2011 CAPS Spring Forecast Experiment Program Plan

April 29, 2011

Table of Content

1. Overview of New Features for 2011 Season

Major changes from 2011:

- **WRF version 3.2.1** is used for 2011 season. New set of physics configuration with the newly available physics options in WRFV3.2.1, including the Milbrand-Yau double-moment microphysics
- Addition of **COAMPS members**
- ~**50** 4-km members.
- Forecast lead-time is increased to **36 h** (from 30 h)
- CI and Lightning Threat algorithm (in ARW members)
- **Microphysics parameter perturbations** sub-ensemble (including WSM6, Thompson, and Ferrier schemes)
- Parameter perturbation in MYJ and ACM2 PBL schemes; also include a YSU mod version (by Greg Thompson)
- Add radar cycled members for ARPS and WRF-ARW, with 18-h forecast lead time.
- Lightning and CI diagnosed variables from ARW members
- **Calibrated QPF products** (reliability-based)
- 1-km grid forecast won't be run in realtime, but the analysis and LBCs will be produced

2011 season uses the same model domain setting as in 2010 season:

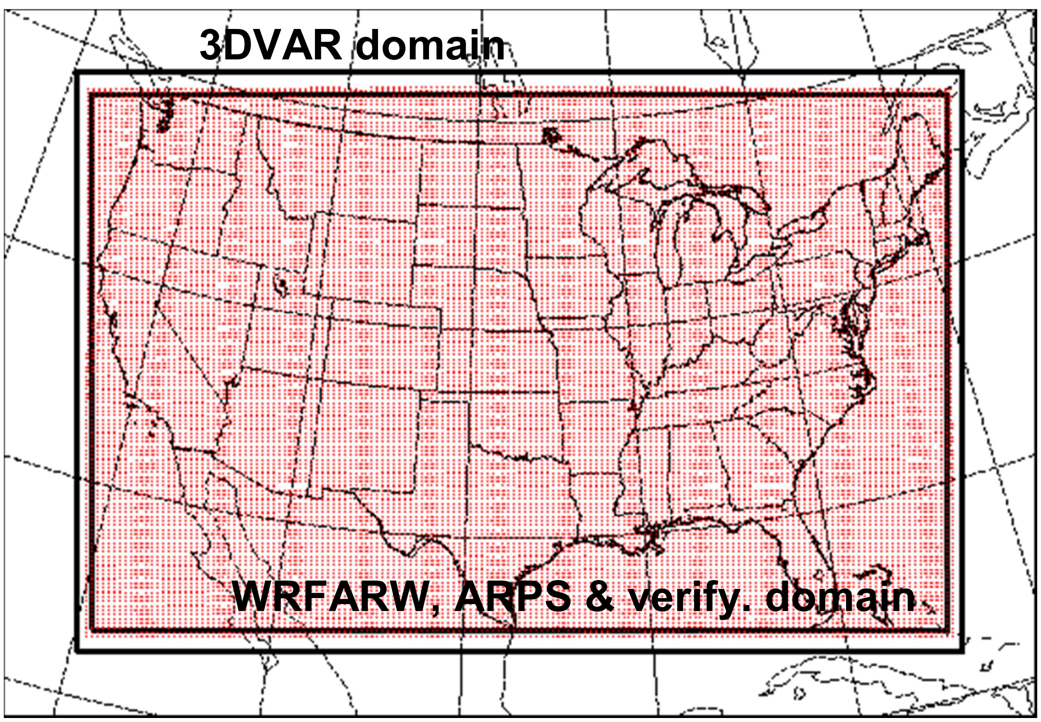

*Figure 1. Computational domains for the 2011 Season. The outer thick rectangular box represents the domain for performing 3DVAR (**Grid 1** – 1200×780). The red dot area represents the WRF-NMM domain (**Grid 2** – 790×999). The inner thick box is the domain for WRF-ARW, COAMPS, and ARPS and also for common verification (**Grid3** - 1160×720 at 4 km grid spacing; 4640×2880 at 1 km grid spacing).*

2. Program Duration

From **25 April 2011** through **10 June 2011**

The 2011 SPC/NSSL HWT Spring Experiment, a joint effort among NOAA Storm Prediction Center (SPC) and National Severe Storm Laboratory (NSSL) and the Center for Analysis and Prediction of Storms (CAPS) at University of Oklahoma, will officially **start on 9 May and end on 10 June**, with four days a week (Monday through Thursday). CAPS 2011 Spring Program begins regular forecast production two weeks earlier on 25 April to identify possible issues and to provide training sample dates for QPF calibration, and remains five days a week (running forecasts on the night of Sunday through Thursday) with possible weekend runs upon SPC request according to weather circumstance.

Related program

CASA:

Starting April 1, 2011, to May 31, 2011

3. Multi-model Forecast System Configuration

Both WRF solvers, ARW and NMM, the Navy COAMPS model system, and the ARPS model system, are used in 2011 Spring Experiment. All forecasts use **51** vertical levels, though horizontal grids are different between ARW and NMM. WRF code (both cores) was modified by CAPS to allow initial hydrometeor fields generated from 3DVAR/ARPS Cloud analysis of WRS-88D radar reflectivity to pass into WRF initial condition, and (for ARW) to write out reflectivity field every 5 min. ARPS members have the same horizontal grid as WRF-ARW.

3.1 4-km grid storm-scale ensemble forecast

All experimental forecasts are generated with both dynamical cores (solvers) of the Weather Research and Forecast (WRF) modeling system (**Version 3.2.1)**, the Advanced Research WRF (ARW) core and the operational NMM core, the Advanced Regional Prediction System (ARPS) developed by CAPS, University of Oklahoma, and the Navy COAMPS model**.** As in 2010 season, the 00Z NAM analyses available on the 12 km grid (218) are used for initialization of control (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, over **Grid 1**. Forecast output at hourly intervals (higher time frequency output for a limited selection of 2D fields) are archived at the NICS mass storage (HPSS).

The *daily* ensemble forecast configuration includes the following, all of which are run on ***Athena***, a Cray XT4 system with over 18,000 cores and one of NSF TeraGrid resources at NICS. Roughly half of Athena (~9800 cores) is dedicated to this project for up to 8 overnight hours a day over the project period.

- ARW: 41-member ensemble at 4 km grid spacing over **Grid 3** initialized at 00 UTC. Model execution begins around 0230 UTC (9:30pm CDT) and finish in 6-8 hours, with results being processed as they become available. **Table 1** lists the configuration and physics options for each ARW member. All forecasts are 36 h, except stated specifically.
    - One control 4 km forecast uses ARPS 3DVAR and cloud analysis (with radar data – both radial wind and reflectivity) with NAM 00 UTC 12-km grid analysis as the background and the 00 UTC NAM forecasts as boundary conditions. The radar analysis is performed over a larger Grid 1, and is trimmed to fit the ARW forecast grid (Grid 3).
    - Another 4 km member is the same as the 4 km control except for using as IC the 12 km NAM 00 UTC analyses directly (no-radar); 18-h forecast
    - One member uses a 10-min ARPS 3DVAR **cycled** analysis as IC; 18-h forecast
    - **17** members include IC/LBC perturbations as well as physics variations. The IC/LBC perturbations are derived from the evolved (through 3 hours) perturbations of the 21 UTC SREF[1], and we will use all 16 SREF's perturbed members, including 4 WRF-ARW perturbed members, 4 WRF-NMM perturbed members, 2 from Eta-KF , 2 from Eta-BMJ, 2 from RSM-SAS, and 2 from RSM_RAS perturbations. The IC perturbations are extracted from the IC-perturbation members of SREF, and added to the IC of control member. The LBCs will come directly from the forecasts of corresponding SREF (perturbed) members. They represent the direct nesting of storm-scale ensemble forecasts within the SREF, with enhanced resolution for the IC. Appendix A5 lists the names of all 21 SREF members archived locally
    - 21 physics-only members, with the same IC/LBC as the 4km control, have different microphysics and PBL options, including parameter perturbation (see Table 1 in the notes for detail).
        - 11 members with different microphysics schemes, including 5 WSM6 sub-set of members with parameter perturbation (change in N_{0R}, N_{0G}, and ρ_G), 1 member with new Ferrier update in NMMB, and 1 member using an old Thompson version (v31)
        - 4 MYJ sub-set members with different surface exchange coefficient paremeter (CZIL) to represent uncertainty in exchange intensity
        - 3 ACM2 sub-set members with different p-parameter representing different vertical mixing strength
- NMM: A daily 36 h, 5-member NMM at about 4 km grid spacing over **Grid 2**, initialized at 00 UTC. **Table 2** lists the configuration and physics options for each NMM member. 700 cores are used.
    - One control 4 km forecast uses ARPS 3DVAR and cloud analysis (with radar data – both radial wind and reflectivity) with NAM 00 UTC 12-km grid analysis as the

[1] As newly updated in October 2009, SREF WRF perturbed members (4 ARW and 4 NMM) now use directly the 3-h forecast GEFS perturbations. The later use ET perturbation technique.

background and the 00 UTC NAM forecasts as boundary conditions. The radar analysis is performed over a larger Grid 1 (only need down once for both cores), and is interpolated using arps4wrf to the NMM forecast grid (Grid 2). The physics options for this control member are the same as NCEP operational forecasts (NAM and NMM 4km) – they are different from ARW's.
    - 4 members with IC perturbations as well as physics variations. The IC/LBC perturbations are constructed similarly as ARW members.
- ARPS: 4-member ARPS forecasts at 4km grid spacing over **Grid 3**, initialized at 00 UTC. **Table 3** lists the configurations. Except the control member which has 36 h forecast, all other three are 18 h forecasts.
    - One member using ARPS 3DVAR and cloud analysis (with radar data – both radial wind and reflectivity) with NAM 00 UTC 12-km grid analysis as the background and the 00 UTC NAM forecasts as boundary conditions. The radar analysis is performed in **Grid 3** with ARPS vertical grid configuration of 53 stretching levels (It may not need a separate 3DVAR analysis, as the Grid 1 analysis can be trimmed to Grid 3 since the same 53 vertical levels are used)
    - One member uses NAM IC without radar analysis; 18-h forecast
    - One member has a 10-min cycle; 18-h forecast
    - One member has a 30-min cycle in 10-min interval; 18-h forecast
- COAMPS: (TBD)

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, CYCLED refers to a 10-min ARPS 3DVAR cycle

Member	IC	BC	Radar data	Microphy	LSM	PBL
arw_cn	00Z ARPSa	00Z NAMf	yes	Thompson	Noah	MYJ
arw_c0 (18h)	00Z ARPSa	00Z NAMf	no	Thompson	Noah	MYJ
arw_cc (18h)	CYCLED	00Z NAMf	yes	Thompson	Noah	MYJ
arw_m4	arw_cn + em-p1_pert	21Z SREF em-p1	yes	Morrison	RUC	YSU
arw_m5	arw_cn + em-p2_pert	21Z SREF em-p2	yes	Thompson	Noah	QNSE
arw_m6	arw_cn – nmm-p1_pert	21Z SREF nmm-p1	yes	WSM6	RUC	QNSE
arw_m7	arw_cn + nmm-p2_pert	21Z SREF nmm-p2	yes	WDM6	Noah	MYNN
arw_m8	arw_cn + rsm-n1_pert	21Z SREF rsm-n1	yes	Ferrier	RUC	YSU

arw_m9	arw_cn – etaKF-n1_pert	21Z SREF etaKF-n1	yes	Ferrier	Noah	YSU
arw_m10	arw_cn + etaKF-p1_pert	21Z SREF etaKF-p1	yes	WDM6	Noah	QNSE
arw_m11	arw_cn – etaBMJ-n1_pert	21Z SREF etaBMJ-n1	yes	WSM6	RUC	MYNN
arw_m12	arw_cn + etaBMJ-p1_pert	21Z SREF etaBMJ-p1	yes	Thompson	RUC	MYNN
arw_m13	arw_cn + rsm-p1_pert	21Z SREF rsm-p1	yes	M-Y	Noah	MYJ
arw_m14	arw_cn + em-n1_pert	21Z SREF em-n1	yes	Ferrier+	Noah	YSU
arw_m15	arw_cn + em-n2_pert	21Z SREF em-n2	yes	WSM6	Noah	MYNN
arw_m16	arw_cn + nmm-n1_pert	21Z SREF nmm-n1	yes	Ferrier+	Noah	QNSE
arw_m17	arw_cn + nmm-n2_pert	21Z SREF nmm_n2	yes	Thompson	Noah	ACM2
arw_m18	arw_cn + rsm-p2_pert	21Z SREF rsm_p2	yes	WSM6	Noah	MYJ
arw_m19	arw_cn + rsm-n1_pert	21Z SREF rsm_n1	yes	M-Y	Noah	MYJ
arw_m20	arw_cn + rsm-n2_pert	21Z SREF rsm_n2	yes	M-Y	RUC	ACM2
arw_m21	00Z ARPSa	00Z NAMf	yes	Ferrier+	Noah	MYJ
arw_m22	00Z ARPSa	00Z NAMf	yes	Ferrier	Noah	MYJ
arw_m23	00Z ARPSa	00Z NAMf	yes	M-Y	Noah	MYJ
arw_m24	00Z ARPSa	00Z NAMf	yes	Morrison	Noah	MYJ
arw_m25	00Z ARPSa	00Z NAMf	yes	WDM6	Noah	MYJ
arw_m26	00Z ARPSa	00Z NAMf	yes	WSM6	Noah	MYJ
arw_m27	00Z ARPSa	00Z NAMf	yes	WSM6-M1	Noah	MYJ
arw_m28	00Z ARPSa	00Z NAMf	yes	WSM6-M2	Noah	MYJ
arw_m29	00Z ARPSa	00Z NAMf	yes	WSM6-M3	Noah	MYJ
arw_m30	00Z ARPSa	00Z NAMf	yes	WSM6-M4	Noah	MYJ
arw_m31	00Z ARPSa	00Z NAMf	yes	Thompson	Noah	QNSE

arw_m32	00Z ARPSa	00Z NAMf	yes	Thompson	Noah	MYNN
arw_m33	00Z ARPSa	00Z NAMf	Yes	Thompson	Noah	MYJ-P1
arw_m34	00Z ARPSa	00Z NAMf	Yes	Thompson	Noah	MYJ-P2
arw_m35	00Z ARPSa	00Z NAMf	Yes	Thompson	Noah	MYJ-P3
arw_m36	00Z ARPSa	00Z NAMf	Yes	Thompson	Noah	ACM2
arw_m37	00Z ARPSa	00Z NAMf	yes	Thompson	Noah	ACM2-A1
arw_m38	00Z ARPSa	00Z NAMf	yes	Thompson	Noah	ACM2-A2
arw_m39	00Z ARPSa	00Z NAMf	yes	Thompson-v31	Noah	MYJ
arw_m40	00Z ARPSa	00Z NAMf	yes	Thompson	Noah	YSU
arw_m41	00Z ARPSa	00Z NAMf	yes	Thompson	Noah	YSU-Thompson

Note 1: For all members: *ra_lw_physics*= RRTM; *ra_sw_physics*=Goddard; *cu_physics*=none
Note 2: All Thompson members, except v31 (*thompsonopt=1*), are using v33 (*thompsonopt=0*)
Note 3: Ferrier+ (*ferrieropt=1*) refers to a subset of changes in the updated version now in NEMS/NMMB. Ferrier is default (*ferrieropt=0*)
Note 4: WSM6 with M1 to M4 refers to various perturbations on intercept parameter N0 and density parameter

- WSM6: norain=$8x10^6$ m^{-4}, n0graupel=$4x10^6$ m^{-4}, dengraupel=500 kg/m^3
- WSM6-M1: norain=$8x10^6$ m^{-4}, n0graupel=$4x10^4$ m^{-4}, dengraupel=913 kg/m^3
- WSM6-M2: norain=$8x10^7$ m^{-4}, n0graupel=$4x10^6$ m^{-4}, dengraupel=500 kg/m^3
- WSM6-M3: norain=$8x10^5$ m^{-4}, n0graupel=$4x10^2$ m^{-4}, dengraupel=913 kg/m^3
- WSM6-M4: norain=$8x10^5$ m^{-4}, n0graupel=$4x10^3$ m^{-4}, dengraupel=913 kg/m^3

Note 5: A1 and A2 refer to modifying the ACM2 to account for weaker and stronger vertical mixing via the "p" parameter

- ACM2: acm2opt=0 (p =2)
- ACM2-A1: acm2opt=1 (p =1.33)
- ACM2-A2: acm2opt=2 (p =2.67)

Note 6: P1 to P3 refers to modifying the MYJ surface exchange coefficient for strong, weak, and f(surface roughness from vegetation)

- MYJ: czilopt=0 (czil=0.1), iz0tlnd=0
- MYJ-P1: czilopt=1 (czil=.01), iz0tlnd=0
- MYJ-P2: czilopt=2 (czil=1.0), iz0tlnd=0
- MYJ-P3: czilopt=0, iz0tlnd=1

Table 2. Configurations for each individual member with NMM core

member	IC	BC	Radar data	mp_phy	lw_phy	sw-phy	sf_phy
nmm_cn	00Z ARPSa	00Z NAMf	yes	Ferrier	GFDL	GFDL	Noah
nmm_m2	nmm_cn + em-n2_pert	21Z SREF em-n2	yes	Ferrier+	GFDL	GFDL	Noah
nmm_m3	nmm_cn + nmm-n1_pert	21Z SREF nmm-n1	yes	Thompson	RRTM	Dudhia	Noah
nmm_m4	nmm_cn + nmm-n2_pert	21Z SREF nmm-n2	yes	WSM 6-class	RRTM	Dudhia	RUC
nmm_m5	nmm_cn + em-n1_pert	21Z SREF em-n1	yes	Ferrier	GFDL	GFDL	RUC

* For all members: *pbl_physics*=MYJ; *cu_physics*= NONE
** Ferrier+ refers to a subset of changes in the updated version now in NEMS/NMMB

Table 3. Configurations for each individual member with ARPS

member	IC	BC	Radar data	Microphy.	radiation	sf_phy
arps_cn	00Z ARPSa	00Z NAMf	yes	Lin	Chou/Suarez	Force-restore
arps_c0 (18h)	00Z ARPSa	00Z NAMf	no	Lin	Chou/Suarez	Force-restore
arps_c10 (18h)	10-min cycle ARPSa	00Z NAMf	yes	Lin	Chou/Suarez	Force-restore
arps_c30 (18h)	30-min cycle ARPSa	00Z NAMf	yes	Lin	Chou/Suarez	Force-restore

* For all members: no cumulus parameterization

Table 4. Configurations for each individual member with COAMPS

member	IC	BC	Radar data	Microphy.	radiation	sf_phy
cmps_cn	00Z ARPSa	00Z NAMf	yes	-	-	-
cmps_c0	00Z NAMa	00Z NAMf	no	-	-	-

* For all members: no cumulus parameterization

**** Members in red are contributing members for HWT (24-25 totals).**

3.2 High-resolution (1 km) deterministic forecast

One 1 km grid spacing forecast over the same ARW domain as the 4 km ensemble (**Grid 3**) will be produced **in non-realtime mode**, using the same physics configuration as the control member *arw_cn*. The forecast is initialized from 00 UTC and last 36 h. For the 2011 season, the 1-km ARPS 3DVAR and cloud analysis will still be performed in realtime, using the same data set as on the 4 km grid. NAM 00 UTC analysis is used as the background and its forecasts are used to provide the LBC.

The 1 km runs will be performed on Kraken (or Athena) in non-realtime mode.

4. Logistics

- Up to 9800 NICS ***Athena*** cores are used for producing realtime 4-km ensemble forecasts, with 120 core for each 4 km NMM member and the ARW members using Ferrier microphysics, and 144 cores each for all other ARW members. All ensemble members are run in parallel and complete in 6-8 hours. An additional 24 cores per member are used for post-processing, running side by side, processing model output when they are produced. ARPS members are using 600 cores plus 24 for post-processing for each member. 1 km forecast will not be run in realtime mode, requiring 12800 NICS ***Kraken*** cores plus 320 cores for post processing.

- The ensemble forecasts are output every hour, and converted to ARPS grid in HDF4 format in high compression (on Grid 3). Hourly gridded output, in native WRF grids (and ARPS grid for ARPS members), are archived at NICS HPSS mass storage for the 4 km ensemble runs and 1 km single runs. Data volume is close to **7 TB** per day on ***Athena*** luster system, while the HPSS archive data are roughly 60% the total size..

5. Forecast Product and Deliverables to HWT

5.1 Products available to HWT (NSSL/SPC, DTC, HPC) in GEMPAK

The NSSL/SPC required list of forecast fields for 2011 HWT Spring Experiment is in Table 5. Variables with field name underlined are hourly maximum. The variables shaded in green are written out only for the PBL-experiment members (arw_cn, arw_m31~41). This dataset is also available to DTC. The number of variables is 34 for each 4 km ensemble member (42 for those PBL-experiment members).

In order to keep realtime data flow into NSSL/SPC server low, the NSSL/SPC GEMPAK fields are over a sub-domain emphasizing the east part of the CONUS. Figure 3 is the desired sub-domain (860×690 grid points in horizontal). A complete set of extracted 2D fields (Table 7) over the full CONUS domain are archived by CAPS for post-analysis and external collaborations.

Two separate sets of variables are also packaged for NSSL/SPC: 1) composite reflectivity of every 15-min in the first 6 h of the forecasts; 2) a 5-variable subset (P01M, VHEL, REFL1KM, VVELMAX, 15-min REFL1KM) in netcdf.

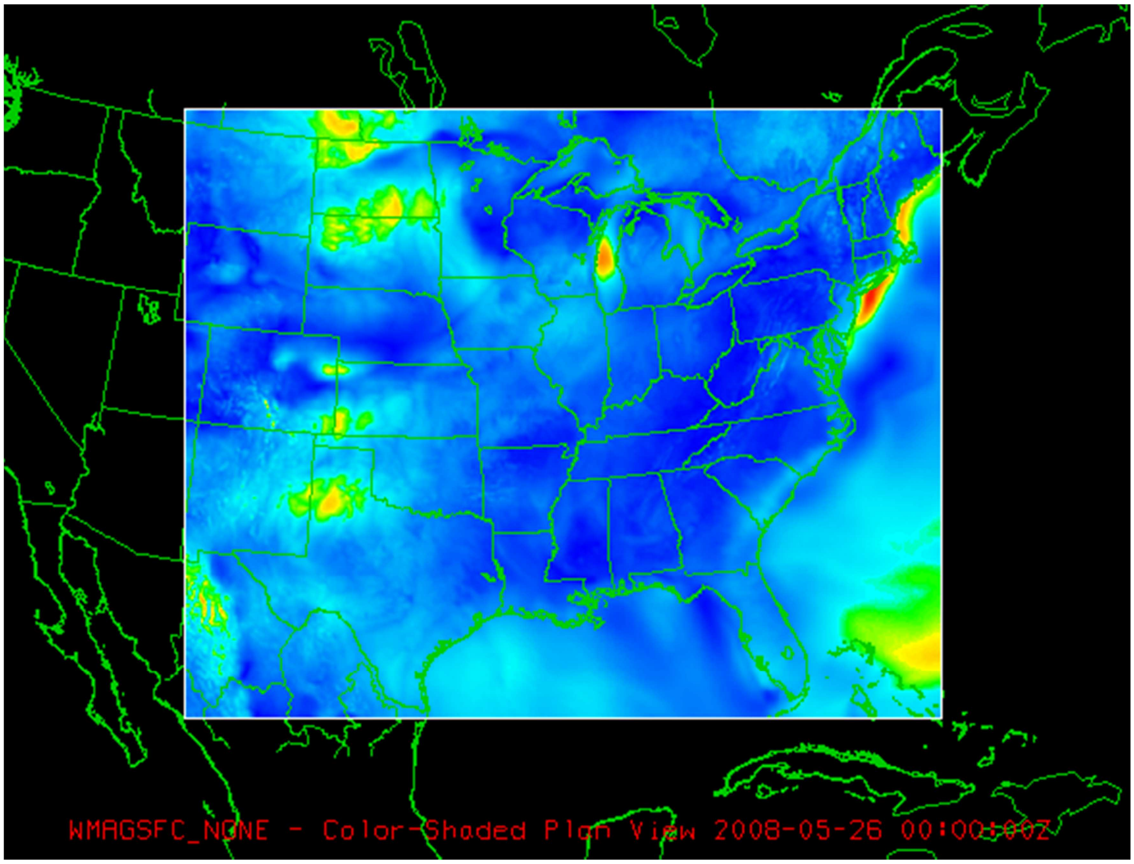

Figure 2. NSSL/SPC sub-domain for the GEMPAK dataset (850×690).

Table 5. 2D fields of each member for NSSL/SPC

Field	GEMPAK name	Unit	Type	Level
Surface pressure	PRES	hPa	Surface/single layer	0
Sea level pressure	PMSL	hPa	Surface/single layer	0
1-h precipitation	P01M	mm	Surface/single layer	0
Temperature at	TMPF	F	Surface/single	0

lowest model level			layer	
Dew point at lowest model level	DWPF	F	Surface/single layer	0
10 m U	UREL	m/s	Surface/single layer	0
10 m V	VREL	m/s	Surface/single layer	0
Surface wind speed (10-m)	WMAGSFC	m/s	Surface/single layer	0
1 km AGL reflectivity	REFL1KM	dBZ	Surface/single layer	0
1 km AGL reflectivity	REFL1KM_HM	dBZ	Surface/single layer	0
Composite reflectivity	REFLCMP	dBZ	Surface/single layer	0
Surface-based CAPE	CAPE	J/kg	Surface/single layer	0
Moist unstable CAPE	MUCAPE	J/kg	Surface/single layer	0
Surface-based CIN	CINS	J/kg	Surface/single layer	0
Moist unstable CIN	MUCINS	J/kg	Surface/single layer	0
Surface-based LCL	HLCL	m	Surface/single layer	0
0-1 km AGL SRH	SRH01	m^2/s^2	Surface/single layer	0
0-3 km AGL SRH	SRH03	m^2/s^2	Surface/single layer	0
Updraft helicity	VHEL	m^2/s^2	Surface/single layer	0
Sfc-400 hPa max W	VVELMAX	m/s	Surface/single layer	0
Sfc-400 hPa min W	VVELMIN	m/s	Surface/single layer	0
0-1 km AGL wind shear	SHR01	1/s	Surface/single layer	0
0-6 km AGL wind shear	SHR06	1/s	Surface/single layer	0
Vertical-integrated Qg	COLQG	kg/ m^2	Surface/single layer	0
Lightning Threat 1	LTG1_MAX	Flashes/km^2/5min	Surface/single layer	0
Lightning Threat 2	LTG2_MAX	Flashes/km^2/5min	Surface/single layer	0

Lightning Threat 3	LTG3_MAX	Flashes/km^2/5min	Surface/single layer	0
1-h precipi. Bias-correct	P01BC	mm	Surface/single layer	0
CI count based on LTG	CI_LTG	Time steps	Surface/single layer	0
CA count based on LTG	CA_LTG	Time steps	Surface/single layer	0
CI count based on w, qr, qg	CI_WQQ	Time steps	Surface/single layer	0
CA count based on w, qr, qg	CA_WQQ	Time steps	Surface/single layer	0
CI count based on >35dBZ at -10°C	CI_REF	Time steps	Surface/single layer	0
CA count based on >35dBZ at -10°C	CA_REF	Time steps	Surface/single layer	0
Temperature at model level 12	TMPC12	C	Surface/single layer	0
Mixing ratio at model level 12	MIXR12	g/kg	Surface/single layer	0
Pressure at model level 12	PRES12	hPa	Surface/single layer	0
u-wind at model level 12	UREL12	m/s	Surface/single layer	0
v-wind at model level 12	VREL12	m/s	Surface/single layer	0
w-wind at model level 12	W12	m/s	Surface/single layer	0
w-wind max at model level 12	WMAX12	m/s	Surface/single layer	0
W12 > 0.25 m/s in the last hour	WDT	Time steps	Surface/single layer	0

5.2 Post-processed ensemble products in GEMPAK

A list of post-processed ensemble products are produced for NSSL/SPC for the 2011 HWT Spring Experiment (see Table 6). The 25 ensemble members contribute to the products, they are:

arw_cn, arw_m4~m20	18-members
nmm_cn, nmm_m2~m5	5-members
arps_cn	1-member
(cmps_cn	1-member)

[24 total members if COAMPS model doesn't run in realtime]

The underlined variables refer to hourly (or 3-hr) maximum. Variables with '*' are also produced from two subsets of ensembles, one with 5 members (arw_cn, nmm_cn, arw_m4, arw_m10, arw_m11) and one with 15 members (same membership as in SE2010: arw_cn, arw_m4~m12, nmm_cn, nmm_m3~m5, arps_cn). The green-shaded variables are computed only from the 18 contributing ARW members. This dataset is also available to DTC and HPC.

Table 6. Ensemble post-processed products for NSSL/SPC

Field	GEMPAK name	Unit	Type	Ens type
Sea level pressure	PMSL	hPa	Surface/single layer	Mean
850 hPa Z	HGHT850	m	Surface/single layer	Mean
500 hPa Z	HGHT500	m	Surface/single layer	Mean
250 hPa Z	HGHT250	m	Surface/single layer	Mean
850 hPa u-wind	UREL850	m/s	Surface/single layer	Mean
850 hPa v-wind	VREL850	m/s	Surface/single layer	Mean
250 hPa u-wind	UREL250	m/s	Surface/single layer	Mean
250 hPa v-wind	VREL250	m/s	Surface/single layer	Mean
500 hPa absolute vorticity	AVORT500	1/s	Surface/single layer	Mean
1-h precip	P01M_PM	mm	Surface/single layer	PM-mean
1-h precip	P01M_M	mm	Surface/single layer	Mean
1-h precip	P01M_MX	mm	Surface/single layer	Max
1-h precip ≥ 0.25 in	PR01MTH1_P	%	Surface/single layer	Prob
1-h precip ≥ 0.50 in	PR01MTH2_P	%	Surface/single layer	Prob
1-h precip ≥ 1.00 in	PR01MTH3_P	%	Surface/single layer	Prob
1-h precip ≥ 0.25 in	PR01MTH1_PN	mm	Surface/single layer	Prob-neighbor (ROI=0, sigma=30)
1-h precip ≥ 0.50 in	PR01MTH2_PN	mm	Surface/single layer	Prob-neighbor (ROI=0, sigma=30)
1-h precip ≥ 1.00 in	PR01MTH3_PN	mm	Surface/single layer	Prob-neighbor (ROI=0, sigma=30)
3-h precip ≥ 0.25-in	PR03MTH1_P	%	Surface/single layer	Prob
3-h precip ≥ 0.5-in	PR03MTH2_P	%	Surface/single layer	Prob
3-h precip ≥ 1.0-in	PR03MTH3_P	%	Surface/single layer	Prob
3-h precip ≥ 0.25-in	PR03MTH1_PN	%	Surface/single layer	Prob-neighbor (ROI=0, sigma=30)

3-h precip ≥ 0.5-in	PR03MTH2_PN	%	Surface/single layer	Prob-neighbor (ROI=0, sigma=30)
3-h precip ≥ 1.0-in	PR03MTH3_PN	%	Surface/single layer	Prob-neighbor (ROI=0, sigma=30)
6-h precip*	P06M_PM	mm	Surface/single layer	PM-mean
6-h precip*	P06M_M	mm	Surface/single layer	Mean
6-h precip*	P06M_MX	mm	Surface/single layer	Max
6-h precip ≥ 0.5-in*	PR06MTH2_P	%	Surface/single layer	Prob
6-h precip ≥ 1.0-in*	PR06MTH3_P	%	Surface/single layer	Prob
6-h precip ≥ 2.0-in*	PR06MTH4_P	%	Surface/single layer	Prob
6-h precip ≥ 0.5-in*	PR06MTH2_PN	%	Surface/single layer	Prob-neighbor (ROI=0, sigma=30)
6-h precip ≥ 1.0-in*	PR06MTH3_PN	%	Surface/single layer	Prob-neighbor (ROI=0, sigma=30)
6-h precip ≥ 2.0-in*	PR06MTH4_PN	%	Surface/single layer	Prob-neighbor (ROI=0, sigma=30)
6-h precip calibrated	P06M_PM_BC	mm	Surface/single layer	PM-mean
6-h precip calibrated	P06M_M_BC	mm	Surface/single layer	Mean
6-h precip calibrated	P06M_MX_BC	mm	Surface/single layer	Max
6-h precip ≥ 0.5-in calibrated	PR06MTH2_P_BC	%	Surface/single layer	Prob
6-h precip ≥ 1.0-in calibrated	PR06MTH3_P_BC	%	Surface/single layer	Prob
6-h precip ≥ 2.0-in calibrated	PR06MTH4_P_BC	%	Surface/single layer	Prob
6-h precip ≥ 0.5-in calibrated	PR06MTH2_PN_BC	%	Surface/single layer	Prob-neighbor (ROI=0, sigma=30)
6-h precip ≥ 1.0-in calibrated	PR06MTH3_PN_BC	%	Surface/single layer	Prob-neighbor (ROI=0, sigma=30)
6-h precip ≥ 2.0-in calibrated	PR06MTH4_PN_BC	%	Surface/single layer	Prob-neighbor (ROI=0, sigma=30)
Lowest model level temp	TMPF	F	Surface/single layer	Mean
Lowest model level dew point	DWPF	F	Surface/single layer	Mean
precipitable water	PWAT	mm	Surface/single layer	Mean
10 m U	UREL	m/s	Surface/single layer	Mean
10 m V	VREL	m/s	Surface/single layer	Mean
1 km AGL reflectivity	REFL1KM	dBZ	Surface/single layer	PM-mean
1 km refl ≥ 40 dBZ*	REFL1KMTH1_PN	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
3-hr max 1 km refl ≥ 40 dBZ*	REFL1KM_3h_PN	dBZ	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)

Composite reflectivity	REFLCMP	dBZ	Surface/single layer	PM-mean
Comp refl ≥ 40 dBZ	REFLCMPTH1_PN	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Surface-based CAPE	CAPE	J/kg	Surface/single layer	Mean
sbCAPE ≥ 500	CAPE05	%	Surface/single layer	Prob
sbCAPE ≥ 1500	CAPE15	%	Surface/single layer	Prob
sbCAPE ≥ 3000	CAPE30	%	Surface/single layer	Prob
Surface-based CIN	CIN	J/kg	Surface/single layer	Mean
sbCIN < -100	CIN100	%	Surface/single layer	Prob
sbCIN < -50	CIN050	%	Surface/single layer	Prob
sbCIN < -25	CIN025	%	Surface/single layer	Prob
Surface-based LCL	HLCL	m	Surface/single layer	Mean
Max Updraft helicity	VHEL	m^2/s^2	Surface/single layer	Max
Updraft helicity ≥ 25 m^2/s^2	VHEL25	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Updraft helicity ≥ 50 m^2/s^2	VHEL50	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Updraft helicity ≥ 100 m^2/s^2	VHEL100	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Max Updraft helicity (3-hr)	VHEL_3h	m^2/s^2	Surface/single layer	Max
Updraft helicity (3-hr) ≥ 25 m^2/s^2*	VHEL25_3h	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Updraft helicity (3-hr) ≥ 50 m^2/s^2*	VHEL50_3h	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Updraft helicity(3-hr) ≥ 100 m^2/s^2	VHEL100_3h	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Max sfc-400 hPa W	VVELMAX	m/s	Surface/single layer	Max
Max sfc-400 hPa W ≥ 10 m/s	VVELMAX10	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Max sfc-400 hPa W ≥ 15 m/s	VVELMAX15	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Max 3-6 km W ≥ 20 m/s	VVELMAX20	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Max sfc-400 hPa W (3-hr)	VVELMAX_3h	m/s	Surface/single layer	Max
Max sfc-400 hPa W (3-hr) ≥ 10 m/s*	VVELMAX10_3h	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Max sfc-400 hPa W (3-hr) ≥ 15 m/s*	VVELMAX15_3h	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Max 3-6 km W (3-hr) ≥ 20 m/s	VVELMAX20_3h	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)

0-1 km AGL wind shear	SHR01	1/s	Surface/single layer	Mean
0-1 km AGL wind shear ≥ 10 m/s	SHR01_10	%	Surface/single layer	Prob
0-1 km AGL wind shear ≥ 15 m/s	SHR01_15	%	Surface/single layer	Prob
0-1 km AGL wind shear ≥ 20 m/s	SHR01_20	%	Surface/single layer	Prob
0-6 km AGL wind shear	SHR06	1/s	Surface/single layer	Mean
0-6 km AGL wind shear ≥ 15 m/s	SHR06_15	%	Surface/single layer	Prob
0-6 km AGL wind shear ≥ 20 m/s	SHR06_20	%	Surface/single layer	Prob
0-6 km AGL wind shear ≥ 25 m/s	SHR06_25	%	Surface/single layer	Prob
Vertical-integrated Qg	COLQG	kg/ m^2	Surface/single layer	Max
Vertical-integrated Qg ≥ 20	COLQG20	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Vertical-integrated Qg ≥ 30	COLQG30	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Vertical-integrated Qg ≥ 40	COLQG40	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Vertical-integrated Qg (3-hr)	COLQG_3h	kg/ m^2	Surface/single layer	Max
Vertical-integrated Qg (3-hr) ≥ 20	COLQG20_3h	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Vertical-integrated Qg (3-hr) ≥ 30	COLQG30_3h	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Vertical-integrated Qg (3-hr) ≥ 40	COLQG40_3h	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Surface wind speed (10-m)	WMAGSFC	m/s	Surface/single layer	Max
Surface wind speed (10-m) ≥ 15 m/s	WMAGSFC15	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Surface wind speed (10-m) ≥ 20 m/s	WMAGSFC20	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Surface wind speed (10-m) ≥ 25 m/s	WMAGSFC25	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Surface wind speed (10-m) (3-hr)	WMAGSFC_3h	m/s	Surface/single layer	Max
Surface wind speed (10-m) (3-hr) ≥ 15 m/s	WMAGSFC15_3h	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Surface wind speed (10-m) (3-hr) ≥ 20 m/s	WMAGSFC20_3h	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Surface wind speed (10-m) (3-hr) ≥ 25 m/s	WMAGSFC25_3h	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Significant Tornado Parameter ≥ 1	SIGTOR1	%	Surface/single layer	Prob
Significant Tornado Parameter ≥ 3	SIGTOR3	%	Surface/single layer	Prob
Significant Tornado Parameter ≥ 5	SIGTOR5	%	Surface/single layer	Prob

Supercell Comp. Parameter ≥ 1	SCP1	%	Surface/single layer	Prob
Supercell Comp. Parameter ≥ 3	SCP3	%	Surface/single layer	Prob
Supercell Comp. Parameter ≥ 9	SCP9	%	Surface/single layer	Prob
W12 ≥ 0.5 m/s	W12P	%	Surface/single layer	Prob-neighbor (ROI=0, sigma=5)
MIXR12 ≥ 9 g/kg	Q09P	%	Surface/single layer	Prob
MIXR12 ≥ 12 g/kg	Q12P	%	Surface/single layer	Prob
MIXR12 ≥ 15 g/kg	Q15P	%	Surface/single layer	Prob
Lightning Threat 3 ≥ 0.02 flashes/km^2/5min	LIGT3_0.02	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Lightning Threat 3 ≥ 0.5 flashes/km^2/5min	LIGT3_0.5	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Lightning Threat 3 ≥ 1.0 flashes/km^2/5min	LIGT3_1.0	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Lightning Threat 3 ≥ 3.0 flashes/km^2/5min	LIGT3_3.0	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Lightning Threat 3 ≥ 6.0 flashes/km^2/5min	LIGT3_6.0	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)

5.3 Products extracted and archived as 2D HDF4 files

5.4 Name convention

SPC/NSSL file name *CAPS web name*

ARW members:

ssef_s4cn_arw_2011041500 SPC4-EF CN WRFARW Fcst

ssef_s4c0_arw_2011041500 SPC4-EF C0 WRFARW Fcst

ssef_s4cc_arw_2011041500 SPC4-EF CC WRFARW Fcst

ssef_s4m4_arw_2011041500 SPC4-EF M4 WRFARW Fcst

ssef_s4m5_arw_2011041500 SPC4-EF M5 WRFARW Fcst

ssef_s4m6_arw_2011041500 SPC4-EF M6 WRFARW Fcst

ssef_s4m7_arw_2011041500 SPC4-EF M7 WRFARW Fcst

ssef_s4m8_arw_2011041500 SPC4-EF M8 WRFARW Fcst ssef_s4m9_arw_2011041500 SPC4-EF M9 WRFARW Fcst

ssef_s4m10_arw_2011041500 SPC4-EF M10 WRFARW Fcst

ssef_s4m11_arw_2011041500 SPC4-EF M11 WRFARW Fcst

ssef_s4m12_arw_2011041500 SPC4-EF M12 WRFARW Fcst

ssef_s4m13_arw_2011041500 SPC4-EF M13 WRFARW Fcst

ssef_s4m14_arw_2011041500 SPC4-EF M14 WRFARW Fcst

ssef_s4m15_arw_2011041500 SPC4-EF M15 WRFARW Fcst

ssef_s4m16_arw_2011041500 SPC4-EF M16 WRFARW Fcst

ssef_s4m17_arw_2011041500 SPC4-EF M17 WRFARW Fcst

ssef_s4m18_arw_2011041500 SPC4-EF M18 WRFARW Fcst

ssef_s4m19_arw_2011041500 SPC4-EF M19 WRFARW Fcst

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ssef_s4m41_arw_2011041500 SPC4-EF M41 WRFARW Fcst

NMM members:

ssef_s4cn_nmm_2011041500 SPC4-EF CN WRFNMM Fcst

ssef_s4m2_nmm_2011041500 SPC4-EF M2 WRFNMM Fcst

ssef_s4m3_nmm_2011041500 SPC4-EF M3 WRFNMM Fcst

ssef_s4m4_nmm_2011041500 SPC4-EF M4 WRFNMM Fcst

ssef_s4m5_nmm_2011041500 SPC4-EF M5 WRFNMM Fcst

1-km run:

ssef_spc1_2011041500 SPC1 WRF Fcst

ARPS members:

ssef_arps_cn_2011041500	SPC4-EF CN ARPS Fcst
ssef_arps_c0_2011041500	SPC4-EF C0 ARPS Fcst
ssef_arps_c10_2011041500	SPC4-EF C10 ARPS Fcst
ssef_arps_c30_2011041500	SPC4-EF C30 ARPS Fcst

COAMPS members:

ssef_cmps_cn_2011041500	SPC4-EF CN COAMPS Fcst
ssef_cmps_c0_2011041500	SPC4-EF C0 COAMPS Fcst

Ensemble summary product:

ssef_s4ens_2010043000	(25-member)
ssef_s4ens15_2010043000	(15-member)
ssef_s4ens5_2010043000	(5-member)