MDE Product Development Team
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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 J. Brown and B. Johnson)

Executive Summary

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

- **RAP implementation at NCEP occurred on 1 May. The RAP has replaced the RUC.**
- RAP version 2 running at GSD, yielding improved 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, proposed for early FY13.
- RAP-dev3 cycle (identical to RAP version 2) 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

- Tests of 3-km GSI cloud analysis on both the ESRL JET supercomputer and the ZEUS supercomputer.
- Continuing work to run RTMA 2DVAR using 3-km HRRR CONUS grid as input (ESRL and NCEP)
- Several GSD personnel reported on recent enhancements to the RAP GSI at conferences and Workshops.

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 testing full GSI at 3-km for initializing HRRR and use of hourly pre-forecast radar data assimilation cycle (with use of radar data every 15 min.) to reduce HRRR spin-up period.
- 9-day June 2011 RAP retrospective runs and nested HRRR runs completed on ZEUS. Results analyzed for upcoming report.
- Good real-time reliability and performance for HRRR since 9 March code freeze

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.

Following the RAP operational implementation at 12z Tuesday 1 May 2012, there have been 2 instances of failure in the post processing (Unipost). These resulted from occasions when the pressure along a lateral boundary did not decrease monotonically as expected. A temporary fix to this problem was devised by Tanya Smirnova for Unipost, and is being tested at NCEP. A more substantive fix will require modification to the WRF code module_initialize_real.F; the likely time involved in thoroughly testing this code at GSD and porting it to NCEP for more testing in the operational environment was judged sufficiently long that inserting Tanya's fix as a temporary measure is considered acceptable.

The Storm Prediction Center forecasters express continued dissatisfaction with RAP as compared with RUC. These center around two issues: occasional situations when the RAP too rapidly mixes out near-surface moisture, and the failure of the RAP soundings to accurately delineate the structure and strength of the "cap", a thin stable layer or inversion separating air with abundant moisture at low levels and a dry, nearly dry-adiabatic "residual layer" above. Having a good estimate of the "strength" (or degree of inhibition) the cap presents to convection originating in the low-level moist air mass is important to ascertaining the likelihood of convective initiation rooted in this surface-based moist layer. Both of these issues are addressed in the RAP2 running in the primary RAP cycle at GSD (and which provides initial conditions for the HRRR). This is a motivation for wanting to see the RAPv2 changes (or at least some of them) implemented at NCEP before the 2013 convection season.

Further enhancements to the RAP2 under consideration or in testing include:

- Improvements to the GSI cloud analysis to take into account partial cloudiness by distinguishing between SCT, BKN and OVC in METAR obs and restoration of full use of satellite cloud observations (RUC-dev cycle at GSD; see Task 5),
- Evaluation of impact of the Vaisala GLD360 lightning product used as a proxy for radar reflectivity in the RAP radar assimilation (GSD-RAP-dev1 cycle on Jet; see task 5)
- Continued development and testing of the WRF MYNN boundary-layer scheme (GSD RAP-dev2 cycle on Jet; see Task 8).

We are also continuing the process of setting up RAP cycles on the new NOAA Environmental Security Computing Center Linux cluster, ZEUS (see FY12Q2 report, Task 4, for more details on ZEUS). What we are calling RAPdev1 on ZEUS is a clone of the RR-primary. This cycle is now working fully and reliably. We are in the process of setting up other development cycles on ZEUS, partly to replace those being lost as part of the conversion of Jet into a mainly Hurricane Forecast Improvement Project machine.

Several papers were prepared for the Joint AMS / CMOS (Canadian Meteorological and Oceanographic Society) meeting in Montreal 29 May - 1 June 2010. These covered various aspects of RAP and HRRR, most of which are at least covered briefly in this report.

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

NCEP
The Rapid Refresh (RAP) replaced the Rapid Update Cycle (RUC) in NCEP operations at 1200 UTC 1 May 2012. The transition was fairly smooth, particularly with regards to FAA usage of the new model output. All of effort EMC put into making everything from RAP look like what came out of RUC, the advanced notification and sharing

of test data sets allowed the users to be prepared for the change, and they did the necessary work to be ready. (Geoff Manikin)

Work is now underway 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)

All RUC dump and PREP jobs were replaced with RAP jobs on 1 May and changes made to add new RAP obs types [radar reflectivity, radar radial wind (GSD version only), satellite radiances (AMSU-A, AMSU-B, MHS, HIRS-3/4, AIRS, IASI, GOES (GSD only), MDCRS aircraft moisture, MAP profiler winds (SODARs at GSD only), GOES-13 and -15 cloud pressure/temperature from NASA Langley (GSD only), GOES-13 cloud pressure/temperature from NESDIS (along w/ GOES-15 which was used in RUC), Lightning (GSD only), MODIS winds, ASCAT winds, WindSat winds. Special WFIP-relocated PREPBUFR files from RAP replaced RUC files on the private ftpprd GSD area. (Dennis Keyser)

GSD
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.

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 maintained real-time availability of SAV and AIV guidance to all vendors from the operational hourly RUC on pressure surfaces on the 80-km AWIPS grid #211 via the NWS Family of Services (FOS) data feed and via the FAA Bulk Weather Data Telecommunications Gateway (FBWDTG). (EMC and NCO)

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

The RAPv1 implementation occurred on 1 May, so NCEP maintained real-time availability through April of full resolution gridded data from the operational RUC runs via anonymous ftp access via the NCEP server site at **ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/ruc/prod/** and at the NWS/OPS site at **ftp://tgftp.nws.noaa.gov/SL.us008001/ST.opnl/** in hourly directories named MT.ruc_CY.00 through MT.ruc_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.** (EMC and NCO)

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

GSD maintains its verification web site for RAP and RUC versions at **http://ruc.noaa.gov/stats/** (Note: RAP-NCEP is designated as "RRrapx" in the GSD statistics. Statistics are also available from the three GSD RAP real-time cycles and are becoming available for the new cycles being set up on ZEUS. Verification of the NCO pre-operational RAP from late December 2011 through April 2012 is also available at this web site ("RRrapx" also during that period). As of 12Z 1 May, the "RRrapx" verification is for the NCEP operational RAPv1.

The RAPv1 implementation occurred on 1 May, so NCEP maintained its capability and provided access to routine verifications of the operational RUC analyses and forecasts through April. 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

Concerns expressed by the SPC have been noted above. Contrary to our experience last year, some areas in the eastern US have been experiencing a dry bias in afternoon dew point. Comparison with the RAPv2 running at GSD indicates that this is related to changes made for RAPv2.

RAP implementation occurred on 1 May. (Manikin)

12.5.4.6 1 Aug 2012 (ESRL, NCEP)
Initial software for RAPv2 changes ready for porting to EMC.

The RAPv2 version running at GSD continues to perform well and has strong promise of fixing the most serious oper RAPv1 issues.
RAP implementation occurred on 1 May. (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. 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.

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 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.

NCEP
The NARRE-TL system was implemented along with the RAP on 1 May 2012. Webpages for both **CONUS** and **Alaska** provide viewing capability. Gridded mean, spread and probability products are on downloadable from **NOMADS here**. In addition, NARRE-TL control file descriptions for have been submitted to NCO, and tests begun. Mean and spread GRADS control files have successfully passed NCO's testing but work still continues on the ensemble probability control files. (BinBin Zhou and Jun Du)

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

Delays in the initial RAPv1 implementation will delay the RAPv2 upgrade until just before or possibly after the moratorium, which would be no sooner than May 2013. (Manikin)

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

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

Work on this project will begin after RAPv1 model is implemented at NCEP. (Tom Black)

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

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. (S. Benjamin)

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**

12.5.4.E2 1 Feb 2012 (ESRL, NCEP)
Update documentation for operational Rapid Refresh.

NCEP and ESRL
CURRENT EFFORTS: COMPLETE.

The RAP website (**http://rapidrefresh.noaa.gov**) has been updated further, consistent with the RAP implementation on 1 May. A new website describing diagnostic methods for RAP output fields is now available at **http://ruc.noaa.gov/rr/RAP_var_diagnosis.html**.

A National Weather Service Technical Implementation Notice (TIN) concerning the RUC to Rapid Refresh transition was posted on 30 November 2011. It can be found at **http://www.nws.noaa.gov/os/notification/tin11-53ructorap.htm**. The document contains an overview of the model and explanation of the differences between the RUC and RAPv1. (Manikin)

12.5.4.E3 1 Oct 2012 (modified) (ESRL, NCEP)
Final code ready for transfer to EMC for Rapid Refresh 2 (RAPv2) package to be implemented in early FY13 (modified)

NCEP
CURRENT EFFORTS: Work will begin on RAPv2 after the RAPv1 is implemented in May 2012. (Manikin)

GSD – RAPv2 code is essentially now ready for testing at EMC. Discussion has taken place about the possibility of starting some testing of RAPv2 at NCEP this summer.

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 May 2013. Discussions continue on whether it may be possible to implement RAPv2 before or after the moratorium. The argument to do so earlier is because RAPv2 code is already essentially frozen (for summer CoSPA HRRR) and ready to go.

12.5.4.E4 30 March 2012 (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.

12.5.4.E5 31 Dec 2012 (ESRL, NCEP)
Pending computer resource availability, complete EMC testing of Rapid Refresh 2 changes for operational RAP at NCEP.

NCEP
CURRENT EFFORTS: Work at NCEP will begin on RAPv2 after the RAPv1 is implemented in May 2012. Work at ESRL has been well underway throughout 2011 and especially during the Oct11-Mar12 period.

PLANNED EFFORTS: Code is now ready to go to EMC for initial testing now that the RAPv1 implementation is complete

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 June 2013.

12.5.4.E6 Ongoing (ESRL, NCEP)
Perform configuration management for Rapid Refresh, including thorough documentation, and respond promptly to any code malfunctions or performance issues.

NCEP
CURRENT EFFORTS: A total of 25 RFCs directly related to Rapid Refresh (RAPv1) codes and scripts were submitted to NCO during the last week of October in preparation for the implementation. Twenty additional RFCs covering related systems and verification codes were also submitted. 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/tin11-53ructorap.htm**. (Manikin)

PLANNED EFFORTS: Implementation of the RAPv2 will likely 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.

12.5.4.E7 Ongoing (ESRL, NCEP)
Monitor Rapid Refresh performance; respond to any problems detected by ESRL, NCEP, or any RAP users, Diagnose cause; develop solution to RR software, test changes and coordinate with NCO on implementation.

ESRL and NCEP
CURRENT EFFORTS: RAP implemented on 1 May. Evaluation of performance of real-time operational RAP has commenced, and some issues have become apparent (see discussions above). Evidence from comparison with the RAPv2 version running at GSD indicates that RAPv2 will alleviate or significantly reduce these problems.

PLANNED EFFORTS: Convert RAPv1 to new computer, and then bring in RAPv2 for testing and implementation in FY13. This should be easier than for all other NCEP models since RAP usually runs on Linux supercomputers like the new NCEP computer.

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 May, GSD data assimilation work continued in 3 main areas: 1) continued work to test a 13-km RAP hybrid / EnKF system on ZEUS (Ming Hu in collaboration with OU/CAPS), 2) work on ZEUS to improve on a HRRR 3-km background for the RTMA 2DVAR analysis (Patrick Hofmann in collaboration with Manuel Pondeca), and 3) running of the full GSI 3DVAR (and just the cloud analysis portion of the GSI) for the HRRR 3-km domain.

Other work included continued testing evaluation of improvements to the RAP cloud analysis (treatment for partial cloudiness, etc.), retrospective testing of assimilation of AIRS satellite retrievals and satellite radiance data (Haidao Lin) and testing and evaluation of lightning data assimilation in the RAP and sat-cast convective initiation indicator data in the RUC. Several branch personnel participated in the NWP conference and EnKF workshop.

The migration to ZEUS went quickly and we now have two parallel real-time RAP cycles and a real-time HRRR running on ZEUS. Then, with assistance from OU/CAPS, Ming Hu was able to prepare and run a 4-day retrospective test of a 40 member 13-km RAP hybrid / EnKF data assimilation system. Initial assessment indicates less skillful performance than for the current GSD parallel (3DVAR) RAP and spread among members that is too small. Factors that may have caused this are being investigated and additional testing is ongoing, Patrick has made good progress on adapting Manual's special 2DVAR version of GSI for use with 3-km HRRR fields and Ming has successfully run the full GSI over the full 3-km and is currently running the GSI cloud analysis prior to the ZEUS real-time HRRR-dev runs. David Dowell is also utilizing this 3-km HRRR capability to test 3-km radar data assimilation for the HRRR-dev (see task 5.24). Haidao Lin continued his satellite assimilation work, porting his RAP retrospective test system over to the ZEUS supercomputer. As part of a separate project, Haidao and Steve Weygandt presented two posters at the GOES-R science week (one on AIRS retrieval assimilation and one on assimilation of extended coverage (over large oceanic regions) lightning data assimilation and sat-cast data assimilation.

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.

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.

Ongoing retrospective and real-time testing led by Haidao Lin in this area. Improvements for the AIRS data from the selective channel removal are being shown in retrospective tests. RAP retrospective system ported to ZEUS supercomputer system.

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

Scripts for off-line NDAS parallel tests were set up to compare using the GEFS ensemble versus the EnKF ensemble in the regional hybrid analysis. The impact test could only be performed when the EnKF was produced routinely in the global pre-implementation parallel tests. Due to resource constraints only 2 cycles per day were used. The results from the limited cases that ran to completion show that using the global EnKF ensemble improved the short term (3-hour) regional forecasts over using the GEFS ensemble and that the resulting hybrid variation-ensemble analysis significantly reduced the error of subsequent regional forecasts. Once the ENKF is implemented in the operational global in mid-May, this will be put into a NAM parallel. (Wu)

12.5.5.4 31 Aug 2012 (ESRL)
Complete testing of GSI changes for RR2 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.

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
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)

12.5.5.6 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. (Manikin, Wu)

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
In May, three RTMA papers with the titles (1) The third upgrade of NCEP's Real-Time Mesoscale Analysis; (2) Improved QC and Metadata Usage in RTMA; and (3) Cloud Ceiling analysis in the RTMA were presented at Numerical Weather Prediction / Weather Analysis and Forecasting sessions of the 2012 **CMOS-AMS Congress**

in Montreal, Canada. The 2012 RTMA upgrade package, which contains RTMA implementations on six distinct domains, is ready to be submitted for implementation and real-time parallels have been set up. Work continued on improving the RTMA cloud ceiling analysis. Results from using the lowest cloud base height (lcbas) as the analysis variable are being compared with those obtained when log10 (lcbas) is the analysis variable. The impact of using a spatially variable correlation length is also being examined. Based on forecaster feedback, a possible afternoon low bias in the new RAP-based first guess temperature over the Seattle Metro area is being investigated. (Manuel Pondeca, Yanqiu Zhu, Steve Levine, Julia Zhu, Jim Purser)

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.

12.5.5.10 1 July 2012 (CAPS, ESRL)
Develop dual-resolution capabilities of EnKF and test it for RR configurations.
Working in conjunction with GSD, work on this task has been completed on this task by Kefeng Zhu and Yujie Pan at CAPS. 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 presented a poster summarizing initial results at an ensemble assimilation workshop and obtained good feedback. Work in this area is ongoing.

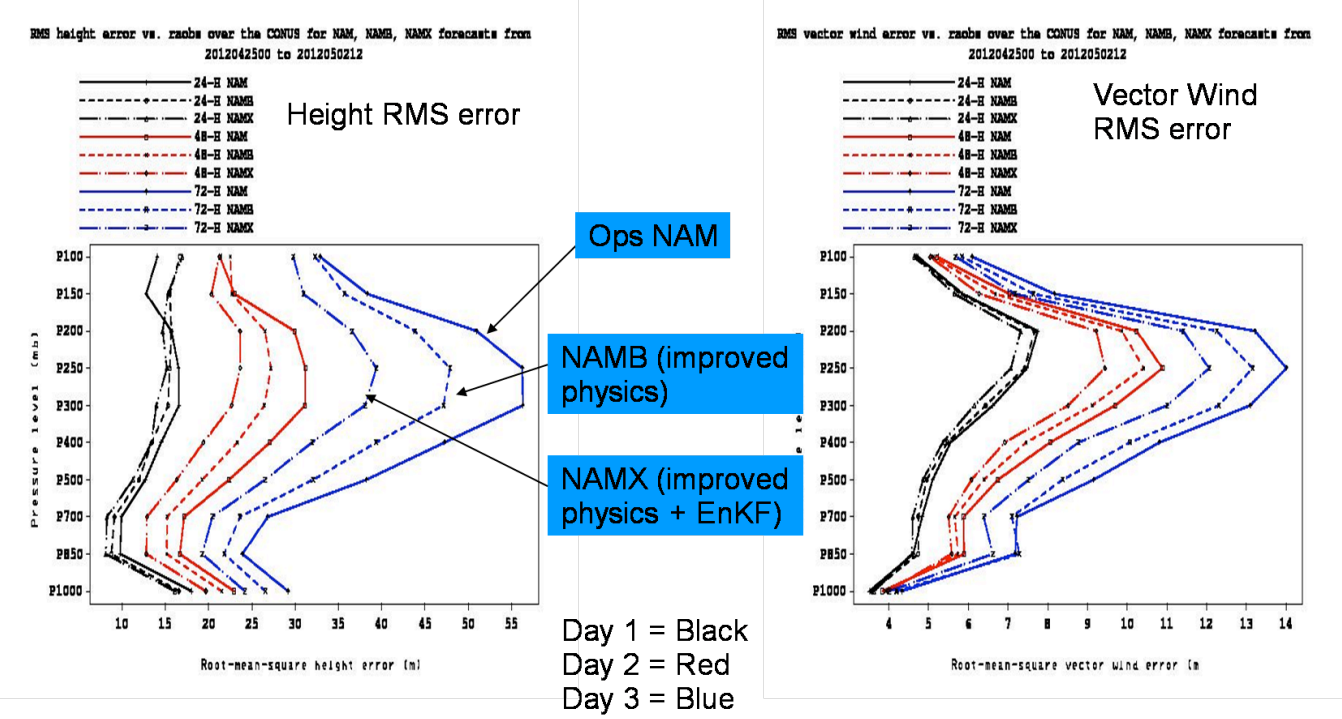
12.5.5.11 31 July 2012 (CAPS, EMC, ESRL)
Complete initial comparison of 13km EnKF/hybrid results using background error covariance fields derived from a global model ensemble vs. those derived from a regional ensemble.

GSD
With assistance from OU/CAPS, 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. Work ongoing by Ming Hu and Jeff Whitaker (ESRL) to resolve some outstanding issues.

NCEP
It was found that changing the job cards related to the threading speed up the wall clock of long jobs. Since the hybrid variational-ensemble analysis took about twice as long to run as the operational 3D-Var the impact of changing the job scripts were larger for hybrid analysis. The proposed change saved about 9% of the wall clock for EnKF/hybrid analysis while no significant impact was found with the operational regional analysis. (Wan-Shu Wu) Threading this way was also found to speed up the RTMA (Pondeca).

NAM vs NAM parallels upper air stats vs raobs

Ops NAM = Solid ; NAMB (with Physics changes) = Dashed ;
NAMX (with physics changes and using global EnKF in GSI) = Dash-Dot



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
VAD wind tests continued. The VAD wind RMS and bias for each station for the period 20120403 to 20120424 were calculated, along with the RMS and BIAS for the u- and v-components. These distributions of RMS and BIAS were then verified. The new VAD wind clearly shows a smaller bias in the v-component. (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
The next operational computer (WCOSS) in NCEP will be a little endian machine versus big endian for the current CCS machines. In preparation for porting to the new machine, the regional GSI was tested on ZEUS (NOAA's R&D), which is also a little endian machine. For conventional and satellite radiance data without thinning, the code produced almost identical results. The thinning, which was used on scatterometer winds (ASCAT) and the satellite radiance data, would produce nontrivial differences between the 2 machines.

The new NRL QC procedure for aircraft data was tested with the parallel analysis system. It was found the new code was not flagging all PIREP temperature and wind obs as they should be. Keyser fixed this error before submission for implementation. (Wan-Shu Wu, Keyser)

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.

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.

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 to delay in NCEP implementation of RAP version 1.

12.5.5E3 1 October 2012 (ESRL)

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

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.

12.5.5.E4 15 Dec 2012 (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
Pending EMC, and NCEP Center initial recommendations, Requests for Change (RFCs) are filed to submit GSI code as part of upgrade for Rapid Refresh 2 software to NCO, pending NCEP readiness.

CURRENT EFFORTS: Work will begin on RAPv2 after the RAPv1 is implemented on 1 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. Move this deadline to 15 Dec 12 but may need to be delayed further due to moratorium.

12.5.5.E5 15 Jan 2013 (ESRL, NCEP)
Pending computer resource availability, implementation of Rapid Refresh 2 changes to operational RAP at NCEP.

ESRL
Request for date change to early FY13.

NCEP
Pending computer resource availability, implementation of Rapid Refresh 2 changes to operational RAP at NCEP.

CURRENT EFFORTS: RAPv1 was implemented on 1 May 2012.

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

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.

12.5.5.E6 30 Sept 2012 (CAPS, EMC, ESRL)
Report on the results of EnKF and hybrid DA systems for the RR configuration.

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
CURRENT EFFORTS: Work will begin after the RAPv1 is implemented in May 2012.

PLANNED EFFORTS: Implement the RAPv1 in May 2012.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS: Delays in the initial RAPv1 implementation will delay the RAPv2 upgrade until after the moratorium, likely no sooner than May 2013.

UPDATES TO SCHEDULE: None

12.5.5.E7 30 Sept 2012 (NCEP)
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)

A new satellite data feed created by direct read-out stations and corrected more quickly than the standard feed were tested and included in the package for the next implementation. In order to use the GOES15 radiances in the analysis, a new version of GSI was checked out from the GSI trunk. The parallel tests indicated the new version produced slightly larger forecast error than the control. Work was done to find out the reason. (Wu)

PLANNED EFFORTS: Continue testing the hybrid variation-ensemble analysis and the new data, i.e., VAD winds, GPSRO bending angles, and surface observations without pressure. 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. Move work to the NOAA R&D computer (ZEUS). (Wu)

PROBLEMS/ISSUES ENCOUNTERED OR ANTICIPATED: The development computer in NCEP is at its full capacity and the off-line parallel does not run to completion often.

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: None.

12.5.5.E8 30 Sept 2012 (CAPS and GSD)
Report on initial results of dual-resolution EnKF for RR configuration.
At the Numerical Weather Prediction conference in Montreal, CN, Patrick Hofmann reported on specific changes

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 OU/CAPS and GSD personnel, including several recent conference / workshop presentations.

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

GSD
Improvements to radar and moisture assimilation in GSI finalized in January-February 2012 have greatly improved the WRF moist precipitation bias at least for RAPv2. We expect some continued moist precipitation bias in the NCEP RAP until the RAPv2 assimilation changes are implemented there.

We have noticed a slight improvement in the ability of the HRRR to develop leading-line / trailing stratiform mesoscale systems during its forecasts in 2012 as compared with 2011. We attribute this, in part at least, to use of the WRFV3.3.1 Thompson microphysics in place of V3.2.1, which was employed during the 2011 convection season. There were some notable busts in HRRR forecasts of mesoscale convective systems during April (insufficient mesoscale organization and longevity), so further improvement in this aspect of HRRR performance is still needed and will be pursued over the next several months.

NCAR/RAL
CURRENT EFFORTS: The only efforts during the month of May was preparation of the research plan for FY2013 and beyond and preparing and presenting at the AWRP review meeting in Boulder, CO at the end of the month.

PLANNED EFFORTS: The next 6 to 9 months will concentrate on the testing and full implementation of the Thompson et al (2008) "aerosol-aware" microphysics scheme. The scheme has been tested only for a couple of cases, but, during Summer 2012, it will be incorporated into a large-scale, long-term model simulation with significant leveraging with the CO Headwaters program at NCAR-RAL. This testing should be sufficient to prepare it for more widespread usage by other users before the end of the calendar year.

PROBLEMS/ISSUES ENCOUNTERED OR ANTICIPATED: No delays at this time.

INTERFACE WITH OTHER ORGANIZATIONS: None reported this time period.

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).

The MYNN PBL and surface-layer scheme continues to run in the RAP-development-2 cycle at GSD. Because this scheme gives wind forecasts that are no worse than the MYJ and often better, we persevere in addressing two other problem areas:

- Near surface warm bias in late afternoon / early evening period, including the evening transition: this is being addressed through modifications to the Yang (2002, *QJRMS*) surface-layer scheme and parameters that control the entrainment at top of the daytime mixed layer. Recent testing indicates that this issue may have been solved.
- Too drastic decoupling of near-surface conditions from the free atmosphere when snow or ice cover is present, leading to extensive spurious nocturnal fog formation in these regions: we are addressing these by modifications to mixing-length formulation under very stable conditions and by more careful mixing of thermodynamically conserved variables (e.g., liquid-water potential temperature).

Despite these concerns, a version of the MYNN that is regarded as superior to the one released with v3.3.1 was submitted to NCAR earlier this year and is part of the WRFV3.4 release by NCAR on 6 April. Because we still consider the MYNN to have promise for improved boundary-layer performance in both RAP and HRRR, work to eliminate remaining problem areas will continue.

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 1 July 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.

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)
Task 12.5.8.13 Deliver a WRF Users' Workshop and WRF Tutorial for the User Community

NCAR is organizing the 13th WRF Users' Workshop, to be held at NCAR's Center Green facility on June 25–29. NCAR finalized the agenda and program schedule, which is now posted on the workshop page: http://www.mmm.ucar.edu/events/2012_wrfusers. The first day of the workshop will provide lectures on convective parameterizations. The following three days will offer presentations spanning the WRF system and its applications: model updates, testing and evaluation, operational applications, physics, chemistry, and data assimilation. On the last day there will be mini-tutorials on visualization packages, regional climate modeling, and verification.

NCAR also worked on the organization of the next WRF tutorial. This will be at NCAR in Boulder on July 16-27. The components will be a basic WRF tutorial the first week, followed by a WRF DA tutorial and a WRF-Chem tutorial the following week.

PLANNED EFFORTS: NCAR will host the 13th WRF Users' Workshop on June 25–29. NCAR will prepare and deliver the next WRF tutorial in July.

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

In WRF boundary layer and land surface physics, Jimy Dudhia of NCAR continued working with visitors Roanne Bakker (Wageningen University, Netherlands) and Pedro Jimenez (CIEMAT, Spain) on testing and evaluating WRF against CASES99 tower data for stable conditions. The tests are focusing on modifying soil properties to improve nighttime cooling, and they are comparing thermal inertia properties with other studies.

Dudhia completed testing of convective-radiative equilibrium code, running to equilibrium after 25 days. The latest test included adding a 1C perturbation to the SST looking at effects on energy fluxes and the mean sounding. He also investigated a reported bugfix for the YSU PBLscheme, sent by a WRF user. This would have a small effect in the direction of reducing mixing in the stable boundary layer.

Lastly Dudhia continued hosting visitors working on WRF wind direction error in complex terrain and (Pedro Jimenez) and adapting MODIS aerosol optical depth for WRF input to radiation schemes (Jose Arias).

PLANNED EFFORTS: The development and incorporation of new physics and dynamics for WRF for the RAP will continue through FY12Q3.

UPDATES TO SCHEDULE: NONE

12.5.8.15 Ongoing (GSD)
Continue development of the RUC LSM for application to both RR (RR2 in FY12 and RR3 in FY13) 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).

There have been no recurrences of spurious sea-ice in low latitudes since additional quality-control safeguards were implemented into usage of the NESDIS 4-km snow cover and sea ice product.

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 15 Dec 2012 (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 early FY13 due to late implementation of initial RAP.

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 early FY13 due to late implementation of initial RAP.

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.

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.

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 for an upcoming presentation. 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.

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 is currently being evaluated in a parallel RAP run.

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.

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.

12.5.24.E2a 1 June 2012 (NCEP, ESRL/GSD) Request delay to 15 July 2012
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 second real-time version of the HRRR (HRRR-dev) is now running on the NOAA R&D site B computer (Zeus Supercomputer in Fairfield, WV). This Zeus HRRR run is supported by a real-time RAP run (RAP-dev3), which is also running on Zeus. Work is ongoing to make the pre- and post- transfer systems on Zeus fully independent of

Jet. This will allow us to maintain continuous real-time production of HRRR runs through planned down times of either machine. The current timeframe for NCEP operational implementation of the HRRR on the NCEP CCS computer is 2015, with some discussion about possible distribution of ESRL generated HRRR grids prior to that time.

(May effort) ESRL and NCEP are preparing status information for the HRRR plans for NCEP. We request delay for actual delivery of the report until 15 July.

Status of MDE Deliverables – 15 May 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)	10/01/12	☐	
12.5.4.E5 Complete testing at EMC of RAPv2 code, pending NCEP readiness (NCEP, ESRL)	12/31/12	☐	
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)	Ongoing	☐	
12.5.4.E8 Report on overall planned changes for FY13 upgrade to Rapid Refresh (ESRL)	11/30/12	☐	This task was originally for a RAPv3 but is now linked to RAPv2.
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)	10/01/12	☐	
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 readiness (NCEP, ESRL)	12/15/12	☐	
12.5.5.E5 Pending computer resources, implement RAPv2 at NCEP (NCEP, ESRL)	01/15/13	☐	NCEP plans a moratorium that may delay this implementation, although ESRL and NCEP will try to implement RAPv2 before it since code is essentially ready as of spring 2012
12.5.5.E6 Report on results of EnKF and hybrid DA systems for the RAP configuration (CAPS, EMC, ESRL)	09/30/12	☐	
12.5.5.E7 Subject to NCEP Director approval, implement NEMS/NMMB version of GSI in NAM/NDAS (NCEP)	09/30/12	☐	

12.5.5.E8 Develop dual-resolution EnKF for RAP configuration (CAPS)	09/30/12	☐	
12.5.5.E9 Report on planned GSI changes for the RAPv2 upgrade to the Rapid Refresh (ESRL)	09/30/12	☐	
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)	10/01/12	☐	Essentially complete now in ESRL RAPv2 but will keep the door open for additional physics mods until fall.
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)	12/15/12	☐	
12.5.8.E4 Pending computer resources, implement RAPv2 at NCEP with new physics configuration (ESRL, NCEP))	01/15/13	☐	
12.5.8.E5 Transfer the coupled aerosol-microphysics scheme into a test version of HRRR (NCAR/RAL)	09/01/12	☐	
12.5.8.E6 Deliver WRF Users' Workshop and WRF tutorial (NCAR/MMM)	07/30/12	☐	
12.5.8.E7 Report on enhancements made to WRF model physics (NCAR/RAL)	09/15/12	☐	
12.5.8.E8 Report summarizing enhancements made to the model physics packages (ESRL)	09/30/12	☐	
12.5.8.E9 Incorporate physics improvements into WRF for future RAP and HRRR (NCAR/MMM)	09/30/12	☐	
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 HRRR during the 2012 CoSPA Prototype Summer Operations	01/15/12	☑	
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	☐	ESRL and NCEP are preparing status information for the HRRR plans for NCEP. We request delay for actual delivery of the report until 15 July.