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

Executive Summary

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

- Continued progress toward RAP implementation at NCEP to replace the RUC, now planned for 20 March, 30-day evaluation is now underway.
- Further upgrades to ESRL RAP implemented at ESRL in January through mid-February, including data assimilation and modeling improvements. All of these will be included in Rapid Refresh v2 with implementation at NCEP by early FY13.

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

- Package of RAP-version2 analysis upgrades (including improved PW assimilation, PBL-based pseudo-observations for moisture, soil nudging, and improved radar/snow specification and cloud building) tested and installed in GSD parallel RAP versions (7 Jan). Improved RAP performance (especially reduced high precipitation bias in early hours) and improved subsequent HRRR forecasts.
- Parallel testing of level 2 radial data assimilation showing neutral to positive impact, ongoing work to reduce latency in data feed. Real-time parallel testing of assimilation of tower and other novel data.
- Work to update RAP-version2 GSI using latest EMC trunk version (with upgrades from NCEP and NASA-GMAO) nearly complete.
- Ongoing retrospective evaluation of RAP forecast performance (upper-air, surface, precipitation, etc.) for new versions with sequences of change bundles.
- Modification developed for GSI to allow GOES cloud building at low-levels.

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

- Thompson v3.3.1 microphysics and MYNN boundary layer and RUC land-surface schemes implemented in RAP-primary at ESRL on 15 Feb.
- ESRL RAP updated to use MODIS land-use data – 15 Feb.

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

- Completed work to upgrade HRRR (and RAP) system to new ARW version 3.3.1+, switch to this version for HRRR expected this week (3rd week Feb).
- Completed work to test and implement a radar reflectivity diagnostic algorithm that is consistent with WRF v3.3.1 Thompson microphysics, including modification for bright banding and accumulation of grapple.
- Evaluation of initial HRRR runs (from Aug. 2011 retro period) using improved RAP-version 2 configuration showing significant improvements (better storm location and structure, reduced spurious convection).

NOTE to all RUC/RAP users: **Now** is the overlap period with ***both*** RUC and RAP data available from NCEP for any users to sort out any transition issues. When the RAP changes status to operational planned for 20 March, there will be no RUC grids available after this date.

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 RR 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 RR. The changes and problem areas listed below involved such cross-component investigation and testing.

The Rapid Refresh (RAP) implementation is now scheduled for 20 March 2012. After the original start of the RAP field test on 12 January, there were two Unipost crashes that were quickly diagnosed by EMC and GSD. However, in each case, once the fixes were made and tested, NCO made the decision to restart the clock on the 4-week field test. (It should be noted that the workflow manager used with the RAP at GSD automatically restarts a failed job, but this does not happen at NCEP. We found evidence that Unipost had been susceptible to rare crashes due to out-of-bounds errors at GSD, but completed successfully after being restarted by the workflow manager so that the flow of output was not interrupted.) Tanya Smirnova did a careful check of the Unipost code after the most recent Unipost crash and found other possible vulnerabilities that have also been eliminated, so we are guardedly optimistic that there will be no further delays in completing the field test. The model itself (as well as the GSI) has been running stably since the change to the non-hydrostatic and Rayleigh-damping upper-boundary-condition options were introduced in late December (see FY12Q1 MDE report).

The bulk of our efforts during January were directed toward developing and testing the next upgrade to the RAP, referred to as RAP2. Due to the impending freeze date of mid-March for this summer's CoSPA configuration of the High-Resolution Rapid Refresh (HRRR), Rapid Refresh upgrades that are anticipated to have particular impacts on the HRRR because of the HRRR's dependency on the RAP for initial conditions are being given highest priority. Our overall strategy is to evaluate these upgrades in the RAP primarily using warm-season retrospective runs, while simultaneously confirming their impacts on cold-season forecasting through use of the RAP parallel cycles at GSD. As we determine that WRF *model* changes for the RAP are favorable, those that are also appropriate for the HRRR are being implemented and evaluated. Of course, change in either the WRF model or the GSI analysis directly affects both the RAP itself and the HRRR.

The substantial changes to the cloud analysis and specification of hydrometeors, as well as the soil nudging and use of water-vapor-only pseudo observations in the mixed layer (see FY12Q1 MDE report for more details) continue to perform well. Preliminary HRRR retrospective testing using initial conditions with these RAP changes are encouraging that they will help both the high moisture bias in RAP and the HRRR over forecasting of convection that was noted during CoSPA 2011.

The biggest challenge during the month proved to be diagnosing the disappointing verification results in the parallel testing of WRFV3.3.1 against V3.2.1, and coming up with a cure. After much detective work by GSD to track down other, unrelated WRF issues that were causing crashes, it was determined through retrospective testing that changes to the G3 convection scheme for V3.3.1 were the cause of the forecast degradation noted with V3.3.1. So, for the summer CoSPA exercise, the RAP cycle that supplies initial conditions for the HRRR will be run with the V3.2.1 G3 scheme, but with V3.3.1 of the WRF model itself and the other physics schemes. The various WRF issues that arose during this effort are being passed on to the WRF developers.

These other changes of slightly less but still notable importance for improving forecast skill have been in development and testing:

- The latest parallel testing on assimilation of level 2.5 radial winds has shown approximately neutral impacts, based on our objective verification. Even though level 2 radial winds are preferable, they are not reliably available before the RAP data cutoff, but the addition of at least level 2 radial winds should help for mesoscale winds in some situations.
- Parallel testing of V3.3.1 continues. Now that we are using the V3.2.1 G3 scheme (see above), any impacts of upgrading to 3.3.1 are expected to be minor except for those resulting from use of the latest NCAR Thompson microphysics. We are also now using the 5th order vertical advection in all the GSD

RAP cycles, as we continue to see evidence of better cloud retention, particularly for west coast marine-layer low stratus and high-level cirrus. Impacts of this vertical advection change in the RAP, and also more directly on the HRRR with this change are expected to be minor, based on test results so far.

- Other evaluation of physics behavior continues (Task 8).
- Comparison of the reflectivity calculation that is part of (and consistent with the microphysics of) the V3.3.1 Thompson microphysics scheme discussed in the FY12Q1 MDE report with the calculation now in Unipost for RAP and also being used in the operational RUC is underway. This new calculation produces somewhat lower values than the present RUC, RAP and HRRR reflectivity's below ~ 40-45 dbZ, and somewhat higher values above. This is of importance for the HRRR, where reflectivity is used to infer a Vertically Integrated Liquid (VIL) value that is used in generating the CoSPA convection product, and a reflectivity-based cloud-top product (18-dbZ thresholds). Other efforts are also underway:
- Assimilation of low-level winds from towers, wind-generator nacelles, and sodars. These proprietary data have been made available via NCEP through leveraging from the Department of Energy-funded Wind Forecast Improvement Project (WFIP). They are available in the upper Midwest of the US and some locations in Texas. The wind tower data and nacelle wind data are under evaluation for RAP assimilation within GSI. The sodar data has being assimilated into the RAP-primary at GSD since 23 Dec 2011.
- (*No work in this item in January but retained for completeness*) Additional changes / enhancements to GSI had some prior effort in 2011, including smaller vertical error correlation and lower rawinsonde observation errors in GSI, and using the NCAR software *gen_be* to derive RR specific background error covariance as a possible alternative to the (current) use of the NAM-derived configuration. Both of these efforts are motivated in part by the need to more faithfully replicate smaller-scale details of the temperature and moisture stratification that can be important for prediction of initiation of convection. (See Task 5.) Data collection for use in generating new background error covariance continues.

NCEP

Subtask 12.5.4.1

The Rapid Refresh (RAP) has been running stably in an EMC parallel environment since December 2010. Work has been done to make "look-alike" products that match those that are currently available from the RUC - output will be available on 13 and 20 km CONUS grids in formats of data on pressure levels and data on native levels. It will also be available at 40 km on pressure levels; the 40 km output on native levels is being discontinued due to lack of demand. In addition, the RUC "surface" output will not be available in the RAP, as the pressure level files contain all those parameters. Finally, an 11-km Alaska grid, a 16-km Puerto Rico grid, and a 32-km full domain grid will be added. Coordination was done with several FAA groups to test RAP files to ensure a smooth transition. The handing off of the codes to NCO occurred in late October once the final configuration of the catch-up cycle was decided upon. Six hours of catch-up are required following a cold-start from the GDAS. The final configuration calls for 2 hours of catch-up to be done each hour during the three hours preceding 09z and 21z when the catch-up first-guess is used instead of the cycled RAP forecast. New dumps of observations are done for each of the catch-up hours in order to bring in any late arriving data. NCO built their parallel system in December, and a formal evaluation began in January. A minor bug in the post processing was discovered and corrected in the middle of January, delaying the evaluation period. RAP implementation is currently scheduled for late March 2012. (Geoff Manikin, Dennis Keyser)

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

GSD continues to make pgrb and bgrb files available from the ESRL/GSD RAP-primary real-time 1-h cycle available from its FTP site. With the ongoing RAP field test, RAP grids from the pre-operational NCEP/NCO cycle have replaced those from Geoff Manikin's EMC RAP, and should be more reliable since it is being run in the operations (not development) environment.

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). (30 Nov 12)
(DiMego)

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

The RAP implementation is now planned for March 2012, so NCEP maintained real-time availability 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**. A limited set of fields from the RUC runs (and other NCEP models) can also be viewed at **http://mag.ncep.noaa.gov/NCOMAGWEB/appcontroller**. (DiMego)

NOTE to all RUC/RAP users: Now is the overlap period with ***both*** RUC and RAP data available from NCEP for any users to sort out any transition issues. When the RAP changes status to operational planned for 20 March, there will be no RUC grids available after this date.

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/**
Statistics are available from the three RAP real-time cycles. Verification of the NCO pre-operational RAP is now available at this web site. This verification will continue with the official RAP implementation now scheduled for 20 March.

The RAP implementation was delayed to Q2FY12, so NCEP maintained its capability and provided access to routine verifications of the operational RUC analyses and forecasts. 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 (DiMego)

12.5.4.5 Ongoing (GSD, NCEP)
Ongoing evaluation of performance of real-time and retrospective runs of RAP system for SAVs, AHPs
The NCEP/NCL pre-operational RAP cycle is equivalent to or outperforms the operational RUC for most variables at most altitudes. Lower troposphere humidity and temperature forecasts are showing further improvement in the ESRL RAP with changes implemented in November and December for soil adjustment and modification in assimilation of PBL-based pseudo-observations as well as the GSI version of the RUC cloud analysis.

12.5.4.6 1 Mar 2012 **(ESRL, NCEP)**
Initial software for RR2 changes ready for porting to EMC.

Delays in the initial Rapid Refresh implementation will delay the Rapid Refresh upgrade to 2013. Move deadline to 1 Sep 12. (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 will be fully set by early March 2012. This version of the RAP will be roughly equivalent to the RAP2 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 RAP2 is transferred to NCEP/EMC later in 2012.

12.5.4.8 31 May 2012 **(ESRL, NCEP)**
Start design of NARRE ARW and NMM model ensembles.

Verification of various physics options in the framework of the NCEP SREF (using ARW and NMM) is continuing. This ensemble configuration can be directly used to the future NARRE ARW and NMM ensembles for aviation forecasts. ESRL and NCEP have compared possible physics configurations for NARRE.

NCEP
Subtask 12.5.4.8

The NARRE-TL system has been sent to NCEP Central Operations for operational implementation. It is expected to be implemented along with RAP near the end of March. Physics were adjusted for the NMMB members in the SREF to reduce its warm bias, while an investigation is going on to determine why ARW_NCAR and ARW_RAP members in the SREF show a cold bias in 2m temperatures. (BinBin Zhou and Jun Du)

12.5.4.9 28 May 2012 (ESRL, NCEP)
Complete testing at EMC of RR2 code, pending NCEP readiness.
Delays in the initial Rapid Refresh implementation will delay the Rapid Refresh 2 upgrade, possibly to 2013. Move deadline to 1 Jan 13. (Manikin)

12.5.4.9a 15 June 2012 (NCEP, ESRL)
Submit Request for Change (RFC) and modified code for RAP2 from EMC to NCO, pending NCEP readiness.

Delays in the initial Rapid Refresh implementation will delay the Rapid Refresh upgrade to 2013. Move deadline to 15 Jan 13. (Manikin)

12.5.4.10 1 July 2012 (ESRL)
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.

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

12.5.4.11 30 September 2012 (GSD, NCEP)
Present improved plan for bringing ARW model code into compliance with then current version of NEMS.

Under non-FAA funding, the Advanced Computing Group within GSD working in close collaboration with Tom Black at NCEP has mostly completed bringing the global Finite-volume flow-following Icosahedral Model (FIM) into the NEMS framework. It is expected that this experience will greatly facilitate converting the then current version of the RAP code into NEMS.

Deliverables
All Option A unless noted otherwise.

12.5.4.E1 20 Dec 2011 (ESRL)
Report on Rapid Refresh status and plans to NCEP Operational Model Production Suite Review meeting. Complete. Stan Benjamin and Steve Weygandt made a joint presentation on the RR / HRRR status at this review, held 6-7 December at NCEP. Presentations will be made available on the web.

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: 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 RAP.

The Rapid Refresh web page at **http://rapidrefresh.noaa.gov** continues to be updated with the latest information on the RAP. The RAP/RUC question/answer forum has been getting more active in recent months – see **http://ruc.noaa.gov/forum/eval**.

GSD has given 3 RAP tutorials via Go To Meeting to Storm Prediction Center forecasters. In addition, two tutorials open to NWS field offices and the other NCEP centers are scheduled on 22 and 29 February.

PLANNED EFFORTS: Implement the RAP in Q2FY12.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: None.

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

NCEP
CURRENT EFFORTS: Work will begin after the RAP is implemented in Q2FY12. (Manikin)

PLANNED EFFORTS:

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: (requested in Jan 2012) *Move deadline to 1 Oct 12 because of delay in initial RAP implementation.*

12.5.4.E4 30 March 2012 (ESRL)
Report on testing of RAP assimilation/model improvements toward planned RR2 upgrade.

Extensive testing complete or underway … see above.

12.5.4.E5 31 July 2012 (request change to FY13) (ESRL, NCEP)
Pending computer resource availability, implementation of Rapid Refresh 2 changes to operational RR at NCEP.

NCEP
CURRENT EFFORTS: Work will begin after the RAP is implemented in Q2FY12. (Manikin)

PLANNED EFFORTS:

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: Move deadline to somewhere between Nov 12 to Feb 13 because of delay in RAP implementation.

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 code 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: Implement the RAP in Q2FY12.

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 RR users, Diagnose cause; develop solution to RR software, test changes and coordinate with NCO on implementation.

ESRL
The ESRL and NCEP versions of the RAP have been evaluated by ESRL and NCEP/EMC on an almost daily basis, including validation against rawinsonde, surface, and precipitation observations available under **http://ruc.noaa.gov/stats**. Storm Prediction Center forecasters have expressed concern about lack of detail in the temperature and moisture stratification sometimes seen in RAP soundings, especially when compared with RUC and raobs. GSD is in discussions with SPC on ascertaining how serious this deficiency is and ways of ameliorating it.

NCEP
CURRENT EFFORTS: The Rapid Refresh had been running stably in parallel for over a year before a series of crashes occurred in late December in the vicinity of a strong mountain wave generated by an intense jet stream over Greenland. Tests were made with a slightly different model configuration (i.e., the wave damping option was modified), and all cases which experienced crashes were run to successful completion. This new configuration was given to NCO at the end of December to update the RAP parallel code. (Manikin)

PLANNED EFFORTS: Implement the RAP in Q2FY12.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: None.

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

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

ESRL/GSD

NCEP operational implementation is now planned for March 20, 2012. Some minor issues in the Unipost post-processing code (unrelated to the GSI assimilation) caused failures of that module in the NCO 30-day test, requiring slight modification to the UniPost code and a restart of the 30-day period.

Following extensive evaluation, on 7 Jan 2012, a package with several changes designed to reduce the RAP positive bias in moisture and precipitation was implemented into the GSI for all three ESRL real-time parallel RAP versions The evaluation included examination of RAP upper-level and surface verification statistics, RAP precipitation verification (especially the 24 x 1 hr. precipitation sums), as well as evaluation of few HRRR forecasts initialized from this new RAP version. Results from this analysis show a reduction in the high precipitation bias within the RAP and the high reflectivity bias within the subsequent HRRR runs. The GSI changes implemented include:

(1) Added soil adjustment for moisture and temperature based upon near-surface temperature and moisture analysis increments
(2) Switched planetary boundary layer pseudo-observations to moisture only (remove temperature pseudo-observations)
(3) Modified GSI forward model for GPS-met PW observations to account for difference in terrain height between observations and model and to limit large PW innovations.
(4) Modified GSI cloud analysis to reduce relative humidity for cloud clearing and to preserve virtual potential temperature when adjusting water vapor for cloud building/clearing
(5) Incorporated new temperature-dependent specification of hydrometeor specification from 3-d radar reflectivity that significantly reduces excessive precipitation during first 1-2h of RAP model forecasts. This modified technique appears to be particularly important in reducing RAP and HRRR moist bias.

A specific focus of the RAP retrospective runs is evaluation of the impact of changes to the moisture assimilation, (PW, PBL pseudo-observations -- moisture only now), cloud analysis (sub-saturating for clearing, virtual potential temperature conservation, etc.), and soil moisture/temperature adjustment on RAP skill for upper-level relative humidity, surface temperature and dew point, precipitation, and subsequent HRRR forecasts. Results from a controlled retrospective run (for the 11-18 Aug. high weather impact period) with all these changes listed above indicate improvements in all of these areas. Specifically, a reduction in the high precipitation bias in the first hour of the RAP, improved upper-level skill scores (likely due to the reduction of spurious parameterized convective precipitation systems), and improved surface dew point forecasts. These changes will be part next version of the RAP at NCEP (RAP-version2) and of the RAP version frozen in March 2012 for the CoSPA exercise.

Work to evaluate impacts from real-time parallel testing of assimilation of low-level winds data from towers, wind-generator nacelles, and sodars is ongoing. These data are available and being evaluated for RR assimilation through leveraging from the Department of Energy-funded Wind Forecast Improvement Project.

Ming Hu has nearly completed work to update the ESRL RAP-version 2 GSI to the latest EMC trunk.

Ming Hu updated the BUFR library for the ESRL GSD version of the RAP to make it consistent with the NCEP version. This restored functionality of the GSI satellite radiance assimilation, which experienced a brief (< 1 day) outage, when the radiance data file feed from NCEP was upgraded (requiring the new version of the BUFR library).

Cloud analysis – new software was developed to re-introduce GOES cloud building but only within 1200m of surface. This software was tested first in the development RUC and then tested within the GSI for the RAP. Additional work will continue in this area both before and after the RAP freeze.

GSD contributors to RR/HRRR effort under FAA and NOAA funding: Ming Hu, Curtis Alexander, Stan Benjamin, John Brown, Tanya Smirnova, David Dowell, Haidao Lin, Joe Olson, Patrick Hofmann, Eric James, Brian Jamison, Xue Wei, and Bill Moninger.

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 RR-dev2 are still neutral to slightly negative, evaluation of factors (data thinning, assumed observation error, etc.) are ongoing, along with effort to move data window (and cutoff) time forward to meet RAP analysis data cutoff time requirement. We are also examining the possibility of using just the level 2.5 data.

12.5.5.1a 31 Jan 2012 (ESRL, NCEP)
Complete preparation of initial GSI changes for RR2 changes ported to EMC.

Weekly meetings are being held with AMB personnel to continually re-assess possible changes and prioritize testing and evaluation of them.

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 RR2.

Ongoing retrospective and real-time testing led by Haidao Lin in this area. Improvements for AIRS data from selective channel removal shown in retrospective tests.

12.5.5.2 31 January 2012 (CAPS, ESRL)
Complete the tuning of 40-km baseline EnKF DA system for conventional data for the goal of obtaining better short-range forecasting than GSI-based forecasts.
Work completed by Kefeng Zhu and Yujie Pan of CAPS as part of collaborative project. See their summary below

12.5.5.3 31 January 2012 (CAPS, EMC, ESRL)
Implement proper vertical covariance localization and test the hybrid DA system using EnKF covariance.
Work completed by Kefeng Zhu and Yujie Pan of CAPS as part of collaborative project. See their summary below

NCEP
Work on the regional 3dvar-ensemble hybrid continues. Codes were changed to incorporate vertically inhomogeneous background errors for blending coefficients for variational and ensemble solutions, as was the code to use a vertically integrated alpha using surface pressure instead of using the first level above the ground. A switch was added to allow an ensemble member perturbed on the regional first guess instead of the global ensemble mean. Each of these features was tested with the off-line parallel and impacts were positive. A test was

conducted to see if it helped to generate a dynamically consistent cyclonic storm structure using the reported/estimated surface pressure at the center of tropical cyclones. This is currently done in the operational global data assimilation (where the system has a strong constraint) but not in the regional. The storm center was not at the observed location and the surface cyclonic flow was much too strong and not symmetric. Extra ensemble members were added by shifting the first guess by one (more) grid point in all directions. More synthetic surface pressure obs were added so that the hybrid GSI could give the ensemble member with the best location the dominant weight. Under these conditions, the hybrid 3dvar-ensemble system was able to generate a more symmetrical cyclonic structure at the observed storm location. The forecast impact was not clear when compared with other relocation tools. (Wu)

12.5.5.2 12.5.5.3 15 January 2012 (CAPS, ESRL, EMC)

Report on test results of implementing the EnKF package and the hybrid GSI-EnKF for RR application.

In our earlier experiments, we found increasing the fixed inflation factor from 10% to 15% degraded the EnKF performance. To see if a smaller inflation factor would help, experiments with the same fixed inflation factor of 10% but a smaller adaptive inflation factor with an 80% first guess spread recovery have been conducted. No positive impacts were found with either CV5 or CV3 random initial and boundary perturbations. Therefore, we will continue to use the setting of 10% fixed inflation factor and an adaptive inflation factor with a 90% spread recovery.

Tests on assimilating satellite radiance within the 4DEnKF continued. Two problems have been found. One is the time window for the satellite radiance data. In the previous tests, to avoid duplicate use of the same observation, half an hour time window was applied during the GSI data processing. However, the hourly satellite radiance data is found to collect mainly half an hour to an hour before the specified file times. Therefore, only a few radiance data had been used in the 4DEnKF tests. Another issue is in the analysis-forecast cycling; we used the same static bias correction coefficients file. In the recent communication with Haidao Lin of GSD, he said that the replacement of this static file with the prior updated bias coefficients might help improve the accuracy of bias correction and improve the forecasts. A test run will be carried out next month to see if the above changes will improve the forecasts.

Dual-resolution EnKF analysis-forecast cycling scripts based on xml and ksh have been developed and tested. A test has been run and the impact on the 13 km grid short-range precipitation forecast has been roughly investigated. As expected, the forecasts from EnKF dual-resolution analyses show flow-dependent rain-band structures. Verification for forecasts from the dual resolution analyses and from direct interpolating of 40 km EnKF analyses are ongoing.

In January, we reran the GSI using the conventional datasets and the same WRF configuration setting as EnKF. To our surprise, the performance of relative humidity variable was greatly improved at middle level when compared with the old GSI setting. One of possible explanations is that in the old GSI setting, we only used four types of observations: u, v, t and q. In the new GSI run, we use full available conventional datasets. The other may be due to the changes of WRF configurations like DFI settings, damping coefficient, etc. When we use these new GSI results for comparison, GSI outperforms EnKF with single-physics scheme for relative humidity variable while for other variables; the EnKF is generally better than GSI. More efforts to improve the EnKF single-physics scheme performance for the relative humidity variable are still needed. The good news is that the multi-physics EnKF and hybrid scheme based on single-physics ensemble still beat the improved GSI.

In addition, the weighting factors for the static and ensemble covariances within the hybrid GSI were examined. Five weight factors for the static covariance (0.0, 0.3, 0.5, 0.7) were tested. It was found that hybrid analyses are improved noticeably when the 0.3 weight factor is used but little improvement is found when larger values are used. Further tests will be performed to determine the optimal weight.

12.5.5.4 1 April 2012 (change to 31 July) (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 July 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.

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 application 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.

NCEP
Checks were done on the conv_vol Canadian radar data, which are used to generate the reflectivity BUFR tank. The problem we have with ring discontinuity was resolved by using conv_vol reflectivity. Checks on the new VAD winds were begun. New VAD winds in the PrepBUFR files were not dumped properly and need to be fixed. (Shun Liu)

12.5.5.6 1 April 2012 (GSD)
Complete testing of Rapid Refresh GSI modifications for RR2 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.

12.5.5.7 15 June 2012 (NCEP, ESRL)
Submit Request for Change (RFC) and modified GSI code for RR2 from EMC to NCO, pending NCEP readiness.
Delays in the initial Rapid Refresh implementation will delay the Rapid Refresh upgrade to 2013.

NCEP
Delays in the initial Rapid Refresh implementation will delay the Rapid Refresh upgrade to 2013. Move deadline to 15 Jan 13. (Manikin, Wu)

12.5.5.8 1 April 2012 (CAPS, ESRL)
Start testing the 40-km EnKF DA system including the satellite radiance data used in RR GSI.

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
Tests have been conducted to determine the value of blending the RAP and NAM downscaled forecasts together to create the RTMA first guess. Results showed the blended fields generally displayed smaller root mean square errors than those associated with the individual downscaled forecasts. The blended approach is already in use in the parallel Alaska RTMA. It will also be applied to the parallel RTMA CONUS/NWRFC, once the NAM downscaled forecast for that domain is available. Cloud amount and cloud base height have been added to the GSI as analysis variables and initial assimilation tests have begun. The goal is to use the analysis of cloud amount and cloud base height to diagnose the cloud ceiling RTMA field. (Manuel Pondeca)

12.5.5.10 1 July 2012 (CAPS, ESRL)
Develop dual-resolution capabilities of EnKF and test it for RR configurations.

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.

NCEP
Working with Wan-Shu Wu, Daryl Kleist, Jacob Carley and Mingjing Tong, multiple upgrades to the hybrid ensemble part of GSI were combined into a single bundle. These include (1) the regional dual resolution option (Parrish); (2) the use of a switch to allow an ensemble member to be perturbed on the regional first guess instead of on the global ensemble mean vertical weighting of static and ensemble background errors, and vertical weighting of the surface pressure contribution from ensemble (Wu); (3) HWRF additions (Tong); (4) NEMS-NMMB format ensemble input (Carley); and (5) several new 4d-var ensemble options that currently only work for global model (Kleist). These changes have been tested and reviewed and should be added to the GSI trunk by mid-February. (Dave Parrish, 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
Forecasts with reflectivity assimilation from 201112019 to 20120116 were verified with 3h STAGE2 precipitation and 24 CPC analysis precipitation. Lower precipitation bias was found with radar data assimilation. (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
Our main effort was to study the character of the NDAS humidity analysis. The relative humidity distributions before and after the analysis procedure were compared as well as those before and after the model forecast. Many more grid points were found saturated between 600-200 hPa during the 3-hour forecast of the NDAS cycling while the analysis procedure produced acceptable changes to the relative humidity distribution. The background error variance for the normalized relative humidity was tuned and a bug related to using the normalized relative humidity as a control variable in GSI was fixed. The impact of these changes will be tested in an off-line parallel. (Wan-Shu Wu)

Work continues on a method to use GFS derived satellite bias correction coefficients directly in the NAM GSI. Setting the top pressure of the NAM to zero is not sufficient for this purpose. It is essential that there be greater resolution (extra model layers) in the stratosphere. The existing feature in GSI to introduce additional levels as necessary for the radiance forward model computation does not help. An alternative approach is being tested that replaces the upper levels of the NAM model with fields from the GDAS guess. A new vertical coordinate is

defined which matches NAM from the surface to 150mb and matches the GFS vertical coordinate from 70mb to the top. This adds additional levels so that there are currently 75 vertical levels (analysis only - the analysis increment is interpolated back to the original NAM vertical coordinate before adding to the NAM guess). Between 150mb to 70mb there is a smooth transition from both the NAM to GFS coordinate and also a smooth blend from all NAM to all GFS. The 150mb to 70mb transition zone choice is not hardwired, but user defined. Coding is still in progress, with no results yet. (Dave Parrish)

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

NCEP
Work will begin after the RAP is implemented in Q2FY12. (Binbin Zhou)

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
Checks were done on the conv_vol Canadian radar data, which are used to generate the reflectivity BUFR tank. The problem we have with ring discontinuity was resolved by using conv_vol reflectivity. Checks on the new VAD winds were begun. New VAD winds in the PrepBUFR files were not dumped properly and need to be fixed. (Shun Liu)

Deliverables - All Option A unless noted otherwise.

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

12.5.5.E2 15 February 2012 (CAPS, ESRL)
Report on the results of 40-km baseline EnKF DA system for conventional data.

12.5.5E3 (28 Feb 12) (NCEP)

Final GSI code transfer complete to EMC for Rapid Refresh upgrade change package to be implemented in spring 2012. (Combined with 12.5.5E1) (Manikin, Wu)

CURRENT EFFORTS: Work will begin after the RAP is implemented in Q2FY12.

PLANNED EFFORTS: Implement the RAP in Q2FY12.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: Move deadline to 1 Oct 12 because of delay in initial RAP implementation.

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

ESRL
Request for change to early FY13.

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

CURRENT EFFORTS: Work will begin after the RAP is implemented in Q2FY12.

PLANNED EFFORTS: Implement the RAP in Q2FY12.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: Early FY13

12.5.5.E5 31 July 2012 (ESRL, NCEP)
Pending computer resource availability, implementation of Rapid Refresh 2 changes to operational RR 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: Work will begin after the RAP is implemented in Q2FY12.

PLANNED EFFORTS: Implement the RAP in Q2FY12.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: Early FY13.

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

NCEP
CURRENT EFFORTS: Work will begin after the RAP is implemented in Q2FY12.

PLANNED EFFORTS: Implement the RAP in Q2FY12.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

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: The use of radiosonde significant levels in GSI was submitted to the GSI trunk. This change uses the radiosonde significant levels to reduce non-meteorological profiles (i. e. super saturation) in the analysis, or reduces the possibility of analysis profiles being further away from the observation than the first

guess. Scripts, executable, input parameters and fix files were also updated to test a new version of GSI in an off line parallel. The retrieved satellite winds were read in from a separate file instead of from the PREPBUFR file. With the new bundle structure it is possible to turn off unused variables in the regional and save 5% computer time. (Wu)

PLANNED EFFORTS: Continue testing the new version of GSI with new background error covariances, significant radiosonde levels, and with new data, i.e., VAD winds, GPSRO bending angles, surface observations without pressure, new satellite radiances and retrieved winds. If the new components pass the parallel tests with at least a neutral impact, the package will be included in the official regional parallel. (Wu)

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED: The development computer in NCEP is at its full capacity and the off-line parallel is running only half of the time.

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.

12.5.5.E9 30 Sept 2012 (ESRL/GSD)
Report on planned GSI changes for the FY13 upgrade to the Rapid Refresh.

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

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

GSD
Our investigation toward understanding why the WRF-ARW RR tends to have a high precipitation bias relative to both observations and the RUC reported on last quarter is not yet complete, as we still need to understand more fully why the RUC and RAP respond differently to what we believe are the same heating inputs during the diabatic (forward) leg of the DFI radar initialization. This will be an emphasis over the next few months.

12.5.8.1 1 Oct 2011 (GSD)
Based on ongoing GSD RR evaluation and feedback from users of the newly operational RR, 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 RR upgrade (RR2).

Modifications to the RR version of the RUC LSM discussed in the FY11Q2 and FY11Q3 reports continue to be working well. Most of these have been committed to the WRF repository to be part of WRF v3.4 scheduled for release this spring.

Joe Olson's version of the MYNN surface and boundary-layer code will likely also become part of the WRFv3.4 release. Pending favorable outcomes of retro runs that have been delayed by more urgently needed testing of the many other RAP changes discussed above and under Tasks 4 and 5, the MYNN will likely be implemented in one of the RR development cycles for further scrutiny and evaluation relative to the MYJ, with an eye toward using the MYNN as the surface-layer and planetary-boundary-layer option for the RAP2. It is also being considered for eventual application in the HRRR.

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

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

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

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

12.5.8.7 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 1 June 2012 (GSD)
Based on RR experience and recent WRF physics progress, begin development and testing of physics enhancements for RR3 implementation planned for FY13 and for future versions of the HRRR.

12.5.8.13 30 July 2012 (NCAR/MMM)
Deliver a WRF Users' Workshop and a WRF tutorial for the user community.

NCAR conducted a WRF tutorial January 24-28. This covered the basic WRF system and consisted of series of lectures and practice sessions. Attendance was approximately 60. The DTC provided a MET (Model Evaluation Toolkit) tutorial on Jan. 30–31.

PLANNED EFFORTS: NCAR will host and deliver the next WRF tutorial in FY12Q4.

UPDATES TO SCHEDULE: NONE

12.5.8.14 30 Sept 2012 (NCAR/MMM)
NCAR continued overseeing the next major WRF release, WRF V3.4, which is targeted for Spring 2012. Candidate features include new/improved physics (including the Noah MP LSM, the UCLA SSiB LSM, and a new surface layer scheme), software framework improvements, and WRFDA parallel 4DVAR.

NCAR conducted regular Release Committee meetings and issued the first friendly-user (beta) release. NCAR is planning on a second beta version in February. Information on the release may be found at: **http://www.wrf-model.org/users/release.php**.

Jimy Dudhia of NCAR/MMM tested updated code for ACM2 PBL scheme and the PX LSM scheme from developer Rob Gilliam of the EPA. The new code fixes the OpenMP problem previously reported and is being proposed for addition to the WRF repository. Dudhia also worked Prof. Y. Xue and Dr. F. DeSales (UCLA) on

finalizing changes to the new SSiB LSM for the WRF release. Ming Chen of NCAR/MMM began testing the code and SSIB landuse data in WPS.

Dudhia helped with the addition of aerosol and ozone effects to prepare WRF for next season's real-time hurricane forecasts at NCAR. This advancement is a collaboration with Ryan Torn of SUNY-Albany and Wei Wang (NCAR/MMM).

PLANNED EFFORTS: The development and incorporation of new physics and dynamics for WRF for the RR will continue through FY12Q2.

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).

The cold start RR, initialized twice daily from the GFS, is using the MODIS 24-category land-use datasets available through the WPS. No problems have been encountered. A rigorous comparison with the corresponding 28-category land-use dataset currently being used in the RR will be made after other higher priority RR changes have been evaluated.

Deliverables

12.5.8.E1 28 Mar 2012 (defer to July 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 June 2012 (defer to Nov 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.E3 30 March 2012 (NCEP) (Option C)
Subject to NCEP Directors' approval, implement in NCEP Operations the physics upgrades of the 2012 NEMS-NAM change package. (May contribute to FY12-13 physics progress within Rapid Refresh and adds to NEMS common physics layer)

12.5.8.E4 15 July 2012 (ESRL, NCEP)
Pending computer resource availability, implementation of Rapid Refresh 2 changes to operational RR 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.

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.

Work continues to identify and correct specific RAP and HRRR model and assimilation issues associated with specific types of HRRR problems (spurious / excessive convection, missed convective events, difficulty propagating leading edge squall-lines in the presence of a strong inversion, etc. Many of the HRRR spurious convection issues appear related to RAP moisture bias issues. A major package of changes was evaluated and incorporated into the GSD parallel RR in Dec. / early Jan. (see task 5.5). These changes will also be included in the RAP version 2, planned for implementation at NCEP in late 2012 / early 2013. First HRRR test runs initialized this new RAP parent (run for an 11 day Aug. 2011 retrospective period) are encouraging and show improved storm location and structure and reduced spurious convection compared to the 2011 real-time HRRR forecasts. Quantitative verification of these runs shows progress in the key focus areas (reduction of the high bias during the first few hours and improvement in the skill (as reflected in the improved CSI). Fig. 1 shows a comparison of this prototype (HRRR 2012) vs. the HRRR configurations run in 2011 and 2011. As can be seen the HRRR 2012 improves upon the CSI from both of the past two years and significantly reduces the high bias seen in the first few forecast hours during 2011. Note there “HRRR 2012” is not yet the final version for this spring. We anticipate additional changes to the RAP and HRRR systems that will yield further improvements. Likely candidates include upgrade to WRF ARW incorporating v3.3.1 changes for both the RRAP and the HRRR, upgrade to GSI analysis incorporating changes from recent NCEP GSI community trunk, and possible 3-km radar assimilation during a 1-hour pre-forecast spin-up.

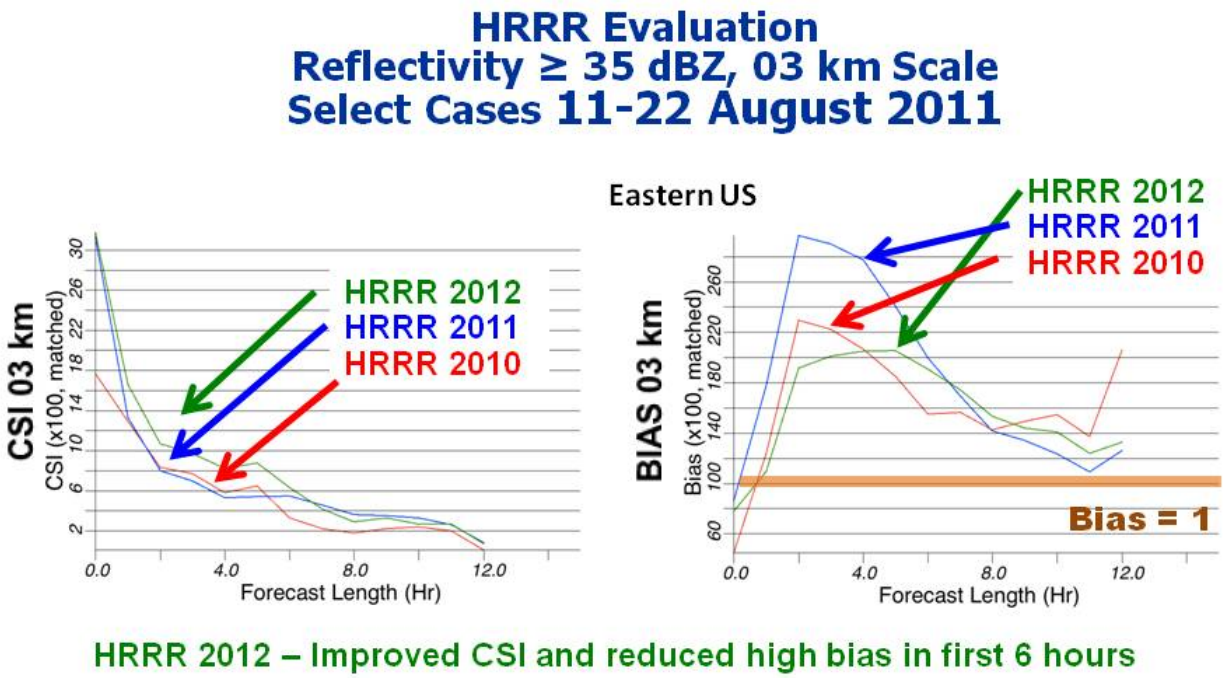

Fig. 1. Comparisons of categorical skill scores from a 3 case aggregate of HRRRs run from the RAP with the new (through Jan 7, 2012) analysis changes and the RAP/HRRR setups from 2011 and 2010.

Tanya Smirnova, Curtis Alexander, and David Dowell have successfully completed worked to get WRF ARW version 3.3.1+ (the plus indicating all the latest RAP/HRRR specific changes not included in the v3.3.1 release) working correctly for the HRRR (and RAP, see task 5.4). They worked through various issues related to quilted output, memory requirements, the Thompson microphysics-specific radar reflectivity processing, and special code to create hourly maximum fields (HMFs) and now have a 3.3.1+ version in the real-time RR-dev2 parallel cycle (in RR-primary as of 15 Feb 2012).

David Dowell also evaluated two additional changes to the ARW model formulation: i) for upper-boundary damping, switch from the current diffusive damping to vertical velocity Rayleigh damping and ii) switch to 5th order vertical advection. The first change greatly reduces the amount of energy gravity wave energy reflecting off the model top. This should help upper-level verification (especially for wind) and may be helpful in avoiding the generation of spurious convection. The second change helps with the retention of clouds, thereby possibly improving ceiling forecasts. It also may help retain the sharpness of capping inversions, possibly helping to reduce HRRR convective false alarms.

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 ongoing. A key set of changes to the RAP system has been incorporated into the GSD RR runs and impact on HRRR-are very positive. Testing and evaluation of addition RAP / HRRR improvements is ongoing.

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

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 proceeding well on improvements to RAP / HRRR system for 2012 with a planned freeze date in March 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**

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