MDE Product Development Team
4th Quarter 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 (RAP)

- RAP at NCEP continues to run without any problems during entire quarter (Jul-Sept)
- RAP version 2 running at GSD, yielding improved upper-air wind/temp/RH forecasts over RAP-NCEP. The same is true for surface moisture and precipitation forecasts, and ready for transfer to NCEP EMC.
- Further changes in testing in development (not primary) ESRL RAP including data assimilation and modeling improvements. All of these will be included in final Rapid Refresh v2 (RAPv2) with implementation at NCEP, now proposed for June 2013 after NCEP implementation moratorium is lifted.
- RAP-dev3 cycle (identical code with Jet RAPv2) running on new NOAA research high performance computing system, ZEUS, supporting a parallel 3-km HRRR on that machine, also 2D RTMA surface analysis application using HRRR forecast as background.

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

- RAP retrospective experiments to examine impact of moisture pseudo-observations on RAP forecasts
- Successful run of RTMA 2DVAR surface analysis using HRRR 3km 1h forecast as background using detailed RTMA-appropriate background error covariance file from NCEP.
- Initial work to process atmospheric motion vector (sat cloud-drift) winds in preparation for retrospective data impact tests.
- Continued work to port code for ingesting SATcast CI indicators from RUC 3DVAR top GSI 3DVAR
- Discussions and planning between ESRL/GSD and EMC personnel for retrospective tests of RAP with background error covariances derived from global EnKF.

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

- Discussions with Greg Thompson and RAP/HRRR team on WRF physics, including cloud physics.
- Testing to correct bug in WRF regarding lack of radiation effects from snow mixing ratio in atmosphere, which has been contributing to a daytime warm bias in the RAP and HRRR at the surface.
- Testing continues of GSD/Olson version of MYNN PBL scheme.

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

- Continued good HRRR reliability during July-September 2012 (new report).
- Initial HRRR report for September 2012 now available also
- Improvement made to the HRRR post-processing code (in UNIPOST) to reduce low echo top bias.
- Retrospective testing to evaluate forecast impact from interaction of snow hydrometeors with shortwave radiation.

Task 12.5.4 Develop, test, implement, and improve the Rapid Refresh

ESRL/GSD

Task 5.4 involves the integrated testing and development of the model, assimilation, post-processing, and script components of the Rapid Refresh. While some changes in the RAP may fall specifically with assimilation (Task 5.5) or model physical parameterizations (Task 5.8), under this task we consider the full-integrated effects of all components of the RAP. The changes and problem areas listed below involved such cross-component investigation and testing.

The operational RAP at NCEP ran without any technical problems (including with the post-processing) through the entire July-September period. The RAP has continued to show improved reliability over the previous RUC at NCEP.

GSD continues to evaluate the updated RAP version 2 at ESRL with its significant data assimilation and modeling modifications implemented at GSD in March 2012 and discussed in previous MDE reports. The FY12Q3 report pointed out that the NCEP operational RAP dew point forecasts during June were sometimes quite poor, often too low, but in areas of recent precipitation, sometimes too high. This led to complaints by the Storm Prediction Center expressed serious concerns over the NCEP RAP for a few challenging severe weather situations. As noted in the FY12Q3 report, the RAPv2 running in the RAP primary cycle at GSD produced much better forecasts. During the July-September quarter the ESRL RAPv2 continued to show improvement over the operational RAP running at NCEP. This has been confirmed by independent evaluation by the Storm Prediction Center (SPC) for surface temperature and dew point and has prompted SPC to request implementation of RAPv2 prior to the 2013 convection season. A decision on this by the NCEP director is pending.

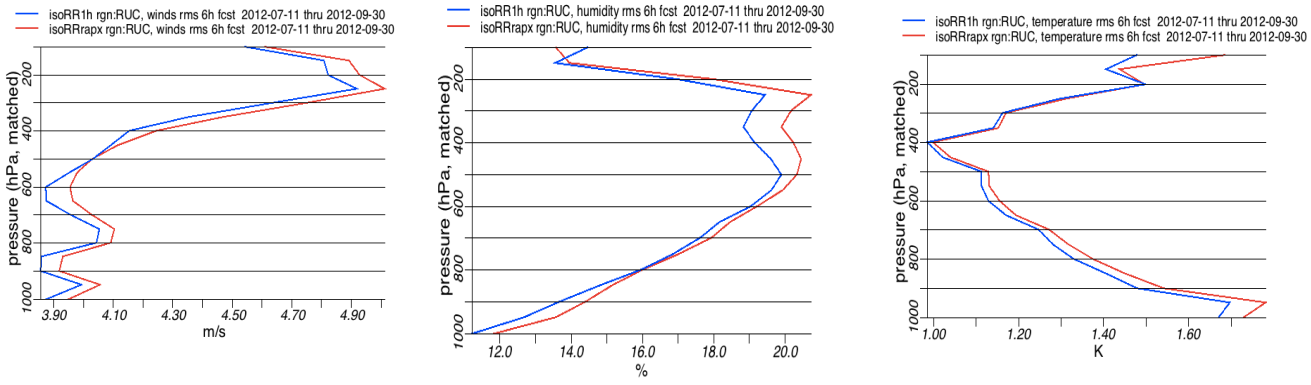

Figure 1. Last 3 months of verification of RAP upper-air 6h forecasts from RAP-ESRL (in blue) and RAP-NCEP-oper (in red) against rawinsonde observations for 20 July – 15 August 2012 on top line and for 11 July – 30 Sept 2012 on lower line. The 3 graphics are for wind (left), temperature (center), and RH (right).

In Fig. 1 (above) for the full July-September quarter, the RAPv2 (RAP-ESRL) continues to show better accuracy (smaller error vs. raobs) at all levels for all 3 of the main upper-air variables – wind (left), temperature (center), and relative humidity (right). This promises very strongly for improvements in RAPv2 versus the current operational RAP forecast. As reported on 15 September, 2m dewpoint errors and biases also show much better performance with RAPv2 vs. the current operational RAP (Figure 2 below).

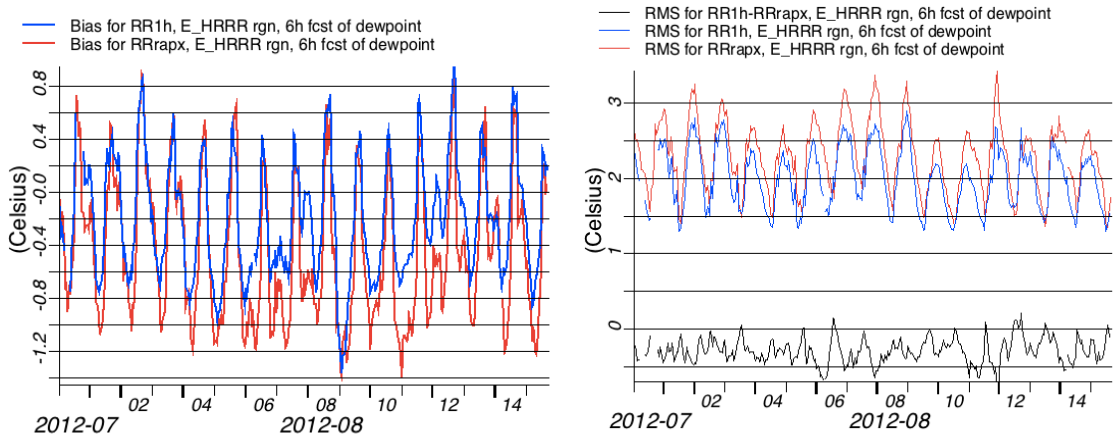

Figure 2. Verification of RAP 6h dew point forecasts RAP-ESRL (in blue) and RAP-NCEP-oper (in red) against METAR observations. Bias (defined as forecast minus observation – negative means moist bias) is shown on left, and RMS difference (smaller is better) is shown on right.

With the NCEP RAP running smoothly and the beginning of the moratorium on NCEP operational implementations due to the transition to the new Linux-based WCOSS computer, there were two main thrusts of RAP work at ESRL/GSD this quarter. One was toward completing the transfer of developmental RAP cycles from the Jet computer in Boulder to the Zeus supercomputer at the NOAA Environmental Security Computing Center (NESCC) in West Virginia. The other was on further improvements to the RAP, both in anticipation of moving the code to NCEP for the RAPv2 implementation as soon as NCEP is in a position to begin testing it there, and looking ahead to a likely RAPv3 implementation prior to the advent of the NARRE (North American Rapid Refresh Ensemble, likely implementation in late FY15 or 16.

The transfer to Zeus is nearly complete, and thanks to the diligence of the Zeus technical management, the queue situation there improved greatly during the quarter despite a heavy load on the machine. Early in the quarter there also were a number of unplanned system outages due to problems ranging from rodents chewing into cable to issues with the job scheduler, but more recently reliability has significantly increased. Since early September the RAPdev1 cycle on Zeus has run without interruption except during overall system outages. Issues with protection of prepBUFR files from NCEP containing proprietary data have also been recently overcome, so that for the past couple of weeks the RAPdev1 cycle on Zeus is using exactly the same data as the RR primary cycle on Jet that supports the HRRR. Forecasts are not identical, but appear to be acceptably close.

Another development of importance was getting WRFV3.4.1, officially released by NCAR on 16 August, running on Jet and Zeus for testing of the RAP and HRRR. Because there are critical parts of the RAP code that are not yet part of the NCAR WRF repository (particularly the DFI and enhancements within the model code to generate specialized fields requested by the SPC and others), this entailed merging the new V3.4.1 code with the RAP WRFV3.3.1 repository code at GSD, as well as overcoming the usual types of run-time issues encountered when attempting to run new codes on Zeus and Jet. A cold-start RAP (initialized with GFS, no cycling) using the V3.4.1 code has been running stably on Zeus since late August. Further, Tanya Smirnova and Steven Peckham have been working with the NCAR WRF developers in validating that these GSD WRF enhancements for RAP are qualified for inclusion into the WRF repository. They will likely become part of the WRFV3.5 release in spring 2013.

A number of tests were conducted to improve 10m wind and overnight 2m temperature forecasts from the RAP and HRRR. These included variations to the land-surface model (RUC LSM) used in RAP and HRRR by decreasing the thickness of the top layer, and also changing roughness lengths over certain land-use types including (for the first time) seasonal variation. These experiments gave very promising results.

Other activities, some noted more fully under other tasks, were undertaken during the quarter.

- Code and script modifications were completed in early July to protect against cold starts with GFS soil moisture (resulting in unrealistically high soil moisture and surface dew points in RAP) and ensure that the most recent RAP soil moisture fields are always used when a cold start is necessary.
- Earth Networks, Inc. offered GSD access to their lightning network data. We are now evaluating it as a potential backup to the Vaisala GLD360 lightning product that has been under testing in the RAPdev1.
- Retrospective testing of satellite radiance bias corrections and choice of background error continues (Task 5).
- Xue Wei found that the 10m wind components coming out of Unipost were on the original u and v grid points of the Arakawa C grid instead of being de-staggered to the mass points. This bug was fixed for the GSD RAP and HRRR runs.
- Eric James conducted a retrospective experiment using our May-June 2011 retro period on the impact of moisture pseudo-obs. Results were consistent with what parallel testing had shown in summer 2011: moisture pseudo-obs very slightly increase the forecast RMS error of temperature, wind, and RH overall, but RH (and the important convective environment) is generally improved at low levels.
- Issues with physics used in RAP and HRRR continue under active investigation (see Task 8).

An added note: Tanya Smirnova has successfully run the WRF/NMM v3.4.1 on Zeus with both the default physics and the physics options used in the HRRR. However, there is still a minor problem with the vertical interpolation in deriving initial fields to start the model, and also in obtaining graphical output suitable for evaluation.

Once the summer 2012 CoSPA freeze period for the GSD RAP primary cycle feeding the HRRR ends (30 October) we are planning more extensive testing of several possible RAP enhancements for both assimilation and model over the next several months in preparation for RAPv2 and perhaps RAPv3 (2014), depending on the timing of the RAPv2 implementation at NCEP. Currently, the possibilities include

- Modifications to the cloud analysis to better account for partial cloudiness
- HRRR cloud analysis
- Partial cycling of HRRR off of RAP
- Radar assimilation for improved HRRR forecasts in the first 1-2h
- Comparison testing of WRFV3.4.1+ (customized for RAP) v current WRFV3.3.1+
- Modification of RAP / HRRR vertical-layer configuration
- Nine-level v six-level RUC LSM configuration
- Modification of Goddard short-wave radiation to account for snow aloft
- New Grell convective deep and shallow parameterization of convection

More discussion of some of these is under the appropriate tasks later in this report.

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

NCEP
The Rapid Refresh (RAP or RAPv1) was implemented at NCEP on 1 May to replace the Rapid Update Cycle (RUC). The larger domain covers much more of North America including Alaska and Puerto Rico. The model uses a WRF-ARW dynamics core and the GSI analysis; it takes advantage of many of the excellent aspects of the WRF while maintaining several of the key features of the RUC including assimilation of radar reflectivity data, the RUC/Smirnova land-surface model, the Grell convective scheme, Thompson microphysics, and the RRTM long wave radiation model. Like the RUC, the RAP is run every hour out to 18 hours with 13 km horizontal grid spacing. Work continues to develop the second version of the RAP (referred to as RAPv2) that will feature updates to both the model (WRF-ARW) and the analysis code (GSI). (Manikin)

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

About 80% of the SODARs are not getting into the RAPv1 because they do not get to NCEP in time for the RAP dumps, and work-arounds are being investigated. An RFC was submitted to NCEP Central Operations (NCO) to prevent outages in the LaRC GOES cloud data when LaRC switches to their backup server, which occurred 6 times in September. The GOES-13 (East) imager and sounder instruments degraded in quality due to an anomaly and went out-of-service on 23 September. On 24 September, NESDIS began sending GOES-14 data as GOES East. The RAP then began using GOES-14 winds and LaRC cloud data. Special ESRL-RAPv2 PREPBUFR files from early and partial cycle RAP runs are still not being copied to the special ftpprd GSD area. Since 6 July, 3 ESRL-RAPv2 SODARs at critical times past the hour consist of only 3 (lowest) levels in the PREPBUFR files. Investigations are underway why these reports are truncated in the NCEP dumps but are complete in the ESRL processing. These three sites, as well as 4 WFIP sites were added to the NCEP reject list on 9 August. The ESRL-RAPv2 does not reject these sites. The GSD MADIS server was down intermittently 13 and 24 August. (Dennis Keyser)

GSD
GSD was also involved in investigations with NCEP on issues regarding availability of profiler and sodar data. A brief delay to the Rapid Refresh at NCEP occurred for the 00z run on 1 August from a problem in aircraft processing at NCEP. NCEP quickly resolved this problem. GSD confirmed that the ESRL RAP was also affected (and the subsequent HRRR) run. GSD and NCEP continue to work to improve the early observational dump for the 00z and 12z RAP runs at ESRL to initialize the HRRR. In fact, the HRRR has had no non-radar data available for its 00z and 12z runs since 1 May when the RUC stopped running and early obs dumps had ended at that point. This point is pointed out in a new FAQ webpage for the HRRR at **http://ruc.noaa.gov/faq/HRRR.faq.html.**

GSD continues to make pgrb and bgrb files from the ESRL/GSD RAP-primary (RAPv2) real-time 1-h cycle available from its FTP site for users in NWS and other labs).

12.5.4.2 Ongoing (NCEP, GSD)
Provide vendors with gridded model data via Family of Services and the FAA Bulk Weather Data Telecommunications Gateway.

NCEP
NCEP maintained real-time availability of SAV and AIV guidance to all vendors from the operational hourly RAP on pressure surfaces via the NWS Family of Services (FOS) data feed and via the FAA Bulk Weather Data Telecommunications Gateway (FBWDTG). (EMC&NCO)

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

NCEP
NCEP maintained real-time availability of full resolution gridded data from the operational RAP runs via anonymous ftp access via the NCEP server site at **ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/rap/prod/** and at the NWS/OPS site at **ftp://tgftp.nws.noaa.gov/SL.us008001/ST.opnl/** in hourly directories named MT.rap_CY.00 through MT.rap_CY.23. This includes hourly BUFR soundings and output grids, which undergo no interpolation. Both sites now contain only grids in GRIB2 format **http://www.nco.ncep.noaa.gov/pmb/docs/GRIB1_to_GRIB2.shtml**. Gridded RAP fields are now also available on **NOMADS** for the CONUS domain on 13 km grid #130 and the larger North American domain on 32 km grid #221. A limited set of fields from the RAP runs (and other NCEP models) can also be viewed at **http://mag.ncep.noaa.gov/NCOMAGWEB/appcontroller**. (EMC&NCO)

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

NCEP
NCEP maintained its capability and provided access to routine verifications of the operational RAP 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 website: **http://www.emc.ncep.noaa.gov/mmb/research/meso.verf.html** . (EMC)

12.5.4.5 Ongoing (GSD, NCEP)
Ongoing evaluation of performance of real-time and retrospective runs of RAP system for SAVs, AHPs

GSD
GSD's verification of the RAP is available from **http://ruc.noaa.gov/stats** . These stats were the basis for Figures 1 and 2 showed earlier in this report. Additional obtions for subareas of CONUS were added by Bill Moninger (+ / - 109^{o} W), chosen to gage impact of satellite-derived Atmospheric Motion Vectors (AMVs) over the Pacific.

NCEP
The Rapid Refresh was implemented at NCEP on 1 May and its performance is being routinely monitored. (Manikin)

12.5.4.6 Delayed to 1 Feb 2013 (ESRL, NCEP)
Initial software for RAPv2 changes ready for porting to EMC.

GSD
The RAPv2 version running at GSD continues to perform well and has strong promise of fixing the most serious operational RAPv1 issues.

NCEP
Delays in the initial RAPv1 implementation will delay the RAPv2 upgrade until after the moratorium, likely no sooner than June 2013. Transition of RAPv1 and RAPv2 codes and scripts to the new WCOSS computers has begun and accounts for ESRL's RAPv2 developers have been applied for. (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 (RAPv2) at NCEP in 2013.

COMPLETE - The configuration of the Rapid Refresh (RAP-primary at ESRL) for the summer 2012 has been set since mid-March. This version of the RAP is nearly equivalent to the RAPv2 version envisioned for NCEP by late 2012 (postponed to 2013 due to upcoming NCEP moratorium). We therefore call this task "complete", but other smaller changes may yet be added at a later time before code for the RAPv2 is transferred to NCEP/EMC later in 2012 or early 2013.

12.5.4.8 31 May 2012 **(ESRL, NCEP)**

ESRL-GSD
Start design of NARRE ARW and NMM model ensembles. Use of ensemble/hybrid data assimilation, likely augmented by different physics suites, provides variability for the ARW and for the NMMB. Work at ESRL, CAPS (not funded currently) and EMC on regional ensemble data assimilation (see 5.5) is critical for improved deterministic and probabilistic forecasts from the NARRE. Part of this subtask will be to do the experiments necessary to decide which of these alternatives gives the more useful ensemble diversity for aviation application, by means of real-time and retrospective testing on the RAP domain. (31 May 12)

GSD
In work initiated in May, Ming Hu reports progress toward adaptation of the GSI ensemble/variational hybrid capability toward use with the RAP. Both GSD and NCEP/EMC agree that hybrid ensemble data assimilation is critical for the NARRE. A presentation was developed on NARRE/HRRRE plans by Stan Benjamin for a

DTC/NUOPC Workshop in September. Further productive discussions on NARRE design occurred in early October between GSD and NCEP to make further plans, especially on how to incorporate ensemble data assimilation into the NARRE and perhaps RAPv2 or RAPv3.

NCEP
The 1 May RAP implementation also included implementation of a North American Rapid Refresh Ensemble (NARRE), which used time-lagged (TL) forecasts from RAP & NAM to fill out its membership. In this NARRE-TL system a label error for reflectivity probability and one for accumulation of precipitation in probability files were fixed. A new RFC for these fixes and a TIN were submitted to NCO. Routine grid-to-grid verifications of NARRE's visibility, reflectivity and icing probability products against new 2.5km RTMA's visibility data, MOSAIC composite reflectivity data, and AWC's ADDS-CIP data, respectively, were built. Primary results for NARRE visibility performance over 3 months (July to Sept 2012) have been obtained, showing improvement over RAP or NAM scores alone. Routine grid-to-grid verifications of surface winds for both NARRE and downscaled SREF against 5km RTMA surface winds were built. A new 16km SREF was implemented on 20 August, consisting of NMMB, NMM and ARW members to enhance physics and IC diversity. (Binbin Zhou and Jun Du) Discussions are to be held between ESRL & EMC developers in October to consider future research needs for the NARRE.

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

NCEP
RAPv2 is delayed due to the late implementation of RAPv1 and the NCO moratorium on model changes. ESRL has provided code to EMC for the GSI, and it will be tested by EMC in the new computer environment (WCOSS) in FY13. Initial tests on the existing computer (CCS) show that the code update leads to better fits to RAOB data and overall model improvement. Implementation is not likely to occur prior to June 2013. (Manikin)

12.5.4.9a Submit Request for Change (RFC) and modified codes for RAPv2 from EMC to NCO, pending NCEP readiness. (15 Jun 12)
RAPv2 is delayed due to the late implementation of RAPv1 and the NCO moratorium on model changes. Transition of RAPv1 and RAPv2 codes and scripts to the new WCOSS computers has begun and accounts for ESRL's RAPv2 developers have been applied for. (Manikin)

12.5.4.10 Commence work toward rendering RAP code, including potential physics suite options, operable within the NEMS (NOAA Environmental Modeling System, which is based on the Earth System Modeling Framework (ESMF), in compliance with the Sept 2007 Rapid Refresh MOU between NCEP and GSD. (1 Jul 12) - Request: Defer until Jan 2013

GSD
Work on this project (modification of WRF-ARW to use NEMS/ESMF) will begin [at ESRL/GSD] when GSD's efforts with NEMS on the FIM global model are complete, a higher priority to allow incorporation FIM into a NEMS-based experimental global ensemble at NCEP.
ESRL continues to work primarily on bringing the FIM global model into NEMS compliance and working with NCEP to make further modifications to NEMS. NEMS design for the global model will set the direction for making ARW NEMS-compatible. Based on this prioritization, Jan 2013 is a more realistic date for this task (S. Benjamin)

NCEP
Work on this project will begin [at ESRL/GSD] now that RAPv1 model was implemented at NCEP on 1 May. The practice of keeping dynamics and physics as separate components, which was a technical aspect of prior NEMS designs, has been broadened to allow their combination into a single solver. This was used successfully in the NMMB. ESRL is expected to take advantage of that in their efforts to include RAP in NEMS. (Black, DiMego)

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

Discussions continue at GSD and at NCEP on how to use ARW within NEMS. It now appears that all agree that ARW will be used in NEMS without splitting physics and dynamics components, which will make this task far easier and straightforward.

Deliverables
All Option A unless noted otherwise.

12.5.4.E1 20 Dec 2011 (ESRL)
Report on Rapid Refresh status and plans to NCEP Operational Model Production Suite Review meeting.

Complete. Stan Benjamin and Steve Weygandt made a joint presentation on the RAP / HRRR status at this review, held 6-7 December at NCEP.

COMPLETE. Available at **http://www.emc.ncep.noaa.gov/GEFS/prod-review/NCEPmodelReview-2011.html**

12.5.4E2 (1 Feb 12) (Manikin)
Update documentation for operational Rapid Refresh.

CURRENT EFFORTS: The Rapid Refresh was implemented at NCEP on 1 May to replace the Rapid Update Cycle. (Manikin)

PLANNED EFFORTS: Item is completed.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: None.

12.5.4E3 (1 Apr 12) (Manikin)
Final code ready for transfer to EMC for Rapid Refresh upgrade change package to be implemented in spring 2012.

CURRENT EFFORTS Work on this project will begin once the operational RAPv1 model is transitioned to the new NCEP WCOSS supercomputer. (Manikin)

PLANNED EFFORTS: Convert RAPv1 to new NCEP computer then bring in RAPv2 for testing and implementation in FY13.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: Delays in the initial RAPv1 implementation will delay the RAPv2 upgrade until after the moratorium, likely no sooner than June 2013. Move this deadline to 1 March 2013.

12.5.4.E4 (30 Mar 12) (ESRL)
Report on testing of RAP assimilation/model improvements toward planned RAPv2 upgrade.

COMPLETE. Extensive testing complete or underway for frozen RAPv2 for summer 2012 CoSPA/HRRR.

NCEP

12.5.4E5 (modified to 31 May 12) (Manikin)
Pending computer resource availability, complete testing at EMC of Rapid Refresh version 2 changes to operational RAP at NCEP.

CURRENT EFFORTS: Work on this project will begin once the operational RAPv1 model is transitioned to the new NCEP WCOSS supercomputer. (Manikin)

PLANNED EFFORTS: Convert RAPv1 to new NCEP computer then bring in RAPv2 for testing and implementation in FY13.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: Delays in the initial RAPv1 implementation delayed the RAPv2 upgrade until after the moratorium, likely no sooner than June 2013. Move this deadline to 30 June 2013.

12.5.4E6 (30 Sep 12) (Manikin)
Perform configuration management for Rapid Refresh, including thorough documentation, and respond promptly to any code malfunctions or performance issues.

CURRENT EFFORTS: Work is underway to make the transition to the new NCEP supercomputing environment. The primary effort involves modifying the operational Rapid Refresh codes to successfully compile in the new framework. Once completed, work will begin on script modification needed to run the model on the new system. WCOSS accounts for ESRL's RAPv2 developers have been applied for. (Manikin)

PLANNED EFFORTS: Implementation of the RAPv2 will have to wait until after the moratorium during which all of NCEP Production has to be moved to the new computer system. The moratorium is expected to last from September 2012 through at least the end of May 2013.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: None.

12.5.4E7 (30 Sep 2012) (Manikin)
Monitor Rapid Refresh performance, respond to any problems detected by ESRL, NCEP, or any RAP users, diagnose cause, and develop solution to RAP software, test changes and coordinate with NCO on implementation.

CURRENT EFFORTS: The Rapid Refresh was implemented at NCEP on 1 May to replace the Rapid Update Cycle. RAP performance is being monitored daily. (Manikin)

PLANNED EFFORTS: Convert RAPv1 to new NCEP computer then bring in RAPv2 for testing and implementation in FY13.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED: Since RAP is developed on a Linux based computer at ESRL/GSD, no major problems are anticipated.

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: None.

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

This date was further delayed a bit given the likely RAPv2 NCEP implementation schedule, although the already-completed RAPv2 reports for the summer 2012 HRRR constitute a preliminary report.
UPDATES TO SCHEDULE: Changed from previous 30 Sept to 30 Nov.

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

ESRL/GSD
A major focus In Q4 FY12 was scoping out RAP assimilation development and testing work for this fall (once the ESRL/GSD real-time experimental RAP / HRRR is released from the code freeze for the 2012 convective season evaluation. This was discussed at status / planning meeting and an update is as follows:

1. Ming Hu is working to update RAP top latest trunk version of GSI. He has run RAP with a June 2012 trunk version of GSI, so the switch should be pretty straightforward.
2. Discussions have taken place with Tom Auligne (NCAR) about a new version of the GEN_BE program that will be used to help generate a new set of RAP background error covariances, using an archive of RAP forecast files that have been saved.
3. Discussions and planning with EMC personnel for a retrospective test of RAP using background error covariances derived from the GFS global ensemble.
4. Results from Patrick Hoffman's retrospective tests with reduced values for the specified raob observation errors showed better analysis fit to raobs, but a slight increase in forecast errors (both parts were expected). We will repeat this test with the reduction in raob observation errors restricted to the lower levels, in hopes captured detailed near surface structure in the raobs, without the adverse affect on forecast skill.
5. Haidao Lin continued his work on bias correction for the satellite radiance assimilation, completing a 2-month spin-up test. Results show reasonable spin-up for some bias predictors, for some channels of some instruments, but slow / poor spin-up for others. The reason for this is thought to the limited coverage (in both time and space) for these polar orbiter satellite observations. Follow-up experiments show that these self-spun-up bias correction coefficients, give results that compete favorably with experiments that start with bias correction taken from the GFS or NAM.
6. Work continued to ingest several new datasets into the RAP including a new form of the SATcast convective initiation indicator dataset.
7. Work continued by Patrick Hofmann in enhancing an RTMA analysis with a special 2DVAR form of the GSI applied to a 3-km HRRR grid. Patrick obtained a new little endian version of the anisotropic background error covariance file from Manuel Pondeca and did some tests on the 3-km grid. Results show more detail in the analysis increments, especially of the complex terrain of the west.
    a. GSD will start to run a 3km RTMA with HRRR background in real-time this fall with the expectation this can subsequently run every 15 min to replace the current STMAS analysis used for a graphical frontal product that is provided in CoSPA. The 15-min RTMA/HRRR analysis will then benefit with wider NOAA/NWS collaboration.

Subtasks

12.5.5.1 31 Dec 2011 (GSD)
Further refinement to the radial velocity analysis component of GSI for Rapid Refresh 2 configuration.

Results from inclusion of radial velocity data assimilation in parallel versions of the RAP are still generally neutral, resulting in its inclusion in the early March frozen version of the RAP. Some further bird-QC refinement may yet be needed – will report more next month.

12.5.5.1a 30 Oct 2012 (ESRL, NCEP)
Complete preparation of initial GSI changes for RAPv2 changes ported to EMC.
Work will begin on RAPv2 after the RAPv1 is implemented in May 2012. (Wu, Parrish)

ESRL
Work on RAPv2 was delayed, due to delays in implementation of RAPv1 (completed May 1, 2012). Considerable work on this occurred during Oct 11 – Mar 12 at GSD. A nearly complete version 2 of the RAP was frozen at GSD in March for the 2012 CoSPA season (parent to the HRRR). This version includes many improvements to the analysis (use of pseudo-innovations for surface moisture, soil temperature and moisture adjustment based on surface innovations, conservation of virtual potential temperature in moistening associated with cloud building, limits of precipitable water innovations) that have resulted in better precipitation and moisture forecasts. With the NCEP computer implementation moratorium now expected to last into Spring 2013, additional work toward RAPv2 enhancements will resume following the end of ESRL RAP summer evaluation code freeze (Oct. 31). Key aspects include improved cloud analysis to allow cloud building at upper levels without introducing a moist bias, improved background error covariance specification (from either generation of new RAP-specific background error covariance files using GEN_BE or from use of global EnKF-based background error covariance files). Other work has included retrospective testing of use of expanded AMV observations (yielded slight impact) and continued evaluation of modification to the cloud building procedure (use of effective cloud amount to determine a cloud fraction for use in limiting the cloud building region).

NCEP
Work will begin on RAPv2 after the RAPv1 is implemented in May 2012. (Wu, Parrish)

12.5.5.1b 31 Dec 2011 (GSD)
Complete initial testing at ESRL of improved satellite radiance assimilation capability (bias correction, time windows, etc.) for RAPv2.

Initial bias correction work previously completed with forecast improvement noted. Ongoing retrospective testing led by Haidao Lin to evaluate further enhancements from the bias correction. All this work is being done on the new supercomputer, Zeus, following successful transition of RAP to Zeus. Additional work by Haidao Lin has included running a two-month retro to examine bias correction spin-up issues for various instruments, channels, and predictors within the RAP system. Results confirm that some of the bias correction coefficient predictors for some instrument channels rapidly stabilize, but for others that are not stabilized even at two months. This is presumably due to the limited data coverage for the various satellite radiance types over the limited regional domain. Despite these bias correction predictor spin-up issues, retrospective tests showed worse forecast verification scores (against raobs) without the cycled bias correction coefficient predictors.

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

NCEP
Now the EnKF has been implemented in the operational global, the EnKF members are being used in the NAM parallels on CCS and on zeus which take advantage of the simple hybrid approach for background error covariance specification in the GSI. Testing a full-blown EnKF data assimilation system is planned for FY13. (Wu, Rogers)

12.5.5.4 31 Aug 2012 (ESRL) COMPLETED
Complete testing of GSI changes for RAPv2 at ESRL.

This task is considered to be complete because the original set of changes for RAPv2 will been completed and extensively tested in the ESRL real-time experimental RAP/HRRR (frozen since Spring 2012).
Results from this test evaluation show substantial improvement in near surface and convective environmental fields. However, with NCEP unable to implement RAPv2 until spring to early summer 2013, ESRL will continue to

test additional RAPv2 enhancements into fall, and will incorporate well-tested additions as they become available this fall.

12.5.5.5 1 Feb 2012 (GSD, NCEP) COMPLETED
Test version of GSI appropriate for 3-km High-Resolution Rapid Refresh (HRRR) configuration, including use of level-2 radar radial wind and reflectivity data.

GSD
This task was completed in January 2012. However, work continues in improving the 3km GSI assimilation since that time.

Work continues to optimize the 3-km sub-hourly assimilation procedure for real-time application. In the system, a one-hour pre-forecast integration is completed, in which 4 application of the diabatic DFI-based radar assimilation is completed. The WRF ARW code has been modified to accomplish within a single model executable. At present, however, 4 separate applications of the GSI (over the 3-km HRRR domain) are needed to create the radar reflectivity-based temperature tendency arrays. We are currently investigating needed changes to the GSI cloud analysis to allow all for the creation of all four of these temperature tendency arrays at a single time. The change would significantly reduce run-time for this pre-forecast spin-up period, increasing the likelihood that we can run it in real-time. It was decided to NOT include this in the operational version of the HRRR for spring/summer 2012.

Ming Hu has recently successfully run this 3-km GSI cloud analysis on both ESRL JET and ZEUS supercomputers, getting about 4 min. run times (64 cores on JET, 72 cores on ZEUS). David Dowell continues to evaluate different strategies for 3-km radar data assimilation using GSI. Ming Hu is examining impact of 3-km cloud analysis on HRRR forecasts.

Work continues on this task, with completion of 3-km GSI analysis including specification of precipitation hydrometeors from radar reflectivity data. Output files from these analyses will be provided to Ken Howard and MRMS team as part of the coordinated work toward the Rapidly Updated Analysis (RUA) product. Work has progressed on two closely related tasks: 1) Work by Patrick Hofmann (in conjunction with Manuel Pondeca – NCEP/EMC) in testing of the 3-km 2DVAR “RTMA type” analysis using HRRR background fields and 2) Work by Ming Hu/David Dowell/Curtis Alexander in running a 3-km GSI analysis to support sub-hourly (15-min) 3-km pre-forecast radar assimilation cycling experiments. Curtis Alexander will report results of this at the upcoming AMS Severe Local Storms conference.

NCEP
After the implementation of the procedure to dump the new VAD winds, the data were available for an impact study. The problem of the observation density being too high in the vertical was fixed with quality control and data thinning. The GSI code changes were incorporated into the version tested in the official parallel and the off line impact test were done. The results showed neutral impact to the short-term forecasts. (Wu, Liu)
Work continues on finalizing the new dual-polarity radar decoder that NCO has written (see 12.5.5.12). Work began on a QC algorithm for the dual-polarity radar variables, which is expected to improve the quality control procedures for radial wind, reflectivity and VAD winds. All variables are QC’d with a fuzzy-logic method developed by NSSL. The performance of the new QC algorithm is very good for the current test case, especially for removing clutter close to a radar site. New BUFR tanks of dual-pol variables were examined and will be further tested in a parallel run. (Shun Liu)

12.5.5.6 Moved to Jan 2013 (GSD)
Complete testing of Rapid Refresh GSI modifications for RAPv2 at EMC, transfer code to NCO, pending NCEP readiness.
Delays in the initial Rapid Refresh implementation will delay the Rapid Refresh upgrade to FY2013. Move this deadline to 31 December 2012. A large set of changes to reduce the high bias in RAP moisture and precipitation forecasts has already been fully tested and included in all three ESRL GSD real-time parallel RAP runs and is in the frozen code for the RAP that serves as the parent for the HRRR in the summer 2012 real-time evaluation.

12.5.5.7 Moved to April 2013 (NCEP, ESRL)

Submit Request for Change (RFC) and modified GSI code for RAPv2 from EMC to NCO, pending NCEP readiness.

Delays in the initial Rapid Refresh implementation will delay the Rapid Refresh upgrade to 2013 – note current estimated date.

NCEP

A package of revisions from ESRL/GSD was committed to NCEP's GSI SubVersion trunk on April 26, 2012. This will form the basis of the RAPv2 GSI testing. The changes that were made follows: Add aircraft observation rejection list to toss bad aircraft temperature, wind, and moisture observations; Add PBL pseudo observations based on surface temperature, moisture, (181,187,183) and wind (281,283,287); Add subroutine to calculate PBL height, which will be used in PBL pseudo observation and cloud analysis; Linear variation of observation error inflation below surface for q, t; Add code in speed observation innovation calculation to use observation height instead of pressure to get observation vertical grid coordinate; Add additional QC for PBL profiler 223, 224, 227; Limit the low level moisture analysis increment over ocean; Update the START_TIME for ARW NetCDF format to reflect the right analysis time; PW adjustment based on the terrain and the innovation limitation; Enhancements and bug fixes to the GSD cloud analysis; and Bug fix for reading cloud observation in setuprhsall.f90. (Manikin, Wu, Lueken, Hu (GSD)

12.5.5.9 31 May 2012 (NCEP and GSD)

Report on testing of 2DVAR GSI assimilation of high spatial and temporal mesonet surface data using analysis grids with 2.5-km or finer resolution and HRRR as background. (Possible 15-minute update for RTMA to support CoSPA, pending Convective Weather PDT support.)

NCEP

Routine access to ESRL's HRRR runs has not yet been established. Single tests using HRRR background in RTMA have been run successfully. Work will focus next year on use of HRRR alone and use of a blend of HRRR and NAM-nest forecasts as background for RTMA. As part of the WCOSS transition, the RTMA has been successfully tested on the initial test machine. The 2DVar enhancements that were made to the GSI as part of the 2012 RTMA upgrade package have been submitted for inclusion in the official GSI code (SubVersion trunk). Among other features, the enhancements add the capability for the GSI to analyze surface visibility, 10m-wind gusts, and planetary boundary layer height. The observation reject/accept lists used with the RTMA-CONUS (Alaska, Hawaii & Puerto Rico-Hispaniola to follow) have been updated using innovation statistics for the months of June, July and August of 2012. Work is now underway to explain the substantial discrepancies that were found between the new and previous lists. While some of the differences may reflect the May 2012 switch from the RUC to the RAP as the model providing the RTMA first guess and it is also believed that some improvements may be needed in the methodology used to create the lists. (Manuel Pondeca, Yanqiu Zhu, Steven Levine)

GSD

Manuel Pondeca at NCEP provided the 2DVAR configured GSI code and some guidance to Patrick Hofmann at GSD, who has completed basic tests of a version using the HRRR model as input and modified the scripts to be consistent with the GSD RAP run environment on JET and ZEUS. Related work on this has been completed by Ming Hu, who has run a 3-km version of the full 3DVAR and used these fields to initialize the HRRR,

In August, work continued by Patrick Hofmann in enhancing the RTMA analysis with a special 2DVAR form of the GSI applied to a 3-km HRRR grid. Patrick obtained a new little endian version of the anisotropic background error covariance file from Manuel Pondeca and did some tests on the 3-km grid. Results show more detail in the analysis increments, especially of the complex terrain of the west.

12.5.5.10 1 July 2012 (defer this date to 1 Jan 2013 due to suspension of CAPS FY12 work in MDE due to lack of a contractual agreement)(CAPS, ESRL)

Develop dual-resolution capabilities of EnKF and test it for RR configurations.

(As previously reported:) Kefeng Zhu and Yujie Pan at CAPS previously developed an Initial dual range capability. Ming Hu of ESRL/GSD has extended this work by completed basic retrospective tests of a full 13-km RAP EnKF.

Analysis of these initial results revealed the spread was too small among the ensemble members and identified steps to be taken to address this deficiency. In late April, Ming reported on this work via a poster presentation summarizing initial results at an ensemble assimilation workshop. This poster report is available at: **http://ruc.noaa.gov/pdf/HU_EnKF_wkshp_May_2012_FINALx.pdf**

July update – Further work on addressing the small spread issue in the RAP EnKF hybrid ensemble is planned after the new DTC GSI code release, tutorial, and associated meetings in Boulder which is occurring in late Aug. Ming Hu has submitted an abstract on this work for the IOAS conference at the AMS Annual meeting.

12.5.5.11 31 July 2012 (EMC, ESRL) (Task modified due to unavailability of CAPS for most of FY12)
Complete initial test of 13km EnKF/hybrid results using background error covariance derived from a regional ensemble.

GSD
Ming Hu has built a 40-member 13-km RAP EnKF / hybrid data assimilation system on ZEUS and completed a 4 day retrospective test. Initial examination of results indicates too small a spread.

Further work to evaluate the sensitivity of the RAP EnKF / hybrid ensemble to choice of regional vs. global covariance fields awaits resolution of the small spread issue (see task 12.5.5.10)

NCEP
The version of the GSI code that included the regional hybrid ensemble capability was ported onto the NOAA R&D computer Zeus. All the input files, including the data, global ensemble and fix files were transformed to native little endian format. The GSI code will have to be compiled in little endian format after the problems of incompatibility with the libraries are solved. The analysis code for the hybrid variational ensemble was also ported to Zeus. Since the regional system that generates the first guess file of the analysis system was updated to use a new NEMS_IO library the GSI code had to be linked to the same update, which made it necessary to update some of the libraries. The ENKF file names were longer than the declared variable in one of the subroutines, which caused the job to fail on Zeus. This bug was fixed and the code executed successfully on Zeus. This code will be used in the official regional parallel with CONUS nest on Zeus. (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
The Digital Filter option is now available in NEMS-NMMB on Zeus where it will be tested in the NAM parallel in FY13. A new radar data decoder that can handle dual-polarity variables is being tested and a few bugs have been found and fixed. Data from the new decoder are being compared to NCEP's current decoder and NSSL's decoder. The level-II radar data processing script was modified to handle data latency due to dual-polarity radar upgrade. The modified script will extend the data processing time window from 1/2 hour to 2 hours and limit the data volume to be processed so the job can be completed within 15 minutes. Two RFCs were submitted to NCO, one to extend the time window of radar data processing and the other to modify the reflectivity mosaic script to give suitable warning of a level2 radar data delay. The two RFCs were implemented in the early of September. (Shun Liu)

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

NCEP
The new GPS data from satellite SAC-C, TerraSAR-X, and C/NOFS were added to an off-line NDAS for an impact study. Since the observational error covariances were easier to define for data closer to the original measurements in the variational analysis method, the GPS bending angle will be used instead of the refractivity currently used in NDAS. New GPS refractivity data from TSX, SAC-C and C/NOFS were then tested in the NDAS. The regional cut-off height of GPS data was set to be 30km, about 12mb for the standard atmosphere. The analysis increments from using refractivity and bending angle data were compared and it was found that although the increment locations were similar and the amplitudes comparable in the middle layers of the domain, increments from the bending angle were smaller than from refractivity at the top of the domain which is good. The off-line parallel NDAS tests show no 3 hr forecast impact from adding GPS refractivity from TSX, SAC-C and C/NOFS and a small mixed impact from switching to bending angle data, so this will be tested in the NAM parallel next quarter. (Wu)

Initial development work has been completed for the new method to allow use of GFS derived satellite bias correction coefficients directly in the NAM GSI. This is currently being tested in the NAM NMMB partial cycling system by Yanqiu Zhu and in the HWRF NMM by Emily Liu. (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.

Further work to evaluate the sensitivity of the RAP EnKF / hybrid ensemble to use of time-lagged ensembles awaits resolution of the small spread issue (see task 12.5.5.10)

NCEP
Work will begin on this now that the RAPv1 was implemented in May 2012. (Binbin Zhou & Wan-Shu Wu)

12.5.5.15 30 August 2012 (CAPS, GSD, NCEP) COMPLETED
Finalize the multi-scale multi-pass configuration for analyzing radial velocity and other data. Report initial results with RR and HRRR testing.

GSD
David Dowell has completed experiments with a series of second pass 3-km analyses at 15-min. intervals during a one-hour pre-forecast cycle to initialize the HRRR. Initial tests have only included use of radar reflectivity data and the forward model portion of the radar DFI code and yielded modest improvement in the first few hours of the HRRR forecast. Separately, Ming Hu has run the full GSI over the 3-km HRRR domain, assimilating all observations, successfully demonstrating the practicality of running the full GSI on the full 3D 3-km HRRR domain. Follow up work will focus on conducting controlled experiments to evaluate the forecast impact from this 2nd pass of the full GSI on the 3-km domain for inclusion of specific observation types (radial velocity, surface observations, etc.)

NCEP
A rare event caused the GSI analysis to fail in the parallel NDAS on 7 May. Although the 88D radar Level 2 data file existed for this forecast cycle, no Level 2 data were usable for the GSI because of problems in upstream data collection. The unit number shared by all data input was not properly closed which caused the program to fail when it tried to read in the next data file. The bug in reading Level 2 radar data was fixed and the program can now run to completion even with a bad Level 2 data file. (Wan-Shu Wu, Shun Liu)

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

COMPLETE: RAP retrospective tests with inclusion of level radial yielding neutral forecast impact, resulting in inclusion of these data in frozen version 2 of RAP. Code transfer to NCEP delayed due to postponement in NCEP implementation of RAP version 1.

12.5.5E3 Change to 1 Dec 2012 **(ESRL)**
Final GSI code transfer complete to EMC as part of Rapid Refresh v2 package to be implemented later in FY13

NCEP
CURRENT EFFORTS: Work with ESRL/GSD will begin on RAPv2 after the RAPv1 is implemented in May 2012.

PLANNED EFFORTS: Implement the RAPv1 on 1 May 2012.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: Delays in the initial RAPv1 implementation will delay the RAPv2 upgrade until after the moratorium, likely no sooner than May 2013. Date changed to 1 Oct 2013

Deliverables

12.5.5.E1. Perform systematic tests and fine tune EnKF and EnKF-GSI hybrid DA systems for RAP grid, running at 1/3 of the RAP resolution for computational efficiency (CAPS) 9/30/2012

12.5.5.E2. Report on initial results of the EnKF and hybrid DA systems for the RAP configuration (CAPS, ESRL) 9/30/2012

During this quarter, the major efforts were focused on debugging and updating the regional EnKF system to the latest EnKF, GSI-hybrid and WRF versions. Issues related to this work are summarized as follows: 1) WRF 3.4 has known errors for current RAP configuration. Earlier tests show that experiments using WRF 3.4 had larger RMSEs than WRF3.2, especially at upper level. In a more recent investigation, we ran a test with the latest released WRF 3.4.1 within the pure GSI-3DVar framework. Compared to WRF 3.4, this version corrected larger RMSEs at the upper levels. However, the overall performance is still not as good as WRF 3.2; 2) the initial and lateral boundary conditions generated from two WRF processing sequences (that is WPS+WRFDA Random CV+ WRF Real) are examined within the EnKF framework. The run using WRF 3.2 is consistently better than WRF 3.4 for surface variables. Therefore, the updated EnKF system still uses the WRF 3.2 sequence at this time; 3) the EnKF code has been updated after we corrected the vertical coordinate calculation with the same formula as GSI and added back the fixed inflation as in the earlier EnKF version; 4) the GPS-PW data can now be used in EnKF after filling the GPS site pressure with surface pressure. For both GSI and EnKF, earlier tests show that GPS-PW has positive impact on RH forecasts, though the improvement in EnKF is not as large as in GSI (but still better than GSI). In an attempt to further improve the GPS-PW impact within EnKF, a series of tests with different vertical localization scales has been conducted but no clear improvement was obtained. Considering that water vapor is mainly concentrated at the lower levels, we are currently employing a relative small vertical correlation scale with $\ln(p_{cut})$ = 0.16, one-tenth the vertical localization length used by surface pressure. To see if potentially unreliable cross-variable covariance might have adversely affected the impact of GPS-PW in EnKF, an experiment with GPS-PW updating RH only was run but the results were slighted worse.
The localization lengths were fully examined within the EnKF-GSI hybrid. Hybrid experiments with full flow-dependent covariance should theoretically be the same as the EnKF if localization and inflation are effectively the same in the two systems. However, we are using observation and height-dependent localization scales in the EnKF, which are not straightforward to implement in the non-sequential hybrid analysis scheme. The hybrid shows higher RMSEs than EnKF in short-range forecasts. In EnKF, the horizontal localization is height-dependent; the vertical is similar but with additional observation type dependency. For RH and temperature T, vertical localization scale $\ln(p_{cut})$ is set to a quarter of 1.1 and half of 1.1 at the surface and the model top, respectively. For U and V, the vertical correlation length is twice as that for RH and T. $\ln(p_{cut})$ is set to 1.6 for surface pressure and GPS-PW observations.

To see if it is indeed the localization that made the differences, we ran the EnKF-hybrid analyses in multiple, with each step using only a group of observations having the same localization scales. The observations are

organized into three groups, i.e., the wind, RH and T, surface pressure and GPS-PW. In each cycle, both EnKF and hybrid run three times with one group of observations assimilated each time. Fixed and adaptive inflation were applied to the last step in EnKF. The analysis increments from this the EnKF and hybrid runs after 5 days of cycled analyses were examined. The analysis increments obtained this way by the hybrid are much closer to those of EnKF, suggesting that indeed the observation-type-dependent localization was primarily responsible for the differences between EnKF and the hybrid.
Experiments with fewer ensemble members were also tested this quarter. The EnKF and hybrid (in 1 way coupled mode with EnKF) schemes with 20 ensemble members were run. The EnKF with 20 members gave higher forecast RMSEs than GSI, the hybrid with 20 members using half flow-dependent/half static covariance was close to the results of hybrid using 40 members and was better than GSI. This indicates that the static covariance in the hybrid is beneficial when the ensemble size is smaller than typical sizes needed to obtain good EnKF analysis.

A manuscript summarizing the EnKF results is undergoing internal revision at CAPS.

12.5.5E3 (Changed to 1 Mar 2013) (NCEP)
Final GSI code transfer complete to EMC for Rapid Refresh v2 change package to be implemented in spring 2013. (Combined with 12.5.5E1)

CURRENT EFFORTS: Initial GSI code transfer from ESRL/GSD was accomplished after the RAPv1 was implemented in May 2012.

PLANNED EFFORTS: Convert RAPv1 GSI code to WCOSS then start testing RAPv2 GSI code.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: Delays in the initial RAPv1 implementation will delay the RAPv2 upgrade until after the moratorium, likely no sooner than May 2013. Move this deadline to 1 March 2013.

12.5.5.E4 Change to 1 May 2013 (GSD, NCEP)
Pending EMC, and NCEP Center initial recommendations, Requests for Change (RFCs) are filed to submit GSI code as part of upgrade for Rapid Refresh v2 software to NCO, pending NCEP readiness.
ESRL
Progress with RAPv2 at ESRL is very promising and would allow this schedule, pending NCEP's readiness to start testing and NCEP's need to get in some other implementations with RAPv2 implementation not having occurred until 1 May 2012.

NCEP
CURRENT EFFORTS: Work began on RAPv2 after the RAPv1 was implemented on 1 May 2012.

PLANNED EFFORTS: RFCs will be filed after the moratorium, likely no sooner than May 2013.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: Delays in the initial RAPv1 implementation have delayed the RAPv2 upgrade until after the moratorium, likely no sooner than May 2013. Move this deadline to 1 May 2013.
12.5.5.E5 Change to 1 July 2013 (ESRL, NCEP)
Pending computer resource availability, implementation of Rapid Refresh 2 changes to operational RAP at NCEP.

ESRL
Request for date change to mid 2013

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

PLANNED EFFORTS: Transition the RAPv1 onto WCOSS then test RAPv2, which runs on Zeus in the meantime.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: Delays in the initial RAPv1 implementation have delayed the RAPv2 upgrade until after the moratorium, likely no sooner than May 2013. Move this deadline to 1 July 2013.

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

CAPS has not been available for MDE work in FY12 until the last quarter due to a contractual agreement problem. EMC and ESRL will provide some initial results in their Q4 MDE reports. Encouraging results from OU/CAPS dual-resolution (40/13 km) test and good progress by Ming Hu on building 13-km test system (see subtask 12.5.5.10). Ming Hu and CAPS personnel presented summaries of this work at an ensemble data assimilation workshop in late April.

GSD and EMC personnel met at NCWCP on 9 Oct. and discussed NARRE configuration aspects with emphasis on data assimilation (DA). DA Options include each system having it own data assimilation or more likely a shared ensemble hybrid DA system. Configuration options include use of background error covariance (BEC) information from the global EnKF system (much less expensive computationally, but may poorly represent mesoscale covariances) and running a regional ensemble for DA (may do better with regional covariance, but much more computationally expensive). Initial testing is focusing on use of global EnKF BEC information.

NCEP
CURRENT EFFORTS: Based on the degree of success of the simple use of global EnKF ensembles in specifying the background error in GSI in the NAM parallel testing, EMC has recommended RAPv2 consider using this technique which is readily available now in the GSI.

PLANNED EFFORTS: Work will begin after the RAPv1 is ported to WCOSS and RAPv2 is running there as well.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: Delays in the initial RAPv1 implementation have delayed the RAPv2 upgrade until after the moratorium, likely no sooner than May 2013.

12.5.5.E7 30 Sept 2012 (NCEP) (deferred to mid 2013)
Subject to NCEP Director approval, implement NEMS/NMMB version of GSI (e.g. strong constraint, revised bkg+obs errors) in NAM/NDAS.

CURRENT EFFORTS: Early in FY12, the idea of porting GSI into NEMS was put on hold while the global implementation of EnKF was completed and especially until EnKF can be extended to the smaller scale NAM & RAP applications. Tests with hourly updated NAM in FY13 on Zeus will help determine if having both the forecast model and GSI in a single executable will be worth the effort. The EMC Data Assimilation Team Lead and others feel having GSI in NEMS will be restrictive and too complicated. The savings in time due to greatly reduced data motion will have to be great to offset these negative aspects of moving GSI into NEMS. (DiMego, Rogers)

The hybrid ensemble analysis with a new GSI version was incorporated into the regional parallel system. The satellite angle bias correction program was also updated to be compatible with the upgraded GSI code. Impact studies of new VAD winds and GPSRO bending angles were performed. (Wu)

PLANNED EFFORTS: Provide NCO with the necessary assistance for pre-implementation tests. Prepare presentations to meet all the requirements for major implementations after WCOSS transition. (Wu)

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED: Although the new analysis package is ready to be implemented, it is waiting for the arranged schedule to pass the pre-implementation tests and NCEP Director's approval after WCOSS transition.

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: None.

12.5.5.E8 30 Sept 2012 (GSD)
Report on initial results of 13km EnKF for RAP configuration. (Modified title)
In late April, Ming reported on this work via a poster presentation summarizing initial results at an ensemble assimilation workshop. This poster report is available at:
http://ruc.noaa.gov/pdf/HU_EnKF_wkshp_May_2012_FINALx.pdf

12.5.5.E9 30 Sept 2012 (ESRL/GSD)
Report on planned GSI changes for the FY13 upgrade to the Rapid Refresh.
Good progress toward this deliverable by GSD personnel, including recent conference / workshop presentations:
http://ruc.noaa.gov/pdf/NWP_2012_RAP_GSI_hu_final.pdf

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

GSD
Work continues with application to both RAP and HRRR with all aspects of the physics receiving some attention during the quarter. This is detailed under Subtask #1 below. The notable success of HRRR in predicting the extremely destructive derecho of 29-30 June 2012 that cut a swath of terror from Indiana and Ohio into the Mid-Atlantic states (including the DC area) has continued to garner considerable attention. An August highlight was a full-afternoon, wide-ranging discussion on physics issues with Greg Thompson of NCAR. We laid plans for future work toward use of the aerosol-aware microphysics (see subtask 8.6) that is under development at NCAR, among other topics.

NCAR/RAL
CURRENT EFFORTS: During the month of September, no additional effort (or funds) was devoted to this task due to priorities on other projects.

PLANNED EFFORTS: Most of the effort will concentrate on the testing and full implementation of the Thompson et al (2008) "aerosol-aware" microphysics scheme. The scheme continues to be prepared for large-scale, long-duration simulations to be started near the end of calendar year 2012 since the new NCAR supercomputer center will become available.

PROBLEMS/ISSUES ENCOUNTERED OR ANTICIPATED: Some delays were encountered due to staff working other projects. We anticipate assigning other staff to the project to regain some lost time, but this is not yet fully decided.

SUBTASKS:

12.5.8.1 1 Oct 2011 (GSD)

Based on ongoing GSD RR evaluation and feedback from users of the newly operational RAP, including other AWRP PDTs, continue developing and begin testing a suite of upgraded or new physics packages using developmental RR real-time cycles and retrospective periods at GSD, in preparation for RAP upgrade (RAPv2).

A version of the MYNN PBL scheme that performs acceptably well in two areas of weakness for this scheme as seen in verification of the RAP-development-2 cycle at GSD (FY12Q3 report), namely, a near-surface warm bias during the "evening transition" from daytime mixed layer to nocturnal inversion, and excessive fog formation over snow-covered land areas, was included in the WRFv3.4.1 release on 16 August. However, further investigation into these issues is ongoing.

The evening warm bias is also seen using the MYJ, and in September/early October, Tanya Smirnova did an experiment with the option to run the RUC LSM with 9 levels instead of 6. This showed a more rapid cool-down of the skin temperature in early evening, resulting in a greater cooling in the 2-m air temperature (a good result – Fig. 3). A comparison test of this simple change using both winter and warm-season retro periods is a possibility (subject to higher priority tests), and will be necessary before implementing this change.

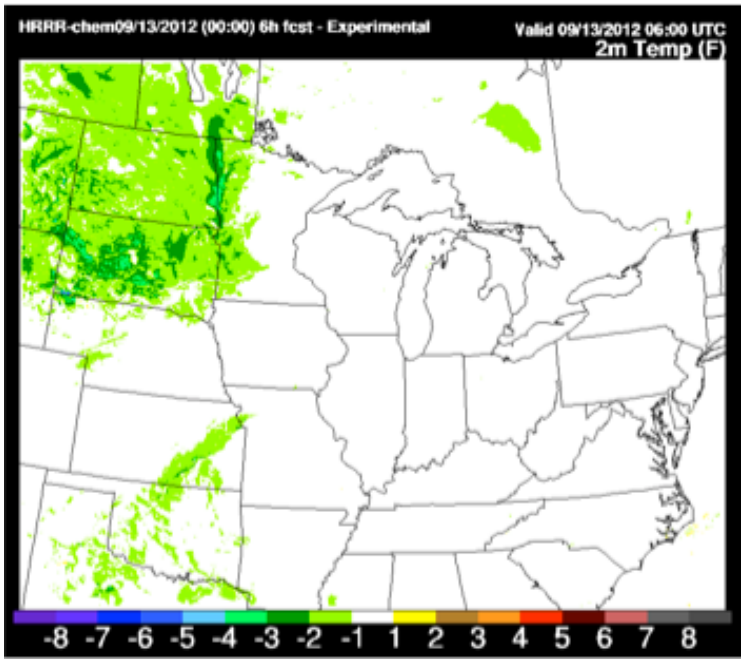

Figure 3. Difference in 2-m temperature resulting from use of 9-level version of RUC LSM as opposed to the standard 6-level version now in RAP and HRRR. The 6-h forecast was initialized at 0000 UTC 13 September 2012, valid 0600 UTC. The 2-m temperature is 1-4C cooler over a portion of the northern Plains as a result of the increased vertical resolution in the soil.

Georg Grell has been advocating for some time that there should be some degree of convective parameterization in convection-permitting models such as the HRRR. The main motivation here is to improve precipitation forecasts (in particular to minimize frequency of occurrence of localized very heavy precipitation amounts). One of the challenges is to do this without compromising the well-established ability of at least some convection-permitting models (for example, the HRRR) to successfully predict mode of deep convection (discrete individual cells, linear organization of cells, small cell complexes, etc.). Tests with the 27 April 2011 Southeast tornado outbreak and the 29-30 June 2012 derecho (both of which were notable successes for the real-time HRRR without any convection parameterization) showed somewhat divergent results. The derecho forecast with convective parameterization was excellent, and very similar to the real-time forecast. However, the dominant mode of isolated super cells on the 27th was less well defined, and the super cellular character of the individual storms on the 27th was not so readily apparent as in the real-time forecast without convective parameterization. More detailed analysis and careful thinking are necessary for further progress in this area, and will continue.

Following our discussions with Greg Thompson on the topic of attenuation of incoming short-wave radiation by snow on 28 August, we discovered that the HRRR had been using the Dudhia short wave radiation scheme

instead of Goddard, although the Goddard scheme has been used in the RAP for over two years. Subsequent tests of the Goddard scheme in the HRRR for the difficult case of 30 May 2012 did show significant reduction of surface-based CAPE in comparing runs with the Goddard scheme with and without Thompson's fix. A more thorough comparison of the Dudhia short-wave scheme, which does crudely account for the presence of snow aloft, with the Goddard scheme with Thompson's fix will be made in coming months.

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.

In his discussion with GSD in August, Greg Thompson advocated for further testing of this scheme before releasing it to us for testing in RAP.

12.5.8.7 Change to 1 Nov 2012 (GSD and NCAR/RAL)
Begin coupling the NCAR aerosol-microphysics scheme with highly simplified version of the GOCART option in WRF-Chem being developed by GSD.

GSD: The potential of this approach will be reevaluated in discussions with NCAR.

12.5.8.8 Moved to Jan 2013 (GSD)
Based on RAP experience and recent WRF physics progress, begin development and testing of physics enhancements for RAPv3 implementation and for future versions of the HRRR.

12.5.8.13 30 July 2012 (NCAR/MMM)
Deliver a WRF Users' Workshop and WRF Tutorial for the User Community

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

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

PLANNED EFFORTS: NCAR will deliver the next WRF tutorial in Boulder on January 28–February 5, 2013. This will cover the basic WRF system, with the MET verification package also being taught. The announcement of the tutorial will be sent out in October.

UPDATES TO SCHEDULE: NONE

12.5.8.14 30 Sept 2012 (NCAR/MMM)
Task 12.5.8.14 Incorporate Physics and Dynamics Improvements into WRF

NCAR issued WRF minor release V3.4.1. This contained some new code features as well as bugfixes, and the changes are listed at **http://www.mmm.ucar.edu/wrf/users/wrfv3.4/updates-3.4.1.html**.

NCAR and the WRF Release Committee are preparing for the next major release, which will be WRF Version 3.5. The release is planned for Spring 2013, and an announcement regarding the release has been sent out by NCAR. The web page describing the release is:
http://www.wrf-model.org/release.php.

In PBL physics, Jimy Dudhia of NCAR worked with Songyou Hong (Yonsei University) on Hong's new shallow convection scheme and on upgrades to the YSU PBL scheme. The latter includes a fix to correct excessive mixing in stable regimes. The YSU PBL changes were added to the WRF repository and issued in V3.4.1. NCAR (Dudhia and Ming Chen) also integrated updates for the SSiB LSM, provided by Yongkang Xue (UCLA), and improved MYNN PBL code, from Joe Olson (NOAA/ESRL), into the V3.4.1 release. Lastly, Dudhia also obtained updated TKE advection option code for the MYNN PBL scheme from Olson. This is planned for implementation in V3.5.

Dudhia hosted and worked with visitor Matt Tastula (Univ. of South Florida), who was evaluating the QNSE EDMF PBL scheme. The scheme was examined for its performance in both subtropical and high latitude applications.

Dudhia obtained code for the Andreas et al. (2012) (*JAS*, **69**, 2520–2537) drag formulation for hurricanes from Craig Mattocks (Univ. of Miami). Dudhia, Wei Wang (NCAR/MMM), and Ryan Torn (State Univ. of New York, Albany) tested this as a possible option for WRF. Dudhia also worked with John Warner (USGS Woods Hole) on code for surface roughness formulations. Among other applications, this would help in future wave model coupling with WRF.

Dudhia collaborated with Stephanie Evan (NOAA/ESRL) on microphysical modifications for the tropical tropopause layer (TTL), as evidence exists that current schemes are deficient in ice nuclei assumptions in that region. This can affect the stratospheric water vapor.

Dudhia obtained new ozone climatology based on recent data from Birgit Hassler of NOAA/CSD. This has been used by Stephanie Evan for stratospheric studies and has been found to improve the tropopause structure. This is a candidate for an option for ozone climatology in radiation schemes for the next release.

Dudhia consulted with John Wong (NCAR/ACD) on a possible new lightning diagnostic code for inclusion in WRF. This is a candidate for WRF-Chem for the V3.5 release.

PLANNED EFFORTS: The development and incorporation of new physics and dynamics for WRF for the RAP will continue through FY13Q1.

UPDATES TO SCHEDULE: NONE

12.5.8.15 Ongoing (GSD)
Continue development of the RUC LSM for application to RAP

Application for (RAPv2 in FY12 and RAPv3 in 2013) and HRRR, based on feedback from users, with particular emphasis on improving treatment of snow, sea ice and tundra, and use of upgraded ground surface datasets now available through the V3.3 WRF Preprocessing System (e.g., MODIS vegetation, lake surface temperature for lakes other than the Great Lakes).

GSD: Very good results from 9-layer RUC LSM – see Fig. 3 above and related text.

Deliverables

12.5.8.E1 1 October 2012 (ESRL, NCEP)
Final model physics code transfer complete to EMC for Rapid Refresh 2 upgrade change package.

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

12.5.8.E2 1 May 2013 (GSD, NCEP)
Pending NCEP computer readiness and EMC and NCEP Center initial recommendations, Requests for Change (RFCs) are filed to submit WRF physics code changes as part of upgrade for Rapid Refresh 2 software to NCO.

UPDATE TO DELIVERABLE:
Change to spring 2013 due to NCEP implementation forcing delay for overall RAPv2 implementation.

12.5.8.E4 15 Jan 2013 (ESRL, NCEP)
Pending computer resource availability, implementation of Rapid Refresh 2 changes to operational RAP at NCEP.

UPDATE TO DELIVERABLE:
Change to spring 2013 due to NCEP implementation forcing delay for overall RAPv2 implementation.

12.5.8.E5 1 Sept 2012 (NCAR/RAL and GSD)
Transfer the coupled aerosol-microphysics scheme into a test version of HRRR.

Delayed until the scheme is more thoroughly tested by NCAR.

12.5.8E6 30 July 2012 (NCAR/MMM)
Deliver a WRF Users' Workshop and a WRF tutorial for the user community.
Complete

12.5.8.E7 15 Sept 2012 (NCAR/RAL)
A written report by mid September 2012 summarizing enhancements made to the model physics packages.
12.5.8.E8 30 Sept 2012 (ESRL/GSD)
Report on overall planned model physics changes for the FY13 upgrade to the Rapid Refresh.

This is already largely set as of March 2012 for the frozen ESRL RAP for summer-2012 CoSPA/HRRR.

12.5.8.E9 30 Sept 2012 (NCAR/MMM)
Incorporate physics and dynamics improvements from the user community, GSD, and NCEP into WRF for use in the Rapid Refresh system. In collaboration with GSD, assist in the evaluation of those physics schemes for the RR that may be tested using the ARW. Perform testing for code acceptance and implementation into WRF repository. Assist in the implementation of WRF bug fixes.

Task 12.5.24
FY 2012, also Priority 7: Develop, test, implement and improve the 3-km WRF-based HRRR

Task 5.24 specifically treats development and testing of the 3-km HRRR model itself. Development and testing work on assimilation of radar data at the 3-km scale is under Task 5.19.

September update – The real-time HRRR continued with very good reliability during the month of September. Reliability statistics for the first three weeks are as follows:

HRRR Jet Availability:
All missed runs: 89%
Excluding single run misses: 96%
Excluding two consecutive run misses: 97%
Excluding three consecutive run misses: 98%

HRRR Zeus Availability:
All missed runs: 77%
Excluding single run misses: 82%
Excluding two consecutive run misses: 84%
Excluding three consecutive run misses: 85%

Key progress was made on the Zeus version of HRRR, including getting the observation data feed to Zeus (there is still an issue on both JET and ZEUS with the 00z and 12z "early" data feeds, which are key for the 00z, 12z HRRR runs. The key remaining action item for enhancing ZEUS HRRR run reliability is establishing computer node reservation on ZEUS for RAP and HRRR. ZEUS IT personnel are aware of this item and working toward it.

Building upon the successful 3-km 15-min cycled radar data assimilation results shown by David Dowell at the NWP conference last May (see below – Fig 4), Curtis Alexander is undertaking a series of 3-km HRRR radar reflectivity assimilation experiments, focused on improving the storm prediction skill during the first few hours of the HRRR forecast. Our current plan is to have some version of the 3-km radar reflectivity assimilation in place in the real-time experimental HRRR for the 2013 convective season.

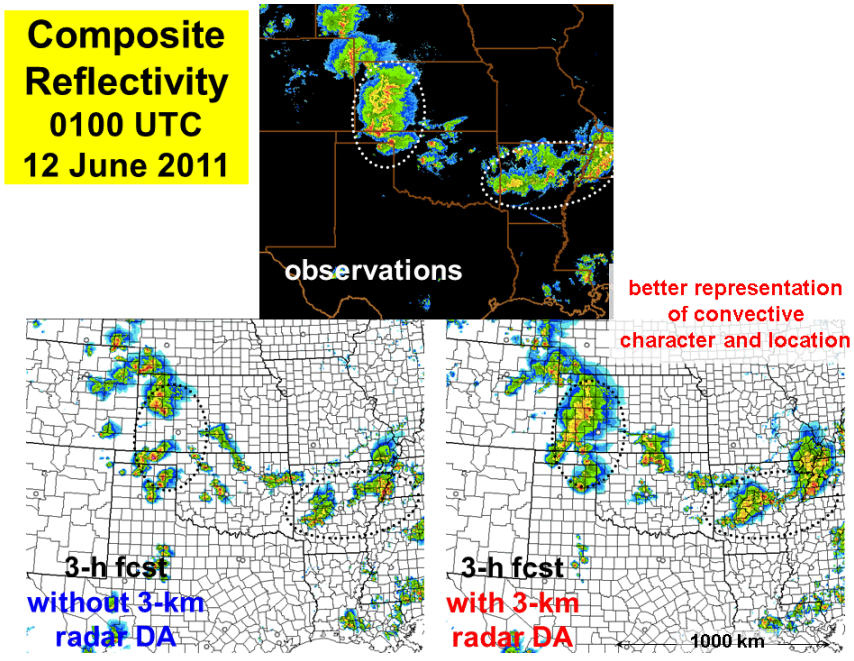

Fig. 4
3-h forecast reflectivity from case with (lower right) and without (lower left) 1-h of 3-km 15-min update pre-forecast radar reflectivity assimilation (via specification of latent heat-based temperature tendency during forward integration.)Comparison with radar observation indicates forecast with 3-km radar assimilation better captures convective clusters.
Subtasks

12.5.24.1 15 Jan 2012 (GSD, with assistance as needed from NCAR/RAL, NCAR/MMM, CAPS, MIT/LL)

Initial design for the assimilation/modeling configuration for the HRRR during the 2012 summer convection forecasting (CoSPA) exercise.

As detailed above, extensive retrospective testing of the coupled RAP / HRRR data assimilation / forecast system for the August 11-21 period is complete. All changes to the RAP / HRRR system have been incorporated into the GSD runs and impact on HRRR-are very positive. GSD real-time RAP / HRRR system with all these upgrades was frozen on March 9, 2012 for 2012 evaluation.

12.5.24.3 30 Sept 2012 (GSD)

Complete 2012 HRRR summer evaluation using modeling and assimilation modifications determined in 2011 exercise. Collaborate on analysis of HRRR tests and deliver summary of results. COMPLETE

Deliverables

An initial report with a preliminary summary of results (reliability, skill scores, case examples) is available at http://ruc.noaa.gov/pdf/HRRR_summer-2012_prelim_summary.pdf

August Summary:
Exercise ongoing with very good overall HRRR performance and reduced false alarms compared to 2011 noted. Storm structure seems to be especially well predicted with this 2012 RAP/HRRR configuration. Excellent HRRR forecast for many cases including the June 29, 2012 derecho event that caused at least 22 fatalities and extensive damage over a wide area from the Ohio Valley into the Mid-Atlantic States. Fig. 4 shows the 12-h HRRR forecast of reflectivity and max 10m winds.

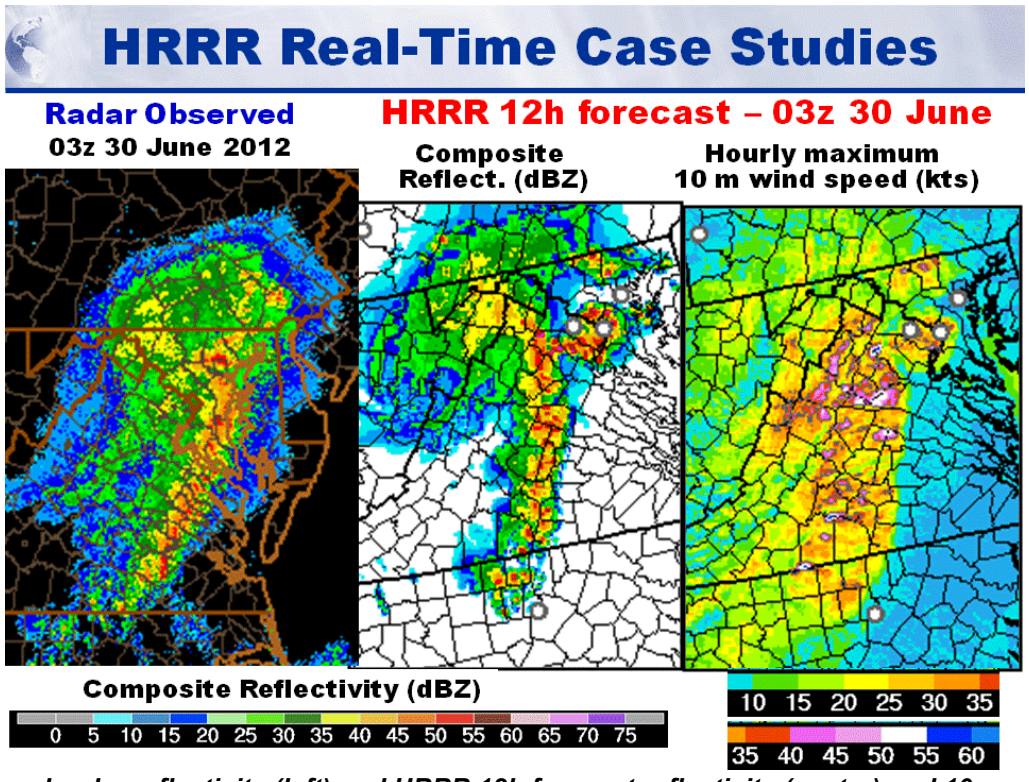

Fig. 4. Observed radar reflectivity (left) and HRRR 12h forecast reflectivity (center) and 10 m wind (right) from the extremely damaging derecho that struck Washington DC at 3z 30 June 2012.

12.5.24.E1 1 April 2012 (ESRL/GSD)
Incorporate all assimilation and model changes that affect the HRRR into a frozen version of HRRR (and parent Rapid Refresh) for the summer 2012 exercise.

As detailed above, work was completed on improvements to RAP / HRRR system for 2012 in advance of the freeze date in March 2012. Frozen on March 9, 2012

12.5.24.E2 15 Sept 2012 (NOAA/ESRL/GSD)
Complete FY12 evaluation with revised 3-km HRRR running every 1 h.

- **Conduct real-time summer 2012 HRRR forecasts using 3-km WRF initialized with radar-enhanced Rapid Refresh over full CONUS domain, monitor performance, modify code/scripts as needed, maintain high reliability working with ESRL computer facility**
- **Coordinate with other AWRP users and other collaborators, including coordination of HRRR grid transfers**
- **Provide project management**
- **Lead writing of report on summer 2012 HRRR experiments**

Real-time project ongoing with good results so far. Excellent HRRR forecast for many cases including the June 29, 2012 derecho event that caused at least 22 fatalities and extensive damage over a wide area from the Ohio Valley into the Mid-Atlantic States (see HRRR forecast images above).

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

Report on computing resource status on NCEP CCS, NOAA R&D Site A and NOAA R&D Site B with regards to possible implementation of HRRR.

A report summarizing the current status was completed and sent on July 15th with the June quarterly report and is also available at **http://ruc.noaa.gov/pdf/HRRR_computing_resources.pdf**

Status of MDE Deliverables – 15 Oct 2012

Legend: ☐ Deliverable on schedule; ☑ Deliverable submitted; ☐ Deliverable overdue

Deliverable and Related Task	Due Date	Status	Comment
12.5.4 Develop, test, implement, and improve the Rapid Refresh			All RAPv2 milestones are delayed until late FY12 or FY13, as noted below and in earlier monthly and quarterly reports.
12.5.4.1 Maintain hourly RAP runs and provide grids of SAV and AHP guidance products (ESRL, NCEP)	Ongoing	☐	
12.5.4.E1 Report on Rapid Refresh Status (ESRL)	12/20/11	☑	
12.5.4.7 Complete testing and evaluation of new RAP capabilities (model physics and data assimilation) – RAPv1 (ESRL)	01/31/12	☑	
12.5.4.E2 Update documentation for operational Rapid Refresh (ESRL)	02/01/12	☑	
12.5.4.6 Initial software for RAPv2 changes ready for porting to EMC (ESRL)	08/01/12	☑	
12.5.4.E4 Report on testing of RAP assimilation/model improvements (ESRL)	03/30/12	☑	
12.5.4.E3 Final code ready for transfer to EMC for Rapid Refresh v2 change package (ESRL)	3/01/13	☐	
12.5.4.E5 Complete testing at EMC of RAPv2 code, pending NCEP readiness (NCEP, ESRL)	5/31/13	☐	This task was originally for a RAPv3 but is now linked to RAPv2.
12.5.4.E6 Perform config mgmt. for RAP (ESRL, NCEP)	Ongoing	☐	
12.5.4.E7 Monitor RAP performance, respond to problems, diagnose causes, develop solutions. (ESRL, NCEP)	Est. 4/1/13	☐	
12.5.4.E8 Report on overall planned changes for FY13 upgrade to Rapid Refresh (ESRL)	11/30/12	☐	
12.5.5 Develop, test, and implement improvements to the Rapid Refresh and the NAM data assimilation			
12.5.5.E1 New version of GSI including revised radial wind assimilation ready for FY13 RAPv2 upgrade (ESRL)	04/01/12	☑	Complete in that RAP-ESRL frozen for HRRR is essentially that planned for RAPv2 @NCEP.
12.5.5.E3 Finalize GSI code ready for transfer to EMC for RAPv2 (ESRL)	02/28/13	☐	
12.5.5.E4 Pending EMC and NCEP Center initial recommendations, Requests for Change (RFCs) are filed to submit GSI code for RAPv2 software to NCO, pending NCEP	05/01/13	☐	NCEP plans a moratorium that may delay this implementation, although ESRL and NCEP will try to

readiness (NCEP, ESRL)			implement RAPv2 before it since code is essentially ready as of spring 2012.
12.5.5.E5 Pending computer resources, implement RAPv2 at NCEP (NCEP, ESRL)	07/01/13	☐	
12.5.5.E6 Report on results of EnKF and hybrid DA systems for the RAP configuration (EMC, ESRL)	09/30/12	☐	Delayed until Feb 2013 although ESRL and EMC have a very good plan on RAP EnKF assimilation following initial success with EnKF/hybrid assimilation in the current parallel NAM.
12.5.5.E7 Subject to NCEP Director approval, implement NEMS/NMMB version of GSI in NAM/NDAS (NCEP)	Deferred to 7/1/13	☐	
12.5.5.E8 Report on initial 13km EnKF testing for RAP configuration (ESRL)	09/30/12	☑	Study completed.
12.5.5.E9 Report on planned GSI changes for the RAPv2 upgrade to the Rapid Refresh (ESRL)	09/30/12	☑	
12.5.8 Improve physical processes in the WRF, especially including those that affect aircraft icing			
12.5.8.E1 Final model physics code transfer complete to EMC for RAPv2 upgrade change package to be implemented by early 2013 (ESRL)	10/01/12	☐	Essentially complete now in ESRL RAPv2 but will keep the door open for additional physics mods until fall.
12.5.8.E2 Pending NCEP computer readiness and EMC and NCEP Center initial recommendations, Requests for Change (RFCs) are filed to submit WRF physics code changes as part of upgrade for Rapid Refresh v2 software to NCO (ESRL, NCEP)	5/1/13	☐	
12.5.8.E4 Pending computer resources, implement RAPv2 at NCEP with new physics configuration (ESRL, NCEP))	7/01/13	☐	
12.5.8.E5 Transfer the coupled aerosol-microphysics scheme into a test version of HRRR (NCAR/RAL)	09/01/12	☐	NCAR reports that this code is not yet ready for transfer.
12.5.8.E6 Deliver WRF Users' Workshop and WRF tutorial (NCAR/MMM)	07/30/12	☑	
12.5.8.E7 Report on enhancements made to WRF model physics (NCAR/RAL)	09/15/12	☐	
12.5.8.E8 Report summarizing enhancements made to the model physics packages (ESRL)	09/30/12	☑	
12.5.8.E9 Incorporate physics improvements into WRF for future RAP and HRRR (NCAR/MMM)	09/30/12	☐	
12.5.24 Develop, test, implement and improve the 3-km WRF-based High Resolution Rapid Refresh			
12.5.24.1 Initial design for the assimilation/modeling configuration for the	01/15/12	☑	

HRRR during the 2012 CoSPA Prototype Summer Operations			
12.5.24.E1 Incorporate all assimilation and modeling changes into HRRR for Summer 2012	04/01/12	☑	
12.5.24.E2 Complete FY12 evaluation with revised 3-km HRRR running every 1 h. (ESRL) • Conduct real-time summer 2012 HRRR forecasts using 3-km WRF initialized with radar-enhanced Rapid Refresh over full CONUS domain, monitor performance, modify code/scripts as needed, maintain high reliability working with ESRL computer facility • Coordinate with other AWRP users and other collaborators, including coordination of HRRR grid transfers • Provide project management • Lead writing of report on summer 2012 HRRR experiments	09/15/12	☑	
12.5.24.E2a Report on computing resource status on NCEP CCS, NOAA R&D Site A and NOAA R&D Site B with regards to possible implementation of HRRR (NCEP, ESRL)	06/01/12	☑	Completed 7/13/2012, available at http://ruc.noaa.gov/pdf/HRRR_computing_resources_13jul2012.pdf