supercell forecast correspond to the timing and location of observed supercells within the evaluation domain?

	NA	0	1	2	3	4	5	6	7	8	9	10
WRF-ARW4	O	O	O	O	O	O	O	O	O	O	O	O
WRF-NMM4	O	O	O	O	O	O	O	O	O	O	O	O
WRF-ARW2	O	O	O	O	O	O	O	O	O	O	O	O

Comments:

C) Overall Comparison Between ARW4 and ARW2 Forecasts

After comparing reflectivity and other output fields from the WRF-ARW4 and WRF-ARW2, comment on significant differences between these two runs that might impact the severe weather forecasting mission, including whether and how these differences might be related to the differences in resolution.

Comments:

II. Next-Day Model Verification Instructions: Mesoscale WRF Models

A) Convective Evolution Only

For each of the models listed below, provide a subjective assessment of the correspondence between observations and model forecasts of convective evolution. All assessments should be based on model 1-hour precipitation forecasts compared to corresponding 1-hour 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 would have provided misleading 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.

Convective evolution: How well did the model 1-hour precipitation forecast correspond to the mesoscale evolution of convection (using 1-hour reflectivity) within the evaluation domain, including direction and speed of system movement, areal coverage, configuration, orientation of mesoscale features, and perceived convective mode?

	NA	0	1	2	3	4	5	6	7	8	9	10
WRF-NMM4	O	O	O	O	O	O	O	O	O	O	O	O
WRF-ARW10	O	O	O	O	O	O	O	O	O	O	O	O
WRF-NMM8	O	O	O	O	O	O	O	O	O	O	O	O
WRF-GFS8	O	O	O	O	O	O	O	O	O	O	O	O

Comments:

Attachment H

Spring Program 2005
WRF Model Supercell Detection Index (SDI)
Background and Formulation

A Brief Description of the Supercell Detection Index[1]

Louis Wicker and Jack Kain, National Severe Storms Laboratory[2]
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 $\sim |0.01\ s^{-1}|$.

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 z 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,

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

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 $\sim |0.0003\ s^{-1}|$, 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] The real title is: **A Brief Description of the Supercell Detection Index and Use of Color #30** (see Jack Kain).
[2] Dave Dowell and Kim Elmore also contributed to this work.

Examples

We thought it might be helpful to show some examples from idealized cloud model simulations as to what these fields might look like. We will show the reflectivity, vertical velocity at z = ~ 1km, and then show both SDI indices. The simulations are run at 2 km horizontal resolution in order to be similar to the WRF 2 km runs.

Case 1

This is a case where there is large CAPE (> 3000 J kg^{-1}) and large vertical shear, especially at low-levels, but it have low relative humidity in the boundary layer. Several cells were triggered along a north-south line. The simulation develops a NE-SW line of storms with some embedded rotating updrafts and at the southern end of the line a supercell storm develops.

See Figures 1-4.

Case 2

This simulation is the "classic" 20 May 1977 simulation that has been used (too often) over the past 20 years or so. A single storm is triggered, and you can see the typical structure that has been documented in both the modeling and observational literature.

See Figures 5-8.

References

Kelvin K. Droegemeier, Steven M. Lazarus and Robert Davies-Jones. 1993: **The Influence of Helicity on Numerically Simulated Convective Storms.** *Monthly Weather Review*: Vol. 121, No. 7, pp. 2005–2029.

Doswell, C.A. III and D.W. Burgess, 1993: Tornadoes and tornadic storms: **A review of conceptual models.** *The Tornado: Its Structure, Dynamics, Prediction, and Hazards* (Church et al., eds). Amer. Geophys. Union, Geophys. Monogr. 79, 161-172.

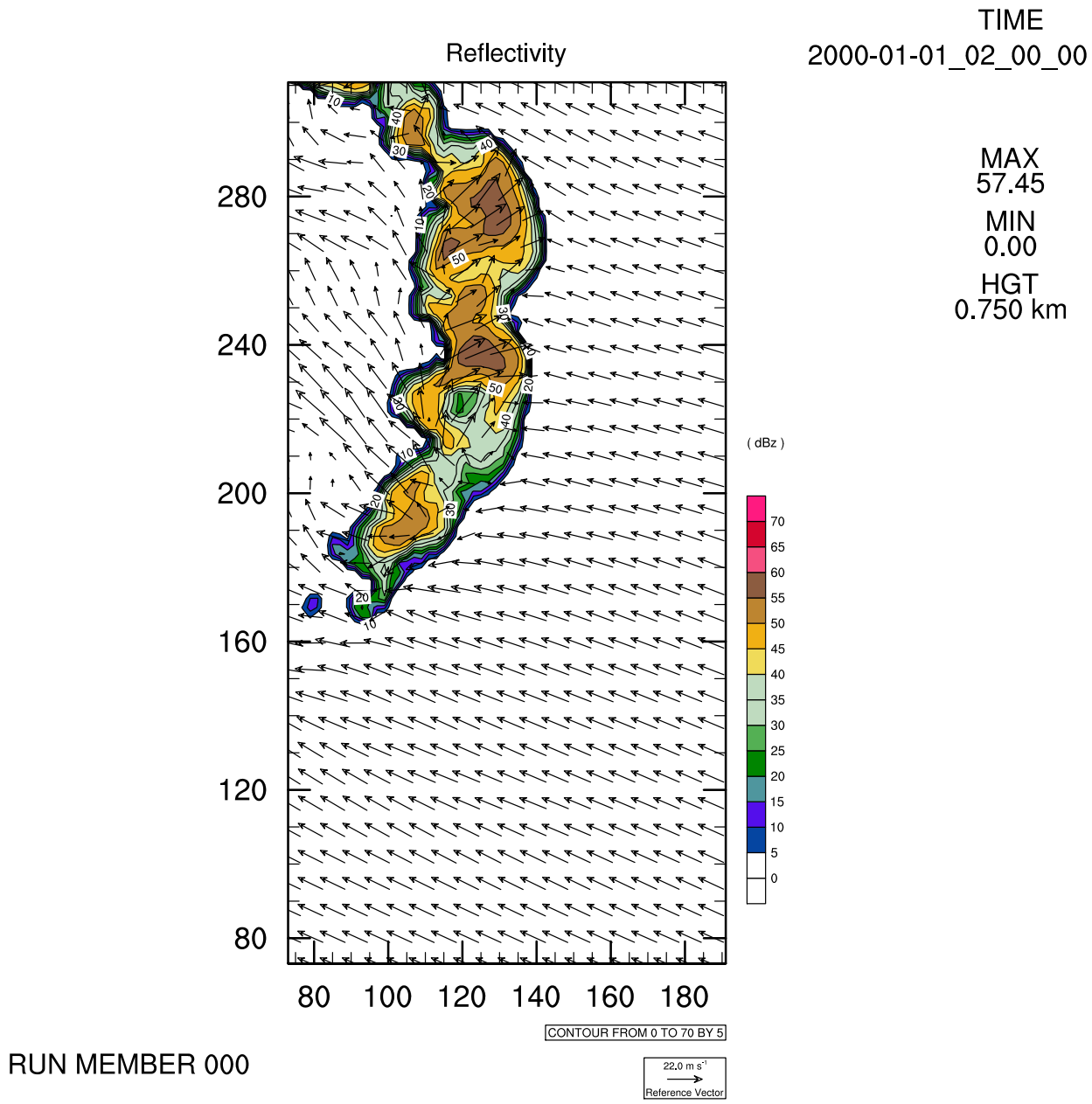

Figure 1: DBZ for squall line

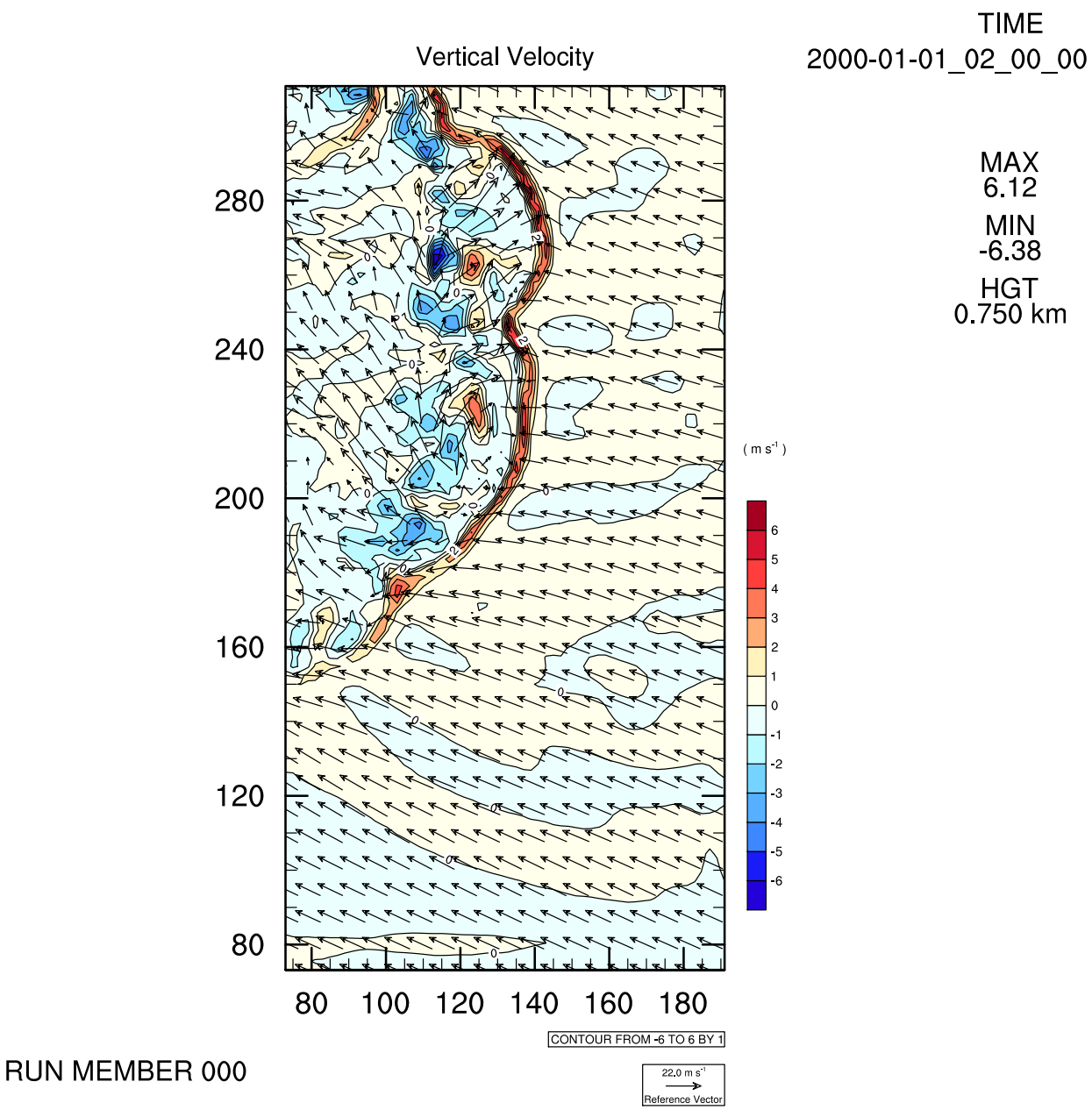

Figure 2: Vertical velocity for squall line

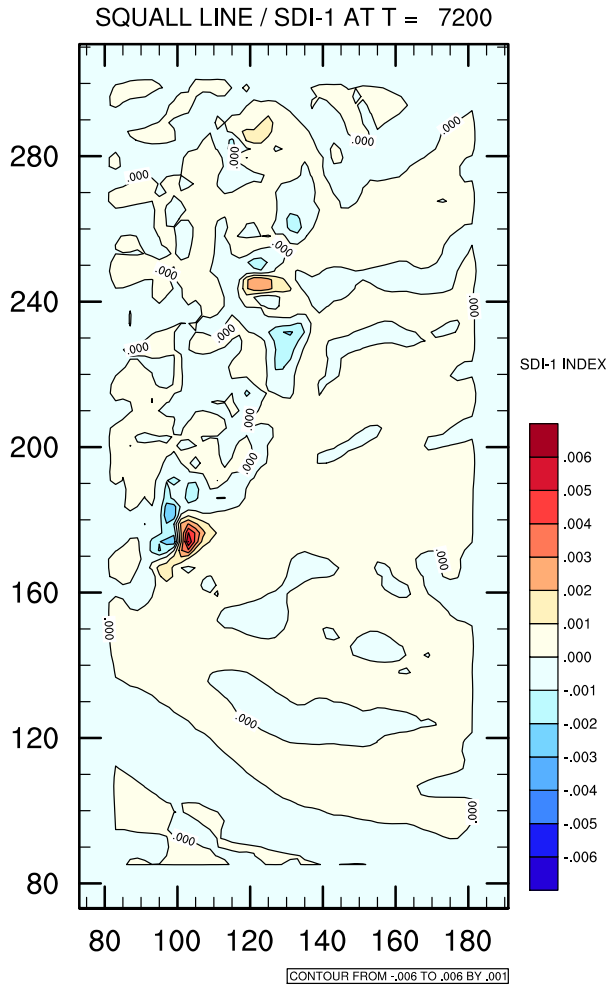

Figure 3: SDI-1 for squall line

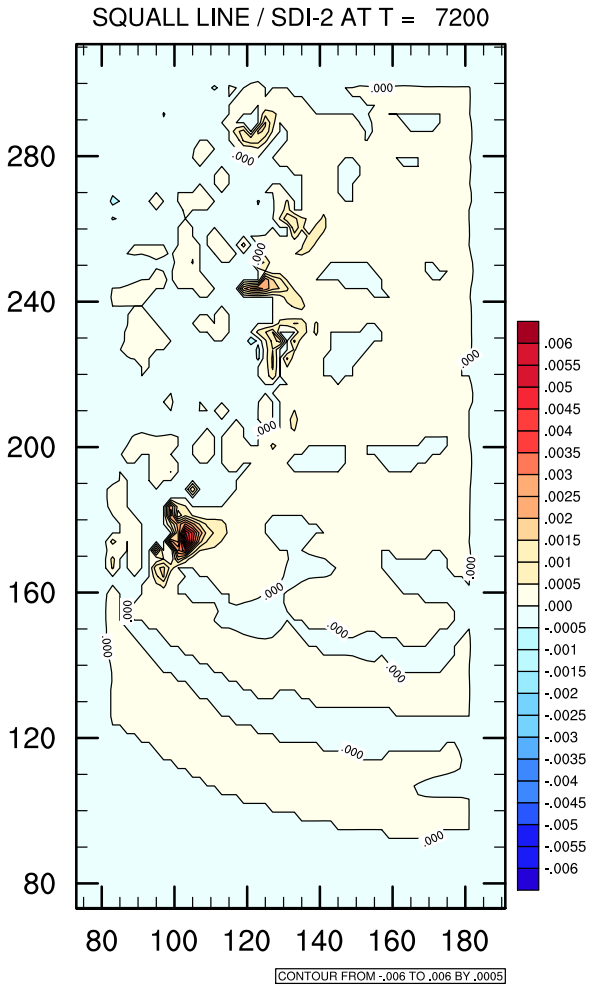

Figure 4: SDI-2 for squall line

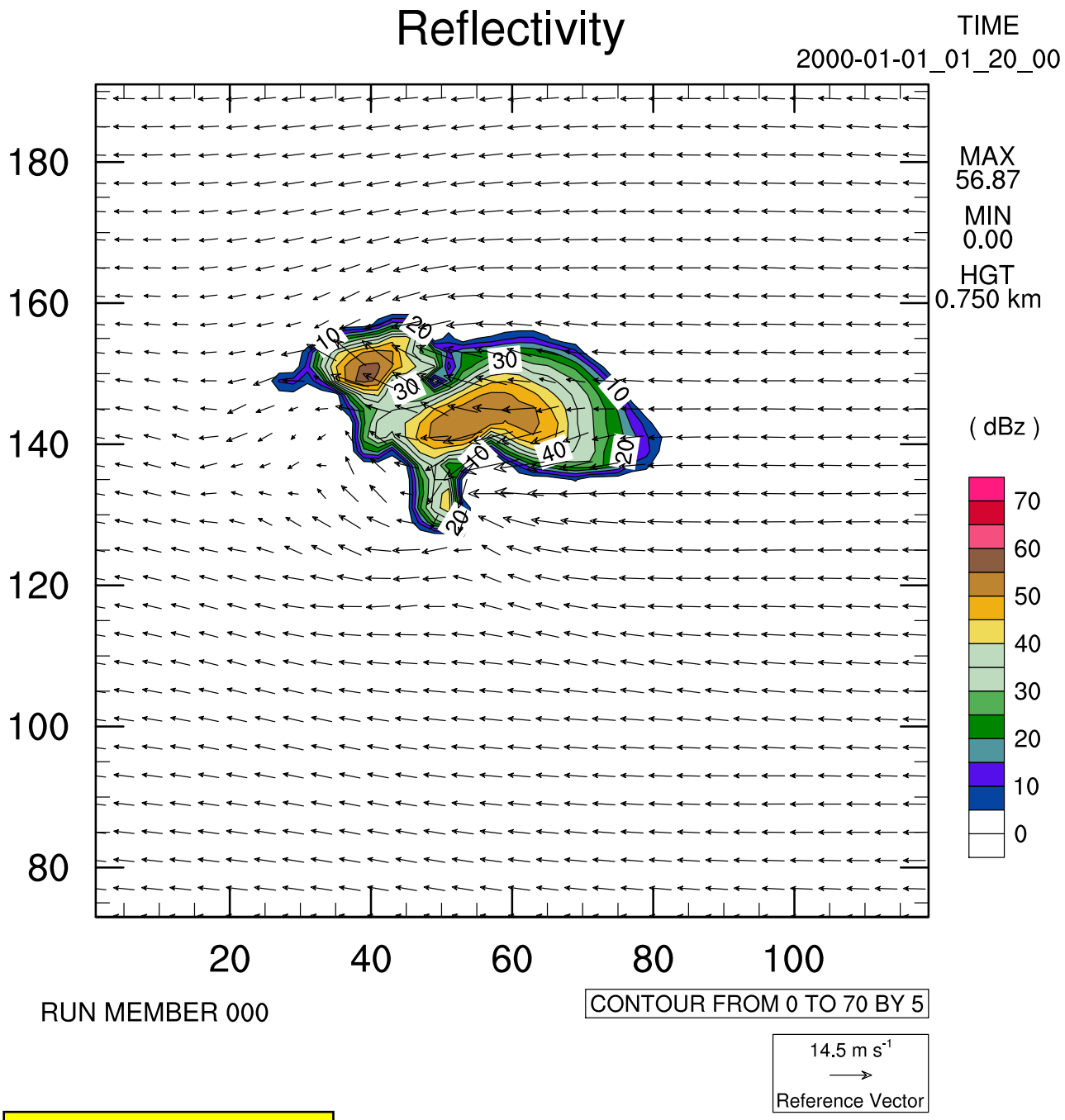

Figure 5: 20 May storm - Reflectivity

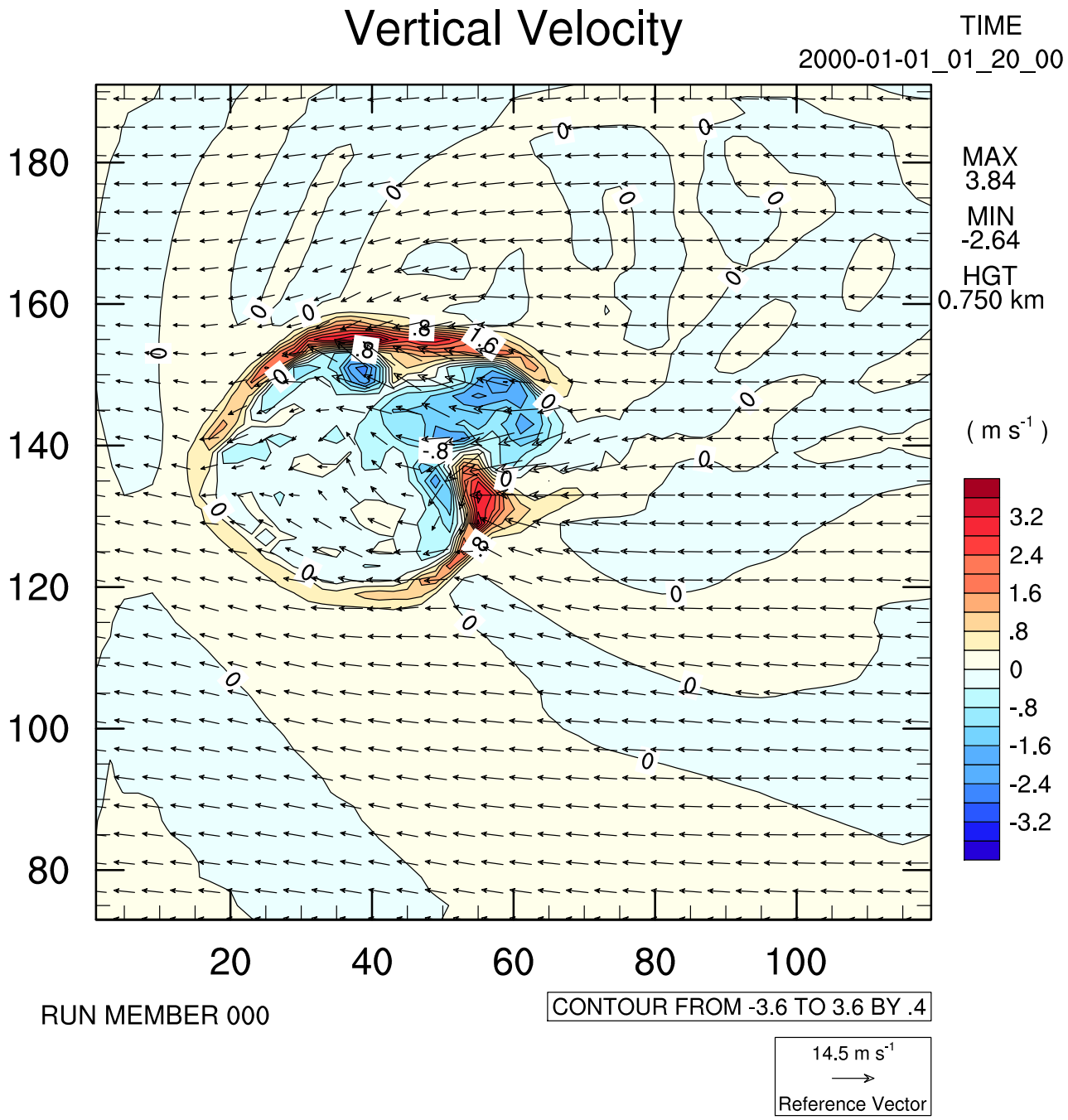

Figure 6: 20 May storm - vertical velocity

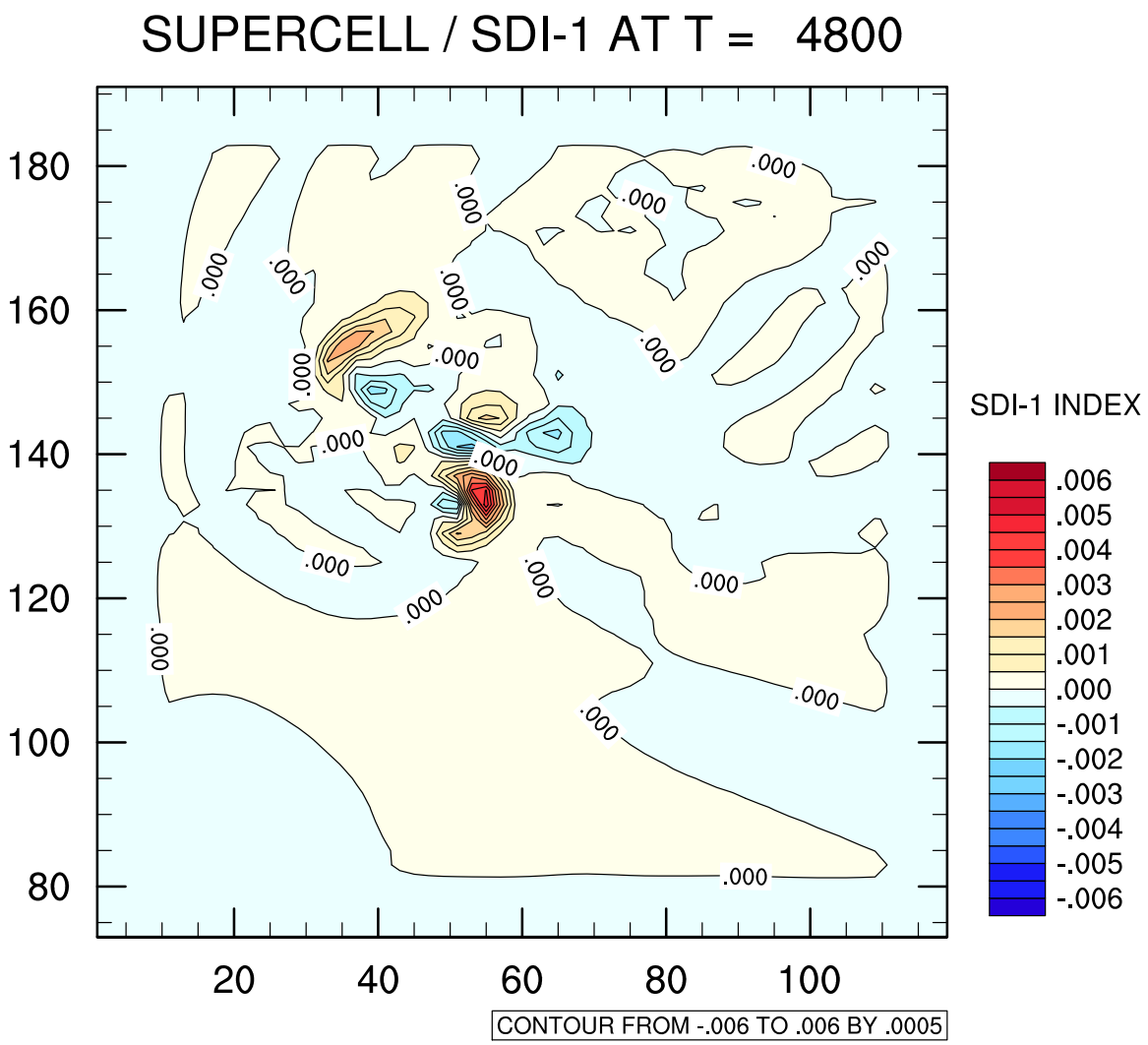

Figure 7: 20 May storm - SDI-1

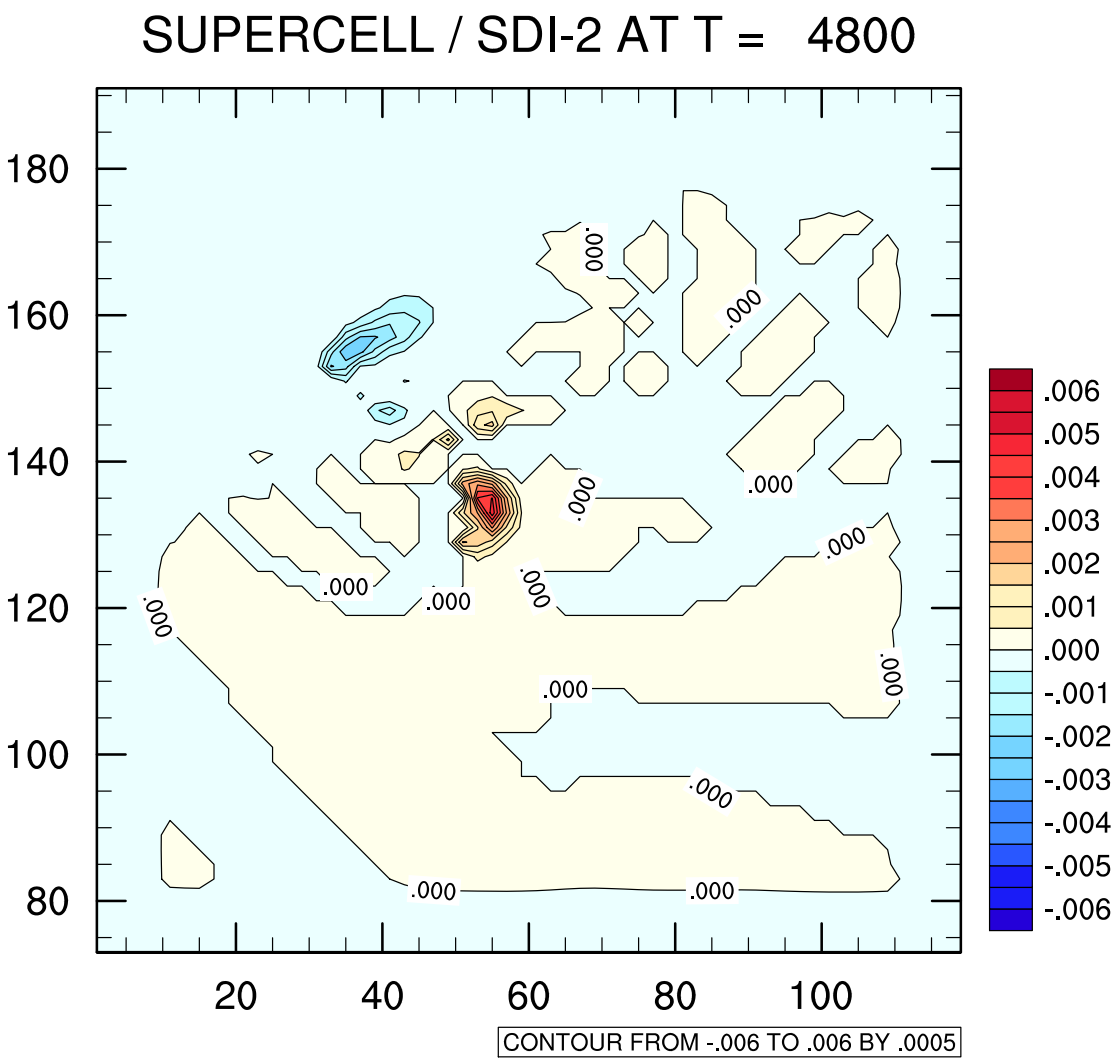

Figure 8: 20 May storm - SDI-2

Attachment I

Spring Program 2005
WRF Model Configuration Change Guidelines

Experimental Model Configuration Change Guidelines

1. Introduction

The NOAA Hazardous Weather Testbed 2005 Spring Program will focus on the evaluation of several high-resolution experimental WRF models during the peak severe convective weather season. The multi-agency collaboration will address a number of scientific and operational forecasting goals, some of which are listed below. Because of the variety of interests being served there can be inevitable conflicts at times, especially since the experimental models are still in various phases of development. Some basic goals of different participants and relevant issues are summarized here:

a) Research scientists are interested in better understanding the simulation of physical processes in the models, in order to understand current model performance and identify areas for improvement. This process may include a statistical evaluation where it is beneficial for each model configuration to be frozen during the testing period in order to maximize sample size and provide more robust statistical results. Changes in model configuration during the relatively short Spring Program time period may jeopardize these results.

b) Model developers would also like to test stable configurations containing very few if any coding errors ("bugs"), but they want the freedom to fix major coding bugs if discovered. If a coding error is identified and a fix is implemented relatively early in the Spring Program period, a smaller but meaningful data sample can still be analyzed. The definition of a "major bug" is subject to varying opinions, so the model developers should demonstrate that the bug has a substantial impact on model performance before model changes are made.

c) Forecasters are most interested in the potential utility of the experimental models to provide improved guidance for operational forecasting. They also prefer a stable model configuration during the experiment in order to test the model 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 Program 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 Program, the developer will be encouraged to fix the code as soon as possible. Note that any model changes after the start of the Program will be limited to fixing major errors in code; changes will not be made to incrementally "fine tune" parameterizations or other physical processes, nor will 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.