MDE Product Development Team
April, May, June, 3rd Quarterly Report – FY 2012
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(Compiled and edited by S. Benjamin and B. Johnson)

Executive Summary

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

- **RAP implementation at NCEP occurred on 1 May. The RAP has replaced the RUC.**
- RAP version 2 running at GSD, yielding improved moisture and precipitation forecasts, and ready for transfer to NCEP EMC.
- Further changes in testing in development (not primary) ESRL RAP including data assimilation and modeling improvements. All of these will be included in final Rapid Refresh v2 (RAPv2) with implementation at NCEP, proposed for early FY13.
- RAP-dev3 cycle (identical 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 application.

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

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

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

- Updated version of WRFv3.3.1 implemented in RAP-primary at ESRL using options tested at ESRL for optimal RAP performance, especially for clouds.
- Updated Thompson v3.3.1 microphysics and RUC land-surface schemes implemented in RAP-primary at ESRL on 15 Feb.
- ESRL RAP updated to use MODIS land-use and fractional sub-grid-scale data – 15 Feb.
- Testing continues of GSD/Olson version of MYNN PBL scheme with some excellent results but testing was insufficient to include MYNN PBL in the frozen summer 2012 RAP/HRRR system.

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

- Very good HRRR performance and reliability during 2012 convective storm season so far, including excellent HRRR skill for recent East coast derecho that caused widespread damage in US Mid-Atlantic states.
- Report on 9-day June 2011 RAP / HRRR retrospective testing presented on June 21, documenting significant improvement from 2011 to 2012.
- Continued testing full GSI at 3-km for initializing HRRR and use of hourly pre-forecast radar data assimilation cycle (with use of radar data every 15 min.) to reduce HRRR spin-up period.
- Good real-time reliability and performance for HRRR since 9 March code freeze

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

ESRL/GSD

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

The highlight of the quarter was the operational implementation of the Rapid Refresh version 1 at 12z Tuesday 1 May 2012. This came after the discovery in March (see FY12Q2 report, Task 4) of a serious scripting error in the NCEP Central Operations (NCO) cycle, and a restart of the field test with this bug corrected. Formal evaluation of RAP for this field test by the Aviation Weather, Hydrometeorological Prediction and Storm Prediction Centers of NCEP gave thumbs up on implementation. This was to the great joy and relief of those from GSD, NCEP/EMC, NCAR and NCEP/NCO, whose collaboration (in the case of the first 3 organizations) over a period of several years overcame many challenges to bring this about, and with gratitude to the FAA's Aviation Weather Research Program for providing crucial financial and administrative support to make this possible.

NCEP RAP issue: Although the implementation went smoothly, an investigation was conducted in June by GSD (as part of the RAP/RUC monitoring task) regarding a single output-time failure in the NCEP RAP post processing (Unipost) that occurred on 2 June. Diagnosing the exact source of this problem required considerable work by Ming Hu (GSD) to obtain and transfer the initial and boundary condition files from NCEP back to GSD so that they could be read (endian conversion) and the problem diagnosed: pressure along a lateral boundary not decreasing monotonically with height as expected. A temporary fix to this problem was devised by Tanya Smirnova (GSD) for Unipost, and has been successfully tested at NCEP. A more substantive fix will require modification to the WRF preprocessing code. The rarity of these crashes and the effort necessary to thoroughly test this code at GSD and port it to NCEP for more testing in the operational environment resulted in the decision by NCEP to have Tanya's fix available as a temporary measure. However, work will be required in the near future to address the more basic problem, which lies with WRF preprocessing code.

ESRL RAP issue: During June, the soil moisture in the ESRL Rapid Refresh (which initializes the HRRR also) was reset twice inadvertently to GFS soil moisture values, resulting in a subsequently moist bias in the ESRL RAP and HRRR for 5-7 days. This event occurred on 12 June and 26 June, both times after scheduled maintenance outages on the Jet computer. After these events, some code mods were developed to better protect against such cold starts with GFS soil moisture and ensure that the most recent RAP soil moisture fields are always used after such outages.

Although the Storm Prediction Center (SPC) gave approval for the NCEP RAP implementation in May, some SPC forecasters subsequently expressed dissatisfaction with RAP as compared with the prior RUC. Their concerns center around two issues: occasional situations when the RAP too rapidly mixes out near-surface moisture, and the failure of the RAP soundings to accurately delineate the structure and strength of the "cap", a thin stable layer or inversion separating air with abundant moisture at low levels and a dry, nearly dry-adiabatic "residual layer" above. Having a good estimate of the "strength" (or degree of inhibition) the cap presents to convection originating in the low-level moist air mass is important to ascertaining the likelihood of convective initiation rooted in this surface-based moist layer. Both of these issues are addressed in the RAP2 running in the primary RAP cycle at GSD (and which provides initial conditions for the HRRR).

This is a strong motivation for wanting to see the RAPv2 changes (or at least some of them) implemented at NCEP before the 2013 convection season. However, it appears that the upcoming moratorium on operational implementations at NCEP will preclude this. This moratorium is necessary for the conversion of existing NCEP codes to enable use of the new WCOSS (Weather and Climate Operational Supercomputing System) IBM computer at NCEP that uses a Linux-based operating system. The moratorium will begin in August 2012 and is likely to last until at least June 2013.

Further enhancements to the RAPv2 now in real-time evaluation this summer include:

- Improvements to the GSI cloud analysis to take into account partial cloudiness by distinguishing between SCT, BKN and OVC in METAR obs, and restoration of full use of satellite cloud observations (RUC-dev cycle at GSD; see Task 5),
- Evaluation of impact of the Vaisala GLD360 lightning product used as a proxy for radar reflectivity in the RAP radar assimilation (GSD-RAP-dev1 cycle on Jet; see task 5)
- Continued development and testing of the WRF MYNN boundary-layer scheme (GSD RAP-dev2 cycle on Jet; see Task 8).
- Modifications to the existing RAPv2 soil moisture/temperature adjustment to allow more moistening of the soil moisture under certain conditions.

During the quarter we expended considerable effort in setting up RAP cycles (as well as a RUCdev cycle for use in the cloud analysis work (first bullet above) on the new NOAA Environmental Security Computing Center (NESCC) Linux cluster, ZEUS (see FY12Q2 report, Task 4, for more details on ZEUS). This entailed overcoming some issues arising from slight compiler and operating system differences with Jet, and significant issues in timely data transfer between GSD and Zeus. These matters have now largely been resolved. What we are calling RAPdev1 on ZEUS is a clone of the RAP-primary. This cycle is now working fully and reliably. We are well along in the process of setting up other development cycles on ZEUS, partly to replace those being lost as part of the conversion of Jet into a mainly Hurricane Forecast Improvement Project (HFIP) machine.

Below is a list of papers pertaining to RAP and HRRR presented by ESRL/GSD authors at the Joint CMOS (Canadian Meteorological and Oceanographic Society) / AMS (American Meteorological Society) Congress at Montreal 29 May - 1 June 2010, covering various aspects of our work on the RAP and HRRR. A major theme of this conference was research and development in operational numerical weather prediction, so it was an ideal venue for presenting our work on the RAP and HRRR.

- Accuracy of boundary-layer wind simulation in low-level jets with the MYNN PBL scheme (Olson)
- GSI modifications for high-frequency cycling in RAP (Hu)
- Convective-storm-scale radar data assimilation (Dowell)
- HRRR low-level wind climatology based on 2-hour forecasts (James)
- GSI cloud analysis modifications and experiments on increasing fit to raobs (Hofmann)
- Rapid Refresh overview and RAP implementation at NCEP (Brown)
- HRRR overview and case examples of HRRR performance (Alexander)
- Enhancements to treatment of snow and ice in the RUC Land-surface Model for application in RAP (Smirnova)

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

NCEP
The Rapid Refresh was implemented at NCEP on 1 May to replace the Rapid Update Cycle. The larger domain covers much more of North America, including Alaska and Puerto Rico. The model uses a WRF-ARW 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/NCAR microphysics, and the RRTM long-wave radiation model. Like the RUC, the RAP is run every hour out to 18 hours at a 13km horizontal resolution. Work continues to develop the second version of the RAP (referred to as RAPv2), which will feature updates to both the model (WRF-ARW) and the analysis code (GSI). (Manikin)

About 80% of the SODARs are not getting into the RAPv1 because they do not get into NCEP in time for the RAP dumps. Ways to get the data into NCEP in time are being investigated. LaRC (NASA Langley Research Center) GOES cloud data was out for 92 hours ending 14z 9 April due to LaRC's switch to a backup server. NCEP will modify its system to detect this situation and make the proper switch. All RUC dump and PREP jobs were

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

GSD
GSD continues to make pgrb and bgrb files from the ESRL/GSD RAP-primary real-time 1-h cycle available from its FTP site. Grids from the operational NCEP RAP became available from GSD beginning 12z 1 May (grids from the pre-operational NCO cycle were available from GSD during the quarter prior to this date).

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 RUC/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 [RUC prior to 1 May] 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 RUC analyses and forecasts until the RAPv1 implementation on 1 May, and after that to the operational RAP. These include grid-to-station verifications versus rawinsonde, surface, aircraft, Profiler, and VAD data computed periodically at NCEP and accessible via NCEP's Mesoscale Modeling Branch (MMB) website:

http://www.emc.ncep.noaa.gov/mmb/research/meso.verf.html (EMC/MMB)

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

GSD
Concerns expressed by the SPC have been noted above. A particularly egregious situation occurred on the evening of 5 June in central Montana in which the operational RAP forecast major surface drying in a region that later experienced super cell storm development that produced tornadoes. The RAPv2 running at GSD had a far superior forecast for this area, indicating that having the RAPv2 enhancements in operations would have avoided

this particular debacle. Using a short retro put together by Eric James, we are investigating this case further to try to isolate which of the RAPv2 changes was most important in improving RAP forecasts of surface parameters.

NCEP
The Rapid Refresh was implemented at NCEP on 1 May to replace the Rapid Update Cycle, and its performance is being routinely monitored. (Manikin)

12.5.4.6 1 Aug 2012 (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 (see subtask 5, above).

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

12.5.4.7 31 Jan 2012 **(ESRL)**
Complete testing and evaluation at ESRL of new Rapid Refresh capabilities in model physics (see 12.5.8) and data assimilation (see 12.5.5, 12.5.15) toward consideration in the upgrade to the RAP (RAP2) at NCEP near end of 2012.

COMPLETE - The configuration of the Rapid Refresh (RAP-primary at ESRL) for the summer 2012 has been set since mid-March. This version of the RAP is nearly equivalent to the RAPv2 version envisioned for NCEP by late 2012 (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)

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.

NCEP
The NARRE-TL system was successfully implemented on 1 May and its output data have been added to the **NOMADS** server and displays are viewable **here**. The NARRE-TL implementation got positive responses from WFOs; Tampa Bay WFO discovered and reported a bug in sea-surface temperature field that was fixed for the RAP. Verification of NARRE-TL's visibility and icing with ADDS/CIP and ADDS/VIS data has been conducted. The downscaled SREF's surface temperature and wind were verified using RTMA and compared against raw SREF and bias-corrected SREF output. An NCEP Storm Scale Ensemble (a precursor to HRRRE) has been constructed using the various convection allowing storm scale runs at NCEP (two HiResWindow runs, Matt Pyle's SPC run, the NAM CONUS nests, and displays of the preliminary results can be viewed **here**. Eventually, HRRR

runs from ESRL or Zeus plus the 10 members from AFWA's 4km CONUS ensemble will be included. (Binbin Zhou and Jun Du)

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

NCEP
RAP V2 is delayed due to the late implementation of RAP V1 and the upcoming 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 this summer. Initial tests 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 upcoming NCO moratorium on model changes. (Manikin)

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

Work on this project will begin [at ESRL/GSD] now that RAPv1 model was implemented at NCEP on 1 May. (Tom Black)

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

Work to start on this in last quarter of FY12.

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

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

ESRL continues to work primarily on bringing the FIM global model into NEMS compliance and working with NCEP to make further modifications to NEMS. NEMS design for the global model will set the direction for making ARW NEMS-compatible. (S. Benjamin)

GSD-See subtask 11.

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: A National Weather Service Technical Implementation Notice (TIN) concerning the RUC to Rapid Refresh transition was amended to change the implementation date to Tuesday May 1, 2012. It can be found at **http://www.nws.noaa.gov/os/notification/tin12-06updates_aids-aac.htm**. The document also contains an overview of the model and explanation of the differences between the RUC and RAPv1. 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 now that RAPv1 model was implemented at NCEP on 1 May. (Manikin)

PLANNED EFFORTS:

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: Delays in the initial RAPv1 implementation will delay the RAPv2 upgrade until after the moratorium, likely no sooner than 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 (31 Jul 12) (Manikin)
Pending computer resource availability, implementation of Rapid Refresh version 2 changes to operational RAP at NCEP.

CURRENT EFFORTS: Work on this project will begin now that RAPv1 model was implemented at NCEP on 1 May. (Manikin)

PLANNED EFFORTS:

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: Delays in the initial RAPv1 implementation will delay the RAPv2 upgrade until after the moratorium, likely no sooner than 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: The Rapid Refresh was implemented at NCEP on 1 May to replace the Rapid Update Cycle. A thorough documentation of the Rapid Refresh codes and downstream dependencies is found in the Technical Implementation Notice found at **http://www.nws.noaa.gov/os/notification/tin12-06updates_aids-aac.htm**. (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 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
In June, GSD data assimilation work continued in 4 main areas: 1) benchmarking a parallel RAP version on the new ZEUS supercomputer (Ming Hu, Curtis Alexander, Patrick Hofmann), 2) continued testing of a 13-km RAP hybrid / EnKF system on ZEUS (Ming Hu), 3) work on ZEUS to improve on a HRRR 3-km background for the RTMA 2DVAR analysis (Patrick Hofmann with assistance from Manuel Pondeca), and 4) running of the full GSI 3DVAR (and just the cloud analysis portion of the GSI) for the HRRR 3-km domain.

Ming Hu was able to quickly migrate the GSD RAP version to ZEUS and create a parallel version running in real-time on ZEUS. Patrick Hofmann also migrated the AMB upper-air verification program over to ZEUS and it confirms similar, bit not quite matched performance to the JET RAP system). This was expected -- there remain a few features of the JET RAP we are working to get transferred into the ZEUS RAP system (latest GSI mods, adaptive aircraft QC system, etc. Ming Hu continues to evaluate and improve his 4-day retrospective test of a 40 member 13-km RAP hybrid / EnKF data assimilation system. Initial assessment indicates less skillful performance than for the current GSD parallel (3DVAR) RAP and spread among members that is too small. Patrick has made good progress on adapting Manual's special 2DVAR version of GSI for use with 3-km HRRR fields (updated Manuel's mods to a newer GSI version and overcame several compile and runtime issues on ZEUS. Patrick now has the special 3-km 2DVAR version of GSI running successfully and is working to resolve some subsequent issue in UNIPOST and analyze the output fields. Ming has successfully adapted the full GSI package to run over the full 3-km domain and has scripted up an ongoing 3-km GSI analysis on ZEUS (using a 1-h ZEUS HRRR forecast as input – see task 5.24 for details on the 3-km HRRR running on ZEUS).

David Dowell is also utilizing this 3-km ZEUS HRRR capability to test 3-km radar data assimilation for the HRRR-dev (see task 5.24). Haidao Lin continued his satellite assimilation work, porting his RAP retrospective test system over to the ZEUS supercomputer. Then, using full 6-hourly satellite radiance files from the GFS global data assimilation system, Haidao is conducting a systematic evaluation of the crucial bias correction aspect of the regional satellite data assimilation. Preliminary results indicate that for some satellites and channels, the bias correction coefficients spin-up to stable (slowly varying) values quickly, but for others the spin-up is quite slow. We also evaluated the impact of the GLD360 lightning data on a parallel version of the RAP and found case study examples of forecast improvement and even a possible slight signal in the objective verification. Under a separate project, work is ongoing to evaluate the forecast impact from the SATCAST (satellite-based indicators of convective initiation). Steve Weygandt presented posters at the GOES-R science week on the assimilation of the extended coverage (over large oceanic regions) lightning data assimilation and assimilation of the GOES-based cloud-growth SATcast data.

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. ESRL's new estimated date for completing RAPv2 GSI code testing at GSD: 30 Aug 2012.

NCEP
Delays in the initial Rapid Refresh implementation will delay the Rapid Refresh upgrade to 2013. Move deadline to 31 Jan 13. (Wu, Parrish)

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

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

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

NCEP
Once the ENKF is implemented in the operational global in May, this will be put into a NAM parallel. (Wu)

12.5.5.4 31 Aug 2012 (ESRL)
Complete testing of GSI changes for RAPv2 at ESRL.
Delays in the initial Rapid Refresh implementation will delay the Rapid Refresh upgrade to FY2013. Move this deadline to 31 Aug 2012. A large set of changes to reduce the high bias in RAP moisture and precipitation forecasts has already been fully tested and included in all three ESRL GSD real-time parallel RAP runs and is in the frozen code for the RAP that serves as the parent for the HRRR in the summer 2012 real-time evaluation. Most changes for RAPv2 are complete, but additional testing is ongoing to improve fit to rawinsonde vertical structures.

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

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

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

In late March, Stan Benjamin noted the absence of data from the Langley Hill radar from western Washington State getting into the RAP at NCEP or ESRL and getting into the HRRR. The Langley Hill data was only installed last fall. Stan started a sequence of emails started resulting in changes at NCEP (Shun Liu) and NSSL to accelerate moving Langley Hill data into full usage in the US radar mosaics and therefore, getting into the RAP and HRRR models by early April.

NCEP
A bug in the HRRR level2 radar QC package was found and fixed. When dumping VAD wind to BUFR tank, one declared array in “vad2bufr.f90” is not consistent with the argument used in BUFR library. A few small details were fixed after examining NCO’s tests of the bug fix. Work has begun to use dual-polarity radar variables in the level 2 radar data QC package. (Shun Liu)

12.5.5.6 Moved to later in 2012 (GSD)

Complete testing of Rapid Refresh GSI modifications for RAPv2 at EMC, transfer code to NCO, pending NCEP readiness.

Delays in the initial Rapid Refresh implementation will delay the Rapid Refresh upgrade to FY2013. Move this deadline to 31 December 2012. A large set of changes to reduce the high bias in RAP moisture and precipitation forecasts has already been fully tested and included in all three ESRL GSD real-time parallel RAP runs and is in the frozen code for the RAP that serves as the parent for the HRRR in the summer 2012 real-time evaluation.

12.5.5.7 15 Dec 2012 (NCEP, ESRL)

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

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

NCEP

Work will begin on RAPv2 after the RAPv1 is implemented in May 2012. 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 in 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

Enhancements were made to the RTMA analysis of surface visibility to achieve a smoother merge of the observation increments with the background when the observations lie in the vicinity of sharply discontinuous areas of low background visibility. Much work was devoted on trying to add a GLERL-type analysis for lake winds to the RTMA, but some issues arising from this method must be addressed before this method can be incorporated into RTMA. Three papers on the NCEP RTMA were presented at the 2012 CMOS-AMS Congress 29 May - 1 June in Montreal. Following feedback from NWS/Seattle forecasters on the RTMA performance, the new RAP-based first guess temperature was found to occasionally exhibit a large afternoon-hours cold bias over the Seattle Metro area. Tentative adjustments to the GSI configuration did not produce any significant improvements. Monitoring will continue to determine if adjustments should be made to the downscaling algorithm that is applied to the RAP forecast to produce the RTMA first guess. RFCs for the next RTMA upgrade package, which contains RTMA implementations for six distinct domains, have been submitted to NCO. Wall clock time for the RTMA-GSI and the RTMA-POST jobs was reduced through the use of more processors, parallel-threads, and code restructuring. (Manuel Pondeca, Yanqiu Zhu, Steven Levine, Yuqiu Zhu, Jim Purser)

GSD

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

Ming Hu, who has run a 3-km version of the full 3DVAR and used these fields to initialize the HRRR.

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

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

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

GSD
Ming Hu has built a 40-member 13-km RAP EnKF / hybrid data assimilation system on ZEUS and completed a 4 day retrospective test. Initial examination of results indicates too small a spread. Work ongoing by Ming Hu and Jeff Whitaker (ESRL) to resolve some outstanding issues.

NCEP
Testing the new GSI code with the 3dvar option began an impact study of the hybrid ensemble analysis, and a neutral forecast impact was found. The hybrid analysis was then turned on in the off-line parallel to make sure things worked properly. Both the bias correction coefficients and the angle bias correction program were updated to work with the new GSI. The scripts and fix files for testing hybrid analysis were prepared and installed in the official regional NAMX parallel. After the package was turned on in the official NAMX parallel Eric Rogers noticed timing issues with the global ENKF files. The scripts were corrected to use the forecasts with longer lead times and/or GEFS forecasts as a backup. The preliminary results show a large positive impact on the Day 2 and Day 3 forecasts. (Wu, Rogers)

Parameters related to the threading were changed to speed up the wall clock of long jobs. Since the hybrid variational-ensemble analysis took about twice as long to run as the operational 3D-Var the impact of the change was more significant for hybrid analysis. The proposed change was implemented in the parallel and it shortened the wall clock by 9% for EnKF/hybrid analysis while no significant impact was found with the change in operational regional analysis. (Wu)

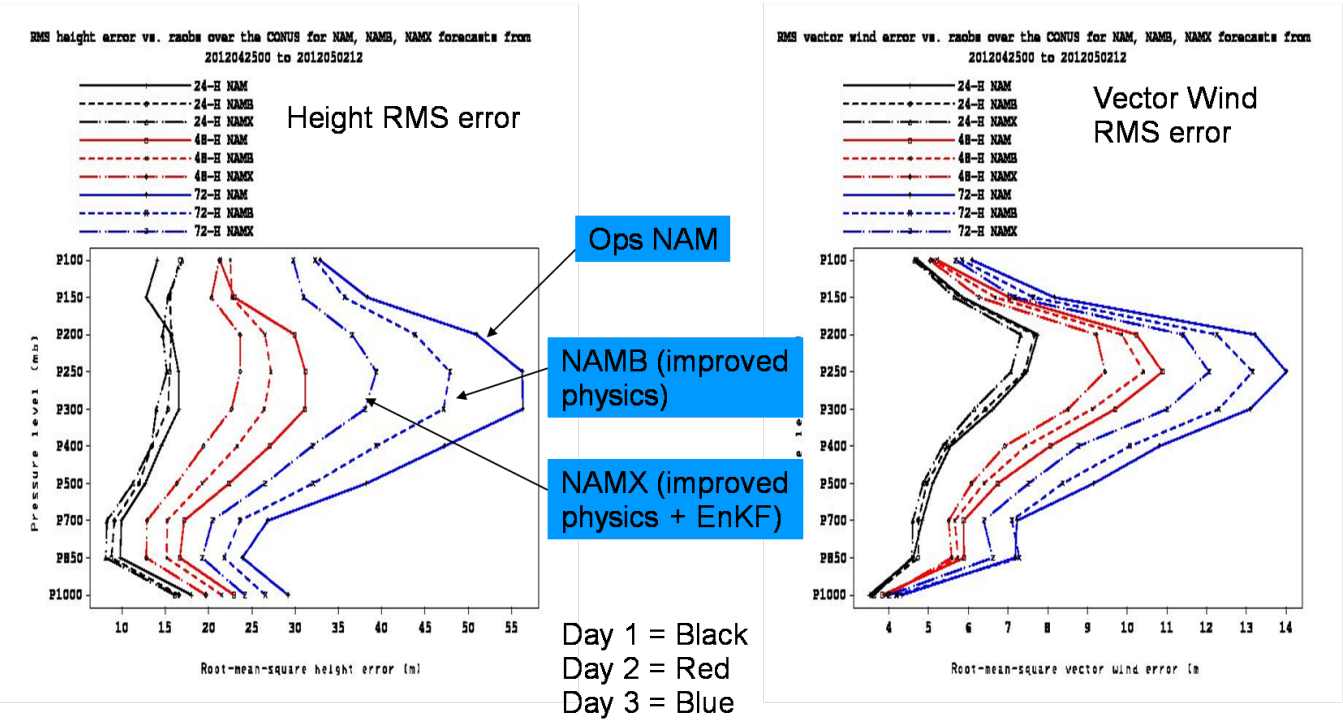

Fig. 1. Evaluation of NAM parallel test runs.

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
A bug in the NAM level2 radar QC package was found and fixed. When dumping VAD wind to BUFR tank, one declared array in "vad2bufr.f90" is not consistent with the argument used in BUFR library. A few small details were fixed after examining NCO's tests of the bug fix. Work has begun to use dual-polarity radar variables in the level 2 radar data QC package. (Shun Liu)

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

NCEP
The next operational computer (WCOSS) at NCEP will be a little endian machine unlike the current big endian CCS. In preparation for porting to the new machine, the regional GSI was tested on the little endian NOAA Zeus machine. For conventional and satellite radiance data without thinning, the code produced almost identical results. The thinning, which was used on scatterometer winds (ASCAT) and the satellite radiance data, will produce nontrivial differences in results between the two machines. (Wu)

The new NRL QC procedure for aircraft data was tested with the parallel analysis system. It was found the new code did not flag all the PIREP temperature and wind observations correctly. Keyser fixed this error before the code was submitted for implementation in July. (Wan-Shu Wu, Keyser)

The erroneous specific humidity values in the NDAS cold-start file at the top layers were found last quarter while experimenting with a new method that allows direct use of GDAS satellite bias coefficients in the NDAS GSI. An error was found in the code that generates the NDAS cold-start. Correcting this error resulted in a substantial improvement in utilization of satellite radiances in single GSI analyses using NDAS cold-start as guess, especially for high peaking channels. The corrected code that generates the cold-start file was tested in an NDAS parallel. After 2 weeks, the bug fix had a neutral impact. (Parrish, Pyle, Rogers)

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

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

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

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

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

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

12.5.5E3 1 October 2012 (ESRL)

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

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

PLANNED EFFORTS: Implement the RAPv1 on 1 May 2012.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

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

Deliverables

12.5.5E3 (28 Feb 12) (NCEP)
Final GSI code transfer complete to EMC for Rapid Refresh upgrade change package to be implemented in spring 2012. (Combined with 12.5.5E1)

CURRENT EFFORTS: Work with ESRL/GSD will begin on RAPv2 after the RAPv1 is 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 15 Dec 2012 (GSD, NCEP)
Pending EMC, and NCEP Center initial recommendations, Requests for Change (RFCs) are filed to submit GSI code as part of upgrade for Rapid Refresh v2 software to NCO, pending NCEP readiness.

ESRL
Progress with RAPv2 at ESRL is very promising and would allow this schedule, pending NCEP's readiness to start testing and NCEP's need to get in some other implementations with RAPv2 implementation not having occurred until 1 May 2012.

NCEP
CURRENT EFFORTS: Work will begin on RAPv2 after the RAPv1 is implemented on 1 May 2012.

PLANNED EFFORTS: Implement the RAPv1 on 1 May 2012.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

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

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

ESRL
Request for date change to early FY13.

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

PLANNED EFFORTS: Transition the RAPv1 onto WCOSS.

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 July 2013.

12.5.5.E6 30 Sept 2012 (CAPS, EMC, ESRL)

Report on the results of EnKF and hybrid DA systems for the RR configuration.

Encouraging results from OU/CAPS dual-resolution (40/13 km) test and good progress by Ming Hu on building 13-km test system (see subtask 12.5.5.10). Ming Hu and CAPS personnel presented summaries of this work at an ensemble data assimilation workshop in late April.

NCEP
CURRENT EFFORTS:

PLANNED EFFORTS: Work will begin after the RAPv1 is implemented in 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 June 2013.

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

CURRENT EFFORTS: Porting of the GSI into NEMS has been put on hold while it completes its transition to EnKF especially for regional applications. Tests with hourly updated NAM will help determine of having model and GSI in a single executable will be worth the effort. Some feel having GSI in NEMS will be restrictive and too complicated. The savings in time due to greatly reduced data motion will have to be great to offset these negative aspects of moving GSI into NEMS. (DiMego, Rogers)

The hybrid ensemble analysis with a new version of GSI code was incorporated into the regional parallel system. The satellite angle bias correction program was also updated to be compatible with the new GSI code. In order to have a test system for impact studies on future changes, efforts were invested in porting and adapting the scripts and codes to work on the NOAA R&D computer (Zeus). Work on updating the background error covariances continues. (Wu)

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. When there was an input radar file but no available radar data, the program failed 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)

PLANNED EFFORTS: Continue tuning the hybrid variation-ensemble analysis and the static background error covariances. Add new data, i.e., new VAD winds, GPSRO bending angles, hourly satwinds, surface observations without pressure to the assimilation system when they become available. If the new components pass the parallel tests with at least a neutral impact, the components will be included in the package for official regional parallel. (Wu)

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: None.

12.5.5.E8 30 Sept 2012 (CAPS and GSD)
Report on initial results of dual-resolution EnKF for RR configuration.
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 (RR and HRRR) and NAM models, especially including those that affect aircraft icing.

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

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

On the other hand, the prediction of derechos, a subset of leading-line / trailing stratiform mesoscale convective systems characterized by extremely strong surface winds behind the leading line, rapid movement, and a several hour lifetime, has been surprisingly successful. Both the 10-11 July 2011 and the extremely destructive derecho of 29-30 June 2012 were handled very well: persistence, phase speed and to a lesser extent, wind speed at 10m, were predicted accurately. The reason for this difference in performance is uncertain.

NCAR/RAL
CURRENT EFFORTS: During the 3rd quarter of FY2012, NCAR-RAL MD&E team diagnosed and fixed a bug in the radar reflectivity code that was delivered to OU-CAPS and many other collaborators. In the month of May, the primary focus was preparing and developing the research plan for FY2013 and beyond and presenting at the AWRP review meeting in Boulder, CO. In June, G. Thompson visited and participated in NOAA's Spring Experimental Forecast program and met many researchers and operational forecasts responsible for the daily severe weather forecasts. Through numerous discussions, a few minor issues were revealed with the behavior of the Thompson microphysics scheme that requires deeper investigation. Overall, however, the scheme is considered by the operational forecasters to be doing a moderately good job compared to other potential microphysics schemes in their ensemble members. The collaboration and leveraging by other MD&E contributors is highly appreciated considering the relatively low amount of time to investigate convective simulations by the NCAR-RAL microphysics development team.
One flaw revealed by this collaboration is the disconnection between the microphysics and radiation schemes. Particularly with the Thompson scheme, its treatment of distinguishing cloud ice from snow is unique (compared to other microphysics schemes) and, unfortunately, nearly all WRF radiation schemes are ignoring the amount of suspended snow and only take cloud ice into account. As such, many cloudy regions that should be greatly reducing incoming solar radiation reaching the surface ignore the ice in the form of snow and allow much too large daytime heating of the surface. This is a potential source of a known bias in the new Rapid Refresh model and will be investigated in the near term. A potential bug fix was provided by NCAR-RAL to NOAA-ESRL. Lastly, recent research results were presented at the WRF User's Workshop.

PLANNED EFFORTS: The remaining 6 months of FY2012 will concentrate on the testing and full implementation of the Thompson et al (2008) "aerosol-aware" microphysics scheme. The scheme has been tested only for a couple of cases, but, during Summer 2012, it will be incorporated into a large-scale, long-term model simulation with significant leveraging with the CO Headwaters program at NCAR-RAL. This testing should be sufficient to prepare it for more widespread usage by other users before the end of the calendar year.

PROBLEMS/ISSUES ENCOUNTERED OR ANTICIPATED: No additional delays are expected.

INTERFACE WITH OTHER ORGANIZATIONS: Besides the direct interactions between NCAR-RAL and NOAA/ESRL/GSD, there were a number of interactions with collaborators at NSSL and OU, including Jack Kain, Fanyou Kong, and Scott Dembek. There were also numerous interactions at the WRF Workshop, including but not limited to Cliff Mass, Mark Stoelinga, and Brian Jewett.

SUBTASKS:

12.5.8.1 1 Oct 2011 (GSD)

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

The MYNN PBL and surface-layer scheme was introduced into the RAP-development-2 cycle at GSD for intensive real-time evaluation by Joe Olson. This scheme gives wind forecasts that are no worse than the MYJ and often better. However, two problem areas persisted and were addressed during the quarter:

- Near surface warm bias in late afternoon / early evening period, including the evening transition: this is being addressed through modifications to the surface-layer scheme and parameters that control the entrainment at top of the daytime mixed layer. Further modifications to the Yang et al (QJRMS, 2002) surface layer as well as comparisons with the original MYNN Zilitinkevich-based formulation were tested in individual cases and in RAP-dev2. Recent testing indicates that this issue may require going back to the Zilitinkevich scheme.
- Too drastic decoupling of near-surface conditions from the free atmosphere when snow or ice cover is present, leading to extensive spurious nocturnal fog formation in these regions: we are addressing these by modifications to mixing-length formulation under very stable conditions and by more careful mixing of thermodynamically conserved variables (e.g., liquid-water potential temperature).

We expect to wrap up our evaluation of the MYNN during the July – September quarter and make a tentative decision on whether to replace the current MYJ with the MYNN in future RAP and HRRR configurations.

A version of the MYNN that is regarded as superior to the one released with v3.3.1 was submitted to NCAR earlier this year and is part of the WRFV3.4 release by NCAR on 6 April.

12.5.8.3 1 July 2012 (NCAR/RAL)

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

12.5.8.4 1 July 2012 (NCAR/RAL)

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

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

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

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

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

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

NCAR delivered the 13th WRF Users' Workshop on June 25–29. Approximately 240 were registered. The workshop began with a half-day of lectures on model convective parameterizations. The main body of the workshop presented sessions on WRF such as physics, model evaluation, and data assimilation. The final day offered mini-tutorials on various topics, such as verification and regional climate modeling. Details on the workshop and selected abstracts may be found at: **http://www.mmm.ucar.edu/events/2012_wrfusers**.

NCAR is working on the next WRF tutorial, which will begin the week of July 16th. The first week will cover WRF, while the following week of July 23rd will present WRFDA and WRF-Chem. The workshop will be held at NCAR's Foothills Lab. Details on the tutorial may be found at:
http://www.mmm.ucar.edu/events/tutorial_127/index.php.

PLANNED EFFORTS: NCAR will host and deliver the next WRF tutorial July 16–27.

UPDATES TO SCHEDULE: NONE

12.5.8.14 30 Sept 2012 (NCAR/MMM)
Task 12.5.8.14 Incorporate Physics and Dynamics Improvements into WRF
In this quarter, NCAR released WRF Version 3.4 on April 6th. New physics scheme include the Noah-MP LSM, UCLA radiation, and Oklahoma microphysics. The new features are described at:
http://www.mmm.ucar.edu/wrf/users/wrfv3.4/updates-3.4.html.

In WRF boundary layer and land surface physics, Jimy Dudhia of NCAR completed working with visitors Roanne Bakker (Wageningen University, Netherlands) and Pedro Jimenez (CIEMAT, Spain) on testing and evaluating WRF against CASES99 tower data for stable conditions. The work focused on modifying soil properties to improve nighttime cooling as well as modifying the vertical mixing criteria.

Dudhia also continued hosting visitors Jimenez, investigating wind direction error in complex terrain, and Jose Arias (Univ. of Jaen, Spain), working on adapting MODIS aerosol optical depth for WRF input to radiation schemes. A new visitor to NCAR, Esa-Matti Tastula (U. South Florida), will work on the EDMF QNSE PBL.

Dudhia completed testing of convective-radiative equilibrium code, running to equilibrium after 25 days. The latest test included adding a 1C perturbation to the SST looking at effects on energy fluxes and the mean sounding. The tests also included a double CO_2 case and adding 1°C to the SST to examine the effects on

energy fluxes and the water cycle. In other radiation physics work he adapted MODIS aerosol optical depth for WRF input to radiation schemes.

Songyou Hong (Yonsei University) is jointly visiting NCAR and NOAA and is working on a new shallow convection scheme. Dudhia also met with Sukanta Basu (Univ. of North Carolina) on a fix to the YSU PBL scheme for stable conditions. This turns out to have a small effect in the direction of reducing mixing in the stable boundary layer.

PLANNED EFFORTS: The development and incorporation of new physics and dynamics for WRF for the RAP will continue through FY12Q4.

UPDATES TO SCHEDULE: NONE

12.5.8.15 Ongoing (GSD)
Continue development of the RUC LSM for application to both RR (RR2 in FY12 and RR3 in FY13) and HRRR, based on feedback from users, with particular emphasis on improving treatment of snow, sea ice and tundra, and use of upgraded ground surface datasets now available through the V3.3 WRF Preprocessing System (e.g., MODIS vegetation, lake surface temperature for lakes other than the Great Lakes).

As a result of an alert Florida National Weather Service forecaster noticing erroneous fog at Tampa in the RAP during the RAP field test in April, and querying Geoff Manikin about it, GSD discovered some spurious sea-ice points in the daily-updated 4-km resolution snow cover and sea ice product from NESDIS. This product is used daily for trimming areas of snow cover (over land) and ice cover (water) where snow and ice are present in the ongoing RAP cycles including at NCEP, but are absent in the NESDIS product. This required introducing, in collaboration with NCEP, additional quality-control safeguards against spurious ice points in this field. These safeguards have been in place since late April for these fields being used in the operational RAP, as well as the RAP cycles run by GSD. There have been no recurrences of this problem.

Deliverables

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

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

12.5.8.E2 15 Dec 2012 (GSD, NCEP)
Pending NCEP computer readiness and EMC and NCEP Center initial recommendations, Requests for Change (RFCs) are filed to submit WRF physics code changes as part of upgrade for Rapid Refresh 2 software to NCO.

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

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

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

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

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

12.5.8.E7 15 Sept 2012 (NCAR/RAL)
A written report by mid September 2012 summarizing enhancements made to the model physics packages.

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

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

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

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

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

The real-time HRRR system continues to run in support of summer evaluation. RAP and nested HRRR runs have been completed for the second retrospective test period (May 30 – June 8, 2011 and the results analyzed and were presented at a telecom on June 21. Similar to the previous retrospective run, results showed substantial improvement reducing the high bias in radar reflectivity during the first few hours and better overall location of storms and depiction of storm structure. Fig. 2 shows a plot of the quantitative verification and an example of the HRRR forecast improvement from the 2011 version to the 2012 version.

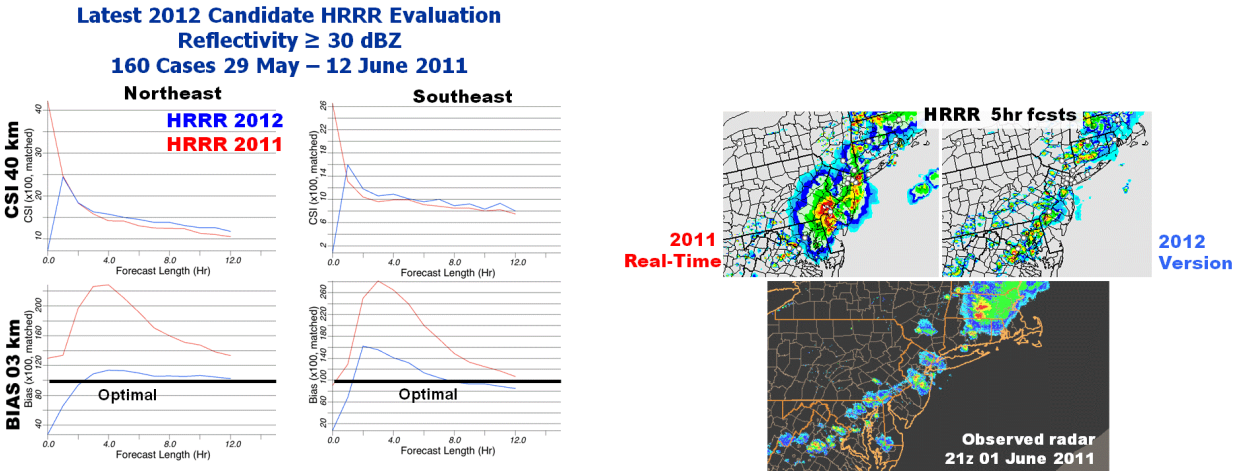

Fig 2) Quantitative verification statistics (CSI top and bias bottom) for Northeast (left) and Southeast (right) regions for the June 2011 retro period. b) Sample 5h HRRR forecast showing that the 2012 RAP/HRRR version greatly improves upon the over-forecast of convective coverage from the RAP/HRRR that was run in real-time in 2011.

The full PPT of this report is available at:
http://ruc.noaa.gov/pdf/FAA_HRRR_RetroResults_2012_Final.pdf

In addition, Ming Hu continues to test and evaluate application of the full GSI 3DVAR on the 3-km HRRRR domain and David Dowell continues his work on 15-min cycled radar assimilation. He presented results from this work at the recent NWP conference in Montreal. His presentation is available at:
http://ruc.noaa.gov/pdf/Dowell_Montreal_30may12_final.pdf

A low bias was identified in the HRRR echo tops (introduced with the new Thompson microphysics scheme and consistent post-processing code). A simple fix was coded up by Curtis Alexander and is currently being evaluated in a parallel RAP run.

Subtasks

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

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

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

12.5.24.3 30 Sept 2012 (GSD)

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

Exercise ongoing with very good overall HRRR performance and reduced false alarms compared to 2011 noted. Storm structure seems to be especially well predicted with this 2012 RAP/HRRR configuration. 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. 2 shows the 12-h HRRR forecast of reflectivity and max 10m winds.

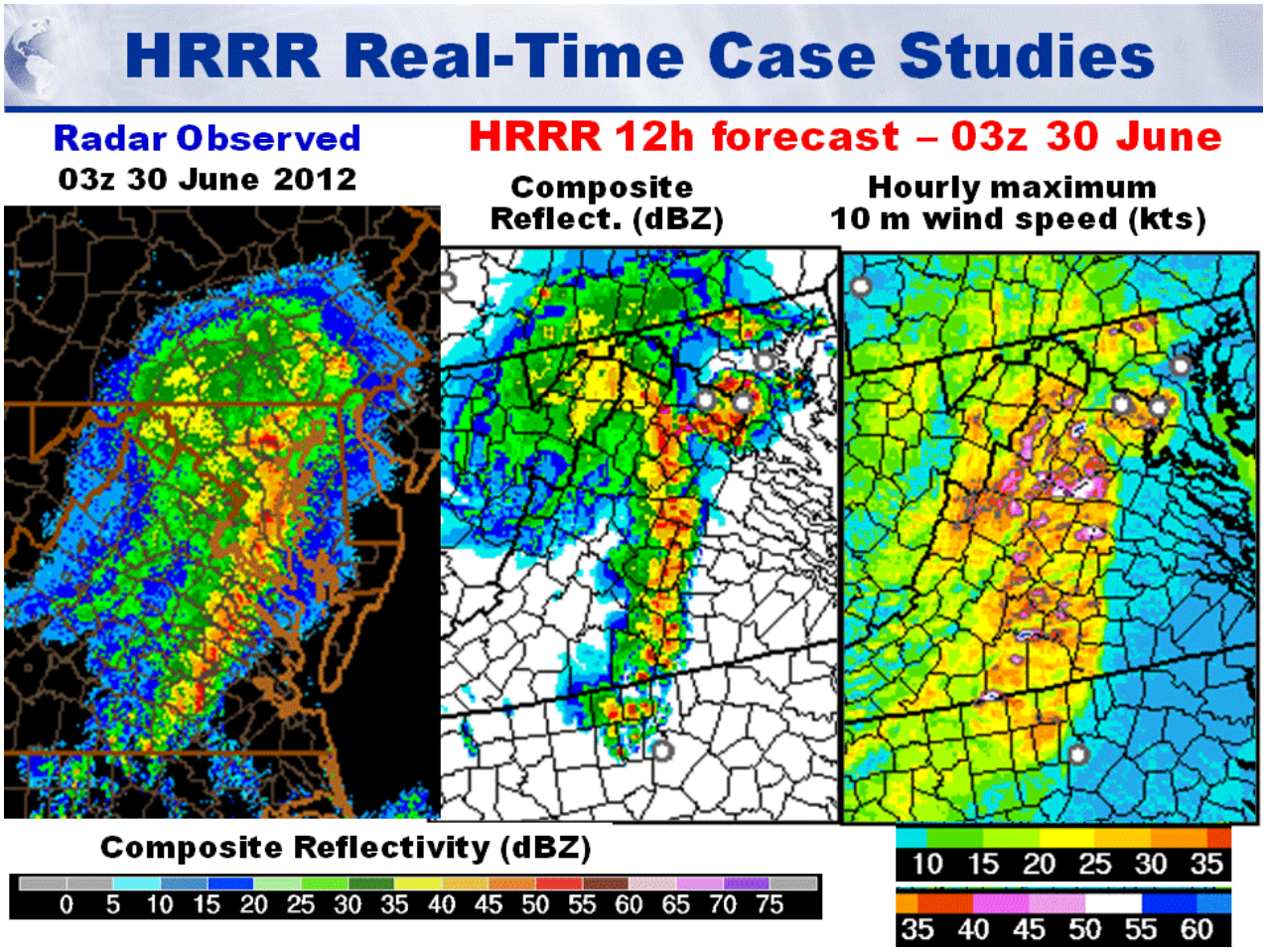

Fig. 3 Observed radar reflectivity (left) and HRRR 12h forecast reflectivity (center) and 10 m wind (right) from the extremely damaging derecho that struck Washington DC at 3z 30 June 2012.

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) Request delay to 15 July 2012 COMPLETED
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 has been completed and is available at:
http://ruc.noaa.gov/pdf/HRRR_computing_resources.pdf

Status of MDE Deliverables – 13 July 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 01/31/12	☑ ☑	
12.5.4.7 Complete testing and evaluation of new RAP capabilities (model physics and data assimilation) – RAPv1 (ESRL)	02/01/12	☑	
12.5.4.E2 Update documentation for operational Rapid Refresh (ESRL)	08/01/12	☐	
12.5.4.6 Initial software for RAPv2 changes ready for porting to EMC (ESRL)	03/30/12	☑	
12.5.4.E4 Report on testing of RAP assimilation/model improvements (ESRL)	10/01/12	☐	
12.5.4.E3 Final code ready for transfer to EMC for Rapid Refresh v2 change package (ESRL)	12/31/12	☐	
12.5.4.E5 Complete testing at EMC of RAPv2 code, pending NCEP readiness (NCEP, ESRL)	Ongoing Ongoing	☐ ☐	This task was originally for a RAPv3 but is now linked to RAPv2.
12.5.4.E6 Perform config mgmt. for RAP (ESRL, NCEP)	11/30/12	☐	
12.5.4.E7 Monitor RAP performance, respond to problems, diagnose causes, develop solutions. (ESRL, NCEP)			
12.5.4.E8 Report on overall planned changes for FY13 upgrade to Rapid Refresh (ESRL)			
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 10/01/12	☑ ☐	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)	12/15/12	☐	
12.5.5.E4 Pending EMC and NCEP Center initial recommendations, Requests for Change (RFCs) are filed to submit GSI code for RAPv2 software to NCO, pending NCEP	01/15/13	☐	NCEP plans a moratorium that may delay this implementation, although ESRL and NCEP will try to implement RAPv2 before it since code is essentially ready

readiness (NCEP, ESRL) 12.5.5.E5 Pending computer resources, implement RAPv2 at NCEP (NCEP, ESRL) 12.5.5.E6 Report on results of EnKF and hybrid DA systems for the RAP configuration (CAPS, EMC, ESRL) 12.5.5.E7 Subject to NCEP Director approval, implement NEMS/NMMB version of GSI in NAM/NDAS (NCEP) 12.5.5.E8 Develop dual-resolution EnKF for RAP configuration (CAPS) 12.5.5.E9 Report on planned GSI changes for the RAPv2 upgrade to the Rapid Refresh (ESRL)	09/30/12 09/30/12 09/30/12 09/30/12	☐ ☐ ☐ ☐	as of spring 2012
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) 12.5.8.E2 Pending NCEP computer readiness and EMC and NCEP Center initial recommendations, Requests for Change (RFCs) are filed to submit WRF physics code changes as part of upgrade for Rapid Refresh v2 software to NCO (ESRL, NCEP) 12.5.8.E4 Pending computer resources, implement RAPv2 at NCEP with new physics configuration (ESRL, NCEP)) 12.5.8.E5 Transfer the coupled aerosol-microphysics scheme into a test version of HRRR (NCAR/RAL) 12.5.8.E6 Deliver WRF Users' Workshop and WRF tutorial (NCAR/MMM) 12.5.8.E7 Report on enhancements made to WRF model physics (NCAR/RAL) 12.5.8.E8 Report summarizing enhancements made to the model physics packages (ESRL) 12.5.8.E9 Incorporate physics improvements into WRF for future RAP and HRRR (NCAR/MMM)	10/01/12 12/15/12 01/15/13 09/01/12 07/30/12 09/15/12 09/30/12 09/30/12	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	Essentially complete now in ESRL RAPv2 but will keep the door open for additional physics mods until fall.
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	04/01/12	☑	
12.5.24.E1 Incorporate all assimilation and modeling changes into HRRR for Summer 2012	09/15/12	☐	
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	06/01/12	☑	
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)			Completed 7/13/2012, available at http://ruc.noaa.gov/pdf/HRRR_computing_resources_13jul2012.pdf

Report on HRRR NOAA implementations – Computing resource status on NCEP operational computer, NOAA R&D Site A (Boulder, CO) and NOAA R&D Site B (Fairmont, WV)

For FAA AWRP audience.

13 July 2012 – initial draft version
Stan Benjamin, not yet vetted by NOAA/NWS but consistent with ongoing discussions between NOAA/ESRL and NOAA/NWS (Steve Lord and Ben Kyger).

NOTE: This report describes current status as of this date but modifications are expected as the situation evolves.

1. Background: There are at least three related efforts to improve the reliability of the High-Resolution Rapid Refresh (HRRR) hourly updated 3km CONUS-domain model. These 3 efforts are related to

1. inclusion of HRRR-related requirements into the future NOAA operational-NCEP computer upgrades (a multi-year, moving-target effort but the ultimate solution),
2. hardening of the Boulder Jet facility and scripts and code itself to maximize the HRRR reliability on that single facility, and
3. development of a 2-computer solution using both NOAA R&D computers (Jet and Zeus) in the interim period to maximize HRRR availability in its experimental real-time status before full implementation of the HRRR on the NCEP operational computer.

This status is summarized in Fig. 1. Since the HRRR model is initialized from the latest version of the 13km Rapid Refresh (currently RAP version 2 or RAPv2), an independent cycle of the RAPv2 also runs on the NOAA R&D computers. Ultimately, an NCEP implementation of the HRRR will be initialized with the current operational version of the Rapid Refresh at NCEP at that point. So the needed resources in the R&D versions of the HRRR are for a combined 3-km HRRR run and an associated independent 13km RAP cycle. In contrast, no additional RAP cycle will be required for the NCEP *operational* HRRR.

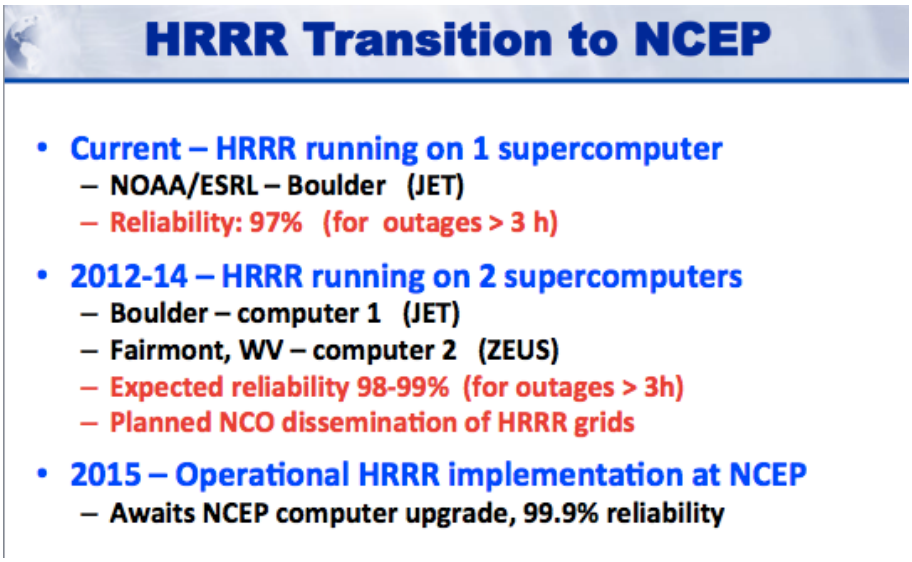

Figure 1. Summary of HRRR transition steps toward operational implementation at NCEP. The 2015 date for that operational implementation is an estimate but not yet guaranteed. However, there is full commitment from NOAA and NCEP to operational implementation of the HRRR even if the date is not fully certain.

2. Current status as of early July 2012:

- HRRR is running for distribution for experimental real-time usage (for CoSPA, etc.) on the Boulder Jet computer system (Site A) *only*, as it has been since the inception of the HRRR real-time runs.
- Allowing for a gap of up to 3h (acceptable to CoSPA processing), the HRRR ran with an average 95.6% completion out to at least 12h for the June-October 2011 period. (Fig. 2).
- Zeus: An initial implementation of the HRRR and an accompanying experimental RAP cycle (code/scripts mimicking the Jet version) has been accomplished. Current reliability of the Zeus HRRR/RAP is about 85%, without any reservation yet provided on Zeus.

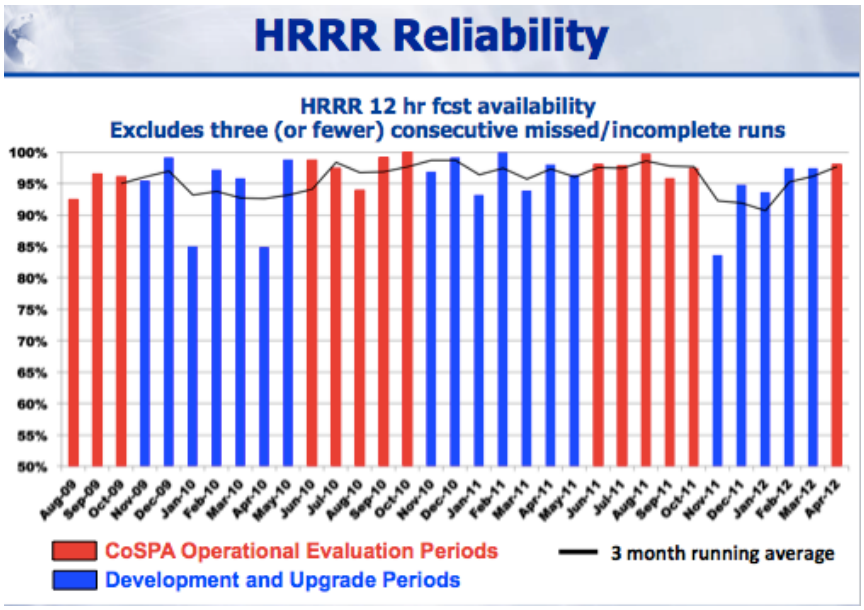

Figure 2, HRRR monthly reliability for August 2009 through April 2012. The red months are for those in which the experimental FAA CoSPA real-time exercises were being conducted. CoSPA (Convective Storm Prediction Algorithm) depends solely on HRRR grids for its 2-8h convective storm forecasts.

Zeus status continued:

- The configuration for the current Jet and Zeus configuration is described in Fig. 3 below. As noted, HRRR grids from neither jet or zeus are not yet ftp'd directly to NCEP. However, a distribution of experimental HRRR grids generated on the NOAA R&D computer(s) is planned by the NCEP Central Operations (NCEP/NCO) to improve HRRR availability and reliability.

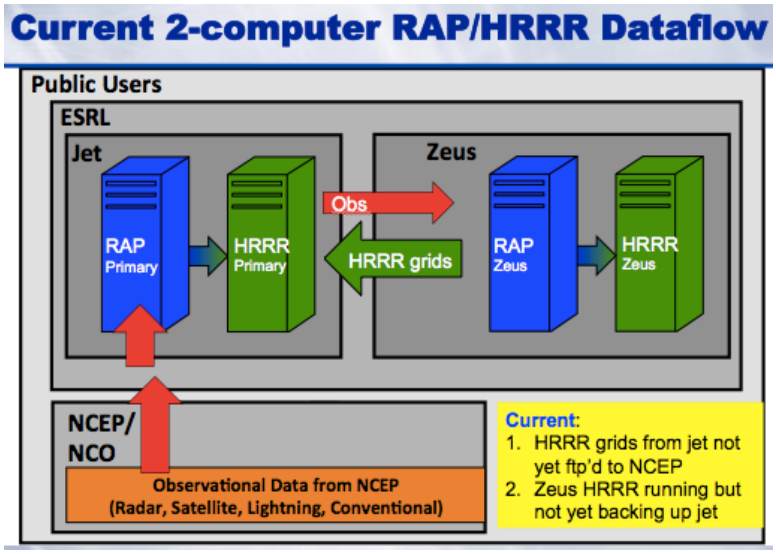

Figure 3. Current 2-computer RAP/HRRR data flow and configuration.

3. Plans for future:

- Step 1: An ftp of HRRR grids from Jet at ESRL in Boulder will be set up so that distribution of HRRR grids can occur directly from NCEP/NCO open to the public for any users. (Fig. 4)
-

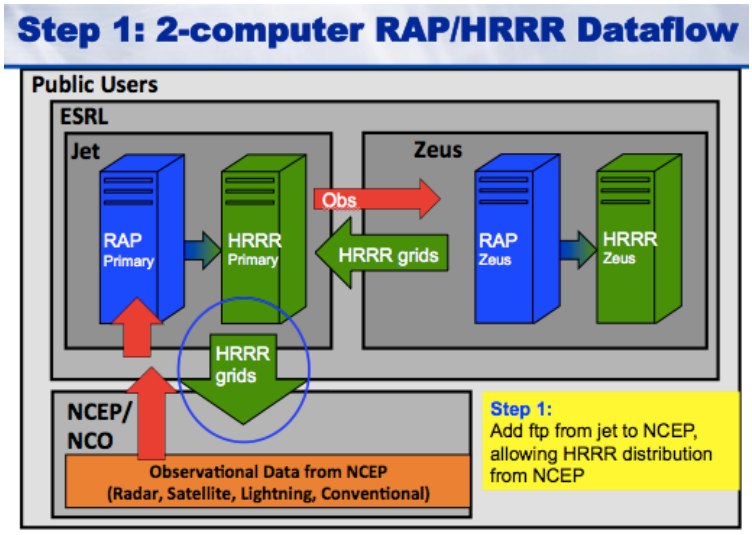

Figure 4. Planned addition of ftp of HRRR grids from jet in Boulder to NCEP to allow distribution of these grids from NCEP/NCO.

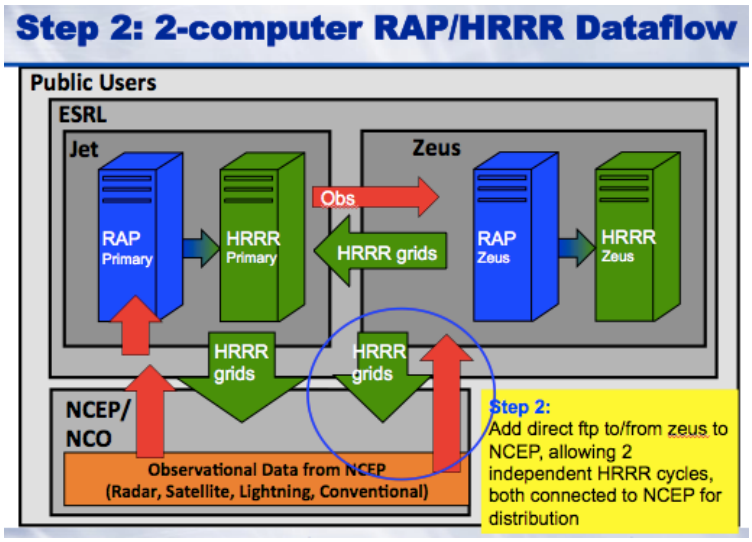

Figure 5. Second step to allow 2 independent HRRR solutions on the NOAA R&D computers to improve reliability.

- Step 2: With the addition of direct ftp connection between the zeus computer and NCEP/NCO (Fig. 5), this will provide 2 *computationally independent* solutions of the HRRR model (using the same code) in this interim solution prior to a full NCEP implementation of the HRRR. This change will avoid vulnerability of zeus HRRR runs to a jet outage and avoid data passing through jet for the zeus HRRR runs.

It is anticipated that the 2-computer solution of the HRRR can be enabled by no later than spring 2013 and perhaps by late 2012 (Fig. 1). This 2-computer redundancy will produce an estimated 98-99% reliability, much better than the current ~95% reliability on a single computer. To the extent possible, maintenance operations on Jet/Boulder and Zeus/Fairmont will be scheduled on separate days to minimize HRRR outages in this 2-computer period. The 2-computer solution will reduce outages from a current ~5% to approximately 1-2%.

The initial implementation of the HRRR at NCEP is best estimated to occur in 2015. The 2015 date for that operational implementation is an estimate but not yet guaranteed. However, there is full commitment from NOAA and NCEP to operational implementation of the HRRR even if the date is not fully certain.

This report will be updated as more information becomes available.