MDE Product Development Team
4th Quarter Report – FY 2011
Submitted 15 October 2011

With contributions from **Geoff DiMego** and **Mary Hart** (NCEP/EMC);
Stan Benjamin, John Brown, and **Steve Weygandt** (NOAA/ESRL/GSD);
Jordan Powers and **Roy Rasmussen** (NCAR); and **Ming Xue** and **Xuguang Wang** (OU/CAPS)

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

Executive Summary

Task 11.5.1: Infrastructure support related to operational running of the RUC and NAM operational modeling systems.

- No problems with operational RUC this quarter. Final testing has continued toward NAM upgrade, delayed during quarter and now planned for next Tues 18 Oct 2011. Note: Rapid Refresh implementation will be about ~2+ months after the NAM upgrade, so NAM implementation delays result in RR delays, as well.
- Correction made to height assignment for RASS observations (used in operational RUC) after ESRL discovery of problem.

Task 11.5.4: Develop, test, and implement Rapid Refresh configuration of the WRF modeling system.

- *The RR run at ESRL/GSD and the real-time parallel RR at EMC continue to show improvement for the September period over RUC for precipitation, reflectivity, wind, temperature, and height, RH about even.*
- *ftp access continues for these grids from RR running at NCEP-EMC, evaluation of RR-NCEP-EMC continues.*
- *Planned date for RR implementation at NCEP is now **mid Dec 2011 to mid Jan 2012**, due to additional delays through the quarter for the NAM implementation, now scheduled for 18 October as of this report.*

Task 11.5.5: Develop, test, and implement 3DVARs for RR and NAM

- Identified issue with height assignment for boundary-layer profiler and RASS observations and worked with NCEP personnel to make specification in PrepBUFR observation consistent with GSI observation processing code (into NCEP RR immediately).
- Completed coding within GSI to add soil temperature and moisture nudging based on lowest model level temperature and moisture analysis increments (into Rapid Refresh v2 at ESRL).
- Continued evaluation of impact on GSI fits to radiosondes profiles as a function of variations in i) vertical correlation length scale, ii) observation error, and iii) increased vertical resolution in the raob data.
- Analysis of GOES SFOV moisture innovations indicates strongly non-Gaussian distribution. Testing of various QC methods underway.
- Adjustments made to improve GSI run-time optimization for NCEP Central Operations (NCO) environment in advance of RR NCEP operational implementation.

Task 11.5.8: Improve physical processes in the WRF (RR and HRRR)

- **WRF v3.3.1 "bugfix" release 22 September 2011**

Task 11.5.15: Develop methods for improved cloud/hydrometeor analysis in RR

- Identified and corrected RR cloud analysis issue, in which dust observations were being interpreted as clouds, leading to spurious cloud building and moistening.
- Inter-comparisons of GOES-related cloud building between RUC-NCEP, RUC-backup-ESRL, and RUC-dev-ESRL continue toward improved initial cloud field in Rapid Refresh in RR2 in 2012. The ESRL RUC-dev includes a new version of GOES-based cloud building designed to avoid moist bias problems found in the previous method in RUC and RR tests.
- Code developed with RUC to specify the radar-DFI latent heating as a function of stability, now running in development RUC.
- Application of GSI cloud analysis at 3-km to generate a radar reflectivity-based temperature tendency array for 3-km sub-hourly (15-min) radar assimilation procedure.

Task 11.5.24: Development/testing of HRRR

- Real-time HRRR runs continue to support summer CoSPA experiment with good overall reliability in real-time HRRR forecast production.

- HRRR time-step adjustment made (eliminates occasional instances where HRRR run does not complete on time, no forecast skill impact).
- New, extensive study of impact from RUC- and RR-based DFI radar assimilation indicates similar forecast improvement overall (in both parent model runs and nested HRRR runs), and increased bias in general for the RR-HRRR runs.
- Testing of 3-km sub-hourly radar reflectivity assimilation.
- Oral presentations by Steve Weygandt and Curtis Alexander at AMS radar conference on RUC/RR radar assimilation impacts on HRRR.

Task 11.5.1 Infrastructure Support Related to Operational running of the non-WRF Rapid Update Cycle System in NCEP Operations

ESRL/GSD
Operational RUC at NCEP has continued to run at 100% reliability since coordinate fix on 17 Nov 2010.

A problem with boundary-layer profiler and RASS observation height assignment was discovered at ESRL in late August. This was traced to a fix needed in NCEP processing, which was accomplished on 13 Sept by NCEP/NCO. This error had not been affecting the operational RUC or NAM (not using PBL profiler or RASS) but it was affecting the experimental RR and NAM, so it was very good to detect this problem make the correction before the upcoming two implementations.

The ESRL development RUC was modified in early August with a change to modulate latent heating from observed radar reflectivity as a function of local thermodynamic stability. The development RUC continues to test re-introducing GOES cloud data over the lowest 1km AGL to improve cloud forecasts without causing an increase in RH error, as found in December 2010 with full troposphere use of GOES-based cloud building. (More under 5.15).

ESRL continues to monitor operational RUC (and two ESRL versions of RUC with differences in cloud assimilation). This evaluation is now especially important since it allows a benchmark for the parallel Rapid Refresh comparisons. Performance of the operational RUC is monitored at both ESRL and NCEP verification websites (see **http://ruc.noaa.gov/stats**). Inter-comparison of verification between the NCEP and ESRL versions of the RUC continue to be monitored by ESRL, also at **http://ruc.noaa.gov/stats**.

NCEP
Details below.

No infrastructure support was needed by the operational RUC during the quarter (except for the RASS issue mentioned above). (Geoff Manikin)

Subtasks
11.5.1.1 Maintain hourly RUC runs and provide grids of SAV and AHP guidance products. (30 Sept 11) - **COMPLETE**

NCEP maintained the hourly runs of RUC through the quarter. No RUC crashes have occurred since 17 November 2010. (Manikin)

11.5.1.2 Provide vendors with gridded model data via Family of Services and the FAA Bulk Weather Data Telecommunications Gateway. (30 Sept 10) - **COMPLETE**

NCEP maintained real-time availability of SAV and AHP (aka AIV) guidance to all vendors from the operational hourly RUC on pressure surfaces on the 80-km AWIPS grid #211 via the NWS Family of Services (FOS) data feed and the FAA Bulk Weather Data Telecommunications Gateway (FBWDTG). (DiMego)

11.5.1.3 Provide full grids from RUC runs on NCEP and NWS/OPS servers. (30 Sept 10) - **COMPLETE**

NCEP maintained real-time availability of full resolution gridded data from the operational RUC runs via anonymous ftp access via the NCEP server site at **ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/ruc/prod/** and at the NWS/OPS site at **ftp://tgftp.nws.noaa.gov/SL.us008001/ST.opnl/** in hourly directories named MT.ruc_CY.00 through MT.ruc_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** . A limited set of fields from the RUC runs (and other NCEP models) can also be viewed at **http://mag.ncep.noaa.gov/NCOMAGWEB/appcontroller** . (DiMego)

11.5.1.4 Maintain access to model verification data. (30 Sept 10) - **COMPLETE**

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

Deliverables

11.5.1E1 (30 September 2011) (Keyser, Liu) - **COMPLETE**
Perform ingest, quality control and preparation of both existing and new observations in support of the operational RUC runs.

CURRENT EFFORTS: The Florida and Georgia DOT mesonet providers remained down. The Kansas DOT mesonet provider has been down since late June. ESRL/MADIS reports that all mesonet latitudes, longitudes and elevations were corrupt in the 1800, 1900 and 2000 UTC files on 7 September. NCEP is not properly decoding moisture for Climate Reference Network (CRN) mesonet reports. There was a 6-hour outage of all wind profiler data on 23 September. The GOES-13 cloud and precipitable water retrievals have not been used since the switch to GOES-13 in April 2010. The NRL-based aircraft quality control (QC) code package is planned to be implemented in early FY12. The new aircraft QC code includes quality controlled high vertical-resolution aircraft ascent & descent profiles near airports, with the nearest METAR report providing the surface level. Earlier memory issues in the code have been corrected and the code has also been revised to run ten times faster. The final step is to update it to properly handle TAMDAR reports. AirDAT provided the full TAMDAR feed to NCEP from 0000 UTC 26 August through 2300 UTC 29 August to support NWP during Hurricane Irene, and approximately 9 times the usual amount of TAMDAR data was assimilated. ESRL discovered that the CAP/MAP profiler and RASS data had the wrong height assignment in the NCEP BUFR files. The NCO decoder had been adding the station elevation to heights above ground level, meaning the observations were being placed at too high a level. This error, which had been present since late 2008 but does not affect NPN wind/RASS data, was corrected on 13 September. (Keyser)

PLANNED EFFORTS: If funded, see also PLANNED EFFORTS listed under Task 11.5.17.E1 below for aircraft quality control issues. Implement NRL QC package. Obtain all TAMDAR data from AirDAT as alternate to MADIS feed and add airframe type and company code to allow the development of improved bias corrections. Continue work to resolve issues like late arrival of GOES 1x1 field-of-view cloud data and bringing in new SSM/IS data from DMSP F-16, F-17 and F-18 satellites to replace discontinued SSM/I products. (Keyser)

PROBLEMS/ISSUES ENCOUNTERED OR ANTICIPATED: A severe backlog has developed in the implementation schedule on the NCEP computers.

INTERFACE WITH OTHER ORGANIZATIONS: NCO, NSSL.

UPDATES TO SCHEDULE: All tasks and milestone/deliverables are complete.

11.5.1E2 (30 September 2011) (Manikin/NCEP, ESRL) - **COMPLETE**
Perform configuration management for RUC, including thorough documentation, and respond promptly to any code malfunctions or performance issues.

CURRENT EFFORTS: No RUC configuration changes were needed during the quarter. (Manikin, IBM and ESRL)

PLANNED EFFORTS: If funded, continue monitoring of RUC performance.

PROBLEMS/ISSUES ENCOUNTERED OR ANTICIPATED: None.

INTERFACE WITH OTHER ORGANIZATIONS: NCO & ESRL.

UPDATES TO SCHEDULE: All tasks and milestone/deliverables are complete.

11.5.1E3 (30 September 2011) (Manikin, ESRL) - **COMPLETE**
Monitor RUC performance, respond to any problems detected by ESRL, NCEP, or any RUC users, diagnose cause, develop solution to RUC software, test changes and coordinate with NCO on implementation.

CURRENT EFFORTS: No RUC crashes have occurred since the 17 November 2010 fix was implemented. (Manikin and NCO/PMB). However, the PBL profiler/RASS height assignment error detected by ESRL and corrected at NCEP during Q4 will avoid problems that would have occurred in the RR and updated NAM.

PLANNED EFFORTS: If funded, continue monitoring.

PROBLEMS/ISSUES ENCOUNTERED OR ANTICIPATED: None.

INTERFACE WITH OTHER ORGANIZATIONS: NCO.

UPDATES TO SCHEDULE: All tasks and milestone/deliverables are complete.

Task 11.5.17 Infrastructure support for operational running of Rapid Refresh, North American Mesoscale, and HiResWindow (and future HRRR) at NCEP, including support for community WRF model

ESRL/GSD
Progress in Rapid Refresh development toward operational implementation at NCEP, now planned for Nov 2011, can be found under the Task 5.4 report.

NCEP
Details under 5.17 tasks below.

Subtasks

11.5.17.1 Maintain hourly RR and four/day North American Mesoscale runs and provide SAV and AHP guidance. (30 Sep 11) - **COMPLETE**

The parallel test of the NEMS/NMMB model in the NAM parallel system continues on the CCS. The run consists of a 12 km parent domain (same as current NAM) with all model and analysis changes that will be implemented into operations. Inside the 12 km parent domain are four high-resolution nested domains (4 km CONUS, 6 km Alaska, 3 km Hawaii, 3 km Puerto Rico) that will run from 0-60 h, and a movable fire weather nest nested inside the CONUS or Alaska nest at 1.33 km or 1.5 km resolution that will run from 0-36 h. Implementation progress and documentation can be tracked at **http://www.emc.ncep.noaa.gov/implementation-docs/impDoc.html.** (Rogers)

During this quarter a few changes were made to improve the assimilation and fix minor code bugs. In July the GSI analysis was modified to exclude any mesonet surface pressure observations where surface pressure was set to or computed based on standard atmosphere. This change significantly improved the first guess fit to mesonet surface pressure. In August, it was discovered that a code compile error was causing the NAM parallel snow analysis update code (nam_snow2mdl) to abort in the NCO parallel. This means that in the NCO parallel NDAS snow was continuously cycling on itself without an analysis update since the last time that NCO restarted the production NDAS parallel from the EMC NDAS parallel (which was ~mid June). This was fixed on 9 August, and NCO restarted the official 30-day evaluation the next day. (Rogers)

Evaluations of the NAM parallel by the NCEP centers revealed some issues that the NCEP Director wanted addressed before approving implementation of the NAM change package. AWC reported that the NMMB vertical velocity was significantly weaker than the operational NAM, and SPC noted that parameters they use to measure the potential for severe convection (hourly maximum updraft speed and updraft helicity) were significantly lower in the 4 km NAM CONUS nest. It was determined that during earlier NMMB testing the baro-tropic (external mode) component of the vertical velocity was subtracted from the full non-hydrostatic vertical velocity field prior to the computation of the non-hydrostatic vertical acceleration. This was done to alleviate a noise problem in the NAM nest. The model code was modified to add back the baro-tropic component to the vertical velocity and apply it to the computation to the SPC severe weather parameter. With this change, the output vertical velocity in the NMMB was much greater and comparable to the operational NAM, and the severe weather parameters used by SPC that were cited above were much higher in retrospective test cases that SPC requested EMC run. With these improvements in place the NCEP Director approved the NAM implementation, which will occur on 18 October. (Rogers)

11.5.17.2 Maintain four/day HRW runs and provide SAV and AHP guidance. (30 Sep 11) - **COMPLETE**

NCEP maintains 4/day runs of WRF-NMM at 4 km and WRF-ARW at 5 km when there are no hurricane runs. Five domains are run with three large domains – East-Central CONUS (00z & 12z), West-Central CONUS (06z) and Alaska (18z), and two small domains - Hawaii (00z & 12z) and Puerto Rico (06z &18z). (Pyle and NCO) A major upgrade to the HRW has been prepared and tested but is not scheduled for implementation until Q2 FY2011 (Mar 2011).

NCEP also maintains four times-per-day runs of ten WRF-based members (5 running NMM and 5 running ARW) within the Short Range Ensemble Forecast (SREF) system. Aviation guidance prepared from the SREF is available from **http://www.emc.ncep.noaa.gov/mmb/SREF/SREF.html** that now includes specific output for Alaska and Hawaii (eastern Pacific). The SREF ensemble product generator includes the following forecasts: minimum, maximum, mode, 10/25/50/75/90 percentiles of many aviation related variable. A developmental Very Short Range Ensemble Forecast VSREF) is run every hour using RUC and NAM time-lagged forecasts. It is being adapted to Rapid Refresh and will be renamed North American Rapid Refresh Ensemble – Time Lagged [NARRE-TL]. (Du, Zhou)

11.5.17.3 Provide vendors with gridded model data via Family of Services and the FAA Bulk Weather Data Telecommunications Gateway. (30 Sep 11) - **COMPLETE**

NCEP maintained real-time availability of SAV and AIV guidance to all vendors from the operational 4/day NAM on pressure surfaces on the 80-km AWIPS grid #211 via the NWS Family of Services (FOS) data feed and the FAA Bulk Weather Data Telecommunications Gateway (FBWDTG). Higher resolution grids (40-km grid #212 and 12-km grid #218) are also made available to FOS (and NOAAPORT) users. (DiMego)

11.5.17.4 Provide full grids from RR, NAM, and the HRW on NCEP and NWS/OPS servers. (30 Sept 11) - **COMPLETE**

NCEP maintained real-time availability of full resolution gridded data from the operational 4/day NAM and HiResWindow (HRW) suite of WRF-NMM and WRF-ARW runs via anonymous ftp access via the NCEP server site at **ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/nam/prod/** (on numerous grids) and at the NWS/OPS site at **ftp://tgftp.nws.noaa.gov/SL.us008001/ST.opnl/**. At the NWS/OPS site, the NAM data are in 4/day

directories named MT.nam_CY.*hh* where *hh*=00, 06, 12 or 18; while the HRW data are in 4/day directories named MT.hires_MR.*mmm*_CY.*hh* where *mmm*=arw or nmm and *hh*=00, 06, 12 or 18. This includes hourly BUFR soundings (NAM only) and output grids which undergo little or no interpolation. Both sites now contain only grids in GRIB2 format, see **http://www.nco.ncep.noaa.gov/pmb/docs/GRIB1_to_GRIB2.shtml**. HRW output will become available to NWS forecast offices with AWIPS OP9. A limited set of fields from the NAM and HiResWindow (HRW) runs (and other NCEP models) can also be viewed at **http://mag.ncep.noaa.gov/NCOMAGWEB/appcontroller** (DiMego)

11.5.17.5 Maintain access to model verification data. (30 Sep 11) - **COMPLETE**

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

During this quarter, final changes were made to the NAM parallel to add output fields needed for downstream applications and NCEP Service Centers. Working with Julia Zhu, during April the codes and scripts were optimized for use in production and the entire package was handed over to NCO. When NCO began running the 4x/day NAM parallel (with all nests) routinely in early June, the EMC parallel run was turned off and all parallel verification and web graphics jobs were changed to use the NCO parallel. NCO began the 30-day real-time parallel NAM test for evaluation by NCEP Service Centers and NWS regions on June 21. (Rogers, DiMego)

Deliverables

11.5.17.E1 30 September 2011 (Keyser, Liu) - **COMPLETE**
Perform ingest, quality control and preparation of both existing and new observations in support of the operational RR, NAM, and HiResWindow runs.

CURRENT EFFORTS: See also the items reported under Task 11.5.1.E1. Since the RR has an extended domain including Alaska and some ocean areas, most of the following also apply. Several erroneous AIREP aircraft waypoint locations were corrected on 5 July. GOES-13 radiances are monitored until the NAM implementation. Due to fall eclipse season, there are potential gaps in GOES data around 0600 UTC since mid-August. NOAA-18 has on-going gyro issues that could lead to unusable products. Another reduced gyro test occurred on 20-21 September. An implementation on 9 August expanded the duplicate-checking of ATOVS 1b reports to include "near" duplicates in location (within 0.01 deg lat/lon) which are due to differences in POES ground system processing. A 7-hour outage of NOAA-18 ATOVS 1b data on 2 August was due to ground equipment problems. Blind orbit problems interrupted all METOP products for 7 hours on 22 August. These were interrupted for 20 hours on 28-29 September for a METOP satellite maneuver. There were several outages of Langley cloud data in July: 2 hours on the 7th, 8 hours on the 8th, 6 hours on the 11th, 7 hours on the 13th and 6 hours on the 19th, all due to disk space issues. Hurricane Irene caused an outage of Langley cloud data on 26-29 August. A hardware error interrupted WindSat data 28 July - 2 August. A 22-hour ASCAT outage occurred on 5-6 July, a 3-hour outage occurred on 23-24 July, and a 10-hour outage occurred on 26 September. On 9 August, the Level 2.5 88D radar decoder was modified to correct an error which output radar station height in feet instead of meters. The following data types are monitored by the NAM-GSI: RASS virtual temperature profiles (NPN and MAP), MAP wind profiles below 400 mb, Mesonet mass data, AIRS AMSU-A radiances, NOAA-19 HIRS-4/AMSU-A/MHS radiances, METOP IASI radiances, ASCAT and WindSAT winds, and MDCRS moisture data. All but RASS are being tested in the NAM parallel. NAM/NDAS PrepBUFR parallel uses the new NRL-based aircraft QC code. RTMA PrepBUFR files are being generated in parallel with 50 km ASCAT and WindSat scatterometer wind data (both non-superob) and these now include surface land, marine and mesonet reports with missing pressure. These missing pressure surface reports are being tested in the RTMA. Production NAM/NDAS dumps of METOP IASI radiances, GPS-RO data and SBUV-2 data are being created and dumps of RARS 1c radiances are being created in parallel. (Keyser)

NCEP generates experimental Rapid Refresh (RR) PrepBUFR files containing WindSat data (non-superob) and 50 km ASCAT for ESRL. These PrepBUFR files are now generated using the new NRL-based aircraft QC code

and no longer flag (reject) MDCRS (UPS and Southwest) and TAMDAR moisture obs. Beginning on 27 July, these PREPBUFR files were modified to run like production except the WFIP-relocatable boundary layer profiler wind, SODAR and RASS data, processed at NCEP since mid-July, won't be rejected so the ESRL RR can assimilate these data. The NCEP RUC/RR (and NAM) PrepBUFR files reject these data. RR dumps of Level 2 and expanded (time-window) Level 2.5/3 88D radial wind data, and GOES single-pixel cloud data from NASA/Langley (covering Alaska) are being copied to a public ftp directory. These, along with early parallel dumps for 0000 and 1200 UTC, are being tested in ESRL's experimental RR runs and the EMC RR parallel. In June the Radar Operations Center (ROC) started their hourly processing of Level 2.5 88D data 25-30 minutes earlier so more data will arrive before the RR cutoff, as it's the only available radial wind data for Alaska. (Keyser)

HiRes initialization scripts were updated and tested, following Matt Pyle's update for HiRes NMMB forecast. Strong constraints were tested again in the HiRes domain, along with Digital filtering (DFI), surface option and hourly cycling. The results from these tests were examined either by plotting surface pressure tendency or by checking RMS and forecast bias. Using an hourly cycle with strong constraints and DFI shows slightly better performance in wind, temperature and moisture verification. But hourly cycling made the surface pressure noisier. (Liu)

In the continuing effort of expanding CIP to GCIP, the code was modified to ingest METAR data from BUFR dump files. The work included interpreting METAR reports in BUFR code, processing stations, mapping the station observations to the GFS master file grid and calculating all affected grid points from nearby stations. As a tool for mapping stations to grid points, a projection method was developed especially for the GFS master model files, since the projection formula was not obtained. (Mao)

PLANNED EFFORTS: If funded, add the use of AIRS AMSU-A radiances to the next NAM-GSI update. Implement NRL quality control package. Change PrepBUFR processing to add report sub-type information for development of bias corrections. Develop a "master use/reject-list" for incoming data. Complete NAM and RR impact tests for TAMDAR (AirDAT feed); mesonet mass and roadway data, and new mesonet data feeds (including "hydro", "snow", modernized and SHEF COOP, UrbaNet, wind energy and late-arriving mesonet data); MDCRS aircraft moisture (WVSSII on Southwest aircraft); new sources of mobile synoptic surface reports (Greenland); NPN and MAP and European RASS virtual temperature profiles; JMA, Hong Kong, European, Canadian, MAP (below 400 mb), DOE and 6-minute NPN profiler winds; GOES 3.9 micron, GOES visible, and AVHRR POES satellite winds; hourly GOES IR and water vapor winds; WindSat and ASCAT scatterometer wind data (with later transition to new-science WindSat data); METOP IASI, and for the RR, METOP 1b, radiances; ozone from NOAA-series SBUV-2 and METOP GOME-2; GPS radio occultation data; SSM/IS wind speed and total precipitable water products; SSM/IS and TRMM/TMI rain rate; METEOSAT-9 IR and visible satellite winds; NOAA-19 AMSU-A, MHS and HIRS-4 radiances; RARS 1c radiances (to fill gaps in NESDIS 1b ATOVS); VAD winds from QC'd NEXRAD Level 2 data; GOES-13 and -14 radiances and winds; 10 meter wind speed from JASON-1 and -2 satellite altimetry data; lightning data from BLM network over Alaska and W. Canada; "tcvitals" records for tropical cyclones; and for the NAM; filling in rawinsonde profiles between significant levels. Maximize Alaska data retrievals (mesonet, aircraft and coastal surface). Add GSI events to NAM PrepBUFR files. Store surface wind speed and direction in PrepBUFR files even if both are not reported. Let GSI use the actual or estimated anemometer, barometer and thermometer heights on ships. Work with NCO to bring in new radar data sources (TDWR, Hurricane Hunter Tail Doppler Radar, Canadian, CASA, additional DOD sites, conversion of Level 2 to dual-polarization). Examine possible use of mixed-satellite (Aqua and Terra) MODIS winds for better coverage and timeliness. Obtain WildFire Automated Biomass Burning Algorithm (WFABBA) products for NAM Fire Weather runs. (Keyser) Strong constraints and DFI will used together to improve HiRes initialization. (Liu) Work on debugging CIP algorithm, now that dataset debugging is finished. (Mao)

PROBLEMS/ISSUES ENCOUNTERED OR ANTICIPATED: A severe backlog has developed in the implementation schedule on the NCEP computers.

INTERFACE WITH OTHER ORGANIZATIONS: ESRL/GSD & NCEP/NCO & NWS/Alaska Region & NESDIS

UPDATES TO SCHEDULE: All tasks and milestone/deliverables are complete.

11.5.17.E2 30 September 2011 (Manikin, ESRL/GSD) - **COMPLETE**
Perform configuration management for RR, including thorough documentation, and respond promptly to any code malfunctions or performance issues.

CURRENT EFFORTS: RR is not yet running in NCEP Production. No problems were detected during parallel testing this last quarter. Implementation progress and documentation can be tracked at **http://www.emc.ncep.noaa.gov/implementation-docs/impDoc.html .** (Manikin)

11.5.17.E3 30 September 2011 (Manikin, Pyle, Rogers, ESRL/GSD) - **COMPLETE**
Monitor RR, NAM & HiResWindow performance, respond to any problems detected by ESRL/GSD, NCEP, or any users, diagnose source/cause of the problem, develop solution, test changes and coordinate with NCO on implementation.

CURRENT EFFORTS: The fixes for the radar reflectivity and visibility in the HiResWindow scheduled to be implemented in July were implemented on 12 July. In response to some non-reproducible operational failures in the HiresW system, an RFC was filed on 9/27 at the request of NCO to eliminate the use of the hpmcount diagnostic tool from several HiresW job scripts. This change iss scheduled for implementation on 4 October. (Pyle)

PLANNED EFFORTS: If funded, monitor performance of the upgraded HiresW.

PROBLEMS/ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: All tasks and milestone/deliverables are complete.

NCAR/MMM
CURRENT EFFORTS: NCAR/MMM personnel prepared and released WRF Version 3.3.1. This was primarily a bug-fix release and was issued in September. Modifications addressed the SBU microphysics scheme, from Yanluan Lin (Stony Brook Univ.), and the Thompson microphysics scheme, from Greg Thompson (NCAR/RAL). A fix was made for the 2-m temperature diagnostics in the case in which the RUC LSM operates with the YSU PBL scheme (Smirnova – NOAA/ESRL and MMM). In addition, the WRF adjoint and tangent linear model code was made consistent with WRF 3.1.1.

Jimy Dudhia of NCAR/MMM continued to work with visitor Marcela Ulate (Univ. Miami) on investigating WRF physics and the simulation of the MJO. This has included diagnosing the mean heating and moistening profiles for a range of cumulus and PBL options on a 50-km WRF test grid. All of WRF's cumulus parameterizations are being looked at in terms of heating and moistening profiles, mostly with the MYJ PBL scheme.

Dudhia worked with Georg Grell (NOAA/ESRL) to address the issue of water conservation in the Grell 3 and Grell-Devenyi cumulus schemes, as it had been found that the schemes were not strictly conservative. A partial fix was implemented in the WRF 3.3.1 release.

Dudhia began an investigation with Ming Chen (NCAR/MMM) and Wayne Angevine (NOAA/ESRL) to resolve stability problems occurring with use of the TEMF PBL scheme. These first appeared in the DTC's testing of this option. NOAA has provided a fix to help stability, and this is being tested.

Dudhia worked with M. Biswas (DTC) on improving physics interoperability between the ARW and HWRF. This includes the NSAS convective scheme, where the detrainment process logic was improved in interactions with various microphysics schemes.

PLANNED EFFORTS: The development and implementation of new physics for WRF will continue per the new Technical Direction.

UPDATES TO SCHEDULE: None.

GSD
CURRENT EFFORTS: GSD continues its work on improved versions of the MYNN boundary layer scheme (Joe Olson) and the RUC land-surface model (Tanya Smirnova). Changes will be submitted to be part of the next WRF update (to benefit non-RR WRF users), and will also be candidates for the Rapid Refresh 2. More under Task 5.8

Task 11.5.4 Develop, test, implement, and improve the Rapid Refresh

ESRL/GSD
NCEP/EMC's Configuration Control Board met Monday 25 July and approved moving forward on the RR implementation with the small caveat of needing to see more quantitative precipitation forecast verification from the RR parallel cycle at NCEP (subsequently provided on 15 Aug). However, the RR operational implementation was pushed back by significant delays in the upgraded NAM implementation, now currently scheduled for 18 October. Barring further setbacks in the NCEP Central Operations implementation schedule, the RR could become operational by mid-December but with the Christmas/New Year moratorium, the RR implementation could occur as late as mid-January 2012. The RR parallel at EMC and the RR primary cycle at GSD continue to run stably, without crashes due to code or scripting problems.

Because of these delays, it has been possible to introduce two very minor enhancements into the GSI, one a RUC-based limitation on analysis increments near coastlines, and the other a safeguard introduced into the cloud analysis to preclude the use of METAR ceiling observations that result from non-hydrometeor particulates (dust, smoke, etc.). Several small adjustments were also made to ensure that WRF Preprocessing System had access to the initial surface pressure field and was initializing soil moisture from the RR correctly in the HRRR. Additional work was also needed to render the output files from UniPost as similar as possible between GSD and EMC. Unipost was also upgraded to output an estimated fractional cloud cover for low, middle and high clouds (three additional 2-d fields), based on the fraction of surrounding grid points containing cloud water or cloud ice in the near vicinity of each grid point.

Ming Hu, working with Geoff Manikin of EMC, Julia Zhu (NCEP/NCO) and Dennis Keyser (NCEP), has made good progress over the past month toward porting the RR code to NCO and getting the code to run in the NCO environment.

With the code set for the initial RR implementation, most effort during the quarter was directed toward test and evaluation of analysis and model changes being considered for the next RR upgrade ("RR2") hoped for in 2012. We continued testing of RR enhancements that have promise toward improvement of convection, both for the parameterized convection in the RR and the explicit convection in the HRRR initialized from the RR. As part of this effort we were able to initiate and to put into reservations on the Jet computer a second development cycle for the RR, dubbed RRdev2. This has accelerated our testing capability significantly, but has also entailed greater attention to details of the configurations of the 3 RR cycles at GSD in order to ensure valid comparisons between the GSD cycles as well as with the ongoing "RAP" cycle at EMC.

Motivated in part by slight high dew point and precipitation bias in the RR over the eastern CONUS and by some overforecasting of convection by the HRRR in the same area, we completed, continued or started testing in the RRdev the following during the July-September period.

- Addition of PBL-based pseudo residuals as described in the FY11Q3 report under Task 4. The first phase of this testing was concluded early in July and the impacts of addition of the pseudo residuals were found to be generally positive overall, and especially for convection forecasts from the HRRR. The FAA Aviation Weather Office team approved moving this change over to the RRprimary (from which the hourly HRRR is initialized) on 6 July, and the change was made effective 00z 7 July. Because the impacts of this change on RR forecasts (as opposed to HRRR) have not been uniformly positive, e.g., for 6-h wind forecasts in the upper-troposphere, we continue to use our capability to conduct retrospective

experiments to test out possible refinements to the procedure. This includes the use of only pseudo-residuals for water vapor, and not for temperature.

- Testing of several GSI modifications designed to improve incorporation of vertical temperature and moisture stratification information from rawinsonde observations (see Task 5.5 for more details).
- Nudging of soil temperature and moisture based on the sign of the observation innovations of 2-m temperature and moisture under certain conditions (see July 2011 monthly report). Testing began late in the month and was successfully completed in early September. This has now been introduced into the RRdev with slight reduction of the eastern CONUS high daytime dew-point bias. Further tuning of the strength of the nudging will continue.

In addition to these RR2 matters, in preparation for giving the final code version to NCO for the initial RR implementation several small adjustments were made to ensure that WRF Preprocessing System had access to the initial surface pressure field and was initializing soil moisture from the RR correctly in the HRRR. Additional work was also needed to render the output files from UniPost as similar as possible between GSD and EMC. Unipost was also upgraded to output an estimated fractional cloud cover for low, middle and high clouds (three additional 2-d fields), based on the fraction of surrounding grid points containing cloud water or cloud ice in the near vicinity of each grid point.

Physics testing underway for RR2 is covered under Task 8.

Several talks were prepared for the American Meteorological Society's 15th Conference on Aviation, Range and Aerospace Meteorology at Los Angeles, 1-4 August (Presentations available from AMS at: **http://ams.confex.com/ams/14Meso15ARAM/webprogram/allauthors.html**

5.4 Evaluation of the National Centers for Environmental Prediction (NCEP) implementation version of the Rapid Refresh and its skill in providing short-term guidance for aviation hazards.

Stephen S. Weygandt, M. Hu, T.G. Smirnova, C.R. Alexander, S. G. Benjamin, G. S. Manikin, J. M. Brown, H. Lin, J. B. Olson, P. Hofmann.

5.5 Improvement and testing of WRF physics options for application to Rapid Refresh and High Resolution Rapid Refresh.

John M. Brown, T. G. Smirnova, J. B. Olson, G. A. Grell, D. C. Dowell, S. Benjamin, C. R. Alexander, E. P. James, S. S. Weygandt, M. Hu, P. Hofmann, and H. Lin.

7.3 Radar-data assimilation into the Rapid Refresh (RR) and High Resolution Rapid Refresh (HRRR) models toward improved convective guidance for aviation.

David Dowell, C.R. Alexander, M. Hu, S. S. Weygandt, S. G. Benjamin, T. G. Smirnova, E. P. James, P. Hofmann, H. Lin, and J. M. Brown.

11.1 Beyond the 2011 Rapid Refresh: hourly updated numerical weather prediction guidance from NOAA for aviation from 2012-2020.

Stan Benjamin, S. S. Weygandt, J. M. Brown, and G. DiMego.

A change log on the ESRL primary and development RR 1h cycles is maintained at **http://ruc.noaa.gov/internal/RR_runs/RR_1h_info.txt**

NCEP

The Rapid Refresh (RR) has been running stably in an EMC parallel environment since December and the code has been frozen since April. Statistical evaluation shows that the Rapid Refresh is now comparable to the RUC for most parameters, with significant improvement shown for upper level wind and height fields. The codes will be handed off to NCO in September and RR implementation is currently scheduled for November. (Geoff Manikin) Various model and model physics configurations have been tested within the new SREF. Ensemble diversity (spread) issue has been investigated. The findings from these tests can also be applied to the future NARRE and HRRRE. (Jun Du). See extensive observation processing work by EMC's Dennis Keyser in support of RR under Tasks 11.5.1 and 11.5.17.

Subtasks

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

ESRL has continued comparisons between the EMC RR (RAPx) cycle and the operational RUC. Comparisons of the NCEP experimental RR and operational RUC (Fig. 1 below) continue to show comparable performance: Temperature somewhat better at upper levels, winds better overall, relative humidity about same overall (not considered important above 400 hPa).

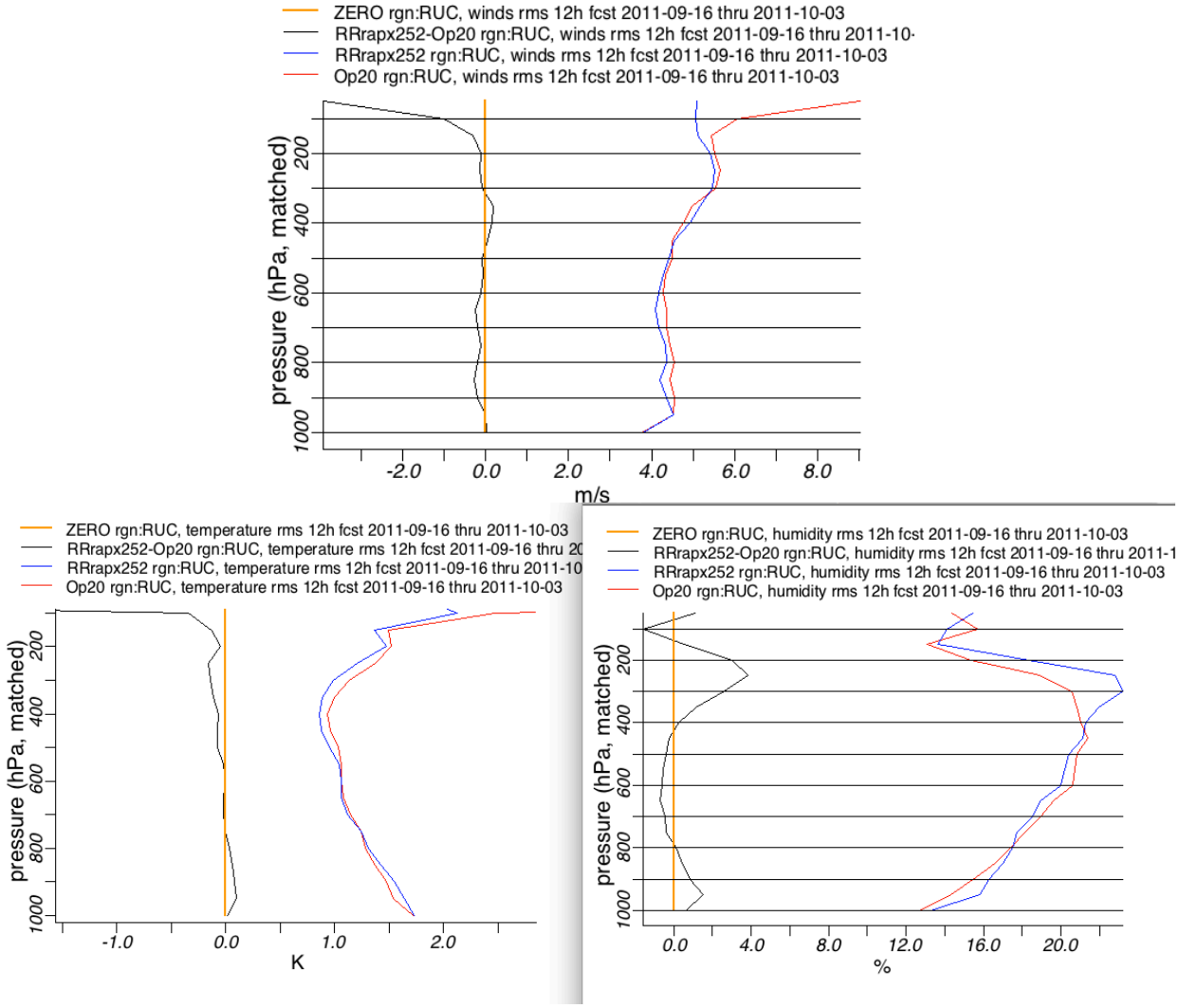

Figure 1. RMS errors for 12h forecasts from NCEP experimental Rapid Refresh (RRrapx252 – in blue) and operational RUC (Op20 – in red) for wind (top) and temperature and RH (below).

11.5.4.2 1 Nov 2010 (GSD) - **COMPLETE**

Solicit and respond to input from RR forecast users (e.g., FAA, AWC, SPC, NWS, other users), as well as AWRP RTs, on performance of Rapid Refresh.

ESRL continues to hold RR-status telecons for FAA and AWC colleagues every 4-5 weeks (last on 6 Oct 2011). All feedback from the other PDTs has been positive. This evaluation has been made possible by the availability of pgrb and bgrb files for the RR in GRIB1 from the EMC test RR cycle output. NCEP has decided to not provide sgrb files since all of the same fields are available in both pgrb and bgrb files (decided 12 Oct 2011).

From late July into August, ESRL held separate telcons with field forecasters from the Western, Central, Eastern and Southern Regions, respectively, of the National Weather Service. These had a dual purpose: briefing on both the RR and HRRR (a limited collection of hourly surface grids from the latter are becoming generally available to field offices), and to obtain feedback on model performance from forecasters. Interaction with field forecasters is extremely valuable toward identifying and addressing performance weaknesses.

The Storm Prediction Center has begun to evaluate BUFR sounding output from the EMC RR test cycle (from both analyses and forecasts) as compared to the RUC. The SPC forecasters use both analysis and forecast soundings extensively as part of their decision process on whether developing weather conditions warrant issuing severe thunderstorm and tornado watches.

Task 11.5.5 Develop, test, and implement improvements to the operational data assimilation supporting Rapid Refresh and North American Mesoscale runs

ESRL/GSD

Ming Hu completed coding of GSI modifications to apply soil temperature and moisture nudging within the RR hourly analysis. The nudging is based on the lowest atmospheric level temperature and moisture (relative humidity) increments. These changes were then included in the development version of the RR (RR-dev) at GSD. Evaluation of the analysis – background stats for the RRdev land the RMS surface temperature (T) and dew point (Td) errors for the RR-dev vs. RR-primary indicates that the soil nudging appears to be working and producing a slight improvement on surface T and Td forecasts. This analysis feature will not be part of the initial RR implementation, but is a likely candidate for the RR version 2 enhancements.

Another minor adjustment was made to the RR GSI to limit the low-level temperature and moisture analysis increment for near coastal oceanic regions. This change adds a feature form the RUC 3DVAR analysis that helps prevent the application of unrepresentative increments derived from coastal observations over near coastal oceanic areas.

Patrick Hofmann continued his testing and evaluation of the impact on GSI fits to radiosondes profiles as a function of variations in i) vertical correlation length scale, ii) observation error, and iii) increased vertical resolution in the raob data. A previous assessment within the real-time parallel RR-dev of just reducing the vertical correlation length scale indicated a modest forecast improvement. Patrick confirmed that our extended application of Wan-Shu Wu's code to provide the radiosonde observations at higher vertical resolution was functioning correctly, but yielding only modest impact of the analyzed sounding structure. As expected, the biggest improvement in the analysis fit to raobs was obtained by reducing the observed error variance. The next phase of this work is focusing on evaluating the impact of adjustments to these three parameters on sounding structure from cases of interest for convection (false alarm cases from early June 2011 and "underprediction" case of 19 August 2011). The analysis will focus on RR sounding structure (vs. observed and RUC analyzed) and on subsequent RR and nested HRRR forecasts.

Haidao Lin is continuing his satellite radiance data assimilation work. Based on suggestions he received from the JCSDA Workshop in May, he has coded up routines to compute Jacobians for the assimilated radiance channels (both for standard atmosphere and for Rapid Refresh background model fields). His results help to quantify the possible negative impacts from assimilating into the Rapid Refresh model (which has a model pressure top of 10 hPa) specific channels with weight functions that peak high in the atmosphere. Haidao is also conducting experiments to assimilate AIRS SFOV temperature and moisture retrievals. Haidao has recently been evaluating the GSI innovations (obs-background differences) for the AIRS SFOV moisture retrievals and found significant departure from Gaussian conditions. In particular there is a long tail on the negative side. Haidao has tried several different QC strategies, yielding some improvement in the innovation distribution, but is still getting negative forecast impact from these data in controlled retrospective tests.

Both GSD Rapid Refresh versions (primary and developmental) began ingesting WFIP boundary layer profiler data in late July (no code change involved). After some initial work by Ming Hu to directly ingest files created locally, Dennis Keyser created special files containing the observations and began sending them out. An issue

with the height assignment for the observations was identified and an interim fix to correct the problem was added to the GSI observation processing code. Once the correction to the height assignment was added prior to the PrepBUFR file generation, the interim fix within GSI was removed.

Ming Hu worked with Geoff Manikin, Julia Zhu and Dennis Keyser of NCEP) to complete important work for the RR NCEP operational implementation. This work included optimizing the GSI running in the NCEP Central Operations (NCO) environment. Ming Hu and Joe Olson also completed work (converting to PrepBUFR etc.) to get nacelle (wind farm turbine) data into the GSD RR cycles for monitoring only.

CAPS

Report on initial test results of implementing the EnSRF package for RR application. After correcting a script error and further tuning localization and inflation configurations, the forecast innovation of EnKF DA finally beat parallel GSI DA in all variables and at all levels, even for the longer hour forecasts. Details of works and explanations are described below.

Earlier in September, when building a 2-way interactive EnKF-hybrid system, a script error with EnKF cycles was identified. The error led an unfair comparison between GSI and EnKF; the EnKF forecasts verification were effectively 3 hours older than the GSI forecasts. When this error was corrected, the forecast errors of EnKF are now lower than those with corresponding GSI DA.

Meanwhile, work on tuning localization length continued. The EnKF was using fixed cutoff radii that are constant with height. In the GSI, the horizontal correlation scale increases with height while the vertical scale decreases with height. A nonlinear function is devised to give height-dependent localization scales have similar in behavior as the de-correlation scales in GSI. This modification further reduced EnKF forecast errors at the upper levels as well as the lower levels.

We further modified the function of cutoff radius of static covariance inflation. The original function resulted in near zero inflation above 200hPa. We added a constant value to the function so that the inflation coefficient is about 1 near the surface and approaches a constant value around 0.5 at the upper levels. This change resulted a slightly reduction in the upper level forecast error, and more importantly, made the upper level spread more consistent with forecast error.

In addition, during this quarter, we tried using multiple-physics ensemble in the EnKF DA cycles. As described in the last monthly report, the 40 members were divided into five groups, each group using different physical schemes with combination of different radiation, cumulus parameterization, surface physicals and PBL schemes. The multi-physics ensemble helps to increase the spread of EnKF and can provide candidate configurations for short-range ensemble forecasting also. Fig.2 (below) shows the 3-hour forecast innovations from the multi-physics and single-physics EnKF as compared to GSI DA. Clearly, the EnKF outperforms GSI for all variables at all levels. Multi-physics (red and dark green lines) are generally better than single physics (pink line). With the red line, due to stability issues during the WRF integration, we made no change in the vertical cutoff radius in fixed inflation. With the dark green line, we modified the function of vertical cutoff radius of fixed inflation as described above but with a smaller constant. In both cases, the overall inflation coefficient for multi-physics in vertical level is smaller than the single physics case. However, the spread of multi-physics are close to or even larger than single-physics case, indicating the enhancement of spread by the multi-physics. We will attempt to further tune the inflation for hopefully even better results.

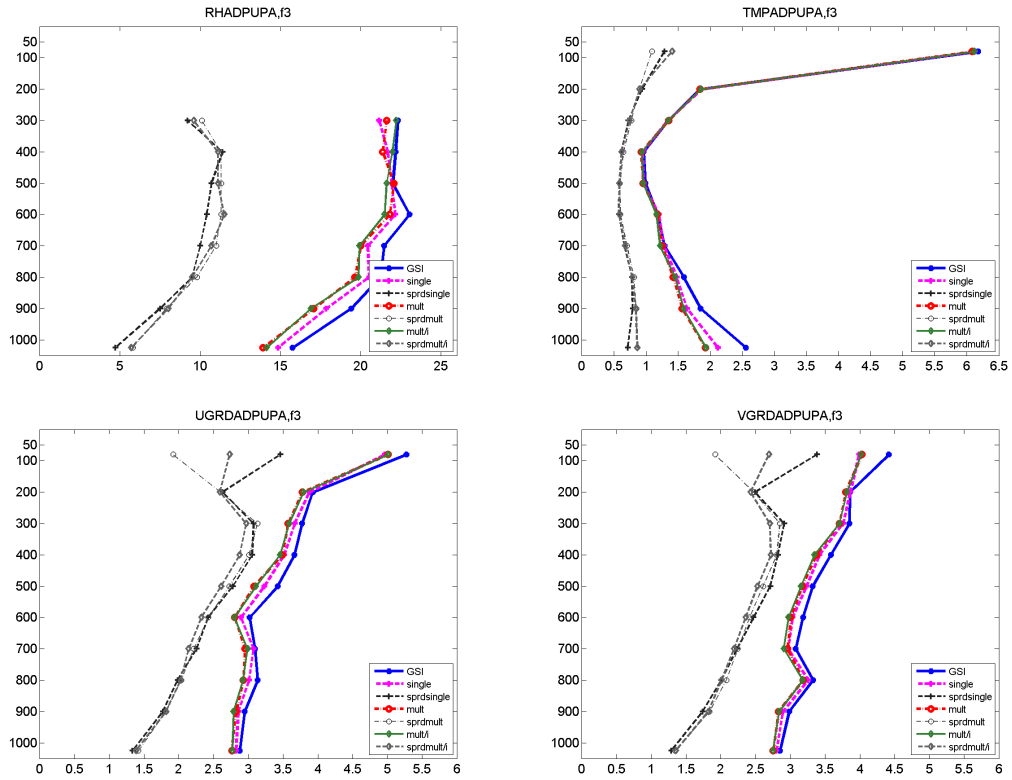

Figure 2. Vertical spread (grey and black) and RMSE (colored) profiles of 3-h deterministic forecasts for (a) relative humidity; (b) temperature (c) x-component wind and (d) y-component wind. All are verified against upper air reports (ADPUPA). The pink line is single physics which uses varied localization length in the horizontal and vertical and as well as the modified function of vertical cutoff radius of fixed inflation. Here, the added constant of fixed inflation coefficient is 0.7. The red and dark green lines are the result of multiple physics. The red line using the varied localization as pink line but without modification in the vertical cutoff radius of fixed inflation. The dark green line uses almost the same setting as pink line of EnKF except fixed inflation coefficient 0.5 is taken.

In addition to the pure EnKF work, the Hybrid-EnKF work also made good progress. EnKF Hybrid 1-way and 2-way interactive procedures were developed. In the 1-way procedure, the analyzed EnKF perturbations are used in the Hybrid-GSI for the flow-dependent part of background error covariance. In Hybrid 2-way, we replace the mean of EnKF analysis using the Hybrid-GSI analysis. Experiments were performed using the tuned horizontal and vertical localization scales but the old vertical cutoff radius of fixed inflation. Preliminary results of both Hybrid 1-way and Hybrid 2-way are very encouraging. As presented in the report of last month, both provide further improvement over EnKF and GSI. Clear comparison experiments are being carried out for comparing EnKF and EnKF-GSI hybrid results.

Also, in September, we are moving part of our experiments to an NSF Teragrid Supercomputer Kraken, a Cray XT-5 at NICS, to reduce burden on ESRL Jet. All modules were successfully complied on Kraken except the GSI. The default GSI configuration does not support ftn complier which is the default complier for the MPI library on Kraken. Many syntax errors within the GSI source codes were identified and corrected. The updated codes are tested and will be uploaded to the GSI repository in the future.

NCEP
Details below.

Subtasks

11.5.5.1 Refine the radial velocity analysis component of GSI and determine the optimal decorrelation scales for different analysis passes. (30 Nov 11)

Work continues to fix a bug in the radial wind assimilation code where the GSI does not handle level 2.5 and level 3 data properly when the observation is too close to a radar station. The GSI code was also modified to use the real station ID for level 2.5 and level 3 data. (Liu)

11.5.5.3 Report on testing of 2DVAR GSI assimilation of high spatial and temporal mesonet surface data using analysis grids with 2.5-km resolution. (31 May 11)

The capability to analyze wind gust, visibility, and planetary boundary layer height has been added to the official GSI code from the subversion server (Yanqiu Zhu, Pondeca)

Code for updating the RTMA "static" observation accept- and reject-lists on a periodic basis has been developed. In particular, this new capability eliminates the need to borrow the RUC mesonet wind accept-lists. An initial update of the lists used with the CONUS and Alaska parallel RTMA's has been performed using 3-month time series of observation innovations (Levine, Pondeca)

11.5.5.4 Adapt Desrozier et al. techniques to RR and apply to refine observational error and background error covariance estimates within the GSI. (30 Jun 11)

The effectiveness of adaptive tuning techniques was studied. It was found that for the types of observation with a large amount of locally dominant data the technique was less effective. For example, the method was less effective in determining the observational error variance of MESONET data, which are dominated by the amount of data near the surface. The tuning results should thus be judged subjectively. (Wu)

11.5.5.5 If authorized by NCEP Director, implement initialization of HiResWindow runs using CAPS/Shun Liu improved techniques for radial velocity analysis in GSI together with Diabatic Digital Filter use of 88D reflectivity Mosaic. (31 Jul 11)

An update in 2011 to HiResWindow was not authorized by NCEP Directors. Strong constraints were tested again in the HiRes domain, along with Digital filtering (DFI), surface option and hourly cycling. The results from these tests were examined either by plotting surface pressure tendency or by checking RMS and forecast bias. Using an hourly cycle with strong constraints and DFI shows slightly better performance in wind, temperature and moisture verification. But hourly cycling made the surface pressure noisier. (Liu)

Work began on adopting GSD's WRF-ARW radar data methodology that applies heating profiles during the diabatic phase of the digital filter into the WRF-NMM model code. The heating profiles are provided by GSI analyses of radar reflectivity data; Shun Liu is working with the GSI to provide that input for the WRF-NMM as currently is possible with the WRF-ARW. Testing of the revised WRF-NMM model code thus far has been limited to defining bogus coherent regions of positive heating to confirm that the expected impacts on the wind, mass, and cloud fields do take place in the initial hours of the model forecast. More realistic testing using actual GSI-generated heating information is anticipated in the coming months. (Pyle)

11.5.5.6 Based on case-study testing and refinement of the research quality code, deliver result in an 'experimental' code for an upgrade package (e.g. strong constraint, improved satellite channel bias correction, improved use of WSR-88D radial wind and/or satellite radiances and/or retuned covariances to the GSI for FY2011 change package to the NAM. (31 Jul 11) - **COMPLETE**

This package will be implemented in NAM October 18. The effort on identifying the significant levels of the rawinsonde data was solved by using the category flag attached to each piece of the observations. The observed profile was interpolated to the model levels between the neighboring report and a significant report. The interpolated values were treated as pseudo-observations and used in the analysis procedure. The goal was to provide better initial conditions around PBL top and tropopause. An extra check was added to the GSI trunk to exclude some MESONET pressures which were derived from the standard atmosphere but misused as surface pressure observations. Code was modified to accept MESONET, SFCSHP, METAR and SYNOP data with missing observational pressure, and observational height was used to locate the observations. Work on the regional 3dvar-ensemble hybrid continued. Codes were changed to incorporate vertically inhomogeneous background errors for blending coefficients of variational and ensemble solutions, as was the code to use a vertically integrated alpha on surface pressure instead of using the first level above the ground. A switch was added to allow an ensemble member perturbed on the regional first guess instead of on the global ensemble mean. Each of these features was tested with the off-line parallel system and a positive impact was found. Artificially dividing the upper layers into sub layers (NLAYERS) in use of satellite data was tested but the impact was neutral. A real solution is still needed here. (Wu)

Deliverables

11.5.5.E1 15 Sep 2011 (Manikin)
Pending EMC, and NCEP Center initial recommendations, Requests for Change (RFCs) are filed to submit GSI code as part of late 2011 upgrade for Rapid Refresh software to NCO.

CURRENT EFFORTS: GSI code is running in EMC's real-time RAP parallel and these codes will be RFCed in October after NAM implementation. (Manikin) Work continues on a bug in the radial wind assimilation code where the GSI does not handle level2.5 and level3 data properly when the observation is too close to a radar station. The GSI code was also modified to use the real station ID for level2.5 and level3 data. (Liu)

PLANNED EFFORTS: Continue checking the differences between radar level-2 data, level-2.5 data and level-3 data. Compare the old level-3 data against the new (high resolution) level-3 data. (Liu)

PROBLEMS/ISSUES ENCOUNTERED OR ANTICIPATED: A severe backlog has developed in the implementation schedule on the NCEP computers.

INTERFACE WITH OTHER ORGANIZATIONS: NCO

UPDATES TO SCHEDULE: DELAYED INTO 2011. All tasks and milestone/deliverables are complete.

11.5.5.E2 30 Sep 2011 (Wu, Parrish, Rogers)
Subject to NCEP Director approval implement NEMS/NMMB version of GSI (e.g. strong constraint, revised bkgs+obs errors) in NAM/NDAS.

CURRENT EFFORTS: The hybrid ensemble part of GSI with generalized control variable format was included in the GSI trunk, along with changes by Ricardo Todling to allow GSI to run with real (4) or real (8) precision. Significant time was spent tracking down small bugs introduced by these changes prior to inclusion in the trunk. This effort has delayed extension of hybrid ensemble dual resolution capability from global to regional. Only occasional assistance was provided to Jacob Carley for his application of hybrid ensemble GSI to 1.33km severe weather warn on forecast. He is now making substantial independent progress. (Parrish)

The package was accepted and the scheduled implementation date is Oct. 18. To create a tag in the SubVersion (SVN) system for the upcoming NDAS implementation in NCEP, GSI codes, fix files and related libraries were prepared and tested. The files were then stored in a GSI project branch in the SVN system. In order to include all the last minute updates, the branch will be tagged after the implementation. (Wu)

Testing of GSD's cloud analysis package for NMMB initialization has begun. An adjusted temperature tendency from the cloud analysis is converted back to temperature increment and an NMMB forecast was made with the

modified temperature field and hydrometer fields. Hourly cycle together with GSD's cloud analysis was setup. A case on 20110918 was used to test the whole package. A few of parameters in cloud analysis package was tuned based on test result. For this case, with radar data assimilation, composite reflectivity is significant improved for 0 to 9 hour forecast (Liu)

PLANNED EFFORTS: If funded, continue with adding dual resolution capability to regional hybrid ensemble GSI. Investigate new variational approach for assimilating radar reflectivity by including a retrieved latent heating estimate as forcing in the temperature tendency part of the regional GSI strong constraint. Continue work on updates to the GSI trunk which include bug fixes and adding new capabilities, such as use of GEFS for ensemble perturbations in the regional hybrid ensemble GSI, currently under extensive development by Wan-Shu Wu. (Parrish)

PROBLEMS/ISSUES ENCOUNTERED OR ANTICIPATED: A severe backlog has developed in the implementation schedule on the NCEP computers.

INTERFACE WITH OTHER ORGANIZATIONS: GSD, NCO

UPDATES TO SCHEDULE: All tasks and milestone/deliverables are complete.

Task 11.5.8 Improve physical processes in the WRF (RR and HRRR) and NAM models, especially including those that affect aircraft icing.

GSD
Modifications to the RR version of the RUC LSM discussed in the FY11Q2 and FY11Q3 reports continue to be working well. It is anticipated these will be committed to the WRF repository soon, now that WRF V3.3.1 has been released (22 September).

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

Modification and testing the MYNN planetary-boundary-layer (PBL) scheme continued. Joe Olson has been collaborating with Mikio Nakanishi, one of the original authors of the scheme, in this effort. Recent retrospective runs using our May 2010 retro period have shown overall good performance by MYNN relative to MYJ, but also issues that need further diagnosis. Additional retro runs are planned. Pending favorable outcomes, and after the conclusion of CoSPA on 31 October 2011, the MYNN will likely be implemented in one of the RR development cycles for further scrutiny and evaluation relative to the MYJ, with an eye toward using it as the surface-layer and planetary-boundary-layer option for the RR2. It is also being considered for eventual application in the HRRR.

NCAR/RAL
Subtasks:

11.5.8.1 Oct '10
Start to evaluate the relatively performance of new microphysics and PBL schemes used in the physics-perturbation-only 4-km CONUS-scale forecasts from CAPS spring forecast experiment.

11.5.8.2a Apr '11
Continue testing newly implemented coupled aerosol-microphysics scheme in case studies and perform sensitivity analyses.

11.5.8.2b May '11
Determine the best method for including aerosols into HRRR's initial analysis and boundary conditions so they are available to the microphysics scheme.

11.5.8E3 Sep '11
Deliver an improved ice nuclei tracking scheme in the two-moment microphysics scheme to ESRL for real-time testing in the WRF Rapid Refresh.

CURRENT EFFORTS: Trude compiled the relevant measurements from the ICE-L case and started to compare model simulation output with the measured wave cloud. The location of the modeled cloud compares very well with the real cloud, both in the horizontal and vertical. The vertical velocity wave structure and temperature are also nicely represented in the model. In parts of the cloud, the modeled droplet concentration is overestimated by a factor of two, but the liquid water content is close to measurements. Because of the thickness of the cloud, homogeneous freezing at the lower temperatures occurred resulting in high ice crystal number concentrations (100 – 300 L-1). These ice crystals were typically measured at the exit of the wave-cloud as they were transported down with the downdraft. In the entrance and main part of the cloud, the ice crystal concentration was much lower (0.1 – 10 L-1). Both the high concentration in the exit region, and the lower ice crystal concentration in the main part of the cloud were captured by the model. But in some places the heterogeneous ice nucleation caused slightly higher number concentration (up to about 30 L-1) in the model. When using the old Cooper parameterization for heterogeneous ice nucleation, the model was over-predicting the ice crystal concentration, both in the region of measured heterogeneous and homogeneous frozen ice crystals.

PLANNED EFFORTS: Continue developing and testing the new aerosol scheme.

PROBLEMS/ISSUES ENCOUNTERED OR ANTICIPATED: None

INTERFACE WITH OTHER ORGANIZATIONS: GSD

UPDATES TO SCHEDULE: None

Task 11.5.15 Develop improved methods of cloud and moisture analysis for use in the Rapid Refresh and NAM Modeling Systems.

GSD
On the night of 28 August 2011, SPC forecasters expressed concern about extremely high MUCAPE (most-unstable Convective Available Potential Energy) values over the lower deserts of California and Arizona in both the RUC and RR. This problem was traced to low ceilings reported at METAR stations as a result of a low lying layer of dust raised earlier by strong outflow from convection over southern AZ. A safeguard against this problem was added in early September to the backup RUC and RRdev cloud analysis to ignore ceiling height from METAR observations when dust or certain other restrictions to visibility are reported, or when the ceiling height is inconsistently low relative to the 2-m dew point depression. This code change has been added to the Rapid Refresh GSI code for the initial implementation of the RR at NCEP.

GSD continued to monitor changes introduced in late July by Stan Benjamin into the RUC-dev code to re-introduce cloud building from GOES cloud retrieval data, but only for within 1500m of the surface. The goal is to improve low-level cloud cover while avoiding the RH bias discovered in December 2010, leading to removal of cloud building in the RR at that point. If this new treatment is successful (which it is so far), this change will also be a candidate for the RR2 upgrade in spring 2012.

Using the RUC cloud analysis as an initial testing ground, Stan also coded a change in the calculation of the radar latent heating-based temperature tendency. The change provides an inverse linear ramping of the temperate tendency based on the degree of convective instability (most unstable Lifted Index – LI) in the model background field. The idea behind this is that for more unstable environments, less latent heating is needed to create a realistic convection evolution. Based on evaluation of this configuration in the RUC-dev (including possible

subsequent HRRR-dev runs), we may proceed to code and test this in the RR-dev for possible inclusion in the RR2 and use for HRRR initialization in 2012. Some HRRR tests were run in August using RUC-dev initial conditions to test this LI-dependent latent heating calibration, with mixed results so far.

With assistance from Ming Hu and Curtis Alexander, David Dowell ran the GSI cloud analysis (variational solver part turned off) to generate a 3-km radar reflectivity-based temperature tendency array for use in 3-km sub-hourly cycled HRRR radar reflectivity assimilation experiments. See task 5.24 for details.

Task 11.5.24 Develop, test, and improve the 3-km WRF-based High-Resolution Rapid Refresh

GSD

Production of real-time hourly HRRR forecasts for the summer CoSPA exercise continued with good overall reliability and skill. Following real-time use of the HRRR-dev parallel slot (new runs every other hour) to evaluate the impact of pseudo-observations within the RR and sensitivity to the model time-step, we began a set of retrospective HRRR runs. These HRRR retrospective runs will focus on an identified period of active weather (11-22 Aug 2011).

A four way comparison of HRRR from the RR and RUC with and without radar assimilation in the parent model has been completed. Reflectivity verification results indicate 1) similar performance for the RR-HRRR and the RUC-HRRR, 2) both the RR-HRRR and the RUC-HRRR improved upon their respective parent models, 3) Radar assimilation in the parent model improved both the RR-HRRR and the RUC-HRRR (compared to HRRR runs without radar assimilation in the parent model).
These results can be seen in Fig. 3, produced from a combined effort by Curtis, Eric, Haidao, Patrick and Steve.

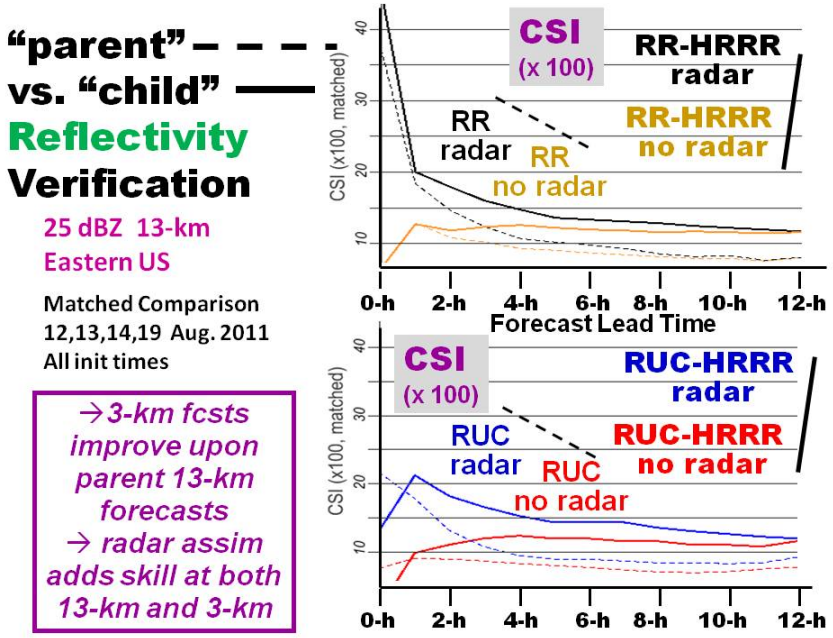

Figure 3. Comparison of CSI scores vs. forecast length for: (top panel) RR-HRRR vs. parent RR (with and without radar data assimilation) and (bottom panel) RUC-HRRR vs., parent RUC (with and without radar data assimilation)

David Dowell and Curtis Alexander continued their work on 3-km reflectivity assimilation (including application of the RR cloud analysis within GSI at 3-km). First, they tested applying the DFI at 3-km which yielded an increased bias and only a small forecast improvement and only during the first hours. Then they tried an experiment in which a temperature tendency from the radar reflectivity was applied (averaged with the temperature tendency

from the microphysics scheme) during an hour long pre-forecast integration period (four different temperature tendency fields applied for 15-min each). Results also showed only modest forecast improvement and only during the first few forecast hours. Steve Weygandt and Curtis Alexander gave oral summaries of this work at the AMS 35th radar conference in Pittsburgh and there will be multiple group presentations at NSSL Warn On Forecast Workshop and the WMO Nowcast Symposium.

An increase to the maximum allowable time-step in the HRRR was made. This change that had not impact on HRRR forecast skill, reduced overall run time by 5-8%. This change has been very helpful in further reducing the small fraction of HRRR runs that have not quite been completing in the allowed wall clock time. Also, using this time-step change and some other configuration optimization steps, the real-time HRRR-dev was switched from running everything third hour to running every other hour. This has allowed more opportunity to evaluate changes in the HRRR-dev cycle. These changes have included the use of the PBL pseudo-obs in the RR (approved as change for the HRRR last month), the minor time-step adjustment, and changes to the vertical length scale of the background error covariance.

Stan Benjamin, Curtis Alexander, and Eric James gave HRRR-related presentations at the ARAM conference in Los Angeles and Stan Benjamin and Steve Weygandt have given hour-long briefings on the RR and HRRR to several NWS regions. Finally, David Dowell has continued his work on testing cycled sub-hourly assimilation, obtaining generally encouraging results.

NCAR/MMM
CURRENT EFFORTS: NCAR acquired the HRRR source code, namelists, and initial conditions for the 11 July 2011 case study from GSD. This selected case is a nocturnal, derecho-like event in which organized convection propagated across Nebraska, Iowa, and Illinois. Given that the RR simulated the event, but the RUC did not, part of the investigation is to understand this performance difference. Jim Bresch (NCAR/MMM) ported the HRRR code was ported to an MMM computer and did preliminary runs.

During September, Bresch ran the HRRR for the test case using two different initial and boundary conditions—one from the RR and the other from the RUC. Output from each of the runs was compared. Preliminary results indicate there may be a problem with the method used to assimilate radar data that leads to physically unrealistic initial conditions from the RR. Additional diagnostics are continuing, and the summary report is in progress.

PLANNED EFFORTS: Completion of analysis and delivery of summary report.

UPDATES TO SCHEDULE: NONE