Monthly Report for February 2009

FY 2009

Submitted 16 March 2009

With contributions from Geoff DiMego and Mary Hart (NCEP/EMC);

Stan Benjamin, John Brown, Steve Weygandt (NOAA/ESRL/GSD);

Jordan Powers, Roy Rasmussen (NCAR);

And Ming Xue (OU/CAPS)

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

Executive Summary

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

- **RUC testing for snow cover, cloud analysis fixes – in testing at NCEP after development and testing at ESRL/GSD**
  - Mods to improve accuracy of snow cover in RUC by using NESDIS satellite data to modify RUC snow
  - Cloud analysis code mods to improve retention of saturation in cloudy 3-d volume after assimilation of METAR and GOES cloud observations.

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

- Continued real-time feed of RR files to other AWRP RTs and Alaska Region NWS and getting feedback from them
- Improvements in RR - DFI, terrain detail, cycling of land-surface variables, development of land-surface physics modifications for snow and ice cover
- NCEP implementation will be delayed from Q2 to Q3 FY2010 due to NCEP computer acquisition delays (reported by Geoff DiMego and Stan Benjamin at AWRP review in Jan 2009).
-

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

- RR GSI – development of new forward model for surface obs to match RUC techniques, sensitivity tests for surface obs, profiler, satellite.

Task 09.5.6: Improve WRF model

- Version 3.1 will be released in spring, likely early April 2009 (NCAR). RR-WRF will be subsequently upgraded to include WRFv3.1 upgrades.

Task 09.5.15: Develop, test, and implement 3DVARs for RR and NAM

- Further modifications to WRFpost to provide consistency with RUC post-processing (e.g., ceiling, visibility, MSLP)

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

- Improvements made to RUC radar-enhanced initial conditions for HRRR
- Initial tests of eastern 2/3 CONUS HRRR for summer 2009 demos.
- Additional GSD progress toward a time-lagged HRRR-based convective probability forecast

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

GSD

GSD continued its effort to improve retention of METAR ceiling/visibility observations in the RUC analysis – see Task 9.15.

GSD also developed a method to improve areal snow cover in the RUC by using NESDIS snow/ice analyses produced daily. This method solves a RUC problem identified by forecasters from NWS and the Weather channel in both of the last 2 cold seasons in that the RUC has held on too long to snow cover, not melting snow cover quickly enough. Now, once daily (at 19z after the daily NESDIS snow analysis becomes available), NESDIS snow cover fields are used to set RUC snow water equivalent to zero at appropriate grid points under certain conditions, including absence of cloud or current 1h precipitation and temperature > 2 deg C.

NCEP/EMC is now running these changes (along with a correction to the run-total precipitation field) in a parallel cycle, with the intent for implementation within the next few weeks, subject to NCEP/NCO constraints.

The cloud analysis change has also been made in early March in the RR, and the snow cover change will be made in the RR within the next few weeks.

NCEP

Dennis Keyser reports that some radiosonde sites are reporting an invalid instrument type. NCEP/NCO is investigating. NOAA Profiler Network wind and RASS data continue to be received via the temporary MADIS GTS patch while the NWS hardware outage that began on 1 October continues. Still waiting for NESDIS to respond to two problems with the GOES 1x1 field-of-view cloud data where a few random files have reports encoded with missing lat/lons and a bogus satellite ID, and the later arrival of the GOES-East data. Efforts are being made to get TAMDAR airframe type and airline code into the PrepBUFR file for ESRL so they can work on an improved bias correction. From 15 December - 6 January, GOES-13 replaced GOES-12 as GOES-East due to a GOES-12 thruster anomaly. During that time, the RUC assimilated GOES-13 IR and WV imager (cloud-top) winds in place of GOES-12 winds but did not use GOES-13 layer PW and cloud data. There were intermittent gaps in all GOES-11/-12 data on 27-28 January from a NESDIS server outage. NESDIS reported that a GOES-12 navigation problem on 29-30 January led to winds being produced some 15 km too far south. An accelerated RFC has been submitted to NCEP/NCO to modify the RUC dump processing to no longer sleep for five minutes and then re-dump all data when no ARINC MDCRS data are available. This led to the 15Z 11 February RUC being delayed 7 minutes (MDCRS data problem from a power failure at the Leesburg FAA facility). After this change is implemented, the RUC will run without ARINC MDCRS data but, most likely, with MDCRS data from the backup AFWA feed.

Geoff Manikin reports that efforts are underway to add a fix to the RUC handling of snow cover. Several users have pointed out cases in the past year in which the RUC model maintains snow cover where it has in reality melted away. The current RUC model fully cycles its own snow cover; the model accumulates snow where it falls in model forecasts and reduces the snowpack with sufficiently warm temperatures. There is no outside analysis used to make adjustments (like NAM or GFS). Code has been written to use a daily NESDIS snow analysis and bring it into the RUC daily at 19z. Points will be found where the model has snow cover but the analysis has none. At these points the snow cover will be eliminated if the temperature is above freezing and no snow has fallen in the previous hour. The amount of snow on the ground will not be changed if both the model and analysis have snow at that point, even if the amounts differ greatly. The analysis code will also be modified to fix a series of bugs that reduce the model's ability to maintain analyzed cloud cover. Statistics demonstrate that there is a significant drop-off in cloud cover between the analysis and the 1-hour forecast, and tests have shown that changing the timing of the call to the cloud analysis code and introducing a loop to reintroduce saturation at points where non-cloud observational increments dry the air can greatly help the issue. NCEP Central Operations is currently in a

"moratorium" state where no code changes will be made, unless there is a bug or significant model problem. Both of these issues seem to fit that criterion, so there is hope of an implementation this spring.

Subtasks

October 2008 through September 2009

09.5.1.1 Maintain hourly RUC runs and provide grids of SAV and AHP guidance products.

09.5.1.2 Provide vendors with gridded model data via Family of Services and the FAA Bulk Weather Data Telecommunications Gateway.

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

09.5.1.4 Maintain access to model verification data.

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

Deliverables

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

CURRENT EFFORTS:

PLANNED EFFORTS:

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED: None.

INTERFACE WITH OTHER ORGANIZATIONS: NCO.

UPDATES TO SCHEDULE: None.

09.5.1. E2 Perform configuration management for RUC, including thorough documentation, and respond promptly to any code malfunctions or performance issues. (GSD, NCEP)

CURRENT EFFORTS:

PLANNED EFFORTS:

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE: None.

09.5.1.E3 Monitor RUC performance, respond to any problems detected by GSD, NCEP, or any RUC users, diagnose cause, develop solution to RUC software, test changes and coordinate with NCO on implementation. (GSD, NCEP)

CURRENT EFFORTS:

PLANNED EFFORTS: Continue monitoring efforts.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE:

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

NCEP
Since many of his activities listed under Task 09.5.1 also pertain to NAM, they are not duplicated here. For the NAM specifically, Dennis Keyser reports AIRS radiance data counts have been below average since last May due to file gaps and late posting of files (as on 27 Feb) caused by hardware issues with NESDIS' processing. Alaskan radiosonde data receipt has improved after NCEP contacted Alaska region, but some sites still need to move up their launch time so the NAM-GSI can use their data. During the 15 December through 6 January, GOES-East switch, the NAM-GSI assimilated GOES-13 IR and WV imager (cloud-top) winds, but only monitored GOES-13 sounder radiances. The quality of NOAA-16 AMSU-B radiances is gradually degrading, but these data are still usable by the NAM-GSI. An emergency implementation on 15 January turned off the NAM-GSI's use of METOP AMSU-A, channel 7 radiances, which are too degraded to use. JMA IR and visible satellite winds were not available on 17-18 February because a temporary satellite transition from MTSAT-1R to MTSAT-2, where the winds were not available. Methods to speed up dump processing of NEXRAD Level II data are being explored. The following data types are now monitored by the NAM-GSI: RASS virtual temperature profiles (NPN and MAP), QuikSCAT 0.5 deg. scatterometer wind superobs (which had an outage 1-2 January from a 2008 leap year issue), Mesonet mass data, and MDCRS moisture data).

Dennis Keyser also reports that, per a request by ESRL/GSD, he added 50 km ASCAT (18 December) and WindSat (28 January) data (non-superobs) to his personal cron runs that generate PREPBUFR files for ESRL's testing of the Rapid Refresh (RR) system in Boulder. The PREPBUFR files will be copied to the private ESRL para directory in ftpprd in early March. ESRL is currently assimilating hourly lightning data from Keyser's dumps in their experimental RR runs. They are looking into testing other new data types currently present in the production RR/RUC PREPBUFR and dump files. These include Multi-Agency Profiler winds, Canadian AMDAR data, QuikSCAT data (up to 2 hours old), and METOP-2 radiances. Keyser has added WindSat and 50 km ASCAT data to his RTMA PREPBUFR cron runs. These new data will eventually be tested in the parallel RTMA. Efforts are underway to remove legacy restrictions on surface observations processed into PREPBUFR file – e.g. the requirement that all surface obs must have a pressure report will be eliminated. This will allow many new surface observations (land, marine and Mesonet) to be assimilated in the RTMA.

Eric Rogers reports that on 26 January the WRF-NMM model running in the NDAS/NAM was changed to fix a bug that had been found in the land-surface model involving the use of the RESTART logical variable required when cycling or cold-starting. The origin of the bug was traced back to the inclusion of the unified NOAH LSM into NAM operations in March 2008. Sadly, there was no regression test for this contingency and it was not detected until partial cycling was implemented in the NDAS in December 2008. The code error was activated at the start of the first (tm12) forecast of each NDAS run when the WRF-NMM forecast model, instead of cycling the frozen soil moisture from the previous NDAS run, was recomputing it using the explicit Flechinger equation. This led to inconsistencies between the frozen soil moisture and the total (liquid+frozen) soil moisture and the soil temperatures, leading to warm 2-m temperature biases in cold regions.

Matt Pyle reports that a HiResWindow bug fix was implemented in early January to solve a problem with the initialization of the Alaskan domain. Several cycles in late December 2008 did not run due to low (< 500 hPa) surface pressures in the model domain. The revised code tolerates both very low and very high (> 1080 hPa) surface pressures if the model topography supports such extreme values. Testing on the new CCS computer was performed, examining both computational performance and quality of model

output relative to the current operational CCS system. These tests revealed no problems for the HiResWindow on the new computer.

Subtasks

09.5.17.1 Maintain four-per-day North American Mesoscale runs and provide SAV and AHP guidance. (NCEP)

09.5.17.2 Maintain four-per-day HiResWindow runs and provide SAV and AHP guidance. (NCEP)

09.5.17.3 Provide vendors with gridded model data via Family of Services and the FAA Bulk Weather Data Telecommunications Gateway. (NCEP)

09.5.17.4 Provide full grids from NAM, and HiResWindow on NCEP and NWS/OPS servers. (NCEP)

09.5.17.4 Maintain access to model verification data. (NCEP)

09.5.17.5 Working with NCO, complete the design, compilation, debugging, test runs and parallel testing of RR, NAM and HiResWindow (and SREF) codes on new CCS computer.

Deliverables

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

CURRENT EFFORTS:

PLANNED EFFORTS:

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS: GSD & NCO.

UPDATES TO SCHEDULE:

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

As requested by other RT's, incorporate new AHP calculations into Operational WRF Model post-processor and product generator.

CURRENT EFFORTS:

PLANNED EFFORTS:

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED: None

INTERFACE WITH OTHER ORGANIZATIONS: NCO

UPDATES TO SCHEDULE: None

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

NCEP

See obs processing work for ESRL's RR testing described under Task 09.5.17, otherwise no NCEP activity to report.

Subtasks

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

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

Verification of standard atmospheric variables (temp, RH, wind) continues to indicate the experimental Rapid Refresh is at least competitive with the RUC at most forecast lengths and output times. Upper level wind and temperature 12h forecast RMS scores for the RR are a slightly improvement over the RUC. 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

Excessive relative humidity (discovered in early March) in the early hours of forecasts from the primary 1-h RR cycle has been traced to a problem with a procedure introduced to ensure that where clouds are present at the beginning of the forecast the relative humidity is guaranteed to be 100%. This is fixed as of 16 March. An issue with excessively smooth terrain in the Rapid Refresh was also uncovered and fixed as of late Feb. 2009.

Verification over the RUC domain does not include Alaska, and much attention has been given to verification over Alaska the past two months, partly as a result of the invitation from the Alaska Weather Symposium (10-12 March in Fairbanks) to discuss our progress toward the RR implementation (see next subtask). For this, we have been using Joe Olson's instantiation of DTC's Meteorological Evaluation Tool for verification over Alaska. This has shown clearly that as of February, there have been serious problems in two areas: In the river valleys of interior Alaska with shallow cold air, and on the northwest coast when winds are onshore. Subsequent modifications are already underway to correct these deficiencies, even during the 9-13 March period. The interior-Alaska difficulty stems partly from the failure of the GSI to respond fully to surface data (see Task 5). Using less smooth terrain improves the response to surface data, since the GSI observational error of METAR stations is related to the difference between the station elevation and the model elevation at the station location. We are now using a terrain file with less smoothing in both RR 1-h cycles. We are also checking to see if our cycling of snow and soil variables is being done correctly.

It seems likely that a complete treatment of this problem will require additional RUC-like modifications to the GSI by introducing pseudo observations to force the analysis to better describe the vertical temperature stratification at low levels over the interior of Alaska and northern Canada. Further, correction of the soil/skin/snow temperature toward the observed 2m air temperature will be considered.

As of this writing (16 March), it is premature to state how much of this interior Alaska warm bias has been corrected by changes in the past 4 weeks (closer fit to surface obs, sharper terrain, cycling of snow temperature for both layers), and how much might yet be related to limitations of the surface and planetary boundary layer (PBL) parameterization schemes (MYJ) in handling the common winter situation of extremely shallow, surface-based cold air. Regarding the latter, the model level test performed by the DTC and reported in the MDERT Quarter 1 FY09 report did show that over the CONUS this stable boundary-layer problem was partly alleviated by using very high vertical resolution at low levels. Currently, the thickness of the lowest layer is a little less than 2 hPa, about as thin as we can use without having to run the forecast using a shorter time step to avoid numerical instability.

The frequent prediction of insufficiently cold temperature during onshore flow in NW Alaska we believe is related to our oversimplified treatment of ice in the RUC Land-Surface Model (LSM). Freshly started work on this is noted under Task 8. There has also been at least one case where the GFS lateral boundary conditions brought excessively cold air into the RR domain, which is only ~200km or so from the coast in this area.

We were successful in compiling the new Q1FY09 version of GSI on wJET and this has been running in the developmental RR 1-h cycle since late February. A new twist to the persistent problem of crashes along the lateral boundaries is that they are occasionally occurring at locations along the lateral boundaries away from terrain, and not always over the Colombian Andes. This problem will receive increased attention in coming weeks.

All codes and scripts associated with the Rapid Refresh real-time cycle continue to reside in a "Subversion" ("SVN", a commonly used revision control system) repository, which provides detailed tracking of all system changes and will greatly assist efforts to synchronize GSI developments at GSD and NCEP. Note, the recent addition of the RR version of the ARW model, WPS pre-processing, and the WPP post-processing software to the SVN repository complements the previously completed inclusion of the GSI code.

We have some preliminary RR vs. RUC precipitation verification statistics, which indicate that the RR skill (as measured by the CSI) slightly exceeds that of the RUC. Biases for the RR are also higher than those for the RUC (and exceed unity), especially at the highest thresholds (where the RUC frequently significantly under predicted precipitation). Qualitative comparisons of RR vs. RUC precipitation fields are consistent with these scores and an enhanced ability of the RR (relative to the RUC) to identify regions of heavy convective rainfall.

We also have some preliminary METAR verification statistics from across CONUS, which indicate that the RR analysis does not fit surface observations as closely as the RUC analysis, but by 12-h the forecast errors are quite similar, except at 1200 UTC, when the RR has a more severe warm bias. These RR surface verification issues are currently being addressed by planned updates to the GSI surface analysis package.

GSD also continues to modify the NCEP version of WRFpost, originally written by NCEP/EMC to postprocess the WRF-NMM. RUC post-processing algorithms for ceiling, visibility, radar reflectivity and the MAPS sea-level pressure algorithm have been introduced into the post, and, particularly for ceiling and visibility results are now much more consistent with RUC behavior (of course, identical behavior is not to be expected since the models are different). Specifically, shallow fog in the model is no longer considered to be low ceiling unless hydrometeors extend to over 100m above the surface.

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 has made many different types of RR files available to users (AWR RTs, NWS) and worked to assist them to access, process and display RR grids within various workstation environments. 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. George Trojan at Alaska Region NWS has ported RR grids to the AWIPS workstation and forecasters at ANC and FAI and the AAWU (Alaska Aviation Weather Unit) have now had a few months to do an initial evaluation of them.

Members of the RR development group at GSD and NWS Alaska Region Science and Operation Officers met by telcon on 10 February to discuss RR issues, including assessment of RR performance. Further discussions were held in person in early March when Stan Benjamin, Steve Weygandt and Joe Olson

participated in the 10-12 March Alaska Weather Symposium (along with Cory Wolff from NCAR/IFIRT). The Alaska folks reiterated their concerns about RR initialization and forecasts of temperatures in the valleys this winter. Temperatures have been either about right but sometimes *much* too warm. Offices with marine responsibilities have also requested that RR assimilate Canadian buoy and scatterometer data (for surface winds). GSD just started regularly accessing an experimental NAM PrepBUFR file from NCEP that contains the QuikSCAT surface winds and is beginning to examine how this data is treated by the GSI. The Alaska-Region forecasters would also like a partial cloudiness product and BUFR soundings for Alaska and adjacent areas.

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) and these are now being used as part of the RUC cloud-analysis augmentation of the GSI in the primary RR cycle.

Various AWRP RTs at NCAR have also been accessing the RR grids and are evaluating the performance of their algorithms on this data. The Icing RT makes revealing displays comparing the hydrometeor fields from the RR vs. RUC. This processing uncovered a grib1 to grib2 conversion issue that was fixed by NCEP/NCO in February.

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.

09.5.4.4 30 Sept 2009 (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.

09.5.4.6 30 Sept 2009 (GSD and NCEP)
Pending EMC, and NCEP Center initial recommendations, Job Implementation Forms (JIFs) are filed to submit Rapid Refresh software to NCO.

Deliverables

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

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

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

09.5.4.E3 30 September 2009 (GSD, NCEP)
Pending EMC, and NCEP Center initial recommendations, Job Implementation Forms (JIFs) are filed to submit Rapid Refresh software to NCO.

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

GSD

Work has continued to update and refine the GSI for Rapid Refresh. The refinement work has benefited

(and been driven) by a now extensive set of real-time RR monitoring diagnostics from two ongoing real-time RR cycles. These real-time diagnostics include display of many fields from both cycles, interactive sounding display capability (with overlay of observed and other model soundings), as well as real-time sounding, surface, and precipitation verification.

Dezso Devenyi has been working to improve the fit of the GSI analysis to surface observations, especially for cases of shallow inversions. A minor change was made in mid February to reduce the specified observation error variance. A more substantial change to add a surface analysis feature found in the RUC 3DVAR (an accounting for the difference in the model vs. actual terrain) is nearly complete. Coding this change has required more substantial changes to the GSI and its associated internal I/O for the observation files. Lastly, Dezso has completed a single case test to examine the impact of adding QUIKSCAT data. Results form the test revealed small differences to the wind and temperature fields over the lowest several levels for the region covered by the particular satellite pass.

Ming Hu has obtained the latest version of GSI (1QFY09) from Russ Treadon at NCEP and completed a series of changes to make it usable for the Rapid Refresh. These include, porting it to wjet and making modifications to make it run on the wjet Linux environment (mostly within library menu), adding back in the RUC/RR cloud analysis package and other RR specific changes, and modifying the error statistics files from those for the global GFS to those from the regional NAM. This latest enhanced version is currently running in a parallel real-time cycle. It has also been crashing periodically along the boundary. Ming has also worked with Tanya Smirnova to begin cycling temperatures in each of the two layers in the RUC LSM snow model.

NCEP

Wan-Shu Wu worked on using the scatterometer winds over oceans (QUIKSCAT) in NDAS. The initial tests showed that the largest analysis response to the QUIKSCAT was not in the first layer but 5 to 10 layers above. Since the data were taken at the surface, this response reflected an error in the background error covariances. She checked into the recursive filters used in the vertical direction and found that although the formulation was correctly self-ad joint, a buffer zone extending beyond the surface was needed in the control variables. Since the domain was extended vertically the distribution of the fields among processors needed to be redesigned. It was also necessary to modify the background error variances. Two impact studies are planned to quantify the influence of the changes in background errors and the influence of using the QUIKSCAT data.

Dave Parrish reports that the new multigrid Helmholtz solver with an extension from regional to global domain was incorporated into the complete forward model for the new regional TLNMC (dynamic constraint). Unfortunately, the global grid extension causes significant problems when incorporated into the complete forward model. The preliminary tests were all done with one Helmholtz equation, used to obtain a balanced mass variable correction from input divergence tendency. But there are three other equations to solve before the balanced wind correction can be obtained, and the domain-extended solver creates highly unrealistic large scale wind corrections. Iterations to simulate a nonlinear normal mode initialization diverge quickly. This work was put on hold for two weeks in order to assist Shun Liu with debugging of the new vertical velocity control variable as it was being merged into the 1st Quarter FY2010 (Q1FY10) version of GSI.

After a further review of normal mode initialization literature, the regional method of Bourke and McGregor (1983) seems to be easiest to implement. They solved the same equations but with simple homogeneous boundary conditions on the edge of the domain. Even though these boundary conditions are not strictly correct, reasonable results were obtained. An earlier test version of the multigrid solver, applied only over the regional domain without extension, was swapped into the full regional TLNMC forward model using the homogeneous boundary condition. A test was performed on the background field, which produced reasonable balance increments for mass and wind. The nonlinear normal mode iteration also converged. In order to do actual test analyses, the ad joint of the new TLNMC forward model is still required. A working ad joint of the multigrid solver (the most complex part of the code) was completed in late February.

Shun Liu continued merging code to include a vertical velocity control variable from the Q1FY08 version of GSI into the latest Q1FY10 version. After merging the codes, the new version cannot duplicate the older version results. Efforts were made to check the ad joint and tangent linear model of the vertical velocity equation. Efforts were also made to check if the strong constraint changes could cause the differences between old and new versions. Bugs were found in the new GSI and fixed and the new code now matches the old result. In addition, Q1FY10 codes related to anisotropic recursive filters were also modified so the vertical velocity control variable can properly work with anisotropic recursive filter codes. Tests of these modifications showed that the vertical velocity can be assimilated properly with Q1FY10 version of GSI.

Manuel Pondeca reports that he added a time-of-the day dependent bias-correction scheme for the RTMA first guess and started its evaluation. He also added the "First Guess at the Appropriate Time (FGAT)" capability to the RTMA, which makes the use of larger assimilation time-windows more justifiable. Evaluation of the scheme's performance has begun. In collaboration with several Weather Forecast Offices, he also re-calibrated the anisotropic background error covariance models used with the RTMA to eliminate the occasional occurrence of unrealistic streaks in the temperature and moisture analysis over complex terrain.

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.

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.

From Q1 report: On 3 October, Real-Time Mesoscale Analysis (RTMA) of temperature and dew point at 2 m, wind at 10 m and surface pressure was implemented for Hawaii and Puerto Rico. These also include estimated analysis uncertainty fields. These grids are at the NWS' NDFD resolution of 2.5 km. On 9 December, the CONUS (5 km) and Alaska (~6 km) RTMA systems were upgraded to the identical version of RTMA that was put in place for Hawaii and Puerto Rico. The RTMA is now based on a unified set of software. (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.
From Q1 report: An hourly cycle requires having a digital filter capability as the RUC has shown. An initial version of a digital filter (from Parrish) was incorporated in a low resolution NDAS system on the R&D machine to run after each analysis step in preparation for the hourly cycling. The necessary changes to the boundary code were done and the scripts were changed to restart the forecasts after the digital filter step. The code for merging the filter results back into the WRF restart file was built and modified to work with the IJK WRF/NMM. The whole system with the digital filter is functional but the test experiments showed mixed impact on the forecasts. (Wu)

09.5.5.3 31 January 2009 (CAPS and GSD)
Testing of and refinement to the radial velocity analysis component of GSI for Rapid Refresh configuration, together with the cloud analysis.

CAPS has been conducting tests of radial velocity assimilation within GSI for a tropical cyclone case. Rapid Refresh evaluation for radial velocity assimilation has been slowed by issues accessing the level 2.5 radial velocity files from NCEP. Initial tests with three hourly files from the NAM will begin shortly and a request has been made to begin creating hourly level 2.5 files for use with the Rapid Refresh. Yang Yi of CAPS has received guidance from Ming Hu (ESRL/GSD) on running the 13-km RR cycle and will be conducting retrospective tests with combined radial velocity and cloud analysis assimilation as soon we

have a good test case.

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.

Preliminary statistical assessment of the Rapid Refresh verification statistics for upper-level winds, surface fields, and precipitation indicates that for most measures the RR meets or exceeds the skill of the RUC. These include upper-level winds and temperatures, 12-h surface fields and precipitation. For surface verification, preliminary METAR statistics from across CONUS indicate that the RR analysis does not fit surface observations as closely as the RUC analysis, but by 12-h the forecast errors are quite similar, except at 1200 UTC, when the RR has a more severe warm bias. These RR surface verification issues are currently being addressed by planned updates to the GSI surface analysis package.
For precipitation verification, CSI scores for the RR are higher than those for the RUC. Bias scores are also larger (and exceed unity), especially at the highest thresholds (where the RUC frequently under predicts precipitation).

Upper level wind and temperature 12h forecast RMS scores for the RR are a slightly improvement over the RUC. 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

09.5.5.5 31 July 2009 (NCEP)
Based on case-study testing and refinement of the research quality code, deliver results in an 'experimental' code for an upgrade package (e.g. strong constraint, improved satellite channel bias correction, improved use of WSR-88D radial wind and/or satellite radiances and/or retuned co-variances to the GSI for FY2009 change package to the NAM. (Pondeca, Yanqiu Zhu, Parrish)

Deliverables

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

CURRENT EFFORTS:

PLANNED EFFORTS:

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED: None.

INTERFACE WITH OTHER ORGANIZATIONS:
Primarily between GSD and NCEP, but some discussions w/ NESDIS, NWS and NASA Langley also on satellite cloud products.

UPDATES TO SCHEDULE:

09.5.5.E2 30 September 2009 (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.

NOTE: Request for deferral until Feb 2010. NCEP computer upgrades in 2009 will force this delay (reported at AWRP PMR in January 2009).

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.

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

Subtasks

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

Several times during January and February our Alaska verification (see Task 4) revealed onshore flow in northwest Alaska as being too warm. We believe this is due to inadequate treatment of snow-covered ice in the RUC LSM, erroneously limiting radiative cooling for cold air over snow-covered ice. Currently we are simply assuming the surface temperature of the ice stays fixed during the RR forecasts at the temperature in the lowest model layer during the forecast integration (as done in the RUC model). Tanya Smirnova is looking into what would be required to treat ice as a land surface, including the accumulation and ablation of snow on the ice, and cycling of snow and ice temperature. We hypothesize that this would permit more realistic buildup and maintenance of cold air over the ice surface through greater negative surface heat flux to the atmosphere.

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.

Trude Eidheimer of NCAR has been testing the new ice nucleation schemes she implemented into WRF during the past month (Meyers, Phillips, and DeMott schemes). She also continues to investigate various aerosol schemes for later inclusion.

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 has been written by the DTC and GSD has 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.

Preparations are being made to make available for evaluation for forecasters at Environment Canada's Arctic Weather Center at Edmonton the real-time RR1-h cycle running at GSD.

Deliverables

09.5.8.E2 30 Sept 2009 (GSD, NCEP)
Pending EMC, and NCEP Center initial recommendations, Job Implementation Forms (JIFs) are filed to submit upgraded WRF model physics code as part of Rapid Refresh software to NCO.

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

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

Complete. See FY09 Quarter 1 report.

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 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 WRF Modeling System.

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. Comparison of RUC and RR analyzed ceiling statistics in February indicated slightly worse scores for the Rapid Refresh. The cloud analysis detective work in the RUC has revealed modifications also needed in the RR GSI/WRF code. Changes were also made to WRFpost to bring the ceiling diagnosis into conformity with that used with the RUC. One particular difference in the WRFpost was causing very extensive low ceilings in the RR post-processed fields but this was fixed as of 10 January 2009.

Improvements have also been made to the lightning assimilation module, including using a better relationship between lightning flash rate and maximum reflectivity.

Stan Benjamin, with help from Steve Weygandt, Bill Moninger, and others, completed a set of RUC changes in the RUC analysis (see 5.1) to improve retention of layers of cloud water, especially in the 1000-3000 ft layer (from IFR to MVFR). The key has been to add 2 changes to ensure saturation in cloudy (non-zero cloud water or ice) 3-d grid volumes at the end of the RUC analysis. These same changes are being introduced into the Rapid Refresh (specifically as part of a new DFI step in the WRF model using a new namelist option to retain 3-d hydrometeor fields from before application of DFI). *Background: GSD verification against METAR ceiling observations had shown that cloud water in these layers was intermittently evaporating in the first hour of the model for both the RUC and WRF Rapid Refresh models. Bill Moninger has developed initial ceiling/visibility verification for the Rapid Refresh. Improvements for the RUC developed from this testing is already being transferred to the Rapid Refresh code also (analysis and model).*

Continued discussions have taken place with NESDIS/CIMSS, NWS, and NASA Langley about options for hourly-updated, North American cloud products from either GOES alone, or a GOES/MODIS mosaic. This problem for RR-appropriate cloud products, including Alaska, is not completely solved yet as of this writing, although a real-time feed will likely soon become available.

Ming Hu has incorporated the Rapid Refresh cloud analysis into the latest GSI version released from NCEP (1QFY09) and implemented this is a real-time parallel cycle at GSD. We will fully merge these new cloud analysis changes (previous paragraph) to the RR, until we had the new GSI version with the cloud analysis up and running the RR cycle. We anticipate introducing both these changes and the surface assimilation changes (see 09.5.5) within the next month.

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

GSD
This code is in place and operating within both Rapid Refresh hourly parallel cycles at GSD. Qualitatively assessment of the impact (relative to an RR version without this capability) was made during the fall of 2008 and a more detailed assessment will be completed in Spring 2009.

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

Deliverables

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

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

NCAR/MMM

CURRENT EFFORTS:
Preparations of the next major release of WRF continued at NCAR. This will be WRF V3.1 and is scheduled for spring 2009. The repository was frozen to new additions prior to Feb., and pre-release code testing was begun. New features include new microphysics, PBL schemes, Noah LSM and UCM updates, and NCEP operational physics and dynamics. A listing of the release features may be found at http://wrf-model.org/users/release.php.

In WRF radiation physics, Jimy Dudhia of NCAR/MMM worked on a correction to the CAM scheme for the uninitialized variable "co2mmr". This affects downward shortwave effects from CO2 and longwave trace gas treatments. The overall effect of the fix is to decrease surface solar flux by 1%.

Addressing PBL schemes, Dudhia fixed minor bugs YSU PBL and MYNN PBL parameterizations identified by users. He also began resolving remaining issues of vertical mixing of clouds by PBL schemes where the ARW sometimes has incomplete tendencies for PBL choices (resulting in no cloud mixing).

Minor fixes were made to the ACM PBL scheme and the Pleim-Xiu LSM. A fix to the QNSE PBL scheme from developer Semion Sukoriansky was added to improve the scheme's behavior in unstable conditions. Dudhia worked with visitor Songyou Hong (YSU) to start development of a new hybrid TKE/YSU PBL scheme and finalized work on the gravity wave drag testing.

Dudhia worked with the Noah LSM group to add fixes, for the V3.1 release, to the Urban Canopy Model regarding emissivity and 2-m diagnostics. He added MODIS table data from the LSM group to LSM

tables in the repository.

Minor bug fixes for the Goddard microphysics scheme were added, and a problem with the KF cumulus scheme related to long-lasting clouds was resolved. The latter was due to a bug in limiting cloud lifetimes that was introduced with the adaptive time step capability in WRF V3.0.

PROBLEMS/ISSUES/SCHEDULE CHANGES:

PLANNED 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.

09.5.6.5 30 Sept 2009 (NCAR/MMM)
Incorporate physics improvements from the WRF user community, GSD, and NCEP into the WRF software infrastructure for use in the Rapid Refresh model. Perform code testing to permit implementation into WRF repository. In collaboration with GSD, assist in the evaluation of those physics schemes for the RR that may be tested using the ARW.

Deliverables

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

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

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

GSD
- Continued planning within ESRL/GSD, also with NCAR and MIT/LL toward 2009 HRRR.

Recap from Q1 report: The GSD group has performed extensive verification and evaluation of the summer 2008 HRRR forecasts and worked with NCAR and MIT/LL to evaluate the combined CoSPA product. GSD HRRR reflectivity verification (at 3-h intervals) indicates 6-h HRRR forecasts with radar assimilation are better than 3-h HRRR forecast without radar assimilation at all times of the day. GSD has further evaluated the relative strengths of the HRRR and RCPF as a function of the diurnal cycle of convection. The RCPF does quite well at identifying mesoscale areas of convective initiation. The HRRR appears to have similar skill for convective initiation (based on verification of HRRR forecasts that have been up-scaled to a 13-km grid). As expected, HRRR improvements from the RUC radar assimilation increase as the initial time convective coverage increases.

GSD has begun preliminary work toward creating 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.

Subtasks

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

GSD

Tanya Smirnova has recently tested an expanded HRRR domain. The new domain, which extends west to the Rocky Mountains and south to the Gulf Coast, is rotated clockwise to minimize grid points over the Atlantic Ocean. There would be several advantages to this expanded HRRR domain: 1) expanded coverage for key hubs including Atlanta, Minneapolis, Dallas and Denver, 2) by placing the western domain edge well west of the mean dry-line position, the western boundary contamination (from large MCSs that are poorly represented in the parent model, entering the HRRR domain) would be greatly reduced. 3) Greater utility to all users, including NOAA operational forecast units. Initial tests indicated about 56 minutes for a 12-h forecast on 480 processors. In additional a code module from NCAR to provide output of VIL and echo top fields every 15 minutes. It has been installed into the WRF HRRR code.

09.5.24.2 15 Aug 2009 (NCAR/MMM)
Evaluate techniques for convection-permitting (e.g., 3-km) forecasting by the ARW core in the HRRR configuration. In collaboration with GSD, perform and evaluate convection-permitting forecasts on test cases using radar-enhanced RUC or Rapid Refresh (13-km) grids from GSD for initial condition fields to identify strengths and weaknesses of HRRR-ARW forecasts. This will include a 2009 analysis on evolution of convective storm mode during first 1-3 hours of model transition from effective resolution 13-km to actual 3-km resolution. Perform fully-explicit tests and evaluate short-term forecast results. Submit summary of results and collaborate with other groups on consolidated summary of results from 2009 HRRR exercise and research results.

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.

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

Deliverables

09.5.24.E1 15 August 2009 (NCAR/MMM)
Submit report on evaluation of HRRR-ARW forecasts.

09.5.24.E2 30 August 2009 (NOAA/ESRL/GSD)
Complete FY09 test in Northeast Corridor U.S. domain with 3-km High-Resolution Rapid Refresh running every 1 h.

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

09.5.24.E2 30 September 2009 (NCAR/RAP and NCAR/MMM)
Collaborate with GSD on analysis of 2009 results. Draft and deliver summary of results.
Evaluate techniques for convection-resolving (e.g., 3-km) forecasting by the Rapid Refresh (ARW core).

Perform and evaluate HRRR convection-resolving forecasts on test cases using Rapid Refresh grids from GSD to identify strengths and weakness of model at high resolution. Perform 2009 experiments to re-evaluate effects of transition from 13-km parameterized convection to 3-km resolved convection in 0-3h forecasts and in lateral boundary conditions from the RUC or Rapid Refresh using the Grell-Devenyi parameterization.

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

Subtasks

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

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

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

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

GSD has been providing, to NCAR, RUC lateral boundary and radar-enhanced initial condition (history file dump directly after the RUC diabatic DFI-based radar assimilation) files for experimental re-runs of selected test cases from the 2007 convective season. Initial work has focused on 5 Sept. . A series of additional case studies has been agreed upon by GSD and NCAR-RAL and GSD has supplied RUC IC / LBC files to NCAR-RAL.

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

To better and objectively evaluate the quality of forecast for our results obtained with tropical storm Erin (at 3 km resolution), especially in terms of the precipitation structure, Kefeng Zhu of CAPS installed Version 1.1 Meteorology Evaluation Tools (MET) package developed at DTC on CAPS computers. MET contains a comprehensive set of verification scores, including those based on identified objects. It has been applied to the Erin case.

Figure 1 below shows the more recent prediction results obtained using the newly QC'ed radar data and the NAM as the analysis background and boundary conditions. Visual inspection indicates that the forecasts assimilating reflectivity data (through cloud analysis, 4th row) and assimilating both radial velocity and reflectivity (last row) are the best, especially at 1200 UTC, which corresponding to 10 hour forecast time. Figure 2 shows example verification scores produced using MET with the neighborhood method and point-to-point method for hourly precipitation, calculated against Stage II precipitation data. The Fraction Skill Score (Fig. 2a) also indicates that the scores are higher for the cases assimilating reflectivity data or both reflectivity and radial velocity, with the score falling off somewhat early in the latter case. The mean precipitation in a sub domain in the Oklahoma region shows generally positive bias before 14 hours (Fig. 2b), with the bias being the greatest in cases where reflectivity data are assimilated. We suspect that the cloud analysis introduces too much hydrometeor, and/or perhaps adds too much heating into the system during the assimilation cycles. Further investigation of the cause is underway.

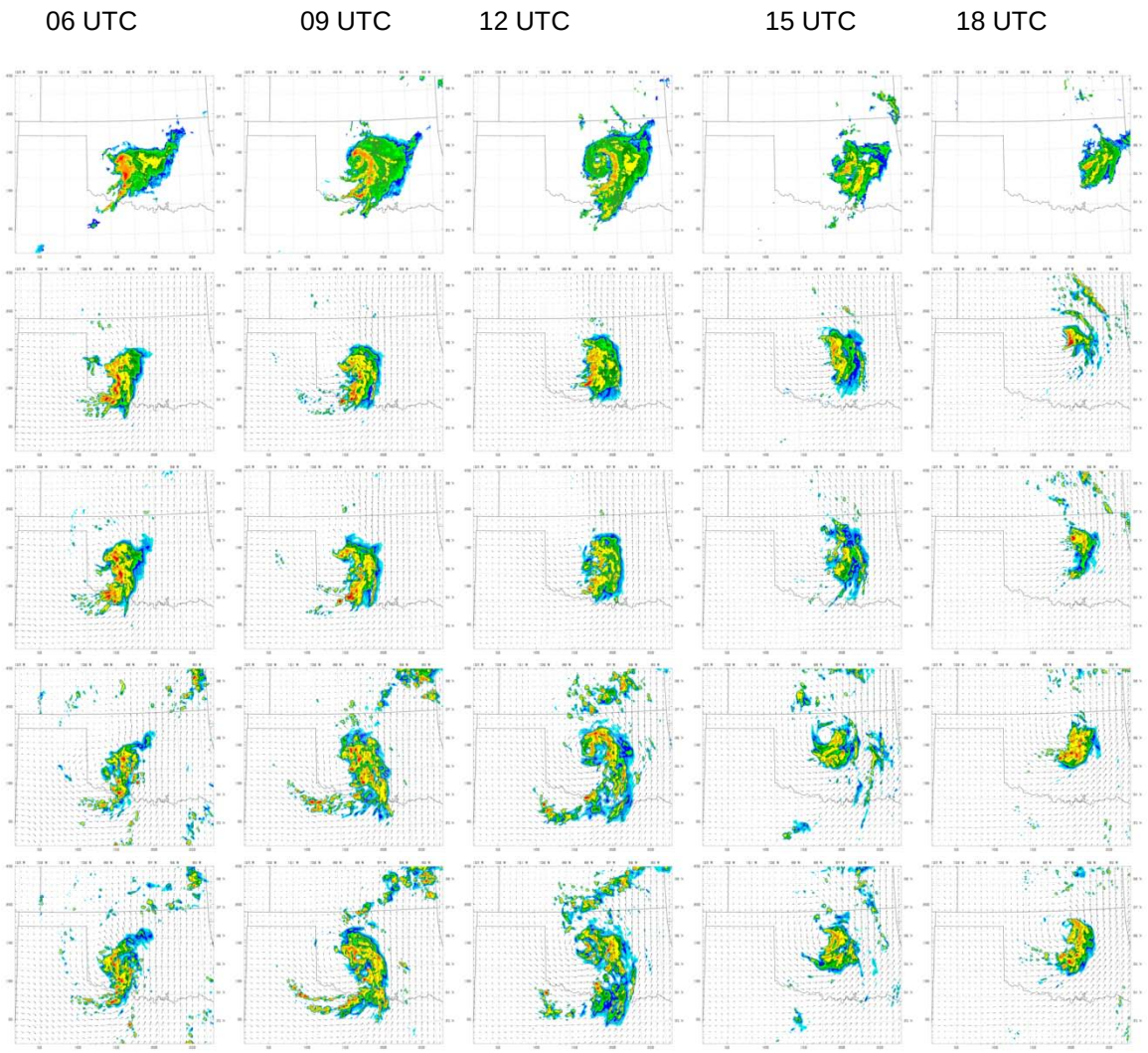
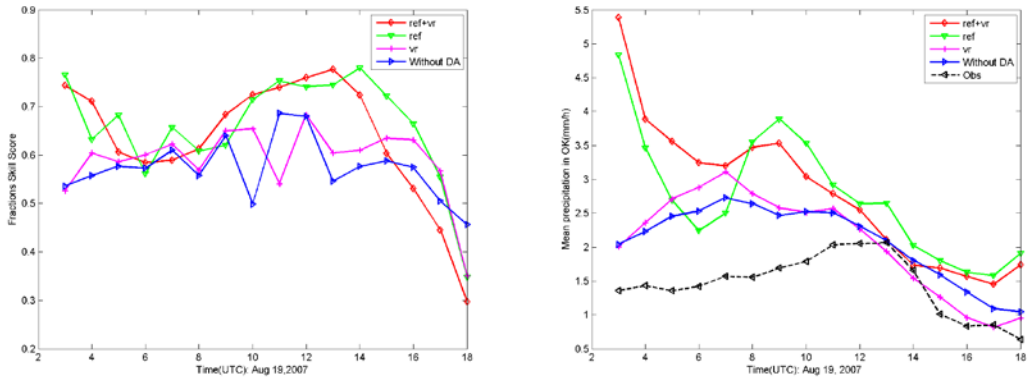


Fig. 1. The observed reflectivity (first row) and forecast reflectivity at 06, 09, 12, 15 and 18 UTC from the experiments without data assimilation (second row), assimilating radial velocity (third row), assimilating reflectivity data (fourth row), and assimilating both of velocity and reflectivity data (fifth row) every 10 minutes between 00 and 02 UTC.



(a) **(b)**

Fig. 2. Verifications of hourly precipitation using MET: (a) Fraction Skill Scores (using the neighborhood method with a 3-grid-point neighborhood and an hourly precipitation threshold of 0.0), and (b) mean

precipitation amount based on point to point verification. Both evaluations are carried out in the Oklahoma region.

In other experiments, conventional data have been assimilated together with radar data using GSI. Different horizontal de-correlation lengths for the background error covariance were tested. It was found that when using the same horizontal de-correlation length that is smaller than the default value of GSI for both convectional and radar data, the results are the best.
Also, using RUC analysis as the initial analysis background, the impacts of Digital Filter Initialization (DFI) (two schemes: digital filter launch and twice DFI) available in the WRF model were examined. It was found that while DFI smoothes the original analysis, a significant portion of the redial velocity analysis increment is still remained after the filtering, even with the use of 'twice DFI'. In preparation for running tests for a new case in the GSD computing environment, Yi Yang repeated some of Erin experiments on a GSD machine, with a Rapid Refresh workflow modified for running retrospective cases. This is to ensure quick integration of the development and findings into the operational version.

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.

Task 09.5.20 Develop ensemble-based probabilistic products for aviation users.

NCEP
Jun Du reports that the transition of the operational SREF system from the current NCEP P5 computer to the new P6 computer was carried out and completed. In addition, a new parallel SREF system (matching the upgrades whose implementation was postponed in December 2008) with hourly output aimed at SPC's & AWC's efforts to improve convection forecast guidance in 2009 was established and is running four-times-per-day on the new P6 computer. This parallel system will replace the current operational system in the near future. The evaluation of this parallel system is underway. A paper on the verification of a fog prediction method using part of the NCEP SREF system was written together with the developer Binbin Zhou. A new method called "neighborhood approach", which might be useful in high-resolution mesoscale runs, was adopted to create a probabilistic forecast based on a single deterministic forecast. It's now being tested using HiResWindow runs as a possible component for the Very Short-Range Ensemble Forecast (VSREF) system. Results will be reported as they become available.

BinBin Zhou is working with MDL & NWS' Pacific Region to develop procedures to verify ceiling/visibility over Hawaii regions. This is another IC4D effort similar to the one going on in NWS' Alaska Region. There are still some issues to be addressed, like how to split flight restriction probabilities at MDL.

Shun Liu has started to run a radar data processing parallel and is archiving GRIB formatted 3D reflectivity mosaic data. This is to allow future retrospective testing to be conducted without the onerous task of retrieving huge files from the Production Suite run-history archive on HPSS.

GSD

GSD and NCEP have developed a outline for hourly-updated post-processing for probabilistic forecasts, coined HFProb (for High-Frequency Probabilistic Forecasts) presented at the AMS Aviation ATM-Weather Symposium by Stan Benjamin. GSD has started developing preliminary probabilistic forecasts from the HRRR as part of this work, which will incorporate the Very Short-Range Ensemble Forecast (VSREF) design including Rapid Refresh time-lagged ensemble forecasts within NCEP's SREF framework.

Subtasks

09.5.20.1 15 January 2009 (NCEP)
Complete 'research quality' version of upgrade to SREF (e.g. higher resolution, more WRF members and more physics diversity) for consideration in November 2010 SREF upgrade package.

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

09.5.20.3 15 April 2009 (NCEP)
NCEP develops and delivers a new fog algorithm used in the SREF product for aviation (fully depending on FAA funding, $60K requested).
A new fog algorithm was designed and developed in FY2007. This algorithm was incorporated into the special ensembles NCEP ran in support of the Beijing Olympic forecast runs. (Zhou)

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

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

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

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

Deliverables

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

CURRENT EFFORTS

PLANNED EFFORTS:

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS: AWS, GSD

UPDATES TO SCHEDULE: