**MDE Product Development Team**
**FY13 July Monthly Report**
**Submitted 15 August 2013**

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and **Ming Xue** (CAPS).

*(Compiled and edited by S. Benjamin and B. Johnson)*

## Executive Summary

### Task 1: Improve turbulence guidance from NWP forecasts

- New comparisons of RAPv1 and RAPv2 1h and 6h forecasts show improvement from RAPv2 of 0.2-0.4 m/s RMS vector error (vs. raobs) for upper-level winds, important for air traffic management and for wind and likely turbulence forecasts.
- New parallel RAP test with 0.75 weight for ensemble background error covariance (vs. variation) in hybrid assimilation gave further improvement to wind forecasts.
- RAPv2 summer 2013 configuration implementation continues to run smoothly on Jet (Boulder, RAP primary cycle) and Zeus (Fairmont WV) supercomputers and initializing experimental HRRR.
- 25 July - Switchover occurred of NCEP operational production suite, including current operational RAP, to new Weather and Climate Operational Supercomputer System (WCOSS)
- RAPv2 now in parallel testing on WCOSS as of early July.
- RAPv2 implementation at NCEP is still currently scheduled for Q1 FY14 (December 2013).
- Three real-time parallel RAP cycles (with extensive verification of each) running on Zeus NOAA research supercomputer located in Fairmont, WV to evaluate further likely enhancements to RAP data assimilation / model system for spring 2014 code freeze.
- NCEP making progress on NAM and NAM-nest

### Task 2: Improve Quality of Convective Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE

- Continuing evaluation of HRRR forecast skill for convective systems indicating improvements over 2012, especially for short lead-time.
- HRRR infrastructure installed on NCEP WCOSS computer and testing underway with implementation tentatively scheduled for Q2 FY14 (Mar 2014), following the RAPv2 implementation now planned for Q1 FY14 (Dec 13).
- Continued work on 15-min RTMA and 3-km radial velocity assimilation.

### Task 3: Improve Quality of Icing Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE

- Upgraded physics configuration now running in both RAPv2 at GSD and in parallel cycle on WCOSS machine at NCEP
- Revised version of MYNN boundary-layer scheme has been running in June in a RAP parallel cycle
- Thompson microphysics scheme used in RAP was successfully ported by NCAR and NCEP to the NMMB under NEMS, setting the stage for more collaboration between NCAR and NCEP on microphysics issues in the future.
- NCAR put on a successful 14$^{th}$ Annual WRF Workshop in late June.

### Task 4: Develop convection-ATM-specific improvements to guidance from the HRRR (and later, HRRRE) and interact with CoSPA (or other) program partner labs and the FAA

- Real-time, frozen RAPv2/HRRR system running successfully with gridded field dissemination, real-time web display of graphics and verification of many forecast fields.
- Ongoing monitoring of RAPv2/HRRR system with regards to reliability (including joint reliability with Jet – Zeus failover) and forecast performance.
- HRRR “failover” capability to use feed from Zeus instead of Jet during Jet downtime is working; enhancements necessary to make Zeus completely independent of Jet will come in July.
- Examination of enhanced verification of HRRR convective forecasts, including VIL and echo-top.

**Task 1: Improve turbulence guidance from NWP forecasts**

Improving turbulence forecast quality involves efforts to improve initial conditions for the RAP and NAM (and HRRR and NAM nests) and to improve the models (WRF-Advanced Research WRF (ARW)-RAP and NOAA Environmental Modeling System (NEMS)- Nonhydrostatic Multi-scale Model – B (NMMB)).

Tasks will include:

- Continuing evaluation of RAPv2 toward early 2014 implementation at NCEP, incorporating changes developed in 2012 and early 2013
- Development of RAPv3 toward 2014 implementation at ESRL and subsequent implementation at NCEP
- Collaborating on developing and testing best approaches for use of hybrid/EnKF/3DVAR data assimilation within common GSI coding structure.

**ESRL**

**Regarding the operational NCEP RAP**

The switchover from the old IBM Power 6 machines to the new Weather and Climate Operational Computing System (WCOSS) at 12Z 25 July went smoothly for the RAP as well as other NCEP operational models including NAM. GSD thanks Geoff Manikin, Dennis Keyser, Geoff DiMego and others at EMC and NCO for their efforts to ensure this major transition went smoothly. Other than minor disruptions due to the switchover, the operational RAP at NCEP continues to run without any technical problems, including post processing.

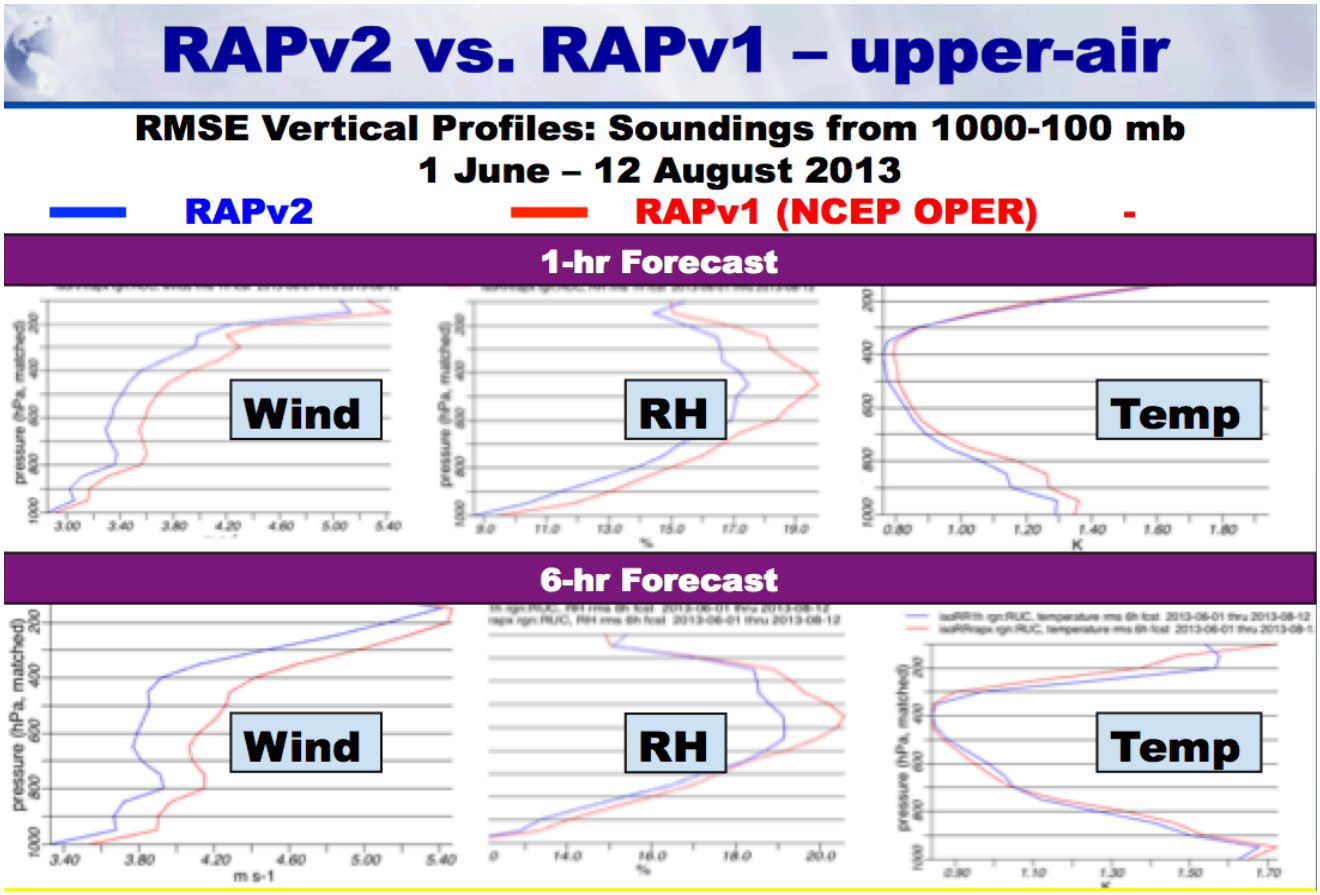


***Figure 1. Verification of RAPv2 (ESRL) vs. RAPv1 (NCEP operational) forecasts vs. rawinsonde observations for 1h and 6h duration for wind, RH, and temperature. Line further to left shows smaller error and more accurate forecast.***

Recent verification of the new RAPv2 for summer 2013 (1 June – 12 August) showed improved (vs. RAPv1, the current operational version of the RAP at NCEP) 1000-100 hPa (from surface through jet levels) for wind, relative humidity (RH), and temperature for both 1h and 6h forecast duration (Fig. 1). We consider this an excellent result for improvements to RAP forecasts from the upcoming switch to RAPv2.

14 August – Stan Benjamin, with help from Geoff Manikin (NCEP/EMC) gave a new update on RAPv2 and HRRR science status to NCEP management at a WCOSS Science Quarterly review meeting – ppt available here **http://ruc.noaa.gov/pdf/EMC_RAPV2_Upgrade-HRRR-final-14aug2013.pdf** . This ppt gives a good summary of the differences between RAPv2 and RAPv1

RAPV3 data assimilation testing

- Ming Hu ran a new 1-week parallel warm-season test with a modification to the hybrid ensemble/variational data assimilation, now using a 0.75/0.25 weighting of ensemble vs. fixed background error covariance instead of the current 0.5/0.5 weighting. This result gave improved upper-level wind forecasts, and if this result is also found in a later cold-season test, this modification will be included in future versions of the RAP at ESRL (implemented in Jan-Mar 2014), where it will also improve the ESRL HRRR. It also will be include in the subsequent (can be called "RAPv3") version at NCEP.
- Another parallel test was run with mesonet observations added (Patrick Hofmann). Results showed slightly better surface wind forecasts and slightly poorer 2m temp forecasts. A new study will next test a further mesonet assimilation impact test but now using a much improved observation use list (developed by Bill Moninger) and modified GSI code to use this modified use list (by Xue Wei), to be run again by Patrick Hofmann.
- NSSL modified the format for their radar reflectivity data on which ESRL tests of RAP and HRRR depend. Curtis Alexander and Ming Hu made quick changes and negotiated a transition period with (very cooperative) NSSL colleagues (led by Carrie Langston).
- A bug was found and corrected in the snow retrieval component of the radar reflectivity treatment within GSI. This bug correction is now included in the NCEP RAPv2 code. It has no effect in warm season but can be important in cold-season heavy snow events such as the quick heavy snow in Omaha on 1-2 May 2013 that led to discovery of this problem.
- Patrick Hofmann made additional parallel tests for full-column cloud building using the GOES CLAVR-X effective cloud amount. (Still better results in avoiding the previous mid-tropospheric moist bias that plagued previous full-column satellite-based cloud building). This change appears to be ready for RAPv3.

RAPv3 model testing

- New case study and parallel tests have been to improve the MYNN boundary-layer scheme. Some case study comparisons showed that MYNN has a stronger high dew point bias where it has more clouds. An entire parallel cycle has been devoted to a new MYNN variation (Joe Olson, Tanya Smirnova, others).
- Investigations are underway to better specify lake surface temperatures after an email from NWS Western Region noting that small lakes in the western US are too cold. (Tanya Smirnova, others)
- A new precipitation-type verification is ready for testing with retrospective and real-time RAP and HRRR tests, as appropriate. (Bill Moninger)

RAPv2 NCEP implementation details

- RAPv2 implementation is currently planned for December 2013.
- Warm-season parallel comparisons between RAPv2 and RAPv2 are currently underway using RAPv2 real-time runs primarily at ESRL but also now partially available from EMC
- Cold-season parallel comparison must be accomplished by a retrospective 30-day test. ESRL/GSD will take the lead on this cold-season test, running on the NOAA Zeus research computer. The test will cover a period approximately from 25 Jan – 26 February 2013.

Other activities, some noted more fully under other tasks, also were undertaken:

- Retrospective testing for both RAP and HRRR of the impacts of proprietary in situ tower wind data and other special data continued under funding from the DOE Wind Forecast Improvement Project.
- Biweekly telecons between GSD and the Storm Prediction Center of NCEP continue to be very beneficial. The purpose of these telecons is to obtain feedback from SPC on RAP (RAPv2 from GSD as well as the operational v1) and GSD HRRR-primary performance, to give SPC opportunity to comment on our ongoing RAP and HRRR development work, and to inform SPC of planned Jet and Zeus computer downtimes.

**NCEP**

Version 2 of the Rapid Refresh continues to run in parallel at NCEP. NCEP Production and Backup are now on WCOSS and the platform is expected to be more stable so that the RAPv2 parallel can be sustained and continuous now. The current target date for implementation is December 2013. Initial work to configure the High-Resolution Rapid Refresh (HRRR) on the NCEP WCOSS machine also continues. A very preliminary target for implementation is spring of 2014. (Geoff Manikin)

NCEP parallel PrepBUFR processing for the RAP running in Boulder at GSD has been transitioned to the WCOSS. This includes non-flagged WFIP RASS and SODAR data. Changes were made to allow this processing to run in real-time on the WCOSS development machine as it is not allowed to run on the production machine. (Dennis Keyser)

A pre-implementation briefing for the Q1 FY2014 RTMA upgrade was given to the EMC director. Work to finalize the upgrade code package is underway, with the goal of submitting it to NCO by August 27, 2013. (Manuel Pondeca, Steve Levine)

NSSE system tests on WCOSS were completed and now NSSE can be routinely run on the WCOSS development machine and its results are displayed on the NSSE web **page**. Six HRRR members have been added to NSSE, and many grib2 conversion issues for HRRR files on WCOSS were solved in conjunction with NCO. (Binbin Zhou)

Efforts were made to find out the cause of level2 radar processing job failures during the 17 July production test on WCOSS. Level2 job scripts were modified so that the scripts can exactly repeat the production run if the level2 radar job failures in production. In addition, a few modifications were made to check for potential raw data problems. A “zero” beam check was added to check “zero” values along a beam and reject the beam if too many “zero” values are detected. The “number of beams” check was added to check valid beams at a tilt. If the number is less than 340, the scan at that elevation angle will be rejected. A “VCP number” check was added to check the consistency of the VCP number at different elevations. A “cross-variable” check was added to check the header information for six radar observation variables. If they do not match each other, the data will be rejected. A memory leak was also examined in the whole level2 data processing package, and memory issues in the radar data decoder were fixed. Assistance was given to NCO to set up and monitor the radar production parallel. With WCOSS going “live” on 30 July, the upgraded quality control that uses the new dual-pol fields is now operational. (Shun Liu)

Work to upgrade the GSI in NDAS was begun on the WCOSS computer, using a new GSI version that includes all bug fixes specific to WCOSS and code to use a few new types of observations. The GSI compilation required an update to link to the latest CRTM library and the compilation script needed to be updated to include the new components from the CRTM too. The new CRTM data files should be used when executing GSI. With help from the code manager to fix the compiling and GSI run scripts, the stand-alone GSI job was tested and run successfully on the development side of the new machine. The NDAS parallel scripts are being adapted to run with a limited part of the NDAS parallel suite so that the impact of GSI code changes and use of new types of data can be tested using a relatively small amount of computer resources. (Wan-Shu Wu)

**CAPS**

For the 1-way coupled dual-resolution hybrid cycled analyses and forecasts, the forecast trajectories gradually deteriorate relative to the forecasts from 40-km single resolution run when continuous cycles are run for a period of time. To investigate the effects of 40 km versus 13 km forecasts, we replaced the 13 km dual-resolution hybrid (deterministic) background forecasts at 00 and 12 Z with interpolated 40 km ensemble mean forecasts (hereafter HybridRP) while still using 13 km background forecasts at other times. The forecasting results were compared with those of hybrid1WCtl (40 km 1-way hybrid experiment), hybridIntrp13KM (pure 13km forecasts launched from interpolated 40 km Hybrid1WCtl hybrid analyses) and Hybrid1WD (13 km forecasts from dual-resolution without background forecast replacement). The RMSEs of HybridRP against soundings were lower than those of HybridIntrp13km and Hybrid1WD, but still larger than Hybrid1WCtl. These results further indicate the RMSEs against sounding data tend to exaggerate errors of high-resolution forecasts. which tend to contain small-scale features, and is further supported by the fact that the 13 km forecasts starting from 40 km analyses have higher RMSEs than forecasts on the 40 km grid. The precipitation verifications show, however, that both HybridRP and Hybrid1WD outperform Hybrid1WCtl and HybirdIntrp13km for 0.1 mm/h after 5 hours and 2.5 mm/h for the first 5 hours, indicating benefit of higher resolution analyses on the 13 km using dual resolution for precipitation forecasts.

And during July, CAPS submitted a co-authored paper (Pan et al. 2013) documenting the hybrid performance for a 10-day long testing period. The abstract is reproduced below:

"A coupled EnKF-En3DVar hybrid data assimilation (DA) system is developed for the operational Rapid Refresh (RAP) forecasting system. The three-dimensional ensemble-variational (En3DVar) hybrid system employs the extended control variable method, and is built on the NCEP operational Grid-point Statistical Interpolation (GSI) 3DVar framework. It is coupled with a GSI-based ensemble Kalman filter (EnKF) system for RAP, which provides ensemble perturbations. Recursive filters are used to localize ensemble covariance in both horizontal and vertical within the En3DVar.

The coupled hybrid system is evaluated with 3-hourly cycles over a 9-day period with active convection. All conventional observations used by operational RAP are included. Targeted at potential operational implementation, the hybrid system is run at 1/3 of the operational RAP horizontal resolution or about 40-km grid spacing, and its performance is compared to parallel GSI and EnKF runs using the same data sets and resolution. Short-term forecasts initialized from the 3-hourly analyses are verified against sounding and surface observations.

When equally weighted static and ensemble background error covariances and 40 ensemble members, the hybrid system outperforms corresponding GSI and EnKF. When the RF coefficients are tuned to achieve a similar height dependency of localization as in the EnKF, the En3DVar results with pure ensemble covariance are close to EnKF. With 20 ensemble members, EnKF, GSI and hybrid perform in ascending order, showing the advantage of the hybrid for small ensembles. Two-way coupling between EnKF and En3DVar did not produce noticeable improvement over one-way coupling. Downscaled precipitation forecast skill on the 13-km RAP grid from the hybrid is better than those from GSI analyses. "

The paper is a follow on to our accepted paper (Zhu et al. 2013 MWR) documenting EnKF performance for the same testing period.

Pan, Y., K. Zhu, M. Xue, X. Wang, J. S. Whitaker, S. G. Benjamin, S. S. Weygandt, and M. Hu, 2013: A regional GSI-based EnKF-variational hybrid data assimilation system for the Rapid Refresh configuration: Results with a single, reduced resolution. *Mon. Wea Rev.*, doi**,** Under preparation.

**Additional information on RAP-related tasks**

**ESRL**

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)**.**

**NCEP**

NCEP maintained real-time availability of SAV and AHP 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)

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 and NARRE [-TL] fields are available on **NOMADS** for the CONUS domain on 13 km grid #130 and the Alaska domain on 11.25 km grid #242. RAP fields are also available for 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 A limited set of fields from the RAP runs (and other NCEP models) can also be viewed at **http://mag.ncep.noaa.gov** . (EMC&NCO)

**Verification of RAP**

ESRL's verification of the RAP is available from **http://ruc.noaa.gov/stats**. 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** .

| Deliverables | Delivery Schedule |
|---|---|
| **Task 1 – Improve turbulence guidance from NWP forecasts** | |
| a. Finalize code for RAPv2 for implementation at NCEP (ESRL, NCEP)<br>• Vigorous effort leading complete package with extensive improvements, summary at: http://ruc.noaa.gov/pdf/ESRLRAPHRRRchanges2013.pdf | Mar 2013<br>**COMPLETE** |
| b. Complete the testing of the 40/13 km dual-resolution hybrid DA system for RAP with 3-hourly cycles with conventional data (GSD, CAPS)<br>• Initial work completed by CAPS, testing of further enhancements to system. GSD testing and inclusion in RAPv2 of hybrid system with full observational data, using GFS ensemble data. Milestones exceed. | Mar 2013<br>**COMPLETE** |
| d. Report on early version of RAPv3 primary cycle at GSD with physics enhancements for initialization of the HRRR. (ESRL) | Dec 2013 |
| e. Report on the optimal configurations for including satellite data in the 40/13 km dual-resolution hybrid system to ensure overall positive impacts of the data (NCEP, ESRL) | Dec 2013 |
| f. Finalize RAP version to initialize experimental HRRR for 2014 real-time use toward operational HRRR (ESRL) | Mar 2014 |
| g. Deliver progress report on development of NARRE (NCEP, ESRL) | Mar 2014 |
| h. Deliver progress report on ensemble/hybrid data assimilation for use in NARRE (ESRL, NCEP) | Mar 2014 |
| i. Subject to NCEP Directors' approval, upgrades to observation processing &/or quality control and/or GSI and/or NMMB systems become Operational at NCEP. (NCEP) | Mar 2014 |
| j. Incorporate physics and dynamics improvements from the user community, GSD, and NCEP into WRF for use in the Rapid Refresh system. (NCAR-MMM) | Mar 2014 |

**Task 2: Improve Quality of Convective Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE**

**GSD**

In July, evaluation of the frozen 2013 HRRR continued, with examination of quantitative reflectivity-based verification, qualitative assessment of forecasts fields and solicitation of feedbacks from users (including planned participation on the Aviation Weather Testbed Summer Program in August by Steve Weygandt and Curtis Alexander. Overall forecast improvement in the 2013 HRRR compared to the 2012 HRRR, especially for short lead-time forecasts, is suggested by a number of subjective and objective measures, including the objective reflectivity-based verification. We have examined skill scores for a number of thresholds and neighborhood scales (not shown) and all show improvement of the 2013 HRRR compared to the 2012 HRRR. We note that these results should be interpreted with some caution as the forecast periods are not event-matched. However, the dates within the respective years (2013 and 2012) are matched (June 10 – Aug. 13) and the sample size is large (~ 50 days), which should minimize skill differences do solely to weather differences. Examination of a number of bias measured (not shown) suggests that overall the 2013 HRRR has a slightly higher bias that the 2012 HRRR, which is consistent with ongoing subjective examination of HRRR runs. This is

especially true during the first few forecast hours, consistent with new 3-km radar reflectivity assimilation incorporated into the HRRR for 2013.

An example of the 2013 HRRR skill is shown in a sample 7-h forecast for a convectively active day is shown in Fig. 2 below. As can be seen in the observed radar reflectivity from the Fig. (bottom panel, valid 22z 9 Aug. 2013), a complex pattern of thunderstorm clusters, line segments and more isolated storms occurred across the eastern U.S. on this day. This degree of complexity is not uncommon during the months of June, July and Aug. and illustrates the difficult convection forecasting challenge. The +7 hour HRRR forecast (initialized at 15z) is shown in the top panel. While the HRRR certainly does not capture all the convective features with the correct location, structure and intensity, it does show skill at capturing some many of the observed convective features. As such it illustrates the degree to which convective model guidance can be used to help identify several hours in advance these regions where more concentrated convection will occur.

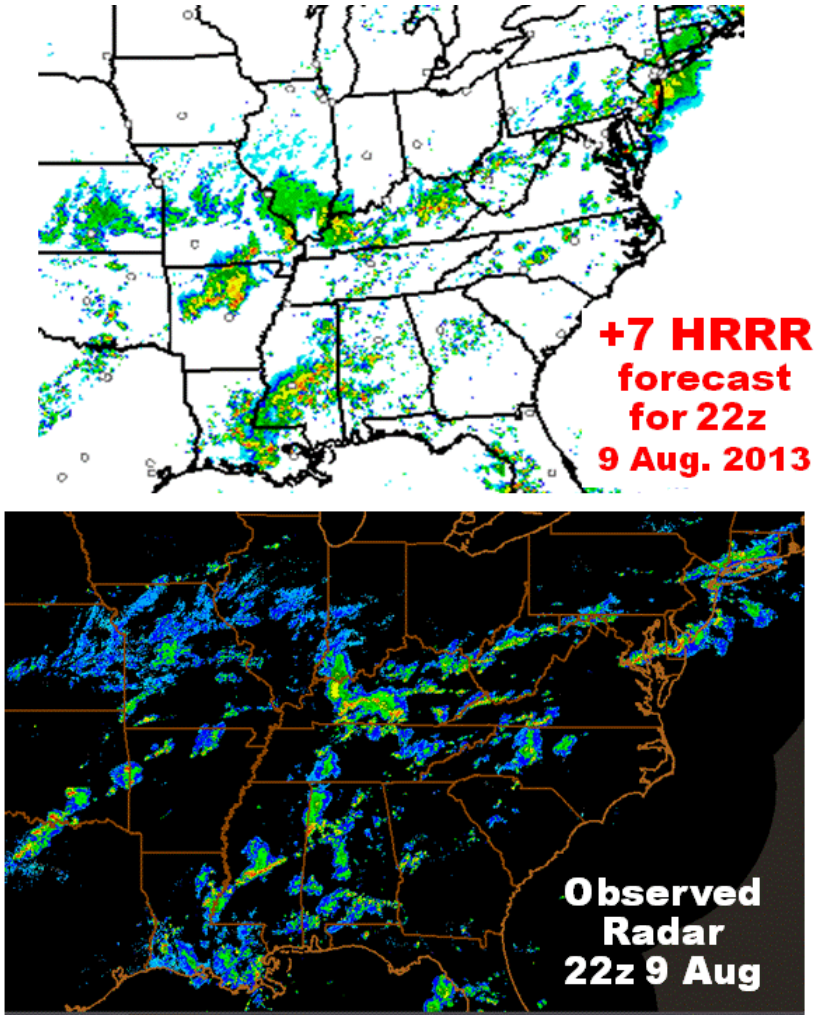


**Figure 2.** ***HRRR 7-h forecast reflectivity (top panel) and observed reflectivity (bottom panel) from 22z 9 August, 2013.***

Major work toward a carefully controlled comprehensive evaluation of the 2013 RAP and HRRR in a retrospective environment continues by Eric James in collaboration with Curtis Alexander and Ming Hu. A 2-week spin-up period has been completed (during the first half of May 2013) and a control run for the last two weeks of May 2013 is underway. Patrick Hofmann continued his work on the 15-min HRRR-based RTMA, converting the scripts and observation feeds from hourly to 15-min. Work also is proceeding to evaluate 3-km assimilation of radial velocity data within the HRRR.

**NCEP**

**NCEP & ESRL**

The computing resources on NOAA R&D machine Zeus are being used by ESRL/GSD to run HRRR, which together with the primary run on Jet comprise a 98.3% reliable source for HRRR. NCEP Central Computing System is being replaced by the Weather and Climate Operational Supercomputing System (WCOSS). WCOSS Phase 1 resources amounting to 65 nodes for the entire 24-hour period have been allocated to HRRR. Scheduling of the HRRR implementation is difficult due to the current issues on WCOSS that have impacted development there. The 'go-live' date slipped to 30 July 2013. It is known that RAPv2 needs to be implemented before HRRR so current emphasis is on a RAPv2 real-time parallel on the development side of WCOSS. A very tentative schedule currently has RAPv2 being implemented in Q1FY2014 (Oct-Nov-Dec) with HRRR being implemented in Q2FY2014 (Jan-Feb-Mar), but these dates have not been confirmed by NCEP Central Operations so they should not be relied upon on nor communicated widely.

| **Deliverables** | **Delivery Schedule** |
|---|---|
| **Task 2 – Improve Quality of Convective Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE** | |
| a. Report on initial tests of 3-km 15-min RTMA cloud / surface analysis for use in frontal diagnostics, CI assessment and other near-surface assessments (ESRL, NCEP)<br><br>• *Good progress toward 3km RTMA and RUA surface and cloud analyses*<br>• *Successful initial tests summarized in report:* **http://ruc.noaa.gov/pdf/GSD_RTMA_report.pdf** | Feb 2013<br><br>COMPLETE |
| b. Incorporate all assimilation and model changes that affect the HRRR into a frozen version of HRRR (and parent Rapid Refresh) for 2013 real-time use (ESRL)<br><br>• *Extensive set of enhancements in place and running in real-time experimental GSD RAPv2 / HRRR system* | Mar 2013<br><br>**COMPLETE** |
| c. Provide preliminary 15-min RTMA surface analyses as experimental improved basis for frontal diagnostics and other diagnostics from surface analyses (ESRL, NCEP)<br><br>**Real-time hourly RTMA restored and showing good results. Work ongoing to automate real-time 15-min. processing of observation files.** | Apr 2013<br><br>**Delayed till August, 2013** |
| d. Report on computing resource status on NCEP Central Computing System, NOAA R&D Site A and NOAA R&D Site B with regards to possible implementation of HRRR (NCEP, ESRL)<br><br>See above discussion concerning ~2014 implementation and Task 4<br><br>HRRR now planned for NCEP operational implementation in Q3 FY14<br>**Delayed till August, 2013** | **June 2013**<br><br>**COMPLETE** |
| e. Complete FY13 internal assessment with revised 3-km HRRR running every hour (ESRL)<br><br>**Assessment ongoing with good results seen for 2013 HRRR in objective and subjective verification** | Sept 2013 |

| Deliverables | Delivery Schedule |
|---|---|
| f. Provide revised 15-min RTMA surface analyses as primary basis for frontal diagnostics and other diagnostics from surface analyses for real-time use in 2014 (ESRL, NCEP) | Feb 2014 |
| g. Finalize all changes to the HRRR for real-time use in 2014 (ESRL) | Mar 2014 |

**Task 3: Improve Quality of Icing Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE**

**GSD**

The RAP physical parameterization configuration resulting from test and evaluation of physics options during the late 2012 – early 2013 period and described in previous reports is also what is being tested now on the NCEP WCOSS computer in preparation for the RAPv2 implementation scheduled for FY2013Q2:

- New 9-level configuration of the RUC land-surface model (RUC LSM)
- Mellor-Yamada-Nakanishi-Niino (MYNN) planetary-boundary- and surface-layer scheme (modified considerably by Joe Olson) in place of the current Mellor-Yamada-Janjic (MYJ) scheme.
- Continue use of the Grell G3 scheme from WRFv3.2.1.
- Continue use the Goddard short wave and RRTM long-wave radiation schemes.
- Use WRFv3.4.1 version of the Thompson microphysics.

The low-level moist bias in the RAPv2 at GSD that was noted during the April-June quarter was indeed reduced by the restoration of the soil temperature and moisture adjustment that had been inadvertently turned off in early April. Recent comparisons with the operational RAP at NCEP have shown that, although a moist bias over the eastern CONUS is often present, it is somewhat less than that of RAPv1. Of some concern is that there often develops a late-morning / early afternoon warm and dry bias over the eastern CONUS in clear regions, whereas over cloudy regions a cool, moist bias is noted. Joe Olson is using the RAP-dev3 cycle to investigate possible hypotheses for this behavior. Despite these issues with temperature and moisture, low-level wind forecasts continue to show substantial improvement over the operational RAP, due to use of the MYNN PBL and surface layer schemes.

Forecasters in the National Weather Service Western Region have called our attention to unexpected forecast wind patterns by the HRRR in the vicinity of small lakes in the western US this summer. This has been traced to the manner in which the high-resolution sea-surface temperature analysis performed by NCEP is interpolated to estimate water temperatures for these lakes… taking the temperature of the nearest large body of water. Anecdotal evidence suggests that this results in assigning a much too cold-water temperature to these lakes, which are often shallow and hence warm by mid-summer. This leads to spuriously strong lake-breeze circulations in daytime. It may be necessary to follow NCEP's example and ignore the presence of these small lakes in the HRRR pending a more satisfactory solution.

Test and evaluation of the Grell-Freitas convective parameterization continues to be temporarily suspended while more urgent concerns (such as the now-solved issues arising from the move to WCOSS as the NCEP production machine in late July, and the aforementioned eastern CONUS temperature and dew point biases) receive attention. We do not anticipate that the Grell-Freitas scheme will be included in the upcoming RAPv2 upgrade.

**GSD requests deferral of Deliverable 3.c (Request for Change for RAPv2 physics) from May to Sept 2013.**
As described earlier under Task 1 efforts, testing is now underway for RAPv2 on the new NCEP WCOSS computer. But this date was inadvertently set too early.

**NCEP**

NCEP/EMC hosted a visit by Greg Thompson of NCAR/RAL from 20-23 May, during which he gave a seminar (20th) and interacted with modelers in the Mesoscale Modeling Branch, the Global Modeling Branch, and the Hurricane Group. Success was achieved in the goal of integrating his cloud microphysics into the NOAA Environmental Modeling

System (NEMS) Nonhydrostatic Multiscale Model on B-grid (NMMB), and establishing a template for coupling his microphysics with the Rapid Radiation Transfer Model (RRTM) radiation package within NEMS. This achievement will allow additional collaborations in the future during which the sensitivity of forecast guidance quality to various cloud microphysics treatments will be examined. (Brad Ferrier)

**NCAR/RAL**

CURRENT EFFORTS: During the month of July, NCAR-RAL completed the analysis of a suite of three-dimensional aerosol sensitivity experiments of the large winter cyclone from 31Jan to 02Feb 2011. We are nearly finished writing a journal article regarding the results using the "aerosol-aware" Thompson et al microphysics scheme. This research was briefly summarized and presented at the American Meteorological Society's 15th Conference on Mesoscale Processes in Portland, Oregon on 8 Aug. A copy of the presentation was provided to AWRP directly by G. Thompson on 12 Aug.

FUTURE EFFORTS: NCAR-RAL will finish the journal paper and submit for publication to AMS as rapidly as possible with a target date of 31 Aug. Then, we will work closely with colleagues at NOAA-GSD to transfer and guide code integration, especially more explicit coupling with their existing WRF-Chem model configuration.

PROBLEMS/ISSUES ENCOUNTERED: Currently we do not foresee any delays, but integration of the aerosol-aware microphysics scheme depends on availability of NOAA-GSD and NCAR-RAL personnel.

INTERFACE WITH OTHER ORGANIZATIONS:
Alison Nugent (PhD student) and Ron Smith, Yale University
Yaitza Luna (PhD student), Howard University
Antonio Parodi, CIMA foundation, Italy

**NCAR/MMM**

**Deliver a WRF Users' Workshop and WRF Tutorial for the User Community**

As reported in the previous report, NCAR organized the 14th WRF Users' Workshop June 24–28, (**http://www.mmm.ucar.edu/events/2013_wrfusers/index.php**). This was given at NCAR's Center Green facility in Boulder on, and the attendance was 220. NCAR gathered participant feedback and will use that in the planning next year's event.

NCAR also organized and delivered a WRF tutorial at its Foothills Lab on July 15–26. This included a basic WRF tutorial, a WRFDA tutorial, a WRF-Chem tutorial, and a WRF regional climate tutorial. Approximately 60 participated, and the tutorial is described at: http://www.mmm.ucar.edu/events/tutorial_137/index.php.

PLANNED EFFORTS: None.

UPDATES TO SCHEDULE: NONE

NCAR began preparation of WRF minor release Version 3.5. This will primarily contain bugfixes and minor updates. The release is expected in August.

Jimy Dudhia (NCAR/MMM) added fixes to the repository in various physics schemes. The packages addressed have been: (i) Tiedtke cumulus scheme, (ii) NSAS cumulus, and (iii) Morrison microphysics (including diagnostic surface snowfall and graupel accumulations).

Dudhia is working with visitor Jose Ruiz-Arias (Univ. Jaen, Spain) on improving surface solar information. He is adding direct-normal and diffuse outputs, while implementing a method to change the solar effect gradually between radiation calls. Dudhia and Ruiz-Arias are ingesting aerosol optical depth (either as a 12-month climatology or as three-hourly analyses using the ECMWF MACC dataset) for use for real-time solar forecasts. Dudhia is also working with Greg Thompson (NCAR/RAL) on how to merge his own aerosol climatology used for the Thompson microphysics package with our methods for radiation.

Dudhia is evaluating QNSE PBL with Peggy Lemone (NCAR/MMM). The scheme shows some issues with too much thermal mixing in stable conditions.

Dudhia is responding to a WRF cold-bias issue noted by DTC in their evaluations, where V3.4.1 and V3.5 have too much surface cooling at night compared to V3.4. This is being examined with Pedro Jimenez (CIEMAT, Spain and Songyou Hong (Yonsei Univ., Korea) visiting), and they suspect that the cold bias in these tests is not coming from the PBL scheme. Other evaluations by Jimenez and Lemone have not shown such behavior, and rather show improved thermal profiles in stable conditions between V3.5 and V3.4. There are indications that switching to the RRTMG radiation scheme will help a large part of this bias, as that warms by 0.5-1°C over the whole day.

For WRF dynamics, Dudhia designed a test version of purely horizontal diffusion (diff_opt=3D2) that would reduce in magnitude in steep coordinate regions. This method may be useful in complex terrain, as it currently is not stable in such conditions. Lastly, in the application of wind-farm modeling, Dudhia and Jimenez have made some suggestions to Joe Olson (NOAA, MYNN PBL developer) on improving his diagnostics for TKE.

PLANNED EFFORTS: The development and incorporation of new physics and dynamics for WRF for the RAP will continue through FY13Q4.

UPDATES TO SCHEDULE: NONE

| **Deliverables** | **Delivery Schedule** |
|---|---|
| **Task 3 – Improve Quality of Icing Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE** | **Delivery Schedule** |
| a. Complete initial evaluation of aerosol-aware microphysics in RAP real-time cycling at GSD for its suitability as part of the RAPv3 prototype for 2014 NCEP implementation (NCAR-RAL, ESRL) | Delay until funding restored to NCAR |
| b. Final model physics code transfer complete to EMC for Rapid Refresh 2 upgrade change package to be implemented at NCEP by spring 2014 (ESRL, NCEP)<br>• Freeze of model physics code for March 2013 version of RAP at ESRL allows this milestone to be met. | Mar 2013<br>**COMPLETE** |
| c. 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 (NCEP, ESRL) | May 2013<br>**Request defer to Sept 2013** |
| d. Transfer upgraded coupled aerosol-microphysics scheme into a test version of HRRR (NCAR-MMM, ESRL) | Dec 2013 |
| f. Finalize microphysics changes and other physics changes to improve icing forecasts for ESRL version of RAP and HRRR for 2014 real-time use (ESRL) | Mar 2014 |
| g. Report summary of icing probability skill measures by quarter for the year. (NCEP) | Mar 2014 |

**Task 4: Develop convection-ATM-specific improvements for guidance from the HRRR (and later, HRRRE) and interact with CoSPA (or other) program partner labs and the FAA**

**Task 4 – Complete implementation of new microphysics for associated reflectivity echo-top diagnostics for 2013 real-time use (ESRL)**

*Current*:

An improved retrieval in GSI of snow hydrometeors from radar reflectivity observations has been tested and will be implemented in the ESRL RAP and HRRR later this year. This improved retrieval will reduce the amount of snow mixing ratio that is specified in very cold regions of the model where low reflectivities are observed. The snow mixing ratio retrieval will be limited to a maximum value of 3 g/kg to avoid excessive snowfall in the model forecast. This change in the retrieval will continue to permit a reversible diagnostic of model reflectivity in WRF from the hydrometeors that both matches the observed reflectivity and is consistent with the model microphysics scheme (Thompson) used in the RAP and HRRR.

A format change in the radar reflectivity observational data feed received at ESRL from NSSL for use in the ESRL RAP and HRRR radar reflectivity data assimilation and forecast verification was implemented on 30-31 July. Efforts are underway to adapt the ESRL RAP and HRRR radar data assimilation pre-processing code and forecast verification code to the new format reflectivity, VIL and echo tops. A feed of legacy format radar data was established to maintain continuity of radar data assimilation in the ESRL RAP and HRRR until the new format can be used.

A new retrospective period from 15-31 May 2013 has been established to begin evaluation of model and data assimilation changes for the 2014 version of the ESRL RAP and HRRR. A control run for the retrospective period is underway using the 2013 ESRL RAP and HRRR versions but also includes an adjustment in soil temperature and moisture that was not available during the real-time runs in early May 2013.

*Planned*:
We plan to complete the transition to the new format radar reflectivity data feed for both the ESRL RAP and HRRR radar data assimilation and forecast verification.

Evaluation of ESRL RAP and HRRR model and data assimilation changes will be conduced using the 15-31 May 2013 retrospective period. An evaluation of the latest Thompson microphysics scheme in WRF-ARW version 3.5.1 will be conducted including testing and calibration of the associated reflectivity, VIL and echo top diagnostics.

**Task 4 – Assess HRRR reliability and provide monthly reporting (ESRL)**

**HRRR Reliability for 0-8 Hour VIL/Echo Tops for July 2013**

**Jet**
All runs: 96.4%
**3 or more consecutive missed runs: 98.9% (most meaningful for CoSPA)**
6 or more consecutive missed runs: 99.9%
3 outages of at least 3 hrs. or longer
1 outage of at least 6 hrs. or longer

**Zeus**
All runs: 84.5%
**3 or more consecutive missed runs: 90.7% (most meaningful for CoSPA)**
6 or more consecutive missed runs: 93.8%
11 outages of at least 3 hrs. or longer
5 outages of at least 6 hrs. or longer

**Combined (Jet or Zeus)**
All runs: 98.0%
**3 or more consecutive missed runs: 99.1% (most meaningful for CoSPA)**
6 or more consecutive missed runs: 99.9%
3 outages of at least 3 hrs. or longer
1 outage of at least 6 hrs. or longer

**Task 4 – Complete implementation of refined SatCast assimilation for HRRR for real-time use in 2014**

Tracy Smith ported SatCast assimilation code (previously developed for use with the RUC analysis) from the RUC to the RAP (GSI package). The code ingests SatCast IR cloud-top cooling data and maps it into a local heating function that is applied to the RAP fields in a similar manner to the way the RAP assimilates radar reflectivity data. Using a sample IR cloud-top cooling rate data set from a convectively active period of 5-11 July 2012, she has now completed the 5-day

retrospective experiment (control run without the SatCast data and experiment with the SatCast data). Preliminary results indicate that for a scattered thunderstorm situation over the Southeastern U.S., assimilation of the SatCast IR cooling rates leads to a better short-term prediction of small-scale convective systems. Further work is ongoing to adjust the strength of the retrieved latent heating rates.

**Task 4 – Interact with CoSPA (or other) program partner labs and the FAA**

Team (ESRL/GSD, NCAR/RAL, and MIT/LL) telecons and e-mail correspondence have and will continue to occur to discuss issues related to the HRRR reliability including scheduled outage periods during the CoSPA 2013 season. An informal discussion with MIT/LL on assessing the HRRR from an air traffic control perspective is planned for late August.

| **Deliverables** | **Delivery Schedule** |
|---|---|
| **Task 4 – Develop convection-ATM-specific improvements to guidance from the HRRR (and later, HRRRE) and interact with CoSPA (or other) program partner labs and the FAA** | |
| Complete implementation of new microphysics for associated reflectivity echo-top diagnostics for 2013 real-time use (ESRL)<br>• Code for revised echo-top / reflectivity diagnostics with revised microphysics implemented in GSD real-time HRRR. | Mar 2013<br>**COMPLETE** |
| Conduct baseline testing of the early 2013 HRRR version (ESRL)<br>• Baseline testing of 2013 HRRR version completed as part of code preparation for freeze. Summary of skill score improvements being prepared. | Mar 2013<br>**COMPLETE** |
| Report on evaluation of new microphysics scheme and associated echo-top and reflectivity diagnostics in ESRL/GSD RAP and HRRR (ESRL)<br>• *Preliminary evaluation completed and summarized in report:*<br>**http://ruc.noaa.gov/pdf/GSD_reflectivity_report.pdf** | Mar 2013<br>**COMPLETE** |
| Assess HRRR reliability and provide monthly reporting (ESRL)<br>Reliability statistics are being reported each month | *Apr 2013*<br>**COMPLETE** *(ongoing)* |
| Report on evaluation of revised WRFv3.4 microphysics for RAP/HRRR for its effects on echo-top and reflectivity in ESRL RAP/HRRR (ESRL) | Mar 2014 |
| Complete implementation of new microphysics for associated reflectivity echo-top diagnostics for 2014 real-time use of HRRR (ESRL) | Mar 2014 |
| Complete implementation of refined SatCast assimilation for HRRR for real-time use in 2014 (ESRL) | Mar 2014 |
| Report on 2014 baseline testing of the HRRR (ESRL) | Mar 2014 |