SPRING FORECASTING EXPERIMENT 2015

Conducted by the

EXPERIMENTAL FORECAST PROGRAM

of the

NOAA/HAZARDOUS WEATHER TESTBED

http://hwt.nssl.noaa.gov/Spring_2015/

HWT Facility – National Weather Center
4 May - 5 June 2015

Program Overview and Operations Plan

Adam Clark[2,3], Israel Jirak[1], James Correia[1,3], Steven J. Weiss[1], Jack Kain[2], Chris Melick[1,3], Patrick Marsh[1], Andy Dean[1,3], Kent Knopfmeier[2,3], Greg Carbin[1], Michael Coniglio[2], and Burkely Twiest[4]

(1) NOAA/NWS/NCEP Storm Prediction Center, Norman, Oklahoma
(2) NOAA/OAR National Severe Storms Laboratory, Norman, Oklahoma
(3) Cooperative Institute for Mesoscale Meteorological Studies, University of Oklahoma, Norman, Oklahoma
(4) School of Meteorology, University of Oklahoma, Norman, Oklahoma

1. Introduction

Each spring, the Experimental Forecast Program (EFP) of the NOAA/Hazardous Weather Testbed (HWT), organized by the Storm Prediction Center (SPC) and National Severe Storms Laboratory (NSSL), conducts a collaborative experiment to test emerging concepts and technologies designed to improve the prediction of hazardous convective weather. The primary goals of the HWT are to accelerate the transfer of promising new tools from research to operations, to inspire new initiatives for operationally relevant research, and to identify and document sensitivities and the performance of state-of-the art convection allowing (1 to 4 km grid-spacing) experimental modeling systems (CAMs).

The 2015 Spring Forecasting Experiment (SFE2015), a cornerstone of the EFP, will be conducted 4 May – 5 June with participation expected from more than 60 forecasters, researchers, and model developers from around the world. Building upon successful experiments of previous years, a main emphasis of SFE2015 will be the generation of probabilistic forecasts of severe weather valid over shorter time periods than current operational products. This will be an important step toward addressing a strategy within the National Weather Service of providing nearly continuous probabilistic hazard forecasts on increasingly fine spatial and temporal scales. As in previous experiments, a suite of new and improved experimental mesoscale and CAM guidance will be central to the generation of these forecasts.

This operations plan summarizes the core interests of SFE2015 and provides information on the operations of the experiment. Detailed information on the organizational structure of the HWT and information on various forecast tools and diagnostics can also be found in this document. The remainder of the operations plan is organized as follows: Section 2 provides details on a number of new products being introduced during SFE2015 and Section 3 describes the core interests and new concepts being introduced for SFE2015. A list of daily participants, details on the SFE forecasting, and more general information on the HWT are found in appendices.

2. Overview of Experimental Products and Models

A primary goal of the SFE2015 forecasting activities will be to test methods for generating probabilistic forecasts of severe weather that are valid over shorter time windows than current SPC operational products. Two separate groups, both led by SPC staff, will issue slightly different sets of convective outlooks for this testing. One group will issue Day 1 and 2 full-period outlooks (16Z – 12Z for Day 1 and 12Z to 12Z for Day 2) for each severe weather hazard (tornado, wind, and hail), along with two 4-h period outlooks within the Day 1 period for each hazard covering the periods 18-22Z and 22Z to 02Z. The other group will be issuing Day 1, 2 and/or 3 full-period outlooks for total severe (i.e., outlook for any type of severe hail, wind, or tornadoes), along with 1-h period outlooks within the Day 1 period for any type of severe covering the period 18Z to 02Z. These products are slightly different from those of SFE2014, but the goals are the same – namely, exploring different ways of introducing probabilistic severe weather forecasts on scales that are not currently addressed with categorical forecast products (e.g., mesoscale discussions and convective watches) and to begin exploring ways of seamlessly merging probabilistic severe weather outlooks with probabilistic severe weather warnings as part of NOAA's warn-on-forecast (Stensrud et al. 2009) and Forecasting a Continuum of Environmental Threats (FACETs; http://www.nssl.noaa.gov/projects/facets/) initiatives.

Generating the forecasts described above will be intensive and will thus rely on deterministic and ensemble CAM output for guidance and to generate first guesses for the severe weather probabilities. Most of the CAMs will be based on recent versions of the Advanced Research Weather Research and Forecasting (WRF-ARW) model. Included in the suite of CAM guidance will be a 20-member, 3DVAR-based and a 13-member, EnKF-based ensemble run with 3-km grid-spacing produced by the University of Oklahoma, Center for Analysis and Prediction of Storms (CAPS), a 10-member, 3-km grid-spacing, EnKF-based ensemble run by NCAR, a 10-member ensemble produced by the Air Force Weather Agency (AFWA), and a 10-member WRF-ARW ensemble produced by NSSL. Additionally, the United Kingdom Meteorological (UKMET) Office will provide three CAM forecasts (two with 2.2 km grid spacing and one with 1.0 km grid spacing) that are based on their Unified Modeling System, and 3-km grid-spacing forecasts over the CONUS will be provided from NCAR's Model for Prediction Across Scales – a global model with a variable-resolution mesh and "scale-aware" physics. Finally, the deterministic CAM output available to SPC operationally (or near operationally) generated by NSSL and the National Centers for Environmental Prediction (NCEP) Environmental Modeling Center (EMC), including the High-Resolution Rapid Refresh (HRRR) WRF-ARW based model, will be combined to produce ensembles of opportunity.

For the generation of first-guess forecasts from the CAM ensembles it is important to extract variables in the forecasts that track the occurrence of severe weather in the models. Previous SFEs and operational experience has shown that fields like hourly-maximum updraft helicity (UH) and hourly-maximum wind speed at the lowest model level can be effective for highlighting occurrences of severe weather in the model (Sobash et al. 2010, Kain et al. 2010, Clark et al. 2013). To support the goal of the SFE2015 to generate forecasts of individual hazards, there will be an effort to explore the ability of new model fields to delineate individual hazards, particularly for the size of hail and threat for tornadoes. Based on findings from SFE2014, updates have been made to the HAILCAST algorithm (Adams-Selin 2012), which predicts maximum hail size using a hail growth model coupled to WRF, so this will be tested again in SFE2015. Also, new hail size diagnostics will be available in the CAPS ensembles, which are based directly on information in the microphysical parameterizations, so these will also be tested and compared to the output from the HAILCAST algorithm. Finally, as in SFE2014, a separate technique for extracting the probability of hail based on a machine-learning algorithm will be explored as time allows. For tornado outlooks, a new set of uncalibrated and calibrated model-derived probabilities from the NSSL-WRF ensemble will be available covering various 1-, 4-, and 24-h time periods. These probabilities are based on a combination of UH and environmental parameters in the preceding hour.

a) CAPS Storm Scale Ensemble Forecast (SSEF) Systems

As in previous years, CAPS will provide a 00Z-initialized 4-km grid-spacing Storm Scale Ensemble Forecast (SSEF) system, but new to the experiment from CAPS this year is an Ensemble-Kalman Filter-based system (SSEF-EnKF) that assimilates WSR-88D radar reflectivity and radial velocity into a separate ensemble of model forecasts. More details on these two ensemble systems are given below.

(1) Legacy CAPS SSEF system

This year's 00Z SSEF system has 20 members and is run at the Texas Advanced Computing Center. The grid-spacing of the SSEF has been reduced from 4-km to 3-km for SFE2015 and, similar to SFE2014, the forecasts will extend to 60 h to support the Day 2 forecasts. SSEF forecasts are generated with WRF Version 3.6.1. As in 2014 season, the 00Z NAM analyses available on the 12-km grid (218) are used for initialization of control and non-perturbed members and as first guess for initialization of perturbed members with the initial condition perturbations coming directly from the NCEP Short-Range

Ensemble Forecast (SREF). WSR-88D data, along with available surface and upper air observations, are analyzed using ARPS 3DVAR/Cloud-analysis system. Forecast output at hourly intervals (higher time frequency output for a limited selection of 2D fields, and of 3D full dump for the visualization application) are archived at the TACC mass storage facility. Model specifications are provided in Table 1.

Table 1. Configurations for ARW members. NAMa and NAMf refer to 12 km NAM analysis and forecast, respectively. ARPSa refers to ARPS 3DVAR and cloud analysis.

Member	IC	BC	Radar data	Microphy	LSM	PBL
*arw_cn	00Z ARPSa	00Z NAMf	yes	Thompson	Noah	MYJ
arw_c0	00Z ARPSa	00Z NAMf	no	Thompson	Noah	MYJ
arw_m3	arw_cn + nmmb-p2_pert	21Z SREF nmmb-p2	yes	P3	Noah	MYNN
*arw_m4	arw_cn + nmmb-n2_pert	21Z SREF nmmb-n2	yes	M-Y	Noah	YSU
*arw_m5	arw_cn + nmm-p1_pert	21Z SREF nmm-p1	yes	Morrison	Noah	MYNN
*arw_m6	arw_cn + nmmb-n1_pert	21Z SREF nmmb-n1	yes	M-Y	Noah	MYJ
arw_m7	arw_cn +nmmb-p1_pert	21Z SREF nmmb-p1	yes	P3	Noah	YSU
*arw_m8	arw_cn + em-n1_pert	21Z SREF em-n1	yes	P3	Noah	MYJ
arw_m9	arw_cn + em-p2_pert	21Z SREF em-p2	yes	M-Y	Noah	MYNN
*arw_m10	arw_cn + nmmb-n3_pert	21Z SREF nmmb-n3	yes	Morrison	Noah	YSU
*arw_m11	arw_cn + nmmb-p3_pert	21Z SREF nmmb-p3	yes	Thompson	Noah	YSU
*arw_m12	arw_cn + nmm-n3_pert	21Z SREF nmm-n3	yes	Thompson	Noah	MYNN
arw_m13	arw_cn + nmm-p2_pert	21Z SREF nmm-p2	yes	Morrison	Noah	MYJ
arw_m14	00Z ARPSa	00Z NAMf	yes	Thompson	Noah	MYNN
arw_m15	00Z ARPSa	00Z NAMf	yes	Thompson	Noah	YSU-T
arw_m16	00Z ARPSa	00Z NAMf	yes	Thompson ICLOUD=3	Noah	YSU-T
arw_m17	00Z ARPSa	00Z NAMf	yes	MY	Noah	MYJ
arw_m18	00Z ARPSa	00Z NAMf	yes	P3-cat2	Noah	MYJ
arw_m19	00Z ARPSa	00Z NAMf	yes	P3	Noah	MYJ
arw_m20	00Z ARPSa	00Z NAMf	yes	Morrison	Noah	MYJ

Note 1: For all members: *ra_lw_physics*= RRTMG; *ra_sw_physics*=RRTMG; *cu_physics*=none
Note 2: YSU-T is the Thompson modified YSU PBL scheme
Note 3: member arw_m16 accounts for sub-grid scale clouds in the RRTMG radiation scheme based on research by G. Thompson.
Note 4: arw_m18 uses the newly developed P3 (Morrison-Milbrandt) microphysics with two-category ice; all other P3 members are with one-category ice.

**** Members in red are contributing members for HWT Baseline SSEF (12 total).**

The basic strategy in constructing the SSEF system is to have a set of members accounting for as many error sources as possible that can be used to generate reliable forecast probabilities (non-shaded members in Table 1). These "core" members have IC/LBC perturbations as well as varied physics and model cores. Other sets of members were configured to allow for various sensitivity experiments (shaded members in Table 1).

(2) CAPS EnKF-based ensemble system

A separate EnKF-based, 3-km grid-spacing, 12-member ensemble of 60-h forecasts will also be produced over the same CONUS domain covered by the SSEF system. This ensemble is run as follows: Starting at 1800 UTC, a six-hour EnKF cycling process with 40 WRF-ARW members is performed at the 3-km grid over the CONUS domain. This ensemble is configured with initial perturbations and mixed physics options to provide input for EnKF analysis. Each member uses WSM6 microphysics with different parameter settings (see Table 2). All members also include random perturbations with recursive filtering of ~20 km horizontal correlations scales, with relatively small perturbations (0.5K for potential temperature and 5% for relative humidity). EnKF analysis (cycling), with radar data and other conventional data, is performed from 2300 to 0000 UTC every 15 min over the CONUS domain, using as background the 40-member ensemble. A 12- member ensemble forecast (out to 60-h) follows using the last EnKF analyses at 0000 UTC (see Table 2). In addition, two deterministic forecasts, one from the ensemble mean analysis at 0000 UTC and another from 3DVAR analysis, are also produced. This suite of forecasts will be run on Darter at the National Institute for Computational Sciences (NICS).

Table 2. Configuration for the EnKF 12-member ensemble forecasts

Member	IC	BC	Microp	LSM	PBL
enkf_cn	enk_m1a	00Z NAMf	Thompson	Noah	MYJ
enkf_m6	enk_m2a	21Z SREF nmmb-n1	M-Y	Noah	MYJ
enkf_m9	enk_m6a	21Z SREF em-p2	M-Y	Noah	MYNN
enkf_m10	enk_m8a	21Z SREF nmmb-n3	Morrison	Noah	YSU
enkf_m5	enk_m10a	21Z SREF nmm-p1	Morrison	Noah	MYNN
enkf_m4	enk_m12a	21Z SREF nmmb-n2	M-Y	Noah	YSU
enkf_m3	enk_m17a	21Z SREF nmmb-p2	P3	Noah	MYNN
enkf_m8	enk_m23a	21Z SREF em-n1	P3	Noah	MYJ
enkf_m7	enk_m26a	21Z SREF nmmb-p1	P3	Noah	YSU
enkf_m12	enk_m37a	21Z SREF nmm-n3	Thompson	Noah	MYNN
enkf_m11	enk_m39a	21Z SREF nmmb-p3	Thompson	Noah	YSU
enkf_mn_thom	enfamean_thom	00Z NAMf	Thompson	Noah	MYJ
enkf_mn_wsm6	enfamean_wdm6	00Z NAMf	WSM6	Noah	MYJ
enkf_3dvar_thom	3dvar_thom	00Z NAMf	Thompson	Noah	MYJ
enkf_3dvar_wsm6	3dvar_wdm6	00Z NAMf	WSM6	Noah	MYJ

b) NSSL WRF

SPC forecasters have used output from an experimental 4-km WRF-ARW run produced by NSSL (NSSL-WRF) since the fall of 2006. Currently, the NSSL-WRF is run twice daily at 00 UTC and 12 UTC throughout the year over a full CONUS domain with forecasts to 36 hours. Output is also available online at a newly designed website: http://www.nssl.noaa.gov/wrf/newsite.

Also included in the experimental numerical guidance for this year's experiment is the addition of nine 4-km WRF-ARW runs that – along with the regular NSSL-WRF – comprise a 10-member NSSL-WRF based ensemble. The additional nine members are initialized at 0000 UTC and use 3-h SREF forecasts initialized at 2100 UTC for initial conditions and corresponding SREF member forecasts as lateral boundary conditions. There is also a member that used the 0000 UTC GFS analysis for ICs and corresponding GFS forecasts for LBCs. The physics parameterizations for each member are identical to the regular NSSL-WRF. Although the unvaried physics will have lower spread than a varied physics ensemble, SPC forecasters are familiar with the behavior of the NSSL-WRF physics, and this type of configuration allows us to isolate the contribution of spread from ICs/LBCs. The ensemble configuration is provided in Table 3. The NSSL-WRF ensemble was first tested last year during SFE2014, with favorable results.

Table 3: Configuration of the NSSL-WRF ensemble

Member	ICs/LBCs	PBL scheme	Micro-physics	Land-surface	Radiation
1	00Z NAM	MYJ	WSM6	Noah	RRTM/Dudhia
2	00Z GFS	MYJ	WSM6	Noah	RRTM/Dudhia
3	21Z em_ctl	MYJ	WSM6	Noah	RRTM/Dudhia
4	21Z nmb_n1	MYJ	WSM6	Noah	RRTM/Dudhia
5	21Z nmb_p2	MYJ	WSM6	Noah	RRTM/Dudhia
6	21Z nmb_ctl	MYJ	WSM6	Noah	RRTM/Dudhia
7	21Z nmb_p1	MYJ	WSM6	Noah	RRTM/Dudhia
8	21Z nmm_ctl	MYJ	WSM6	Noah	RRTM/Dudhia
9	21Z nmm_n1	MYJ	WSM6	Noah	RRTM/Dudhia
10	21Z nmm_p1	MYJ	WSM6	Noah	RRTM/Dudhia

New to SFE2015 will be a set of probabilities for individual severe hazards derived from severe proxy variables in the NSSL-WRF ensemble: UH for tornadoes, 10m wind for severe convective winds, and maximum hail size (derived from the coupled HAILCAST algorithm) for hail. Probabilistic forecasts for severe hail, severe wind, and tornadoes are computed over 24-h, 4-h, and 1-h time scales. Environmental information relating to each hazard is also incorporated into another set of probabilistic forecasts, with a focus on tornadoes for this year's experiment. Four different filters combining parameters and proxy variables are used in objectively creating the tornado forecasts. Details of parameters used to compute probabilities with each filter can be found in Table 4 below. These probabilities are referred to as *uncalibrated probabilities* because they are generated solely from raw ensemble output on a daily basis.

Table 4 Parameters used in tornado probabilities.

Tornado Probability Filters				
	UH ≥ $75 m^2 s^{-2}$	STP ≥ 1	LCL ≤ 1500m	SBCAPE/MUCAPE > .75
UnFilt	✓			

LCL 1500	✓		✓	✓
STP 1	✓	✓		
LCL, CAPE, STP	✓	✓	✓	✓

Another set of tornado probabilities are conditioned on Apr-June 2014. Reliability diagrams were created for the 24-h period of each of the above filters during Apr-June 2014, and linear fits were determined to adjust the probabilities for perfect reliability during Apr-June 2014. The same linear fits are applied to the 24-h probabilities generated daily for the 2015 season, and are referred to as *calibrated probabilities*.

The final set of tornado probabilities relies upon the significant tornado parameter (STP). Forecasters from the Storm Prediction Center have found a relationship between the conditional probability of tornado damage intensity and the regional STP based on six years of tornado reports. This relationship was used to generate probabilities of tornado intensity from the NSSL-WRF ensemble using the forecast value of the STP and the observed conditional probabilities of tornado occurrence given the STP. These probabilities are referred to as *STP probabilities*.

c) SPC Storm Scale Ensemble of Opportunity (SSEO)

The SSEO is a 7-member, convection-allowing ensemble consisting of deterministic models available operationally to SPC. This “poor man’s ensemble” provides a practical alternative to a formal/operational storm-scale ensemble which will not be available in the next few years because of computational/budget limitations. Similar to the other SSEF systems, hourly maximum storm-attribute fields, such as simulated reflectivity, updraft helicity, and 10-m wind speed are produced from the SSEO. Member specifications are provided in Table 5. Members marked with “-12h” in the Model column are 12h time-lagged members, initialized 12h earlier than the other members. All members are initialized with a “cold-start” from the indicated modeling system – i.e., no radar data assimilation or cloud model is used to produce ICs. Forecasts are available at 0000 and 1200 UTC.

Table 5 SSEO member specifications.

Updated 12 Aug 2014	Grid Spacing	Vert Levels	Fcst Length	ICs/ LBCs	PBL	Micro
NSSL WRF-ARW	4 km	35	36 h	NAM/ NAM	MYJ	WSM6
EMC HRW WRF-ARW	4.2 km	40	48 h	RAP/ GFS	YSU	WSM6
EMC HRW WRF-ARW; 12-h time lag	4.2 km	40	48 h	RAP/ GFS	YSU	WSM6
EMC HRW NMMB	3.6 km	40	48 h	RAP/ GFS	MYJ	Ferrier updated
EMC HRW NMMB; 12-h time lag	3.6 km	40	48 h	RAP/ GFS	MYJ	Ferrier updated
EMC CONUS WRF-NMM	4 km	35	36 h	NAM/ NAM	MYJ	Ferrier
EMC CONUS NAM NEST	4 km	60	60 h	NAM/ NAM	MYJ	Ferrier-Aligo

d) Air Force Weather Agency (AFWA) 4-km ensemble

The U.S. Air Force Weather Agency (AFWA) runs a real-time 10-member 4-km WRF-ARW ensemble. Forecasts are initialized at 0000 UTC and 1200 UTC using 6 or 12 hour forecasts from three global models, the Unified Model (UM), the NCEP Global Forecast System (GFS), and the Canadian Meteorological Center Global Environmental Multiscale (GEM) Model. Diversity in the AFWA ensemble is achieved through IC/LBCs from the different global models and varied microphysics and boundary layer parameterizations. SPC is currently ingesting the AFWA grids in their real-time data feed and these forecasts will be available for examination during SFE2015.

Table 6. AFWA ensemble member specifications.

Member	Atmospheric IC/LBC	Land IC	Surface	PBL	Microphysics
01	UM	LIS	NOAH	YSU	WSM5
02	GFS	LIS	RUC	BouLac	Morrison
03	GEM	LIS	NOAH	YSU	WDM6
04	GEM	LIS	NOAH	BouLac	Ferrier
05	UM	LIS	RUC	ACM2	WDM6
06	GFS	LIS	NOAH	ACM2	Thompson
07	GEM	LIS	NOAH	YSU	Morrison
08	GFS	LIS	NOAH	YSU	Ferrier
09	UM	LIS	RUC	ACM2	Thompson
10	GFS	LIS	NOAH	ACM2	WSM5

e) UK-Met Office convection allowing models

The Met Office Unified Model (UM) is the name given to the suite of numerical modelling software used by the Met Office. Three fully (or quasi) operational, nested limited-area high-resolution versions of the UM (two at 2.2 km and one at 1.1 km horizontal resolution) running once per day will be supplied to SFE2015. These operational nested hi-res versions will incorporate the latest UM settings that are used over the UK, except for a recent reduction to the rate of graupel production where this will be the first operational implementation.

The 2.2-km version has 70 vertical levels (spaced between 5m and 40 km) across a slightly sub-CONUS domain. Taking its initial and lateral boundary conditions from the 00z 17-km horizontal grid-spacing global configuration of the UM, the 2.2-km model initializes without data assimilation and runs out to T+48. This model configuration uses a 3D turbulent mixing scheme using a locally scale-dependent blending of Smagorinsky and boundary layer mixing schemes, stochastic perturbations are made to the low-level resolved-scale temperature field in conditionally unstable regimes (to encourage the transition from subgrid to resolved scale flows) and the microphysics is single moment. Partial cloudiness is diagnosed assuming a triangular moisture distribution with a width that is a universally specified function of height only. There is no convection parametrization in this or any of the high resolution UM configurations.

The 1.1-km horizontal resolution version of the UM is nested within the 2.2-km model and runs over a 1300 km by 1800 km domain. By default this is centred on Oklahoma but may be relocated if required. The 1.1-km model takes its initial and lateral boundary conditions from the T+3 step of the 00z 2.2-km run, thus reducing spin-up time within the 1.1-km model, and runs out to T+33 (this may be extended to T+45 at request). As with the 2.2-km model, the 1.1-km model initializes without data assimilation and uses the same 70 vertical level spacing as the 2.2-km. The 1.1-km model has identical planetary boundary layer and microphysics schemes as the 2.2-km model.

Finally, a parallel version of the 2.2-km model is being run with a new parametrization of partial cloudiness. This builds on the prognostic scheme used in the global model ("PC2") but includes an additional parametrization of subgrid moisture variability that is linked to the PBL turbulence. This is being tested as a potential replacement to the fixed width diagnostic scheme in high resolution applications.

f) ESRL High Resolution Rapid Refresh (HRRR) model

The HRRR model developed by the NOAA/Earth Systems Research Laboratory (ESRL) will continue to be examined in SFE2015. The experimental ESRL version of the 3-km grid-spacing HRRR model is nested within the hourly development version of the 13 km RAP model, which provides ICs/LBCs for the HRRR. The HRRR uses a version of the WRF-ARW, and hourly forecasts out to 15 hours are made over a full CONUS domain. A unique aspect of the RAP is the hourly Gridpoint Statistical Interpolation (GSI) data assimilation system that incorporates a wide array of observational datasets including radar reflectivity via the radar-Diabatic Digital Filter Initialization. As usual, numerous enhancements to the RAP/HRRR were made to the current operational versions primarily to improve the afternoon warm/dry bias over the plains during the warm season.

g) NCAR EnKF-based Ensemble

New for SFE2015, NCAR will be providing a 10-member, CONUS domain, 3-km grid-spacing, EnKF-based ensemble with forecasts to 48 h. This ensemble is based on WRF version 3.6.1 and uses NCAR's DART (Data Assimilation Research Testbed) software. The analysis system is comprised of

50 members that are continuously cycled using the ensemble adjustment Kalman filter (EAKF). New analyses are produced every 6 h with 15-km grid-spacing. Other specifications include: 40 vertical levels with a 50 hPa top, a horizontal localization of 1270 km and vertical localization of 2 scale heights, adaptive prior inflation, adaptive localization, sampling error correction, and freely-evolving soil states. The following observational sources are utilized: MADIS ACARS, METARs, radiosondes, NCEP MARINE, CIMMS cloud-track winds, and Oklahoma Mesonet. All members have constant physics, which include Tiedtke cumulus parameterization, Thompson microphysics, MYJ PBL, NOAH land-surface model, and RRTMG shortwave and longwave radiation with aerosol and ozone climatologies.

The 10-member forecasts are initialized daily at 0000 UTC with ICs provided by downscaled members of 0000 UTC WRF/DART EAKF analyses (described above). Perturbed LBCs from GFS forecasts are used. The physics are the same as from the data assimilation system, but without cumulus parameterization.

h) NCAR's Model for Prediction Across Scales (MPAS)

Another new modeling addition for SFE2015 is NCAR's Model for Prediction Across Scales (Skamarock et al. 2012). MPAS will produce daily 0000 UTC initialized forecasts at 3-km grid-spacing over the CONUS with forecasts to 120 h. The MPAS horizontal mesh is based on Spherical Centriodal Voronoi Tesselations (SCVTs). These meshes allow for both quasi-uniform discretization of the sphere and local refinement with smoothly varying mesh spacing between regions with differing resolutions. Importantly, the smoothly-varying mesh eliminates the major problems encountered with mesh transitions in forecast systems using traditional grid-nesting. The C-grid discretization, where the normal component of velocity on cell edges is prognosed, is especially well-suited for higher-resolution mesoscale and convective-scale atmosphere simulations where horizontally divergent motions (e.g. convection) is least-well resolved. Idealized convective tests, in addition to real-data hindcasts tests on 3-km global meshes, show the MPAS produces convective realizations similar to that of the ARW model. Figure 1 shows an example of the type of MPAS grid proposed for the experiment (though not to scale).

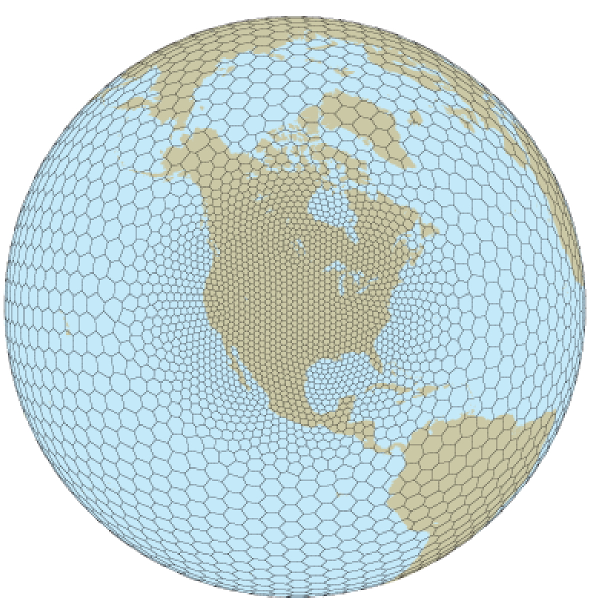

Figure 1 Example of a variable resolution MPAS Voronoi mesh.

i) NSSL Experimental Warn-on-Forecast System for ensembles (NEWS-e)

The NSSL Experimental Warn-on-Forecast System for ensembles (NEWS-e) is a 36-member WRF-based ensemble data assimilation system used to produce very short-range (0-1 h) probabilistic forecasts of supercell thunderstorm rotation, high winds, and flash flooding. Storm-scale ensemble analyses and forecasts of severe weather events from spring 2015 will be produced on a 3-km event-dependent grid. This storm-scale ensemble is nested within a 15-km continental United States (CONUS) ensemble constructed from initial and boundary conditions provided by members of the Global Ensemble Forecast System (GEFS) forecast cycle starting at 1800 UTC the previous day. The WRF physics options are varied amongst the ensemble members to address uncertainties in model physics. Around the time of convective initiation, radar and satellite (i.e., cloud water retrievals) data are assimilated every 15 min using the ensemble Kalman filter (EnKF) approach encoded in the Data Assimilation Research Testbed (DART). A 90-min ensemble forecast will be initialized from the resultant storm-scale analyses at the bottom of each hour of the storm event. These forecasts will be viewable using the web-based PHI-tool.

3. SFE2015 Core Interests/Daily Activities

a. Forecast products and activities

Similar to previous years, the experimental forecasts this year will continue to explore our ability to add temporal specificity to longer-term convective outlooks. We will continue to split the participants into two desks: one forecasting total severe and the other forecasting individual hazards. For the hazards desk, the first forecast will mimic the SPC operational day 1 convective outlooks by producing separate probability forecasts of large hail, damaging wind, and tornadoes within 25 miles (40 km) of a point valid 1600 UTC to 1200 UTC the next day. This is the second year the SPC desk has issued outlooks for individual hazards; past experiments only produced combined probabilities of hail, wind, and tornadoes ("total severe") over this time period. The first forecast for the other desk will also cover the 1600 to 1200 UTC time period, but cover only total severe. A text product will accompany each day 1 outlook that describes the meteorology of the day and the usefulness of the suite of model guidance during the creation of the severe storm forecasts. A separate day 1 forecast will be made at each desk. The experimental forecasts cover a limited-area domain with a center-point selected based on existing SPC outlooks and/or where interesting forecast challenges are expected.

Each desk will then manually stratify the experimental Day 1 outlooks into periods with higher temporal resolution. The individual hazards desk will generate separate probability forecasts of large hail, damaging wind, and/or tornadoes in two 4-h periods: 1800-2200 UTC and 2200-0200 UTC. As an alternative way of stratifying the day 1 outlook, the other desk will generate probability forecasts of total severe *every hour* from 1800-0000 UTC. The goal of testing these two different methods is to explore different ways of introducing probabilistic severe weather forecasts on scales that are currently addressed with mostly categorical forecast products (mesoscale discussions and convective watches) and to begin to explore ways of seamlessly merging probabilistic severe weather outlooks with probabilistic severe weather warnings as part of the NOAA warn-on-forecast and FACETS initiatives.

During previous experiments, calibrated severe guidance from the SSEO was used to temporally disaggregate a 1600-1200 UTC period human forecast. A scaling factor was formulated by matching the full-period calibrated severe SSEO guidance to the human forecast, then this scaling factor (unique at every grid point) was applied to the SSEO calibrated severe guidance for each individual period, and finally consistency checks were conducted to arrive at the final temporally disaggregated forecasts.

These automated forecasts from SFE2012 - SFE2014 fared favorably both in terms of objective metrics (e.g., CSI, FSS) and subjective impressions when compared to manually drawn forecasts. Similarly for SFE2015, the 1600-1200 UTC human forecasts for the individual hazards will be temporally disaggregated into the 4-h periods (1800-2200 UTC and 2200-0200 UTC) to provide a first guess for the two forecast periods.

The first set of short-time-window forecasts will be issued by 11:15am local time for both desks. At both desks, the lead forecaster will generate the short-time-window forecasts on the N-AWIPS machines. However, the participants will generate separate short-time-window forecasts differently. Participants at each desk will split into five groups and use a web-based tool to generate their own short-time window probability forecasts. This will be accomplished using Google Chromebooks and a web-based tool known as the Probabilistic Hazard Information (PHI) tool. The PHI tool will have first guess probability fields generated from CAM forecasts, as well as other important observational and model fields for participants to utilize in the forecast generation process.

Once the teams issue the short-time-window forecasts, there will be a 15-minute break and from 11:30 am to 12pm there will be a map discussion summarizing forecast challenges and highlighting interesting findings from the previous day. After the map discussion, we'll break for lunch from noon to 1pm, but there will be a 15-minute briefing of Experimental Warning Program participants beginning at 12:45pm for those interested.

After lunch, both desks will transition to examining the Day 2 period. Teams will examine operational guidance as well as experimental CAM guidance that will extend into Day 2 and generate probability forecasts similar to Day 1, but valid from 1200 UTC the next day to 1200 UTC the following day (day 3). This is the second year of testing Day 2 outlooks for individual hazards. The total severe desk will also produce a Day 3 forecast if time allows. A text product will accompany each Day 2 or Day 3 outlook that describes the meteorology of the day and the usefulness of the suite of model guidance during the creation of the severe storm forecasts. The Day 2 and Day 3 outlooks will be issued by 2pm.

During the time period from 2pm to 3pm, scientific evaluation will take place (summarized in the next section). Finally, from 3pm to 4pm, each team will examine observational trends and morning/afternoon model guidance to update the short-time-window forecasts made earlier in the day. Because the forecast process for these updates will begin at 3pm, only the forecasts valid from 2200-0200 UTC will be updated for the individual hazards in addition to 1-h probabilistic forecasts of tornadoes valid 2200 to 0200 UTC. The total severe desk will update their 1-h probabilistic forecasts for the 2100 to 0000 UTC period. In addition, new 1h probabilities will be issued for the 0000 to 0200 UTC time periods. All these new and updated forecasts will be issued by 4pm.

b. Formal Evaluation Activities

(1) Subjective Evaluation of Experimental Forecasts

In the next day evaluations, the individual period team forecasts and the first-guess forecasts will be compared to observed radar reflectivity, reports of severe weather, NWS warnings, and radar-estimated hail sizes and rotation tracks over the same time periods. The SFE participants will provide their subjective evaluations of the strengths and weaknesses of each of the forecasts. This evaluation will include examining and comparing calibrated guidance, temporal disaggregation first guess, NSSL-WRF-based first guess and human initial and update forecasts. The goal is to determine the relative skill of the first-guess guidance and the human-generated forecasts over all periods.

(2) Objective Evaluation of Experimental Forecasts

Similar to SFE2014 year, experimental probabilistic forecasts of tornado, wind, and hail will be evaluated using Critical Success Index (CSI) and Fractions Skill Score (FSS) based on the local storm reports (LSRs) as the verification. For the first time, however, supplemental observations for hail from multi-hourly MRMS MESH will be used in near real-time to calculate skill scores and gauge the usefulness of alternative sources for verification. A quality control measure was applied to the hourly MESH grids using CG lightning flashes. Further, only spatially filtered grids were considered to ensure the presence of contiguous swaths in the high resolution MESH tracks (Melick et al. 2014). Similar to LSRs, Practically Perfect hindcasts (Brooks et al. 1998) will be created from the MESH to provide valuable baselines to measure the skill of the probabilistic severe hail forecasts during the 2015 SFE.

In addition, comparisons of results from the experimental forecasts to the first-guess automated fields will be possible. CSI will be calculated at a couple of fixed probability thresholds used in SPC operational outlooks. The utility of verification metrics in assessing forecast skill for long and short periods will continue to be explored by comparing the scores to the subjective impressions of the participants.

(3) Comparison of CAPS 3DVAR- and EnKF-based ensembles and deterministic forecasts

An evaluation activity will focus on the first 6 h of the CAPS 3DVAR and EnKF-based ensembles. The activity will focus on a regional area of interest and evaluate how well the "control" members of each ensemble depict storms in the initial conditions and their subsequent evolution during the first 6 h of the forecast. The control member of the EnKF-based ensemble is the member with the same physics as the control member in the 3DVAR-based ensemble. Additionally, probabilistic forecasts of simulated reflectivity and other convection-related fields will be compared during the first 6 h to diagnose differences in forecast skill and ensemble dispersion.

Other evaluations will also be conducted for the 3DVAR and EnKF-based ensembles, but their focus will be on the Day 1 forecast period (i.e., 12 to 36 h lead time), and the other ensembles will also be evaluated (i.e., AFWA, SSEO, and NCAR).

(4) Evaluation of model guidance for hail

Similar to SFE2014, there is interest in evaluating the ability of CAMs to predict hail size because of the increased focus on forecasting individual thunderstorm hazards in the SFE2015. Thus, for the second year, the HAILCAST algorithm implemented in WRF-ARW will be used to predict hail size (Adams-Selin 2013), which is based on the algorithm in Brimelow (2002) and Jewell and Brimelow (2009). Rather than predict hail size explicitly, the HAILCAST model uses convective cloud and updraft attributes to determine the growth of hail from initial embryos. The cloud attributes for the model are those predicted explicitly in the WRF-ARW forecasts and the snow, ice and graupel mixing ratios at the first level above the freezing level at which they exist are used to determine the initial embryo size.

During SFE2014, it was very apparent that HAILCAST over-predicted hail sizes. Practically every storm contained greater than 1-inch hail. As a result, after SFE2014 changes were made to HAILCAST that resulted in more realistic hail size forecasts. Specifically, rime soaking and variable density options were added, and the dependency on microphysics scheme was removed by using 5 constant initial embryo sizes as opposed to those predicted in the schemes themselves. The changes were implemented in the NSSL-WRF and NSSL-WRF ensemble on 9 July 2014. Additionally, the updated HAILCAST algorithm will be available in both CAPS ensembles.

New to SFE2015 is a hail size diagnostic derived directly from the microphysics parameterizations, which was implemented by Greg Thompson of NCAR. This diagnostic will be available from the double-moment microphysics schemes in both CAPS ensembles (i.e., Morrison, Thompson, and Milbrandt-Yau). As part of the evaluation activity, the utility of the hail size forecasts using both methods will be compared. The explicit predictions of hail size will be evaluated against storm reports and the WSR-88D-derived Maximum Expected Size of Hail (MESH) product developed by NSSL as part of the Warning Decision Support System – Integrated Information (WDSS-II) suite of algorithms. The forecasts will also be compared to forecasts of hourly maximum UH to determine if the HAILCAST model output gives more information on the potential for severe hail beyond what has been construed from UH tracks in the model.

(5) UK Met Office and NSSL-WRF evaluations

The United Kingdom Meteorology Office (Met Office) has provided 48 h forecasts over the continental US from convection-allowing versions of their Unified Model (UM) for the SFEs since 2013 (ICs/LBCs derived from the global version of the UM). Additionally, several Met Office researchers and forecasters participated in the SFEs, while monitoring UM data flow and forecast products. So far, this collaboration has been extremely beneficial. The Met Office has been able to implement some of the unique storm-scale diagnostics developed at NSSL/SPC like simulated reflectivity and updraft-helicity, as well as examine forecast quality over a much more geographically diverse region than the United Kingdom. Meanwhile, NSSL and SPC have been able to examine forecasts of convection from a high-resolution modeling system completely independent of the WRF model and other US modeling systems. Also, because the Met Office has devoted a very large effort to accurately depicting the boundary layer due to its importance in the UK, the NSSL/SPC have been particularly interested in the quality of forecast low-level vertical profiles from the convection-allowing versions of the UM since this is a well-known weakness in US models.

To gauge the quality of the convection-allowing UM forecasts, daily subjective comparisons of simulated reflectivity will be made to the 4-km grid-spacing NSSL-WRF and corresponding observations. The NSSL-WRF has been used to provide storm-scale guidance to SPC forecasters since 2006 and is generally highly regarded. Thus, it served as a well-known baseline against which to compare the UM forecasts. In addition, because of the striking differences noted during SFE2014 for forecast vertical profiles of temperature and moisture when capping inversions were present, an effort will be devoted to forecast sounding comparisons between the UM and NSSL-WRF models again during SFE2015. During SFE2014 it was noted that the UM oftentimes very accurately depicted the sharp gradients in temperature and moisture at the interface of the boundary layer and elevated mixed layer, while the NSSL-WRF and high resolution WRF model simulations in general had very smoothed out temperature/moisture gradients at this interface (e.g., Figure 2).

(a) NSSL-WRF 24 h forecast sounding - FWD (b) UKMET 24 h forecast sounding - FWD

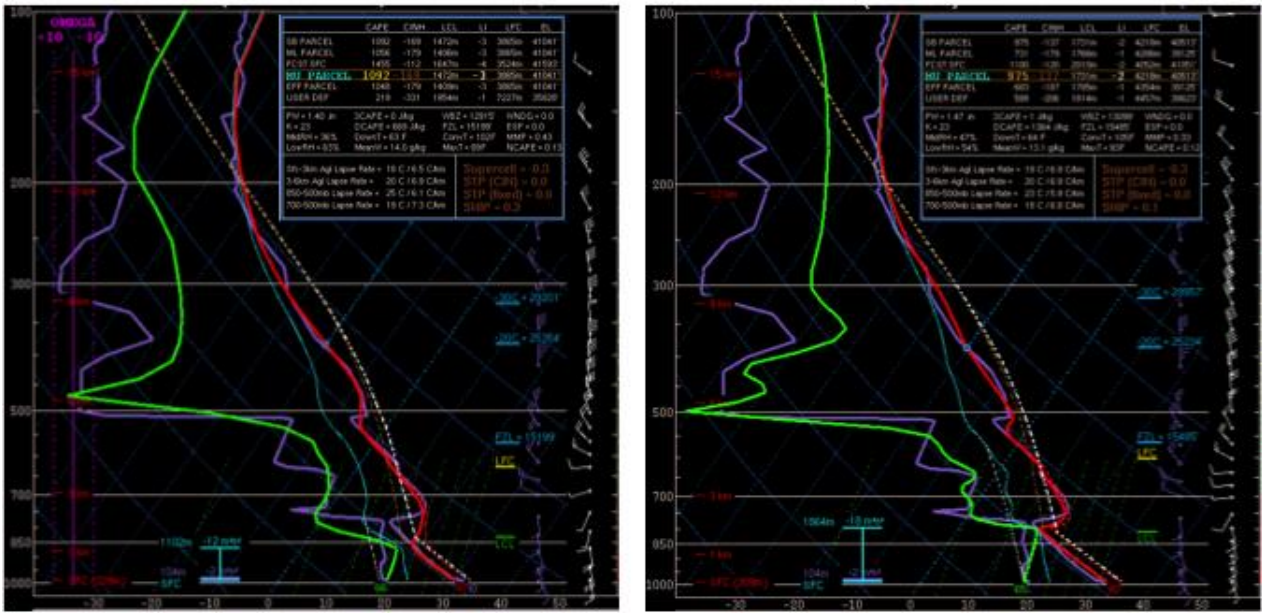

Figure 2 Forecast soundings valid 3 June 2014 for FWD from 24 h forecasts of the (a) NSSL-WRF, and (b) the UKMET. In both panels, the corresponding observed sounding is overlaid in purple.

c. SFE2015 Daily Activities Schedule - Scheduled activities are in local (CDT) time.

Individual Hazards **Total Severe**

0800 – 0845: **Evaluation of Experimental Forecasts & Guidance**

Subjective rating relative to radar evolution/characteristics, warnings, and preliminary reports and objective verification using preliminary reports and MESH

- Day 1 & 2 full-period probabilistic forecasts of tornado, wind, and hail
- Day 1 4-h period forecasts and guidance for tornado, wind, and hail

- Days 1, 2, & 3 full-period probabilistic forecast of total severe
- Day 1 1-h period forecasts and guidance for total severe

0845 – 1115: **Day 1 Convective Outlook Generation**

Hand analysis of 12Z upper-air maps and surface charts

- Day 1 full-period probabilistic forecasts of tornado, wind, and hail valid 16-12Z over mesoscale area of interest
- Day 1 4-h probabilistic forecasts of tornado, wind, and hail valid 18-22 and 22-02Z*

- Day 1 full-period probabilistic forecast of total severe valid 16-12Z over mesoscale area of interest
- Day 1 1-h probabilistic forecasts of total severe valid 18-00Z*

1115 – 1130: **Break**

Prepare for map discussion and discuss relationship/translation from probabilities to watch

1130 – 1200: **Map Discussion**

Overview and discussion of today's forecast challenges and products
Highlight interesting findings from previous days

1200 – 1300: **Lunch**

Brief EWP participants at 1245

1300 – 1400: **Day 2 Convective Outlook Generation**

- Day 2 full-period probabilistic forecasts of tornado, wind, and hail valid 12-12Z over mesoscale area of interest

- Day 2 or Day 3 full-period probabilistic forecasts of total severe valid 12-12Z over mesoscale area of interest

1400 – 1500: **Scientific Evaluations**

- Convection-allowing ensemble comparison (reflectivity and HMFs): SSEO, AFWA, NSSL, SSEF, SSEF EnKF, NCAR EnKF.
- EMC parallel CAM comparison (reflectivity): NAM Nest, HiResW, HRRR

- Met Office CAMs: vertical resolution
- SSEF 3DVar vs. EnKF Comparison: impact on first few hours of control forecast
- Model forecasts of explicit hail size: HAILCAST, Thompson
- MPAS

1500 – 1600: **Short-term Outlook**

- Update 4-h probabilistic forecasts of tornado, wind, and hail valid 22-02Z*
- Generate 1-h probabilistic forecasts of tornado valid 22-02Z

- Update and generate 1-h probabilistic forecasts of total severe valid 21-02Z*

* Denotes forecasts also made by participants using the PHI tool on Chromebooks.

d. Other specialized activities

For the second year in the HWT Spring Forecasting Experiments, CAM output in three-dimensional (3D) displays will be presented in real-time as part of the daily activities. Selected 3D model fields over our mesoscale region of interest at 10-minute output frequency for 18 – 30 h forecasts will be interrogated using VIS5D. The goal is to explore CAM storm characteristics like vertical vorticity, graupel mixing ratio, simulated reflectivity, and cold pools in 3D to learn more about how simulated storms are structured on WRF-ARW convection-allowing grids (see Figure 3 for an example of what this display looked like in SFE2014). The model storm structures will be compared to the structures of storms observed by the WSR-88D network and displayed within VIS5D. We will also examine characteristics of the storm environments in CAM forecasts like depth of water vapor mixing ratio in the PBL and depictions of low-level convergence boundaries and how they may play a role in the initiation of convection in the model. Since this is still an initial exploration into the detailed structures of storms and model forecast environments in real time as part of a forecast process, this activity will be somewhat informal and less structured than the other SFE2015 activities.

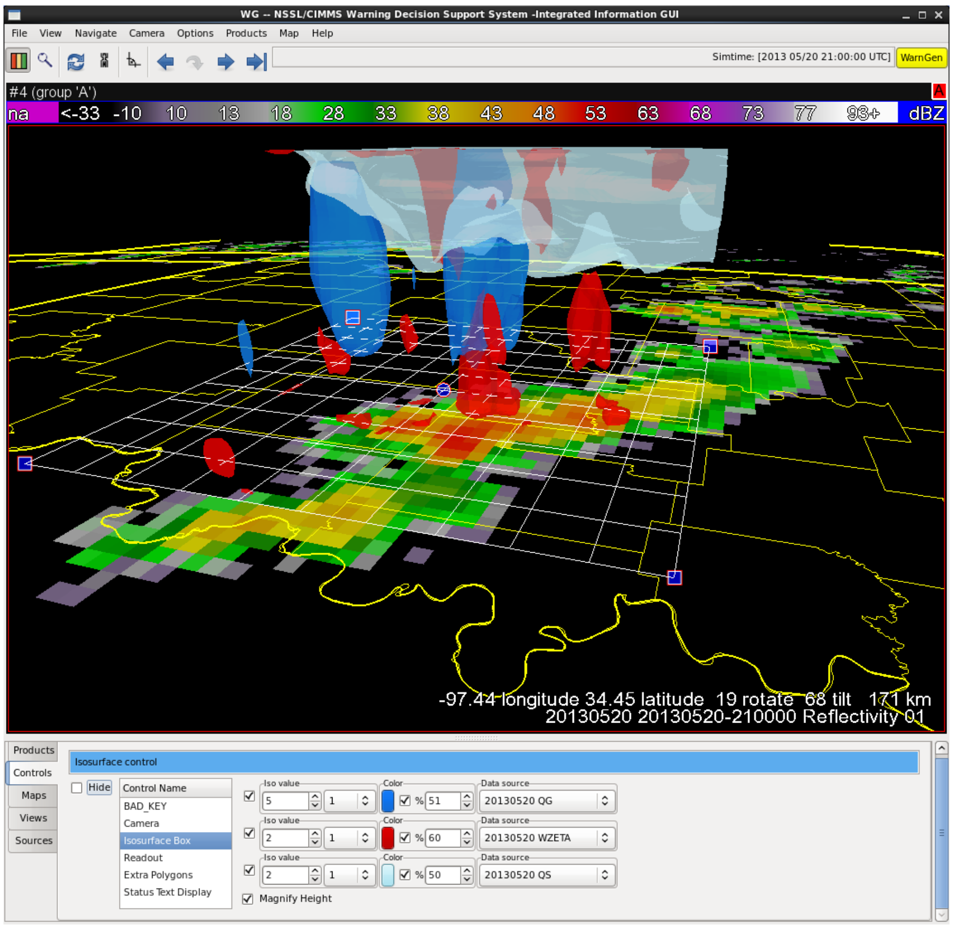

Figure 3. Example of how CAM forecasts will be interrogated for a select few runs from the CAPS SSEF system. The 2D field is the simulated reflectivity on the lowest model level (color scale near the top of the image) with 3D isosurfaces of vertical velocity x vertical vorticity (w*ζ) > 2 m s^{-2} (red areas), graupel mixing ratio > 5 g kg^{-1} (dark blue areas), and snow mixing ratio > 2 g kg^{-1} shown within the box outlined in white.

Appendix A: List of scheduled SFE2015 participants. Facilitators/leaders for SFE2015 include: Adam Clark (CIMMS/NSSL), Kent Knopfmeier (CIMMS/NSSL), Israel Jirak (SPC), James Correia Jr. (CIMMS/SPC), Chris Melick (CIMMS/SPC), Andy Dean (CIMMS/SPC), Greg Carbin (SPC), and Steve Willington (UKMO).

Week 1	Week 2	Week 3	Week 4	Week 5
May 4-8	**May 11-15**	**May 18-22**	**May 26-29**	**June 1-5**
Nick Grahame (Met Office)	Nick Grahame (Met Office)	Mark Seltzer (Met Office)	Brent Walker (Met Office)	Brent Walker (Met Office) M-W
Jason Otkin (CIMSS) M-Th	Mark Seltzer (Met Office)	Kirsty Hanley (Met Office)	Michael Fowle (WFO ABR)	Steve Ramsdale (Met Office)
Michael Dutter (WFO MQT)	Jacob Carley (EMC)	Rob Hepper (AFWA)	Brad Ferrier (EMC)	Eric Aligo (EMC)
Jun Du (EMC)	Curtis Alexander (GSD)	Lance Bosart (SUNYA)	Isidora Jankov (GSD)	Brian Kolts (FirstEnergy)
Tara Jensen (DTC) M-Th	Eric James (GSD)	Matt Vaughan (SUNYA)	Jaymes Kenyon (GSD)	Ed Szoke (GSD)
David Dowell (GSD)	Brock Burghardt (TTU)	Kyle Pallozzi (SUNYA)	Mike Watts (FedEx)	TJ Turnage (WFO GRR)
Terra Ladwig (GSD)	Pat Spoden (WFO PAH)	Jeff Beck (GSD)	Mike Lawson (WFO AFC)	Tom Lonka (WFO MHX)
Becky Adams-Selin (AFWA)	Glen Romine (NCAR)	John Brown (GSD)	Harald Richter (BOM)	Steven Cavallo (OU)
Brian Montgomery (WFO ALY)	Bruce Entwistle (AWC)	Harald Richter (BOM)	Ryan Torn (SUNYA)	Dan Zacharias (AWC)
Bill Skamarock (NCAR)	Gail Hartfield (WFO RAH)	Jeremy Berman (SUNYA)	Junella Tam (Hong Kong)	Stephen Konarik (WFO MFL)
Casey Crosbie (CWSU ZID)	Brad Mickelson (WFO GGW)	Lou Wicker (NSSL)	Hugh Morrison (NCAR) Th-F	Junella Tam (Hong Kong) M-Th
Ryan Sobash (NCAR)	Sarah Perfater (WPC) T-Th	Mark Klein (WPC)	Clark Evans (UW)	Aaron Kennedy (UND)
Mark Loeffelbein (WRHQ)	James Thomas (WFO SGX)	David Gagne (OU)	Clark's student (UW)	David Goines (UND)
David Imy (SPC Ret.) M-Th	Kate-Lynn Walsh (OU student)	Bill Lapenta (NCEP) Th-F	Todd Chambers (WFO BYZ)	Ron Stenz (UND)
		Rich Bann (WPC)		

Appendix B: Experimental Severe Thunderstorm Forecasts

Severe weather graphics for the full-period Day 1 (1600-1200 UTC) and Day 2 (1200-1200 UTC) individual hazard probabilities will be in the same format as that used for the operational SPC day 1 outlooks (categorical and general thunderstorm outlooks will not be made). For reference, the Probability-to-Categorical conversion for individual hazards used for the SPC Day 1 Outlook, and is shown below. These same probabilities will be used for generating the individual hazard forecasts in the four-hour periods.

Day 1 Probability to Categorical Outlook conversions

Day 1 Outlook Probability	TORN	WIND	HAIL
2%	MRGL	Not Used	Not Used
5%	SLGT	MRGL	MRGL
10%	ENH	Not Used	Not Used
10% with Significant Severe	ENH	Not Used	Not Used
15%	ENH	SLGT	SLGT
15% with Significant Severe	MDT	SLGT	SLGT
30%	MDT	ENH	ENH
30% with Significant Severe	HIGH	ENH	ENH
45%	HIGH	ENH	ENH
45% with Significant Severe	HIGH	MDT	MDT
60%	HIGH	MDT	MDT
60% with Significant Severe	HIGH	HIGH	MDT

Total severe weather probabilities for the full period Day 1 (1600-1200 UTC) and Day 2 (1200-1200 UTC) total severe storm hazards will be in the same format as that used for the operational SPC Day 2 outlooks (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. For reference, the Probability-to-Categorical conversion for total severe used for the SPC Day 2 Outlook, and is shown below. For the hourly probabilities of total severe, the severe weather probability within 25 miles of a point in any given hour is expected to be low, so the contours of 2% and 10% can be added to the probability contours that can be drawn.

Day 2 Probability to Categorical Outlook conversions

Day 2 Outlook Probability	Combined TOR, WIND, HAIL
5%	MRGL
15%	SLGT
15% with Significant Severe	SLGT
30%	ENH
30% with Significant Severe	ENH
45%	ENH
45% with Significant Severe	MDT
60%	MDT
60% with Significant Severe	HIGH

Appendix C. Organizational structure of the NOAA/Hazardous Weather Testbed

NOAA's Hazardous Weather Testbed (HWT) is a facility jointly 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 are situated between the operations rooms of the SPC and OUN. The proximity to operational facilities, and access to data and workstations replicating those used operationally within the SPC, creates a unique environment supporting collaboration between researchers and operational forecasters on topics of mutual interest.

The HWT organizational structure is composed of three overlapping programs (Fig. 4). The Experimental Forecast Program (EFP) is focused on predicting hazardous mesoscale weather events on time scales ranging from 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 annual SPC/NSSL Spring Experiments. For more information see http://www.nssl.noaa.gov/projects/hwt/efp/.

The Experimental Warning Program (EWP) 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. For more information about the EWP see http://www.nssl.noaa.gov/projects/hwt/ewp/. A key NWS strategic goal is to extend warning lead times through the "Warn-on-Forecast" concept (Stensrud et al. 2009), which involves using frequently updated short-range forecasts (≤ 1h lead time) from convection-resolving ensembles. This provides a natural overlap between the EFP and EWP activities.

The GOES-R Proving Ground (established in 2009) exists to provide pre-operational demonstration of new and innovative products as well as the capabilities available on the next generation GOES-R satellite. The overall goal of the Proving Ground is to provide day-1 readiness once GOES-R launches in late 2015. The PG interacts closely with both product developers and NWS forecasters. More information about GOES-R Proving Ground is found at http://cimss.ssec.wisc.edu/goes_r/proving-ground.html.

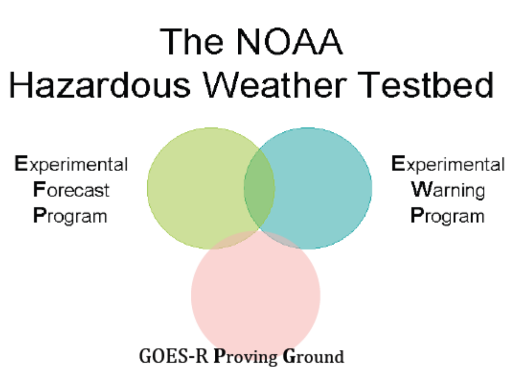

Figure 4: The umbrella of the NOAA Hazardous Weather Testbed (HWT) encompasses two program areas: The Experimental Forecast Program (EFP), the Experimental Warning Program (EWP), and the GOES-R Proving Ground (GOES-R).

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 http://www.nssl.noaa.gov/hwt/. Detailed historical background about the EFP Spring Experiments, including scientific and operational motivation for the intensive examination of high resolution NWP model applications for convective weather forecasting, and the unique collaborative interactions that occur within the HWT between the research and operational communities, are found in Weiss et al. (2010 – see http://www.spc.noaa.gov/publications/weiss/hwt-2010.pdf) and Clark et al (2012b).

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