MODEL DEVELOPMENT AND ENHANCEMENT
RESEARCH TEAM

Quarterly Report for July, August and September 2008
Submitted 15 October 2008

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

Executive Summary

Task 08.5.1: Infrastructure support related to operational running of the RUC and NAM operational modeling systems.

- RUC upgrade implementation planned for early Nov 2008.
- NCO/NCEP continues testing for RUC upgrade package code (radar reflectivity assimilation, TAMDAR, radiation, Grell/Devenyi upgrade). Real-time comparisons continue in http://wwwt.emc.ncep.noaa.gov/mmb/ruc2/para.
- GOES PW 1x1 near-term change for RUC implemented at NCEP on 16 Sept 2008. Note: Higher-resolution GOES PW data now used only over water – related to moist bias over land.

Task 08.5.4: Develop, test, and implement Rapid Refresh configuration of the WRF modeling system.

- Newly updated web-page with hourly cycled experimental RR at http://rapidrefresh.noaa.gov .
- TAMDAR data, including PenAir (Alaska), Mesaba (Midwest), and Chautauqua (e. US), now being used in experimental RR.
- Two 1-h cycles using WRF version 3.0, DFI, and latest regional GSI version (March 2008) continue to run reliably at GSD. Daily side-by-side comparison of different run configurations underway.
- Solution implemented to prevent occasional RR 1-h cycle crashes along southern boundary found (issues related to large analysis increments along the boundary from Colombian observations).
- Tarball with Rapid Refresh specific elements (GSI, WPS, WRF, and WRFpost) transferred to NCEP computer "vapor" to begin experimental RR work at NCEP.
- Rapid Refresh now planned to run out to 18h duration hourly**.**

Task 08.5.5: Develop, test, and implement 3DVARs for RR and NAM

- Further modifications incorporated into RR version of GSI

Task 08.5.15: Develop improved methods of cloud and moisture analysis for use in the WRF modeling system.

- Cloud analysis for GSI incorporating METAR cloud and GOES cloud-top data (similar to the RUC cloud analysis) continues to run regularly in a 1-h cycle with the Rapid Refresh.
- Minor modifications to cloud analysis being made to conform with EMC coding practices

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

- 15-min VIL output from hourly HRRR available at: http://ruc.noaa.gov/hrrr/vil
- New HRRR reflectivity "matrix" web-page at: http://ruc.noaa.gov/hrrr/reflectivity.cgi

Task 08.5.1: Infrastructure Support for Operational Running of the RUC at NCEP

GSD

Updates on two change packages to operational RUC:

a. Small change package for GOES 1x1 PW

b. Larger upgrade (early Nov 08) change packages to RUC

a. GOES 1x1 PW change - update

This near-term change was implemented on 16 Sept. Background: NESDIS was waiting for a RUC change to cease production of 3x3 field-of-view (FOV) precipitable water (PW) data, which the operational RUC had been assimilating. Thus, this change was modifications to the RUC analysis to allow use of the much denser 1x1 FOV PW data.

Background: During July and early August, it was determined that the GOES PW data has a substantial moist bias, from 2-6 mm. The effect of this bias was initially exaggerated by the introduction of the 1x1 PW data. Therefore, after tests at GSD, it was decided to use GOES 1x1 PW data only over the oceanic areas and use the GPS PW data (no bias) as the only PW observations to be assimilated over land areas. This change was introduced to the GSD devRUC13 (http://ruc.noaa.gov/pig.cgi?13km_D2) on 6 August 2008.

b. RUC upgrade for model, assimilation, and post-processing

The RUC upgrade continues in testing by NCEP/NCO, transferred from NCEP/EMC in July. Real-time comparisons continue to be available at http://wwwt.emc.ncep.noaa.gov/mmb/ruc2/para.

Collaborative work between EMC (Geoff Manikin and Shun Liu), GSD and NSSL overcame an issue that was holding up the beginning of a cold season retrospective test. Because there were no cold season radar reflectivity data available for the Feb 2008 test period, NSSL supplied several tar files of data and a C-based reader routine. Ming Hu (GSD) converted the C-based reader to F90, which could be compiled and run at NCEP. Collaborative work by GSD (primarily Stan Benjamin) and Geoff Manikin resolved the final issues and the retrospective test is now underway**.**

Additional TAMDAR observations (Chautauqua) now added to NCEP RUC parallel RUC, almost doubling the number of TAMDAR observations and increasing geographical coverage.

Current planned implementation date – Early Nov 2008.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

NCEP

Task 08.5.1: Infrastructure Support for Operational Running of the RUC at NCEP

Subtasks

08.5.1.1 Maintain hourly RUC runs and provide grids of SAV and AIV guidance products.

The Build-10 radar data processing is in parallel testing at NCO. Super-resolution reflectivity in the build data is converted to a legacy resolution which is used to generate SRC files. The reflectivity mosaic package is producing a 3D mosaic from the SRC tank for the RUC. Some missing SRC files were found during NCO's parallel testing due to a wrong fix file setting. That bug was fixed and it was verified that NCO's parallel can produce a 3D reflectivity mosaic properly. (Liu)

A change to the operational RUC to start reading 1x1 GOES precipitable water retrievals instead of 5x5 values was implemented on 16 September in response to a NESDIS request to shut off the 5x5 data feed. GSD modified the RUC analysis code to handle the much larger volume of GOES precipitable water data. GSD/EMC discovered that the new precipitable water feed has a high moisture bias, so the code was updated to not use this data over land.

The more significant RUC package is slightly behind schedule. This version ingests hourly reflectivity mosaic files which are used in the digital filter initialization to specify the 3-d profile of latent heating. Other changes include the assimilation of TAMDAR data and of mesonet wind data from a list of approved providers, a change in the longwave radiative scheme from Dudhia to RRTM, a modification to the snow component of the land-surface model to decrease excessively cold 2-meter temperatures over fresh snow at night, another change to the snow model to allow for warmer temperatures during warm advection events over snow cover, and a modification to the convective scheme to decrease widespread coverage of light precipitation.

After evaluating the new version of the model and finding subjective and statistical improvement, the code was turned over to NCO in July. But the non-stop string of Critical Weather Days caused by extremely active tropical weather from late August through early September delayed the start of the outside evaluation of the RUC test product generated by NCO. This evaluation by the various NCEP service centers and regional National Weather Services offices will be completed in late October, and implementation of this package will likely occur in early November. (Manikin)

08.5.1.2 Provide vendors with gridded model data via Family of Services (FOS), and the FAA Bulk Weather Data Telecommunications Gateway (FBWDTG).

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).

08.5.1.3 Provide full grids from RUC runs on NCEP and NWS/OPS servers.

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/ . This includes hourly BUFR soundings, output grids which undergo no interpolation and, as such, are on the models' computational grid (so-called native-native grids). These now contain grids packed into GRIB2 format, see http://www.nco.ncep.noaa.gov/pmb/docs/GRIB1_to_GRIB2.shtml , and an index for each file is also provided. (EMC Team and NCO)

08.5.1.4 Maintain access to model verification data.

NCEP maintained its capability and provided access to routine verifications performed at NCEP of the operational RUC system forecasts. These include grid-to-station verifications (versus rawinsonde, surface, aircraft, Profiler, and VAD data) scores computed periodically at NCEP. Routine verifications have been performed and are accessible from NCEP's Mesoscale Branch's website: http://www.emc.ncep.noaa.gov/mmb/research/meso.verf.html (Rogers, Manikin, and Keyser)

GSD continues its verification against raobs, precip, and surface data for 5 versions of the RUC (oper-NCEP, hardened-GSD (previously called "backup"), development-13-GSD, 20-km-w/TAMDAR, 20km-noTAMDAR) . GSD is also now comparing RUC performance using this verification with that from the experimental Rapid Refresh.

Deliverables

08.5.1.E1 1 October 2007 - 30 September 2008 **EMC** (Rogers, Manikin, Keyser)
Perform observation ingest, quality control, and preparation in support of the operational RUC runs.

CURRENT EFFORTS:
Since the beginning of April, Level II reflectivity (and radial wind) data from an increasing number of WSR-88D radar sites have been unavailable due to their switch from Build 8 to Build 10 software. Since 15 September no data have been available because all 130 sites have switched. The Build-10 radar data processing is in parallel testing at NCO. This processing includes a new decoder for build-10 radar data and a recombination algorithm to make build-8 look-alike radar data. Efforts were made (and continue) to verify radar data from the build-10 decoder. Super-resolution data and legacy resolution data from NCO's decoder were compared with data from NSSL's decoder. It was verified that NCO's build-10 data decoder and recombination algorithm work properly for the majority of radars. (Liu)

An 8 July implementation replaced the 5x5 matrix GOES cloud data with the improved 1x1 GOES data. Two continuing problems with the new GOES data are random files (2-4 per day) where NESDIS encodes 1 or 2 early reports with missing lat/lon and a bogus satellite id, and the late arrival of the GOES-East data which reduces the number of obs in the RUC dump files for some cycles (NESDIS has been contacted on both issues). GOES 1x1 layer-PW (over water only) replaced GOES 5x5 layer-PW (over land and water) on 16 September. Also on this date, the data processing system for the future Rapid Refresh [RR] system was established. A single set of hourly PREPBUFR files are now created for both the RUC and the RR. Changes for the RR also affecting the RUC include the processing of SYNOP data and the processing of upper-air data up to 1 mb. Changes for the RR that do not affect the RUC include processing data over the expanded NAM domain; processing 1b radiances for NOAA/METOP (HIRS-3, HIRS-4, MHS, AMSU-A, AMSU-B), AIRS (IR and AMSU-A) and GOES (1x1); processing MODIS, EUMETSAT and JMA satellite winds; processing AIREP, PIREP, AMDAR and TAMDAR aircraft data; processing SSM/I brightness temperatures and NN3 products; processing NEXRAD Level 2.5 and 3 radial wind superobs; and processing QuikSCAT wind superobs. To improve run time with so much more data now being processed, the PREPBUFR processing is threaded into 12 simultaneous load-balanced steps. There is a 30 second increase in run time for the combined dump and PREPBUFR steps in the new RUC/RR processing vs. the previous RUC-only processing. Parallel testing of TAMDAR and Canadian AMDAR aircraft temperature and wind data is underway. At the request of ESRL/GSD, efforts are being made to get TAMDAR airframe type and company code (currently not provided in either the ESRL MADIS or AirDAT feeds) to allow for improved bias corrections. On 10 September, TAMDAR data from PenAir (over Alaska) was added to the NCEP data feed from ESRL (joining Mesaba and Chautauqua data in the production RUC/RR PREPBUFR files). On 16 September, the TAMDAR aircraft data from ESRL were restricted in order to meet the requirements set forth by both AirDAT and the NWS. Also on 16 September, roadway temperature and icing data were added to the dumps of DOT mesonet data providers, and the restriction category was corrected for several mesonet providers. On 23 September, the METAR dump processing was updated to store each report's temperature and moisture at their full precision. These had been truncated in cases when the latest receipt for a report did not include a "remarks" section. Multi-Agency Profiler [MAP, previously Cooperative Agency Profiler (CAP)] and RASS data are not yet available through an alternate ESRL MADIS feed, but NCO is now actively working on decoding these data. (Keyser)

PLANNED EFFORTS:
Parallel testing of Build-10 radar data processing will be completed and implemented in October. After the implementation Shun Liu will continue monitoring and examine the full radar data processing data flow. (Liu)

Concerning new aircraft quality control module and change to PREPBUFR, see PLANNED EFFORTS under Task 08.5.17.E1 below. Complete RUC impact tests for Canadian AMDAR and TAMDAR (AirDAT vs. current ESRL MADIS feed), hourly WSR-88D 3-D reflectivity, 6-minute wind profilers, mesonet wind and roadway data, new mesonet data feeds (including "hydro", "snow", modernized COOP and UrbaNet), and lightning data. (Keyser)

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED: None.

INTERFACE WITH OTHER ORGANIZATIONS: GSD & NCO.

UPDATES TO SCHEDULE: None.

Task 08.5.4: Develop, test, and implement Rapid Refresh configuration of the WRF modeling system.

ESRL/GSD

During the quarter, work continued toward making GSD's Rapid Refresh (RR) 1-hour cycle more reliable and more efficient. During the quarter, RR has been running with major upgrades to both the WRF model component (version 3.0) and GSI analysis component (March 2008 release) of the real-time hourly cycled RR at GSD.

Numerous issues were diagnosed and resolved during the quarter. These included occasional model blowups in the adiabatic backwards portion of the DFI due to computational (CFL) instability, and a periodic problem with the lateral boundary condition files used for the DFI. The former problem was addressed by introducing a capability to run with a different (shorter) time step in the DFI than in the free forecast. The latter was fixed by using a separately read-in lateral boundary condition files every third hour when the pathology occurs. A permanent fix is being investigated by GSD and NCAR as a possible WPS bug. In addition, the wall execution time of the model was sped up considerably through use of the quilting I/O option available in WRF through the namelist—this dedicates a specified number of nodes for I/O purposes and allows I/O on these nodes whilst the other nodes are doing model execution. Thanks to Tom Henderson of GSD for helping with this important enhancement.

We are now using the 6th order diffusion option in the WRF-ARW model, motivated by the desire to reduce the likelihood of model crashes due to violation of CFL criterion in localized regions of strong vertical motion.

With assistance from Dennis Keyser and others at EMC, the problem associated with the unreliability of the real-time RR PrepBUFR (and satellite radiance) observation data feed from NCEP was resolved during August. The processing to create these files for the operational RUC is now running operationally within NCO at NCEP and PrepBUFR files are now being obtained from an NCEP ftp site. The feed for the RR has been switched to these file stream and the previous temporary data feeds have been discontinued.

We have also explored use of an adaptive time step option in WRF 3.0, in which the time step is increased (or decreased) during the run according to the maximum value over the domain of the Courant number in the preceding large time step. This option is now being used in the cold-start RR forecasts. However, further testing will be required to optimize the bounds on the time step before implementation in the 1-h cycle. Design of a further modification that we see as crucial to increasing the efficiency of the model was worked on during the quarter. This is the capability to call the Thompson microphysics less often than every large model time step. (We think that calling the microphysics every other large time step, i.e., every 2 min, will speed up the wall time of the forecast by up to 5% without degrading the forecast.) This capability exists in the RUC, but not presently in the WRF-ARW.

The causes of a sporadic model crashes due to extreme vertical velocities along the southern boundary of the domain has been identified and a solution put in place. Ming Hu traced the problem (in which a build-up of vertical velocities over many hourly cycles would eventually lead to a crash) to large analysis increments along the southern boundary (where the main cordillera of the Andes in Colombia intersects this boundary) to Colombian observations (both METAR and aircraft observations). For these high elevation METAR observations, the problem is compounded by a significant mismatch between the observed and model terrain. A solution that has so far proved fairly robust is to ramp down the magnitude of the analysis increments along a 5 gridpoint wide band along the horizontal boundaries. Overall, the cycle has been running quite stably, but we are investigating a crash that recently occurred along the southern boundary.

We have recently added a second real-time 1-hour experimental Rapid Refresh cycle. This has allowed us to begin crucial daily side-by-side comparisons of RR cycled runs with variations in various

components and settings (starting with an examination of the performance of the cloud analysis and radar assimilation modules).

A tarball with Rapid Refresh (RR) specific elements (GSI, WPS, WRF, and WRFpost) has been transferred to NCEP vapor machine to begin experimental RR work at NCEP. Also, with assistance from Yoshi Sato, Ming Hu has been working on a parallel track to get Yoshi's NAM retro cycle scripts running on vapor. This DTC effort also benefits the RR effort (and longer term efforts toward a more unified code structure for the 2012 ensemble Rapid Refresh) as NCEP IBM-specific elements of the NAM scripting and boundary condition processing can be incorporated into the RR cycle on vapor. In particular, Chris Harrop's workflow manager, which is used to coordinate the RR runs at GSD is not supported at NCEP and will be replaced by modified versions of similar procedures used for the NAM at NCEP.

A special note: On Tues 12 Aug, NCEP/EMC agreed with AWC and SPC that the Rapid Refresh should run hourly out to 18h. GSD and NCEP will be working together on the design for the 18h RR forecast duration. We see this overall as a very beneficial development for aviation weather forecast users.

PLANNED EFFORTS: Continue to closely monitor and compare the forecast performance for the two parallel RR cycles, track down issues negatively impacting forecast performance, and implement solutions. Continue to experiment with procedures to speed up execution of both the GSI and the model.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED: None

INTERFACE WITH OTHER ORGANIZATIONS: DTC, NCEP, NCAR

UPDATES TO SCHEDULE: None.

NCEP
A focused effort will continue in FY 2008 to configure the WRF model and the Gridpoint Statistical Interpolation (GSI) analysis for the Rapid Refresh (RR) replacing the RUC assimilation/model system. The transition from the RUC to the RR will be evolutionary, not revolutionary, by using model physics and assimilation techniques in the RR similar to those in the RUC that have proven beneficial to aviation weather forecasting.

Subtasks

08.5.4.1 30 December 2007 (GSD, NCEP) COMPLETE
Begin real-time hourly cycling of RR model with GSI over RR domain with availability at GSD of hourly PrepBUFR files from NCEP having begun on 12 October 07.

CURRENT WORK:
See discussion above for description of ongoing development of the Rapid Refresh real-time 1-h cycle at GSD.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED: None

INTERFACE WITH OTHER ORGANIZATIONS: NCEP, NCAR, NWS regions

UPDATES TO SCHEDULE: None

08.5.4.2 1 March 2008 (GSD) [COMPLETE]
Begin collaborative evaluation with planned NOAA Rapid Refresh users, including AWC, SPC, NWS in Alaska and Puerto Rico. Arrange to have GSD RR grids available to examine and solicit feedback on RR performance.

Three sets of real-time Rapid Refresh grids (full RR domain -- #220, CONUS -- #130 and Alaska -- #249

sub-domains) with the correct parameter settings in the grib files are now being created and made available to FAA AWRP RTs and various NWS users. Work was recently completed to update the Alaska feed from grib1 to grib2 versions of #249 grid (with inventory files) to Alaska Region of NWS. In order to get the inventory files to work for some of the RUC fields, GSD ITS folks rebuilt the grib2 grib tables.

08.5.4.3 1 March 2008 (GSD) [COMPLETE]
Begin collaborative evaluation of Rapid Refresh with Inflight Icing, Turbulence, National Ceiling/Visibility, and Convective Weather RTs. Arrange to have GSD RR grids available to examine and solicit feedback on RR performance.

We continue to supply grids (native level and pressure level) to the various RTs and answer questions about their use.

08.5.4.4 30 May 2008 (GSD, NCAR, NCEP)
Report on status of tactical planning for making RR-WRF code for 2012 in compliance with Earth System Modeling Framework (ESMF) as specified in the Sept 2007 Rapid Refresh MOU between NCEP and GSD.

Under separate funding, Tom Henderson (ESRL/GSD) continues his work toward putting the ESRL FIM (Flow-following Icosahedral Model, under development, test and evaluation within GSD) into the ESMF framework, a necessary step if it is to contribute members to NCEP's Global Ensemble. In the process of doing this, Tom is working closely with Tom Black of EMC. Tom Henderson has FIM running under NCEP's flavor of ESMF version 3.1. Experience gained with this effort will strongly facilitate the process of putting the RR (and ARW dynamic core) under ESMF in the 2010-11 time period.

08.5.4.5 Ongoing (GSD)
Further enhancement to WRFpost version for Rapid Refresh application, including modifications for generation of RUC-specific fields.

Output from the RR 1-h cycle at GSD, as well as that from the full-domain cold-start and run continue to be available. Also, real-time products are now available over an Alaska window sub-domain for both the RR 1-h cycle and cold start. They can be viewed at: http://rapidrefresh.noaa.gov/alaska/

08.5.4.6 Ongoing (GSD, DTC later)
Ongoing evaluation of performance of real-time and retrospective runs of RR system for SAVs, AHPs.

Now that the 1-h cycle is running more consistently on wJET using version 3 of WPS and WRF and the March 2008 version of GSI, quantitative statistical validation is underway. These statistics confirmed a serious cold bias in the 1-h cycled runs (see FY08 Quarter 3 report) and helped to verify that it has been mostly resolved. Real-time products in the web displays noted above continue to permit qualitative evaluation.

Deliverables

08.5.4.E1 30 Aug 2008 (GSD)
Have available for delivery to NCEP initial 'experimental level' WRF Rapid Refresh code for start of EMC testing toward 2009 Rapid Refresh implementation.

A tarball with Rapid Refresh (RR) specific elements (GSI, WPS, WRF, and WRFpost) has been transferred to NCEP vapor machine to begin experimental RR work at NCEP. Also, with assistance from EMC scientist Yoshi Sato, Ming Hu has been working on a parallel track to get Yoshi's NAM retro cycle scripts running on vapor. Yoshi has generously provided his NAM retrospective infrastructure (code, scripts, etc.), which will provide a reference framework for the NCEP computing environment. Ming's work with the NAM retro scripts benefits both DTC the RR effort (and longer term efforts toward a more unified code structure for the 2012 ensemble Rapid Refresh) as NCEP IBM-specific elements of the NAM scripting and boundary condition processing can be incorporated into the RR cycle on vapor. In

particular, Chris Harrop's workflow manager, which is used to coordinate the RR runs at GSD is not supported at NCEP and will be replaced by modified versions of similar procedures used for the NAM at NCEP. Besides Ming, several GSD scientists have obtained accounts on the new NCEP research computer (vapor), where initial NCEP testing of the RR will occur.

Task 08.5.5 Develop, test, and implement improvements to the operational 3DVAR for WRF Rapid Refresh and WRF NAM.

NCEP

GSD

Work in August focused on diagnosing the cause of sporadic model crashes due to extreme vertical velocities along the southern boundary of the domain. A cause was identified and a solution has been put in place. Ming Hu traced the problem (in which a build-up of vertical velocities over many hourly cycles would eventually lead to a crash) to large analysis increments along the southern boundary (where the main cordillera of the Andes in Colombia intersects this boundary) to Colombian observations (both METAR and aircraft observations). For these high elevation METAR observations, the problem is compounded by a significant mismatch between the observed and model terrain. A solution that has so far proved quite robust is to ramp down the magnitude of the analysis increments along a 5 gridpoint wide band along the horizontal boundaries.

Examination of rawinsonde statistical verification for 12-h forecasts from the RR 1-h cycle vs. the operational RUC for a 2-week period in Sept. when the RR 10h cycle ran quite stably continued to indicate temperatures and winds errors were similar to the RUC. There continues to be a bit of a cold bias in RR low-level temperature forecasts and a dry bias in RR lower Tropospheric moisture. Examination of the 00-h forecast statistics indicates that the GSI is not fitting temperature or moisture observations as closely as the RUC. The assumed errors for the background and observations have not been adjusted for the RR, and we will be considering changes to these values as we continue to monitor the performance of the real-time RR cycle. With assistance from Dennis Keyser and Jack Woolen of NCEP Dezso Devenyi and Ming Hu have completed a capability within the GSI to ingest newly available aircraft observations.

Alaskan regional PenAir TAMDAR observations have been made available for the Rapid Refresh and have been used in real-time since 11 Sept. GSD coordinated the data availability into the Rapid Refresh via MADIS through extensive discussions with NCEP/EMC and NCO over the past 3 weeks.

08.5.5.1 31 December 2007 (GSD and CAPS) COMPLETE

Progress report on 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.

Based on recommendations received from John Derber and Russ Treadon (at a GSD/EMC GSI meeting at NCEP in June), Ming Hu has completed modest modifications to portions of the generalized cloud analysis to conform to specific EMC coding practices (restructuring the I/O, etc.). Following this, an extensive retro test evaluation was completed to ensure that the modified code did not impact the cloud analysis results. A tarball with these changes has been sent to Russ Treadon at EMC for possible inclusion in the next GSI release.

08.5.5.2 31 December 2007 (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.

A new forward model to use the wind direction was introduced and tested in an effort to use the directional information of wind obs from mesonet source which have been kept out of the analysis due to low wind speed bias. The tests showed that the solutions were unbounded (hence, unusable) if the wind directions were assimilated without the wind speeds. It was also shown that adjusting the U/V observations proportionally, to maintain the first guess wind speed while fitting the observational wind

direction, produced better 3dvar convergence than using the direction and the speed separately. **Complete.**

08.5.5.3 31 January 2008 (NCEP and CAPS)
Further refine the radial velocity analysis component of GSI in response to model resolution changes. Examine data impact at higher assimilation frequencies and higher spatial resolutions. Consider issues on data quality, super-obbing, and optimal de-correlation scales.

Recombined legacy resolution radial wind from build-10 radar data became available in NCO's parallel and the new data were used in the GSI analysis. From a set of test runs it appears that the observation-minus-background became larger with the build-10 than with the build-8 data. The gross check for radial wind was made tighter to reject noisy data from build-10 radial winds. The cloud analysis package for reflectivity assimilation from GSD was modified to use the WRF-NMM background. Initial tests showed temperature adjustments were too large. Tuning is needed to suitably utilize it for the assimilation of reflectivity in WRF-NMM. (Liu)

08.5.5.4 28 February 2008 (GSD)
Report on statistical evaluation of Rapid Refresh forecasts initialized with the GSI, including examination of upper-level winds, surface fields, and precipitation.

See discussion above about ongoing statistical comparisons of the RR 1-h cycle vs. the operational RUC upper-level winds (over the matched CONUS radiosondes stations). With the second real-time RR 1-h cycle in place, we have begun to examine reflectivity and precipitation differences between the RR cycle with and without the radar assimilation.

08.5.5.5 31 July 2008 (NCEP)
Based on case-study testing and refinement of the research quality code, deliver result in an 'experimental' code for an upgrade package (e.g. improved use of WSR-88D data and satellite radiances and co-variances) to the WRF-GSI for FY2009 change package to the NAM-WRF.

The adaptive tuning of observational error using the method by Desroziers et al. (2001) was added as an option within the official GSI code, and is now available with each update of both the global and regional systems. The latest version of GSI were adapted and tested in regional mode with a real-time off line parallel. The most important upgrade (besides some bug fixes) was a new version of the community radiative transfer model (CRTM) used for the satellite radiance data. This upgrade changed the differences between the first guess and observations for all satellite instruments and consequently the analysis results. This upgrade was necessary in order to use the METOP data. The quality control of conventional data in the regional system was examined and refined. The limits of the gross check are increased if data are originally rejected and are re-accepted in the second or the third outer iteration. The weightings to the variational quality control are tuned according to the forecast performance. The code was modified to accept observations in the uppermost layer. A bug in adjusting the observational error for the rawinsonde, pibal and profiler data was found. With the bug removed the observations in the upper layers receive proper weighting and the gross check functions properly. The sensitivity of the vertical grid on the NDAS system was also studied. There is a positive impact on the forecasts when global-like vertical grid spacing is used. Work continues since retuning the physics is needed when the vertical grid is changed. (Wu)

A new approach is being attempted to improve the regional version of TLNMC in GSI. The normal mode balance increments are obtained using a nested multi-grid technique, which in a computationally feasible manner allows any regional domain to be embedded in a series of successively coarser grids until the coarsest grid covers the entire global domain. The solution is obtained by iterative relaxation and the transfer of corrections between grids, with an exact solution obtained spectrally on the coarsest grid. Coding of a preliminary multigrid scheme has been completed, but tests are still ongoing to fully understand how multigrid works. (Parrish)

The RTMA system has been unified so that the same set of executables now works for all NDFD grids of interest - CONUS, Alaska, Hawaii, Puerto Rico and eventually Guam. Operational implementation for Hawaii and Puerto Rico will take place in October 2008, and upgrades for CONUS and Alaska will also go to NCO in October. A 2.5-km resolution CONUS RTMA was built to replace the current 5-km resolution system on the next NCEP computer. Work to add planetary boundary layer height, visibility, and wind gust to the list of parameters analyzed by the RTMA was also initiated. Last, the code for the anisotropic recursive filter was optimized and as a result the time needed to run the GSI-2DVar in the CONUS-RTMA was reduced by a factor of 2.5. (Pondeca, Yanqiu Zhu, Parrish)

Using NCEP's Global Ensemble, extensive testing of ensemble-based background error covariance matrices for both regional and global GSI-based assimilation systems was performed. However, the forecast scores were only barely improved over the default system using isotropic background error co variances. We suspect that this might be partly due to a lack of adequate spread in the Global Ensemble. Further investigation is underway by comparing the Global Ensemble input data with the ensemble fields generated within a Kalman Filter data assimilation system. (Yoshi Sato, Pondeca)

08.5.5.E1 30 March 2008 EMC (Wu, Parrish, Pondeca, Liu)
Subject to NCEP Director approval implement upgrades to WRF-GSI used in NAM/NDAS.

CURRENT EFFORTS: The new version of the GSI with METOP data was tested in a full resolution full domain parallel data assimilation system. Preliminary results showed a small positive impact in all variables. TAMDAR, Canadian AMDAR and METOP (AMSUA, HIRS, and MHS) radiances have been incorporated in the GSI part of the NAM upgrade package and are being used parallel runs made by EMC and NCO. A field evaluation of the latter will begin in October. This work is complete and implementation is expected in December 2008. (Wu)

PLANNED EFFORTS: Implement NAM upgrade in December and continue work on the GSI tangent linear normal mode constraint for 2009. (Parrish)

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED: None.

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE:

08.5.5.E2 30 August 2008 (GSD)
Rapid Refresh code delivery date to NCEP/EMC for initial testing of RR version of GSI.

A tarball with Rapid Refresh (RR) elements (including an RR specific version of GSI) has been transferred to NCEP vapor machine to begin experimental RR work at NCEP. As described in milestone 08.5.4.E1, these RR elements will be fused with NCEP IBM specific computing infrastructure (scripts, etc.) to construct the test 1-h cycle environment on the EMC vapor computer. In particular, Chris Harrop's workflow manager, which is used to coordinate the RR runs at GSD is not supported at NCEP and will be replaced by modified versions of similar procedures used for the NAM at NCEP. We are indebted to Yoshi Sato of EMC, who has generously provided his NAM retrospective infrastructure (code, scripts, etc.), which will provide a reference framework for the NCEP computing environment.

08.5.5.E3 30 September 2008 EMC (Liu)
Deliver enhancement package for radial velocity data analysis for further implementation testing.

CURRENT EFFORTS: The Level II radial wind QC package was modified to process recombined build-10 radar data and the BUFRTAB.006 for radar data processing was updated. It was found in NCO's parallel that the new BUFRTAB was used in the QC job but old one was used in the tranjb job. Both QC package and jobs scripts were modified to use the same BUFRTAB. Tests with the central US 8 km window system and the enhanced GSI for use with radial velocity data were marginally positive. (Liu)

PLANNED EFFORTS: Plans for 2009 are to take this package and implement it to initialize Matt Pyle's daily 4 km NMM run made for SPC and to also use the reflectivity in a diabatic initialization as well. (Liu)

Task 08.5.6 Develop, test, and evaluate the performance of the nonhydrostatic Weather Research and Forecasting (WRF) modeling system.

NCAR/MMM

In this quarter, NCAR issued two minor WRF releases, 3.0.1 and 3.0.1.1, addressing bug fixes. Examples were code to prevent use of the Pleim-Xiu LSM if the user has non-standard numbers of land categories and code for the Lin microphysics scheme to define properly the graupel ventilation factor.

In this quarter, NCAR conducted the second WRF tutorial of the year. This was held in Boulder on July 14-18 and over 70 people attended. The tutorial covered model structure, preprocessing, and operation, and practical sessions provided opportunities to run components and make simulations. On July 21–22, NCAR/MMM put on the first separate WRF-Var tutorial, with 52 people attending. It covered the entire WRF-Var system, from observation preprocessing, to operation, to background error generation.

In PBL and LSM-related physics work in the quarter, Jimy Dudhia of NCAR worked with Brian Reen (Penn State) to improve the PBL height computations by the MYJ PBL scheme. Dudhia worked with Y.-H. Yang from China and Changhai Liu (NCAR/MMM) on testing PBL schemes and comparisons with large-eddy simulation in idealized PBL growth situations. In LSM work, Dudhia worked with Mukul Tewari and Fei Chen (NCAR/RAL) to allow snow albedo to be based on land-use type as an option in the Noah LSM. Dudhia also worked with visitors on a new multi-layer urban canopy model (UCM) and its addition to the MYJ PBL scheme. A fix for the skin temperature calculation in the UCM in certain cases, related to small exchange coefficients occurring in weak winds, was also developed. A time-dependent snow albedo capability was developed for the Noah LSM and subsequently improved.

Dudhia worked with visitor Joe Galewsky (U. New Mexico), and did idealized testing with WRF, including generalization of the sea-breeze case to read levels from the namelist. The sea-breeze case was corrected for situations where a v-component of the wind may be added. In radiation physics work, Dudhia collaborated with Dave Gochis and Wei Yu (NCAR/RAL) on the implementation of topographic slope effects in the CAM radiation scheme.

NCAR has recently added various fixes to the WRF repository. One reported by users was made to the Lin microphysics scheme to improve water conservation. A fix was applied to the CAM radiation to prevent out-of-bounds references. Dudhia worked with John Michalakes (NCAR/MMM) and the Univ. of Miami for a fix to the Thompson microphysics initialization to prevent it from being called every time a nest moves, which was unnecessary and costly. This change was merged with a new Thompson double-moment rain scheme.

GSD

GSD developed and has tested a version of ARW in which the Thompson microphysics scheme is NOT called every dynamics time step. In this test within the Rapid Refresh, microphysics was instead called every other dynamics step, resulting in a 5% reduction in overall run-time. More code needs to be developed to save tendencies and apply them less abruptly.

Task 08.5.8: Improve physics in the WRF model, especially that bearing on prediction of aircraft icing.

GSD

The planned 2008 RUC change bundle continues in parallel testing at NCEP (see discussion under Task 08.5.1).

GSD and DTC

The test of the impact of changing the vertical distribution of vertical levels in the WRF-ARW was planned and executed in a collaborative effort between GSD and DTC. The particular impacts examined were on forecasts of 2-m temperature and dew point and 10-m wind, as well as low ceiling and visibility. Of particular concern were situations having low-level warm advection over snow-covered ground, a condition that has caused systematic daytime cold biases in 2-m temperature forecasts (subtask 1, below). The hypothesis is that higher resolution in the lowest ~500m above ground will improve these forecasts beyond what has already been achieved by alterations to the RUC LSM (subtask 1). Preliminary indications are that, compared to a more standard WRF-ARW configuration in which the lowest model layer is about 40m thick, over the eastern half of the US the higher resolution near the surface (lowest layer about 15-20m thick) currently being used in the 1-h cycle RR improves the diurnal variation of 2-m temperature and 10m wind. However, the amplitude of the diurnal variation of temperature and wind speed is still too small, i.e., temperature is too cool during the daytime and too warm at night, and winds are too strong at night. Evaluation of these experiments is continuing.

Mariusz Pagowski, working under non-FAA funding from the DTC, has implemented the Mellor-Yamada-Nakanishi-Ninno (MYNN) scheme into WRF and Joe Olson, a postdoc working with J. Brown has been testing its performance against the existing PBL schemes in WRF using a subset of the RR domain covering much of Alaska. These tests, focused on the interaction of strong low level southerly flow with the terrain of southeast Alaska for a case having aircraft data for validation, are ongoing. Retrospective tests of RR using the MYNN scheme are planned.

Subtasks

08.5.8.1 31 Dec 2007 (GSD)

Begin systematic GSD evaluation of physics performance in GSD 1-hour RR cycle and address issues that arise in preparation for 2009 RR implementation. Particular attention will be given to microphysics and interactions between microphysics and the other parameterized physical processes.

Code modifications and testing have begun by GSD to call the microphysics parameterization in the WRF-RR-ARW less frequently, at multiples of the long (non-acoustic) time step. Initial testing in which the microphysics was called every other long time step, and the changes over the single long time step when the microphysics was called were doubled, proved to be not fully satisfactory. Efforts now are going toward computing tendencies for potential temperature and water vapor mixing ratio changes computed in the microphysics, as well as for the hydrometeor types, and saving these tendencies to be applied at each subsequent consecutive time step when the microphysics is not called. As noted under Task 4, this will save some run time (estimated at least 5%) and, based on our experience with RUC, should give similar results to the present procedure of calling microphysics at every long time step. This capability has never been available previously with the WRF-ARW dynamic core, although it has been with the WRF-NNM dynamic core.

Qualitative and quantitative evaluation of the RR cycled runs for physics effects continues. Of particular interest for this time of year is the performance of upper level winds, where similar concerns led to withdrawal of the latest version of the Grell-Devenyi convective scheme in favor of an earlier version for the upcoming RUC change package (Task 1). We will also be exploring possible sources of a remaining small low level cold bias.

08.5.8.3 May 2008 (NCAR):
Expand the current one moment microphysical scheme to two moments and add a variable for aerosol particles in order to improve forecasts of freezing drizzle and icing. Computer storage and run time considerations will be considered as a constraint on the development. (NCAR)

A two moment scheme for rain was completed and tested on various cases. This improved scheme is available to ESRL for testing in the WRF Rapid Refresh. Trude Eidheimer was hired to implement an aerosol scheme into the microphysics scheme during the next fiscal year. She previously worked at CSU

as a Postdoc under Sonja Kreidenweiss' aerosol group.

Deliverables

08.5.8E3 May 2008: (NCAR)
Improved microphysics scheme to ESRL for evaluation in WRF Rapid Refresh. (NCAR)

08.5.8.5 31 Mar 2008 (DTC, GSD)
Report on GSD-DTC RR retrospective testing of land-surface model formulations for snow, and, as appropriate, other physics.

See above discussion on the retrospective test of vertical resolution in WRF. These tests were done with a restriction to the rate of snow melt recently introduced into the RUC LSM. Tests with this modification in RUC have shown improved (though still with some cold bias) spring-season daytime temperature forecasts over snow cover. The DTC has prepared a draft report for GSD on this testing and GSD has provided comments on this draft.

Task 08.5.15: Develop improved methods of cloud and moisture analysis for use in the WRF Modeling System.

Subtasks

08.5.15.1 31 October 2007 (NCEP)
Based on parallel testing and refinement of the experimental code, deliver the 'pre- implementation' code to NCO including improved diabatic initialization (e.g. nudging to analyzed precipitation and GOES cloud-top) for the March 2008 NAM change package.

08.5.15.2 30 Jan 2008 (GSD) COMPLETE
Develop and evaluate performance of diabatic digital filter initialization (DDFI) in the RR WRF model without use of radar data
Although this was reported as complete in previous months, we note that this work was described in a paper by Steven Peckham, Tanya Smirnova, Stan Benjamin, John Brown (all from ESRL/GSD), and NCAR/MMM colleagues at the 9th Annual WRF Workshop in late June (go to paper 1.3) . An issue with the DDFI occasionally causing the RR 1-h cycle to crash was recently isolated and resolved, by shortening the time-step in the backward integration.

08.5.15.3 30 March 2008 (GSD and CAPS)
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.

Ming Hu introduced the generalized cloud analysis into the latest GSI version (March 31, 2008) and has conducted systematic tests within the RR retrospective test environment. This version is now running in the RR 1-h cycle at GSD. Ming Hu has completed modest modifications to portions of the generalized cloud analysis to conform to specific EMC coding practices (restructuring the I/O, etc.). Following this, an extensive retro test evaluation was completed to ensure that the modified code did not impact the cloud analysis results. A tarball with these changes has been sent to Russ Treadon at EMC for possible inclusion in the next GSI release. Ming Hu has recently (Sept.) improved the lightning assimilation by deriving an improved statistical relationship between lightning and reflectivity.

08.5.15.4 30 May 2008 (NCEP)
Based on development efforts, deliver 'research quality' diabatic initialization upgrades (e.g. initial use of Level II reflectivity) for consideration in the March 2009 change package for NAM.

08.5.15.5 30 Mar 2008 (GSD)
Include radar reflectivity-based latent heating within diabatic digital filter initialization (DDFI) in the RR

WRF model.

The components for RR reflectivity assimilation are in place with the release of WRF version 3 including diabatic digital filter initialization and cloud analysis capability within GSI (upgraded to latest GSI version during the quarter). Testing and refinement of DDFI within 1-h cycle and of various cloud analysis options (including reflectivity assimilation) continue. An option to use a shorter time step during the DFI has been implemented to prevent sporadic crashes during the backward portion of the DFI. However, this option apparently will not be needed, as an unrelated cause for the crashes has identified and fixed (see task 08.5.4). Recently, we have begun side-by side comparisons of RR 1-h cycles with and without the radar assimilation.

08.5.15.6 30 July 2008 (NCEP)
Based on case-study testing and refinement of the research quality code, an 'experimental' WRF code is delivered with diabatic initialization upgrades (e.g. initial use of Level II reflectivity) for the March 2008 change package for NAM.

Deliverables

08.5.15.E1 30 March 2008 (NCEP)
Subject to NCEP Director approval, the WRF-NMM code with upgraded diabatic initialization capability (e.g. nudging to analyzed precipitation and GOES cloud-top) becomes operational at NCEP as part of the March 2008 change package to NAM.

08.5.15.E2 30 Aug 2008 (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.

Ming Hu introduced the generalized cloud analysis into the latest GSI version (March 31, 2008) and has conducted systematic tests within the RR retrospective test environment. This version is now running in the RR 1-h cycle at GSD. Ming Hu has completed modest modifications to portions of the generalized cloud analysis to conform to specific EMC coding practices (restructuring the I/O, etc.). Following this, an extensive retro test evaluation was completed to ensure that the modified code did not impact the cloud analysis results. A tarball with Rapid Refresh (RR) elements (including an RR specific version of GSI with the cloud analysis code) has been transferred to NCEP vapor machine to begin experimental RR work at NCEP. In addition, a tarball with these changes has been sent to Russ Treadon at EMC for possible inclusion in the next GSI release.

Task 08.5.17 Infrastructure support for running operational WRF model in RR, North American Mesoscale and HiResWindow modes at NCEP.

NCEP
Dennis Keyser reports that there appears to be an improvement in the receipt of some of the Alaskan radiosonde data, as sites like Shemya (70414) are now usually available before the NAM data cutoff. NCEP contacted Alaska in late winter about this issue, but there is still a need for some sites to move their launch time so their data can be received in time for the NAM-GSI. This will also benefit the Rapid Refresh. Since the beginning of April, Level II reflectivity (and radial wind) data from an increasing number (at least 100) WSR-88D radar sites are unavailable due to their switch from Build 8 to Build 10 software and the inability of NSSL's qc code to deal with the super-res format of Build 10. Level 2.5 winds are used when Level 2 winds are unavailable. NCEP/NCO has submitted a Request For Change (RFC) to implement a recombination code which will ingest these data and convert them back to a Build-8 look-alike format. During at least three periods since the last half of July, some Level 2.5 radial wind superobs have been unavailable to the NAM-GSI due to corrupted input files leading to errors in the uncompression code (NCO is investigating). Since early May, AIRS radiance data counts have been lower than average due to late posting of files associated with hardware issues with NESDIS' processing machines. This should improve later this year when NESDIS ports their AIRS system to new Linux machines. AIRS AMSU-A radiances have not been available to the NAM-GSI since mid-April when

AMSU-A channel 4 went bad. Efforts are underway to modify the GSI to allow the remaining AMSU-A channel data to be used. Some radiosondes are not receiving the proper instrument type due to obsolete entries in the NCEP/NCO upper-air dictionary. NCO has filed an RFC (Request For Change) to correct this and it should be implemented as soon as critical weather ends. The following data types are now monitored by the NAM-GSI: RASS virtual temperature profiles, QuikSCAT 0.5 deg. scatterometer wind superobs, TAMDAR (via ESRL MADIS feed) and Canadian AMDAR aircraft temperature and wind. Efforts to speed up the dump processing of NEXRAD Level II data are being explored. Cooperative Agency Profiler (CAP) and RASS data are not yet available through an alternate ESRL MADIS feed.

Eric Rogers reports that the testing of model/analysis modifications for the Fall 2008 NAM change package continues. WRF-NMM model changes being tested which address model biases include changes to the radiation parameterization (doubling the absorption coefficients for water and ice), changes to the land-surface physics, and changes to vertically mix and diffuse each hydrometeor species separately. Assimilation/analysis changes include a new version of the GSI analysis, assimilation of TAMDAR/Canadian AMDAR/METOP2 data, and "partial" cycling (using GDAS atmospheric first guess for the first GSI analysis in each NDAS cycle). Changes to the shallow convection parameterization were dropped on the advice of NCEP's Storm Prediction Center due to adverse impact on NAM forecasts of Convective Available Potential Energy. This bundle was successfully briefed to the EMC Change Control Board on 4 September and RFC's submitted the next day.

Shun Liu continued working with NCO to test radar build-10 data decoder and super-resolution data recombination algorithm and he is also working with NCO to setup and verify NCO's parallel run. It is found about ten percent of radar data are not processed in NCO's parallel. The reason is under investigation.

Subtasks

08.5.17.1 Maintain four-per-day North American Mesoscale runs and provide SAV and AIV guidance.
The assimilation of AIRS satellite radiance data in the NDAS/NAM GSI analysis, which was supposed to be implemented with the 31 March 2008 NAM change package, was not done on that date due to an error in the scripts provided to NCO. This error was fixed on 22 April 2008.

Parallel testing of the final Fall 2008 NAM change package was started on 1 August 2008. Modifications include changes to the GSI analysis (see above: latest code release with new CRTM, assimilation of TAMDAR and Canadian AMDAR data and METOP satellite radiance data), the NDAS (so-called "partial cycling" option where the GDAS atmospheric states are used as a first guess to the NDAS analysis at the start of the 12-h NDAS run) and the WRF-NMM forecast model (doubling the absorption coefficients for cloud ice/water in the radiation parameterization, modifications to the land-sfc physics to improve cool season performance). Also, the new, higher resolution (~23 km) AFWA snow depth analysis will replace the current AFWA 45-km snow depth analysis. All changes have been handed off to NCEP Central Operations (NCO), who will begin real-time parallel testing for evaluators in October 2008. (Rogers)

08.5.17.2 Maintain four-per-day HiRes Window runs and provide SAV and AIV guidance.

NCEP runs 4/day runs of WRF-NMM at 4 km and WRF-ARW at 5 km when there are no hurricane runs. Most of this quarter, the HiResWindow runs have been preempted by hurricane runs. NCEP maintains twice-per-day runs of six WRF-based members (3 running NMM and 3 running ARW) of the Short Range Ensemble Forecast (SREF) system with aviation guidance available from http://wwwt.emc.ncep.noaa.gov/mmb/SREF/SREF.html which now includes Alaska and Hawaii (eastern Pacific). (EMC and NCO)

08.5.17.3 Provide vendors with gridded NAM 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 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 users. (EMC Team and NCO)

08.5.17.4 Provide full grids from NAM, and the HiRes Window on NCEP and NWS/OPS servers.

NCEP maintained real-time availability of full resolution gridded data from the operational 4/day NAM and the HiResWindow (HRW) suite of WRF-NMM and WRF-ARW runs via anonymous ftp access via the NCEP server site ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com. For NAM, this includes hourly BUFR soundings and output grids which undergo no interpolation and, as such, are on the models' computational grids (so-called native-native grids). HRW run output is now mapped to 5 km output grids and packed into GRIB2 format, see http://www.nco.ncep.noaa.gov/pmb/docs/GRIB1_to_GRIB2.shtml and these data are scheduled to be added to the NOAAPORT feed with AWIPS OB9. A limited set of fields from the 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)

08.5.17.5 Maintain access to model verification data. (see subtask report under Task 08.5.1.4)

08.5.17.6 Provide assistance to Inflight Icing, Turbulence, Convective Weather, Ceiling and Visibility and Oceanic Weather PDTs when their algorithms and product generation systems are ready to transition into NCEP's operational Production suite.

The transition work on icing codes FIP, CIP and CIP-Severity has been stymied at NCEP by inability to recruit and hire a suitable contractor.

Deliverables

08.5.17.E1 1 October 2007 - 30 September 2008 **EMC** (Parrish, Derber, Wu, Keyser)
Perform observation ingest, quality control and preparation in support of the operational North American Mesoscale WRF runs.

CURRENT EFFORTS:
There appears to be an improvement in the receipt of some Alaskan radiosonde data as sites such as Shemya (70414) now usually arrive before the NAM data cutoff; but there is still a need for some sites to move their launch time so that their data can be received in time for the NAM-GSI. Since early April, Level II radial wind (and reflectivity) data from an increasing number of WSR-88D radar sites is unavailable due to their switch from Build 8 to Build 10 software, as NSSL's QC code can't deal with the super-res format of Build 10. Since 15 September all 130 sites have switched to Build 10. NCEP/NCO has submitted a Request For Change (RFC) to implement a recombination code to convert them back to a Build-8 look-alike format, which is scheduled for implementation in October. Level 2.5 radial winds are used when Level 2 winds are unavailable, but during at least three periods since late July some Level 2.5 radial wind superobs have been unavailable to the NAM-GSI due to corrupted input files leading to errors in the uncompression code (NCO is investigating). Since early May, AIRS radiance data counts have been below average due to late posting of files because of hardware issues with NESDIS' AIRS processing machines; this will improve once NESDIS ports their AIRS system to new Linux machines. In mid-April AMSU-A channel 4 went bad and AIRS AMSU-A radiances are no longer available to the NAM-GSI. NAM-GSI is being modified to allow the remaining AMSU-A channel data to be used. A crisis change was implemented on 11 July to correct a program memory problem that caused the t.c. vitals quality control processing and the subsequent tropical cyclone first guess relocation processing to not recognize hurricane Bertha. On 16 September, roadway temperature and icing data was added to the dumps of DOT mesonet data providers, and the restriction category was corrected for several mesonet providers. On 23 September, the METAR dump processing was updated to store each report's temperature and moisture at full precision. These had been truncated in cases when the latest receipt for a report did not include a "remarks" section. The following data types are now monitored by the NAM-GSI: RASS virtual temperature profiles, QuikSCAT 0.5 deg. scatterometer wind superobs, TAMDAR (via ESRL MADIS feed) and Canadian AMDAR aircraft temperature and wind. Efforts to speed up the dump processing of NEXRAD Level II data are being explored. Multi-Agency Profiler [MAP, previously

Cooperative Agency Profiler (CAP)] and RASS data are not yet available through an alternate ESRL MADIS feed, but NCO is now actively working on decoding these data. (Keyser)

The Level II radial wind QC package was modified to process recombined build-10 radar data and the BUFRTAB.006 for radar data processing was updated. It was found in NCO's parallel that the new BUFRTAB was used in the QC job but old one was used in the tranjb job. Both QC package and jobs scripts were modified to use the same BUFRTAB. (Liu)

PLANNED EFFORTS:
Add a new aircraft quality control module based on code from Naval Research Lab. This was recently updated to run more efficiently and to fix some bugs but work still needs to be done to improve run times when profiles are generated. This code is now being checked out in daily real-time Regional and Global parallel runs. 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 vs. current ESRL MADIS feed) and Canadian AMDAR aircraft; 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); METOP-2 1B HIRS-4, AMSU-A and MHS radiances; aircraft moisture; RASS temperatures; JMA, European and MAP profiler winds; 3.9 micron and visible satellite winds; WindSat scatterometer wind data; GPS radio occultation data; and METEOSAT-9 IR and visible satellite winds. Coordinate with the field to speed up more Alaskan RAOB processing to arrive in time for the NAM dumps. Try to retrieve as much data as possible over Alaska (especially mesonet, aircraft and coastal surface). Add GSI events to the NAM PREPBUFR files. In the GSI, make use of the actual or estimated anemometer, barometer and thermometer heights on ships. Generate and QC high vertical-resolution aircraft profile data near airports. (Keyser)

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS: GSD & NCO.

UPDATES TO SCHEDULE:

08.5.17.E2 1 October 2007 - 30 September 2008 **EMC** (Parrish, Derber, Wu, Keyser)
As requested by other PDT's, incorporate new AIV calculations into Operational WRF Model post-processor and product generator.

CURRENT EFFORTS: No requests were made by other PDTs during this period.

PLANNED EFFORTS:
PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED: None

INTERFACE WITH OTHER ORGANIZATIONS: NESDIS, GSD & NCO

UPDATES TO SCHEDULE: None

Task 08.5.19: Develop ability to assimilate WSR-88D radial velocity and reflectivity data through GSI and Rapid Refresh toward High-Resolution Rapid Refresh.

GSD
HRRR forecasts continue to benefit from changes made in early June to initialize the HRRR directly from the RUC DFI-initialized grids. Previously, the HRRR was initialized from RUC analysis grids which resulted in the use of older reflectivity data (because the radar assimilation is applied within the DFI portion of the RUC model, which occurs after the analysis). This change has significantly improved the effective radar reflectivity assimilation for the HRRR. This was possible only after a redesign of the RUC post-processing and scripts (see 5.19.E1 text).

Currently, the RUC-DFI data is only available from the GSD "development-13" experimental RUC, not the "backup-13" RUC generally made available to outside users. A transfer to the backup RUC has started but not completed for the code and script changes required for output of the RUC-DFI grids (also valid at 00h but requiring a number of changes to avoid confusion with the different RUC analysis grids, also valid at 00h).

Ongoing monitoring of the HRRR runs with this enhancement continues to indicate that the HRRR forecasts with the direct use of the DFI-initialized RUC grids depict well the evolution of ongoing convection. Analysis of quantitative reflectivity verification statistics (produced by Barry Schwartz, see more details on 08.5.24) confirm the HRRR forecast improvement from the RUC radar assimilation and shed light on important diurnal and scale factors in the forecast improvement.

During September, we analyzed reflectivity verification statistics for summer 2008 HRRR runs with and without radar assimilation. Results (shown in Fig. 1) indicate that the HRRR forecast improvement from the radar assimilation gradually decreases with forecast length, but extends out to at least 12-h. In addition, the diurnal cycle was analyzed, revealing the expected relationship between the degree of forecast improvement and the amount of ongoing convection at the model initial time.

08.5.19 31 August 2008 (CAPS)
Complete 3-km GSI data assimilation experiments for potential application within the HRRR assimilating radial wind. Evaluate impact using 3-km HRRR-WRF model configuration as used by GSD.

At CAPS, using WRF 2.2 and an earlier version of GSI, Aimei Shao completed a series of 3-km assimilation and forecast experiments with 30-min assimilating cycles for up to 6 hours to evaluate the combined or individual impact of radar radial velocity and reflectivity data on the forecast of tropical cyclone Erin.

During the period, impacts of the different background error de-correlation length scales in GSI and some other parameters including the positive-definite moisture variable advection in WRF model were examined. Different domain sizes were experimented to determine the influence of lateral boundary conditions to the vortex prediction. Furthermore, One-km resolution nested-grid forecasts were conducted to see its impact on the intensity and structure of predicted Erin. The set of results used NAM analysis as initial guess and NAM forecasts as boundary conditions. More details, including example graphics, can be found in the July and August monthly reports.

Efforts are going on to quantitatively verifying the prediction results, against radar observed reflectivity and radial velocity fields at the radar elevation levels. Correlations between forecast and observed fields are calculated, as are regular and relaxed ETS (equitable threat score). The relaxed scores try to account for spatial displacement of the vortex and embedded rain bands. A phase error correction procedure is also employed where the forecast vortex center is moved to the location estimated from observations before the gridded fields are mapped to the radar elevations for score calculation. Detailed results will be reported later.

A new visiting scientist, Dr. Yi Yang, and a new visiting Ph.D. student, Kefeng Zhu, joined the project during the quarter, with the expected departure of Dr. Aimei Shao in later October. Yi Yang, repeated and expanded the experiments made by Aimei Shao, using the newly released WRF version 3.0.1.1 and the latest version of GSI, and using RUC instead of NAM analyses as the analysis background and boundary conditions. Radar data are assimilated at up to 10 min frequency.

The forecasts obtained are of similar quality as the NAM-based forecasts but there is a tendency for the vortex using the NAM analyses to propagate a little slower while that using RUC analyses to propagate a little faster than observed. There is also sensitivity to model microphysics. Further investigation is being made. Given the general sensitivity to the assimilation frequency and length, to model configurations as well as to initial background and boundary conditions, we plan to expand our examination of the forecast results in a probabilistic framework, using forecasts starting at different times of the assimilation cycles.

Other problems needing further investigation include the apparently ineffectiveness of the 3DVAR-cloud analysis-based analysis system in removing spurious rain-bands in the forecast background, which is not surprising given the analysis method. Further efforts are being made to see if more frequent (~5 to 10 minutes) analysis cycles, over perhaps a shorter window, can prevent spurious rain bands from developing. Initial results using 10-minute intervals over 2-hour period are producing similar results. New efforts are underway to include wind profiler, surface mesonet data in the frequent analysis cycles. Radial velocity QC will be further examined.

Both earlier and newer versions of WRF and GSI are running successfully on an AMD-processor-based Linux supercomputer at the Texas Advanced Supercomputing Center (TACC).

Subtasks

08.5.19.1 30 May 2008 (GSD, NCAR/RAL, CAPS)
Select initial case studies from 2007 and 2008 for 3-km HRRR data assimilation case studies.

For the summer 2008, we have initially focused on several days, including the first week of June, June 27, July 10, and 20-23 July 2008. Also, MIT/LL has compiled a comprehensive list of key days from the summer 2008 season, including a summary of the operational status of each components of the test CoSPA system. A telecom was held between the three core CoSPA groups (ESRL/GSD, MIT/LL, and NCAR/RAL), QART, and Warren to discuss verification efforts for 2008 case days. A set of seven preliminary days was identified, though not finalized.

08.5.19.2 31 August 2008 NCAR-RAL
Run case studies using 3km HRRR using different RUC-based initial conditions

- Run case studies from spring/summer 2008 using 3-km HRRR on GSD jet computer using different RUC-based initial conditions
    - Operational RUC (without radar reflectivity assimilation)
    - Radar-DFI enhanced RUC (probably from GSD)
    - Radar-DFI RUC using unsmoothed latent heating
    - Test of 3-km radar-DFI when code ready from GSD
- Use Northeast US Corridor domain for HRRR runs as used at GSD.
- Provide detailed report on case studies by 15 Sept 08

Quantitative reflectivity verification of real-time (3-hourly) runs of the HRRR from the GSD experimental RUC (with radar data assimilation) and the NCEP operational RUC (without radar data assimilation) indicate significant forecast improvement for the radar assimilating RUC-based HRRR. Based on evaluation of the verification statistics and case studies, we are beginning to understand the diurnal aspect to the forecast improvement and important characteristics relating to the spatial character of the convection.

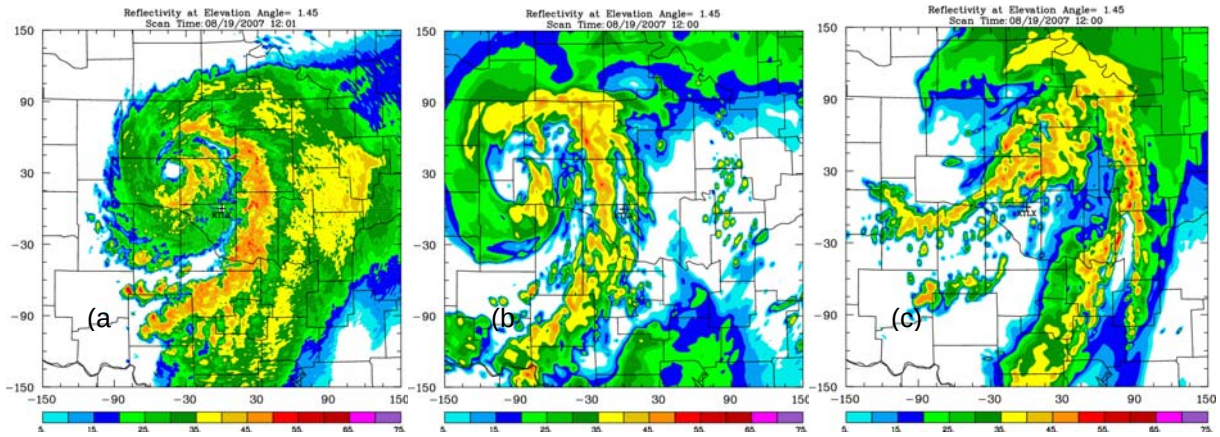
08.5.19 31 August 2008 (CAPS)
Complete 3-km GSI data assimilation experiments for potential application within the HRRR assimilating radial wind. Evaluate impact using 3-km HRRR-WRF model configuration as used by GSD.

At CAPS, Dr. Aimei Shao, using WRF 2.1 and an earlier version of GSI, completed a series of 3-km assimilation and forecast experiments with 30-min assimilating cycles for up to 6 hours to evaluate the combined or individual impact of radar radial velocity and reflectivity data on the forecast of Tropical Storm Erin. The results show that both variational radial velocity assimilation and reflectivity assimilation via cloud analysis have positive impact. Radial velocity and reflectivity combined produce the best results.

One-km resolution two-way nested-grid forecasts were conducted in which 3-km analyses at 00, 02, 04, 06 UTC were used as initial condition, corresponding to 0, 2, 4 and 6-hour long assimilation windows including radar data, respectively. The predicted position and intensity of the vortex center are in general

agreement with 3 km forecasts started at the same time, with the main differences being in the detailed structure of spiral rain bands. The precipitation amounts from the two grids are generally similar, and both over-predict the maximum amount, which is a common problem with explicit QPF at few kilometer resolutions.

For comparison purpose, nested 3- and 1-km forecasts are made, using the 0000 UTC NAM analysis as initial condition. Six-hour forecast from the 1 km grid valid at 1200 UTC is shown in panel (c) of Figure, which is compared to the forecast starting from the initial condition with a 6-hour assimilation window (b) and to observation (a). The reflectivity fields have been projected to the 1.45° elevation of the Oklahoma City radar for direct verification. Clearly, the forecast with radar assimilation is much better. Further quantitative verification is underway.



radar assimilation (c).

New CAPS scientist, Dr. Yi Yang, repeated the experiments of Aimei Shao with the newly released WRF version 3.0.1.1 and the latest version of GSI, and using RUC instead of NAM analyses as the analysis background and boundary conditions. Radar data are again assimilated at 30-min intervals for up to 6 hours.

The forecasts obtained are of similar quality as the NAM-based forecasts but there is a tendency for the vortex using the NAM analyses to propagate a little slower while that using RUC analyses to propagate a little faster than observed. There is also sensitivity to model microphysics. Further investigation is being made.

Remaining problems needing investigation include the apparently ineffectiveness of the analysis system in removing spurious rain bands in the forecast background, which is not surprising for the given analysis system. Efforts are being made to see if more frequent (~5 to 10 minutes) analysis cycles, over perhaps a shorter window, can prevent spurious rain bands from developing.

08.5.19.4 30 Sept 2008 (GSD)

- Develop new stand-alone 3-km processor from raw 3-d reflectivity tiles to 3-km HRRR domain, similar to software developed for 13-km RUC
- Develop and test code at 3-km for assimilation of radar reflectivity using observation-based specification of latent heating within WRF-DFI.

As part of his HRRR verification package, Barry Schwartz is mapping NSSL reflectivity tiles to the HRRR 3-km domain. Work ongoing to convert reflectivity to temperature tendency and ingest into WRF DFI-based radar and lightning assimilation.

Deliverable

08.5.19.E1 GSD, CAPS, NCAR-RAL 30 Sept 2008
Complete improved version of 13km/3km radar assimilation techniques for demonstration in FY09 exercises.

In the spring, GSD modified several components in the RUC processing to allow direct output and post-processing of DFI-initialized grids. While we do not advocate use of these grids as RUC analyzed fields for aviation and other user applications, it did allow tests to initialize the HRRR model with the DFI grids including the latest radar reflectivity instead of the RUC analyzed grids, which effectively does not. These tests were finally performed in early June and showed a significant improvement in 1h-6h forecasts in 3 different case studies. Based on these results, this variation in the HRRR (using RUC-DFI-radar initial conditions immediately after DFI) was implemented into the real-time HRRR runs. Thus, this new modification is now affecting HRRR grids ftp'd to NCAR and MIT/LL.

VIL output at 15-min frequency is now available from a real-time HRRR web site at http://ruc.noaa.gov/hrrr/vil. This is the first time that any RUC/RR/HRRR graphical products have been available at a 15-min output frequency.

Task 08.5.20: Develop ensemble-based probabilistic products for aviation users.
UNFUNDED

Task 08.5.24

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

Subtasks
08.5.24.1 30 September 2008 (GSD, NCAR/RAL, NCAR/MMM)
Conduct HRRR summer exercise. Collaborate on analysis on HRRR tests. Draft and deliver summary of results.

Real-time ftp transfer of HRRR grids to NCAR and MIT/LL since mid April. VIL fields with 15-min output added to HRRR grids and also ftp'd to NCAR (accomplished in mid-May). Modification made to HRRR scripts to speed up processing time by 1 hour, resulting in improved HRRR guidance. In order to do this, the backup RUC was changed to run out to 13h (instead of 12h) on an hourly basis, so that each HRRR run can be started as soon as the new RUC analysis (or post-DFI) file is available, using lateral boundary conditions (BCs) from the *previous* RUC forecast. This trade-off in using older (less accurate) BCs was considered acceptable to get the new HRRR forecast out 45-60 min faster.

A second, very important change to the HRRR initialization procedure was made in June to directly use the RUC DFI-initialized grids. Previously, grids from the RUC 3DVAR (containing older radar information) were used to initialize the HRRR. This change (which required a redesign of the RUC post-processing and scripts -- see 5.19.E1 text) has significantly improved the effective radar reflectivity assimilation for the HRRR.

More recently, a new HRRR reflectivity "matrix" web-page has been created that allows the users to quickly view the HRRR reflectivity fields for multiple forecast times and multiple initialization times. The page can be found at: http://ruc.noaa.gov/hrrr/reflectivity.cgi

Additional minor changes have been made by Tanya Smirnova to make the HRRR runs more reliable and to improve the runtime. GSD continues to interact many times per week with MIT/LL and NCAR on the HRRR contribution to the CoSPA real-time 0-6h forecasts. GSD keeps the CoSPA partners abreast of changes in HRRR processing and computer availability.

Additional improvement to speed up processing of RUC radar assimilation fields used to drive the HRRR, resulting in further substantial improvement in the HRRR. Real-time verification of HRRR reflectivity

forecasts is ongoing. Real-time monitoring of HRRR forecasts has revealed some issues related to the limited HRRR domain size and propagation of convective systems into the HRRR domain

Barry Schwartz coded up a reflectivity verification package, which ran for much of the summer and has provided invaluable information for diagnosing HRRR model performance and understanding aspects of the convective predictability problem. As expected, statistical verification of forecast reflectivity for the HRRR initialized with the RUC DFI fields vs. a corresponding 3-km grid initialized from the operational RUC (with no radar assimilation) indicates a significant forecast improvement in the HRRR from the radar assimilation on the parent RUC grid. Improvement is greatest for short-range forecasts (3-h and 6-h), but extends out to 12-h (even in average statistics) for certain times of the day. Analysis of the statistics continues and we are evaluating the relationship between reflectivity forecast skills, the diurnal cycle of convection and the scale of observed and assimilated convection.

During September, we analyzed reflectivity verification statistics for summer 2008 HRRR runs with and without radar assimilation. Results (shown in Fig. 1 - below) indicate that the HRRR forecast improvement from the radar assimilation gradually decreases with forecast length, but extends out to at least 12-h. In addition, the diurnal cycle was analyzed, revealing the expected relationship between the degree of forecast improvement and the amount of ongoing convection at the model initial time. Work is also nearly complete to map the 3-km HRRR reflectivity to the RUC 13-km grid, which will allow a direct comparison of reflectivity forecasts between those models.

A telecom was held between the three CoSPA groups (ESRL/GSD, MIT/LL, NCAR/RAL), QART, and Warren to discuss verification efforts for 2008 case days. A set of seven preliminary days was identified, though not finalized.

A summary of the HRRR results was presented at FPAW and 2 selected figs. are included here. The first (fig. 1) shows that the HRRR forecast improvement as a function of forecast length (illustrating that the improvement extends through 12-h forecasts). The second (Fig. 2) shows a case study example from 20 July 2008, illustrating a sample 6-h forecast improvement.

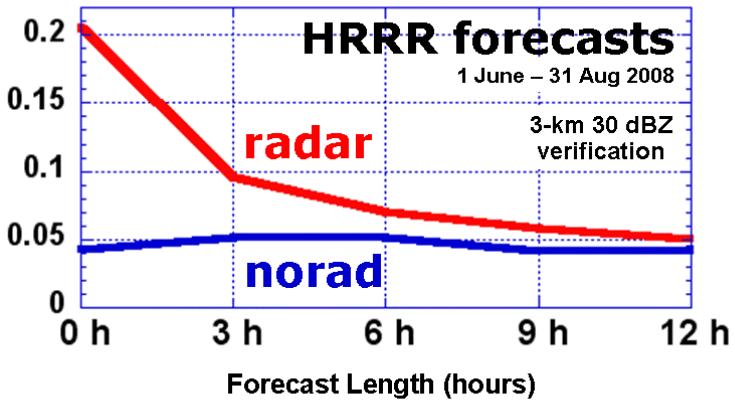


Fig. 1 Comparison of 3 month average (JJA) critical success index verification scores as a function of forecast length for HRRR with radar assimilation (on parent RUC grid—"radar") and HRRR without radar assimilation ("norad").

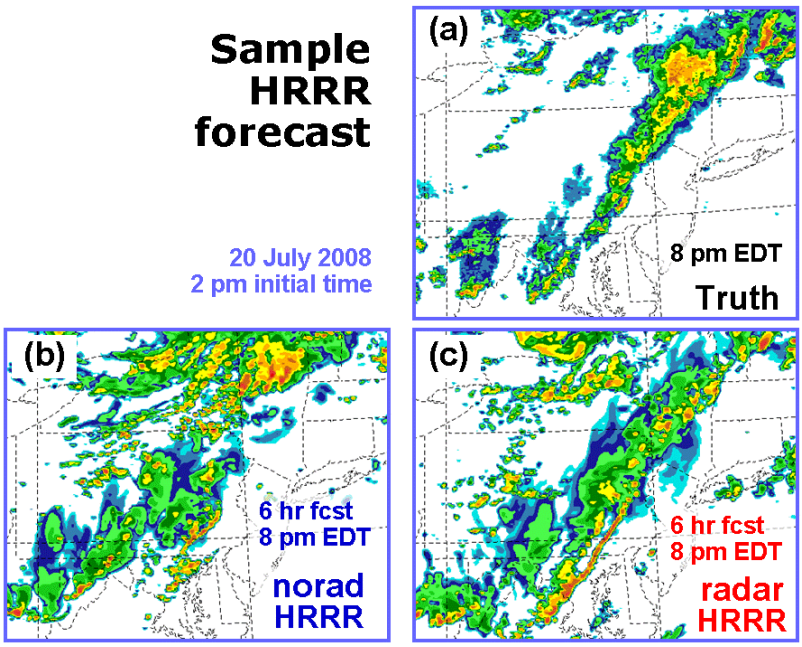


Fig. 2. Comparison of sample 6-h HRRR forecast (from 20 July 2008) with and without radar assimilation. (a) 8 pm EDT verification reflectivity, (b) 6-h HRRR forecast without radar assimilation (norad), (c) 6-h HRRR forecast with radar assimilation (on the parent RUC grid – radar).

The FPAW PPT can be viewed at the following link:

http://ruc.fsl.noaa.gov/faa-mde/Weygandt_FPAW08_FINAL.ppt

Additional material on the HRRR results will be presented in a set of two papers at the AMS Severe Local Storms Conference in Savannah, GA the last week of Oct. Extended abstracts will be submitted by 22 Oct. and posted to the GSD RUC/RR/HRRR web-site.

5.24.2 NCAR-MMM

Evaluate HRRR forecasts with different initializations using GSD HRRR runs

- Compare 3-km HRRR forecasts using initial conditions from 2 versions of the RUC: radar-enhanced RUC from GSD, no-radar RUC from NCEP.
- All HRRR runs performed at GSD, from spring/summer 2008
- Perform analysis of evolution of convective storm mode during first 1-3 hours of model transition from effective resolution 13-km to actual 3-km resolution.

Deliverables

08.5.24.E1 30 August 2008 (NOAA/ESRL/GSD)

Complete FY08 test with small Northeast U.S. domain with 3-km High-Resolution Rapid Refresh running every 1 h.

- Conduct real-time summer 2008 HRRR forecasts using 3-km WRF initialized with radar-enhanced RUC over Northeast US Corridor domain
- Coordinate with other AWRP users and other collaborators

- Provide project management
- Lead writing of report on summer 2008 HRRR experiments

Summer 2008 HRRR demonstration test completed successfully in collaboration with CoSPA partners (NCAR, MIT/LL). Much learned from synergistic effort. Recent work at GSD to evaluate statistical reflectivity verification leading to new insights on radar data assimilation benefits related to the diurnal cycle of convection and the horizontal scale of convection.

(See subtask 08.5.24.1)

08.5.24.E2 30 September 2008 (NCAR/RAP and NCAR/MMM)

Collaborate with GSD on analysis of results. Draft and deliver summary of results. Evaluate techniques for convection-resolving (e.g., 3-km) forecasting by the Rapid Refresh (ARW core) in preparation for development of high-resolution RR (HRRR). Perform and evaluate RR convection-resolving forecasts on test cases using radar-enhanced RUC or Rapid Refresh grids from GSD to identify strengths and weakness of model at high resolution. 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. Analysis of numerous HRRR case studies indicates that parameterized RUC convection passing into the HRRR domain from the RUC lateral boundary conditions has a significantly negative impact on the HRRR forecast over a portion (mainly western and northwestern part) of the HRRR domain. This forecast degradation can extend several hundred kilometers in from the upstream boundary, impacted Chicago (from a boundary in western IA). We have also used the 15-min VIL output to analyze the transition from 13-km to 3-km, confirming that much of it occurs during the 1st hour.

See 08.5.24.E1 for discussion of preliminary analysis of results