MDE Product Development Team
Q1 Quarterly 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 28 February, 30-day evaluation started on 12 Jan.
- Upgrade to ESRL RAP – data assimilation and modeling improvements for 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

- RAP (including RAP-version of GSI) frozen at NCEP Central Operations (NCO), NCO operational center evaluation started on 12 Jan 2012.
- 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. 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.
- Ongoing work to update RAP-version2 GSI using latest EMC trunk version
- Encouraging results from experiments to bias correct surface METAR observations based on wind direction
- Ongoing retrospective evaluation of RAP forecast performance (upper-air, surface, precipitation, etc.) for new versions with sequences of change bundles

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

- Testing of modifications continue for Thompson v3.3.1 microphysics and MYNN boundary-layer and RUC land-surface schemes – likely implementation of each in ESRL RAP/HRRR in next 6 weeks.

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+ (including fixes to accommodate hourly maximum field extraction), testing underway in parallel and retrospective cycles.
- Complete 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).
- Good results from tests of i) vertical velocity damping upper boundary condition and ii) 5^{th} order advection in HRRR (and RR).

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.

Tentative date for the Rapid Refresh implementation is now 28 February 2012, barring further setbacks to the NCEP Central Operations (NCO) implementation schedule and pending a successful 4-week parallel test and National Weather Service (NWS) field evaluation. (Henceforth, the Rapid Refresh will be abbreviated as RAP rather than RR, to be consistent with NCEP usage.) The good news is that this parallel testing at NCO is running successfully and the NWS field evaluation was started on 12 January.

A road bump occurred in later December when the NCEP RAP model crashed for a few runs, even though there was no similar problem with the ESRL RAP version. This was the first model crash of any kind that had ever occurred with the Rapid Refresh, and was mysterious in that it did not occur in both computer environments. It was determined that the NCEP compiler had produced more sensitivity to numerical results, resulting in at NCEP-only excessive vertical motions (violating "CFL" constraints) in the stratosphere associated with a strong mountain wave over southern Greenland. Near heroic efforts by Ming Hu (while on vacation out of state) and Geoff Manikin enabled the crash to be reproduced with NCO initial conditions using Geoff's EMC-cycle scripts, a key step in establishing that the crash was most likely meteorological in origin. Rerunning with the non-hydrostatic name-list option in WRF (which we had been using prior to early April 2011), and replacing the option for enhanced horizontal diffusion near the top boundary with the Rayleigh damping option introduced with version 3 of WRF, was successful. These name list changes were promptly made in the NCO cycle and it has since run consistently to completion. We have introduced these name list changes into the RAP primary and development cycles at GSD and conducted short retrospective experiments to find that these changes actually improved our winds aloft forecasts a bit without degrading forecasts of other variables.

The bulk of our efforts during the quarter 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.

Considerable effort is required to design and construct retro experiments that properly isolate the impacts of individual changes. During the quarter, work focused on reducing the RAP's warm-season low-level moist bias over the eastern half of the CONUS—as discussed in earlier MDE reports, this is thought to be the primary contributor to frequent over forecasting of convection by the HRRR noted during the 2011 convective storm season. We have achieved at least partial success toward this goal by the following:

- Use of water-vapor-only pseudo-observations in conjunction with adjustment to soil moisture and temperature within GSI based on near-surface temperature and moisture increments (as done in RUC). Both these were introduced to RR-primary and HRRR at ESRL on 7 Nov.
- Modifications to the cloud analysis in GSI (see Task 5) were evaluated in a retro run and also introduced on 7 Nov. These reduce the RAP moist bias while simultaneously bringing GSI into closer conformity to the RUC.
- Modifying specification of hydrometeors from 3-d radar reflectivity to a temperature-dependent scheme to prevent excessive addition of total water content in the warm season. This change was the most significant of all in reducing excessive precipitation in the first hour in RAP model runs.

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 radial winds has shown approximately neutral impacts, based on our objective verification.
- Owing to some fine detective work by Tanya Smirnova, Curtis Alexander, Joe Olson and others in tracking down several subtle issues, WRF V3.3.1 is now running stably in the RR configuration with the non-hydrostatic option. 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. Retrospective and parallel testing of V3.3.1 compared with V3.2.1+ is underway.
- Evaluation of physics behavior, especially that of the MYNN surface-layer and PBL schemes continues (Task 8).
- David Dowell made a few runs of individual HRRR cases to investigate the possible benefits of 5th order positive-definite vertical advection as an alternative to the 3rd order monotonic advection name list option now being used in both RAP and HRRR. The 5th order vertical advection had a tendency to reduce slightly the CAPE and increase CIN, as well as to reduce the horizontal scale of reflectivity and precipitation features in the Southeast US, but overall the effects on convection were minimal for this change. However, it did reduce the tendency for development during the forecast of excessive dilution of clouds at all levels including aviation-sensitive ceilings, and so has promise to improve forecasts of sub-VFR conditions.
- The use of the Rayleigh vertical velocity damping in the top portion of the domain (same option as discussed above for RAP) had a dramatic effect in reducing internal gravity-wave noise in the HRRR. This will be further quantified and tuned next quarter within the HRRR context.
- David Dowell and Curtis Alexander have replaced the existing UniPost calculation of reflectivity by the inline procedure that is part of the new v3.3.1 Thompson microphysics module in WRF. For the first time in either the RAP (RAP2 only … the initial implementation of the RAP will use the same reflectivity calculation procedure as the RUC) or HRRR, the reflectivity fields are now consistent with the model microphysics. (The RAP also incorporates a simple Z-R relationship for the reflectivity contribution from the parameterized convection.) UniPost would then read these fields from the RAP or HRRR WRF wrfout or binary output files and convert them to GRIB.

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 Wind Forecast Improvement Project. The wind tower data and data from nacelles is under evaluation for RR assimilation. The sodar data is being assimilated at GSD.
- Finding an explanation for our observation that the diabatic DFI in the Rapid Refresh produces weaker initial vertical motion fields than the diabatic DFI in the RUC. We expect to soon have a viable hypothesis.
- Changes / enhancements to GSI, 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 has now commenced.

NCEP
Subtask 12.5.4.1

RFCs for the initial version of the Rapid Refresh were filed in late October, and code was transferred to NCO in early November. NCO spent the second half of November and early December building their version of the system and starting a real-time parallel by the middle of December. Grids matching the RUC domain will be available at 13, 20, and 40 km. A 32 km full domain grid as well as an 11 km Alaska grid and 16 km Puerto Rico grid are also available. Statistics show that the RAP matches or exceeds the performance of the RUC for most parameters. The official evaluation period will begin in mid-January, and the implementation scheduled for late February. (Manikin)

RFCs for RAP obs processing scripts and codes submitted on 18 October, and are now running in the NCO parallel. Update includes dump and PREPBUFR file generation for catch-up cycles to bring in late arriving data. Parallel RAP dump/PREPBUFR files used by ESRL/GSD were modified on 23 Dec 12 to not reject WFIP-relocated RASS data. All WFIP-relocated data (profiler, sodar, RASS) are now being analyzed by ESRL/GSD RAP. The NCEP RAP continues to reject all of these data. (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 beginning of the RAP field test on 12 January, 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 was delayed to Q2FY12, 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)

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. With the onset of the RAP field test on 12 January, verification of the NCO pre-operational RAP will also become available at the above web site. This verification will continue with the official RAP implementation now scheduled for 28 February.

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

During the quarter the NCEP/EMC RAPx cycle continued to outperform the operational RUC for most variables at most altitudes. Results showed this for wind and temperature, where the RAPx was consistently better for 6-hour forecasts. For relative humidity, the RAPx is better at middle levels, with a mixed result closer to the surface. Lower troposphere humidity and temperature forecasts are showing further improvement in the ESRL RAP with recent 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.

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).

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.

The configuration of the Rapid Refresh 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. We will therefore call this task “complete” after next month, 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
Part of this subtask will be to do the experiments necessary to decide which of these alternatives gives the more useful ensemble diversity for aviation application, by means of real-time and retrospective testing on the RAP domain. (31 May 12)

GSD's Hi resolution RAP members are not available. As an initial start, NCEP's NAM nest and high resolution ARW and NMM runs made by Matt Pyle are being looked at. One issue is that the domains of Matt Pyle's run don't cover the whole CONUS, but are subsets of the CONUS, so that these runs have to be interpolated to cover the CONUS. Those grids will be expanded to cover the full CONUS in a HiResWindow upgrade later this year or early in 2013. (Jun Du & Binbin Zhou)

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.

NCEP and ESRL will get more specific about this plan during the next quarter. (ESRL and Tom Black)

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**.

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 April 2012 (ESRL, NCEP)
Final code ready for transfer to EMC for Rapid Refresh upgrade change package to be implemented in spring 2012.

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 1 Oct 12 because of delay in 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 (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 28 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**.

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
A few minor changes to the RAP system were completed for the initial NCEP implementation (mostly very small model and post-processing adjustments) and the NCEP Central Operations (NCO) 30-day operational center evaluation began on 12 Jan 2012.

Extensive evaluation of modifications to the Rapid Refresh (RAP) data assimilation system continues. These changes will be included in version 2 of the NCEP operational RAP (implementation expected early FY13) and also be included in the RAP system run as the parent for the HRRR in the 2012 real-time evaluation. Several RAP GSI data assimilation changes were implemented into all the GSD real-time RAP runs during the quarter:

(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) Added dust/cloud fix to avoid assimilation of low ceiling observations due to blowing dust
(4) Reduced analysis increments of temperature and moisture over oceans to prevent generation of localized high CAPE values
(5) Modifications to GPS-met PW analysis to account for difference in terrain height between observations and model and to limit large PW innovations.
(6) Modifications to cloud analysis to reduce relative humidity for cloud clearing and to preserve virtual potential temperature when adjusting water vapor for cloud building/clearing
(7) Development of 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 Wind Forecast Improvement Project.

Other work toward RAP analysis goals includes ongoing work to update RAP-version2 GSI to latest EMC trunk, archiving needed files (good progress), work to use *gen_be* to obtain improved estimate of background error covariance and analysis of radar DFI implementation in RR vs. RUC.

Xue Wei and Bill Moninger have been testing a procedure for bias correcting the METAR wind observations based on wind direction. This builds off of Bill's work to collect long term statistics of observation fits to analyses, stratified in insightful ways. These results indicate more effective use of even METAR data by accounting for detectable biases based on wind direction.

Haidao Lin is continuing his work with satellite radiance assimilation and assimilation of AIRS single-field of view (SFOV) moisture retrievals. Radiance work has focused on calculation of Jacobians and determination of channels that should be removed because a significant portion of the signal comes from a part of the atmosphere above the RAP model top. Tests of the removal a first set of channels showed positive forecast impact For the SFOV, he created a series of innovation histograms, highlighting the dry bias of the SFOV moisture observations relative to the RR background field. He then tested a number of simple bias correction schemes couple with gross error check quality control procedures. He found that adding 15% to SFOV moisture innovation (normalized to the background water vapor mixing ratio), combined with rejecting all observations for which the absolute value of the innovation (normalized by the background water vapor mixing ratio) exceeded 30%, yielded modest forecast improvements. The improvement (evaluated against raobs) was greatest for moisture and wind and less for temperature. –Haidao completed a set of experiments to further evaluate the assimilation of AIRS radiance data. He added a two-week spin-up period prior to his 9-day retrospective period and removed a number of AIRS channels that have a substantial portion of their response at levels above the Rapid Refresh model top. Results indicate modest positive impact on Rapid Refresh Upper-level forecast verification. . Recent work has focused on documenting the likely existence of a diurnally varying height dependent bias in the SFOV temperature retrievals. Work is nearly complete to code a simple bias correction and test in a retrospective run.

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.

After correcting an issue that was causing both level 2 and level 2.5 radial velocity data to be assimilated, real-time parallel testing of level 2 radial data assimilation is now showing neutral to slight positive impact. Work is ongoing to reduce the latency in data feed, so these data will be available in time for use in GSD real-time RAP runs. Tests of the use of just the level 2.5 data will be completed, with hopes of assimilating these data in real-time runs until the latency issue with the level 2 data is resolved.

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.

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.

12.5.5.3 31 January 2012 (CAPS, EMC, ESRL)
Implement proper vertical covariance localization and test the hybrid DA system using EnKF covariance.

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 October 2011 (CAPS, ESRL, EMC)

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

During this quarter, several developments, tests and tuning have been made to the current EnKF and hybrid GSI-EnKF system.

Satellite radiance data have been included in the EnKF. While tests are still ongoing, initial tests show no positive impact. One of the possible explanations could be that hourly-binned satellite radiance data when used in current

three-hourly data assimilation cycle could result in incorrect satellite data bias correction. We are still working to resolve this problem.

4DEnKF have been implemented in the regional EnKF system following the current global EnKF. More data within the 3-hour window are now used. The initial test results show a slightly positive impact for the wind component when compared to the original EnKF system. Further tuning of this 4DEnKF is ongoing. For example, in the experiment of last month, it was found that 4DEnKF had smaller spread than the original EnKF. During this report period, we increased the fixed inflation from 10% to 15%, which however degraded the performance. Therefore, an experiment with smaller adaptive inflation is being conducted.

New initial and lateral boundary ensembles have been created using the CV5 instead of CV3 option in the WRFDA system. To do this, we ran forecasts for a month long period from May 1 to May 31, 2010 using the current 40km configuration. The gen_be scripts in WRFDA were modified to be adapted to the JET supercomputer environment. Tuning of CV5 is ongoing.

A problem in the verification of upper levels is identified and fixed. In the previous reports, we noticed larger RMSE in the model top levels, especially for the temperature, U and V when verified against ADPUPA data. In the operational Rapid Refresh system, when converting variables from model grid levels to pressure levels, the default WPP process turned off the output above 50hPa. This resulted in larger RMSE in the top levels. After correction, the RMSE is greatly reduced and is now comparable to the global EnKF results.

Efforts on tuning the EnKF continue. A serial of tests with different horizontal and vertical localization settings have been conducted. For the horizontal localization, we found the observation dependent horizontal localization is no-longer necessary. For the vertical localization, we redesigned the vertical localization length profile to roughly fit the vertical correlation length scale of the static covariance of the GSI. The EnKF now performed much better with these tuned localization.

Dual-resolution (DR) capability within the EnKF was implemented and tested. The strategy for DR is that an ensemble of forecasts is running at low-resolution (LR), which provides the background error covariance estimation when updating both the LR background ensemble and the single high-resolution (HR) background. The steps are: (1) Integrate the single HR model and the ensemble of LR model forward to the next analysis time; (2) calculate the Hx for the single HR background and the ensemble of Hx for the LR background ensemble; (3) Interpolate LR ensemble forecasts to HR grid within the EnKF using the bilinear method to provide covariance for the update of the HR background; (4) LR background ensemble is updated by the covariance provided by the LR ensemble; HR background is updated by the covariance provided by the ensemble interpolated from LR in step 3; (5) The LR and HR EnKF analyses are used as the initial condition for the LR ensemble forecasts and for the single HR forecast, respectively. The above procedures repeat. By far, the single observation test and one data assimilation cycle test have been done. The single observation test indicates the program work well. When assimilating all the conventional data, increment in most areas of the domain look fine except a large height gradient shown in the northwest corner in the low-level. More tests will be done in the coming month to understand this behavior.

Progress on the hybrid GSI-EnKF continues. In the last quarter, we found the hybrid EnKF was better than the pure EnKF and GSI, especially at the jet level. During this report period, the reason was further investigated. Experiments with 50% weight on the static covariance and 50% weight on the flow-dependent EnKF covariance and 100% weight on the EnKF covariance have been conducted. It was found that the improvement of the hybrid upon EnKF was coming from the static covariance of GSI.

12.5.5.4 1 April 2012 (ESRL)
Complete testing of GSI changes for RR2 at ESRL.

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.

NCEP
Work continued on radar data assimilation with an hourly cycle, which includes both radial wind and reflectivity analysis. Radial wind is assimilated by the GSI and reflectivity is assimilated with a modified cloud analysis package from GSD. Reflectivity verification was set up to examine forecast performance with and without radar data assimilation and 10 cases were verified. The forecast with radar data assimilation from 3 h to 6 h and from 15 h to 36 h is better than the forecast without radar data. The digital filter performance for the cloud analysis was examined. The total condensate shrank after digital filtering, which occurs in areas where the simulated reflectivity is in the wrong location compared to observations. This indicates that DFI plays a positive role in high-resolution forecast initialization with radar data. Radial wind assimilation and cloud analysis codes were upgraded to use the current GSI trunk code. Limited tests with the new codes were completed. Work began on assimilating latent heating rate derived from reflectivity. Two cases are being used to examine the performance of this method for forecasts without radar reflectivity assimilation, with temperature increment assimilation, and with temperature tendency assimilation. NCO's Canadian radar data dumps were checked and the radar antenna heights were missing from the Canadian radar BUFR file. This is reported to NCO and fixed. Canadian radars were found to report two types of data, but NCO is decoding only one. A quality problem was found in the decoded data and NCO is working on a decoder for the other type of data, which will then be checked for quality. (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.

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.

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
Work continues to add a unified downscaling code to the RTMA prep-processing step to downscale forecasts from the RAP, NMM and GFS models. A diurnal blacklist for temperature observations and a direction-stratified accept list for wind observations have been created and are being tested in the RTMA parallel systems. In preparation for adding a GLERL-type analysis for lake winds to the RTMA, the observation file has been enhanced to include lake pseudo-wind observations, i.e., duplicates of the near-shoreline land wind observations adjusted for the water conditions. (Manuel Pondeca, Steve Levine)

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
Work was completed on the regional dual resolution option for the hybrid ensemble GSI. Current tests using operational global ensemble forecasts (GEFS) interpolated to NAM resolution to simulate the regional hybrid ensemble GSI use the same resolution for the analysis increment and ensemble perturbations. To achieve practical run times, the analysis resolution was increased to 36km from the operational value of 17km. With the new dual resolution capability, it will be possible to keep the analysis resolution at 17km while storing the ensemble perturbations at a resolution (~50km) that is comparable to the GEFS. (Parrish, 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
Work began on adopting GSD's WRF-ARW radar data methodology that applies heating profiles during the diabatic phase of the digital filter into the NEMS/NMMB model code. The heating profiles are provided by GSI analyses of radar reflectivity data; the GSI is being modified to provide that input for the NEMS/NMMB as WRF-ARW does for the RAP. Tests of the revised NMMB model code thus far has been limited to defining bogus coherent regions of positive heating to confirm that the expected impacts on the wind, mass, and cloud fields do take place in the initial hours of the model forecast. (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
Work was done to make the transition from NOAA 11 to NOAA 15 smooth and correct. An extra check was added to the GSI to exclude some MESONET pressures that were derived from the standard atmosphere but misused as surface pressure observations. Code was modified to accept MESONET, SFCSHP, METAR and SYNOP data with missing observed pressure. The observed height was used to locate these observations. Artificially dividing the upper layers into sub layers (NLAYERS) in the satellite data was tested but had no impact. Since the NCEP CCS machine was reserved for model implementation tests, off-line parallel tests were given lower priority. These scripts and programs were changed to run with fewer nodes, so that though an individual job took longer to run the whole series of jobs had faster turn-around. In the process of merging changes to enhance radiosonde levels into the GSI trunk, the first guess fit to the data was found to be different in the trunk from the version of GSI in the operational NDAS. The differences were traced to the generation of the analysis grid, a bug found in the operational GSI code and a fix was submitted. A recent version of GSI (the top of the trunk) was tested in the off-line parallel. The fix files will be updated and this system tested as the base of the future regional GSI analysis for the official regional parallel. (Wu)

Work has begun on finding a way to use GFS derived satellite bias correction coefficients directly in the NAM GSI. It is suspected that NDAS derived satellite bias coefficients reinforce the NAM model bias, which is different than the GFS bias, and may contribute to synoptic scale errors in NAM forecasts. Initial findings are that the principal problem is in the NAM vertical structure where the top pressure is too large, and vertical model resolution is insufficient near the model top. A possible solution is to set the NAM top pressure to zero and use an existing

GSI feature, which introduces additional levels as necessary for the radiance forward model computation. (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
Work will begin after the RAP is implemented in Q2FY12. (Wu, Parrish, 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
A more thorough investigation toward understanding why the WRF-ARW RR tends to have a high precipitation bias relative to both observations and the RUC continued through the quarter. (The HRRR initialized from the RR tends to also produce more precipitation than HRRR initialized from RUC.) A major finding was that the 0-1h precipitation forecast in the RAP had a very high bias in precipitation in the warm season. This excess precipitation in turn led to too high soil moisture, creating a feedback process by creating an excessively moist daytime boundary layer in the RR, as noted under Task 4. Our search for the cause of this feedback led to reexamination of cycling procedures in the GSI, particularly those that involved some remaining RUC enhancements that had not yet been fully implemented in the RAP. Among these, nudging of soil properties based on observation innovations over land areas when a well-developed daytime mixed layer is present, proved significant, but others more directly related to treatment of moisture in the GSI were also critical (see discussions under Task 4 and 5). This illustrates how performance issues can be intertwined between analysis / cycling procedures and physics. The investigation 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. We expect to learn more in the January – March quarter, especially about remaining model precipitation bias issues remaining after key assimilation problems causing excessive 1h precipitation have been resolved (see discussion under Task 12.5.5).

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 were committed to the WRF repository in October to be part of WRF v3.4 scheduled for release next spring.

Joe Olson, after making some further minor mods to the MYNN surface-layer scheme, submitted his revamped MYNN code to NCAR. It was included in the NCAR WRF subversion repository in December, and 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.

CURRENT EFFORTS: NCAR began planning for the next WRF tutorial at NCAR, which will be held January 23–31, 2012. The first week will present the basic WRF tutorial, while a MET (Model Evaluation Toolkit) tutorial (put on by the DTC) will be held on Jan. 30–31. Registration for the tutorial is open.

PLANNED EFFORTS: NCAR will host and deliver the next WRF tutorial in FY12Q2.

UPDATES TO SCHEDULE: NONE

12.5.8.14 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 bugfixes.

NCAR is overseeing the next major WRF release, which is targeted for Spring 2012, and it conducted regular Release Committee meetings. 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 will conduct testing on the code frozen for the release, and it will release beta versions next quarter. Information on the release may be found at: **http://www.wrf-model.org/users/release.php**.

In WRF PBL physics, NCAR added modifications from Wayne Angevine (NOAA/ESRL) for the TEMF PBL scheme to solve a stability issue. Dudhia helped Julien Pergaud (Numtech, France) with the finalization of the new QNSE PBL scheme, which has an EDMF (eddy diffusivity mass flux) unstable BL treatment. Dudhia added

to the repository an updated version of the MYNN scheme from developer Joe Olson (NOAA/ESRL) and obtained updated code for the ACM2 PBL PBL from Gilliam of the EPA.

In LSM development, Dudhia finalized work on the SSiB LSM from UCLA. This was added to the repository and will be in the V3.4 release. He also obtained updated code for the PX LSM from Rob Gilliam (EPA). The PX LSM changes, however, are currently not passing an OpenMP test, and they have been sent back to the developers. They will be examined again in the next quarter.

In microphysics, Dudhia obtained the CAM5 Morrison-Gettelman microphysics (with new chemistry options) from Jerome Fast (PNNL). He is working with Steven Peckham (ESRL) to port this to WRF.

In radiation physics, Dudhia consulted with a new NCAR visitor, Jose Arias (Univ. Jaen, Spain), on the implementation of MODIS observed aerosol optical depth information in WRF radiation schemes. He also obtained monthly climatological aerosol optical depth data from Steve Ghan (PNNL) for possible implementation in WRF radiation schemes. Dudhia added the new Fu-Liou-Gu (UCLA) package for shortwave and longwave radiation to the repository, and it will be in the V3.4 release.

As minor bugfixes, Dudhia added corrections (from scheme developers) for the Grell shallow cumulus scheme and the Morrison microphysics package. He worked with NCAR visitor Jose Arias (Univ. of Jaen, Spain) on a minor addition to get a more accurate solar time that accounts for the "equation of time" correction of up to 15 minutes depending on time of year. This is important for solar energy applications and verification. Dudhia also worked with Ming Chen (NCAR/MMM) on the Jimenez surface-layer revisions and surface-wind corrections. These will be in the WRF V3.4 release.

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 (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 (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 (Funding reduced under overall MDE 25% reduction)
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. As an example, Fig. 1 shows a comparison of a 4-h forecast (valid 16z 14 Aug. 2011) from one of these new 2012 HRRR proto-type runs with the real-time HRRR from 2011 and the radar observations. As can be seen, improvements from the 2011 version to the 2012 prototype version include reduction of the spurious convection over North Carolina and improvement in the convective coverage over New Jersey, Delaware and Eastern Maryland. Smaller improvements can also be seen in other locations (western West Virginia, northwestern Pennsylvania). Work continues evaluating the impact of RAP modifications on both RAP forecasts and subsequent HRRR forecasts. This will be followed by evaluation of changes specific to the HRRR formulation.

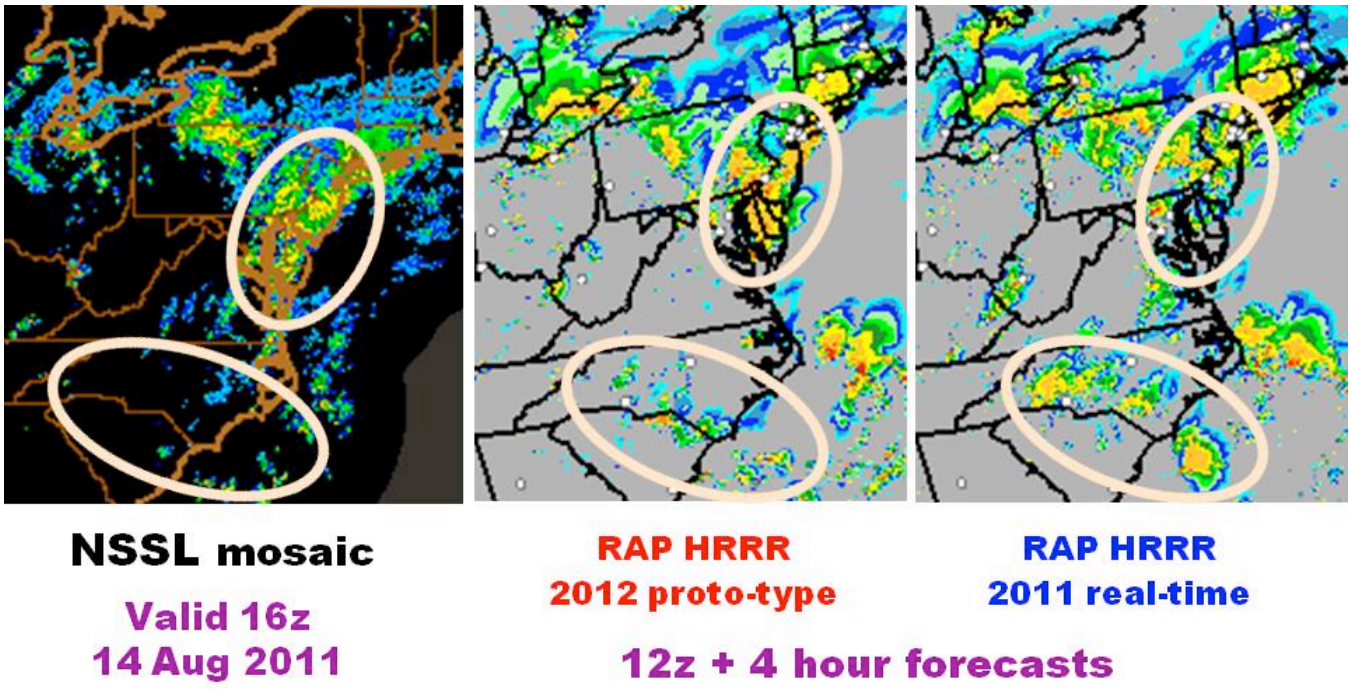

Fig. 1. Radar observed (left panel) and HRRR 4-h forecast reflectivity valid 16z 14 Aug. 2011. Comparison of the current 2012 proto-type HRRR (center panel -- with changes to the parent RAP to improve environmental moisture fields) against the 2011 real-time HRRR (left panel) shows improvements.

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.

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.

Additional HRRR retrospective runs are planned in the next few weeks to evaluate the impact of RR model and especially assimilation changes (see tasks 5.4 and 5.5) on HRRR forecasts. Initial retrospective testing of the coupled RR / HRRR system has focused on the convectively active 11-21 August period. This will be followed by retrospective testing for another period of convective interest, early June 2011. A detailed listing of this ongoing work was presented at a CoSPA meeting on Dec. 13, 2011 with a second presentation planned for Jan. 31, 2012.

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 appear 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.