**MDE Product Development Team – July 2009**

**FY 2009**

**Submitted 17 August 2009**

With contributions from Geoff DiMego and Mary Hart (NCEP/EMC);
Stan Benjamin, John Brown, Steve Weygandt (NOAA/ESRL/GSD);
Jordan Powers, Roy Rasmussen (NCAR);
and Ming Xue (OU/CAPS)
*(Compiled and edited by S. Benjamin and B. Johnson)*

## Executive Summary

**Task 09.5.1: Infrastructure support related to operational running of the RUC and NAM operational modeling systems.**

- Continued evaluation of RUC and NAM, Canadian aircraft (non-turboprop) reports added into ESRL RUC to be added to operational RUC at NCEP as part of upcoming extension to 18h duration.

**Task 09.5.4 Develop, test, and implement Rapid Refresh configuration of the WRF modeling system.**

- Continued real-time feed of RR files to other AWRP RTs and Alaska Region NWS and getting feedback from them
- Changes made to WRF model to improve RR robustness with 1-h cycling
- Improvements in WRF-RR: testing of WRFV3.1 and options in 1-h cycle
- Serious file-system problems on ESRL supercomputer continued to cause major disruption in testing of RR 1-h cycle (but nearing end)
- Scripting in development for partial cycling for Rapid Refresh

**Task 09.5.5: Develop, test, and implement 3DVARs for RR and NAM**

- RR GSI – completion for elevation correction for surface obs to match model value
- 4 papers related to GSI and its application to Rapid Refresh at AMS NWP/WAF conference

**Task 09.5.6: Improve WRF model**

- Version 3.1 released 9 April 2009 (NCAR). Version 3.1.1 released in July.

**Task 09.5.15: Develop methods for improved cloud/hydrometeor analysis** in RR

- Discussions on GOES cloud data for full RR domain including Alaska (replacing CONUS GOES cloud data), not yet in test RR.

**Task 08.5.24/19: Begin 3km High-Resolution Rapid Refresh testing / Improve radar assimilation**

- Continued evaluation of larger-domain HRRR over eastern 2/3 CONUS – consistently strong performance including 13 May case with strong convection across central US, VORTEX2 cases.
- HRRR moved to new file system – 17 August 2009 – reliability will improve. Reliability for HRRR and CoSPA had been degraded from problems in previous file system.
- Additional GSD progress on a time-lagged HRRR-based convective probability forecast
- Two papers presented on HRRR at AMS NWP/WAF conference

**Test 09.5.20 Probabilistic forecasts**

- Initial VSREF framework developed by NCEP/EMC, additional discussions in May
- Improvements in HCPF forecasts

**Task 09.5.1** **Infrastructure Support Related to Operational running of the non-WRF Rapid Update Cycle System in NCEP Operations**

**GSD**

GSD modifications to ESRL RUC in July and early August

- Assimilation of Canadian aircraft data. Obs-background differences were re-examined for these data and found to now be of good quality. Canadian aircraft contribute a large number of observations, over 1000 reports/hour. Therefore, Canadian aircraft were added to the devRUC and will be added soon to the backup RUC.
- Assimilation of NASA Langley cloud data. Langley has begun producing hourly GOES-based cloud fields (top pressure, top temperature, liquid water path, ice water path) over most of the Rapid Refresh domain. Code was developed to assimilate this larger-domain data into the RUC, and was implemented into the devRUC at ESRL. After testing for a few weeks ago, similar changes will be introduced into the similar cloud analysis code in the GSI used in the Rapid Refresh. This will allow the first use of cloud-top data over Alaska.

**NCEP**

Dennis Keyser reports that NCEP/NCO is investigating radiosonde sites that report an invalid instrument type. Still waiting for NESDIS to respond to two problems, the GOES 1x1 field-of-view cloud data (where a few random files have data problems) and the late arrival of GOES-East data. All sources of TAMDAR data that were shut off on 7 April returned on 6 July apparently due to renegotiated agreements between NWS and AirDAT. Work can now continue on getting TAMDAR airframe type and airline code into the PrepBUFR file for ESRL's bias correction work. The NCO/EMC drop-out team discovered that the elevations for many radiosonde and surface sites are incorrect in the NCEP station dictionaries. Testing of elevation corrections in the analyses resulted in a slight positive impact, so the dictionaries will be updated in early August. Work continues with NCO/PMB to transition observation ingest, dump and quality control and processing codes and scripts to the new computer (stratus) whose acceptance is expected in August. An updated version of the NCEP BUFR library software is being tested for implementation later this summer.

***Subtasks***

October 2008 through September 2009

09.5.1.1 Maintain hourly RUC runs and provide grids of SAV and AHP guidance products
There were no issues related to RUC performance this quarter, and the continuing NCO moratorium prevented us from testing anything. (Manikin)

09.5.1.2 Provide vendors with gridded model data via Family of Services and the FAA Bulk Weather Data Telecommunications Gateway.
NCEP maintained real-time availability of SAV and 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). (EMC Team and NCO/PMB/Dataflow Group)

09.5.1.3 Provide full grids from RUC runs on NCEP and NWS/OPS servers. (30 Sept 09)
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 packed into GRIB2 format, see 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://www.nco.ncep.noaa.gov/pmb/nwprod/analysis/. (EMC Team and NCO/PMB/Dataflow Group)

09.5.1.4 Maintain access to model verification data. (30 Sept 09)
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 Since December 2008, this capability runs as part of the operational NCEP Production Suite, and is much more reliable since it is automatically switched with the rest of the suite when it is necessary to failover operations from one computer to another. (EMC Team and NCO/PMB)

09.5.1.5 Working with NCEP/NCO and NCEP/EMC, complete the design, compilation, debugging, test runs and parallel testing of RUC codes on new CCS computer.

**Deliverables**

09.5.1. E1 Perform ingest, quality control and preparation of both existing and new observations in support of the operational RUC runs. (NCEP, GSD)

CURRENT EFFORTS:
Changeover to P6 computer for all models, including RUC, occurred successfully on 12 August 2009.

INTERFACE WITH OTHER ORGANIZATIONS: NCO.

UPDATES TO SCHEDULE: None.

**09.5.1E2** (30 September 2009) (Manikin)
Perform configuration management for RUC, including thorough documentation, and respond promptly to any code malfunctions or performance issues.

**09.5.1E3** (30 September 2009) (Manikin, Keyser)
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:

PLANNED EFFORTS: Continue monitoring efforts.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED: None.

INTERFACE WITH OTHER ORGANIZATIONS: NCO.

UPDATES TO SCHEDULE: None.

*ESRL/GSD papers on RUC, Rapid Refresh, HRRR presented at 23rd WAF / 19th NWP Conference in Omaha:*

**Experiments with anisotropic background error correlations in the Rapid Refresh system**
Dezso Devenyi, S. Weygandt, M. Hu, S. Benjamin
http://ams.confex.com/ams/23WAF19NWP/techprogram/paper_154308.htm

**Monitoring observation-model differences in the real time Rapid Refresh System**
Dezso Devenyi, W. R. Moninger, S. R. Sahm, M. Hu, S. G. Benjamin, and S. S. Weygandt
http://ams.confex.com/ams/23WAF19NWP/techprogram/paper_154298.htm

**Adaptation and implementation of the Gridpoint Statistical Interpolation (GSI) for Rapid Refresh**
Ming Hu, Devenyi, Weygandt, Benjamin -
http://ams.confex.com/ams/23WAF19NWP/techprogram/paper_154318.htm

**Status report on Rapid Refresh development**
Steve Weygandt, T. G. Smirnova, M. Hu, J. M. Brown, D. Dévényi, S. G. Benjamin, W. R. Moninger, S. E. Peckham, G. A. Grell, K. J. Brundage, B. D. Jamison, C. W. Harrop, and J. B. Olson
http://ams.confex.com/ams/23WAF19NWP/techprogram/paper_154330.htm

**Implementation and testing of WRF Digital Filter Initialization (DFI) at NOAA/ESRL**
Tatiana G. Smirnova, S. E. Peckham, S. G. Benjamin, and J. M. Brown
http://ams.confex.com/ams/23WAF19NWP/techprogram/paper_154325.htm

**The High Resolution Rapid Refresh (HRRR): an hourly updated convection resolving model utilizing radar reflectivity assimilation from the RUC / RR**
Steve Weygandt, T. G. Smirnova, S. G. Benjamin, K. J. Brundage, S. R. Sahm, C. R. Alexander, and B. E. Schwartz
http://ams.confex.com/ams/23WAF19NWP/techprogram/paper_154317.htm

**Probabilistic thunderstorm guidance from a time-lagged ensemble of High Resolution Rapid Refresh (HRRR) forecasts**
Curtis R. Alexander, D. A. Koch, S. S. Weygandt, T. G. Smirnova, S. G. Benjamin, and H. Yuan
http://ams.confex.com/ams/23WAF19NWP/techprogram/paper_154254.htm

**Task 09.5.17 Infrastructure support for operational running of WRF-based modeling system in North American Mesoscale and HiResWindow at NCEP.**

**NCEP**
Eric Rogers's reports that on 29 July the Mesoscale Modeling Branch began running the NEMS-based NDAS/NAM real-time parallel system on the P6 supercomputer. This includes the NMMB (Non-Hydrostatic Multi-scale on B-grid) forecast model, and all codes (including the GSI analysis) that have been converted to run on the B-grid. This system will be used to run several case studies of problematic operational NAM forecasts to help assess the performance of the NEMS- and NMMB-based NAM and to debug these and other codes adapted to the B-grid.

Since many activities listed under Task 09.5.1 also pertain to NAM, they are not duplicated here. For the NAM specifically, Dennis Keyser reports that the mesonet wind uselist was found to contain errors in some provider listings. These errors cause the loss of over 600 sites in the NAM-GSI. A request to correct the uselist will be submitted in early August (following the lifting of the moratorium). Some Alaskan radiosonde sites still need to move up their launch time so the NAM-GSI can use their data. A request to add NOAA-19 1B HIRS-4, AMSU-A and MHS radiances to the 1B ingest and dumps, submitted in May, is awaiting implementation by NCO sometime in August. On July 9 no METOP-2 HIRS-4 radiance data were available for 18 hours due to its failing NESDIS' calibration checks. This also occurred for NOAA-17 HIRS-3 radiance data for 13 hours over July 6-7. Consultation with NESDIS revealed that NCEP's logic for checking the calibration flag is not correct. When the flag is set, the calibration quality for each channel should be examined since some channels may still be good. Since this change results in more data passing through the NESDIS QC, it will first be tested in the parallel GSI in August. Methods to speed up dump processing of NEXRAD Level II data are being explored. The following data types are monitored by the NAM-GSI: RASS virtual temperature profiles (NPN and MAP), QuikSCAT 0.5 deg. scatterometer wind superobs, Mesonet mass data, and MDCRS moisture data. Work continues with NCO/PMB to transition observation ingest, dump and quality control and processing codes and scripts to the new computer (stratus), which was accepted on 12 August. Crons are generating NAM/NDAS PrepBUFR files with 50 km ASCAT and WindSat scatterometer wind data (both non-superobed) and NAM/NDAS dumps of METOP IASI radiances, GPS-RO data and SBUV-2 data. These changes to obs monitoring plus several NMM bug-fixes are being tested in Eric Rogers' real-time P6

parallel NDAS/NAM. Tests are planned to evaluate the impact of using the GFS tropical cyclone relocation procedure to update the global first guess fields which are input to the t-12 hour NDAS in medium to strong tropical cyclone cases. This could replace the current synthetic wind data bogus. Dennis Keyser continues efforts to remove a legacy restriction that surface data must have a pressure report to be processed into the PrepBUFR files. This will allow many new surface observations (land, marine and Mesonet) to be assimilated in the RTMA.

***Subtasks***

09.5.17.1 Maintain four-per-day North American Mesoscale runs and provide aviation guidance grids. (30 Sept 09)

No new report for July, previous report in Q3 MDE report.

09.5.17.2 Maintain four-per-day HiRes Window runs and provide aviation guidance grids. (30 Sept 09)

09.5.17.3 Provide vendors with gridded NAM model data via Family of Services and the FAA Bulk Weather Data Telecommunications Gateway. (30 Sept 09)
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 grd #218) are also made available to FOS (and NOAAPORT) users. (EMC Team and NCO)

09.5.17.4 Provide full grids from NAM, and the HiRes Window on NCEP and NWS/OPS servers. Maintain access to model verification data. (30 Sept 09)
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 packed into GRIB2 format, see http://www.nco.ncep.noaa.gov/pmb/docs/GRIB1_to_GRIB2.shtml. All NCEP steps to make HRW output available to the Silver Spring distribution center for AWIPS-SBN and NOAAPORT were completed in this year's 1st quarter. Actual transmission is awaiting a bandwidth audit by NWS/OPS. The data should become available to NWS forecast offices with the full deployment of AWIPS Build OP9. A limited set of fields from the NAM and HiResWindow (HRW) runs (and other NCEP models) can also be viewed at http://www.nco.ncep.noaa.gov/pmb/nwprod/analysis/. (EMC Team and NCO/PMB/Dataflow Group)

**09.5.17.5** Working with NCO, complete the design, compilation, debugging, test runs and parallel testing of NAM and HRW (and SREF) codes on new CCS computer. (30 Sept 09)

Fine-tuning (with NCO) on the HiResWindow model task counts on the new CCS has been completed. (Pyle) NAM and NDAS have been stable. (Rogers, Keyser)
The second half of NCEP's new computer system in Gaithersburg, MD (known as stratus) was accepted by the government on June 29th after a full 30-day acceptance test. Because of the length of the test period, the NCO moratorium that was scheduled to last until late July (Quarter 4 of FY2009) has been extended until at least mid-August. (Hart)

**Deliverables**

**09.5.17.E1** 30 September 2009 **EMC** (Rogers, Pyle, Keyser, Liu)
Perform ingest, quality control and preparation of both existing and new observations in support of the operational WRF runs.

CURRENT EFFORTS:
Transfer to new P6 computer.

PLANNED EFFORTS:
Use AIRS AMSU-A radiances in the next NAM-GSI update (assimilation stopped in April 2008 when channel 4 went bad). Add a new aircraft quality control module from NRL, as soon as run times improve. This code is now being tested in daily real-time parallel runs and being evaluated by NCO. Change PrepBUFR processing to add report sub-type information so the analysis can use different obs errors and develop bias corrections based on data sub-types (airframes and ascent/descent tags, mesonet providers and sub-providers, radiosonde instrument type and on-site correction indicators). Complete impact tests in NAM for several new data types: TAMDAR (from AirDAT feed); QuikSCAT 0.5 deg. scatterometer wind superobs (eventually using "new science" QuikSCAT); mesonet mass and roadway data, and new mesonet data feeds (including "hydro", "snow", modernized COOP, UrbaNet and late-arriving mesonet data); MDCRS aircraft moisture; NPN and MAP RASS virtual temperature profiles; JMA, European and MAP profiler winds; GOES 3.9 micron and visible satellite winds; WindSat and ASCAT scatterometer wind data; METOP IASI radiances; ozone from NOAA-series SBUV-2 and METOP GOME-2; GPS radio occultation data; SSM/I and TRMM/TMI rain rate; METEOSAT-9 IR and visible satellite winds; NOAA-19 AMSU-A, MHS and HIRS-4 radiances. Coordinate with the field to speed up more Alaskan RAOB processing for the NAM dumps. Maximize Alaska data retrievals (especially mesonet, aircraft and coastal surface). Add GSI events to the NAM PrepBUFR files. Let GSI use the actual or estimated anemometer, barometer and thermometer heights on ships. Generate and QC high vertical-resolution aircraft profile data near airports. Explore (with NCO) the possibility of a use-list to keep experimental data arriving on operational channels out of the operational analyses. Develop a platform-specific surface quality control module within the PrepBUFR processing framework. Work with NCO to bring in new sources of radar data (e.g., TDWR, Tail Doppler Radar from hurricane hunter P3 aircraft, Canadian, CASA). (Keyser)

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:
Lack of disk space on cirrus & stratus P6 machines.

INTERFACE WITH OTHER ORGANIZATIONS: GSD & NCO.

UPDATES TO SCHEDULE:

**09.5.17.E2** 30 September 2009 **EMC** (Rogers, Pyle, Keyser)
As requested by other RT's, incorporate new AHP calculations into Operational WRF Model post-processor and product generator.

CURRENT EFFORTS: No requests from other RT's were received during the second quarter.

PLANNED EFFORTS:

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED: None.

INTERFACE WITH OTHER ORGANIZATIONS: NCO

UPDATES TO SCHEDULE: None

**Task 09.5.4 Develop, test, and implement the Rapid Refresh.**

**NCEP**

Dennis Keyser reports that his experimental Rapid Refresh (RR) PrepBUFR files containing 50 km ASCAT, WindSat data (non-superob) and expanded (time-window) QuikSCAT data (0.5 deg lat/lon superobs) continue to be copied to a private ESRL directory on the NCEP ftpprd server. RR dumps of expanded (time-window) Level 2.5/3 NEXRAD radial wind data are also being copied to a public ftp

directory. These and hourly lightning data are being tested in ESRL's experimental RR runs. ESRL plans to test other new data types present in the production RR PrepBUFR and dump files, to include Multi-Agency Profiler winds, Canadian AMDAR data, QuikSCAT data (up to 2 hours old) and METOP-2 radiances. EMC and GSD are requesting that the ROC move up their hourly processing of Level 2.5 NEXRAD data by 10 minutes so more data will make the RR data cutoff time.

**GSD**

The conversion of the Rapid Refresh to run Version 3.1 of WRF (released 9 April 2009), including merging with the recent ESRL-developed changes to the RR-WRF, was fully completed. This includes the WRF Preprocessing System (WPS), the WRF ARW model and the WRFpost.

Progress has been made in 3 areas that have bearing on the every 3-4 day crashes of the RR 1-h cycle.

- Limits to latent heating in WRF model designed and successfully tested. These limits are similar to those used in the RUC model. In another recent case the proximate cause of the crash was excessive vertical motion, brought on by grid-scale latent heat release in a deep layer of saturated, conditionally unstable lapse rate (again over Colombia). Although this still leaves open the definitive answer to the question of why this situation occurs only in the cycled runs, we believe it is because small-scale features in the moisture and wind fields build up during the cycling, thereby making the forecasts more prone to the possibility of strong grid-scale saturated moist ascent.
- Radar-based latent heating fields were found to be erroneous in areas away from CONUS. This was corrected immediately.
- A smaller cause of crashes was found to be related to the presence of a new capability in the surface driver of WRFv3.1 to diagnose fractional sea ice during the forecast in order to more accurately predict surface fluxes. A simple namelist change for WRF appears to have eliminated this problem.

A decision was made by ESRL and NCEP/EMC in June to implement "partial cycling" for the Rapid Refresh, similar to that implemented for the operational NAM in December 2008. In partial cycling, the atmospheric fields will be rederived in a catch-up hourly update cycle once or twice daily, starting from GFS (likely due to the higher top than in the NAM) or NAM grids. The land-surface and cloud/hydrometeor fields will be fully cycled within the Rapid Refresh. This partial cycling design takes advantage of the improved data assimilation for longer waves from the global GSI than found possible for the regional GSI used in the NAM and RR. The components for the partial cycling RR already exist but new scripts are close to completion for the parallel RR at ESRL.

GSD continues work toward preparing the WRFpost for the Rapid Refresh. Work began in July to introduce the NCAR-Thompson microphysics-based precipitation-type algorithm that has served RUC users very well.

GSD has also developed a possible new domain for the Rapid Refresh based on the rotated lat-lon grid for its WRF-ARW dynamical core. The rotated lat-lon projection is already used with the WRF-NMM dynamic core and became available for the ARW core in the last few months. The possible new domain is very similar to the present Lambert-conformal domain, and has about 3% fewer grid points. but with identical maximum grid spacing, so it should be more computationally efficient. Comparison runs between this new domain and the present one will be conducted and notice given to native-grid users of RR output before any changes are made.

The past two months we have been reporting the trials and travails of the largest and most advanced file system (Lustre File System, /lfs0) on the wJET/hJET computer. The situation continues to be precarious because so many old and possibly unrecoverable files remain on the system, causing it to be very full and subject to serious slowdowns. However, we are hopeful that before the end of August this situation will be resolved by the availability of nJet for running the HRRR and resolution of the /lfs0 issue itself by one last attempt at recovery of corrupted files. We have been promised that after this final attempt /lfs0 will be reformatted and should be restored to full capacity. There continues to be close communication and collaboration with the Raytheon systems people during all of this and we acknowledge their strenuous

efforts to deal with these matters.
NOTE: As of 17 Aug 2009, the HRRR began using a new file system at ESRL made available today.

***Subtasks***

09.5.4.1 Ongoing evaluation of performance of real-time and retrospective runs of RR system.

**GSD**
Starting in late October 2008 (but subject to the recent serious interruptions discussed above) two parallel full hourly cycled versions of the Rapid Refresh have been running at GSD, with files from the primary RR going to many users (including AWR RTs), also with verification and web-based plots.

Verification of standard atmospheric variables (temp, RH, wind) through early March over the RUC verification domain continued to indicate the experimental Rapid Refresh is competitive with the RUC at most forecast lengths and output times. Upper level wind RMS errors were almost an exact match to the RUC, except near the tropopause where scores were a bit worse. Beginning in mid-late March, however, performance of the RR has been intermittently worse, particularly for winds and temperature near the tropopause. That aircraft reports were not being used in the GSI during part of this period contributed, but is not the full explanation. Efforts to more fully evaluate and resolve this issue have been complicated by the ongoing computer issues, but are continuing. Verification over Alaska continues, but is seriously impaired by the computer issues.

**NCEP**
Experimental RR PrepBUFR files containing 50 km ASCAT, WindSat data (non-superob) and expanded (time-window) QuikSCAT data (0.5 deg lat/lon superobs) are being copied to a private ESRL directory on the NCEP ftpprd server. RR dumps of expanded (time-window) Level 2.5/3 NEXRAD radial wind data are also being copied to a public ftp directory. These and hourly lightning data are being tested in ESRL's experimental RR runs. ESRL plans to test other new data types present in the production RR PrepBUFR and dump files, including Multi-Agency Profiler winds, Canadian AMDAR data, QuikSCAT data (up to 2 hours old) and METOP-2 radiances. EMC and GSD are requesting that the ROC move up their hourly processing of Level 2.5 NEXRAD data by 10 minutes in order to allow more data to make the RR data cutoff time. (Keyser)

09.5.4.2 1 Nov 2008 (GSD, NCEP)
Continue to solicit input from Inflight Icing, Turbulence, National Ceiling/Visibility, and Convective Weather RTs and NWS forecasters in Alaska and Puerto Rico, as well as AWRP RTs, on performance of pre-implementation Rapid Refresh. Arrange to have GSD RR grids available to examine and solicit feedback on RR performance.

**(ESRL/GSD)**
GSD continues to make many different types of RR files available to users (AWR RTs, NWS). We are currently producing 4 flavors of RR files (native level, pressure level, surface field, and precip fields) for each of 3 grids (full RR, Alaska 249, CONUS) and in grib1 and grib2 formats.

PPT presentations (from the Alaskan Weather Symposium from 10-12 March in Fairbanks, AK). Summarizing Rapid Refresh verification as of that date can be viewed at:
http://ruc.noaa.gov/pdf/RR-AK-Wx-Symp-Mar09-pt1.pdf and
http://ruc.noaa.gov/pdf/RR-AK-Wx-Symp-Mar09-pt2.pdf

As a result of discussions with Alaska forecasters late last year, NASA Langley initiated an effort to produce GOES-based cloud products over most of the Rapid Refresh domain (more under 09.5.15). The real-time feed for this data is now in place, and it has been introduced into the RUC dev13 cycle at GSD for evaluation as of 6 August 2009. Initial results look good and the Langley GOES cloud-top data covering Alaska will be introduced into the RR over the next month.

Various AWRP RTs at NCAR have also been accessing the RR grids and are evaluating the performance

of their algorithms on this data. Bob Sharman (Turbulence PDT) has informally expressed concern over noise in the 500 hPa field grids they are receiving, and smoothing to remove small-scale detail from the heights of constant pressure surfaces was introduced into the WRFpost late in July. GSD has now added changes to WRFpost to address this issue, now in testing in the "cold start RR" and soon in the 1h-cycle RR. The Icing PDT makes revealing displays comparing the hydrometeor fields from the RR vs. RUC.

09.5.4.3 30 May 2009 (GSD, NCEP, NCAR)
Updated report on status of tactical planning for making RR-WRF ARW model code for 2012 in compliance with Earth System Modeling Framework (ESMF) in agreement with the Sept 2007 Rapid Refresh MOU between NCEP and GSD.

See Q3 MDE report.

09.5.4.4 30 Sept 2009 **(previously extended to Q2 FY10 @ Jan09 AWRP meeting – DiMego and Benjamin)** (GSD, NCEP)
Complete pre-JIF evaluation of Rapid Refresh in accordance with NCEP pre-implementation checklist for major implementations. Respond to evaluation questions, present information on Rapid Refresh pre-implementation testing and evaluation results in various forums, as required.

09.5.4 30 Sept 2009 **(previously extended to Q2 FY10 @ Jan09 AWRP meeting – DiMego and Benjamin)** (GSD and NCEP)
*Pending EMC, and NCEP Center initial recommendations, Job Implementation Forms (JIFs) are filed to submit Rapid Refresh software to NCO.*

**Deliverables**

09.5.4.E1 20 Dec 2008 (GSD)
Report on Rapid Refresh testing at annual NCEP Production Suite Review meeting.

A presentation summarizing the RR testing and refinement was given by Steve Weygandt at the NCEP Annual Product Review (see PPT slides for RUC/RR presentation under
http://www.emc.ncep.noaa.gov/annualreviews/2008Review/index.html

09.5.4.E2 1 September 2009 (GSD, NCEP)
Complete documentation (in Technical Procedures Bulletin-like document) of Rapid Refresh system.

09.5.4.E3 30 September 2009 **(previously extended to Q2 FY10 @ Jan09 AWRP meeting – DiMego and Benjamin)** (GSD, NCEP)
*Pending EMC, and NCEP Center initial recommendations, Job Implementation Forms (JIFs) are filed to submit Rapid Refresh software to NCO.*

**Task 09.5.5 Develop, test, and implement improvements to the operational 3DVARs for Rapid Refresh and North American Mesoscale runs.**

**NCEP**
Wan-Shu Wu reports that the tests to separate the bias correction files of the satellite data with respect to time of the day were carried out, and based on the performance of the low resolution NDAS system on the NOAA R&D computer at NCEP, the experiment produced a neutral impact on the forecasts although the resulting bias corrections did show clear differences among those for different times of the day. In preparation for the next NDAS upgrade, NOAA 19 radiances were tested in the off-line full-resolution parallel and the results showed a neutral impact on short-range forecasts. She also worked on upgrading the current operational GSI for the expected BUFRLIB changes, and submitted the code for implementation.

Dave Parrish reports the GSI with NMMB interface (B-grid and generalized vertical coordinate) is now in

the new GSI subversion repository. It was successfully checked out by Eric Rogers and is now running in his NMMB NDAS parallel. Changes to RTMA by Manuel Pondeca and new code developed by Yosiaki Sato were added to the dparrish branch of the GSI repository, and have been submitted for review and inclusion in the main repository. A generalization of the control variable structure in GSI designed by Yanqiu Zhu is being added to the dparrish repository branch. This is a major undertaking due to substantial differences between the new GSI and the previous non-subversion Q1FY10 GSI. These changes may take two months to complete, but will allow for much greater flexibility and ease in adding new analysis variables. For example, Yanqiu used this new structure to test adding wind gust and visibility variables to the 2D/RTMA capability of the GSI analysis.

Shun Liu worked on dumping VAD wind from 2008 version radar QC package. Because the current VAD winds transmitted to NCEP are generated with different local configurations and are generated locally where NSSL QC has not yet been performed, it is expected VAD winds generated at NCEP using a single standard configuration and using data processed through NSSL QC will be superior to the current VAD winds. Shun worked on updating the radar QC package to the 2009 version, where the VAD wind processing was further improved. However, since LAPACK lib was first used in 2009 version of QC package, LAPACK is not yet available in NCEP's CCS (cirrus/stratus). Similar subroutines in ESSL on the CCS were tested as a substitute for the LAPACK lib subroutines and differences are being assessed. Shun Liu and Binbin Zhou have set up grid-vs.-grid verification for HiRes forecasts using both composite reflectivity and echo top. Composite reflectivity Equitable Threat Scores (ETS) were improved in the 3 hour forecast and 24 - 36 hour forecasts after assimilating radar radial wind. The impacts on other forecast periods were very small.

**GSD**

Dezso Devenyi has completed his work on a set of modifications to map the surface observations from the actual terrain to the model terrain (using a local lapse rate from the background field). By providing for a more accurate innovation, an improved fit to the surface observation should be obtained. Without this change, surface observations for which there is a significant height difference between the actual and the model would just be down-weighted, resulting in a less close analysis fit to these observations. Following Dezso's successful off-line testing, Ming Hu has merged these changes into a GSI snapshot pulled from the GSD operational RR cycle (Boulder GSI SVN revision #69, based on the NAM March 2008 version with GSD RR-specific modifications). These changes will be tested in the RR retro system. The current work with the retro system to diagnose and resolve the periodic model crashes has taken longer than expected because of persistent computer reliability issues, however it appears as though a solution to that problem may be at hand (see discussion under task 5.4). Continuing his work with the 1QFY09 version of GSI, Ming Hu has added in the code needed to do the radar reflectivity processing (completing all the changes needed to make this version RR-enabled). Following successful off-line tests, Ming is introducing this GSI version into the parallel real-time RR cycle (both the GSD operational RR and the GSD parallel RR are already using WRF version 3.1).

Ming Hu has scripted and has begun initial testing of a partial cycling capability. Within the new partial cycling run, A pre-forecast RR spin-up period is begun with a cold start off of the GFS +3h forecast (but with a fully cycled specification of land surface model fields) at 3z and 15z. The hourly cycled pre-forecast is then run for six hours (with just a 1-h forecast made to advance the cycle) and a free forecast RR is initiated at 09z and 21z. Under this formulation, the partial cycling would (with a six-hour pre-forecast spin-up) would occur two times per day with regular hourly cycling at all other times. Additional experiments will consider alteration to the partial cycling frequency (2x vs. 4x per day) and to the hourly spin-up period (6-h vs. 3-h).

Dezso Devenyi continues his work with Bill Moninger on creating a web-based utility for tracking O-B and O-A statistics. The prototype is up and running and will be extremely helpful for diagnosing observation using including QC issues etc. Dezso gave presentations on both the surface assimilation and observations monitoring work at the recent NWP and WAF conferences, respectively. Also, work has begun to scope out possible techniques for converting the cloud analysis which is currently non-variational to a variational formulation. Four scientists from GSD will visit NCEP/EMC the third week of August to discuss these plans.

09.5.5 30 May 2009 (CAPS and GSD)
Testing and refinement to the radial velocity analysis component of the GSI for Rapid Refresh configuration together with the cloud analysis.

See Q3 MDE report.

New:
Using the selected test case (from 15 June overnight into 16 June 2009) Yi Yang of CAPS has recently completed a set of mini-retrospective experiments to evaluate the forecast impact from assimilation of level 2.5 radial velocity data (from NCEP files). Work is ongoing to verify the forecast from the different experiments.

***Subtasks***

09.5.5.1 31 December 2008 (NCEP and GSD)
Report on testing of 2DVAR GSI assimilation of high spatial and temporal mesonet surface data using analysis grids with 5-km or finer resolution.

The RTMA system has been built for the Guam NDFD grid, and its evaluation is underway. In addition, work has been performed on calibrating the background error covariance model of the 2.5 km resolution CONUS RTMA, which is to replace the current 5 km resolution system. (Pondeca)

09.5.5.2 31 December 2008 (NCEP)
Establish hourly cycled NAM assimilation system on NOAA R&D computer at NCEP (machine called "haze") using GSI and WRF-NMM to be adapted to ARW-based RR by GSD.

The cycled assimilation system with the digital filter is functional on vapor. (Wu)

09.5.5.4 28 February 2009 (GSD)
Report on preliminary statistical evaluation of Rapid Refresh forecasts initialized with the GSI, including examination of upper-level winds, surface fields, and precipitation.
Extensive evaluation of the RR in late February (in advance of our trip to Alaska to discuss RR with Alaska NWS folks) indicated satisfactory results in most verification statistics.

Details are included in the following PPTs, presented at the Alaska Weather Symposium: PPT presentations (from the Alaskan Weather Symposium from 10-12 March in Fairbanks, AK), summarizing the most recent Rapid Refresh verification can be viewed at:
http://ruc.noaa.gov/pdf/RR-AK-Wx-Symp-Mar09-pt1.pdf and
http://ruc.noaa.gov/pdf/RR-AK-Wx-Symp-Mar09-pt2.pdf

The computer disk outage is late May has greatly complicated efforts to evaluate and refine the Rapid Refresh cycle since that time. A change was made to the ARW damping coefficients in early May (just before the disk issues), that made the verification scores worse. This change was removed late in the month. Preliminary precipitation verification indicates improved CSI scores compared to the RUC, but slightly higher biases.

09.5.5.5 Based on case-study testing and refinement of the research quality code, deliver 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 co variances) to the GSI for FY2009 change package to the NAM. (31 Jul 09)
(Pondeca, Yanqiu Zhu, Parrish)

See Q3 MDE report.

***Deliverables***

**09.5.5.E1** 31 March 2009 **EMC** (Rogers, Wu, Parrish, Pondeca, Liu)
Subject to NCEP Director approval, implement upgrades (e.g., partial cycling, TAMDAR) to GSI used in NAM/NDAS.

CURRENT EFFORTS: The NAM/NDAS upgrade was implemented in December 2008 just prior to the NCO moratorium. (Wu, Rogers)

PLANNED EFFORTS: Continue preparations of the 'experimental' version of the next GSI upgrade package which, if it doesn't make it in as a possible late 2009 regional GSI minor upgrade, will be included in the next major NAM implementation. Continue checking the new TLNMC code. Run assimilation tests with the low-res WRF-NMM test bed comparing the no constraint, existing TLNMC, and new TLNMC. (Wu, Parrish)

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED: None.

INTERFACE WITH OTHER ORGANIZATIONS: NCO

UPDATES TO SCHEDULE: Completed December 2008.

09.5.5.E2 30 September 2009 **(previously extended to Q2 FY10 @ Jan09 AWRP meeting – DiMego and Benjamin)** (GSD, NCEP)
*Pending EMC, and NCEP Center initial recommendations, Job Implementation Forms (JIFs) are filed to submit GSI code as part of Rapid Refresh software to NCO.*

09.5.5.E3 30 September 2009 (CAPS and GSD)
Finalize enhancement package for radial velocity data analysis to begin testing at GSD toward future implementation for Rapid Refresh.

09.5.5.E4 30 August 2009 (GSD, NCEP)
Complete report on Rapid Refresh performance, including that from the GSI component of the RR, in comparison with the operational RUC.

PROBLEMS / ISSUES ENCOUNTERED: Significant computer downtime due to major issues with the main GSD supercomputer disk system completely compromised the Rapid Refresh (and HRRR) real-time cycle during much of the month of May with sporadic outages continuing into August. GSD personnel quickly transferred operations to other disks, but I/O was slower resulting in many missed runs. In addition, work to transfer GSI enhancements (such as the surface observations terrain matching code) to the real-time cycle was greatly hampered. The disk became available again in early June, but, as noted under Task 4, reliability continues inadequate for careful evaluation. We look for this situation to improve by late August as a new file system (already used in the HRRR as of 8/17) becomes available and storage on the previous file system becomes available.

CURRENT EFFORTS: Two parallel RR cycles, and a retrospective cycle are running at GSD and being used to evaluate RR / GSI enhancements, but efforts to finalize the system and obtain documentation of the forecast impact from the latest changes have been significantly hampered due to computer reliability issues (see PROBLEMS / ISSUES below). Intensive effort ongoing by the ESRL IT personnel to resolve lingering computer issues related to the major disk crash in late May 2009. This has involved sporadic scheduled (and unscheduled) downtimes for the disk systems. We have coordinated with the IT personnel to automate procedures to failover RR cycles to secondary disk systems and handle other computers disruptions as much as possible.

**Task 09.5.8** **Improve physics in the WRF model, especially that bearing on prediction of aircraft icing.**

***Subtasks***

09.5.8.1 31 July 2009 (GSD)
Complete systematic GSD evaluation of physics performance in GSD 1-hour RR cycles for initial RR implementation.

Joe Olson continues testing the new WRFV3.1 version of the Nakanishi-Niino-Mellor-Yamada boundary-layer scheme that was implemented by Mariusz Pagowski of GSD. A more physically based formulation of the mixing length has been implemented in the scheme. This has eliminated pockets of unrealistically large mixing lengths and turbulence kinetic energy in the upper troposphere in several test cases. Testing and evaluation of this scheme will continue.

Although not strictly a physics issue, we have had a long-standing concern about the WRF procedure to diagnose 2m temperature and mixing ratio over land from the skin temperature and surface soil moisture. In particular, in this diagnosis, the predicted lowest atmospheric layer temperature and mixing ratio are not used. Tanya Smirnova has begun to test modifications that take these values into account.

09.5.8.3 30 July 2009 (NCAR)
Research and testing on addition of the new explicit aerosol variable(s) in initiating cloud water and ice. Computer storage and run time considerations will be considered as a constraint on the development. (NCAR task)
Trude Eidhammer wrote a report (http://ruc.noaa.gov/faa-mde/Report-5.8-Jul09-NCAR.doc) summarizing her work in developing and implementing a new ice nucleation scheme in WRF based on new ice nucleation parameterizations of Paul DeMott and others. This scheme also includes a new routine to account for dry deposition of dust due to turbulent transfer to the surface. This routine is also based on WRFchem GOCART module (as the emission and gravitational settling routines are), but an assumed size distribution is used instead of using size binning. The report was delivered to Stan Benjamin on July 30 on schedule (deliverable 09.5.8.3).

**Deliverables**

09.5.8.3 Jul '09: Report on research and testing on addition of the new explicit aerosol variable(s) in initiating cloud water and ice. Computer storage and run time considerations will be considered as a constraint on the development. (NCAR task). Available at (http://ruc.noaa.gov/faa-mde/Report-5.8-Jul09-NCAR.doc)

09.5.8.5 Dec '09: Report on FY07-funded ESRL-NCAR RR retrospective testing of the impact of different thickness of vertical model layers close to the surface and, as appropriate, other physics. (Joint NCAR and ESRL task)

09.5.8E2 Sep '09: Provide an improved microphysics scheme to ESRL for evaluation toward FY11 Rapid Refresh upgrade. (NCAR )

09.5.8E3 Aug '09: Complete FY09 physics improvement for icing, C&V, turbulence and convective forecasts. (NCAR)

09.5.8.5 1 December 2008 (DTC, GSD)
Report on FY07-funded GSD-DTC RR retrospective testing of the impact of different thickness of vertical model layers close to the surface and, as appropriate, other physics.
A draft report was written by the DTC and GSD provided comments on this draft.

09.5.8.6 1 August 2009 (GSD)
Begin to explore possibilities for enhancing treatment of sea ice and tundra (including spring-time pooling)

in Rapid Refresh domain toward FY11 Rapid Refresh upgrade.
See subtask 8.1 for modifications already made for sea ice. Ftp arrangements were made to make RR grids available for evaluation for forecasters at Environment Canada's Arctic Weather Center at Edmonton the real-time RR1-h cycle running at GSD.

**Deliverables**

09.5.8.E2 30 Sept 2009 **(previously extended to Q2 FY10 @ Jan09 AWRP meeting – DiMego and Benjamin)** (GSD, NCEP)
Pending EMC, and NCEP Center initial recommendations, Job Implementation Forms (JIFs) are filed to submit upgraded WRF model physics code as part of Rapid Refresh software to NCO.

09.5.8.3 Jul '09: Report on research and testing on addition of the new explicit aerosol variable(s) in initiating cloud water and ice. Computer storage and run time considerations will be considered as a constraint on the development. (NCAR task)

09.5.8.5 Dec '08: Report on FY07-funded ESRL-NCAR RR retrospective testing of the impact of different thickness of vertical model layers close to the surface and, as appropriate, other physics. (Joint NCAR and ESRL task)

09.5.8E2 Sep '09: Provide an improved microphysics scheme to ESRL for evaluation toward FY11 Rapid Refresh upgrade. (NCAR)

09.5.8E3 Aug '09: Complete FY09 physics improvement for icing, C&V, turbulence and convective forecasts. (NCAR)

**Task 09.5.15 Develop improved methods of cloud and moisture analysis for use in the Rapid Refresh.**

***Subtasks***

09.5.15.2 5 Jan 2009 (GSD and CAPS)
Continue testing and evaluation of the generalized cloud/hydrometeor assimilation (including GOES cloud-top data and METAR cloud/visibility/weather data) within a cycled GSI on the full Rapid Refresh domain.

**GSD**
Work by GSD continues on refining the GSI cloud analysis for Rapid Refresh. Extensive report on this task in April Q2 MDE report. Main task this month *by Ming Hu) has been completion of porting the cloud analysis modifications to the new GSI version (1QFY09).

09.5.15.3 30 Jan 2009 (GSD)
Develop and evaluate performance of diabatic digital filter initialization (DDFI) in the 13-km RR WRF model including assimilation of radar reflectivity data

**GSD**

09.5.15.4 30 May 2009 (GSD and CAPS)
Request in February from Stan Benjamin and Ming Xue: DEFER due date from 30 March to 30 May. Assumed approved.

Further refine the generalized cloud analysis for the target RR resolution, model physics scheme and use of additional data. Perform forecast test evaluations to document the impact of the cloud analysis refinements.

09.5.15.6 30 Mar 2009 (GSD)
Include radar reflectivity-based latent heating within diabatic digital filter initialization (DDFI) in the RR WRF model

The DDFI-based radar assimilation continues to run with desired results in the GSD operational and now the parallel RR cycles.

**Deliverables**

09.5.15.E2 30 Sept 2009 (GSD)
Complete testing of GSI generalized cloud analysis for Rapid Refresh and deliver code to NCEP as part of Rapid Refresh package delivered to EMC, pending availability of NCEP testing capability.

**Task 09.5.6 Develop, test, and evaluate the performance of the nonhydrostatic WRF modeling system.**

**NCAR/MMM**
CURRENT EFFORTS:

PLANNED EFFORTS

PROBLEMS/ISSUES/SCHEDULE CHANGES:

***Subtasks***

09.5.6.3 1 September 2009 (NCEP)
Maintain and further develop WRF Post-processing system including necessary RR capabilities and updates to all documentation, in response to community requirements.

GSD – Some improvements in WRF-Post described under 09.5.4, yet to be submitted to NCEP (Huiya Chuang). SVN repository set up for all ESRL changes to WRF-post.

09.5.6.4 30 June 2009 (NCAR/MMM)
Deliver a WRF Users' Workshop and a WRF tutorial for the user community.

CURRENT EFFORTS:
NCAR convened the 10th Annual WRF Users' Workshop on June 23-26. Approximately 270 people attended. The workshop featured both plenary and parallel sessions, including a developers' forum and a poster session. The final day had instructional presentations on model-related utilities.

Preparation for the next WRF tutorial is underway at NCAR. It will be held July 13-24. It will offer a basic WRF component, a WRF-Var tutorial, a WRF-Chem tutorial, and a MET (Model Evaluation Tools) tutorial.

NCAR put on the WRF tutorial on July 13-24 in Boulder. It offered a basic WRF component, a WRF-Var tutorial, a WRF-Chem tutorial, and a MET (Model Evaluation Tools) tutorial. Over 60 people attended the basic WRF tutorial.

UPDATES TO SCHEDULE: NONE

09.5.6.5 30 Sept 2009 (NCAR/MMM)
NCAR released WRF Version 3.1 in April 2009. Preliminary work involved completing testing and certification of the code for release.

CURRENT EFFORTS:
NCAR released WRF version 3.1.1. This minor release primarily contained bug fixes, with the main improvements addressing:

(i) observation and spectral nudging; (ii) nesting ratios of 1:2 and 1:5 where a large number of processors is used; (iii) various fixes for physics and dynamics options, including the restart capability and the use of OpenMP; and (iv) reduced memory usage. A list of updates in V3.1.1 may be found at http://www.mmm.ucar.edu/wrf/users/wrfv3.1/updates-3.1.1.html.

Jimy Dudhia of NCAR obtained a revised YSU PBL scheme from S. Hong (Yonsei Univ.) for the next WRF release. This fixes some minor conservation and consistency issues in the flux calculations. Dudhia helped visitor T. Prabhakaran (India) with use of the WDM6 microphysics scheme, resolving issues with WDM6 developers at Yonsei Univ. in initializing CCN concentrations in nested runs. He also began working with Steven Cavallo (NCAR/MMM visitor) on the problem of unrealistic cooling at the model top, which is due to an underestimated downward longwave flux. The problem is mostly seen for tops higher than 50 hPa.

Lastly, Dudhia is collaborating on WRF physics with NCAR visitor Jeff Mirocha (Livermore Nat'l Labs) in preparing his sub-grid turbulence package (the NBA scheme) for inclusion in WRF and Jared Bowden and Zach Subin (UC Berkeley) in updating the CLM3.5 land model for WRF Version 3.1.

PLANNED EFFORTS: The collaborations on physics and the implementation of modifications/bug fixes will continue.

Recent WRF changes (during June-July) developed by ESRL/GSD in association with the Rapid Refresh development will be contributed to the WRF repository in the next 2 months.

PLANNED EFFORTS:
A minor release, V3.1.1 will be issued in July. Physics testing and implementation will continue through the end of the FY.

UPDATES TO SCHEDULE: NONE

**Deliverables**

09.5.6. E1 30 June 2009 (NCAR/MMM)
Deliver a WRF Users' Workshop and a WRF tutorial for the user community

09.5.6.E2 30 September 2009 (NCAR/MMM)
Incorporate physics improvements from the user community, GSD, and NCEP into the WRF software infrastructure for use in the Rapid Refresh model. Perform code testing to permit implementation into WRF repository. In collaboration with GSD, assist in the evaluation of those physics schemes for the RR that may be tested using the ARW.

**Task 09.5.24 Test WRF Rapid Refresh model at 3-km resolution toward High-Resolution Rapid Refresh**

**GSD**
8/17/2009 update – As of today, ESRL/GSD has moved the HRRR processing to a new file system (/lfs1) that just became available. It is expected that HRRR reliability will now increase significantly with this new file system.

July – early August - As part of the real-time CoSPA demonstration, GSD AMB staff have also worked closely with NCAR, MIT/LL and FAA personnel to provide timely communication concerning HRRR reliability and whenever possible to schedule HRRR downtimes for periods of inactive weather across the region of interests. As part of this effort, a real-time HRRR status web-page was developed to provide

users with a quick look source for information on the current status of the real-time HRRR runs. The link is: http://ruc.fsl.noaa.gov/hrrr/Status.cgi
Latency is now clearly identified, usually now about 2h.

May-July: Significant computer down time do to major issues with the main GSD supercomputer disk system problems since late May has lead to sporadic missed HRRR runs and a few longer periods of HRRR downtime. Previous efforts were described in previous MDE reports.

Work to maintain the real-time HRRR data feed has been supplemented by case study evaluation of the new larger-domain HRRR in May and June reported in the previous MDE report.

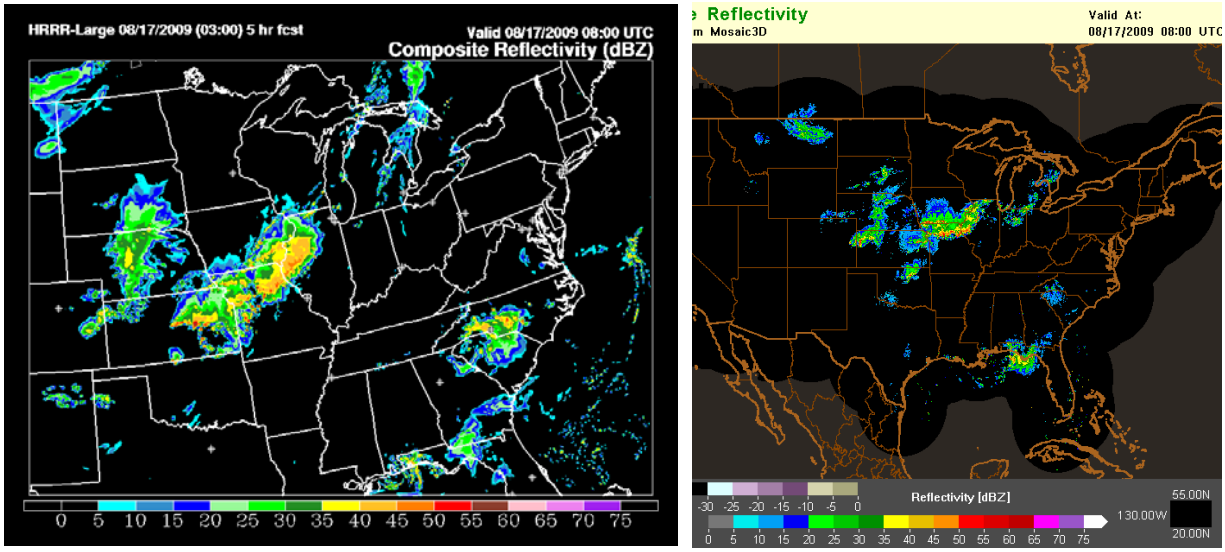



*Fig. 1 (Top) HRRR 5-h forecast simulated maximum reflectivity valid 0800 UTC, 17 Aug 2009. (Bottom) NSSL maximum reflectivity mosaic used as validation.*

Ongoing evaluation of real-time HRRR runs has continued through July and early August, now in the mid-summer regime, and has re-enforced previous very good results shown by VORTEX-2, at the AMS NWP meeting, and at the WRF meeting. The HRRR has produced quite realistic storm structure (often correctly forecasting regions of super cells, multi-cells, bow-echoes and multi-cell storms. In addition, the HRRR has been quite good at indicating locations of significant convection, often to within a couple of counties. A recent example (not cherry-picked!) is shown in Fig.1, with an excellent forecast of a bow echo in Missouri, but kept an area of convection going too long in North Carolina.

GSD has developed a prototype time-lagged ensemble-based convective probability forecast product from the HRRR and NCAR has preliminary results from a statistical assessment of HRRR time-lagged forecasts, described under Task 5.20. As of late July the system is running in real-time with verification and several improvements have been implemented yielding significantly better scores.

***Subtasks***

09.5.24.1 15 Feb 2009 (GSD, NCAR/RAL, NCAR/MMM, CAPS, MIT/LL)
Design the assimilation/modeling configuration for the HRRR during the 2009 summer convection forecasting (CoSPA) exercise.

09.5.24.2 15 Aug 2009 (NCAR/MMM)
Evaluate techniques for convection-permitting (e.g., 3-km) forecasting by the ARW core in the HRRR configuration.

CURRENT EFFORTS: NCAR ran the ARW in real time at 3-km resolution twice-daily using 13-km Rapid Refresh grids for initial conditions. This was in support of the Storm Prediction Center's Spring Forecast Experiment (SFE). Two forecasts a day were run through the end of June (0000 and 1200 UTC initializations). Two cases from the SFE period are being chosen for evaluation, based on GSD input. These will be analyzed jointly by NCAR/MMM and GSD.

PLANNED EFFORTS: The analyses of the chosen RR-initialized forecasts will be completed in the next quarter. Summaries will be written of the analyses.

09.5.24.3 15 Sept 2009 (NCAR/MMM, GSD)
Collaborate on analysis of convection-permitting tests using HRRR cases. Draft and deliver summary of results.

Coordinated evaluation of specific case studies is ongoing with monthly meetings between GSD and NCAR. Sensitivities to grid resolution, model numerics, and microphysics have been examined. Other experiments have illustrated the benefit of using the RUC initial fields (with the DFI-based radar assimilation).

09.5.24.4 30 Sept 2009 (GSD, NCAR/RAL)
Complete 2009 HRRR summer exercise using modeling and assimilation modifications determined in 2008 exercise. Collaborate on analysis of HRRR tests and deliver summary of results.

A significant effort to make the HRRR production and file delivery system robust has been completed, including placing HRRR within the jet reservation system, adding new post-process variables, calibrating the number of cores to optimize the run time and working with user communities to achieve timely and reliable transfer of various output files. Additional work is ongoing to evaluate real-time HRRR runs, identify strengths and weaknesses, and resolve issues. One issue that we have identified is the presence of streamers in the vorticity field entering from the upstream boundary. This is likely due to inconsistencies in the WPS interpolation from the external native model grid. Tests using pressure level data from the external model have not shown this problem.
It was hoped that the new version (3.1) of the WRF pre-processing system would have corrected this problem, but recent tests indicate that the problem remains. Active investigation of this issue continues.
As part of planning for a 2010 full CINUS demonstration, Tanya Smirnova completed a couple of test runs of a possible CONUS domain.

**Deliverables**

09.5.24.E1 30 August 2009 (NCAR/MMM)
Submit report on evaluation of HRRR-ARW forecasts.

CURRENT EFFORTS: The forecast cases are being chosen in collaboration with GSD. The evaluation is occurring in this quarter, but the report has not been written yet.

PLANNED EFFORTS: The analyses of the chosen RR-initialized forecasts will be completed in this quarter, along with the report.

UPDATES TO SCHEDULE: None

09.5.24.E2 30 August 2009 (NOAA/ESRL/GSD)
Complete FY09 test in eastern 2/3 U.S. domain with 3-km HRRR running every 1 h.

- Conduct real-time summer 2009 HRRR forecasts using 3-km WRF initialized with radar-enhanced Rapid Refresh over Northeast US Corridor domain
- Coordinate with other AWRP users and other collaborators
- Provide project management
- Lead writing of report on summer 2009 HRRR experiments

09.5.24.E2 30 September 2009 (NCAR/RAP and NCAR/MMM)
Collaborate with GSD on analysis of 2009 results. Draft and deliver summary of results.
Evaluate techniques for convection-resolving (e.g., 3-km) forecasting by the Rapid Refresh (ARW core). Perform and evaluate HRRR convection-resolving forecasts on test cases using Rapid Refresh grids from GSD to identify strengths and weakness of model at high resolution. Perform 2009 experiments to re-evaluate effects of transition from 13-km parameterized convection to 3-km resolved convection in 0-3h forecasts and in lateral boundary conditions from the RUC or Rapid Refresh using the Grell-Devenyi parameterization.

**Task 09.5.19 Develop ability to assimilate WSR-88D radial velocity and reflectivity data through GSI and Rapid Refresh toward High-Resolution Rapid Refresh.**

**GSD**
Recent studies by GSD have revealed the following:

- Convection sometimes too late in HRRR
- Issues with high-based convection in high plains areas
- Issues with limited radar near coastline

GSD continues to examine how the convergence / divergence fields initialized in the HRRR (from the RUC radar reflectivity assimilation) evolve down-scale during the first 1-3 hours of the HRRR model run to yield 3-km-scale convective systems. Curtis Alexander has made plots of the HRRR initial (00-h from the 13-km RUC diabatic-DFI) and HRRR 1-h divergence fields, illustrating the scale-contraction and intensification of the low-level convergence.

Coordinated work with CAPS continues on a comprehensive set of experiments to further evaluate radial velocity assimilation both within the 13-km RR and the 3-km HRRR. All relevant data have been retrieved for a test case from 15-16 May 2009. Yi Yang is continuing his work with the radial velocity assimilation experiments using GSI. Initial experiments are focusing on 13-km application for the RR, which will be used as input for a 2$^{nd}$ pass at 3-km using the GSI with shorter correlation length scales.

**CAPS**
Complete new 3-km GSI data assimilation experiments toward improved assimilation of radial wind.

In July, Yi Yang of CAPS began running tests for a new case from 15 June overnight into 16 June 2009 for evaluating the impact of assimilating level-2.5 radial velocity data with RR configuration on GSD computers. Four basic experiments were performed: run with no reflectivity (Z) or radial velocity (Vr) assimilation, Z assimilation only, radial velocity assimilation only, both Z and Vr assimilation. Moreover, for the experiments with Vr assimilation, a sub-set of experiments was conducted: one that assimilated Vr and other observations simultaneously in one pass, and the other that assimilated Vr data in the second pass with smaller spatial correlation scales. All experiments cold-started off GFS at 15Z 15 June and did 1-h assimilation cycles through 06z 16 June with 12-h forecast. The outputs have been passed on to GSD for systematic evaluation using standard verification tools and results will be reported in the future.

In addition to the standard procedure currently planned for RR, which assimilates reflectivity data through latent heat forcing in the forward step of DDFI, Yi Yang also compared its performance against two variations. One variation uses the temperature adjustment provided by the ARPS-based cloud analysis procedure (which is part of the generalized cloud analysis package implemented within GSI). This temperature adjustment is applied directly to the temperature field at the beginning of the forward DFI step and as an add-on adjustment to temperature. Cumulus parameterization and microphysics remains active (unaltered) in the DDFI step. The other variation is that latent heating rate derived from reflectivity is added gradually in the forward step of DDFI, as is done in the standard procedure, but without turning off cumulus parameterization or replacing microphysical heating (not as is done in current standard DDFI). Three corresponding experiments, Exp-RR, Exp-directly and Exp-gradually, were performed. These experiments used GFS as background and lateral boundary conditions, the initial forecasts started from 2100 UTC, June 15, 2009 and assimilated observations (conventional, radiance and reflectivity data)

at 0000 UTC June 16, followed by 3-h WRF model forecast. The forecast accuracy (ACC), frequency bias (FBIAS), probability of detecting Yes (PODY), false-alarm rate (FAR), Critical Success Index (CSI, also known as the Threat Score TS), Gilbert Skill Score (GSS, also known as the Equitable Threat Score ETS), and the Heidke Skill Score (HSS) computed from the 3-h accumulated precipitation for all the experiments with different thresholds are given in Figure 1. These scores suggest that the standard procedure of RR gives the best results. Additional experiments including full increments (including those for water vapor and microphysical variables) from the complex cloud analysis procedure applied at one time (at the beginning of the DDFI step) or over the period of DDFI (similar to the Incremental Analysis Update or IAU procedure in the ARPS) with and without cumulus/microphysics heating rate replacement, will performed and compared to these experiments. The goal is to identify the best procedure, for 13 km RR and 3-km HRRR resolutions.

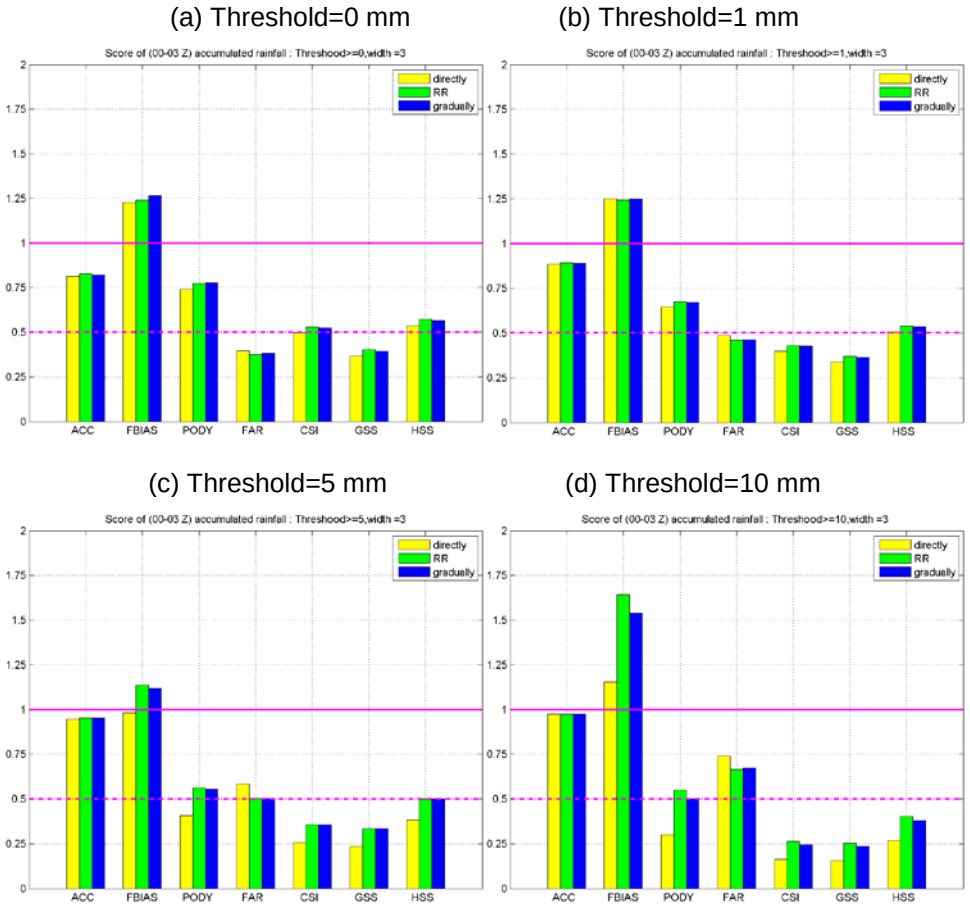



*Fig.1 The ACC, FBIAS, PODY, FAR, CSI, GSS and HSS scores computed from the 3-h accumulated precipitation valid at 0300 UTC 16 June 2009 for three experiments testing reflectivity-based temperature adjustment procedures at a thresholds of (a) 0 mm, (b) 1 mm, (c) 5 mm and (d) 10 mm.*

In July, Kefeng Zhu started working on the manuscript on Erin case, focusing mainly on two aspects: the radar data quality control using 88D2GSI (automatically) and SOLO (manually); applying various MET (Meteorology Evaluation Toolkit) verification methods including neighborhood, object-based and wavelet to the grid precipitation fields. He will start working on cases next month on GSD WJET

***Subtasks***

09.5.19.1 30 October 2008 (GSD, NCAR/RAL, CAPS)
Select initial case studies from summer 2008 for 3-km HRRR data assimilation case studies.

**GSD**
A set of 8 summer 2008 cases has been selected for coordinated GSD, NCAR, and MIT/LL evaluation. These include 20, 27 July; 2, 8, 13, 15 Aug; 6 Sep. We are also looking at some other cases for specific HRRR analysis including 31 July, 13 Sept. and 5 Sept.

09.5.19.2 31 August 2009 (GSD, NCAR-RAL)
Run case studies from early 2009 using 3-km HRRR on GSD jet computer using different RR-based initial conditions

- Radar-DFI enhanced RR
- Radar-DFI RR using unsmoothed latent heating
- Test of 3-km radar-enhanced diabatic digital filter initialization (DDFI)

GSD has been providing, to NCAR, RUC lateral boundary and radar-enhanced initial condition (history file dump directly after the RUC diabatic DFI-based radar assimilation) files for experimental re-runs of selected test cases from the 2007 convective season. Initial work has focused on 5 Sept.

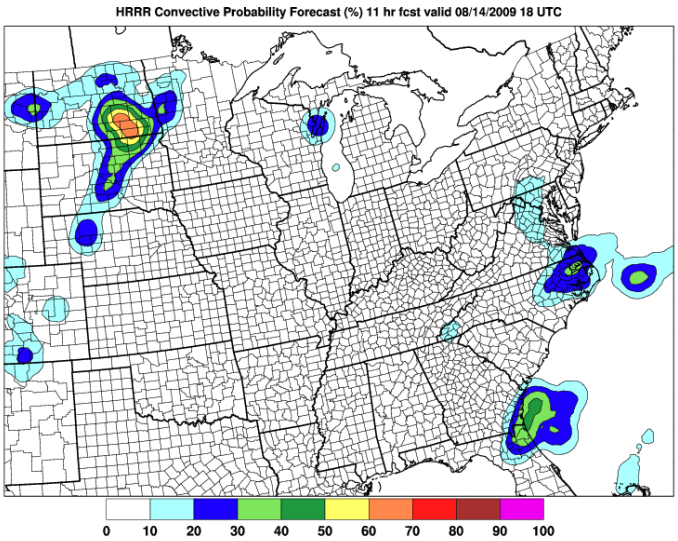
09.5.19.3 30 Sept 2009 (CAPS)
Complete new 3-km GSI data assimilation experiments toward improved assimilation of radial wind.

09.5.19.4 30 Sept 2009 (GSD)
Develop and test improved DFI assimilation of radar reflectivity at 3-km using observation-based specification of latent heating within WRF-DFI developed by GSD and NCAR in FY08.

**Deliverables**
09.5.19.E1 30 Sept 2009 (GSD, CAPS, NCAR/RAL )
Complete improved version of 13km/3km radar assimilation techniques for demonstration in FY09 exercises.

**<u>Task 09.5.20</u> Develop ensemble-based probabilistic products for aviation users.**

**GSD**
Many refinements were made in July to the HRRR Convective Probability Forecasts (HCPF - http://ruc.noaa.gov/hcpf/hcpf.cgi), resulting in much higher reliability compared to observations.



**NCEP**
Jun Du reports that the work on bias correction on model native grids continues. Preparations are being made to implement the SREF upgrade as soon after acceptance of the new machine is possible. Both SPC and especially AWC are ken to get the hourly output that will come along with this upgrade. Since February, SPC has been using the EMC parallel SREF on P6/cirrus to accumulate enough cases to calibrate a new convection/thunder probability which is now being used at AWC as part of the guidance shared among the generators of the CCFP.

A manuscript about ensemble fog forecasting (which was submitted to Weather and Forecasting) was substantially revised according to the reviewers' suggestions. The verification shows that with various approaches including a new fog-detection scheme (developed by Binbin Zhou), an ensemble technique, multi-model approach and an increase in ensemble size, the improvement of fog-forecasting accuracy at 12-36hr forecast length improved steadily and dramatically with the addition of each of the approaches. Accuracy improved from a basically no-skill-at-all (ETS=0.063) result to a skill level equivalent to that of warm-season precipitation forecasts (ETS=0.334). Since this fog diagnostic scheme can be easily included in an NWP model post processor, fog forecasts can now be conveniently and centrally produced from an operational NWP model. The practical application of this study is clear, especially to the aviation community and navy operations.

BinBin Zhou is planning a visit to AWC scheduled for October 2009. Work continues on the VSREF which is being run semi-routinely for evaluation purposes. The new fog algorithm has been added to VSREF. BinBin finished a 3 hourly cycle updating framework and will now upgrade to an hourly updating framework. He began the probabilistic verification of SREF composite reflectivity and echo-tops using Shun Liu's implementation of NSSL's 88D national mosaics.

**CAPS**
***Subtasks***

09.5.20.1 Complete 'research quality' version of upgrade to SREF (e.g. higher resolution, more WRF members and more physics diversity) for consideration in November 2010 SREF upgrade package. (31 Jan 09)
See Q3 MDE report.

09.5.20.2 15 February 2009 (NCEP)
NCEP visits AWC to conduct continued training and education on SREF applications, receive feedback on existing guidance, and to acquire new requirements (fully depending on FAA funding).

09.5.20.3 Develop & deliver a new fog algorithm used in SREF product for aviation. (30 Apr 09)
A new fog algorithm was designed and developed in FY2007 and incorporated into the special ensembles NCEP ran in support of the Beijing Olympic Games in August 2008. A paper about the verification of a fog prediction method using part of the NCEP SREF system was written by Binbin Zhou and Jun Du and is under internal review prior to submission to Weather and Forecasting. (Zhou)

09.5.20.4 31 August 2009 (NCEP)
Based on case-study testing and refinement of the research-quality code, deliver the upgrade SREF codes to NCO for November 2010 SREF upgrade package.

09.5.20.5 31 March 2009 (GSD and NCEP)
Develop a preliminary procedure appropriate for aviation users from Very Short-Range Ensemble Forecast (VSREF) system using high-resolution RR and NAM existing runs.

GSD has identified a new scientist to work on the VSREF project with NCEP – more on this topic by next month's report.

09.5.20.6 1 July 2009 (GSD and NCEP)
Further calibrate probabilities and potential echo-top (improve statistical reliability) ensemble cumulus information.

***Deliverables***

09.5.20.E1 31 August 2009 EMC (Du, Zhou)
Demonstrate products from experimental VSREF probabilistic forecasts updated hourly.

CURRENT EFFORTS:
Initial work on VSREF products based on the RUC and NAM forecasts, using the SREF ensemble product generator, and the general framework for the VSREF procedure was completed. These products include cloud base/top, visibility, turbulence, icing, low level wind shear, jet stream probability and reflectivity. These preliminary products are updated daily on the VSREF website http://www.emc.ncep.noaa.gov/mmb/SREF_avia/FCST/VSREF/web_site/html/vsref.html. (Zhou, Du)

PLANNED EFFORTS:
Work will continue on convection products in VSREF, by adopting GSD's convection code. An echo-top ensemble product will be added using the ensemble product generator. (Du, Zhou) turbulence, icing, low level wind shear and jet stream probability

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:
No ceiling/cloud amount is available from ARW SREF members, and no reflectivity is available from the Eta members and some RSM members.

INTERFACE WITH OTHER ORGANIZATIONS: AWS, GSD

UPDATES TO SCHEDULE: None.