MDE Product Development Team
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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

- Good progress toward RR implementation at NCEP to replace the RUC, currently planned for 10 Jan 2011
- Upgrade to ESRL RR – data assimilation and modeling improvements for RR2

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

- Following completion of the RR-primary / HRRR freeze period, several important RR GSI analysis upgrades (soil nudging, pseudo-obs for moisture only, dust/cloud fix, near-coast increment limits) implemented in the RR-dev to RR (after successful testing in the RR-dev)
- Modifications made to RR GSI cloud analysis procedure to correct METAR-based building responsible for spurious excessive moist unstable CAPE values
- Continued evaluation of RR GSI fits to radiosonde profiles and RR GSI moisture analysis increments for cases with subsequent excessive convection on the HRRR
- Improved impact for use of GOES SFOV moisture innovations based on new combined bias-correction / quality control procedure

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 RR/HRRR in next 2 months.

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

- Completed summer 2011 real-time HRRR evaluation on Oct. 31 with very good overall reliability statistics for the evaluation period.
- Continued extensive coordinated analysis of HRRR results and key RR assimilation / model aspects for key retrospective period in mid-August, with emphasis on moisture aspects in the RR and DFI radar assimilation.
- Participation and presentation by several AMB scientists at two very useful meetings relating to short-range assimilation and prediction, especially for convection (NOAA Warn-On-Forecast radar assimilation workshop, WMO Symposium on use of NWP for Nowcasting).

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 (RR) implementation is now 10 January 2012, barring further setbacks to the NCEP Central Operations (NCO) implementation schedule and pending a successful 1-month parallel test and evaluation. The RR parallel at EMC and the RR primary cycle at GSD continue to run stably, without crashes due to code or scripting problems. The RR code/scripts have been rebuilt in the NCEP/NCO environment, but the RR field test has not yet begun.

A minor but nagging concern involving the appearance of occasional spotty, unrealistically large most-unstable CAPE (MUCAPE) values in the RR initial analysis was intensively investigated in late October and early November. The problem was determined to be mainly due to building of cloud by the cloud analysis when METAR ceilings are present and there is a temperature inversion in the background. A fix was implemented into GSI to properly account for the elevation difference between the METAR station and model grid points (as had already been done in the RUC). Since this involved only a minor code change to the cloud analysis with minimal impact on the forecast, this was acceptable to NCEP and will be included in the initial RR implementation.

Beyond these matters, we are continuing to push ahead toward developing and testing the next upgrade to the RR, referred to as RR2. This upgrade includes

- Boundary-layer pseudo-observations (water-vapor only). It was found that assimilation of boundary-layer pseudo-observations for temperature gave slightly poorer wind and temperature forecasts in the middle and upper troposphere, so that is not included in this change, but the assimilation of water vapor-only PBL pseudo-obs improves RH forecasts in the lower troposphere. (Introduced to RR-primary and HRRR at ESRL on 7 Nov)
- Adjustment within GSI to soil moisture and temperature from near-surface temperature and moisture increments (as done in RUC). This change showed an improvement in a parallel RR test during Sept-Oct 2011 for all variables. (Introduced to RR-primary and HRRR at ESRL on 7 Nov)
- Assimilation of radar radial wind (in parallel testing in RR-dev2 as of 11/15/2011)
- Upgrade to WRFv3.3.1 from WRFv3.2.1+.
- Continued test and evaluation of the impacts of various physics changes (see Task 8).
- Revised procedure for calculation of reflectivity consistent with WRFv3.3.1 version of the Thompson microphysics.

Other changes are under consideration:

- Assimilation of low-level winds from towers, wind-generator nacelles, and sodars. These data are available and being evaluated for RR assimilation through leveraging from the Department of Energy Wind Forecast Improvement Project.
- Smaller vertical error correlation and lower rawinsonde observation errors in GSI, and also examining possible benefits of 5^{th} order vertical advection in WRF; both of these efforts are motivated by a desire to more faithfully replicate smaller-scale details of the temperature and moisture stratification that can be important for prediction of initiation of convection.
- 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.

Extensive testing to evaluate the impacts of these upgrades is performed through the three hourly real-time RR cycles (RR primary, RRdev and RRdev-2) at GSD, as well as through a large number of retrospective experiments.

NCEP

Subtask 12.5.4.1

The Rapid Refresh (RAP) has been running stably in an EMC parallel environment since December 2010. A slight modification to the building of model cloud based on surface observations was made in October in response to the infrequent but significant development of unstable layers associated with the addition of cloud. Work has been done to make "look-alike" products that match those that are currently available from the RUC - this will assist users in making the transition. Like 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 fields from those files. Finally, an 11-km Alaska grid and 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 was delayed by NAM implementation delays, but this finally 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 will be building their parallel system and should have it running by the middle of November, at which time a formal evaluation will begin. RR implementation is currently scheduled for January 2012. (Geoff Manikin, Dennis Keyser)

12.5.4.1 Ongoing (NCEP, GSD)

Maintain hourly RR runs and provide grids of SAV and AHP guidance products.

GSD continues to make pgrb and bgrb files from the GSD RR primary real-time 1-h cycle available from its FTP site. NCEP/EMC does the same thing for its parallel version RR (or RAP)

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.

12.5.4.3 Ongoing (NCEP, GSD)

Provide full grids from RR runs on NCEP and NWS/OPS servers.

12.5.4.4 Ongoing (NCEP, GSD)

Maintain access to model verification data.

GSD continues to maintain its verification web site for RR and RUC versions at **http://ruc.noaa.gov/stats/** Statistics are available from the three RR real-time cycles as well as for the RR retrospective experiments and the real-time RR cycle maintained by EMC. The operational run of the RR will also appear here once it commences.

12.5.4.5 Ongoing (GSD, NCEP)

Ongoing evaluation of performance of real-time and retrospective runs of RR system for SAVs, AHPs

The EMC RAPx cycle continues to outperform the operational RUC for most variables at most altitudes. Below we see this for wind and temperature, where the RAPx is consistently better for 6-hour forecasts. For relative humidity, the RAPx is better at middle levels, with a mixed result closer to the surface.

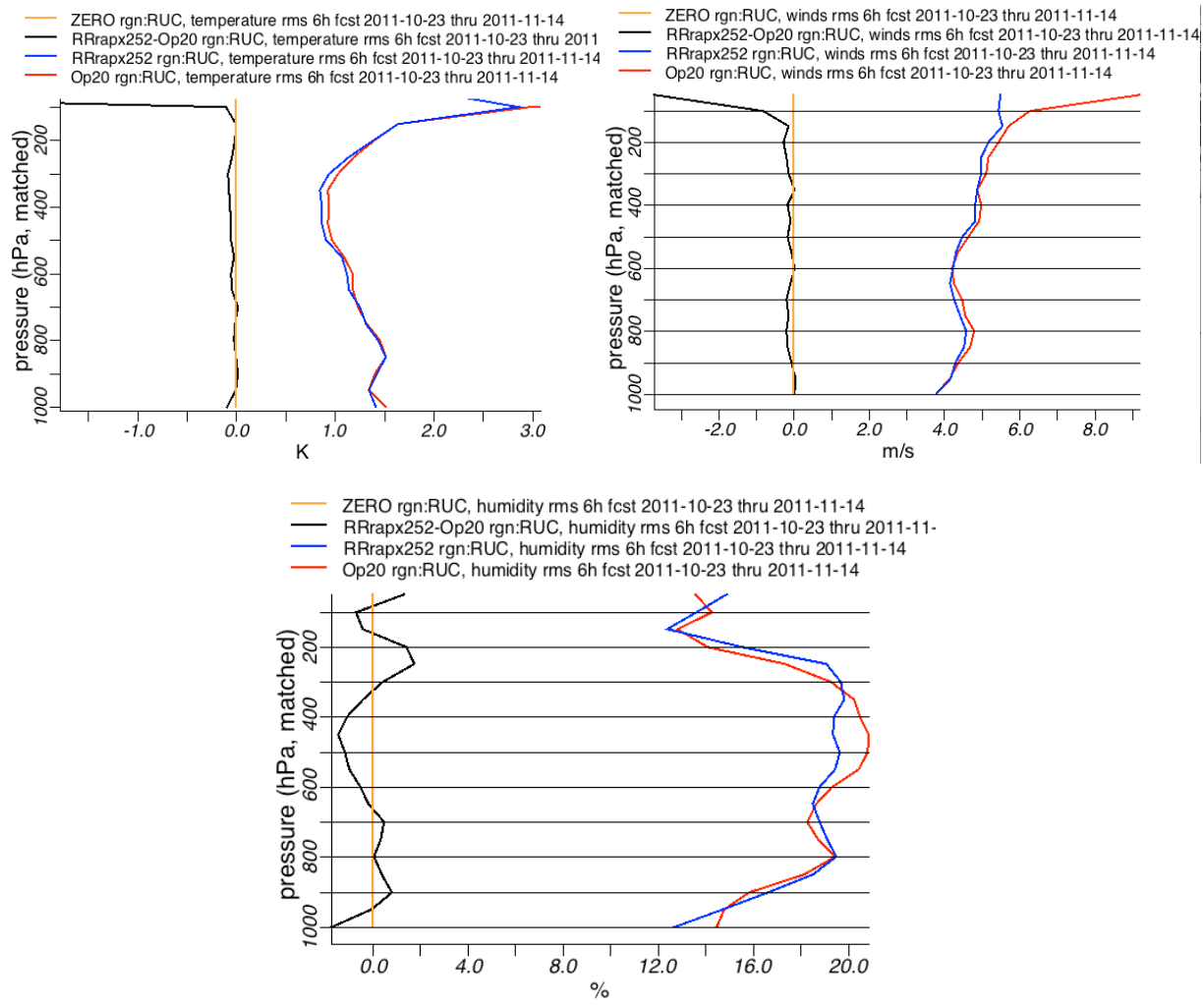

Figure 1. 6h forecast skill for NCEP experimental RR (RRrapx) vs. NCEP operational RUC for temperature and wind (above) and relative humidity (below).

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

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 RR (RR2).

12.5.4.8 31 May 2012 **(ESRL, NCEP)**
Start design of NARRE ARW and NMM model ensembles. Using different physics suites will derive these. 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 RR domain.

NCEP
Subtask 12.5.4.8
Various physics options have been tested and used in the framework of the NCEP SREF using ARW and NMM. The verification is underway now. The preliminary results show that multi-physics do provide the desired wide ensemble spread. This ensemble configuration can be directly used to the future NARRE ARW and NMM ensembles for aviation forecasts. (Jun Du)

12.5.4.9 28 May 2012 (ESRL, NCEP)
Complete testing at EMC of RR2 code, pending NCEP readiness.

12.5.4.9a 15 June 2012 (NCEP, ESRL)
Submit Request for Change (RFC) and modified code for RR2 from EMC to NCO, pending NCEP readiness.

12.5.4.10 1 July 2012 (ESRL)
Commence work toward rendering RR 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.

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 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 RR 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.

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

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.

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

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

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.

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.

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

Following the completion of the Summer 2011 real-time CoSPA evaluation (and associated ESRL RR-primary and ESRL HRRR freeze period), several key RR GSI analysis changes were implemented in the ESRL RR primary. The changes were first successfully evaluated in retrospective and real-time parallel RR runs and associated HRRR-dev and retro runs and then implemented in the ESRL RR-primary starting with the 23 UTC 07 November 2011 cycle.

The GSI changes implemented into the primary RR at ESRL on 7 Nov included:

(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) Correction to cloud analysis (details below).

Change 5 included key changes to address a minor analysis CAPE issue were made and also transferred to the NCEP EMC test version of the RR (for inclusion in the initial NCEP RR implementation). A change was made to build clouds at a consistent height above sea level in the vicinity of a given METAR (as done in the RUC) instead of at a consistent height above the local grid point elevation. The change also included modifying the lapse-rate threshold for cloud building to a larger value (more stable) and introduced relative humidity and water vapor increment thresholds to avoid occasional saturation in low stability situations, resulting in anomalously large values of most-unstable-CAPE.

With this set of GSI analysis changes now migrated to the RR-primary, the RR-dev and RR-dev2 real-time cycles were freed up for other changes waiting in the queue for real-time parallel testing. For the RR-dev2 cycle we have just added radial velocity to again test its impact. Results were neutral to slightly negative when we last tested this back in spring 2011. For the RR-dev, we will be adding in the GOES sounder data and turning on the predictive radiance bias correction procedure in the GSI. Both GSD Rapid Refresh versions (primary and developmental) continue to ingest WFIP boundary layer profiler and evaluation of their impact continues.

Patrick Hofmann continued his evaluation of GSI fits to radiosonde profiles for cases with spurious convection in the subsequent HRRR. David Dowell also began examining RR GSI moisture analysis increments for similar cases. David's has lead to a more detailed investigation of the precipitable water (PW) treatment in the GSI and how it differs from the PW treatment in the RUC. This investigation is still ongoing.

Haidao Lin is continuing his work with satellite radiance assimilation and assimilation of AIRS single-field of view (SFOV) moisture retrievals. 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 is also beginning a set of experiments to further evaluate the assimilation of AIRS radiance data. He is added a two-week spin-up period prior to his 9-day retrospective period to evaluate the impact on the GSI bias correction and forecast impact.

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, 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.

RR-dev2 has been switched to test assimilation of radial velocity data to evaluate the forecast impact.

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

Bi-weekly meetings are being held with AMB personnel to catalog possible changes and prioritize testing and evaluation of them.

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.

Retrospective and real-time tests in this are by Haidao Lin beginning in early Nov.

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.

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.

Misled by the static values used in the vertical correlation length in GSI in the previous test, we applied vertical correlation function whose correlation scale decreasing with height for the EnKF. In the new test, a reversed vertical correlation function whose correlation scale increasing with height was applied. In addition, to be consistent with GSI, the vertical correlation length scales applied for temperature and relative humidity are half of that for wind. This correction did reduce the middle and upper level forecast error for the U component verified against the PROFLER observations for forecast at longer lead-time (e.g., 15-hour, see Fig.2(a)). For other variables, slightly positive to neutral improvements were found.

In addition to improving the vertical correlation, the satellite radiance data have been added to the current regional EnKF system. A program bug was identified in GSI during the debugging process. This bug was currently only found in the version checked out from the GSI Community Repository. The EMC GSI Repository does not have such error. Fig.2(b) shows the root mean square error of the V wind at 18-hour lead time verified against the PROFLER observation. Note that the current setting for satellite radiance assimilation uses the single-physics scheme. Encouragingly, improvement was found after assimilating the radiance data for the V component in the middle to upper level (the red line) even when compared with the EnKF assimilating only conventional data but using the multi-physics scheme. In the future, to reveal the impact of the satellite radiance data, a clean apple-to-apple comparison will be conducted.

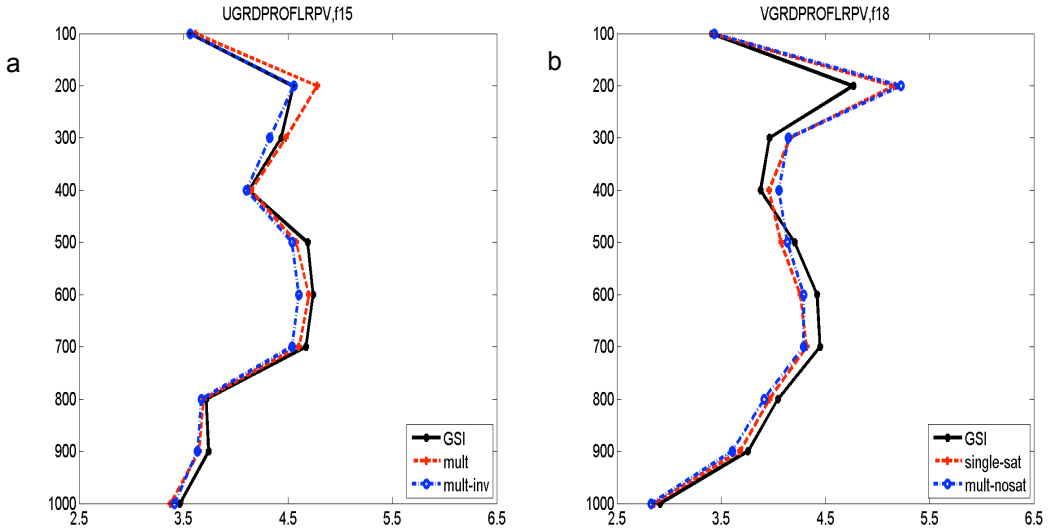

Figure 2. (a) RMSE profiles of 15-h deterministic forecasts of U verified against PROFLER. *The black line is GSI-initialized model forecast error; the red line is test using vertical correlation length decreased with height and the blue line is test which using vertical correlation length increased with height. (b) RMSE profiles of 18-h deterministic forecasts of V verified against PROFLER. The blue line is test without satellite radiance data but using multi-physics schemes. The red line is test with satellite radiance data assimilated but using uniform microphysics scheme.*

In the previous experiments of GSI-EnKF hybrid, the hybrid was found to be better than the pure EnKF and GSI, especially at the level of Jet. In these hybrid data assimilation experiments, the background error covariance was composed with 50% weight on the static covariance and 50% weight on the flow-dependent EnKF covariance. To understand the impact of the inclusion of the static covariance in the hybrid, we conducted another experiment where the static covariance was assigned with zero weight. In addition to changing the weight of the static covariance, in these new experiments, the EnKF in both the 1-way and 2-way coupled hybrid are now using the parameter settings of the optimal EnKF. Fig.3 shows the profiles of the RMSE of the 3-h deterministic forecast error. The hybrid with 50% weight assigned on the static covariance (red line) is better than the one without static covariance (green line), which indicates the improvement of the hybrid at the Jet level upon the EnKF indeed comes from the static covariance of GSI. Further, we compared the results of the hybrid using single physics with the pure EnKF using the multi-physics scheme. In general, the hybrid (half static covariance, red line) is close to the EnKF with multiple physics (dark red line), slightly worse than the latter at lower level but general better at the Jet level. In the coming month, we will run a hybrid data assimilation experiment in which the EnKF with the multi-physics schemes will be employed.

In addition, the initial test of the EnKF on the NSF Teragrid Supercomputer Kraken was found to be time consuming. The reason is that the I/O in that machine is expensive. To solve this problem, the EnKF interface which reads in the diagnose files was redesigned. Instead of reading single combined diagnose file, the EnKF I/O interface was modified to directly read in the diagnose information (diag*) output from each process of GSI. This modification saves a lot of I/O time especially when a large number of nodes are required. Further improvements of I/O are still needed in future.

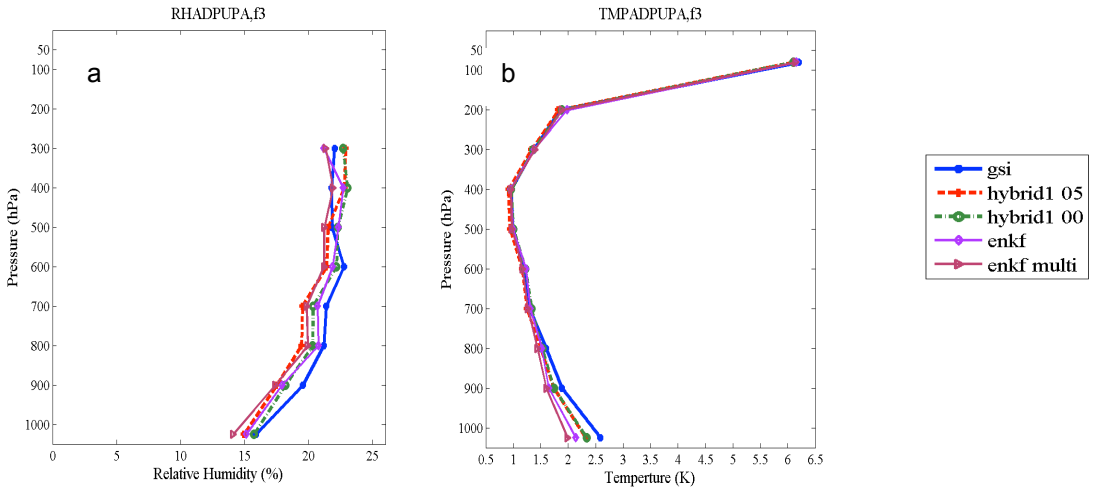

Figure 3. *RMSE profiles of 3-h deterministic forecasts for (a) relative humidity; (b) temperature (c) U-component wind and (d) V-component wind. All four are verified against upper air reports (e) U-component wind (f) V-component wind against profiler. (Blue line: GSI DA; Red line: hybrid employing half static covariance; Green line: hybrid employing none static covariance; Purple line: optimal single-physic EnKF; Brown line: optimal multi-physics EnKF)*

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. The radar data assimilation cycle includes both radial wind and reflectivity analysis. Radial wind is assimilated by the GSI and reflectivity is assimilated with a modified cloud analysis package developed by GSD. Reflectivity verification was set up to examine the forecast performance for the experiment with and without radar data assimilation. Ten 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 assimilation. The digital filter performance was examined in detail for the cloud analysis. The total condensate shrank after digital filter, which occurs in the area where the simulated reflectivity is in wrong location compared with reflectivity observations. This indicates that DFI plays a positive role in high resolution forecast initialization with radar data. (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

Work continues to enable dual resolution for regional hybrid ensemble GSI, and to allow the global version of NEMS-NMMB to be used by GSI. The initial goal of this new work will be to create satellite radiance bias coefficients from a global data assimilation using global NEMS-NMMB with the same vertical structure as the now operational NAM NEMS-NMMB. The hope is that these satellite bias coefficients can be used directly in the NDAS, avoiding problems that may be caused by the current operational practice of evolving different satellite bias coefficients directly in the NDAS. The longer-term goal of this work is to have a test GDAS which uses the global NEMS-NMMB. This will be required for upcoming inter-comparison between the next version of GFS and new candidate global model NEMS-NMMB. (Dave Parrish)

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
Testing and calibration of a parallel CONUS 2.5km RTMA system that uses the downscaled RAP forecast as its first guess has begun. The system is scheduled for operational implementation in February of 2012. Work on adding the capability to create the RTMA first guess inside of the RTMA system itself is underway. The work consists of consolidating the three separate downscaling subroutines for the RAP, NMM and GFS and porting the resulting code into the RTMA as a unified, MPI enabled downscaling subroutine. With a built-in downscaling capability, the RTMA developers will be able to test changes to the downscaling approach more efficiently within the RTMA parallel systems. (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.

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; Shun Liu is working with the GSI to provide that input for the NEMS/NMMB as is currently possible with the WRF-ARW for example for RAP. Testing 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. More realistic testing using actual GSI-generated heating information is anticipated shortly. (Matt Pyle)

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

NCEP
The NAM implementation was completed on Oct. 18. The implemented GSI code and fix files were tested and tagged in the SVN GSI repository. Under the assumption that the hybrid 3dvar-ensemble system provides a balancing mechanism similar to a strong constraint (which is missing from the regional GSI), a test was conducted to see if it could help to generate a dynamically consistent cyclonic storm structure using the reported/estimated surface pressure at the center of tropical cyclones. This is done in the global GSI but that system has benefit of a strong constraint. It was found that the resulting storm center was not at the observed location and the surface cyclonic flow was not symmetric and much too strong. In order to provide the correct initial condition for tropical cyclones, more work was needed. With the advantage of localization, extra ensemble members were added by shifting the first guess by one (more) grid point in all directions. Extra synthetic surface pressure data were added so that the hybrid GSI could identify the correct ensemble member and give it the dominant weight. With these added conditions, the hybrid 3dvar-ensemble system was able to generate a more symmetrical cyclonic structure at the observed storm location. But the forecast impact was not clear compared with other relocation tools. (Wan-Shu Wu)

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

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 – see text under 12.5.5.5.

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.

12.5.5.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.

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

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

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.

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.

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 is being undertaken by David Dowell and others in GSD. (The HRRR initialized from the RR tends to also produce more precipitation than HRRR initialized from RUC.) This is clearly tied to there being a moister boundary layer in the RR, as noted in previous reports. This is not necessarily purely a physics issue, possibly also involving fundamental differences between the RUC and WRF-ARW models, and how they respond to imposed latent heating as part of the radar assimilation. This investigation will continue and is likely to help focus developments in both physics and assimilation during FY12.

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 released next spring. The remaining portion will be committed as soon as a stubborn compiler issue is resolved.

Some further modification and testing of the MYNN planetary-boundary-layer (PBL) scheme continued. Joe Olson has been collaborating with Mikio Nakanishi, one of the original authors of the scheme, in this effort. Recent retrospective runs using our May 2010 retro period have shown overall good performance by MYNN relative to MYJ, but also issues that need further diagnosis. Additional retro runs are planned. Pending favorable outcomes, 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 it as the surface-layer and planetary-boundary-layer option for the RR2. 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.

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.

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).

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.

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.

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.

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.

As described under task 5.5, work is ongoing to analyze aspects of the RR analysis for specific cases from the August 2011 retrospective period, for which there were problems with the subsequent HRRR forecasts. These problems included excessive convection, missed convection, difficulty propagating the leading line of convective systems and other errors. A primary focus in this investigation has been cases with spurious or excessive convection and assessment of the moisture in the parent RR model and comparisons against similar RUC and RUC-HRRR runs. Indications of excessive moisture and CAPE and too little CIN have been seen in several of these cases. David Dowell has been leading work to determine the origin of these biases, including an assessment of PW assimilation, partial cycle updating from the GFS, and a soil moisture feedback from excessive precipitation in the RR.

As part of this work, Haidao Lin is running an RR with DFI radar reflectivity assimilation retrospective to duplicate the real-time RR runs that were used to initialize the real-time HRRRs and Eric James is running a RUC with DFI radar reflectivity assimilation retrospective to duplicate the real-time RUC. These retrospectives will also facilitate examination of another key issue for the HRRR, the ability of the radar DFI to induce low-level convergence and upper-level divergence. The goal in all of these experiments is to find the causes of specific arch-type deficiencies noted in the HRRR forecasts from the 2011 summer evaluation and to develop model and assimilations enhancements to eliminate these deficiencies.

Additional work has focused on testing WRF ARW version 3.3.1 as an upgrade for both the RR and HRRR. Preliminary testing has revealed some issues for both RR and HRRR setups and further testing and evaluation is ongoing with a strong expectation of using these versions for the summer 2012 HRRR evaluation.

Several AMB scientists attended and presented at two very beneficial meetings focused on short-range assimilation and modeling (especially of convection). First, David Dowell, Ming Hu, Curtis Alexander, and Steve Weygandt attended/presented at a NOAA Warn-On-Forecast radar data assimilation workshop. There was good discussion of radar assimilation strategies (including the DFI radar technique used in the RR and more advanced EnKF hybrid techniques) and also discussion on important mesoscale model bias issues (moisture and PBL especially). Insights gained at this meeting have been very helpful in focusing our current work to improve the HRRR prediction for summer 2012. Second, the same four scientists, plus Stan Benjamin and John Brown attended the WMO Symposium on use of Numerical Weather Prediction Systems for Nowcasting in Boulder (with Stan, Curtis and Steve presenting), which included significant participation from colleagues around the world. This meeting was similarly helpful. Finally, Stan Benjamin presented an update on the HRRR and Rapid Refresh models at the Friends and Partners of Aviation Weather (FPAW) conference also in October.

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.

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, extensive coordinated testing of various aspects of the RR and HRRR is ongoing to find optimal changes to eliminate issues identified in the summer 2010 real-time HRRR evaluation. Several members of the AMB group are meeting formally every 1-2 weeks and more frequently informally to assess test results, and plan next experiment steps (what to evaluate in real-time test cycles, retrospective cycles, and individual case study tests). All aspects of the RR/HRRR system are under investigation (RR analysis and model configuration, HRRR model configuration, 3-km radar assimilation, etc.)

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.