MDE Product Development Team – August 2009

FY 2009

Submitted 15 September 2009

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(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.

- Testing underway at NCEP for 18h RUC, also including adding Canadian aircraft (non-turboprop) reports, fix to cloud analysis for warm clouds, investigation underway on use of TAMDAR moisture data in NCEP RUC

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

- Changes made to WRF model and bug-fix to cloud analysis involving MPI appear to improve RR robustness with 1-h cycling
- New file system became available, greatly alleviating the serious file-system problems on ESRL supercomputer; RR 1-h cycle now much more reliable.
- Partial cycling for Rapid Refresh running at GSD, giving improved results
- Improvements in WRF-RR: testing of WRFV3.1.1 and options in 1-h cycle
- Continued real-time feed of RR files to other AWRP RTs and Alaska Region NWS and getting feedback from them

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; work underway on coastline regime-dependent background for assimilation of surface obs.
- Visit by GSD to NCEP in August - discussions between GSD and NCEP on GSI changes for RR cloud analysis after initial RR

Task 09.5.6: Improve WRF model

- WRF Version 3.1.1 released in July, changes underway toward next version

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), coding to test Langley feed in RR in progress.

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 much improved.
- Initial test of CONUS-domain HRRR conducted on new, faster nJet computer.
- Additional GSD progress on a time-lagged HRRR-based convective probability forecast
- Three papers presented on HRRR at WSN09 symposium.

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

Testing of 18h RUC with changes at NCEP underway, conducted by NCEP/EMC with new code from ESRL/GSD. Key components:

- Extension of hourly RUC forecasts from 12h out to 18h every hour (i.e., new forecasts with hourly output to 18h to be produced in every RUC cycle 24x/day).
- Addition of Canadian aircraft data (see below), often over 1000 reports/hour. Previously, Canadian aircraft was from turboprop planes, with poor heading information and poor quality wind data. However, reports from those aircraft are now excluded (by Canada), leaving regional jet data of high quality.
- Correction to saturation of 3-d volumes with warm clouds. This problem was detected in late April after investigating a problem with RUC data reported by WSI. A fix was made to the GSD RUC versions at that time, and now is being added to the operational RUC at NCEP.
- As part of the RUC testing, it was found last week that the TAMDAR moisture observations are not being used in the operational RUC even though they were properly assimilated back in November 2008 as part of the RUC upgrade. An investigation is now underway and whatever change is needed will be quickly implemented.

GSD modifications to ESRL RUC in July and 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 in early August and to the backup RUC in late August.
- Assimilation of NASA Langley cloud data. Langley began 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 in early August and into the backup RUC in late August. Soon, 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. Discussions with NESDIS and NASA Langley about also testing a new NESDIS cloud product to allow comparisons with the Langley product.

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. TAMDAR data were not decoded on 20-26 August due to an unadvertised change in the “data source” value for these data in the MADIS netCDF files that NCO decodes; the decoder was updated on 26 August and data added to the “critical” tracking list. Decisions from the new NRL-based aircraft QC code were compared with those from the existing QC code for two weeks in August; the new code is superior so NCEP will move the new code into production. The NCO/EMC drop-out team discovered that the elevations for many radiosonde and surface sites are incorrect in the NCEP station dictionaries, which were corrected on 4 August. It was discovered that some drifting buoys are not being decoded properly when they have a missing station pressure. NCO is looking into this problem. An updated version of the NCEP BUFR library software is being tested for implementation this fall.

Geoff Manikin began work on extending the operational Rapid Update Cycle to 18 hours. The current RUC configuration features runs to 12 hours every third cycle (0000 UTC, 0300 UTC, etc) and to 9 hours for all in-between cycles. The new configuration will have all 24 cycles run to 18 hours. A parallel cycle has been set up to make sure that there are no model problems with the extended run time and to also be certain that all extra products are successfully created. This code will be turned over to NCEP Central Operations in late September in hopes of a late fall implementation.

UPDATES TO SCHEDULE: None.

ESRL/GSD papers on RUC, Rapid Refresh, HRRR presented WMO 2009 Symposium on Nowcasting (WSN09), Whistler, BC, 31 Aug – 4 Sept 2009
(Soon to be posted under http://nowcasting.ca)

Integrated assimilation of radar, satellite, and METAR cloud data for initial hydrometeor/divergence fields to improve hourly updated short-range forecasts from the RUC, Rapid Refresh, and HRRR,
Stan Benjamin, Ming Hu, Steve Weygandt, Dezso Devenyi

Overview of the Rapid Update Cycle and Rapid Refresh
Stephen S. Weygandt, T. G. Smirnova, M. Hu, J. M. Brown, D. Devenyi, S. G. Benjamin, W. R. Moninger, S. E. Peckham, G. A. Grell, K. J. Brundage, B. D. Jamison, C. W. Harrrop, J. B. Olson (presented by John Brown)

Evaluation of the High Resolution Rapid Refresh (HRRR): an hourly updated convection resolving model utilizing radar reflectivity assimilation from the RUC / RR
Steve Weygandt, Stan Benjamin, Tanya Smirnova, Kevin Brundage, Curtis Alexander, Ming Hu, Brian Jamison, Susan Sahm

Probabilistic thunderstorm guidance from a time-lagged ensemble of High Resolution Rapid Refresh (HRRR) forecasts
Curtis Alexander, Doug Koch, Steve Weygandt, Tanya Smirnova, Stan Benjamin, and Huiling Yuan

Assimilation of surface observations for RUC and Rapid Refresh
Dezso Devenyi, Stanley G. Benjamin, Stephen S. Weygandt, Ming Hu (presented by Stan Benjamin)

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 continued running the NOAA Environmental Modeling System (NEMS)-based NDAS/NAM real-time parallel system on the P6 supercomputer (which took over operational production on 18 August). Several fixes were installed in various codes to remove egregious errors and improve performance. Additionally, a full retrospective capability with the NEMS-based system was built and used to run several case studies of problematic operational NAM forecasts to help assess performance.

In the WRF-NMM NDAS/NAM parallel, degraded performance (higher upper level temperature biases) led to the temporary removal of two bug fixes to the microphysics installed in July: 1) a dummy variable representing the mean mass of large ice particles (snow) was instead the first-guess mean diameter of the ice particles. This bug occurs only when the first-guess number concentrations of large ice particles are outside of a predefined range; and 2) enforce a minimum number concentration for large ice particles (1 per liter) at all temperatures, rather than not enforcing it at >0C in the operational code where a fixed mean diameter is assumed. Examination of the skill score time series showed that the first change was causing the higher temperature bias, which disappeared when it was removed. The second change had no adverse impact and will be reinstated in early September. NCO has given a tentative implementation date for this minor bug fix bundle of 13 October.

Since many obs-processing activities listed under Task 09.5.1 also pertain to NAM, they are not duplicated here. For the NAM specifically, Dennis Keyser reports there are errors in the mesonet wind uselist provider listings, which caused the loss of over 600 sites in the NAM-GSI. A request to correct the uselist was submitted in August after NCO's moratorium ended. Some Alaskan radiosonde sites still

need to move up their launch time so the NAM-GSI can use their data. A request (from May) to add NOAA-19 1B HIRS-4, AMSU-A and MHS radiances to the 1B ingest and dumps, is awaiting implementation by NCO (hopefully in September). Consultation with NESDIS revealed that NCEP's logic for checking the calibration flag for ATOVS HIRS-3 and HIRS-4 radiances is incorrect. When the flag is set, NCEP currently disregards all channels instead of checking the calibration quality for each channel and allowing good channels to be used. This change was tested in the parallel GSI and is included with the NOAA-19 change request package. 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. A final comparison of observational dump counts between the P5 (Dew) and P6 (Stratus) computers (before the P6 took over operational production on 18 August) showed generally the same number of observational data in both from the NCO-based decoders (which handle mainly non-satellite observations), slightly more satellite data in the P6 dumps (mainly due to their being ingested more frequently), and slightly less Level II NEXRAD radial wind data. The cause of the lower P6 NEXRAD dump counts is being looked into. 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 parallel NDAS/NAM. Tests are underway to evaluate the impact of using the GFS tropical cyclone relocation procedure to update the global first guess fields input to the t-12 hour NDAS in medium to strong tropical cyclone cases. This could replace the current synthetic wind data bogus. Efforts continue 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. The geographical domain for the RTMA dumps, currently the same as the expanded NAM domain, will soon expand to include the Guam region.

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 (especially radial wind data) will make the RR data cutoff time. This is critical for the Alaska portion of the expanded RR domain where Level II 88D data are not transmitted and the only source of radial wind data are the Level 2.5/3.

GSD

We are happy to report that since an additional large file system (/lfs1) became available on 17 August runs of both the RR and HRRR have become much more reliable. There remain some issues with the MOAB Reservation system that occasionally causes jobs to start improperly and fail; these are being addressed. Another item of good news is that nJet, a new machine with more cores that are nearly twice as fast as those on wjet and hJet, is now also available. nJet is primarily dedicated to another funded project, but 408 cores of this machine are available for the HRRR runs. We expect that the regular 2/3 CONUS HRRR runs will be moved to this machine over the next 2 months. There continues to be close communication and collaboration with the Raytheon systems team during all of this and we acknowledge their strenuous efforts to deal with these matters.

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

- Radar-based latent heating fields were found to be erroneous in areas away from CONUS. This was corrected immediately.
- Limits to latent heating in WRF model were designed and successfully tested. These limits are

similar to those used in the RUC model. Imposing a latent-heating limit allowed the RR 1-h cycle to run continuously to nearly 5 days in both the primary RR 1-h cycle and the retro-period cycles. It also eliminated CFL violation messages from occurring in the interior portions of the domain, confirming that the latent-heat limit does control vertical motion brought on by grid-scale latent-heat release. However, the less-frequent crashes continued to occur in the southeast corner of the domain as before, following a gradual buildup of moisture and CAPE in this area.

- A recent discovery of a bug in the GSI cloud analysis may be an important piece of the puzzle. On GSI computational tiles where cloud data was present and used to alter the moisture field, specific humidity was converted to mixing ratio, but then not converted back to specific humidity at the conclusion of the cloud analysis. (For the same water vapor content in the air, the water-vapor mixing ratio is very slightly larger than the specific humidity, but both are small, usually less than 0.02 kg/kg.) Eliminating this inconsistency appears to have eliminated the gradual buildup of moisture in the southeast corner of the domain and, as of this writing (15 Sept), there have been no further model crashes.

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 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. Ming Hu has coded a test partial cycling system for the RR and it is in real-time testing at GSD. The system cold starts from the GFS two times per day (03z and 15z) and performs an hourly updated pre-forecast cycle for 6-h (through 9z and 21z respectively). Then a regular fully hourly cycled RR proceeds until the next partial cycling time. Very preliminary results suggest improved performance for 3-h for the partially cycled RR compared to the GSD fully cycled RR.

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 (in a slightly different formulation for the Arakawa C grid) is already used with the WRF-NMM dynamic core and became available for the ARW core in the last few months. This possible new domain is very similar to the present Lambert-conformal domain, and has about 3% fewer grid points. But with identical maximum and slightly larger minimum grid spacing, so it should be more computationally efficient. Comparison runs between this new domain and the present one have been conducted. However, code enhancements to WRFpost to allow use of the rotated lat-lon projection with the ARW core as input will be necessary before this projection is used for any of the routine RR runs. Notice will be given to native-grid users of RR output in advance of any changes to the native-grid output.

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 serious interruptions due to file-system problems beginning in spring and continuing until very recently), two parallel full hourly cycled versions of the Rapid Refresh have been running at GSD, together with verification and web-based plots, with files from the primary RR going to many users (including AWR PDTs).

Verification of standard atmospheric variables (temp, RH, wind) through early March over the RUC verification domain continued to indicate the experimental Rapid Refresh was 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 evaluate and resolve this issue have been complicated by the computer and crash issues of the past few months, but are continuing. Using our retrospective cycle period, we will soon take a close look at the adverse effect that introduction of Rayleigh damping near the top boundary of the model may be having on upper-level wind forecasts.

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 Ming Hu is currently coding the changes to the RR GSI version to ingest the Langley GOES cloud-top data covering Alaska.

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 has been introduced into the WRFpost for both the “cold start RR” and ~~in~~ the primary 1-h cycle The Icing PDT makes revealing displays comparing the hydrometeor fields from the RR vs. RUC.

At the recent World Meteorological Organization Symposium on Nowcasting, we had extensive discussions with Alistair Lang, a supervisory forecaster at the Prairie Weather Center in Edmonton. These mainly centered on the properties and forecast challenges in prediction of stratocumulus clouds in arctic air masses. This is also a challenge for forecasters in Alaska. These discussions will likely lead to some refinements in the RR cloud analysis.

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.

09.5.4.5 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. **Moved to 31 July 2010 per updated FY10 MDE milestone plans (with start/top dates) sent to Warren Fellner on 10 Sept 2009.**

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.

UPDATES TO SCHEDULE

09.5.4.4, 09.5.4.5, 09.5.4.E2, 09.5.4.E3 – see above, all in previous reports

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 angle dependent part of the bias correction of the satellite data is quite similar between the global and regional systems. The global corrections do a better job than the regional by removing the angle dependent signal more completely. Although the mean corrections of the slow changing angle dependent part of bias correction are different between global and regional systems, the fast changing bias corrections from the atmospheric contributions can easily absorb the differences. An attempt to use the global angle dependent bias corrections in the regional NDAS was done with the low resolution system and the atmospheric part of the satellite bias correction still evolves with the data assimilation system. A month of data assimilation is being done to show the impact of this change. A test with the full-precision location (latitude and longitude) of the ATOVS data in the operational regional analysis was also done in preparation for the data upgrade. The results show little impact on the analysis.

Dave Parrish uncovered a bug in the GSI code as applied to the NMMB in Eric Rogers' NMMB NDAS parallel. The bug created a large amplitude gravity wave pulse originating at the North Pole and was first noticed by Matt Pyle during routine monitoring. The bug was fixed and a rerun of one cycle of NMMB NDAS parallel verified that the gravity wave was removed. The bug fix was added to the trunk of subversion GSI. Many changes and additions have been committed to the trunk GSI this month. However, other than the bug fix just mentioned, these changes have no impact on the GSI running in the NMMB NDAS. Test results gave bitwise identical results between the latest GSI executable and what is currently being used in the NMMB NDAS parallel. The new version of GSI regional TLNMC (strong constraint) was installed into the subversion GSI and committed to the trunk. Results from a test case used during development of the new code closely matched the subversion implementation. The initial preparation for retrospective low resolution testing was completed. The installation of Yanqiu Zhu's

control variable generalization in the new subversion GSI was postponed until 1st quarter 2010. The changes are extensive and will take significant resources to complete.

Shun Liu continued his work on dumping VAD wind from the 2008 version (still our newest) radar QC package. Because the current VAD winds transmitted to NCEP are generated onsite with different local configurations and without benefit of NSSL QC, 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. Test runs continue to be assessed. Shun also worked to output PBL height estimates from the VAD wind processing but these are lacking the expected amplitude of diurnal cycle of minimum at night and maximum during the day when the radar estimates are too low.

Shun is testing his enhanced use of radial winds in the GSI in tests initializing high resolution convective resolving runs paralleling Matt Pyle's special SPC runs. Verification of the forecasts is now based on Binbin Zhou's grid-vs.-grid verification for both composite reflectivity and echo top using the NSSL mosaics as truth. Composite reflectivity Equitable Threat Scores (ETS) were improved in both the 3 hour forecast and 24 - 36 hour forecasts after assimilating radar radial wind. The impact on other forecast periods was 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. Stan Benjamin gave a report on this work at the WSN09 Symposium and Dezso is now working on a set of modifications to handle coastline 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). 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 has introduced this GSI version into the parallel real-time RR cycle.

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) occur two times per day with regular hourly cycling at all other times. Very preliminary results indicate improved performance for 3-h wind and temperature forecast from the partial cycling system compared to the fully cycled system.

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 visited 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. A RR retro test is ongoing (15 Sept) to see if this change is the cause of the degraded upper-level wind scores.

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.
Moved to 28 February 2010 per updated FY10 MDE milestone plans (with start/top dates) sent to Warren Fellner on 10 Sept 2009.

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 continued to be inadequate for careful evaluation through mid August.

CURRENT EFFORTS: The switch to a new file system in late Aug. has significantly improved the reliability for both the RR and HRRR.

UPDATES TO SCHEDULE: See 09.5.5.E2, E4 – mentioned in previous reports

<u>Task 09.5.8</u> 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.

Tanya Smirnova is reexamining the coupling between the RUC LSM, the MYJ surface-layer and PBL codes for inconsistencies, particularly in the treatment of surface fluxes. This is partly motivated by our long-standing concern that the diurnal cycle in the RR is slightly damped in amplitude relative to METAR observations when the MYJ surface and boundary layer schemes are used.

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 is testing 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)

A module to account for wet scavenging of dust particles by rainout (precipitation particles colliding with the dust particles) has been implemented in the Thompson microphysics scheme. Wet deposition is the most efficient removal process of dust in the size range centered around 1 micrometer in diameter. The rain out module is based on a wet scavenging module in WRFchem in the MOSAIC framework, but modified to work in the simpler WRF code. The scheme was tested using the ideal hill test case for different dust loading and cloud top scenarios

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).

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 in MDE FY09Q3 report for modifications already made for predicting sea ice temperature and snow accumulation and melting on top of the sea ice. Ftp arrangements were made to make RR grids from the real-time RR1-h cycle running at GSD available for evaluation by forecasters at Environment Canada's Arctic Weather Center at Edmonton.

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).
Report is available at (http://ruc.noaa.gov/faa-mde/Report-5.8-Jul09-NCAR.doc)

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 ’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)

09.5.8E3 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

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.

Code has been ported to NCEP and testing of the system is ongoing as are efforts with EMC personnel to fully integrate the cloud analysis changes within the EMC SVN repository. Also, a key MPI bug in the cloud analysis was found and fixed in late Aug. (related to updating conversions between water vapor variables on the various model sub-domains).

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

NCAR/MMM
CURRENT EFFORTS:

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 conducted the WRF tutorial on July 13-24 in Boulder. This task has been completed for FY09. NCAR is in the process of providing for another tutorial, to be held in England in late September.

PLANNED EFFORTS: NCAR will be putting on a tutorial in Cambridge, England September 29-October 2 in collaboration with the UK's National Centre for Atmospheric Science (NCAS). This is part of the Joint NCAR-NCAS Workshop and Tutorial to be held at the Univ. of Cambridge.

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.

09.5.6.5 Incorporate physics improvements from the WRF user community, ESRL, and NCEP into the WRF software infrastructure for use in the Rapid Refresh model 30 September 2009 (NCAR/MMM)

CURRENT EFFORTS: Jimy Dudhia of NCAR continued work with Steven Cavallo (NCAR/MMM) on diagnosing a cool bias near the WRF model top. They have seen unrealistic cooling at the model top, for model tops higher than 50 mb. The bias is due to an underestimated downward longwave flux and is related to the longwave radiation treatment. The two are testing possible fixes through better representation of the model-top downward longwave flux.

Dudhia began hosting two Spanish visitors (Pedro Jimenez and Daniel Argueso) working on WRF applications for wind and regional climate forecasting. Jimenez is working on a wind climatology using WRF at high resolution. He and Dudhia are evaluating wind biases due to large-scale pressure pattern biases in some situations. Argueso is using WRF for regional climate modeling in southern Spain, with testing being done on physics options for multi-year simulations.

Dudhia worked on adding tracers to the WRF code as part of a DOE ARM tropical convection project. These tracers are used to find origins of air transported by resolved convective clouds in a 1-km grid in the Tropical West Pacific ARM site near Australia. Initial simulations are being run.

PLANNED EFFORTS: The collaborations on physics and WRF application analyses and the on implementation of modifications will continue.

UPDATES TO SCHEDULE: NONE

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

NCAR
CURRENT EFFORTS: Dudhia is working on evaluating RUC initialization in NCAR 3-km convective forecasts for 2009 season. The period included cases with and without this initialization, so comparisons are being made. Dudhia is in the process of writing the report for this task.

PLANNED EFFORTS: Continuation of work and completion of report material.

UPDATES TO SCHEDULE: NONE

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 – 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.

Ongoing evaluation of real-time HRRR runs has continued through July and August, now in the late-summer regime, and has re-enforced previous very good results shown by VORTEX-2, at the AMS NWP meeting, and at the WRF meeting.

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.

Barry Schwartz has run reflectivity verification for a 6 week period of HRRR forecasts. Initial verification at 3-km showed similar results to last year. 3-km verification is, however, extremely unforgiving for small phase errors and does not fully capture the actual forecast that does exit. Barry has recently upgraded the verification to systematically upscale the fields and is recomputing scale dependent scores that will allow us to assess HRRR skill as a function of horizontal scale.

Subtasks

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). NCAR and GSD have had ongoing meetings through the summer and more extensive discussions in early Sept. that have helped us to understand several HRRR/CoSPA issues, including evolution of the HRRR fields following the initialization, time dependencies in the HRRR phase correction and how the HRRR is bias-corrected.

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
GSD participated with NCAR in a Convection Weather Retreat at NCAR in early September. In preparation for this meeting, GSD has been able to identify a list of possible changes in radar processing, primarily within the RUC and Rapid Refresh that are promising for improving HRRR forecast accuracy. Many of these are related to the previously-reported deficiencies in the HRRR-2009 version:

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

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

Yi Yang performed more experiments comparing different procedures for analyzing reflectivity data, using a new test case provided by GSD. Specifically, two procedures were implemented and compared. With both procedures, temperature, water vapor and microphysical increments are obtained from the generalized cloud analysis package implemented in GSI. With the first experiment, the full set of increment was added at one time at the beginning of the forward DFI step with cumulus parameterization and microphysics remaining active (unaltered) in this step. In the other experiment, the increments were added gradually in the forward step of DFI, again without modification to the cumulus or microphysical procedure in the WRF model. The first procedure differs from the typical RR DDFI because of the use of full increments and the application of increments at one instance. The second experiment is essentially the Incremental Analysis Update or IAU procedure available in the ARPS, except for the application of a digital filter. The application of temperature increment in IAU is similar to that in RR DDFI, but without turning off cumulus parameterization or replacing/modifying microphysical heating. The two experiments were performed at 13 km resolution, used GFS as analysis background and lateral boundary conditions, the initial spin-up forecasts started from 2100 UTC, June 15, 2009; and radar reflectivity and lighting observations were assimilated at 0000 UTC June 16, and 3-h WRF forecasts were then made. The precipitation forecast accuracy (ACC), frequency bias (FBIAS), probability of detecting Yes (PODY), false-

alarm rate (FAR), Critical Success Index (CSI or Threat Score TS), Gilbert Skill Score (GSS or Equitable Threat Score ETS), and the Heidke Skill Score (HSS) were computed against NCEP Stage IV precipitation data, for the 3-h accumulated precipitation at different thresholds. The preliminary results for this case show that the final analysis increments compared to the initial analysis background from Exp-gradually are larger than those from Exp-directly; and the scores show that Exp-directly gives better 3-h rainfall forecast. These results will be further compared to the standard RR DDFI procedure for reflectivity assimilation.

Future experiments will be performed adding radial velocity data to reflectivity data. So far, the impact of radial velocity data on the 13 km grid has been relatively small.

In August, Kefeng Zhu continued to work on a manuscript focusing on the verification for the tropical storm Erin experiments. He also started learning the workflow on GSD computing systems, and performing tests with the June 15, 2009 case. He also spent time learning the Ruby language used by GSD workflow.

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. Tanya Smirnova has run 3-km HRRR experiments using the diabatic DFI.

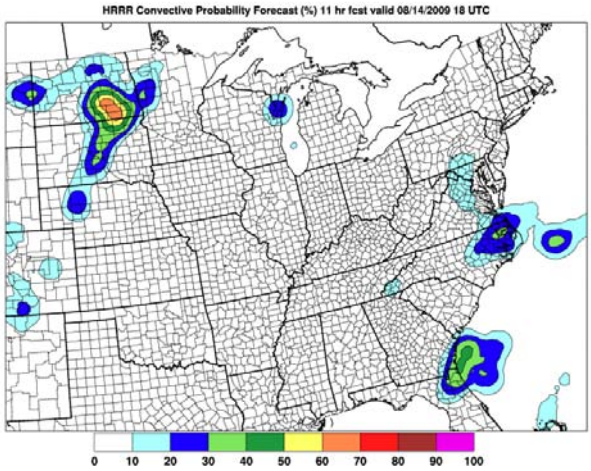
09.5.19.3 30 Sept 2009 (CAPS)
Complete new 3-km GSI data assimilation experiments toward improved assimilation of radial wind.

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. A report on the HCPF was made to the WSN09 Nowcasting Symposium (see papers under 5.1)



NCEP

Jun Du reports that a presentation package on the evaluation results for the SREF system upgrade was compiled for an implementation approval briefing to NCEP director Louis Uccellini on 9 September. The implementation is tentatively scheduled for 13 October.

BinBin Zhou is planning a visit to AWC in October 2009. A new fog diagnostic method has been added to VSREF. BinBin finished a VSREF upgrade to an hourly updating framework. He is working on the probabilistic verification of SREF composite reflectivity and echo-tops using Shun Liu's implementation of NSSL's 88D national mosaics.