MDE Product Development Team
July 2012 Monthly Report – FY 2012
Submitted 15 August 2012

With contributions from **Geoff DiMego** and **Mary Hart** (NCEP/EMC);
Stan Benjamin, John Brown, and **Steve Weygandt** (NOAA/ESRL/GSD);
Jordan Powers (NCAR/MMM) and **Roy Rasmussen and Greg Thompson** (NCAR/RAL).

(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 July.
- 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 application.

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

- RAP retrospective experiments to examine impact of cloud analysis enhancements on RAP moisture bias
- Progress toward evaluation of 3-km HRRR CONUS RTMA 2DVAR using background error covariance file from NCEP.
- Improvements to land surface model (LSM) cycling portion of RAP scripts at GSD to avoid resetting LSM fields to smooth GFS values.
- Initial work to process atmospheric motion vector (sat cloud-drift) winds in preparation for retrospective data impact tests.

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

- Updated version of WRFv3.3.1 implemented in RAP-primary at ESRL using options tested at ESRL for optimal RAP performance, especially for clouds.
- Updated Thompson v3.3.1 microphysics and RUC land-surface schemes implemented in RAP-primary at ESRL on 15 Feb.
- ESRL RAP updated to use MODIS land-use and fractional sub-grid-scale data – 15 Feb.
- Testing continues of GSD/Olson version of MYNN PBL scheme with some excellent results but testing was insufficient to include MYNN PBL in the frozen summer 2012 RAP/HRRR system.

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

- Continued good HRRR performance and reliability during 2012 convective storm season.
- Improvement made to the HRRR post-processing code (in UNIPOST) to reduce low echo top bias.
- Retrospective testing to evaluate forecast impact from use of cumulus scheme within 3-km HRRR.

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 July.
GSD continues to test the updated RAP version 2 at ESRL with significant data assimilation and modeling modifications finalized in March 2012 and discussed in previous MDE reports. For the month of July, the ESRL RAPv2 continues to show improvements over the operational RAP running at NCEP.

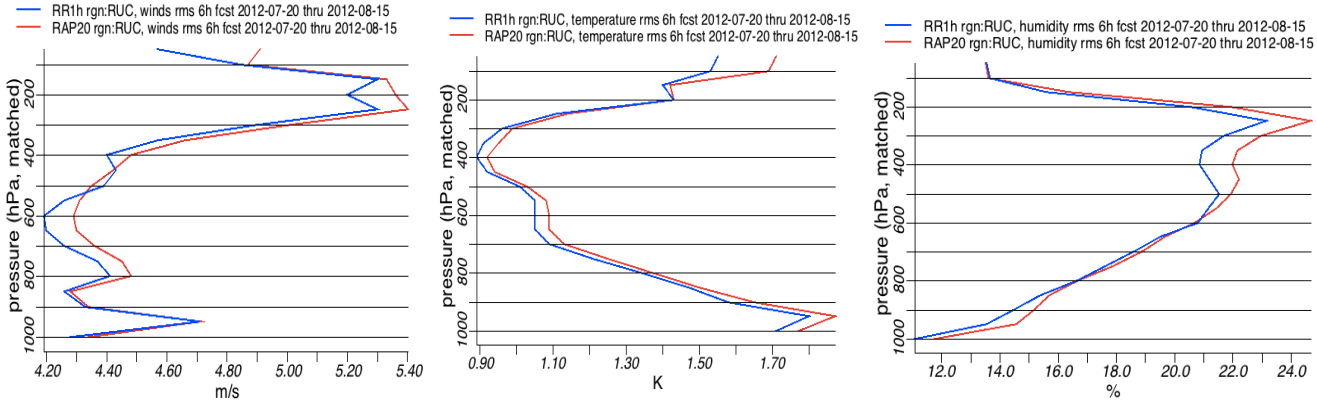

Figure 1. Verification of RAP upper-air 6h forecasts from RAP-ESRL (in blue) and RAP-NCEP-oper (in red) against rawinsonde observations for 20 July – 15 August 2012. The 3 graphics are for wind (left), temperature (center), and RH (right).

In Fig. 1 (above), the RAPv2 (RAP-ESRL) shows 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). 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.

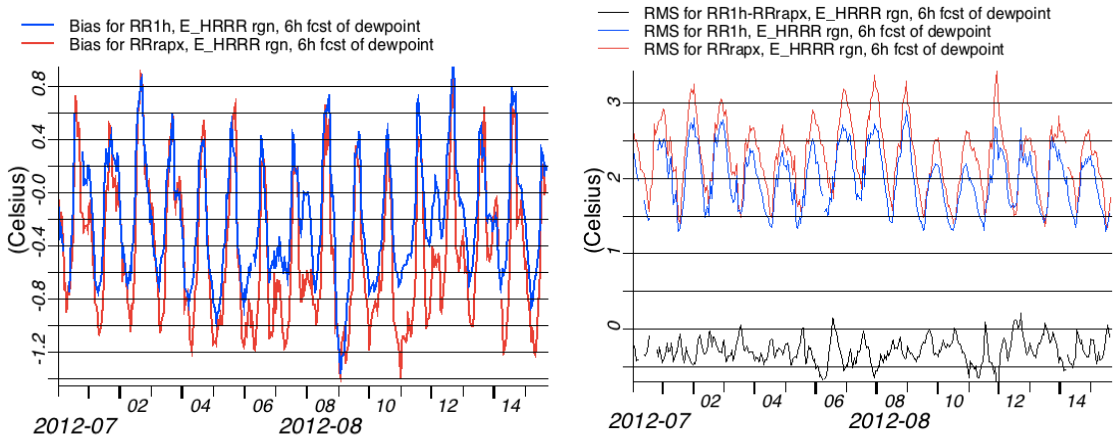

Figure 2. Verification of RAP 6h dew point forecasts RAP-ESRL (in blue) and RAP-NCEP-oper (in red) against METAR observations. Bias (defined as forecast minus observation – negative means moist bias) is shown on left, and RMS difference (smaller is better) is shown on right.

There continue to be occasions when the RAP-NCEP daytime surface dew point forecasts over the eastern half of the CONUS have been unsatisfactory, often too low, but in areas of recent precipitation, sometimes too high. This latter issue is reminiscent of the situation over the same geographical areas in 2011, which was a much wetter summer in most of the central and eastern CONUS. The low-bias situation was discussed in the FY12Q3 report, where it was pointed out that the RAPv2 upgrades in the ESRL RAP address systematic errors in both directions.

Also as reported in the FY12Q3 report, an ESRL RAP issue with excessive dew points occurred twice in June as a result of two lengthy scheduled maintenance outages on the Jet computer. After diagnosis of these events, code mods were developed and tested during July to protect against cold starts with GFS soil moisture and ensure that the most recent RAP soil moisture fields are always used after such outages.

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. Although this machine has only been available for general use since March, *Zeus* is already at capacity, and as a result the RAP cycles, as well as the HRRR development cycle, are often missing hours or not running to completion. This situation will soon be resolved by putting these runs under reservations (not yet available on *Zeus*) so that they will run on dedicated cores and not be subject to the vagaries of resource availability. Soon, only the RAP primary cycle, running the March 2012 RAP configuration (known as RAPv2) in support of the HRRR, and the HRRR itself will be the only real-time ESRL-GSD regional cycles running on the Jet computer in Boulder.

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 cloud assimilation, soil adjustment, and radar assimilation. They also include modifications to physics and numerical configurations for the WRF model. More details will be provided on this in future reports.

GSD has also been approached by Earth Networks offering access to their lightning network data. We plan to ingest this and evaluate it as a potential backup to the Vaisala GLD360 lightning product. Further, retrospective testing of satellite radiance bias corrections and choice of background error continues (Task 5). Regarding the WRF-ARW model, physics deficiencies continue under active investigation (see Task 8) and WRFv3.4.1 will be evaluated after it is released later this quarter.

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

NCEP
Work is continues 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)

A new comprehensive aircraft quality control program was implemented on 18 July. This is used in RAP, NAM, and GFS data assimilation systems. It replaces a legacy program that was implemented in 90's and did not consider all aircraft data and especially did not consider the now quite voluminous ACARS data. The new program was adapted for NCEP use from one developed at the Navy Research Laboratory by Dr. Pat Pauley. (Dennis Keyser)

About 80% of the SODARs are not getting into the RAPv1 because they do not get to NCEP in time for the RAP dumps. Ways to get the data to NCEP faster are being investigated. NCEP will modify its 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. NCEP/NCO has been notified. Starting 6 July, three ESRL-RAPv2 SODARs (AN2NE, LD2ND, and JY2MN) at critical times past the hour 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. (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.

GSD continues to make pgrb and bgrb files from the ESRL/GSD RAP-primary real-time 1-h cycle available from its FTP site. Grids from the operational NCEP RAP became available from GSD beginning 12z 1 May (grids from the pre-operational NCO cycle were available from GSD during the quarter prior to this date).

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 RUC/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 [RUC prior to 1 May] 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

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
The Rapid Refresh was implemented at NCEP on 1 May to replace the Rapid Update Cycle, and its performance 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 (RAP2) at NCEP near end of 2012.

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)

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. There is nothing new otherwise.

NCEP
The NARRE-TL system was implemented along with the RAP on 1 May 2012 so this subtask is complete. Webpages for both **CONUS** and **Alaska** provide viewing capability. Gridded mean, spread and probability products are downloadable from **NOMADS** **here.** The upgrade package for SREF underwent final testing by NCO taking the whole development machine to ensure all timings were accurate. (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 (redesign 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: Work to start on this in last quarter of FY12.

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)

PLANNED EFFORTS:

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 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)

PLANNED EFFORTS:

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 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.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

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
In July, GSD data assimilation work continued in several areas, including developing and testing of new aspects to the RAP data assimilation, correcting discovered shortcomings and beginning work to assimilate new

observations. Also work continued to bring multiple RAP real-time parallel cycles to a stable state, including working through a number of computer issues related to the new machine. An issue in which a large bias occasionally occurred in the GSD RAP surface moisture fields was detected and traced back to a subtle non-robustness in the GSD scripting. Under certain missing run conditions, the RAP land surface model fields could end up getting reset to values from the parent GFS model (instead of diurnally matched values from a previous RAP cycle. A fix to this problem was developed in early July, eliminating this problem.

Patrick Hofmann continued his retrospective testing of GSI cloud analysis modifications to reduce the high bias in mid-level moisture. He also continued his collaborative work with Manuel Pondeca of NCEP/EMC to run a 2DVAR 3-km version of the GSI using background error covariances from Manuel's work. Eric James worked to get a new observation type, atmospheric motion vectors derived from satellite imagery. Additional work was focused on refining techniques for assimilation of lightning data within the RAP and satellite-based convective initiation indicators within the RUC, and ports this code to the RAP.

Haidao Lin continued his work to optimize satellite radiance assimilation within the RAP, focusing on the bias correction. Specifically he ran a multi-week retrospective period to spin-up the bias correction coefficient. Initial comparisons show substantial improvement in upper-air verification for the retrospective experiment with the spun-up bias coefficients compared to one with no spin-up of the bias coefficients. This work builds upon his previous work to optimize the bias coefficients and apply channel selection procedures based on the relatively low RAP model top (10 hPa).

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)
Complete testing of GSI changes for RAPv2 at ESRL.
Delays in the initial Rapid Refresh implementation will delay the Rapid Refresh upgrade to FY2013. Move this deadline to 31 Aug 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. Most changes for RAPv2 are complete, but additional testing is ongoing to improve fit to rawinsonde vertical structures.

Strictly speaking, the deadline for this task will be met since RAPv2 will have been extensively tested. However, with NCEP unable to implement RAPv2 until spring to early summer 2013, ESRL will continue testing RAPv2 into fall, and will incorporate well-tested additions as they become available this fall.

12.5.5.5 1 Feb 2012 (GSD, NCEP)
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
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.

In late March, Stan Benjamin noted the absence of data from the Langley Hill radar from western Washington State getting into the RAP at NCEP or ESRL and getting into the HRRR. The Langley Hill data was only installed last fall. Stan started a sequence of emails started resulting in changes at NCEP (Shun Liu) and NSSL to accelerate moving Langley Hill data into full usage in the US radar mosaics and therefore, getting into the RAP and HRRR models by early April.

NCEP
The implementation of the procedure to dump the new VAD winds has made it possible to gather data for an impact study later this quarter. The problem of the observation density being too high in the vertical was fixed with quality control and data thinning. (Shun Liu)

The latest GSI code changes (top of the SVN trunk) were incorporated into the version being tested in the official parallel. Prior to turning over to Eric Rogers, an off-line impact test was setup and is now running. (Wan-Shu Wu)

12.5.5.6 Moved to later in 2012 (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 15 Dec 2012 (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. The RTMA has been successfully tested on the SGI R&D machine called Zeus using input binary files in Zeus' native little-endian format. As part of the WCOSS transition, the RTMA has also been successfully compiled on the WCOSS prototype machine Current, and test runs are underway. (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,

Continued TO collaborate work in July, with Manuel successfully porting his RTMA system to *Zeus*, including creating little endian background error covariance (BEC) files. This has enabled Patrick Hofmann of ESRL to begin running 3-km HRRR-based 2DVAR using Manuel's BEC files.

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 version of the GSI code that included the hybrid ensemble capability for regional was ported to Zeus (a NOAA R&D) computer. All the input files, including the data, global ensemble and fix files were transformed to the machine's little endian format. The GSI code will be compiled in little endian format once problems of incompatibility with the system libraries are solved. (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
A new radar data decoder that can handle dual-polarity variables is being tested and a few bugs have been found and fixed. Data from the new decoder are being compared to those from NCEP's current decoder and NSSL's decoder. The level-II radar data processing script is being modified to handle data latency due to dual-polarity radar upgrade. The modified script will extend the data processing time window from 1/2 hour to 2 hours and limit the data volume to be processed so the job can be completed within 15 minutes. (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 satellite data (radio occultation) from SAC-C, TerraSAR-X, and C/NOFS were added to an off-line version of NDAS for an impact study. Since in the variational analysis method observational error covariances were easier to define for data closer to the original GPS measurements, we also plan to use the GPS bending angle instead of the derived refractivity currently used in NDAS. (Wan-Shu Wu)

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)
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

12.5.5E3 (Changed to 28 Feb 12) (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. The notable success of HRRR in predicting the extremely destructive derecho of 29-30 June 2012 that cut a swath of terror

from Indiana and Ohio into the Mid-Atlantic states (including the DC area) has continued to garner considerable attention. The long life and track of this event were predicted with impressive accuracy; the speed of travel and intensity of peak 10m wind gusts were a bit underdone, but still remarkably good. Why these types of events seem to be forecast well by the HRRR, but more mundane "leading-line / trailing "stratiform" Mesoscale convective systems tend to not form as readily or hang together as well in the HRRR as is seen in reality is an intriguing question that is not likely to be readily answered

NCAR/RAL

CURRENT EFFORTS: During the month of July, G. Thompson attended the 8th Cloud Modeling Workshop in Warsaw, Poland. With leveraging from other projects at NCAR, the Thompson et al (2008) microphysics scheme was tested in a series of simulations of melting snow (workshop case#5) and a squall line event (case#2). In the case of melting snow, the results of the bulk scheme were compared to various observations taken during the 2010 Winter Olympics and also to other model results from the I. Geresdi bin-microphysics scheme and J. Milbrandt's bulk scheme. The group discussions and intercomparisons will lead to further improvements to the bulk scheme, particularly the treatment of number of rain created by melting snow.

The squall line case drew many international collaborators and generated significant interest due to widely different simulation results. The variety of models used and variety of microphysics schemes used helps to focus future work on shortcomings and deficiencies in the representation of convective squall lines, which often impact the nation's air transportation system. Concentrated focus by numerous international leaders in numerical modeling helps advance the state of the science of convective weather forecasting using WRF (HRRR) and the Thompson et al (2008) microphysics scheme.

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.

INTERFACE WITH OTHER ORGANIZATIONS: Due to the Cloud Modeling Workshop in Warsaw, there were numerous interactions with many international scientists including: A. Muhlbaer (Univ Washington), I. Geresdi (Univ Pecs, Hungary), M. Khairoutdinov (Stony Brook), B. Shipway & A. Hill (UK Met Office), J. Milbrandt (Env Canada), J. Harrington (Penn State), C. Hoose (Karlsrhue, Germany), and others.

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, has been committed to the WRF repository at NCAR for release with WRFv3.4.1. This release will occur later this quarter.

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 (noted above) have shown some promise, but more experimentation is needed.

We also expect to be working with Greg Thompson of NCAR to properly account for the attenuating effects of snow on short-wave radiation. This has been a long-standing WRF deficiency, and will be of potential benefit to forecasts of both the RAP and 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

As described, NCAR delivered the 13th WRF Users' Workshop on June 25–29. Approximately 240 were registered. Details on the workshop and selected abstracts may be found at:
http://www.mmm.ucar.edu/events/2012_wrfusers.

NCAR delivered a WRF tutorial, held at Foothills Lab on July 16–27. The first week covered WRF, while the second covered WRFDA and WRF-Chem. Details on the tutorial may be found at:
http://www.mmm.ucar.edu/events/tutorial_127/index.php.

PLANNED EFFORTS: NONE

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

NCAR began preparing for the next release, which will be WRF V3.4.1. This minor release will incorporate bugfixes and miscellaneous improvements to existing physics packages from the V3.4 major release and is scheduled to be issued in August.

Jimy Dudhia of NCAR worked with Songyou Hong (Yonsei University), jointly visiting NCAR and NOAA. He collaborated on Hong's new shallow convection scheme and on upgrades to the YSU PBL scheme, which includes a fix to correct excessive mixing in stable regimes. The YSU PBL changes were added to the WRF repository and will be in the V3.4.1 release.

Dudhia hosted and worked with visitor Matt Tastula (Univ. of South Florida), who is starting work on an evaluation of the QNSE EDMF PBL scheme for his thesis work. This PBL scheme is being examined for its performance in both subtropical and high latitude applications.

Dudhia obtained updated MYNN PBL code from Joe Olson (NOAA/ESRL). The code reflects improvements and modifications and was added to the WRF repository for the V3.4.1 release. NCAR (Dudhia and Ming Chen) also worked on updates for the SSiB LSM provided by Yongkang Xue (UCLA). This updated version of the LSM will also appear in V3.4.1.
PLANNED EFFORTS: The development and incorporation of new physics and dynamics for WRF for the RAP will continue through FY12Q4.

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.

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.

July update – Real-time HRRR continues to run with good reliability and forecast skill. The issue with the low echo top bias has been resolved with minor adjustment to within the UNIPOST post-processing software to address this problem without causing any other issues. The resolution of this problem including Patrick Hofmann adding an echo-top verification capability to his gridded verification package and use of the verification results to calibrate the post-processing adjustment. The change to the echo height calculation was implemented into the real-time experimental HRRR at 15z 27 July 2012. The result has been an improvement in the low bias of HRRR echo top heights with no reports of any adverse impacts.

An additional area of HRRR related work in July has been the off-line retrospective testing of a modification to the HRRR model physics formulation in which the Grell 3D cumulus parameterization scheme is turned on to augment the explicit 3-km representation of deep convection. This approach has been adopted by other groups and shown positive impact high-resolution precipitation forecasts, but at the possible expense of fidelity in the detailed storm structure. Retrospective experiments were carried out by Eric James (with input from Curtis Alexander and Georg Grell). Initial qualitative assessment of the results is consistent with expectations -- especially with the degradation of isolated supercell storm structures in the April 27, 2011 Alabama tornado outbreak case.

Update from June quarterly report – with lots of still relevant information:
The real-time HRRR system continues to run in support of summer evaluation. RAP and nested HRRR runs have been completed for the second retrospective test period (May 30 – June 8, 2011 and the results analyzed and were presented at a telecom on June 21. Similar to the previous retrospective run, results showed substantial improvement reducing the high bias in radar reflectivity during the first few hours and better overall location of storms and depiction of storm structure. Fig. 3 shows a plot of the quantitative verification and an example of the HRRR forecast improvement from the 2011 version to the 2012 version.

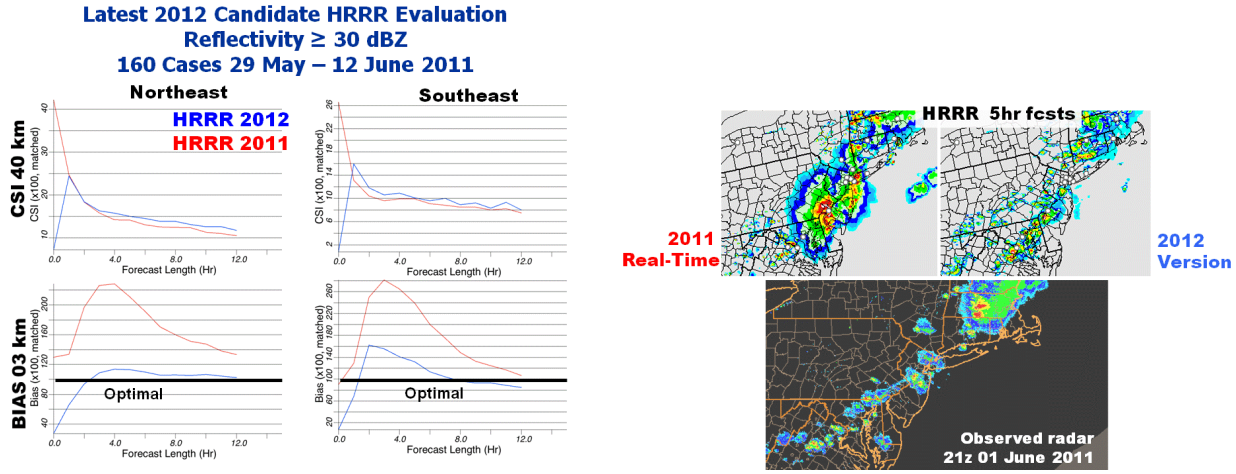

Fig 3. Quantitative verification statistics (CSI top and bias bottom) for Northeast (left) and Southeast (right) regions for the June 2011 retro period. b) Sample 5h HRRR forecast showing that the 2012 RAP/HRRR version greatly improves upon the over-forecast of convective coverage from the RAP/HRRR that was run in real-time in 2011.

The full PPT of this report is available at:
http://ruc.noaa.gov/pdf/FAA_HRRR_RetroResults_2012_Final.pdf

In addition, Ming Hu continues to test and evaluate application of the full GSI 3DVAR on the 3-km HRRRR domain and David Dowell continues his work on 15-min cycled radar assimilation. He presented results from this work at the recent NWP conference in Montreal. His presentation is available at:
http://ruc.noaa.gov/pdf/Dowell_Montreal_30may12_final.pdf

A low bias was identified in the HRRR echo tops (introduced with the new Thompson microphysics scheme and consistent post-processing code). A simple fix was coded up by Curtis Alexander and was implemented in early August to the HRRR after agreement from MIT/LL and approval by FAA (Jamie McMillon)

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. 2 shows the 12-h HRRR forecast of reflectivity and max 10m winds.

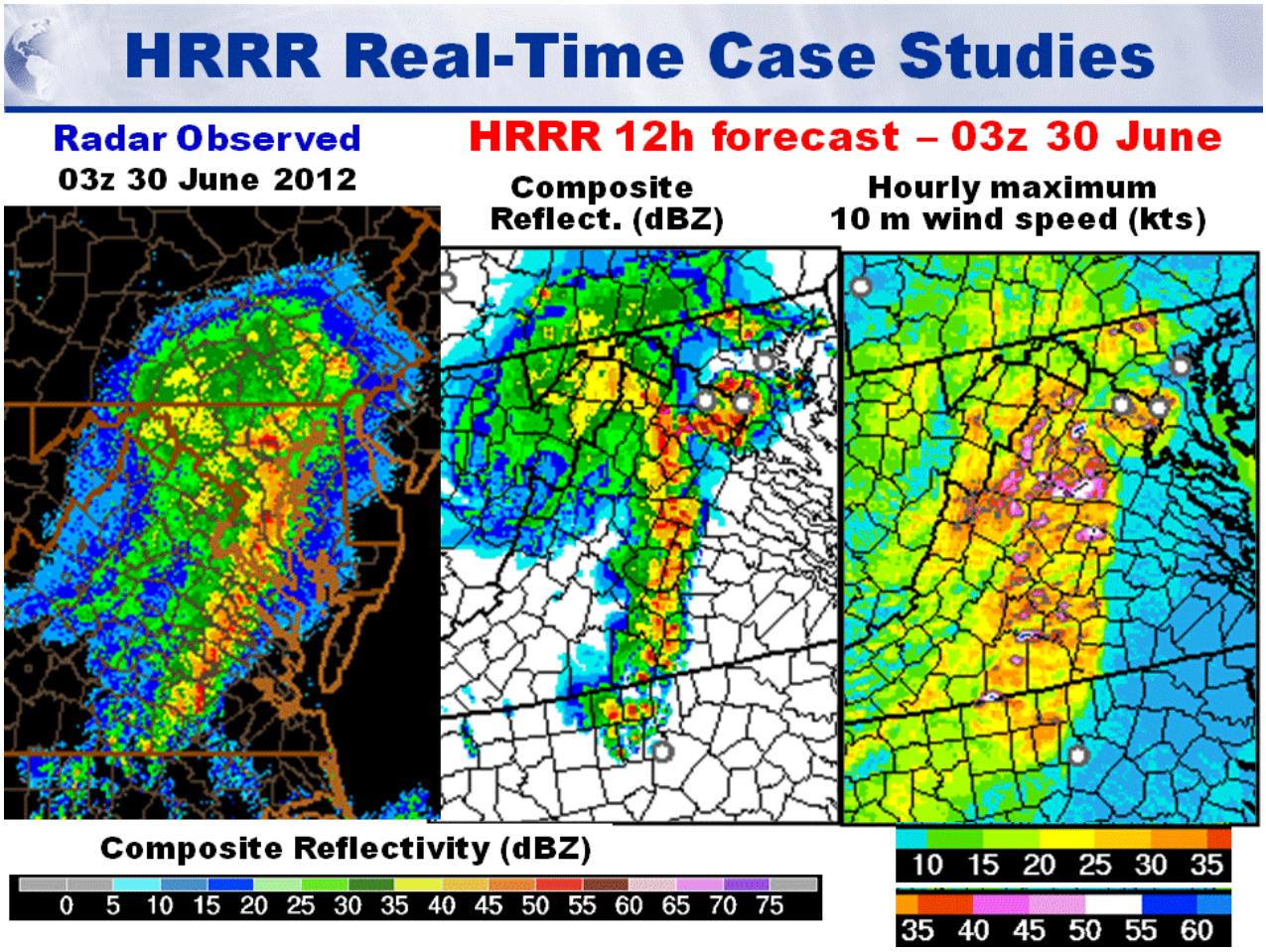

Fig. 4. Observed radar reflectivity (left) and HRRR 12h forecast reflectivity (center) and 10 m wind (right) from the extremely damaging derecho that struck Washington DC at 3z 30 June 2012.

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 – 15 August 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