MDE Product Development Team
(Based on Work Plan for 12-month Period from 1 April 2014 through 31 March 2015)
FY14 3rd Quarter Report
Submitted 15 July 2014

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

Executive Summary

Task 1: Improve Turbulence Guidance From NWP Forecasts From RAP, HRRR, NAM, NAM-Nests And, Eventually, NARRE And HRRRE

- Operational RAPv2 continues to run reliably at NCEP.
- RAPv3 and HRRR code frozen for 2014 warm season exercise at beginning of quarter. Strong effort to isolate and eliminate daytime warm-season warm / dry bias.
- Development continues for further assimilation and model improvements in RAP.
- Results of test of initial pre-NARRE 8-member ensemble (4-NMMB, 4-ARW) retrospective experiment very encouraging.

Task 2: Improve Quality Of Convective Weather Forecasts From RAP, HRRR, NAM, NAM-Nests And, Eventually, NARRE And HRRRE

- HRRR performed particularly well in many convection cases this quarter.
- New RAPv3 showing much less night-time cold bias over snow than operational RAPv2.
- Continued work at GSD on warm and dry daytime bias in 2-m temperature and dew point in prefrontal southerly flow in RAPv3, with tests focusing on adding temperature pseudo-innovations, modifications to forward model for surface temperature assimilation, and sub-grid-scale shallow cumulus parameterization.

Task 3: Improve Quality Of Icing Weather Forecasts From RAP, HRRR, NAM, NAM-Nests And, Eventually, NARRE And HRRRE

- Extensive set of the physics changes, along with data assimilation and other model improvements to both the RAP and HRRR forecast systems were implemented for the 2014 warm season evaluation as summarized in the following report: **http://ruc.noaa.gov/pdf/ESRLRAPHRRRchanges2014.pdf.**
- Initial successful tests run made at GSD within Rapid Refresh of aerosol-aware microphysics scheme from NCAR (Greg Thompson) within WRFv3.6.
- Initial tests also made within RAP of improved lake surface temperatures through WRF CLM (Community Land Model) lake model also within WRFv3.6.

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

- GSD froze all data assimilation and model changes for ESRL RAPv3/HRRRv2 as of 10 April 2014 on Jet and Zeus. The ESRL RAPv3/HRRRv2 changes will be implemented at NCEP in 2015.
- The real-time frozen ESRL RAPv3/HRRRv2 system will continue to run with gridded field dissemination during the CoSPA season that began on 17 April 2014 and will run until 01 October 2014.
- ESRL HRRR "failover" capability to use feed from Zeus instead of Jet during Jet downtime continues to work.
- ESRL HRRR output format changes for alignment with the NCEP HRRR operational implementation will be coordinated with COSPA program partner labs**.** A final CoSPA planning telecon was held on 07 April 2014 with the partner labs and the FAA to provide more detailed information regarding the ESRL HRRRv2 changes implemented on 10 April 2014.
- Initial discussion with MIT/LL regarding a capability to provide hourly updated vertically integrated liquid and echo top estimates from the ESRL RAP for oceanic regions outside of the HRRR domain.

Task 1: Improve Turbulence Guidance From NWP Forecasts From RAP, HRRR, NAM, NAM-Nests And, Eventually, NARRE And HRRRE

Improving turbulence forecast quality involves efforts to improve initial conditions for the RAP and NAM (and HRRR and NAM Nest models) 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 RAPv3 toward 2015 implementation at NCEP, incorporating changes developed in 2013 and early 2014
- Development of RAPv4 toward 2016 implementation at ESRL and subsequent implementation at NCEP. (Note, some improvements from RAPv4 will be thoroughly tested in all seasons and included in the RAPv3/HRRRv2 package for 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 RAPv2 continues to run well in NCEP operations, without any model or post-processing issues during May.

The RAP web page **http://rapidrefresh.noaa.gov** was updated with information on the operational RAPv2 configuration including a February 2014 NWS webinar ppt on RAPv2 - **http://ruc.noaa.gov/pdf/RAPv2-NWSwebinar-18feb2014-FINAL.pdf.** A link to the RAPv2 Technical Implementation Notice is there also. A webpage on RAP output grids from NCEP is at **http://ruc.noaa.gov/rr/RAP-NCEP-output-grids.html.**

RAPv3 model testing and evaluation
After intensive development, testing and evaluation during the January – March quarter, changes were made to the warm-season RAPv3 configuration in the RAP-primary cycle at GSD on 5 April. This cycle continues to drive the HRRR-primary running at GSD in support of the 2014 warm-season exercise. We expect to keep this cycle frozen through 30 September 2014. A summary of the upgrades from RAPv2 going to RAPv3 (and HRRRv2) has been published on the web **http://ruc.noaa.gov/pdf/RAPv3-HRRR-April2014.pdf** with a more detailed description available at **http://ruc.noaa.gov/pdf/ESRLRAPHRRRchanges2014.pdf**. Except as discussed below, this version has been running well, with a substantially reduced nighttime cold bias in the forecast, particularly over snow cover, relative to that of the operational RAPv2. (See FY2014 Q2 report, Task 3 for changes made to mitigate this cold bias.)

During the quarter, and particularly after 1 May, an increasing daytime warm and dry forecast bias became evident east of the Rockies under conditions of mostly clear skies and low-level southerly flow with dry soil conditions. The evidence for this was apparent both using the ongoing daily RAP verification and visual inspection of forecasts. We also received feedback on this from the Storm Prediction Center and others. This is not a new problem; the RAPv3 performance in this regard is, in fact, slightly better than for the RAPv2 now running at NCEP. Nevertheless, the Storm Prediction Center, in particular, regards this as a serious issue and it came under intensive investigation by GSD during the quarter. This appears to be a many-faceted problem, including both physics (see Task 3) and, to a lesser extent, data assimilation. Related to this, when there is a southern-plains dry line, the dry line position often tends to be slightly too far east. As discussed under Task 3, we are pursuing several leads toward ameliorating, if not eliminating this deficiency, and we are optimistic that this daytime warm / dry bias issue will be resolved before we must port the RAPv3 code to NCEP in October.

Tanya Smirnova has nearly completed merging WRFv3.6+ (i.e., an NCAR WRF repository version from early June with several bug fixes from the original WRFv3.6 release in April) with GSD enhancements not yet in the WRF repository. A retrospective comparison of v3.6 with the current v3.5.1 will be conducted to validate that v3.6+ is ready for testing with physics upgrades, including the NCAR aerosol-aware microphysics (Task 3). This early testing of a new WRF release is a departure from the practice in previous years due to the October 2014 deadline (Task 1 deliverable E4) for having RAPv3 and HRRRv2 code ready for transfer to NCEP. This code transfer will also include merger of a new GSI release with RAPv3 upgrades by Ming Hu.

NARRE-related activities

Major progress in May-June - Now that GSD has successfully run the NMMB on Zeus, including the same version of the Unified Postprocessor (UPP) as used in the RAP, Isidora Jankov (GSD-AMB) has completed testing a preliminary ensemble configuration using both ARW and NMMB cores on retrospective cases. There are 4 NMMB members and 4 ARW members running over the RAP domain. The members are initialized from the Global Ensemble Forecast System (GEFS), either from the GFS control member (one member from each core, or from particular GEFS members (the other 3 members from each core). The ARW members have different physics configurations as well. Examination of the forecast ensembles resulting from this testing is very encouraging, showing desirable properties regarding reliability (verification falls mostly within the range of solutions provided by the ensemble) and ensemble spread.

Presentations relating to RAP, HRRR and NARRE were made at the 15th Annual WRF Users Workshop in June at NCAR in Boulder by Steve Weygandt (RAP / HRRR update), Isidora Jankov (NARRE), and Joe Olson (ongoing work on parameterization of shallow convection with Georg Grell), and at an ancillary land-surface processes meeting (organized by Michael Ek of NCEP), by Tanya Smirnova (RUC land-surface model updates).

Subtasks

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

There were no issues with the RAP in June (or during the quarter). More pieces of the HRRR were handed off to NCO in June to help build their test system, which will become the official parallel for an August field evaluation. As of the end of June, the system is running nearly end-to-end on WCOSS each hour in test mode. There have been some issues with configuring the model to fit within its allotted time slot and resources, but significant progress was made in June. (Manikin, Keyser)

14.5.1.2 28 July 2014 **(NCEP, ESRL & CAPS)**
Groups collaborate on developing and testing best approaches for use of hybrid/ EnKF/3DVAR and 4d-ens-var within common GSI coding structure.

Several bug fixes related to running the cloud analysis for the NMMB were committed to the GSI repository. One fix led to an occasional 50% increase in processing speed when running the GSI on Zeus. A second fix allowed the background to be updated with the analysis increments, allowing many more observations to be assimilated. A third fix eliminated GSI failures when writing out the cloud analysis fields to NMMB restart files. The last two bugs were introduced in recent non-NCEP changes to the GSI repository. (Carley, Wu, Parrish)

ESRL

GSD (Ming Hu) is preparing a new GSI repository from which MDE research partners (GSD, EMC, CAPS, OU, others) will check out common software for regional ensemble data assimilation toward NARRE. This will be completed after Ming's leadership at the GSI Tutorial in July.

Ming Hu performed new experiments in April for different localization options for the hybrid/EnKF data assimilation for the RAP. He found that the current configuration, although with relative small localization scales, seems to produce equal or optimal results.

NCEP

Work has not begun as of May. (Carley, Wu, Parrish)

14.5.1.3 30 Sept 2014 **(CAPS, GSD, EMC)**
Test and evaluate direct radial velocity and reflectivity data assimilation within the 40-20km/13km dual resolution hybrid system. (Resolution dependent on computing resources)

CAPS

For FY2014, development works at CAPS for direct assimilation of radar data in the EnKF and hybrid systems will be limited (most of this work was proposed under plan B for FY2014 which was not funded). In June, initial efforts were made at CAPS implementing direct reflectivity assimilation capabilities in the GSI hybrid system, including adding reflectivity

observation operator that consider ice phases into the hybrid GSI cost function. New hydrometeor state variables were also added. Testing will start soon.

EMC

NAM retrospective scripts were modified in June to investigate the impact of a cold bias that developed in the forecasts after using the digital filter initialization (DFI) temperature tendencies (DFI_TTEN). A suitable setting for the magnitude of the DFI_TTEN was found to reduce the cold bias for two recent cases. Parallel runs using the DFI_TTEN also showed improved 3-h precipitation forecasts compared to the pre-implementation NAMX parallel system. (Liu, Carley)

14.5.1.4 1 Jan 2015 **(ESRL, CAPS)**
Test the 40/13 km dual-resolution system with hourly DA cycles including all observation types, including radar reflectivity data via cloud analysis and DDFI.

14.5.1.5 28 Feb 2015 **(NCEP, ESRL & NCAR)**
Groups collaborate on developing and testing physics schemes between WRF and NEMS' physics layer.

NCEP
NEMS 12-km test runs were used to debug changes made to an experimental version of the Ferrier-Aligo (F-A) microphysics, which included the addition of a new ice category (frozen drops/"hail"). Many different versions of the scheme were tested, with errors and algorithmic limitations debugged using detailed diagnostics included within the microphysics. These simulations were followed up with multiple 4-km runs of the June 2012 derecho, which identified more changes that need to be made to the microphysics based on cross sections and analysis provided by Eric Aligo. The first part of a paper describing the F-A microphysics was drafted and is under review by all the authors. Several NMMB codes were changed to address failures when the model was run with traps and other error checks turned on. The HiResWindow developer was provided with different versions of the WSM6 microphysics, with modified processes affecting the formation of graupel. The result of this work is reported in subtask 14.5.4.E2. (Ferrier, Aligo, Jovic)

GSD

GSD successfully tests a preliminary NARRE configuration testing ARW with RAP and NAM-like physics and also with NMMB using NAM physics, and will next expand the NMMB options including the Thompson MP scheme.

14.5.1.6 28 Feb 2015 **(NCEP)**
Complete testing of improved or extended 88D processing and quality control, taking advantage of dual-pol where possible.

In June the processed data was successfully ingested in real-time parallel runs, and so the modified radar decoder code will soon be submitted for operational implementation. (Liu)

14.5.1.7 15 Mar 2015 **(ESRL, CAPS, NCEP)**
Complete readying of initial regional ensemble data assimilation capability to initialize real-time parallel RAP version and NAMRR.

NCEP
The diurnal reject lists for surface observations, developed by the RTMA group and used in the upcoming regional implementation, were also used in NAMRR system, which resulted in more data being used. There was a big update to the GSI repository that contained significant structure changes by GMAO group. Following the update, there were several bugs found and fixed in regional model. The number of vertical levels for the NMM pressure levels in met-guess input and for TV in-state tendencies were changed. The call to a subroutine was moved forward so that a variable defined in the subroutine can be used later in the code. Another undefined logical variable causing the job to fail on WCOSS when an MPI read was initiated was found and fixed. Changes were made to the NAMRR in June to streamline processing. (Carley, Wu, Parrish)

14.5.1.8 28 Mar 2015 **(NCEP and ESRL)**
Negotiate Data Mining List priorities with NCEP Central Operations and external points of contact associated with the most desirable new sources of observations.

NCEP

No new items were requested so Data Mining List remained unchanged. (Keyser, Whiting).

GSD

New agreements with energy companies for use of their proprietary tower and nacelle wind data were drafted in May by GSD and coordinated with NWS. This proprietary wind data is already on the DML.

14.5.1.9 31 March 2015 **(NCEP)**
Establish a pre-implementation version of the hourly updated NAMRR with a goal to use the common regional ensemble data assimilation.

No work was done in May or June. (Carley)

Deliverables

All Option A unless noted otherwise.

14.5.1.E1 10 April 2014 **(ESRL)**
Finalize RAPv3 and HRRRv2 for summer 2014 real-time exercise.

COMPLETE. A summary of the spring 2004 RAPv3 and HRRR v2 configurations has been published on the web at **http://ruc.noaa.gov/pdf/ESRLRAPHRRRchanges2014.pdf**

14.5.1.E2 31 May 2014 **(NCEP)**
With approval of NCEP Director, NAMv3.1 upgrade package is implemented at NCEP.

NCO in started the pre-implementation parallel mid-May, with the official 30-day evaluation scheduled to begin in early June. (Rogers)

14.5.1.E3 30 July 2014 **(NCAR/MMM)**
Deliver a WRF Users' Workshop and a WRF tutorial for the user community.

NCAR conducted the 2014 WRF Users' Workshop June 23–27 at its Center Green facility. There were 221 registrants. The workshop included a lecture series on WRF modeling best practices, followed by three days of talks on developments and applications, modeling area group discussions, and a poster session. The last day offered mini-tutorials on MPAS, WRF-Hydro, NCL, VAPOR, and LAPS. Among the many presentations were those from GSD by Steve Weygandt on the RAP/HRRR, by Joe Olson on updates and research for the MYNN PBL scheme (used in the HRRR and RAP), Tanya Smirnova on latest changes to the RUC land-surface model, and posters by Georg Grell (WRF-Chem) and Isidora Jankov (pre-NARRE experiment).

NCAR/MMM is planning the next WRF tutorial. This will be held July 21–August 1 at NCAR. It will include a basic WRF tutorial, a WRF -DA tutorial, a WRF regional climate tutorial, and a WRF-Chem tutorial.

PLANNED EFFORTS: NCAR will host and conduct a WRF tutorial July 21–August 1, 2014.

UPDATES TO SCHEDULE: NONE

14.5.1.E4 20 Oct 2014 **(ESRL)**
Code for RAPv3 and HRRRv2 finalized for transfer to NCEP/EMC for 2015 implementation.

Progress has been steady with testing having started with WRFv3.6, earlier in the year than GSD has done previously with the annual WRF release. This includes testing of aerosol-aware cloud microphysics as described in more detail under Task 3. Merger of WRFv3.6+ with RAP / HRRR enhancements is nearly complete and real-time testing will start soon.

14.5.1.E4.1 31 Mar 2015 **(ESRL)**
Report on wind accuracy from RAP and HRRR by quarter for previous year, strongly related to turbulence guidance.

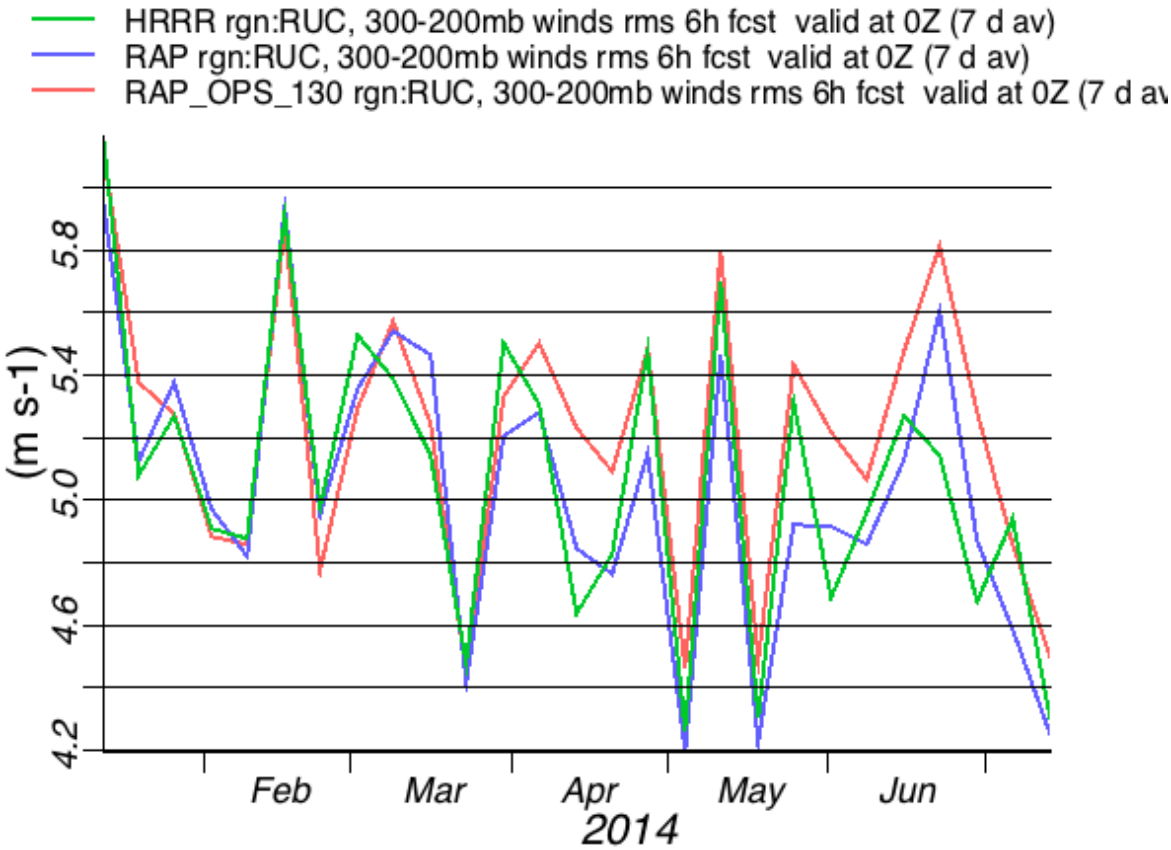

Figure 1: Upper-level (300-200 hPa) wind forecast RMS vector error vs. raobs for 6h forecasts from RAPv3 (ESRL, in blue), RAPv2 (NCEP, in red), and HRRR (ESRL, green). All scores are from native gridded data, not from isobaric coordinate data and show 7-day averages for forecasts valid at 00z. Units – m/s.

An initial look at upper-level 6h forecast wind accuracy over the last 6 months shows relatively similar wind accuracy between the operational RAP (red), ESRL RAP (blue), and ESRL HRRR (green) as shown in Fig. 1. After the introduction of RAPv3 and HRRRv2 in the ESRL runs in early April, those updated runs are generally showing improved wind forecast skill over that from the NCEP RAP (red). This also implies that turbulence guidance, heavily dependent on upper-level wind forecast accuracy, has also been improved from this update. Details on the RAP-HRRR updates in early April 2014 are described in **http://ruc.noaa.gov/pdf/RAPv3-HRRR-April2014.pdf** and **http://ruc.noaa.gov/pdf/ESRLRAPHRRRchanges2014.pdf**. Verification against aircraft observations is also shown in Fig. 2 but only for the ESRL RAP (changing from RAPv2 to RAPv3 in early April). In future months, results from the NCEP RAP and HRRR models will be added to allow comparison for winds vs. aircraft observations.

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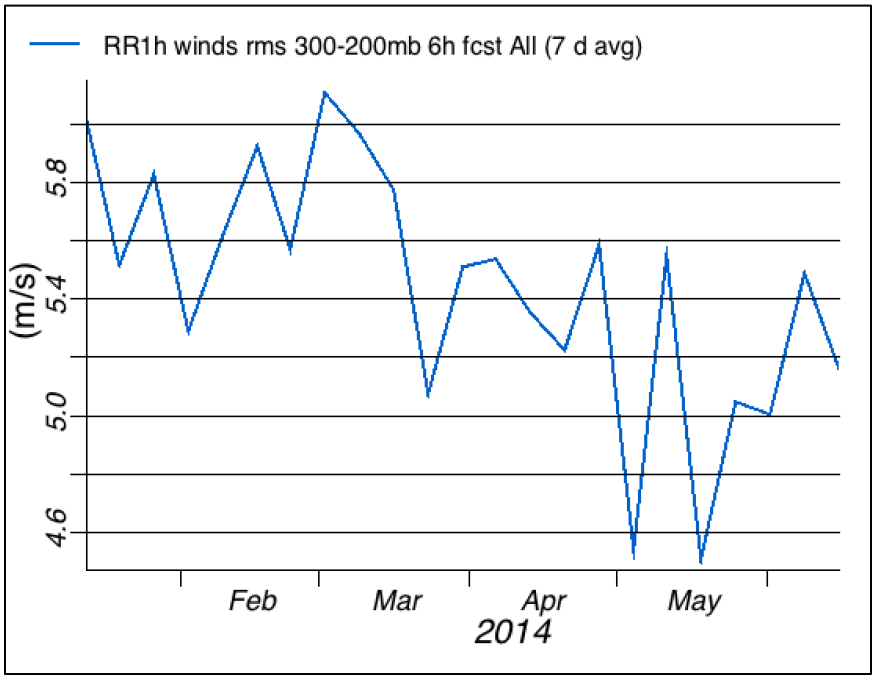

Figure 2: Upper-level (300-200 hPa) wind forecast RMS vector error vs. aircraft for 6h forecasts from RAPv3 (ESRL, in blue). Units – m/s.

14.5.1.E5 31 Oct 2014 **(ESRL, CAPS, NCEP)**
Complete the testing of the 40-20/13 km dual-resolution hybrid DA system for RAP with 3-hourly cycles with conventional data.

CAPS

In June, Gang Zhao of CAPS worked on verifying and analyzing the results from 40-km coupled hybrid GSI-EnKF system for RAP on Zeus with test data during 20100507-20100517. The results are consistent to the results made by Drs. Kefeng Zhu and Yujie Pan. Next, the new test data of summer 2013 will be used.

NCEP
No work was done this quarter. (Carley)

GSD

GSD has tested localization options for the GFS-ensemble-based covariances for the 40km hybrid DA system for RAP. GSD is also setting up a GSI repository for use for common GSD-NCEP-CAPS experimentation for hybrid ensemble data assimilation development.

14.5.1.E6 20 Dec 2014 **(ESRL)**
Report on RAPv3 model and data assimilation configuration and progress. This will include a report on wind verification and its improvements in RAPv3 vs. RAPv2.

14.5.1.E7 31 Jan 2015 **(ESRL and NCEP)**
Finalize code for RAPv3 to NCO for implementation at NCEP.
The RAPv3 code being tested by ESRL will not be given to EMC until after the HRRR implementation. (Manikin)

GSD

GSD is carefully evaluating RAPv3 performance as described in the general information under Task 1 above. A set of further changes anticipated as possible for fall changes to the ESRL RAP code before transfer to NCEP for the final NCEP-RAPv3 configuration has been established. This set includes WRFv3.6, aerosol-aware microphysics, and improvements to GSI data assimilation including treatment of surface observations and assimilation of cloud and radar data.

NCEP

14.5.1.E8 31 Jan 2015 **(ESRL, NCEP)**
Pending NCEP computer readiness and EMC and NCEP initial recommendations, Requests for Change (RFCs) are filed to submit code changes as part of upgrade for RAP v3 software to NCO.

NCEP

This work will not begin until after the HRRR implementation. (Manikin)

14.5.1.E9 31 March 2015 **(NCAR/MMM)**
Incorporate physics and dynamics improvements into WRF from the user community, GSD, and NCEP for use in the RAP and HRRR. Oversee code preparation and integration of these improvements into the WRF repository for future model version releases and FAA use. Assist in the implementation of bug fixes. In collaboration with GSD, assist in the development and evaluation of physics schemes for the RAP and HRRR that are contributed to the ARW.

NCAR released WRF Version 3.6 on April 18, 2014. This major release contained WRFDA 3.6, as well as updates to WPS, HWRF, and WRF-Chem. The preparation work is described in the previous quarterly report. Details of WRF V3.6 may be found at: **http://wrf-model.org/users/release.php**.

Jimy Dudhia (NCAR/MMM) and Ming Chen (NCAR/MMM) investigated and corrected an issue with the Penn State shallow convection scheme. The problem appeared in differences in results from serial and parallel runs, and they passed the fix back to Penn State. The scheme was modified to standardize a 3D array, which allows its output and use in restarts. Dudhia and Chen resolved blow-up issues for 20-km tests. This scheme is being prepared for a future WRF release.

Dudhia and Jim Bresch (NCAR/MMM) continued working on the WRF option for diffusion along horizontal surfaces in complex terrain. They developed formulations for diffusion in steep terrain gradients with this option and are testing a deformation-dependent component. The improved version of the diffusion option is expected for release in V3.6.1.

Dudhia and Pedro Jimenez (NCAR/RAL) tested a new oceanic surface roughness formulation, evaluating it via verification of WRF forecast winds with ocean wind energy site observations. Their work recommends a new roughness length formulation for shallow seas. Development is ongoing. Dudhia and Jimenez (NCAR/RAL) also set up WRF-Solar to ingest aerosol information. They are checking on whether ESRL's RAP-Chem output can be used to provide sufficient information to the aerosol-aware version of the Thompson microphysics scheme, as well as optical depth information for the RRTMG radiation scheme.

Dudhia worked with NCAR visitors Liduin Burgering (Wageningen Univ., Netherlands), and Esa-Matti Tastula (Univ. of South Florida). Burgering is doing surface evaluations of WRF performance at Cabauw site in Netherlands, and Tastula is evaluating the QNSE-EDMF scheme for simulation of the daytime PBL.

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

UPDATES TO SCHEDULE: NONE

14.5.1.E10 31 March 2015 **(ESRL and NCEP)**
Deliver progress report on development of NARRE.

NCEP

WPC was provided with the new products from the NCEP Convection-Allowing Ensemble (NCASE) for their Flash Flood and Intense Rain (FFaIR) experiment. The ensemble product generator was modified to make SREF-like products from the GEFS out to 240 hours. (Du, Zhou, Yang, Jovic)

Deliverables **Task 1: Improve Turbulence Guidance From NWP Forecasts**	**Delivery Schedule**
A. Finalize RAPv3 and HRRRv2 for summer 2014 real-time exercise.	APR 2014 **COMPLETE**
B. Code for RAPv3 and HRRRv2 finalized for transfer to NCEP/EMC for 2015 implementation. **Strong progress toward this at GSD through RAPv3/HRRRv2 current real-time evaluation.**	OCT 2014
C. Complete the testing of the 40-20/13 km dual-resolution hybrid DA system for RAP with 3-hourly cycles with conventional data.	OCT 2014
D. Report on RAPv3 model and data assimilation configuration and progress. This will include a report on wind verification and its improvements in RAPv3 vs. RAPv2. **Preliminary RAPv3 configuration already available in http://ruc.noaa.gov/pdf/RAPv3-HRRR-April2014.pdf.**	DEC 2014
E. Finalize code for RAPv3 to NCO for implementation at NCEP.	JAN 2015
F. Report on wind accuracy from RAP and HRRR by quarter for previous year strongly related to turbulence guidance. **Initial evaluation on wind accuracy from RAP and HRRR vs. raobs and aircraft observations has been started and included in this monthly report.**	MAR 2015
G. Requests for Change (RFCs) filed to submit code changes as part of upgrade for RAPv3 software to NCO.	MAR 2015
H. Deliver progress report on development of NARRE.	MAR 2015

Task 2: Improve Quality Of Convective Weather Forecasts From RAP, HRRR, NAM, NAM-Nests And, Eventually, NARRE And HRRRE

Subtasks

14.5.2.1 15 April 2014 **(GSD)**
Report on enhancements to RAP 13-km and HRRR 3-km radar data assimilation for beginning 2014 warm-season evaluation using the ESRL-updated version of the HRRR (i.e., HRRRv2).

COMPLETE: As reported in the April 2014 MDE report:
Following extensive testing and evaluation, a RAP/HRRR change bundle was made in late March 2014. The package includes changes to both the data assimilation and model portions of both the RAP and HRRR forecast systems and is summarized in the following report: **http://ruc.noaa.gov/pdf/ESRLRAPHRRRchanges2014.pdf**

The testing involved single-case study experiments, retrospective evaluations, and real-time parallel cycles of individual changes and grouping of changes to check all aspects of the change bundle. The change bundle was a mix of addressing known issues and adding new capabilities. Highlights of the change bundle for the RAP include enhancements to the hybrid data assimilation and the cloud analysis, improvements in the snow cycling and dew point assimilation, and upgrades to the Grell-Freitas (GF) cumulus parameterization and the MYNN planetary bounder layer scheme. Highlights for the HRRR include most of the RAP enhancements plus adding a hybrid assimilation procedure and adjustments to the strength of the reflectivity-based diabatic heating. Also, both the WRF model and GSI analysis were updated to the latest community repository versions.

Statistical evaluation of both the RAP and HRRR retrospective and real-time parallel runs showed broad improvement in nearly all aspects (upper-air, surface, precipitation, reflectivity, etc.). Real-time performance has been good, though evidence of a warm, dry bias has been seen for pre-frontal, southerly flow regions. A variety of aspects related to this are being investigated in off-line, retrospective, and real-time parallel tests, including partial cloudiness, radiation and land surface model issues, and surface temperature assimilation factors. Specific data assimilation changes include creation of pseudo-innovations to the 1h forecast depth of the PBL (planetary boundary layer) for surface temperature

observations (similar to the pseudo-innovation created for surface dew point observations) and modification to the forward model for surface temperatures.

14.5.2.2 15 May 2014 **(GSD)**
Improved (optimized weight factors, and observation selection) 15-min HRRR-based RTMA.

Request for Delay to 1 Sept 2014.
A key scientist to work on this task left GSD for another position in March. There has been some experimentation done on improved observation selection for the HRRR-based RTMA but more work will be done before the new requested due date. Experiments will also examine the run time for 15-min RTMA analysis with goal of reducing it to near 10 min.

14.5.2.3. 5 August 2014 **(GSD)**
Complete testing of updated version of 3-km sub-hourly radar assimilation within HRRR pre-forecast cycling period.

Testing continues, though highest priority is on RAP warm, dry bias. Changes were made for 2014 warm season evaluation, resulting in reduction of high bias during first few HRRR forecast hours.

14.5.2.4 20 Oct 2014 **(GSD)**
Complete 2014 HRRR summer evaluation using modeling and assimilation modifications determined in 2013 exercise. Collaborate on analysis of HRRR tests and deliver summary of results.

14.5.2.5 15 Dec 2014 **(GSD)**
Based on 2014 RAP and HRRR results, provide update report on development and testing of data assimilation and model enhancements important for improving forecasts of convective weather within the RAP and HRRR.

14.5.2.6 5 Dec 2014 **(GSD)**
Single-case test of storm-scale ensemble data assimilation completed for HRRR over small Northeastern U.S. domain.

14.5.2.7 15 March 2015 **(NCEP)**
Establish routine verification of NCEP suite of convective weather guidance and begin design of calibration strategy for ensemble systems.

No work was done in June. (Zhou, Du, Yang, Shafran)

Deliverables

14.5.2.E1 1 August 2014 **(NCEP and ESRL)**
HRRRv1 implemented at NCEP pending available computing resources.

NCEP and ESRL

ESRL

Request for Delay until 30 Sept. 2014

HRRRv1 implementation currently scheduled for 16 Sept. 2014.

Extensive code optimization work by Geoff Manikin and Curtis Alexander (with assistance Ming Hu and from NCEP computer experts) has reduced total run time for the HRRR system on WCOSS to just within the required 60 min. window. The ability to build and test the HRRR system directly on the WCOSS system and the excellent work of the NCO SPA was extremely beneficial for expediting the process of transferring the HRRR system to NCO. All model, assimilation and pre- and post-processing codes now built on running on the NCO WCOSS machine, with informal evaluation ongoing in July, the formal 30-day evaluation scheduled for August, and a planned implementation date of 16 Sept. 2014.

(NCEP)

More pieces of the HRRR were handed off to NCO in June to help build the official parallel for an August field evaluation. As of the end of June, the system is running nearly end-to-end on WCOSS each hour in test mode. There have been some issues with configuring the model to fit within its allotted time slot and resources, but significant progress was made in June. (Manikin)

14.5.2.E2 1 April 2014 **(NCEP)**
Subject to NCEP Directors' approval, upgrades to HiResWindow and initial convection-allowing-scale ensemble (NSSE) becomes Operational at NCEP.

HiResWindow ARW experimental runs using the latest WSM6 microphysics found that the changes increased the radar echo-top heights (good) but they also tended to reduce the composite radar reflectivity's, which is (not good). The changes were made to address complaints from AWC that the forecast echo-top heights from the recently updated ARW runs were too low. This work is also related to efforts in support of subtask 14.5.1.5. (Pyle)

14.5.2.E3 1 April 2014 **(NCEP)**
With approval of NCEP Director, RTMAv6 upgrade package is implemented at NCEP.

14.5.2.E4 15 July 2014 **(ESRL)**
Report on status of enhancements to HRRR for 2014 version, based on retrospective and real-time testing.

Testing and evaluation of RAPv3 / HRRRv2 system ongoing to address a warm, dry bias seen in pre-frontal southerly flow areas (see subtask 14.5.2 for details).

14.5.2.E5 15 Oct 2014 **(ESRL)**
Complete 2014-summer evaluation with revised 3-km HRRR running every 1 h.

- Conduct real-time summer 2014 HRRR forecasts using 3-km WRF with 3-km assimilation 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 2014 HRRR experiments

14.5.2.E5.1 31 Mar 2015 **(ESRL)**
Report on convective weather forecast accuracy from HRRR by quarter for previous year.

14.5.2.E6 15 Nov 2014 **(ESRL and NCEP)**
Based on real-time parallel and retrospective testing, HRRRv2 code finalized and ready for transfer to NCEP/EMC

ESRL

Operational implementation of RAPv3 / HRRRv2 scheduled for April 2015, so this date appears reasonable, though a slight delay possible. Changes from ongoing testing and evaluation of warm, dry bias will be incorporated into this code upgrade package. GSD continued to evaluate HRRRv2 during the real-time 2014 warm-season exercise.

NCEP
HRRRv1 must be implemented at NCEP before any transfer to EMC of the HRRRv2 code currently being tested at ESRL can be considered. The slip in the HRRRv1 implementation into September means this deadline may need to slip as well. (Manikin)

14.5.2.E7 15 Jan 2015 **(ESRL, assistance from CAPS under 5.1 support)**
Report on initial retrospective test of storm-scale ensemble data assimilation for small Northeast U.S. domain.

14.5.2.E8 31 Jan 2015 **(ESRL/GSD, NCEP)**
Pending NCEP computer readiness and EMC and NCEP initial recommendations, Requests for Change (RFCs) are filed to submit HRRR code changes as part of upgrade for HRRR v2 software to NCO.

NCEP

This work has not yet started. (Manikin)

ESRL

This work awaits final HRRRv1 operation implementation, completion of testing of changes for HRRRv2 at ESRL/GSD, and transfer of these changes to NCEP/EMC.

14.5.2.E9 1 Feb 2015 **(ESRL and NCEP)**
Provide revised 15-min RTMA surface analyses as improved alternative for frontal diagnostics and other diagnostics from surface analyses for CoSPA.

ESRL

This work awaits final HRRRv1 operation implementation, completion of testing of changes for HRRRv2 at ESRL/GSD, and transfer of these changes to NCEP/EMC.

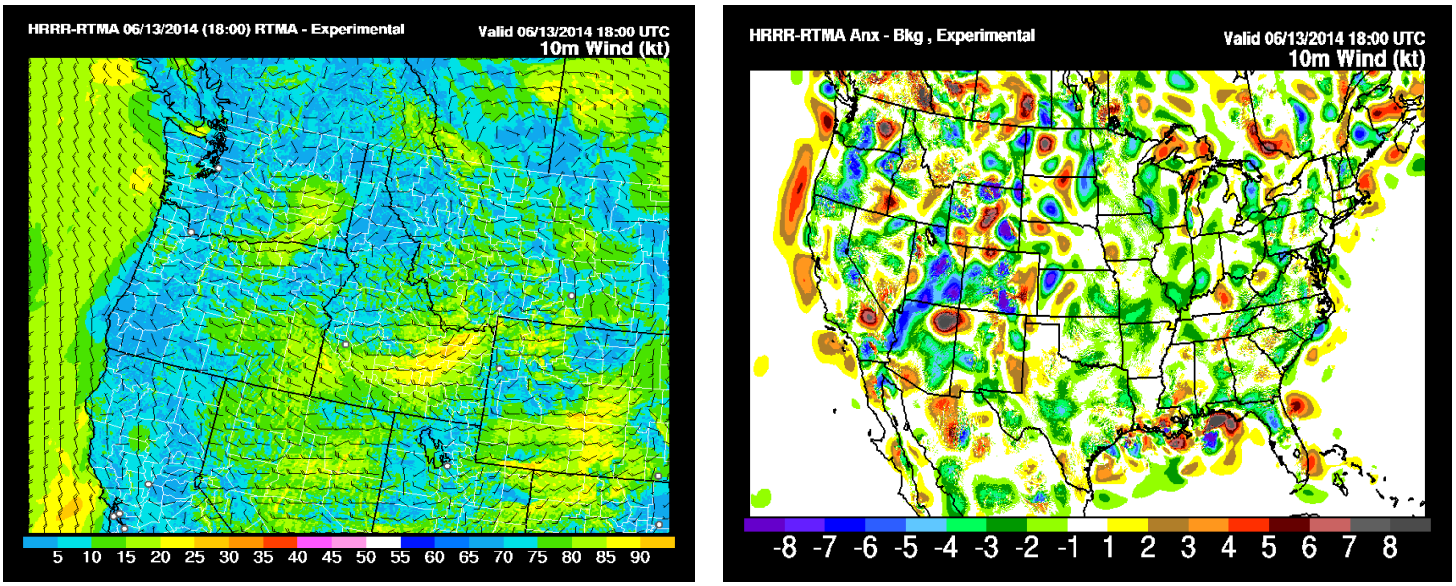

Figure 3: 10m wind speed and direction from RTMA with HRRR background for 18z 13 June 2014. a) Full field, (above), b) analysis increment using observations and HRRR background.

NCEP
Work towards a 15-min RTMA must wait for completion of the HRRRv1 implementation. The capability to analyze 10-m wind speed, 2-m dew point, daily maximum and minimum temperatures, mean sea level pressure, and significant wave height was added to the the GSI in June. The changes were also merged with the official GSI code, which underwent a major upgrade recently. Extensive testing of the new analyses is underway. (Manuel Pondeca, Steve Levine, Jim Purser)

14.5.2.E10 15 March 2015 **(ESRL)**
Finalize all changes to the HRRR for the summer 2015 exercise into a frozen version of HRRR (and parent experimental RAP). This will include latest results on reflectivity verification.

Deliverables **Task 2: Improve Quality Of Convective Weather Forecasts**	**Delivery Schedule**
A. HRRRv1 implemented at NCEP pending available computing resources **STATUS: HRRRv1 operational implementation planned for 16 Sept. 2014.**	AUG 2014 **Request Delay till 30 Sept. 2014**
B. Report status of enhancements to HRRR for 2014 version, based on retrospective and real-time testing. **STATUS: Good progress toward mid-summer report. Testing of enhancements for warm, dry bias in RAP, HRRR ongoing**	JUL 2014
C. Complete 2014-summer evaluation with revised 3-km HRRR running every 1 h. Conduct real-time summer 2014 HRRR forecasts using 3-km WRF with 3-km assimilation 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 2014 HRRR experiments. **STATUS: 2014 evaluation ongoing, evaluation of warm, dry bias in RAP**	OCT 2014

D. Based on real-time parallel and retrospective testing, HRRRv2 code finalized and ready for transfer to NCEP/EMC.	NOV 2014
E. Report on initial retrospective test of storm-scale ensemble data assimilation for small Northeast U.S. domain.	JAN 2015
F. Requests for Changes (RFCs) are filed to submit HRRR code changes as part of upgrade for HRRRv2 software to NCO.	JAN 2015
G. Provide revised 15-min RTMA surface analyses as improved alternative for frontal diagnostics and other diagnostics from surface analyses for CoSPA.	FEB 2015
H. Report on convective weather forecast accuracy from HRRR by quarter for previous year.	MAR 2015
I. Finalize all changes to the HRRR for the summer 2015 exercise into a frozen version of HRRR (and parent experimental RAP). This will include latest results on reflectivity verification.	MAR 2015

Task 3: Improve Quality Of Icing Weather Forecasts From RAP, HRRR, NAM, NAM-Nests And, Eventually, NARRE And HRRRE

Subtasks

14.5.3.1 1 Apr 2014 **(GSD NCEP and NCAR/RAL)**

Begin initial testing of the current version of NCAR "aerosol-aware" microphysics in RAP and HRRR models. This will use a climatological aerosol distribution for cloud-condensation nuclei and ice nuclei initially.

The WRFv3.6 release version including the NCAR-developed aerosol-aware microphysics has been running at GSD twice daily, cold starting from the GFS initial conditions, for well over a month. We are comparing this to a parallel cold-start running with the RAPv3 configuration (WRFv3.5.1 Thompson microphysics). Figs. 4 and 5 show an example of comparison between 12-h accumulated precipitation and total cloud cover from a pair of cold-start runs. Because there are other WRF-model differences between these two runs other than microphysics it is not possible to argue that all the differences seen below are due to the aerosol-aware microphysics but more are from the aerosol-aware microphysics. Note that there are somewhat larger areas covered by precipitation with the aerosol aware microphysics, in some cases larger precipitation amounts, also more area of scattered or broken cloud cover with the aerosol microphysics, more area of solid or clear with the aerosol unaware. More extensive controlled testing will be necessary to establish to what extent these differences are characteristic.

RAP Cold-start runs with Thompson microphysics initialized 1200UTC 10 Jun

WRFv3.5.1 Aerosol unaware WRFv3.6 Aerosol-aware

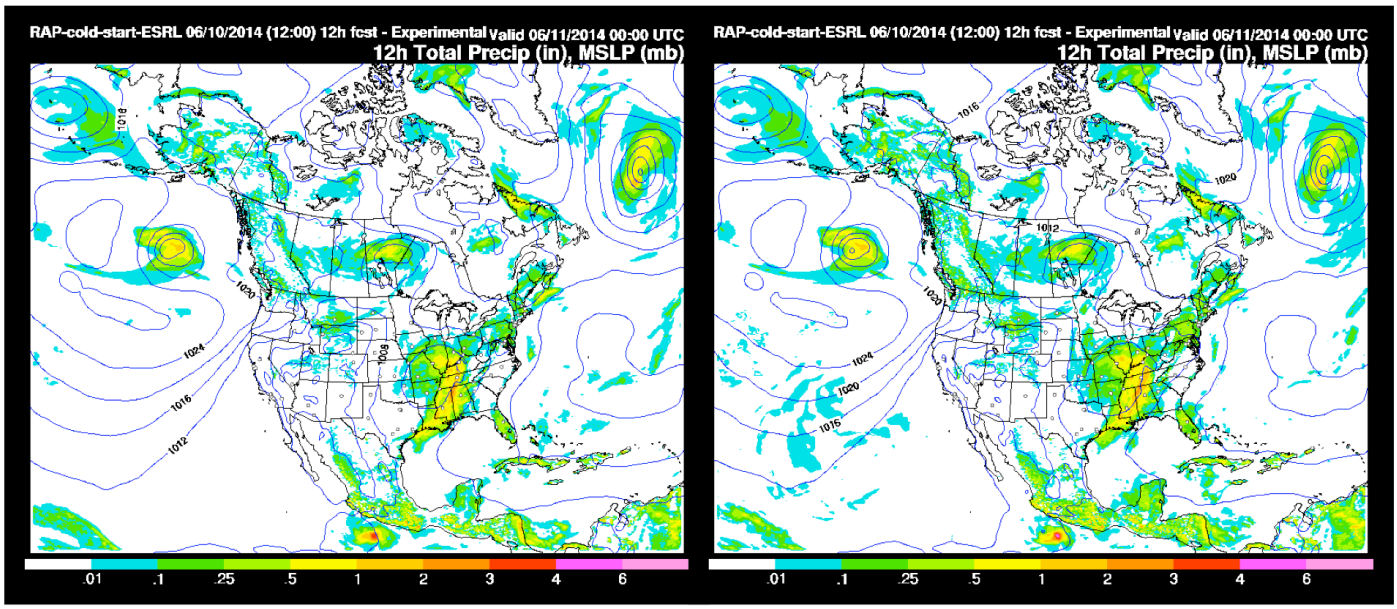

Figure 4: Accumulated 12h precipitation in inches from cold start runs initialized 1200 UTC 10 June 2014. Image on the right is using the aerosol-aware microphysics.

RAP Cold-start runs with Thompson microphysics initialized 1200UTC 10 Jun

WRFv3.5.1 aerosol unaware WRFv3.6 Aerosol-aware

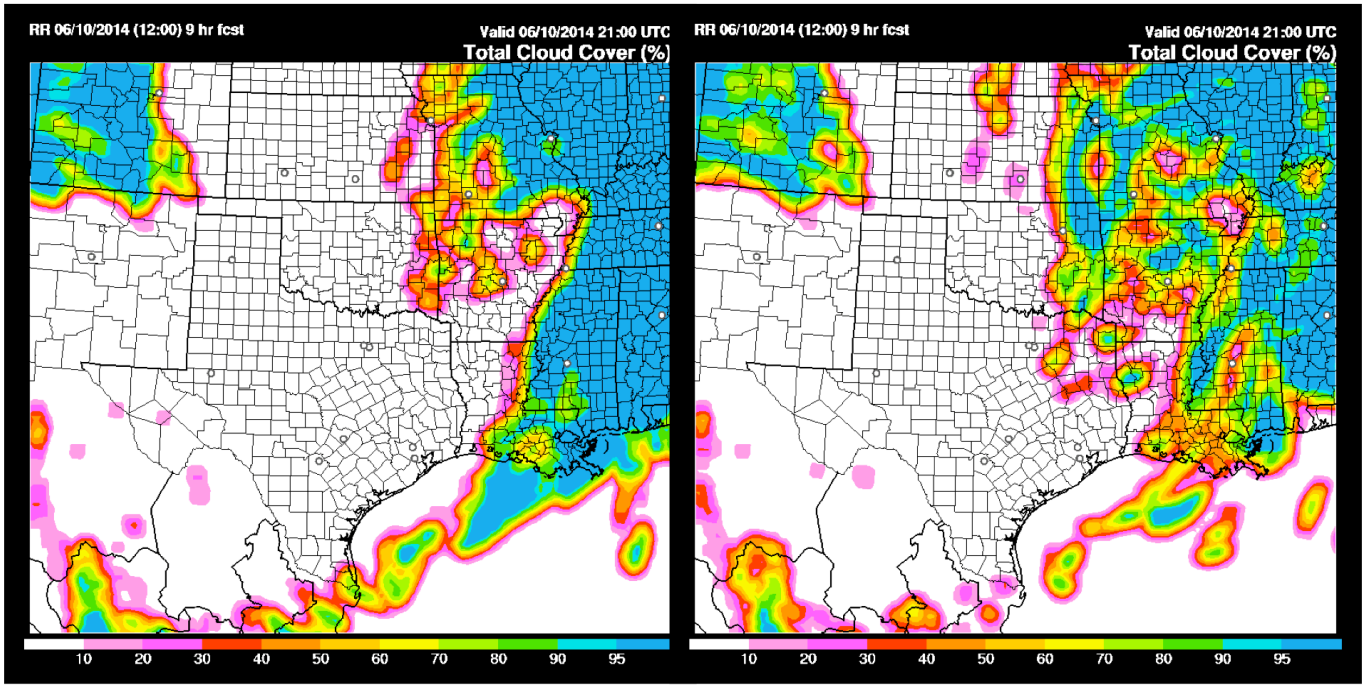

Figure 5: As Fig. 1 for total cloud cover (per cent) from cold-start 9-h forecasts from 1200 UTC 10 Jun 2014 valid 2100 UTC 10 June 2014.

GSD is also now testing another new physics parameterization, using the Common Land Model (CLM, from NASA) lake component to give an improved estimate of lake surface temperatures. GSD is also using this lake model within its real-time RAP WRFv3.6 cold-start runs. This lake model will likely be a component to RAPv4 and possibly to the NCEP-RAPv3 in testing this fall. Its use will likely improve near-surface conditions in the RAP and HRRR models in areas near small-size lakes (i.e., smaller than the size of the Great Lakes) for which we do not have good lake surface temperatures currently. We will report more on this in subsequent quarters.

NCEP

No work was done in May and June using "aerosol-aware" microphysics in any of the NMMB systems. (Ferrier, Aligo)

14.5.3.2 1 Apr 2014 **(GSD)**
Continue evaluation and modification of proposed RAPv3 physics suite in preparation for submission of code to NCEP, pending NCEP readiness, later in 2014.

The modifications (see Task 3 in FY2014 Q2 report) made for RAPv3 to ameliorate the nighttime cold bias over snow cover are working well. Although the bias is not eliminated, it is substantially reduced over that in RAPv2.

As noted under Task 1, east of the Rockies we have been seeing, in both RAP and HRRR a systematic, daytime warm temperature bias and low dewpoint bias in regions of southerly flow in the warm sector of surface cyclones. The problem seems to be exacerbated when soil moisture is very dry. (Although this bias is somewhat reduced in RAPv3 vs. RAPv2, it is still unacceptably large.) An ancillary issue is that when there is a dry line over the southern Plains, it is often forecast a little too far east. We have noted this type of behavior in previous years with the MYNN scheme and retro runs suggested that our current use of the RRTMG with its accounting for attenuation of solar radiation by climatological aerosol should have been helpful.

One specific serious consequence of this bias is that during the daytime, the mixed layer becomes excessively deep, too quickly weakening or wiping out the capping stable layer at it's top. Because the RAP provides the initial conditions for the HRRR 1-h pre-forecast spin up cycle, this has in a few cases contributed to spurious convective initiation in the HRRR. (The HRRR forecasts themselves also suffer from the same issue, but the bias is less than in either RAPv2 or RAPv3, because the HRRR can produce some explicit shallow convection that attenuates incoming solar radiation.) A particularly egregious case occurred on 17 June in eastern Nebraska and northeast Kansas that has provided a good test

case for investigation. We have had discussions with SPC that have helped us better define some of the issues. One of these is that with the excessive entrainment of drier air into the mixed layer from above that occurs with the mixed layer growing too deep, our use of moisture pseudo-observations may be injecting too much moisture near the top of the mixed layer, contributing to spurious intense convective initiation as happened on the 17th. We are also looking into use of temperature pseudo observations under the hypothesis that their use can restrain growth of the mixed layer in forecasts initialized during the daytime.

Our initial diagnosis pointed to possible remaining issues with the MYNN boundary-layer and surface schemes, but the scope of the investigation widened when changes to MYNN and its coupling with shallow convection and radiation were not achieving hoped-for benefits. An important step forward was made when it was noted that our incoming solar radiation was too high as compared with a SURFRAD site at Booneville IL. (As part of a DOE solar energy project we recently started verifying our solar insolation forecasts.) It turns out we had inadvertently turned off the attenuation of incoming solar radiation by (climatological) atmospheric aerosol in the RRTMG radiation. This very recent discovery will unquestionably reduce the warm / dry bias. How much, we will know within a few days of this writing.

Meanwhile, we are pursuing two other approaches. A further effort toward deriving a workable formulation for the attenuation of incoming solar radiation consistent with the Grell-Freitas shallow convection is continuing. Joe Olson working with Georg Grell is addressing this issue, using the RAP-dev2 real-time cycle for evaluation of the shallow component of the Grell-Freitas convection scheme and it's coupling with radiation. Joe and Jaymes Kenyon are also examining reformulations of the MYNN surface-layer scheme that has promise of reducing the surface heat flux during the middle of the day without making it too large during the subsequent evening transition. Further, alterations to the MYNN boundary layer scheme that better account for counter gradient heat flux near the top of the mixed layer are also being tested. Evaluation of these changes in the context of the RRTMG short-wave radiation with aerosol attenuation activated and using real-time and retrospective runs, including a short retro for the days just prior and including 17 June 2014, is underway.

Record pre-monsoonal heat in the Sonoran Desert of northwest Mexico led to a crash in the RUC land-surface scheme during the HRRR pre-forecast step in early June. This was tied to large skin-temperature changes due to imbalances in the surface energy budget at the first time step of the pre-forecast cycle, exacerbated by the downscaling from RAP to HRRR (the RAP experienced no problems). A fix to extend the range of possible skin temperatures in the RUC LSM prevented further crashes. A limit to skin temperature change per model time step will likely be later added to the RUC LSM, similar to the limit to latent heating from cloud microphysics installed into WRF to similarly improve model stability.

14.5.3.3 1 May 2014 **(GSD and NCAR/RAL)**
Begin efforts toward adding aerosol species or size categories as tracers to the RAPv3 and HRRR configurations of the WRF model, including surface sources, which are highly parameterized in the first version of the new microphysics scheme. Interact with WRF-Chem experts for aerosol source datasets, surface emission inventories, and translation of specific aerosol variables into the constituents needed by the microphysics scheme.

Discussions have started between GSD and NCAR about how to incorporate prognostic aerosol information from the RAP-Chem run into experimental versions of the RAP and HRRR.

14.5.3.4 1 May 2014 **(NCEP)**
Perform case-study simulations of high-impact weather events in order to evaluate NMMB model running the existing and newly added Thompson et al (2008) microphysics schemes.

Tests of the Thompson scheme were run in both 12-km and 4-km NMMB runs from fall 2013 through spring 2014. However, the coupling of the microphysics with the RRTM radiation has proven to be a slow process. NMMB science changes proposed by NCAR needed modifications before they could be added into the NEMS NMMB and tested and the RRTM changes are still in regression testing. There are also RRTM changes from John Michalakes that need to be included before tests can begin of the NMMB using Thompson microphysics coupled with the RRTM v3 radiation. (Ferrier, Aligo, Lin)

14.5.3.5 1 Jun 2014 **(NCAR/RAL)**
Test and evaluate the ice initiation mechanisms via aerosols to ensure the water-ice balance is relatively un-changed versus the prior scheme or else the updated scheme may result in significant loss of skill of aircraft icing forecasts since water is rapidly depleted by ice when too many ice crystals are supplied.

14.5.3.6 1 Sep 2014 **(NCAR/RAL)**

Continue to increase the complexity and interactions between the newly added aerosol variables in the microphysics with the PBL, radiation, convection, and shallow convection schemes. Particular focus will be the depletion of aerosols nucleated by sub-grid-scale eddies, the effects of which are represented by the PBL and convection schemes.

Current efforts: G. Thompson attended the WRF user workshop and gave a presentation on the new aerosol-aware microphysics scheme in WRFv3.6. T. Eidhammer continues creating lookup tables to compute aerosol optical depth from the reduced set of aerosol variables for ultimate use within the radiation scheme.

Future work: NCAR-RAL will assist NOAA-GSD to adopt/utilize the new scheme. Trude Eidhammer will resume additional testing of the ice initiation by aerosols in the next month or two.

Problems encountered/Delays: Subtask #6 contains many unknowns due to numerous dependencies with other physics routines. Work may not begin on this subtask until after 1 Oct 2014.

Interface with other organizations: Various DOE Solar-WRF team members including GSD

Deliverables
(All Option A unless noted otherwise)

14.5.3.E1 1 Aug 2014 **(NCAR)**
Submit updated cloud microphysics code to WRF repository; document changes and purpose of changes in a report.

14.5.3.E2 31 Aug 2014 **(ESRL)**
Complete initial evaluation of aerosol-aware microphysics in RAP/HRRR test evaluation/demonstration at GSD for its suitability for future NCEP implementation.

14.5.3.E3 1 Dec 2014 **(NCAR)**
Submit a report and possible journal manuscript related to the aerosol-ice sensitivity experiments including specific application to aircraft icing.

14.5.3.E4 20 Dec 2014 **(ESRL)**
At the annual NCEP Product Suite Review report on RAP / HRRR physics upgrades. This will include metrics on improvement to cloud and RH forecasts from these physics upgrades.

14.5.3.E4.1 31 Mar 2015 **(ESRL)**
Report on RH/cloud forecast accuracy from RAPv3 and HRRRv2 by quarter for previous year, related to icing guidance.

14.5.3.E5 31 Jan 2015 **(ESRL/GSD, NCEP)**
Pending NCEP computer readiness and EMC and NCEP initial recommendations, Requests for Change (RFCs) are filed to submit WRF physics code changes as part of upgrade for Rapid Refresh v3 software to NCO.

NCEP

This work has not yet started. (Manikin)

Deliverables **Improve Quality Of Icing Weather Forecasts**	**Delivery Schedule**
A. Complete initial evaluation of aerosol-aware microphysics in RAP/HRRR test evaluation/demonstration at GSD for its suitability for future NCEP implementation. **ESRL/GSD: The aerosol-aware microphysics is now running in an experimental real-time RAP run ("Cold-Start-Run-2")**	AUG 2014
B. At the annual NCEP Product Suite Review report on RAP/HRRR physics upgrades. This will include metrics on improvement to cloud and RH forecasts from these physics upgrades.	DEC 2014
C. Requests for Change (RFCs) are files to submit WRF physics code changes as part of upgrade for Rapid Refreshv3 software to NCO.	JAN 2015
D. Report on RH/cloud forecast accuracy from RAPv3 and HRRRv2 by quarter for previous year, related to icing guidance.	MAR 2015

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

Subtasks

14.5.4.1 15 Aug 2014 **(GSD)**
Initial testing toward variational / ensemble cloud analysis scheme within the GSI framework.

A preliminary planning meeting was held with ESRL/GSD and NCAR to present and discuss approaches for a variational/ensemble cloud analysis. This discussion included a work plan to create a common GSI source code repository and add cloud water and cloud ice control variables and static background errors in GSI. Longer-term plans include creation of cloud water and ice observations based on cloud coverage and testing of cloud water/ice retrievals in a variational framework that can be compared to the original non-variational cloud analysis.

14.5.4.2 15 Nov 2014 **(GSD, NCEP)**
Finalize new cloud/hydrometeor analysis for 2015 RAPv3/HRRRv2

GSD
A WRF-ARW version 3.6 code release has been merged with the ESRL RAP/HRRR code repository for preliminary testing in ESRL RAP/HRRR retrospective runs including the updated Thompson microphysics scheme that will be used as a basis for observation operators and model diagnostics when assimilating radar reflectivity observations for precipitating hydrometeors. Initial plans have been made to improve the analysis of cloud ice information from satellite observations by incorporating both cloud ice mixing ratio and number concentration into the cloud analysis process for use by the Thompson microphysics scheme. Preliminary case-study testing of full-column cloud and precipitating hydrometeor building in the HRRR cloud/hydrometeor analysis has been completed.

NCEP

No work done this quarter. (Liu, Wu, Carley)

14.5.4.3 15 Feb. 2015 **(GSD, NCEP)**
Report on progress toward variational/ensemble cloud analysis

NCEP

No work done this quarter. (Liu, Wu, Carley)

14.5.4.4 15 March 2015 **(NCEP, ESRL)**
Groups collaborate on initial work toward cloud analysis scheme for use in NARRE ensemble system.

NCEP

No work done this quarter. (Liu, Wu, Carley)

14.5.4.5 31 March 2015 **(ESRL, NCEP)**
Establish routine verification of NCEP suite of ceiling & visibility guidance and begin design of calibration strategy for ensemble systems.

NCEP
Testing and documentation of the grid-to-grid (g2g) verification upgrade is complete and an RFC was submitted to NCO for implementation. The grid2grid ensemble (g2gE) verification of FIM forecasts has been set up to run on Zeus in support of the High Impact Weather Prediction Project (HIWPP). (Zhou, Shafran, Du, Yang)

Deliverables

14.5.4.E1 1 April 2014 **(NCEP)**
With approval of NCEP Director, RTMAv6 upgrade package is implemented at NCEP (including visibility).

The RTMA/URMA upgrade version 2.2.1 was implemented on January 28, 2014, (Manuel Pondeca, Steve Levine, Yanqiu Zhu, Ying Lin, Jeff McQueen, Geoff Manikin, Jim Purser, Dave Parrish, Yuqiu Zhu)

14.5.4.E2 1 June 2014 **(NCEP)**

With approval of NCEP Director, SREF, HiResWindow and NAM upgrade packages are implemented at NCEP (including corrections to ceiling, visibility and cloud field prediction & diagnoses).

Work on the next SREF upgrade is in progress. Use of three available analyses (GDS, NDAS and RAP) as ICs among the 26 SREF members is in testing. SREF membership has been increased from 21 to 26. Model vertical resolution has been increased from 35 to 41 levels. The downstream impacts associated with upcoming changes to the operational NAM on the NARRE-TL were assessed. (Du, Zhou, Yang, Jovic, Pyle, Rogers)

14.5.4.E3 15 Dec 2014 **(ESRL/GSD)**
Finalize cloud/hydrometeor assimilation for RAPv3 and transfer code to NCEP.

14.5.4.E4 15 Feb 2015 **(ESRL/GSD)**
Report on variational / ensemble/hybrid cloud analysis development for RAP and NARRE

14.5.4.E5 31 March 2015 **(NCEP)**
Subject to NCEP Directors' approval, upgrades to RTMA/URMA (addition of total cloud and cloud base height [ceiling]) become Operational at NCEP.

Real time diagnostic RTMA and RTMA parallel webpages are being maintained. The old GSI-RTMA code that analyzed cloud ceiling heights and total cloud amounts was ported to the GSI repository and merged with the developmental version of the RTMA-GSI. (Pondeca, Carley, Levine)

Deliverables **Task 4: Develop Convection-ATM-Specific Improvements**	**Delivery Schedule**
A. Report on ATM impact related to skill of HRRR forecast.	FEB 2015
B. Complete implementation of new microphysics scheme and associated reflectivity and ET diagnostics in real-time ESRL/GSD RAP and HRRR prior to code freeze for 2015-exercise release.	MAR 2015
C. Report on baseline testing of the early 2015 HRRR version.	MAR 2015
D. Report on evaluation of revised Thompson aerosol-aware microphysics for RAP/HRRR for its effects on echo-top and reflectivity in ESRL RAP/HRRR.	MAR 2015