MDE Product Development Team
August 2012 Monthly Report – FY 2012
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(Compiled and edited by S. Benjamin and B. Johnson)

Executive Summary

Task 12.5.4: Develop, test, implement and improve the Rapid Refresh (RAP)

- RAP at NCEP continues to run without any problems during August.
- RAP version 2 running at GSD, yielding improved upper-air wind/temp/RH forecasts over RAP-NCEP. The same is true for surface moisture and precipitation forecasts, and ready for transfer to NCEP EMC.
- Further changes in testing in development (not primary) ESRL RAP including data assimilation and modeling improvements. All of these will be included in final Rapid Refresh v2 (RAPv2) with implementation at NCEP, now proposed for June 13 after NCEP moratorium.
- RAP-dev3 cycle (identical code with Jet RAPv2) running on new NOAA research high performance computing system, ZEUS, supporting a parallel 3-km HRRR on that machine, also 2D RTMA surface analysis application using HRRR forecast as background.

Task 12.5.5: Develop/test/implement improvements to operational data assimilation supporting RAP/NAM

- RAP retrospective experiments to examine impact of moisture pseudo-observations on RAP forecasts
- Successful run of RTMA 2DVAR surface analysis using HRRR 3km 1h forecast as background using detailed RTMA-appropriate background error covariance file from NCEP.
- Initial work to process atmospheric motion vector (sat cloud-drift) winds in preparation for retrospective data impact tests.
- Continued work to port code for ingesting SATcast CI indicators from RUC 3DVAR top GSI 3DVAR

Task 12.5.8: Improve physical processes in WRF (RAP and HRRR) and NAM models, especially for icing

- Discussions with Greg Thompson and RAP/HRRR team on WRF physics, including cloud physics.
- Testing to correct bug in WRF regarding lack of radiation effects from snow mixing ratio in atmosphere, which has been contributing to a daytime warm bias in the RAP and HRRR at the surface.
- Testing continues of GSD/Olson version of MYNN PBL scheme.

Task 12.5.24: Develop / test / implement improved 3-km HRRR

- Continued good HRRR performance and reliability during Aug. 2012
- Improvement made to the HRRR post-processing code (in UNIPOST) to reduce low echo top bias.
- Retrospective testing to evaluate forecast impact from interaction of snow hydrometeors with shortwave radiation.

Task 12.5.4 Develop, test, implement, and improve the Rapid Refresh

ESRL/GSD

Task 5.4 involves the integrated testing and development of the model, assimilation, post-processing, and script components of the Rapid Refresh. While some changes in the RAP may fall specifically with assimilation (Task 5.5) or model physical parameterizations (Task 5.8), under this task we consider the full-integrated effects of all components of the RAP. The changes and problem areas listed below involved such cross-component investigation and testing.

The operational RAP at NCEP ran without any technical problems (including with the post-processing) during August. The RAP has continued to improve reliability over the previous RUC at NCEP.

GSD continues to evaluate the updated RAP version 2 at ESRL with significant data assimilation and modeling modifications brought to completion in March 2012 and discussed in previous MDE reports. For the month of August, the ESRL RAPv2 continues to show improvements over the operational RAP running at NCEP. This has been confirmed by independent evaluation by the Storm Prediction Center (SPC) for surface temperature and dew point and has prompted SPC to request implementation of RAPv2 prior to the 2013 convection season. A decision on this by the NCEP director is pending.

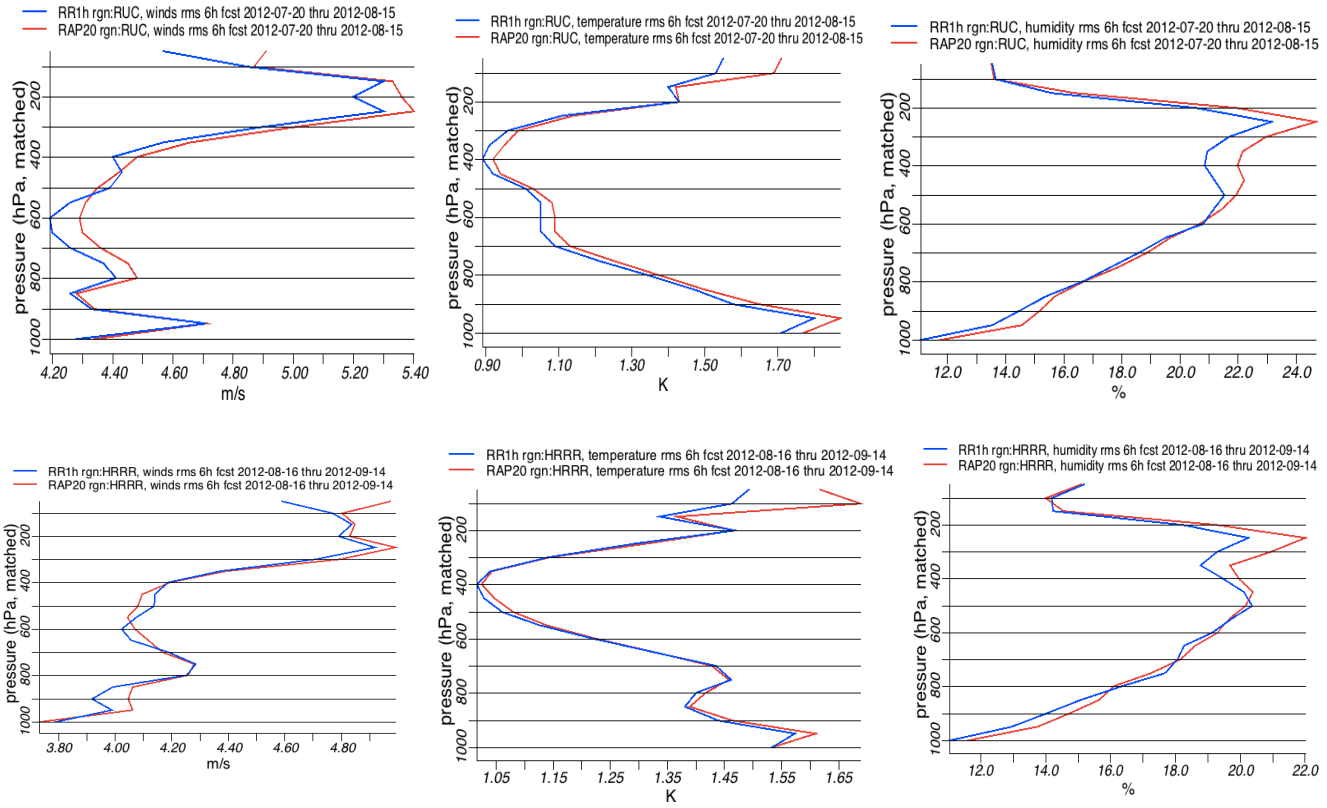

Figure 1. Last 2 months of verification of RAP upper-air 6h forecasts from RAP-ESRL (in blue) and RAP-NCEP-oper (in red) against rawinsonde observations for 20 July – 15 August 2012 on top line and for 16 Aug – 14 Sept 2012 on lower line. The 3 graphics are for wind (left), temperature (center), and RH (right).

In Fig. 1 (above), the RAPv2 (RAP-ESRL) continues to show better accuracy (smaller error vs. raobs) at almost all levels for all 3 of the main upper-air variables – wind (left), temperature (center), and relative humidity (right) in the most recent 30 day period (lower row) and that reported last month (top row). (Dew point verification below repeated from last month but worth noting) GSD also found that surface dew point forecasts (critical for thunderstorm environment) showed lower (generally 0.2-0.5K) RMS error (verified against METAR observations,

Fig. 2 on left)) and smaller bias (Fig. 2, on right). RAPv2 and RAP-oper both show a diurnal cycle in dew point bias (moist from afternoon through evening (21z-05z) and dry in late night (08z-12z). But the afternoon moist bias is much smaller with RAPv2. It is interesting to see these positive results for the July-August period.

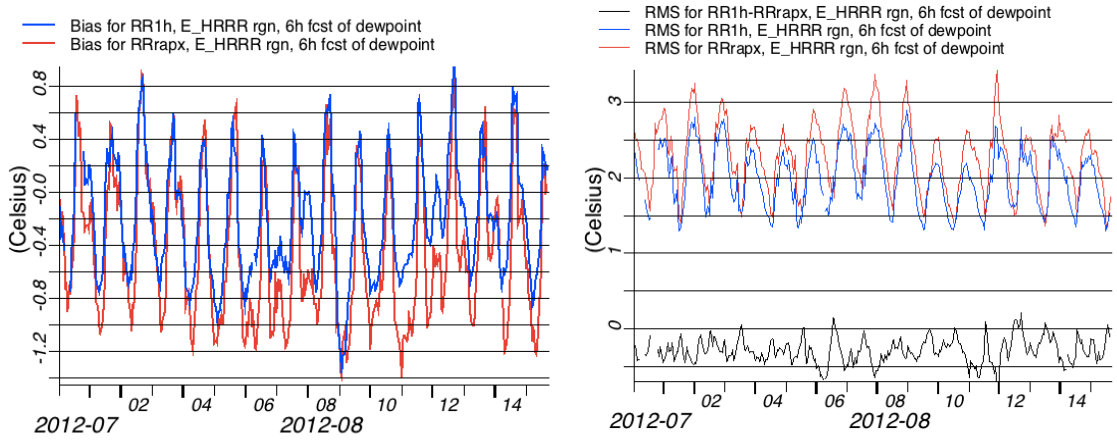

Figure 2. Verification of RAP 6h dew point forecasts RAP-ESRL (in blue) and RAP-NCEP-oper (in red) against METAR observations. Bias (defined as forecast minus observation – negative means moist bias) is shown on left, and RMS difference (smaller is better) is shown on right.

The main accomplishment this month was getting WRFV3.4.1, officially released by NCAR on 16 August, running on Jet and Zeus in testing of the RAP and HRRR. Because there are critical parts of the RAP code that are not yet part of the NCAR WRF repository (particularly the DFI and enhancements within the model code to generate specialized fields requested by the SPC and others), this entailed merging the new V3.4.1 code with the RAP WRFV3.3.1 repository code at GSD as well as overcoming the usual types of run-time issues encountered when attempting to run new codes on Zeus and Jet. Tanya Smirnova and others completed this task in late August and a cold start (no cycling, initialized with GFS) has been running stably on Zeus. Beyond this, Tanya is working with Steve Peckham to prepare the DFI code for inclusion into the NCAR WRF repository. Further, Xue Wei found that the 10m wind components coming out of Unipost were on the original u and v grid points of the Arakawa C grid instead of being de-staggered to the mass points. This bug was fixed for the GSD RAP and HRRR runs.

Work continued toward completing the set-up of RAP cycles, as well as a RUC development cycle on Zeus, the supercomputer at the NOAA Environmental Security Computing Center (NESCC) in West Virginia. While the RAP and HRRR code is running well, Zeus does not yet allow reservations of jobs to run at specific times as provided on Jet where the current HRRR runs. A capability for reservations on Zeus is expected to be added in October. Until that time, we cannot run real-time cycles effectively on Zeus, which is slowing up our progress.

Looking farther ahead, we are developing plans for further improvements for both assimilation and model in fall 2012 to be tested once our *Zeus* RAP cycles are more stable and the summer 2012 CoSPA freeze period for the GSD RAP primary cycle feeding the HRRR ends (30 October). These include modifications to model physics, cloud assimilation, soil adjustment, and radar assimilation. Comparison of the RAP-customized version of WRFV3.4.1 to the present WRF3.3.1 being used for RAPv2 will also be performed.

12.5.4.1 Ongoing (NCEP, GSD)
Maintain hourly RAP runs and provide grids of SAV and AHP guidance products.

NCEP
Work continues at ESRL/GSD to prepare the first update to the RAP, featuring new versions of the WRF-ARW and GSI analysis code. With the upcoming NCEP moratorium on implementations, this upgrade is not likely to be scheduled until mid-calendar year 2013. (Geoff Manikin)

About 80% of the SODARs (wind profilers are not getting into the RAPv1 because they do not get to NCEP in time for the RAP dumps. A "Request for Change" has been submitted to NCEP/NCO to modify the system to prevent outages in the LaRC GOES cloud data when LaRC switches to their backup server. Special ESRL-RAPv2 PREPBUFR files from early and partial cycle RAP runs are still not being copied to the private ftpprd GSD area. Three ESRL-RAPv2 SODARs (AN2NE, LD2ND, and JY2MN) at critical times past the hour continue to consist of only three (lowest) levels in the PREPBUFR files. Investigations are underway why these reports are truncated in the NCEP dumps but are complete in the ESRL processing. These three sites, as well as WFIP sites BD2TX, CC2TX, JTNTX, and SUXIA (RASS and wind profiler), were all added to the NCEP reject list on 9 August. The ESRL-RAPv2 does not reject these sites. The GSD MADIS server was down intermittently 13 and 24 August. Work is beginning to prepare data for the 2011 Winter quarter WFIP data denial experiments, which will cover WFIP profiler, sodar and RASS data for the period 30 Nov - 6 Dec 2011. (Dennis Keyser)

GSD
GSD was also involved in investigations with NCEP on issues regarding availability of profiler and sodar data. A brief delay to the Rapid Refresh at NCEP occurred for the 00z run on 1 August from a problem in aircraft processing at NCEP. NCEP quickly resolved this problem. GSD confirmed that the ESRL RAP was also affected (and the subsequent HRRR) run. GSD and NCEP continue to work to improve the early observational dump for the 00z and 12z RAP runs at ESRL to initialize the HRRR. In fact, the HRRR has had no non-radar data available for its 00z and 12z runs since 1 May when the RUC stopped running and early obs dumps had ended at that point. This point is pointed out in a new FAQ webpage for the HRRR at **http://ruc.noaa.gov/faq/HRRR.faq.html**.

12.5.4.2 Ongoing (NCEP, GSD)
Provide vendors with gridded model data via Family of Services and the FAA Bulk Weather Data Telecommunications Gateway.

NCEP
NCEP maintained real-time availability of SAV and AIV guidance to all vendors from the operational hourly RAP on pressure surfaces via the NWS Family of Services (FOS) data feed and via the FAA Bulk Weather Data Telecommunications Gateway (FBWDTG). (EMC&NCO)

12.5.4.3 Ongoing (NCEP, GSD)
Provide full grids from RAP runs on NCEP and NWS/OPS servers.

NCEP
NCEP maintained real-time availability of full resolution gridded data from the operational RAP runs via anonymous ftp access via the NCEP server site at **ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/rap/prod/** and at the NWS/OPS site at **ftp://tgftp.nws.noaa.gov/SL.us008001/ST.opnl/** in hourly directories named MT.rap_CY.00 through MT.rap_CY.23. This includes hourly BUFR soundings and output grids, which undergo no interpolation. Both sites now contain only grids in GRIB2 format **http://www.nco.ncep.noaa.gov/pmb/docs/GRIB1_to_GRIB2.shtml**. Gridded RAP fields are now also available on **NOMADS** for the CONUS domain on 13 km grid #130 and the larger North American domain on 32 km grid #221. A limited set of fields from the RAP runs (and other NCEP models) can also be viewed at **http://mag.ncep.noaa.gov/NCOMAGWEB/appcontroller**. (EMC & NCO). GSD continues to monitor these runs on various real-time verification applications against rawinsondes (balloons), surface observations, and precipitation observations (**http://ruc.noaa.gov/stats**).

12.5.4.4 Ongoing (NCEP, GSD)
Maintain access to model verification data.

NCEP
NCEP maintained its capability and provided access to routine verifications of the operational RUC analyses and forecasts until the RAPv1 implementation on 1 May, and after that to the operational RAP. These include grid-to-station verifications versus rawinsonde, surface, aircraft, Profiler, and VAD data computed periodically at NCEP and accessible via NCEP's Mesoscale Modeling Branch (MMB) website:

http://www.emc.ncep.noaa.gov/mmb/research/meso.verf.html (EMC/MMB).

12.5.4.5 Ongoing (GSD, NCEP)
Ongoing evaluation of performance of real-time and retrospective runs of RAP system for SAVs, AHPs

GSD
GSD's verification of the RAP is available from **http://ruc.noaa.gov/stats** . These stats were the basis for Figures 1 and 2 showed earlier in this report.

NCEP
Performance of the Rapid Refresh is being routinely monitored. (Manikin)

12.5.4.6 Delayed to 1 Feb 2013 (ESRL, NCEP)
Initial software for RAPv2 changes ready for porting to EMC.

GSD
The RAPv2 version running at GSD continues to perform well and has strong promise of fixing the most serious operational RAPv1 issues.

NCEP
Delays in the initial RAPv1 implementation will delay the RAPv2 upgrade until after the moratorium, likely no sooner than June 2013. (Manikin)

12.5.4.7 31 Jan 2012 **(ESRL)**
Complete testing and evaluation at ESRL of new Rapid Refresh capabilities in model physics (see 12.5.8) and data assimilation (see 12.5.5, 12.5.15) toward consideration in the upgrade to the RAP (RAPv2) at NCEP in 2013.

COMPLETE - The configuration of the Rapid Refresh (RAP-primary at ESRL) for the summer 2012 has been set since mid-March. This version of the RAP is nearly equivalent to the RAPv2 version envisioned for NCEP by late 2012 (postponed to 2013 due to upcoming NCEP moratorium). We therefore call this task "complete", but other smaller changes may yet be added at a later time before code for the RAPv2 is transferred to NCEP/EMC later in 2012 or early 2013.

12.5.4.8 31 May 2012 **(ESRL, NCEP)**

ESRL-GSD
Start design of NARRE ARW and NMM model ensembles. Use of ensemble/hybrid data assimilation, likely augmented by different physics suites, provides variability for the ARW and for the NMMB. Work at ESRL, CAPS (not funded currently) and EMC on regional ensemble data assimilation (see 5.5) is critical for improved deterministic and probabilistic forecasts from the NARRE. Part of this subtask will be to do the experiments necessary to decide which of these alternatives gives the more useful ensemble diversity for aviation application, by means of real-time and retrospective testing on the RAP domain. (31 May 12)

GSD
In work initiated in May, Ming Hu reports progress toward adaptation of the GSI ensemble/variational hybrid capability toward use with the RAP. Both GSD and NCEP/EMC agree that hybrid ensemble data assimilation is critical for the NARRE. A presentation was developed on NARRE/HRRRE plans by Stan Benjamin for a DTC/NUOPC Workshop in September. Further discussions on NARRE design will occur in October between GSD and NCEP.

NCEP
Label errors in the NARRE-TL system (implemented concurrently with RAP in May) for reflectivity probability and precipitation accumulation were fixed, and an RFC (Request for Change) for the fixes was filed with NCO. Routine grid-to-grid verifications of NARRE's visibility, reflectivity and icing probability products against new 2.5km

RTMA's visibility data, MOSAIC composite reflectivity data, and AWC's ADDS-CIP data were built. Routine grid-to-grid verifications of surface winds for both NARRE and downscaling SREF against 5km RTMA surface winds were also built. On 21 August the NCEP SREF system was upgraded to output new aviation products like low-level wind shear, composite reflectivity, echo top, and ceiling/visibility. (BinBin Zhou and Jun Du)

12.5.4.9 12 Dec 2012 (ESRL, NCEP)
Complete testing at EMC of RAPv2 code, pending NCEP readiness.

NCEP
RAP V2 is delayed due to the late implementation of RAP V1 and the upcoming NCO moratorium on model changes. ESRL has provided code to EMC for the GSI, and it will be tested by EMC in the new computer environment this summer. Initial tests show that the code update leads to better fits to RAOB data and overall model improvement. Implementation is not likely to occur prior to June 2013. (Manikin)

12.5.4.9a Submit Request for Change (RFC) and modified codes for RAPv2 from EMC to NCO, pending NCEP readiness. (15 Jun 12)

RAPv2 is delayed due to the late implementation of RAPv1 and the upcoming NCO moratorium on model changes. (Manikin)

12.5.4.10 Commence work toward rendering RAP code, including potential physics suite options, operable within the NEMS (NOAA Environmental Modeling System, which is based on the Earth System Modeling Framework (ESMF), in compliance with the Sept 2007 Rapid Refresh MOU between NCEP and GSD. (1 Jul 12) - Request: Defer until Jan 2013

GSD: Work on this project (modification of WRF-ARW to use NEMS/ESMF) will begin [at ESRL/GSD] when GSD's efforts with NEMS on the FIM global model are complete, a higher priority to allow incorporation FIM into a NEMS-based experimental global ensemble at NCEP.
ESRL continues to work primarily on bringing the FIM global model into NEMS compliance and working with NCEP to make further modifications to NEMS. NEMS design for the global model will set the direction for making ARW NEMS-compatible. Based on this prioritization, Jan 2013 is a more realistic date for this task (S. Benjamin)

12.5.4.11 Present improved plan for bringing ARW model code into compliance with then current version of NEMS. (30 Sep 12)

GSD: Discussions continue at GSD on how to provide use ARW within NEMS.

Deliverables
All Option A unless noted otherwise.

12.5.4.E1 20 Dec 2011 (ESRL)
Report on Rapid Refresh status and plans to NCEP Operational Model Production Suite Review meeting.

Complete. Stan Benjamin and Steve Weygandt made a joint presentation on the RAP / HRRR status at this review, held 6-7 December at NCEP.

COMPLETE. Available at **http://www.emc.ncep.noaa.gov/GEFS/prod-review/NCEPmodelReview-2011.html**

12.5.4E2 (1 Feb 12) (Manikin)
Update documentation for operational Rapid Refresh.
CURRENT EFFORTS: A National Weather Service Technical Implementation Notice (TIN) concerning the RUC to Rapid Refresh transition was amended to change the implementation date to Tuesday May 1, 2012. It can be found at **http://www.nws.noaa.gov/os/notification/tin12-06updates_aids-aac.htm**. The document also

contains an overview of the model and explanation of the differences between the RUC and RAPv1. The Rapid Refresh was implemented at NCEP on 1 May to replace the Rapid Update Cycle. (Manikin)

PLANNED EFFORTS: Item is completed.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: None.

12.5.4E3 (1 Apr 12) (Manikin)
Final code ready for transfer to EMC for Rapid Refresh upgrade change package to be implemented in spring 2012.

CURRENT EFFORTS: Work on this project will begin now that RAPv1 model was implemented at NCEP on 1 May. (Manikin)

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: Delays in the initial RAPv1 implementation will delay the RAPv2 upgrade until after the moratorium, likely no sooner than June 2013. Move this deadline to **1 March 2013**.

12.5.4.E4 (**30 Mar 12)** **(ESRL)**
Report on testing of RAP assimilation/model improvements toward planned RAPv2 upgrade.

COMPLETE. Extensive testing complete or underway for frozen RAPv2 for summer 2012 CoSPA/HRRR.

NCEP
12.5.4E5 (modified to 31 May 12) (Manikin)
Pending computer resource availability, complete testing at EMC of Rapid Refresh version 2 changes to operational RAP at NCEP.

CURRENT EFFORTS: Work on this project will begin now that RAPv1 model was implemented at NCEP on 1 May. (Manikin)

UPDATES TO SCHEDULE: Delays in the initial RAPv1 implementation will delay the RAPv2 upgrade until after the moratorium, likely no sooner than June 2013. Move this deadline to 30 June 2013.

12.5.4E6 (30 Sep 12) (Manikin)
Perform configuration management for Rapid Refresh, including thorough documentation, and respond promptly to any code malfunctions or performance issues.
CURRENT EFFORTS: The Rapid Refresh was implemented at NCEP on 1 May to replace the Rapid Update Cycle. A thorough documentation of the Rapid Refresh codes and downstream dependencies is found in the Technical Implementation Notice found at **http://www.nws.noaa.gov/os/notification/tin12-06updates_aids-aac.htm**. (Manikin)

PLANNED EFFORTS: Implementation of the RAPv2 will have to wait until after the moratorium during which all of NCEP Production has to be moved to the new computer system. The moratorium is expected to last from September 2012 through at least the end of May 2013.

UPDATES TO SCHEDULE: None.

12.5.4E7 (30 Sep 2012) (Manikin)
Monitor Rapid Refresh performance, respond to any problems detected by ESRL, NCEP, or any RAP users, diagnose cause, and develop solution to RAP software, test changes and coordinate with NCO on implementation.

CURRENT EFFORTS: The Rapid Refresh was implemented at NCEP on 1 May to replace the Rapid Update Cycle. RAP performance is being monitored daily. (Manikin)

PLANNED EFFORTS: Convert RAPv1 to new NCEP computer then bring in RAPv2 for testing and implementation in FY13.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED: Since RAP is developed on a Linux based computer at ESRL/GSD, no problems are anticipated.

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: None.

12.5.4.E8 30 Nov 2012 (ESRL/GSD)
Report on overall planned changes for the FY13 upgrade to the Rapid Refresh.

This date was further delayed a bit given the likely RAPv2 NCEP implementation schedule, although the already-completed RAPv2 reports for the summer 2012 HRRR constitute a preliminary report.
UPDATES TO SCHEDULE: Changed from previous 30 Sept to 30 Nov.

Task 12.5.5 Develop, test, and implement improvements to the operational data assimilation supporting Rapid Refresh and North American Mesoscale runs.

ESRL/GSD
A major focus In August was scoping out RAP assimilation development and testing work for this fall (once the ESRL/GSD real-time experimental RAP / HRRR is released from the code freeze for the 2012 convective season evaluation. This was discussed at status / planning meeting and an update is as follows:

1. Ming Hu is working to update RAP top latest trunk version of GSI. He has run RAP with a June 2012 trunk version of GSI, so the switch should be pretty straightforward.
2. Discussions have taken place with Tom Auligne (NCAR) about a new version of the GEN_BE program that will be used to help generate a new set of RAP background error covariances, using an archive of RAP forecast files that have been saved.
3. Results from Patrick Hoffman's retrospective tests with reduced values for the specified raob observation errors showed better analysis fit to raobs, but a slight increase in forecast errors (both parts were expected). We will repeat this test with the reduction in raob observation errors restricted to the lower levels, in hopes captured detailed near surface structure in the raobs, without the adverse affect on forecast skill.
4. Haidao Lin continued his work on bias correction for the satellite radiance assimilation, completing a 2-month spin-up test. Results show reasonable spin-up for some bias predictors, for some channels of some instruments, but slow / poor spin-up for others. The reason for this is thought to the limited coverage (in both time and space) for these polar orbiter satellite observations. Follow-up experiments show that these self-spun-up bias correction coefficients, give results that compete favorably with experiments that start with bias correction taken from the GFS or NAM.
5. Work continued to ingest several new datasets into the RAP including a new form of the SATcast convective initiation indicator dataset.
6. Work continued by Patrick Hofmann in enhancing an RTMA analysis with a special 2DVAR form of the GSI applied to a 3-km HRRR grid. Patrick obtained a new little endian version of the anisotropic background error covariance file from Manuel Pondeca and did some tests on the 3-km grid. Results show more detail in the analysis increments, especially of the complex terrain of the west.

a. GSD will start to run a 3km RTMA with HRRR background in real-time this fall with the expectation this can subsequently run every 15 min to replace the current STMAS analysis used for a graphical frontal product that is provided in CoSPA. The 15-min RTMA/HRRR analysis will then benefit with wider NOAA/NWS collaboration.

Subtasks

12.5.5.1 31 Dec 2011 (GSD)
Further refinement to the radial velocity analysis component of GSI for Rapid Refresh 2 configuration.

Results from inclusion of radial velocity data assimilation in parallel versions of the RAP are still generally neutral, resulting in its inclusion in the early March frozen version of the RAP. Some further bird-QC refinement may yet be needed – will report more next month.

12.5.5.1a 30 Oct 2012 (ESRL, NCEP)
Complete preparation of initial GSI changes for RAPv2 changes ported to EMC.
Work will begin on RAPv2 after the RAPv1 is implemented in May 2012. (Wu, Parrish)

ESRL
Work on RAPv2 was delayed, due to delays in implementation of RAPv1 (completed May 1, 2012). Considerable work on this occurred during Oct 11 – Mar 12 at GSD. A nearly complete version 2 of the RAP was frozen at GSD in March for the 2012 CoSPA season (parent to the HRRR). This version includes many improvements to the analysis (use of pseudo-innovations for surface moisture, soil temperature and moisture adjustment based on surface innovations, conservation of virtual potential temperature in moistening associated with cloud building, limits of precipitable water innovations) that have resulted in better precipitation and moisture forecasts. ESRL's new estimated date for completing RAPv2 GSI code testing at GSD: 30 Aug 2012.

NCEP
Delays in the initial Rapid Refresh implementation will delay the Rapid Refresh upgrade to 2013. Move deadline to 31 Jan 13. (Wu, Parrish)

12.5.5.1b 31 Dec 2011 (GSD)
Complete initial testing at ESRL of improved satellite radiance assimilation capability (bias correction, time windows, etc.) for RAPv2.
Initial bias correction work previously completed with forecast improvement noted. Ongoing retrospective testing led by Haidao Lin to evaluate further enhancements from the bias correction. All this work is being done on the new supercomputer, Zeus, following successful transition of RAP to Zeus.

12.5.5.3 Implement proper vertical covariance localization and test the hybrid DA system using EnKF covariance. (Completed 31 Jan 2012)

NCEP
Once the ENKF is implemented in the operational global in May, this will be put into a NAM parallel. (Wu

12.5.5.4 31 Aug 2012 (ESRL) COMPLETED

Complete testing of GSI changes for RAPv2 at ESRL.

This task is considered to be complete because the original set of changes for RAPv2 will been completed and extensively tested in the ESRL real-time experimental RAP/HRRR (frozen since Spring 2012).
Results from this test evaluation show substantial improvement in near surface and convective environmental fields. However, with NCEP unable to implement RAPv2 until spring to early summer 2013, ESRL will continue to test additional RAPv2 enhancements into fall, and will incorporate well-tested additions as they become available this fall.

12.5.5.5 1 Feb 2012 (GSD, NCEP) COMPLETED
Test version of GSI appropriate for 3-km High-Resolution Rapid Refresh (HRRR) configuration, including use of level-2 radar radial wind and reflectivity data.

GSD
This task was completed in January 2012. However, work continues in improving the 3km GSI assimilation since that time.

Work continues to optimize the 3-km sub-hourly assimilation procedure for real-time application. In the system, a one-hour pre-forecast integration is completed, in which 4 application of the diabatic DFI-based radar assimilation is completed. The WRF ARW code has been modified to accomplish within a single model executable. At present, however, 4 separate applications of the GSI (over the 3-km HRRR domain) are needed to create the radar reflectivity-based temperature tendency arrays. We are currently investigating needed changes to the GSI cloud analysis to allow all for the creation of all four of these temperature tendency arrays at a single time. The change would significantly reduce run-time for this pre-forecast spin-up period, increasing the likelihood that we can run it in real-time. It was decided to NOT include this in the operational version of the HRRR for spring/summer 2012.

Ming Hu has recently successfully run this 3-km GSI cloud analysis on both ESRL JET and ZEUS supercomputers, getting about 4 min. run times (64 cores on JET, 72 cores on ZEUS). David Dowell continues to evaluate different strategies for 3-km radar data assimilation using GSI. Ming Hu is examining impact of 3-km cloud analysis on HRRR forecasts.

NCEP
Work continues on finalizing the new dual-pol decoder that NCO has written (see 12.5.5.12). Work began on a QC algorithm for the dual-polarity radar variables, which is expected to improve the quality control procedures for radial wind, reflectivity and VAD winds. (Shun Liu)

12.5.5.6 Moved to Jan 2013 (GSD)
Complete testing of Rapid Refresh GSI modifications for RAPv2 at EMC, transfer code to NCO, pending NCEP readiness.
Delays in the initial Rapid Refresh implementation will delay the Rapid Refresh upgrade to FY2013. Move this deadline to 31 December 2012. A large set of changes to reduce the high bias in RAP moisture and precipitation forecasts has already been fully tested and included in all three ESRL GSD real-time parallel RAP runs and is in the frozen code for the RAP that serves as the parent for the HRRR in the summer 2012 real-time evaluation.

12.5.5.7 Moved to April 2013 (NCEP, ESRL)
Submit Request for Change (RFC) and modified GSI code for RAPv2 from EMC to NCO, pending NCEP readiness.
Delays in the initial Rapid Refresh implementation will delay the Rapid Refresh upgrade to 2013 – note current estimated date.

NCEP
Work will begin on RAPv2 after the RAPv1 is implemented in May 2012. A package of revisions from ESRL/GSD was committed to NCEP's GSI Subversion trunk on April 26, 2012. This will form the basis of the RAPv2 GSI testing. The changes that were made follows: Add aircraft observation rejection list to toss bad aircraft temperature, wind, and moisture observations; Add PBL pseudo observations based on surface temperature, moisture, (181,187,183) and wind (281,283,287); Add subroutine to calculate PBL height, which will be used in PBL pseudo observation and cloud analysis; Linear variation of observation error inflation below surface for q, t; Add code in speed observation innovation calculation to use observation height instead of pressure to get observation vertical grid coordinate; Add additional QC for PBL profiler 223, 224, 227; Limit the low level moisture analysis increment over ocean; Update the START_TIME for ARW NetCDF format to reflect the right analysis time; PW adjustment based on the terrain and the innovation limitation; Enhancements and bug fixes to the GSD cloud analysis; and Bug fix in for reading cloud observation in setuprhsall.f90. (Manikin, Wu, Lueken, Hu (GSD)

12.5.5.9 31 May 2012 (NCEP and GSD)
Report on testing of 2DVAR GSI assimilation of high spatial and temporal mesonet surface data using analysis grids with 2.5-km or finer resolution and HRRR as background. (Possible 15-minute update for RTMA to support CoSPA, pending Convective Weather PDT support.)

NCEP
All RFCs necessary to implement the RTMA upgrade package were submitted, but NCO has stated it will not be scheduled for implementation until after the moratorium in 2013. RTMA work is focusing on transitioning the model to run on the future NCEP WCOSS. (Manuel Pondeca)

GSD
Manuel Pondeca at NCEP provided the 2DVAR configured GSI code and some guidance to Patrick Hofmann at GSD, who has completed basic tests of a version using the HRRR model as input and modified the scripts to be consistent with the GSD RAP run environment on JET and ZEUS. Related work on this has been completed by Ming Hu, who has run a 3-km version of the full 3DVAR and used these fields to initialize the HRRR,

In August, work continued by Patrick Hofmann in enhancing the RTMA analysis with a special 2DVAR form of the GSI applied to a 3-km HRRR grid. Patrick obtained a new little endian version of the anisotropic background error covariance file from Manuel Pondeca and did some tests on the 3-km grid. Results show more detail in the analysis increments, especially of the complex terrain of the west.

12.5.5.10 1 July 2012 (defer this date to 1 Jan 2013 due to suspension of CAPS FY12 work in MDE due to lack of a contractual agreement)(CAPS, ESRL)
Develop dual-resolution capabilities of EnKF and test it for RR configurations.

(As previously reported:) Kefeng Zhu and Yujie Pan at CAPS previously developed an Initial dual range capability. Ming Hu of ESRL/GSD has extended this work by completed basic retrospective tests of a full 13-km RAP EnKF. Analysis of these initial results revealed the spread was too small among the ensemble members and identified steps to be taken to address this deficiency. In late April, Ming reported on this work via a poster presentation summarizing initial results at an ensemble assimilation workshop. This poster report is available at:
http://ruc.noaa.gov/pdf/HU_EnKF_wkshp_May_2012_FINALx.pdf

July update – Further work on addressing the small spread issue in the RAP EnKF hybrid ensemble is planned after the new DTC GSI code release, tutorial, and associated meetings in Boulder which is occurring in late Aug. Ming Hu has submitted an abstract on this work for the IOAS conference at the AMS Annual meeting.

12.5.5.11 31 July 2012 (EMC, ESRL) (Task modified due to unavailability of CAPS for most of FY12)
Complete initial test of 13km EnKF/hybrid results using background error covariance derived from a regional ensemble.

GSD
Ming Hu has built a 40-member 13-km RAP EnKF / hybrid data assimilation system on ZEUS and completed a 4 day retrospective test. Initial examination of results indicates too small a spread.

Further work to evaluate the sensitivity of the RAP EnKF / hybrid ensemble to choice of regional vs. global covariance fields awaits resolution of the small spread issue (see task 12.5.5.10)

NCEP
The analysis code with hybrid variational-ensemble ability was ported to the NOAA Zeus machine. Since the regional system that generates the first guess file of the analysis system was updated to use a new NEMS_IO library, the GSI code had to be linked with the same update which made it necessary to update some of the libraries. The ENKF file names were longer than the declared variable in one of the subroutines which produced no error on CCS but caused the job to fail on Zeus. This bug was fixed and the code was executed successfully on Zeus. This code will be used in the official regional parallel with CONUS nest on Zeus. (Wan-Shu Wu)

12.5.5.12 31 July 2012 (NCEP)
If authorized by NCEP Director, implement initialization of the convection-resolving NAM nests and HiResWindow runs using CAPS/Shun Liu improved techniques for radial velocity analysis in GSI together with Diabatic Digital Filter use of 88D reflectivity Mosaic.

NCEP
Testing of the radar data decoder for dual-polarity variables continued in August and more bugs were found and fixed. Two RFCs were submitted to NCO. One is to extend time window of radar data processing. Another is to modify reflectivity mosaic script to give suitable warning information when level2 radar data delay. The two RFCs are under NCO's parallel test. In addition, NCO's test results were examined and the RFCs were further modified based on NCO's feedback. (Shun Liu)

12.5.5.13 31 July 2012 (NCEP)
Based on case-study testing and refinement of the research quality code, deliver result in an 'experimental' code for an upgrade package (e.g. improved satellite channel bias correction, improved use of WSR-88D radial wind and/or satellite radiances and/or retuned covariance's to the GSI for FY2013 change package to the NAM.

NCEP
New GPS refractivity data from TSX, SAC-C and C/NOFS were tested in the NDAS. The regional cut-off height of GPS data was set to be 30km, which was about 12mb for the standard atmosphere. The analysis increments from using refractivity and bending angle data were compared and it was found that although the increment locations were similar and the amplitudes comparable in the middle layers of the domain, bending angle increments were smaller than from refractivity at the top of the domain. The off-line parallel NDAS tests show no 3-hour forecast impact from adding GPS refractivity from TSX, SAC-C and C/NOFS and a small mixed impact from switching to bending angle data. (Wan-Shu Wu)
Initial development work has been completed for the new method to allow use of GFS derived satellite bias correction coefficients directly in the NAM GSI. Yanqiu Zhu will test this in the NAM NMMB partial cycling system. (Dave Parrish)

12.5.5.14a 1 August 2012 (CAPS, ESRL)
Explore the use of time-lagged ensemble for increasing the ensemble size within the EnKF and EnKF hybrid.

Further work to evaluate the sensitivity of the RAP EnKF / hybrid ensemble to use of time-lagged ensembles awaits resolution of the small spread issue (see task 12.5.5.10)

NCEP
Work will begin on this after the RAPv1 is implemented in May 2012. (Binbin Zhou & Wan-Shu Wu)

12.5.5.15 30 August 2012 (CAPS, GSD, NCEP) COMPLETED
Finalize the multi-scale multi-pass configuration for analyzing radial velocity and other data. Report initial results with RR and HRRR testing.

GSD
David Dowell has completed experiments with a series of second pass 3-km analyses at 15-min. intervals during a one-hour pre-forecast cycle to initialize the HRRR. Initial tests have only included use of radar reflectivity data and the forward model portion of the radar DFI code and yielded modest improvement in the first few hours of the HRRR forecast. Separately, Ming Hu has run the full GSI over the 3-km HRRR domain, assimilating all observations, successfully demonstrating the practicality of running the full GSI on the full 3D 3-km HRRR domain. Follow up work will focus on conducting controlled experiments to evaluate the forecast impact from this 2nd pass of the full GSI on the 3-km domain for inclusion of specific observation types (radial velocity, surface observations, etc.)

NCEP
A rare event caused the GSI analysis to fail in the parallel NDAS on 7 May. Although the 88D radar Level 2 data file existed for this forecast cycle, no Level 2 data were usable for the GSI because of problems in upstream data collection. The unit number shared by all data input was not properly closed which caused the program to fail when it tried to read in the next data file. The bug in reading Level 2 radar data was fixed and the program can now run to completion even with a bad Level 2 data file. (Wan-Shu Wu, Shun Liu)

12.5.5.E1 1 April 2012 (GSD)
New version of GSI including revised radial wind assimilation ready for NCEP for RR upgrade.

COMPLETE: RAP retrospective tests with inclusion of level radial yielding neutral forecast impact, resulting in inclusion of these data in frozen version 2 of RAP. Code transfer to NCEP delayed due to postponement in NCEP implementation of RAP version 1.

12.5.5E3 Change to 1 Dec 2012 **(ESRL)**

Final GSI code transfer complete to EMC as part of Rapid Refresh v2 package to be implemented later in FY13

NCEP CURRENT EFFORTS: Work with ESRL/GSD will begin on RAPv2 after the RAPv1 is implemented in May 2012.

PLANNED EFFORTS: Implement the RAPv1 on 1 May 2012.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: Delays in the initial RAPv1 implementation will delay the RAPv2 upgrade until after the moratorium, likely no sooner than May 2013. Date changed to 1 Oct 2013

Deliverables

12.5.5.E1. Perform systematic tests and fine tune EnKF and EnKF-GSI hybrid DA systems for RAP grid, running at 1/3 of the RAP resolution for computational efficiency (CAPS) 9/30/2012

12.5.5.E2. Report on initial results of the EnKF and hybrid DA systems for the RAP configuration (CAPS, ESRL) 9/30/2012

In August, the RAP regional EnKF system was updated to use the latest GSI and WRF versions and was successfully migrated to the new NOAA HPC system ZEUS. Several issues were identified and corrected during the tests: 1) the latest version of WRF 3.4 has known errors for the current RAP configuration. Testing results using WRF 3.4 had larger RMSEs than WRF 3.2, especially at the upper levels. Therefore, the updated EnKF system still uses WRF 3.2 at this time; 2) the parallelization of wind analysis of the latest GSI-hybrid is not working properly. Fortunately, the GSI-3DVar has no such problems. We are currently using the latest GSI for the pure EnKF but an earlier version of the GSI hybrid; 3) in the latest GSI, the wind vectors in the diagnosed files (observation innovations) were rotated to the earth U and V which is not consistent with the regional EnKF and was changed back to the model grid U and V; 4) the vertical coordinate of the latest EnKF for the ARW part is not consistent with GSI - it uses dry air pressure as its model pressure level. This has been corrected by using the same pressure formula as in GSI; 5) in the latest EnKF, the fixed inflation scheme was removed. This fixed inflation scheme was found to have positive effects in our earlier tests and experiments without fixed inflation show insufficient spread and larger RMSEs – this option has been added back to the EnKF; 6) the GPS-pw is found to have not to be used by the EnKF system due to the missing pressure value for the GPS sites. In tests using pure GSI-3DVar, GPS-pw data have been found to improve RH analysis and forecasts, and various surface variables. We have filled the GPS site pressure with surface pressure. Initial tests with this modification show positive impact for RH within EnKF, making EnKF outperform GSI for RH also; 7) pseudo-RH is tested within the

new EnKF system as the analysis variable. Compared to using water vapor mixing ratio (Qv), this change improves the surface variables.

The aforementioned tests did not included satellite radiance data since earlier tests including the data did not show possible impacts. An effort on satellite radiance assimilation within EnKF framework does continue. Previous tests were using the hourly interval radiance data, the same data for the current RAP system. Negative impacts were found. Recently, we obtained the global radiance data from Haidao Lin of GSD and found through comparison that the RAP datasets were incomplete. Possible explanation, after discussing with Ming Hu of GSD, is that the global system waits longer for the data to arrive and is therefore more complete. We developed programs and scripts to split the global data into 3 hourly batches interval. Two bias correction procedures using those radiance data have been tested within the current EnKF system. One is to employ variational bias correction within the GSI but turn off the bias correction in EnKF. The other is to use the air mass bias correction within the EnKF module. In both procedures, the bias coefficients will be updated for each analysis and forecast cycle. Tests have been conducted using AMSU-a radiance data. Initial results with first bias correction scheme show positive impact on wind vectors. It also improves the middle level RH but deteriorates the upper levels somewhat. Further tuning is still needed. The second bias correction scheme is under testing on ZEUS. Experiments with the EnKF-GSI hybrid have been rerun employing optimal settings found for the single-physics EnKF. Both 1-way and 2-way Hybrid has been tested successfully on ZEUS. The RMSEs of those two were quite similar. With half static covariance and half flow-dependent covariance, as in previous tests, hybrid results show advantage over pure EnKF and GSI-3DVar for most of the surface variables examined, except for the 2m surface temperatures. Based on the RMSEs against ADPUPA sounding observations, for different forecast times and for level averages, the results are still consistently better than pure EnKF except for the RH at the jet level and temperature at the lower levels. Additionally, the impact of GPS-pw data has also been tested with the GSI hybrid. Quite similar to the GSI case, assimilating GSP-pw significantly reduces the RMSEs for all variables, especially for the surface variables and for RH verified against soundings.

Experiments with multiple physics schemes have also been tested within the EnKF-GSI hybrid framework. The 40 WRF ensemble forecast members were divided into five groups, each group using different physical schemes with a combination of different radiation, cumulus parameterization, surface physics, and PBL schemes. Initial results show that the multiple physics scheme that improves pure EnKF also the GSI hybrid.
Hybrid experiments with full flow-dependent covariance should theoretically be the same as the EnKF, but presumably due to the beneficial use of the height and observation dependent localization scheme used by the EnKF, the hybrid shows higher RMSEs than EnKF, especially at the jet level. We have since added the height dependent localization to the hybrid. However, tests with the modification did not further improve the hybrid performance. Observation-dependent localization will be considered next although to do it will involve running the hybrid analysis scheme multiple times, increasing computational costs.
In the previous tests, the weights for the static and flow-dependent covariance are constant in the hybrid system. Tests with the weights suggested benefits including the static covariance. While the equal weighting did better at most times and most levels, a 90% static and 10% flow-dependent combination was best for the relative humidity at the jet level. Experiments with height-dependent weighting schemes were performed although no clear improvement has been found so far. Tests continue.

12.5.5E3 (Changed to 1 Mar 2013) (NCEP)
Final GSI code transfer complete to EMC for Rapid Refresh v2 change package to be implemented in spring 2013. (Combined with 12.5.5E1)

CURRENT EFFORTS: Work with ESRL/GSD will begin on RAPv2 after the RAPv1 is implemented in May 2012.

PLANNED EFFORTS: Convert RAPv1 GSI code to WCOSS then start testing RAPv2 GSI code.

UPDATES TO SCHEDULE: Delays in the initial RAPv1 implementation will delay the RAPv2 upgrade until after the moratorium, likely no sooner than May 2013. Move this deadline to 1 March 2013.

12.5.5.E4 Change to 1 May 2013 (GSD, NCEP)
Pending EMC, and NCEP Center initial recommendations, Requests for Change (RFCs) are filed to submit GSI code as part of upgrade for Rapid Refresh v2 software to NCO, pending NCEP readiness.

ESRL
Progress with RAPv2 at ESRL is very promising and would allow this schedule, pending NCEP's readiness to start testing and NCEP's need to get in some other implementations with RAPv2 implementation not having occurred until 1 May 2012.

NCEP
CURRENT EFFORTS: Work will begin on RAPv2 after the RAPv1 is implemented on 1 May 2012.

UPDATES TO SCHEDULE: Delays in the initial RAPv1 implementation will delay the RAPv2 upgrade until after the moratorium, likely no sooner than May 2013. Move this deadline to 1 May 2013.

12.5.5.E5 Change to 1 July 2013 (ESRL, NCEP)
Pending computer resource availability, implementation of Rapid Refresh 2 changes to operational RAP at NCEP.

ESRL
Request for date change to mid 2013

NCEP
CURRENT EFFORTS: Work will begin in earnest after the moratorium in 2013.

PLANNED EFFORTS: Transition the RAPv1 onto WCOSS.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: Delays in the initial RAPv1 implementation will delay the RAPv2 upgrade until after the moratorium, likely no sooner than May 2013. Move this deadline to 1 July 2013.

12.5.5.E6 30 Sept 2012 (EMC, ESRL)

Report on the results of EnKF and hybrid DA systems for the RAP and future NARRE configuration.

CAPS has not been available for MDE work in FY12 until the last quarter due to a contractual agreement problem. EMC and ESRL will provide some initial results in their Q4 MDE reports. Encouraging results from OU/CAPS dual-resolution (40/13 km) test and good progress by Ming Hu on building 13-km test system (see subtask 12.5.5.10). Ming Hu and CAPS personnel presented summaries of this work at an ensemble data assimilation workshop in late April.

NCEP

12.5.5.E7 30 Sept 2012 (NCEP) (deferred to mid 2013)
Subject to NCEP Director approval, implement NEMS/NMMB version of GSI (e.g. strong constraint, revised bkg+obs errors) in NAM/NDAS.

CURRENT EFFORTS: Porting of the GSI into NEMS has been put on hold while it completes its transition to EnKF especially for regional applications. Tests with hourly updated NAM will help determine of having model and GSI in a single executable will be worth the effort. Some feel having GSI in NEMS will be restrictive and too complicated. The savings in time due to greatly reduced data motion will have to be great to offset these negative aspects of moving GSI into NEMS. (DiMego, Rogers)

The hybrid ensemble analysis with a new version of GSI code was incorporated into the regional parallel system. The satellite angle bias correction program was also updated to be compatible with the new GSI code. In order to have a test system for impact studies on future changes, efforts were invested in porting and adapting the scripts

and codes to work on the NOAA R&D computer (Zeus). Work on updating the background error covariances continues. (Wu)

A rare event caused the GSI analysis to fail in the parallel NDAS on 7 May. Although the 88D radar Level 2 data file existed for this forecast cycle, no Level 2 data were usable for the GSI because of problems in upstream data collection. When there was an input radar file but no available radar data, the program failed when it tried to read in the next data file. The bug in reading Level 2 radar data was fixed and the program can now run to completion even with a bad Level 2 data file. (Wan-Shu Wu, Shun Liu)

PLANNED EFFORTS: Continue tuning the hybrid variation-ensemble analysis and the static background error covariances. Add new data, i.e., new VAD winds, GPSRO bending angles, hourly satwinds, surface observations without pressure to the assimilation system when they become available. If the new components pass the parallel tests with at least a neutral impact, the components will be included in the package for official regional parallel. (Wu)

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:
UPDATES TO SCHEDULE: None.

12.5.5.E8 30 Sept 2012 (GSD)
Report on initial results of 13km EnKF for RAP configuration. (modified title)
In late April, Ming reported on this work via a poster presentation summarizing initial results at an ensemble assimilation workshop. This poster report is available at:
http://ruc.noaa.gov/pdf/HU_EnKF_wkshp_May_2012_FINALx.pdf

12.5.5.E9 30 Sept 2012 (ESRL/GSD)
Report on planned GSI changes for the FY13 upgrade to the Rapid Refresh.
Good progress toward this deliverable by GSD personnel, including recent conference / workshop presentations:
http://ruc.noaa.gov/pdf/NWP_2012_RAP_GSI_hu_final.pdf

Task 12.5.8 Improve physical processes in the WRF (RAP and HRRR) and NAM models, especially including those that affect aircraft icing.

GSD
Work continues with application to both RAP and HRRR. This is detailed under Subtask #1 below. A highlight this month was a full-afternoon, wide-ranging discussion on physics issues with Greg Thompson of NCAR. We laid plans for future work toward use of the aerosol-aware microphysics that is under development at NCAR, among other topics.

NCAR/RAL
CURRENT EFFORTS: During the month of August, only a minor amount of time was spent on this task by meeting to discuss recent efforts and near-term plans for the aerosol component of the Thompson et al microphysics scheme with various team members at NOAA-ESRL.
PLANNED EFFORTS: Most of the effort will concentrate on the testing and full implementation of the Thompson et al (2008) "aerosol-aware" microphysics scheme. The scheme continues to be prepared for large-scale, long-duration simulations to be started near the end of calendar year 2012 since the new NCAR supercomputer center will become available.
PROBLEMS/ISSUES ENCOUNTERED OR ANTICIPATED: No additional delays are expected.

SUBTASKS:

12.5.8.1 1 Oct 2011 (GSD)

Based on ongoing GSD RR evaluation and feedback from users of the newly operational RAP, including other AWRP PDTs, continue developing and begin testing a suite of upgraded or new physics packages using developmental RR real-time cycles and retrospective periods at GSD, in preparation for RAP upgrade (RAPv2).

A version of the MYNN PBL scheme that performs acceptably well in two areas of weakness for this scheme as seen in verification of the RAP-development-2 cycle at GSD (FY12Q3 report), namely, a near-surface warm bias during the "evening transition" from daytime mixed layer to nocturnal inversion, and excessive fog formation over snow-covered land areas, was included in the WRFv3.4.1 release on 16 August.

Georg Grell has been advocating for some time that there should be some degree of convective parameterization in convection-permitting models such as the HRRR. The main motivation here is to improve precipitation forecasts (in particular to minimize frequency of occurrence of localized very heavy precipitation amounts). One of the challenges is to do this without compromising the well-established ability of at least some convection-permitting models (for example, the HRRR) to successfully predict mode of deep convection (discrete individual cells, linear organization of cells, small cell complexes, etc.). Tests with the 27 April 2011 Southeast tornado outbreak and the 29-30 June 2012 derecho (both of which were notable successes for the real-time HRRR without any convection parameterization) showed somewhat divergent results. The derecho forecast with convective parameterization was excellent, and very similar to the real-time forecast. However, the dominant mode of isolated super cells on the 27th was less well defined, and the super cellular character of the individual storms on the 27th was not so readily apparent as in the real-time forecast without convective parameterization. More detailed analysis and careful thinking are necessary for further progress in this area, and will continue.

Following our discussions with Greg Thompson on the topic of attenuation of incoming short-wave radiation by snow on 28 August, we discovered that the HRRR had been using the Dudhia short wave radiation scheme instead of Goddard, although the Goddard scheme has been used in the RAP for over two years. Subsequent tests of the Goddard scheme in the HRRR did show significant reduction of surface-based CAPE when we did include Thompson's fix in the HRRR.

12.5.8.3 1 July 2012 (NCAR/RAL)
Continue to increase the complexity and possible interactions between various aerosol constituents and microphysics. For example, the first version of the scheme uses a constant hygroscopicity value whereas different aerosol constituents have different values of this parameter. Also, as the grid spacing of HRRR decreases, NCAR and GSD will incorporate large urban sources of sulfates and other aerosols directly into the model.

12.5.8.4 1 July 2012 (NCAR/RAL)
More closely couple/link the aerosols and cloud droplet/ice characteristics to the radiation scheme(s). Aerosols directly affect the radiation, but also indirectly affect radiation through changes in cloud characteristics. Both are essentially ignored at this time. Also, directly utilize model output variables of cloud species and aerosols to develop better ceiling & visibility forecasts.

12.5.8.5 1 July 2012 (NCAR/RAL)
Assemble a series of well-known benchmark case studies pertaining to the new aerosol-microphysics package in order to evaluate future improvements as well as test its sensitivities. Cases will be picked from intensive operation periods of large field programs such as PacDEx, PLOWS, IMPROVE, VOCALs, etc.

12.5.8.6 1 Sept 2012 (GSD and NCAR/RAL)
Transfer the NCAR coupled aerosol-microphysics scheme into test versions of RR and HRRR and begin testing on individual cases (including HRRR summertime Mesoscale Convective System cases) using climatological aerosol distributions.

12.5.8.7 Change to 1 Nov 2012 (GSD and NCAR/RAL)
Begin coupling the NCAR aerosol-microphysics scheme with highly simplified version of the GOCART option in WRF-Chem being developed by GSD.

GSD: The potential of this approach will be reevaluated in discussions with NCAR.

12.5.8.8 Moved to Jan 2013 (GSD)
Based on RAP experience and recent WRF physics progress, begin development and testing of physics enhancements for RAPv3 implementation and for future versions of the HRRR.

12.5.8.13 30 July 2012 (NCAR/MMM)
Deliver a WRF Users' Workshop and WRF Tutorial for the User Community

CURRENT EFFORTS: NCAR delivered the Users' Workshop in June and the WRF tutorial in July.

PLANNED EFFORTS: NCAR issue the announcement for the next WRF tutorial in Boulder in the September–October time period. Preparation for the tutorial will begin in that time frame also.

UPDATES TO SCHEDULE: NONE

12.5.8.14 30 Sept 2012 (NCAR/MMM)
Task 12.5.8.14 Incorporate Physics and Dynamics Improvements into WRF

CURRENT EFFORTS: NCAR issued WRF minor release V3.4.1. This contained some new code features as well as bug-fixes, and the changes are listed at **http://www.mmm.ucar.edu/wrf/users/wrfv3.4/updates-3.4.1.html**. Also in August, the WRF Release Committee (RC) reorganized for the next major release of WRF. The RC will begin the cycle for this release in September.

Jimy Dudhia of NCAR obtained code for the Andreas et al. (2012) (*JAS*, 69, 2520–2537) drag formulation for hurricanes from Craig Mattocks (Univ. of Miami). Dudhia is working with Ryan Torn (State Univ. of New York, Albany) and Wei Wang (NCAR/MMM) to test this as a possible option for WRF.

Dudhia participated in the NUOPC (National Unified Operational Prediction Capability) Physics Interoperability working group. This group is considering ideas for a unified method to code physics in different models. He contributed a list of physics input and output variables that would apply to all models.

Dudhia consulted with John Wong (NCAR/ACD) on a possible new lightning diagnostic code for inclusion in WRF. The current focus is on putting it in WRF-Chem, but NCAR/MMM would also like to put it into WRF itself.

PLANNED EFFORTS: The incorporation of physics and dynamics improvements into WRF will continue through the end of FY12.

UPDATES TO SCHEDULE: NONE

12.5.8.15 Ongoing (GSD)
Continue development of the RUC LSM for application to RAP

Application for (RAPv2 in FY12 and RAPv3 in 2013) and HRRR, based on feedback from users, with particular emphasis on improving treatment of snow, sea ice and tundra, and use of upgraded ground surface datasets now available through the V3.3 WRF Preprocessing System (e.g., MODIS vegetation, lake surface temperature for lakes other than the Great Lakes).

Deliverables

12.5.8.E1 1 October 2012 (ESRL, NCEP)
Final model physics code transfer complete to EMC for Rapid Refresh 2 upgrade change package.

UPDATE TO DELIVERABLE:
Change to early FY13 due to late implementation of initial RAP.

12.5.8.E2 1 May 2013 (GSD, NCEP)

Pending NCEP computer readiness and EMC and NCEP Center initial recommendations, Requests for Change (RFCs) are filed to submit WRF physics code changes as part of upgrade for Rapid Refresh 2 software to NCO.

UPDATE TO DELIVERABLE:
Change to spring 2013 due to NCEP implementation forcing delay for overall RAPv2 implementation.

12.5.8.E4 15 Jan 2013 (ESRL, NCEP)
Pending computer resource availability, implementation of Rapid Refresh 2 changes to operational RAP at NCEP.

UPDATE TO DELIVERABLE:
Change to spring 2013 due to NCEP implementation forcing delay for overall RAPv2 implementation.

12.5.8.E5 1 Sept 2012 (NCAR/RAL and GSD)
Transfer the coupled aerosol-microphysics scheme into a test version of HRRR.

Delayed until the scheme is more thoroughly tested by NCAR.

12.5.8E6 30 July 2012 (NCAR/MMM)
Deliver a WRF Users' Workshop and a WRF tutorial for the user community.
Complete

12.5.8.E7 15 Sept 2012 (NCAR/RAL)
A written report by mid September 2012 summarizing enhancements made to the model physics packages.
12.5.8.E8 30 Sept 2012 (ESRL/GSD)
Report on overall planned model physics changes for the FY13 upgrade to the Rapid Refresh.

This is already largely set as of March 2012 for the frozen ESRL RAP for summer-2012 CoSPA/HRRR.

12.5.8.E9 30 Sept 2012 (NCAR/MMM)
Incorporate physics and dynamics improvements from the user community, GSD, and NCEP into WRF for use in the Rapid Refresh system. In collaboration with GSD, assist in the evaluation of those physics schemes for the RR that may be tested using the ARW. Perform testing for code acceptance and implementation into WRF repository. Assist in the implementation of WRF bug fixes.

Task 12.5.24
FY 2012, also Priority 7: Develop, test, implement and improve the 3-km WRF-based HRRR

Task 5.24 specifically treats development and testing of the 3-km HRRR model itself. Development and testing work on assimilation of radar data at the 3-km scale is under Task 5.19.

August update – The real-time HRRR had very good reliability during the month of August, with no major outages and the following reliability percentages: all runs 89%, outages 3-h or less 99.6%, outages 6h or less 100%).
In late Aug., AMB personnel met with Greg Thompson of NCAR to discuss aspects of his microphysics and use of it in the HRRR, including cloud hydrometeor specification and interactions of the shortwave radiation scheme with the microphysics scheme. Based on these discussions, a test version of HRRR that included interaction of the snow hydrometeors with the Goddard shortwave radiation was made. The case selected was one in which an ongoing cluster of storms (with a large anvil) stabilized the mesoscale environment. Associated with this, a portion of new squall propagating into the region and decayed upon encountering the adverse environmental conditions. In contrast, the HRRR predicted squall line maintained strength. The retrospective experiment tested the possibility that accounting for the increased shading of the mesoscale environment from the anvil of the initial cluster of storms might reduce the strength of the squall line, but results showed limited impact from the change.

In associated work, Ming Hu continued progress toward creating a Rapidly Updated Analysis (RUA) using a 3-km HRRR background field. This work focuses on applying the full cloud / hydrometeor analysis to the HRRR background field.

Curtis Alexander was included on a submitted manuscript (to *Weather and Forecasting*) describing verification of HRRR predicted precipitation type. Stan Benjamin and John Brown are nearing completion of a shorter manuscript (also to *W&F*) describing the precipitation-type diagnosis for the RAP and HRRR. Stan Benjamin and Steve Weygandt gave presentations to NOAA management on 11-13 Sept about the skill of the HRRR in very accurately predicting the Ohio Valley – Mid-Atlantic extremely damaging derecho event of June 29.

Subtasks

12.5.24.1 15 Jan 2012 (GSD, with assistance as needed from NCAR/RAL, NCAR/MMM, CAPS, MIT/LL)

Initial design for the assimilation/modeling configuration for the HRRR during the 2012 summer convection forecasting (CoSPA) exercise.

As detailed above, extensive retrospective testing of the coupled RAP / HRRR data assimilation / forecast system for the August 11-21 period is complete. All changes to the RAP / HRRR system have been incorporated into the GSD runs and impact on HRRR are very positive. GSD real-time RAP / HRRR system with all these upgrades was frozen on March 9, 2012 for 2012 evaluation.

12.5.24.3 30 Sept 2012 (GSD)

Complete 2012 HRRR summer evaluation using modeling and assimilation modifications determined in 2011 exercise. Collaborate on analysis of HRRR tests and deliver summary of results.

Deliverables

Exercise ongoing with very good overall HRRR performance and reduced false alarms compared to 2011 noted. Storm structure seems to be especially well predicted with this 2012 RAP/HRRR configuration. Excellent HRRR forecast for many cases including the June 29, 2012 derecho event that caused at least 22 fatalities and extensive damage over a wide area from the Ohio Valley into the Mid-Atlantic States. Fig. 3 shows the 12-h HRRR forecast of reflectivity and max 10m winds.

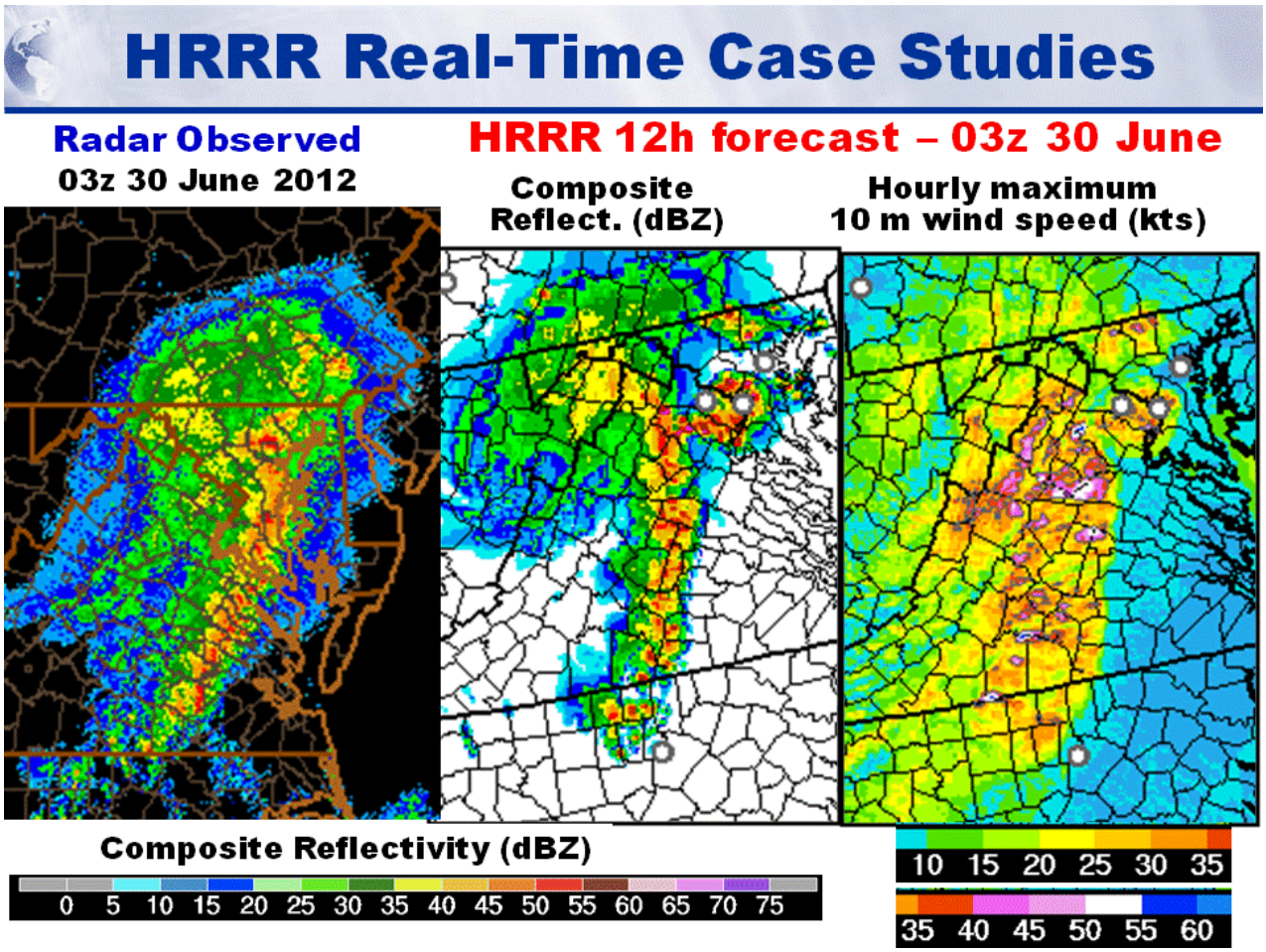

Fig. 3. Observed radar reflectivity (left) and HRRR 12h forecast reflectivity (center) and 10 m wind (right) from the extremely damaging derecho that struck Washington DC at 3z 30 June 2012.

12.5.24.E1 1 April 2012 (ESRL/GSD)
Incorporate all assimilation and model changes that affect the HRRR into a frozen version of HRRR (and parent Rapid Refresh) for the summer 2012 exercise.

As detailed above, work was completed on improvements to RAP / HRRR system for 2012 in advance of the freeze date in March 2012. Frozen on March 9, 2012

12.5.24.E2 15 Sept 2012 (NOAA/ESRL/GSD)
Complete FY12 evaluation with revised 3-km HRRR running every 1 h.

- **Conduct real-time summer 2012 HRRR forecasts using 3-km WRF initialized with radar-enhanced Rapid Refresh over full CONUS domain, monitor performance, modify code/scripts as needed, maintain high reliability working with ESRL computer facility**
- **Coordinate with other AWRP users and other collaborators, including coordination of HRRR grid transfers**
- **Provide project management**
- **Lead writing of report on summer 2012 HRRR experiments**

Real-time project ongoing with good results so far. Excellent HRRR forecast for many cases including the June 29, 2012 derecho event that caused at least 22 fatalities and extensive damage over a wide area from the Ohio Valley into the Mid-Atlantic States (see HRRR forecast images above).

12.5.24.E2a 1 June 2012 (NCEP, ESRL/GSD) COMPLETE

Report on computing resource status on NCEP CCS, NOAA R&D Site A and NOAA R&D Site B with regards to possible implementation of HRRR.

A report summarizing the current status was completed and sent on July 15th with the June quarterly report and is also available at **http://ruc.noaa.gov/pdf/HRRR_computing_resources.pdf**

Status of MDE Deliverables – 14 Sept 2012

Legend: ☐ Deliverable on schedule; ☑ Deliverable submitted; ☐ Deliverable overdue

Deliverable and Related Task	Due Date	Status	Comment
12.5.4 Develop, test, implement, and improve the Rapid Refresh			All RAPv2 milestones are delayed until late FY12 or FY13, as noted below and in earlier monthly and quarterly reports.
12.5.4.1 Maintain hourly RAP runs and provide grids of SAV and AHP guidance products (ESRL, NCEP)	Ongoing	☐	
12.5.4.E1 Report on Rapid Refresh Status (ESRL)	12/20/11	☑	
12.5.4.7 Complete testing and evaluation of new RAP capabilities (model physics and data assimilation) – RAPv1 (ESRL)	01/31/12	☑	
12.5.4.E2 Update documentation for operational Rapid Refresh (ESRL)	02/01/12	☑	
12.5.4.6 Initial software for RAPv2 changes ready for porting to EMC (ESRL)	08/01/12	☑	
12.5.4.E4 Report on testing of RAP assimilation/model improvements (ESRL)	03/30/12	☑	
12.5.4.E3 Final code ready for transfer to EMC for Rapid Refresh v2 change package (ESRL)	3/01/13	☐	
12.5.4.E5 Complete testing at EMC of RAPv2 code, pending NCEP readiness (NCEP, ESRL)	5/31/13	☐	This task was originally for a RAPv3 but is now linked to RAPv2.
12.5.4.E6 Perform config mgmt. for RAP (ESRL, NCEP)	Ongoing	☐	
12.5.4.E7 Monitor RAP performance, respond to problems, diagnose causes, develop solutions. (ESRL, NCEP)	Est. 4/1/13	☐	
12.5.4.E8 Report on overall planned changes for FY13 upgrade to Rapid Refresh (ESRL)	11/30/12	☐	
12.5.5 Develop, test, and implement improvements to the Rapid Refresh and the NAM data assimilation			
12.5.5.E1 New version of GSI including revised radial wind assimilation ready for FY13 RAPv2 upgrade (ESRL)	04/01/12	☑	Complete in that RAP-ESRL frozen for HRRR is essentially that planned for RAPv2 @NCEP.
12.5.5.E3 Finalize GSI code ready for transfer to EMC for RAPv2 (ESRL)	02/28/13	☐	
12.5.5.E4 Pending EMC and NCEP Center initial recommendations, Requests for Change (RFCs) are filed to submit GSI code for RAPv2 software to NCO, pending NCEP	05/01/13	☐	NCEP plans a moratorium that may delay this implementation, although ESRL and NCEP will try to

readiness (NCEP, ESRL) 12.5.5.E5 Pending computer resources, implement RAPv2 at NCEP (NCEP, ESRL) 12.5.5.E6 Report on results of EnKF and hybrid DA systems for the RAP configuration (EMC, ESRL) 12.5.5.E7 Subject to NCEP Director approval, implement NEMS/NMMB version of GSI in NAM/NDAS (NCEP) 12.5.5.E8 Report on initial 13km EnKF testing for RAP configuration (ESRL) 12.5.5.E9 Report on planned GSI changes for the RAPv2 upgrade to the Rapid Refresh (ESRL)	 07/01/13 09/30/12 Deferred to 7/1/13 09/30/12 09/30/12	 ☐ ☐ ☐ ☐ ☐	implement RAPv2 before it since code is essentially ready as of spring 2012
12.5.8 Improve physical processes in the WRF, especially including those that affect aircraft icing 12.5.8.E1 Final model physics code transfer complete to EMC for RAPv2 upgrade change package to be implemented by early 2013 (ESRL) 12.5.8.E2 Pending NCEP computer readiness and EMC and NCEP Center initial recommendations, Requests for Change (RFCs) are filed to submit WRF physics code changes as part of upgrade for Rapid Refresh v2 software to NCO (ESRL, NCEP) 12.5.8.E4 Pending computer resources, implement RAPv2 at NCEP with new physics configuration (ESRL, NCEP)) 12.5.8.E5 Transfer the coupled aerosol-microphysics scheme into a test version of HRRR (NCAR/RAL) 12.5.8.E6 Deliver WRF Users' Workshop and WRF tutorial (NCAR/MMM) 12.5.8.E7 Report on enhancements made to WRF model physics (NCAR/RAL) 12.5.8.E8 Report summarizing enhancements made to the model physics packages (ESRL) 12.5.8.E9 Incorporate physics improvements into WRF for future RAP and HRRR (NCAR/MMM)	 10/01/12 5/1/13 7/01/13 09/01/12 07/30/12 09/15/12 09/30/12 09/30/12	 ☐ ☐ ☐ ☐ ☑ ☐ ☐ ☐	Essentially complete now in ESRL RAPv2 but will keep the door open for additional physics mods until fall.
12.5.24 Develop, test, implement and improve the 3-km WRF-based High Resolution Rapid Refresh 12.5.24.1 Initial design for the assimilation/modeling configuration for the	 01/15/12	 ☑	

HRRR during the 2012 CoSPA Prototype Summer Operations			
12.5.24.E1 Incorporate all assimilation and modeling changes into HRRR for Summer 2012	04/01/12	☑	
12.5.24.E2 Complete FY12 evaluation with revised 3-km HRRR running every 1 h. (ESRL) • Conduct real-time summer 2012 HRRR forecasts using 3-km WRF initialized with radar-enhanced Rapid Refresh over full CONUS domain, monitor performance, modify code/scripts as needed, maintain high reliability working with ESRL computer facility • Coordinate with other AWRP users and other collaborators, including coordination of HRRR grid transfers • Provide project management • Lead writing of report on summer 2012 HRRR experiments	09/15/12	☐	
12.5.24.E2a Report on computing resource status on NCEP CCS, NOAA R&D Site A and NOAA R&D Site B with regards to possible implementation of HRRR (NCEP, ESRL)	06/01/12	☑	Completed 7/13/2012, available at http://ruc.noaa.gov/pdf/HRRR_computing_resources_13jul2012.pdf