MDE Product Development Team
January FY11 Monthly Report – FY 2011
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(Compiled and edited by S. Benjamin and B. Johnson)

Executive Summary

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

- NCEP-RUC – continues running at 100% reliability since coordinate fix on 11/17/2010
- An investigation on the precipitation-type algorithm using the RUC led to discovery of a problem and subsequent correction to the RR and HRRR and RUC-development. This problem gives too much mixed rain-snow when surface temperature is near freezing.

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

- *RR continues to show strong improvement in January over RUC for wind, temperature, RH, height.*
- *RR ceiling forecasts showed additional improvement over RUC in January*
- *ftp now available for RR running at NCEP-EMC, evaluation of RR-NCEP-EMC continues.*
- *Current planned date for RR implementation at NCEP is Aug-Sept 2011.*

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

- Additional data sources now being used in GSI for RR (radial velocity from WSR-88D radars, TAMDAR moisture, WVSS aircraft moisture)
- All components (GSI, ARW, Unipost, others) updated so that binary I/O results match netcdf I/O results, allowing start to produce BUFR station soundings from RR
- Work continues to evaluate value added from radiance assimilation in RR (via GSI) including assessment of bias correction by channel for AMSU data.

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

- RR using frozen version of GSI cloud analysis yielding significant improvement in short-range ceiling and visibility forecasts.
- Successful test of adaptation of GSI cloud analysis for 3-km CONUS HRRR application to obtain radar latent heating-based temperature tendency fields for conducting 3-km HRRR radar DFI experiments

Task 11.5.24: Development/testing of HRRR

- June 2010 RUC / HRRR retro 8-day experiments (comparing full strength vs. thirds strength LH in Diabatic DFI) complete, results indicate full better for first few hours, then third slightly better.
- Extensive 10-day July 2010 HRRR retrospective case study ongoing, with comparison of many aspects of HRRR forecast systems (parent models, HRRR ARW formulation, radar assimilation methods). Results driving decisions on HRRR formulation for 2011 season.
- Further useful additions made completed on RUC / RR / HRRR radar reflectivity verification system including capability to stratify results by forecast length. Full system indispensible for rapid evaluation of retrospective case studies.
- Creation of sample grib2 HRRR 15-min output files completed.
- Analysis of HRRR Convective Probability Forecasts (HCPF) from July 2020 period and creation of HRRR/HCPF overlay display concepts.

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

ESRL/GSD

NCEP-RUC – Change:
Operational RUC at NCEP has continued to run at 100% reliability since coordinate fix on 17 Nov 2010.

As always, ESRL continues to monitor operational RUC (and two ESRL versions of RUC with some differences in radar and cloud assimilation). Performance of the operational RUC is monitored at both ESRL and NCEP verification websites (see http://ruc.noaa.gov/stats). Inter-comparison of verification between the NCEP and ESRL versions of the RUC continue to be monitored by ESRL at http://ruc.noaa.gov/stats -- no unexpected differences occurred during July. Reminder: the backup RUC at ESRL is used to initialize the HRRR (http://rapidrefresh.noaa.gov/hrrr).

NCEP
A major upgrade to the NCEP BUFR library, critical to all observational ingests and impacts both the RUC and the NAM, was implemented on 25 January. Work continues on issues like dropping 88D report counts for Level 2 and Level 2.5 (locally generated super-obs), three radiosonde sites that report an invalid instrument type (we are in contact with some of the sites); late arrival of Shemya radiosonde (Alaska folk have been contacted), late arrival of GOES 1x1 field-of-view cloud data; bringing in new SSM/IS data from DMSP F-16, F-17 and F-18 satellites to replace discontinued SSM/I products; use of TAMDAR data from AirDAT as a MADIS alternative; and NRL-based aircraft QC code implementation preparation. There was an NPN profiler outage for part of 25 January. The Florida and Georgia DOT and Aberdeen PG mesonet providers remained down. GOES-13 cloud and precipitable water retrievals have not been used since the switch to GOES-13 in April 2010. (Dennis Keyser)

The changes made in November to address the CFL failures in the operational RUC have been a complete success. Following a December without any problems, there were again no CFL crashes in the RUC during January. (Geoff Manikin)

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

ESRL/GSD

Progress in Rapid Refresh development toward operational implementation at NCEP can be found under Task 5.4 report.

NCEP
Parallel tests of the NEMS/NMMB model in the EMC NAM parallel system continue on the CCS during January. Two NMMB parallels are running, one a 12 km control run and the other a 12 km experimental run with model and/or analysis changes for inclusion in the control run. The experimental parallel is running all four nested domains (4km CONUS, 6km Alaska, 3km Hawaii, & 3km Puerto Rico/Hispaniola) and a movable fire weather nest over either the CONUS (1.33km) or Alaska (1.5km). During EMC parallel testing the fire weather nest is moved to different regions with interesting weather. (Eric Rogers)

In January, two significant changes were made to the parallel NMMB runs. Digital filter initialization, tested in December in the experimental parallel, was implemented in the control parallel. The filter (“Twice-DFI”, Huang and Lynch 1994) consists of a 40-minute backwards-adiabatic integration with filtering and a 40-minute forward Diabatic integration with filtering. This filter is applied only in the 3-h NDAS forecasts. The other change was made to remove computational noise in the 1.333/1.5 km Fire Weather nest, although it will be applied to all domains. The NMMB model was changed to gradually reduce dw/dt near the top of the model by assuming attenuation of dw/dt of the form cos**2 in the top 15 hPa of the atmosphere, i.e., in the top 1.5% of the mass of the atmosphere. The noise had occurred in the fire weather run since it has high horizontal resolution and a high model top (2 mb) so that the horizontal resolution near the top becomes higher than the vertical resolution, which is opposite to the situation lower in the atmosphere. (Eric Rogers)

NCEP generates experimental Rapid Refresh (RR) PrepBUFR files containing WindSat data (non-superob) and 50 km ASCAT, which are copied to a private ESRL directory on the NCEP ftpprd server. As of 20 January these PrepBUFR files are generated using the new NRL-based aircraft QC code and no longer flag MDCRS and TAMDAR moisture. RR dumps of Level 2 and expanded (time-window) Level 2.5/3 88D radial wind data, hourly lightning data, and GOES single-pixel cloud data from NASA/Langley (covering Alaska) are also copied to a public ftp directory. These, along with early (T+0:26 minute) parallel dumps for 0000 and 1200 UTC are being tested in ESRL's experimental RR runs and the RR parallel being run at NCEP. ASCAT and WindSAT data dump time windows have been moved back 30 minutes to try to obtain more data for the RR. The AQUA AIRS and NOAA/METOP AMSU-A, AMSU-B, HIRS-3/4 and MHS, radiance dump time windows were moved from back 1 hour to try to obtain more data for the RR. There are many unavoidable gaps in the WindSAT data due to problems upstream of NCEP. Langley cloud data were unavailable for parts of 13 and 25 January due to upstream issues. Data tests have been performed (Wan-Shu Wu) on Multi-Agency Profiler winds and METOP-2. Future data tests will include RARS radiances (RARS parallel dumps began 20 January) as well as “tcvitals” records for tropical cyclones. NCEP/NCO's modification of the Level 3 (“NIDS”) radial wind decoder to handle a 12 January resolution change in these raw data by the NWS was implemented on 11 January. EMC and GSD requested the Radar Operations Center (ROC) start their hourly processing of Level 2.5 88D data 25-30 minutes earlier so more data will arrive before the RR cutoff, as it's the only available radial wind data for the Alaska portion of the expanded RR domain. Adding a 5th hourly ingest run for Level 2 88D radar data is being discussed with NCO. There is strong evidence that the amount of Level 2 and Level 2.5 data being processed at NCEP has significantly decreased over the past two months, even when seasonal trends are taken into account, and is under investigation. (Dennis Keyser)

For the NAM specifically, the problem found with the Shemya radiosonde (70414), in which folks in Alaska too late for the NAM-GSI and the RR, are currently being address the launch time. The NDAS is not able to process the complete set of APRX WeatherNet mesonet data due to the large number of duplicate reports coming from MADIS. NCO is working with MADIS to resolve this issue. AQUA AIRS and AQUA MODIS data were very low or unavailable for 5 hours on 27 January due to a fiber cable cut. METOP-2 polar satellite data (all instruments) was lost for several hours on 21 and 24 January due to system issues and again on 27 January due to a fiber cable cut. GOES-13 radiances are monitored but will not be used until the next NAM update. NOAA-18 has on-going gyro issues that could lead to unusable products within 6 months. NESDIS engineers still need to conduct the last of three 24-hour tests where the corrupted navigation data will not be sent to NCEP. The following data types are monitored by the NAM-GSI: RASS virtual temperature profiles (NPN and MAP), MAP wind profiles below 400 mb, Mesonet mass data, AIRS AMSU-A radiances, NOAA-19 HIRS-4/AMSU-A/MHS radiances, METOP IASI radiances, ASCAT and WindSAT winds, and MDCRS moisture data. All but RASS of these are being tested in Eric Rogers' parallel. Ten meter wind speed from JASON-1 and -2 altimetry data will soon be monitored. NAM/NDAS and RTMA PrepBUFR files are being generated in parallel with 50 km ASCAT and WindSat scatterometer wind data (both non-superob). As of 22 January the NAM/NDAS PrepBUFR files are generated using the new NRL-based aircraft QC code. Production NAM/NDAS dumps of METOP IASI radiances, GPS-RO data and SBUV-2 data are being created and, as of 22 January, dumps of RARS 1c radiances are being created in parallel. Use of the GFS tropical cyclone relocation procedure (for medium to strong tropical cyclones) to update the global first guess fields input to NDAS is also being tested in parallel, but this can only be done at the t-12 hour start time of the NDAS. A legacy restriction (that only surface data with a reported pressure is processed) will be removed to allow many new surface observations (land, marine and Mesonet) to be assimilated in the RTMA and possibly in the NAM/NDAS. This is now being tested in the RTMA. (Dennis Keyser)

The codes to ingest Unisys radar basic reflectivity data into NCEP's version of the Current Icing Potential (CIP) algorithm have been completed. Debugging of the whole CIP software package has begun. (Yali Mao)

NCAR

CURRENT EFFORTS:

NCAR held a WRF tutorial on Jan. 31-Feb. 8, 2011. This covered WRF structure and operation, as well as related model components, such the Metgrid verification tool. Attendance was approximately 65.

NCAR continued preparations for WRF major release V3.3. The code was frozen and a friendly user version made available to vendors for testing. Preparatory testing at NCAR, at the DTC, and with contributors is underway. Information on the release and a list of candidate features may be found at http://www.mmm.ucar.edu/wrf/users/release_3.3.html.

Jimy Dudhia of NCAR/MMM worked on various facets WRF physics development. In preparation of the V3.3 release, he unified TKE variables from different PBL schemes to a single name and updated the new Goddard scheme to comply better with WRF standards. He also updated codes for gravity wave drag and the WDM microphysics scheme with changes from the developers at YSU.

Dudhia continued working with Pedro Jimenez (Univ. Complutense Madrid, Spain; MMM visitor) to evaluate WRF surface wind biases in a large, multi-year, northern Spain dataset and 2-km simulation output. They are finding ways to improve WRF surface wind output in complex terrain based on topographic properties.

Dudhia continued working with MMM visitor Dipu Sudhakar (Indian Institute of Tropical Meteorology). The work investigated the effects of dust transport on radiative heating, with the setting being a case study in the Indian region. They modified the code to diagnose the direct effect of aerosols on solar radiation.

Lastly, Dudhia collaborated with visitor Anna Fitch (Univ. of Bergen, Norway) on testing the effects of wind farms with WRF simulations. She has implemented, with John Michalakes (NREL), a wind farm parameterization for inclusion in the V3.3 release

PLANNED EFFORTS: The development and implementation of new physics for WRF will continue through FY11Q1.

UPDATES TO SCHEDULE: NONE

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

ESRL/GSD

Rapid Refresh pre-implementation testing continues both at GSD and at EMC. The RR performance continues to be generally superior to the RUC (EMC RR equivalent or better than the oper RUC, and GSD RR primary better than the RUC backup at GSD), although with one remaining area of investigation. This issue is that the snow cover in the RR is sometimes deficient. This then contributes to a warm 2-m temperature bias in areas of snow-cover deficiency. We are actively exploring various avenues to fix this problem, which we now believe is due to a combination of 2 main contributors. These include a) WRF use of land-use-dependent albedo when snow cover is present (results in lower snow albedo than used in RUC), and b) an effect of the DFI configuration currently necessary for the WRF (the use of the DFI time-filtered water vapor and hydrometeor mixing ratios to initialize the free forecast, rather than using the RUC procedure of restoring the hydrometeor fields and relative humidity after the DFI to the values produced by GSI, including the cloud analysis. The performance degradation in wind and temperature when we use this RUC procedure in the WRF-ARW RR, and what is required to (probably) fix it, was discussed in the October 2010 MDEPT report.) We are currently testing various procedures, including one that restores the original hydrometeors and water vapor (but, the latter at temperatures below freezing only) after the

DFI. Restoration of these fields under this condition only would presumably introduce less initial hydrostatic imbalance into the free forecast.

The capability for use of binary (instead of NetCDF) output files from the model and GSI was partially completed last year prior to the switch from the Lambert Conformal to Rotated Lat-lon grid. This has long been an NCEP RR requirement to allow production of BUFR-format model sounding output as in the RUC, and is also slightly more efficient than NetCDF. At this writing, Ming Hu has GSI and WRF working correctly and is checking out the special boundary-condition code *update_bc* for the binary output at GSD. Tanya Smirnova has made necessary changes to UniPost to read in binary output from WRF. Ming will transfer this to NCEP for testing there as soon as it is completely checked out at GSD. NOTE: This use of binary-output executable does NOT change the RR output.

TAMDAR moisture observations (BUFR observation type 134q) and WVSS (Water Vapor Sounding System) aircraft moisture observations (type 133q) were added to the RRdev at GSD during the month. Approval for using these in the operational RR has been granted, and a request has been made to NCEP to use the new NAM observation error in the prepBUFR that GSD receives from NCEP so that good QC flags are being applied to these observations. Once the impact of these observations has been confirmed to be satisfactory at GSD, we expect to start using them in the RR cycle at EMC.

Radial winds from the WSR-88D network have been used for several months in a special 3-h RR cycle Ming Hu has been running at GSD. However, only since 20 January have these winds become available sufficiently timely for inclusion in the RR 1-h cycles running at GSD, and with this change, the radial winds are being used successfully in the RR-dev at ESRL.

Regarding UniPost, some changes were made to the originally RUC-based precipitation-type algorithm to reduce excessive areas described as being in mixed (rain/snow/sleet/freezing rain) precipitation type (also discussed briefly under Task 5.1). These improved the precipitation-type product for the late January precipitation events over the eastern US, and received approval by forecasters in these areas. The problem with erroneous GRIB2 files being produced for fields that are uniformly zero has now been fixed.

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

Due to a backlog of implementations at NCEP Central Operations, the best estimate for the operational implementation of the RR has fallen back into the August-September 2011 time frame.

Subtasks

11.5.4.1 Ongoing (GSD, NCEP)

Ongoing evaluation of performance of real-time and retrospective runs of RR system for SAVs, AHPs

GSD: The RR 1-h cycles at GSD on the Rotated Lat-Lon domain continue to verify consistently better for RMSVE winds, RMS temperatures aloft and relative humidity than the operational RUC (see Fig. 1). Further, the EMC RR cycle ("RAPX") is equivalent to or a bit better than the operational RUC. The substantial mid-upper troposphere moist bias noted in December has been largely removed in late December by eliminating building of cloud based on satellite observations in the GSI cloud analysis.   In fact, RR forecasts are now showing a substantial improvement over the operational RUC for mid-upper troposphere RH. The GSD RR-primary 2-m temperature verification is satisfactory and generally as good or better than RUC except for being too warm in areas of deficient snow cover. Dew point at 2m is tending to run a little high except in dry areas of the interior Southwest, where dew points are running too dry.

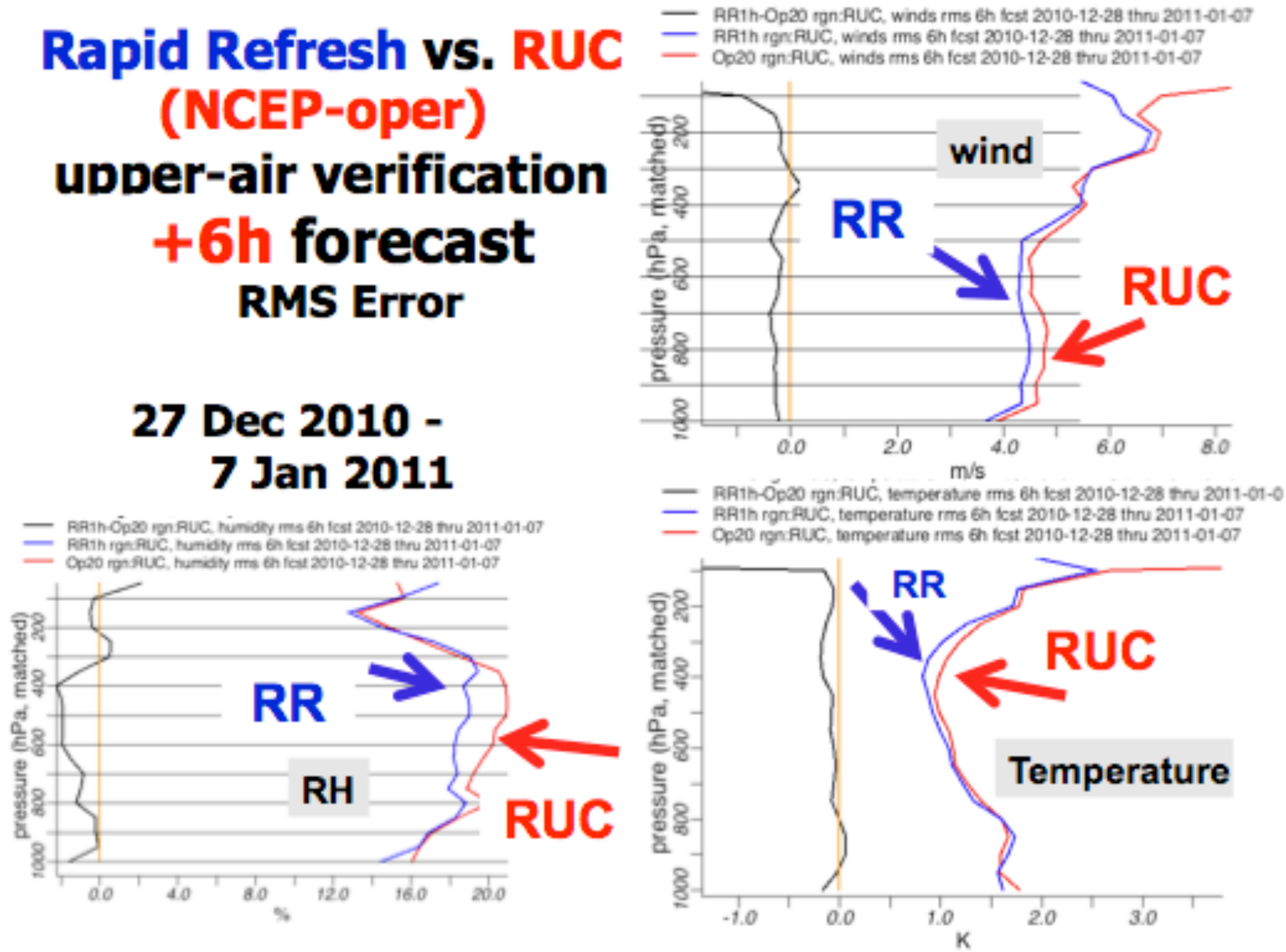

Figure 1. Verification of Rapid Refresh vs. RUC (operational at NCEP) for 27 Dec 2010 – 7 Jan 2011 as a function of pressure level for wind (upper right), temperature (lower right), and RH (lower left).

NCEP

The Rapid Refresh has been running stably in an EMC parallel environment with no major code changes since December. Statistical evaluation has shown that the Rapid Refresh is now at least comparable to the RUC for most parameters. GRIB and GRIB2 files have been made available to the FAA, the service centers, and other users of the RUC on an ftp site, and informal evaluation of the model performance is underway. Implementation is currently scheduled for late summer. (Geoff Manikin)

See extensive observation processing work by EMC's Dennis Keyser in support of RR under Task 11.5.17.

11.5.4.2 1 Nov 2010 (GSD)

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

pgrb, sgrb and bgrb files are now available in GRIB1 from the EMC test RR cycle output, and limited, though not unfavorable feedback has been received so far. We hope to receive more feedback from the other PDTs during the next few weeks.

Stan Benjamin, Tanya Smirnova and Joe Olson are planning to visit Alaska in March to present an update on status of the Rapid Refresh including enhancements to the land-surface scheme to improve temperature forecasts near the Alaska coast by accounting for heat conduction within sea ice and accumulation and ablation of snow cover on top of the sea ice, and to discuss Rapid Refresh performance issues.

11.5.4.2a (EMC, GSD)
Complete bringing ARW model code into compliance with than current version of NEMS, including successfully running forecasts and verifying integrity of ARW running under NEMS. (30 Sept 2011)

Work has not yet started. (Black, Manikin, GSD)

11.5.4.3 Start design of NARRE ARW physics ensembles. These will be derived either by varying parameters within the physics suite planned for the initial RR implementation, or by using different physics suites. Part of this subtask will be to do the experiments necessary to decide which of these alternatives gives the more useful ensemble diversity for aviation application, by means of real-time and retrospective testing on the RR domain. (30 Sept 2011)

Work will begin on this subtask in January 2011. (Du, Manikin)

Deliverables

11.5.4.E1 20 Dec 2010 (GSD)
Report on Rapid Refresh status and plans to NCEP Operational Model Production Suite Review meeting.

Complete. Presentation available at http://www.emc.ncep.noaa.gov/annualreviews/2010Review/

11.5.4E1a (28 February 2010) (EMC - Manikin)
Update documentation for operational Rapid Refresh.

CURRENT EFFORTS:
Experimental Rapid Refresh grids from the EMC parallel run are now available at ftp://ftp.emc.ncep.noaa.gov/mmb/mmbpll/rap. Inside the directory for each date, you will find the following for each cycle:

13 km grids covering current RUC domain w/ data on native levels (awp130bgrb)*
20 km grids covering current RUC domain w/ data on native levels (awp252bgrb)
13 km grids covering current RUC domain w/ data on pressure levels (awp130pgrb)*
20 km grids covering current RUC domain w/ data on pressure levels (awp252pgrb)
11 km grids covering Alaska (awp242)
32 km grids covering the full domain (awip32)
* - available in grib1 and grib2 (all others only in grib1)
We may make grib2 available for more of the files at a later time. Note that bufr output is not currently available but should be within the next month.

The files covering the current RUC domain will have the same parameters as the current operational RUC files, but the order of some fields will be different. The content of the Alaska and full domain files is subject to change, so do not run any scripts that expect a particular order of the records.

Having these grids now will allow all users to examine Rapid Refresh data for the ongoing cold season. Your assessments of the model performance (good and bad) will be appreciated and can be sent to geoffrey.manikin@noaa.gov and stan.benjamin@noaa.gov Operational implementation of the Rapid Refresh at NCEP is currently planned for late summer. The parallel model codes will still undergo a few minor changes over the next few months, but major changes to the codes are not currently expected.

If you are interested in examining output but do not want to download files, graphics are available at http://www.emc.ncep.noaa.gov/mmb/gmanikin/rap/para

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS: NCO, ESRL & FAA.

UPDATES TO SCHEDULE:

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

ESRL/GSD

(Recapping from the January 2011 MDE report)

> *Based on group work spearheaded by Ming Hu, a frozen version of the GSI for the Rapid Refresh implementation was obtained in November. The biggest change was to switch from use of a NAM-based background error covariance (BEC) file to a GFS-based BEC file. Based on detailed comparisons of single-observation analysis increments from GSI using the NAM and GFS BEC files, Ming made changes to the GFS BEC specification (changes to the amplitude and vertical correlation length scale) that resulted in equal or slightly superior RR forecasts from the GFS BEC compared to the NAM BEC. Rapid testing and evaluation of these changes was greatly facilitated by Haidao Lin's retrospective runs from a May 2010 5-day test case and application of Bill Moninger's radiosonde verification package. Additional testing and evaluation was completed using the two parallel real-time RR cycles at NCEP. Updated code was then passed to Geoff Manikin's real-time RR cycle running at NCEP.*
>
> *Geoff Manikin's RR cycle has been running in a stable configuration since early Dec. with detailed quantitative and qualitative forecast evaluation ongoing. This evaluation has included statistical verification by Geoff as well as porting Geoff's files from Geoff's RR back to ESRL for ingest into Bill Moninger's (ESRL) upper air verification database. In addition, Geoff Manikin's real-time RR/RUC comparison webpage (with analysis increment and RR-RUC difference plots) has been extremely helpful in evaluating RR forecasts. One remaining item that emerged from this analysis was a high RR bias and larger RMS for mid- and upper-level moisture. Work by Ming Hu lead to a modification in the treatment of cloud top data that resolved this issue, leading to an improved mid- and upper-level moisture forecasts for the RR compared to the RUC. The change was to use a combination of NESDIS and NASA (larger coverage) products to just trim excess cloudiness in the Rapid Refresh background field. The change was made first in the GSD RR cycle, then transferred over to Geoff Manikin's EMC RR cycle on 29 Dec. 2010.*

Ming Hu made other enhancements to the RR GSI. First, he added in the use of two additional observation types (both used in the RUC) into the RR. These observations are TAMDAR/WVSS aircraft moisture and PBL profiler winds. In addition, Ming added code in the GSI to make use of an aircraft observation rejection list (generated based on average innovation statistics compiled by GSD) including modification of the code to check aircraft observation by tail number and MDCRS number (both can be used in the prepbufr file). More recently, improvements to the time availability of the radar radial velocity data have allowed these observations to be included in the GSI for RR at ESRL.

Ming Hu has also been working to fully benchmark the performance of the entire RR system cycling with binary I/O compared to netcdf I/O. Initial efforts to get this working an s a proof of concept were completed late last summer, with final work deferred until all scientific changes had been made to the RR system. Owing to an updated version of the GSI, a few issues were encountered in the binary I/O GSI. These have been overcome and Ming is testing the final piece of the system, update_bc.

GSD personnel (Stan Benjamin, Ming Hu, Steve Weygandt, Curtis Alexander, Patrick Hofmann, Eric James) attended the ARAM Symposium on Weather and Air Traffic Management at the AMS Annual Meeting in late December. Several presentations and posters on RR, HRRR, HCPF, and other related topics were given at the

ARAM and other conferences. A website with a list of the presentations and posters (from our GSD group and a few others from colleagues, links to PPTs and posters are being added) is: http://ruc.noaa.gov/pubs.cgi#1.

CAPS

Report on initial test results of implementing the EnSRF package for RR application.

During the last month, we merged the regional EnKF with the latest global EnKF, by moving codes specific to regional EnKF into a unified version. Experiments using that unified version showed EnKF's first guess errors (i.e., 3 hour forecasts) were comparable to GSI in the lower level but obviously higher in the middle and upper level (see Fig.2, EnKFfixA02L06, green). It was believed that the EnKF code was working properly, but some configurations, like horizontal and vertical localization scale as well as adaptive inflation factor, still need to be tuned. Therefore, three more experiments EnKFfixA09L12 (blue), EnKFfixA09L12V (magenta) and EnKFfixA09L10V (red) were conducted for this report period. In EnKFfixA09L12, we increased the horizontal localization radius from 600km to 1200 km and increased the parameter used in the adaptive inflation from 0.2 to 0.9. Previous experiment using parameters of 600km and 0.2 respectively was denoted as EnKFfixA02L06. 3-hour forecast innovation showed that improvements have been made for T (temperature) and Q (relative humidity) after the tuning. Although we got smaller forecast errors for the U and V in the upper level, higher forecast errors were found in the lower level. One possible reason is that we used the same horizontal localization length scale for all layers and such scale is probably too large for the layers near the surface. Since in GSI, the horizontal correlation scale increases with the height, we further tuned the EnKF localization as followed. We multiplied a monotonic function 'min(5,500/P_{ob})' to the horizontal localization length scale of 1200km, which will result in a localization scale of 600km and 6000km for the 1000hPa and 100hPa respectively. As expected, experiment EnKFfixA09L12V got lower error levels below 500 hPa when compared to the experiment EnKFfixA09L12. However, the layers above 500hPa became worse, which is probably because we assign too large localization scales above 500hPa in this tuning.

We also further tuned the localization scale based on the observation types (EnKFfixA09L10V). In addition, to see the impact of vertical correlation length, we further reduced the scale from 2.0 to 1.2. Compared with experiment EnKFfixA09L12V, the forecast innovations of most observation types were improved. Moreover, in the lower level, the 3hr forecast error is now smaller when compared to GSI. For the x-component wind, significant improvement was also found between 850 hPa and 550 hPa. The x-component of wind for EnKF performed similarly to GSI below 550hPa, but still worse than GSI at upper levels.

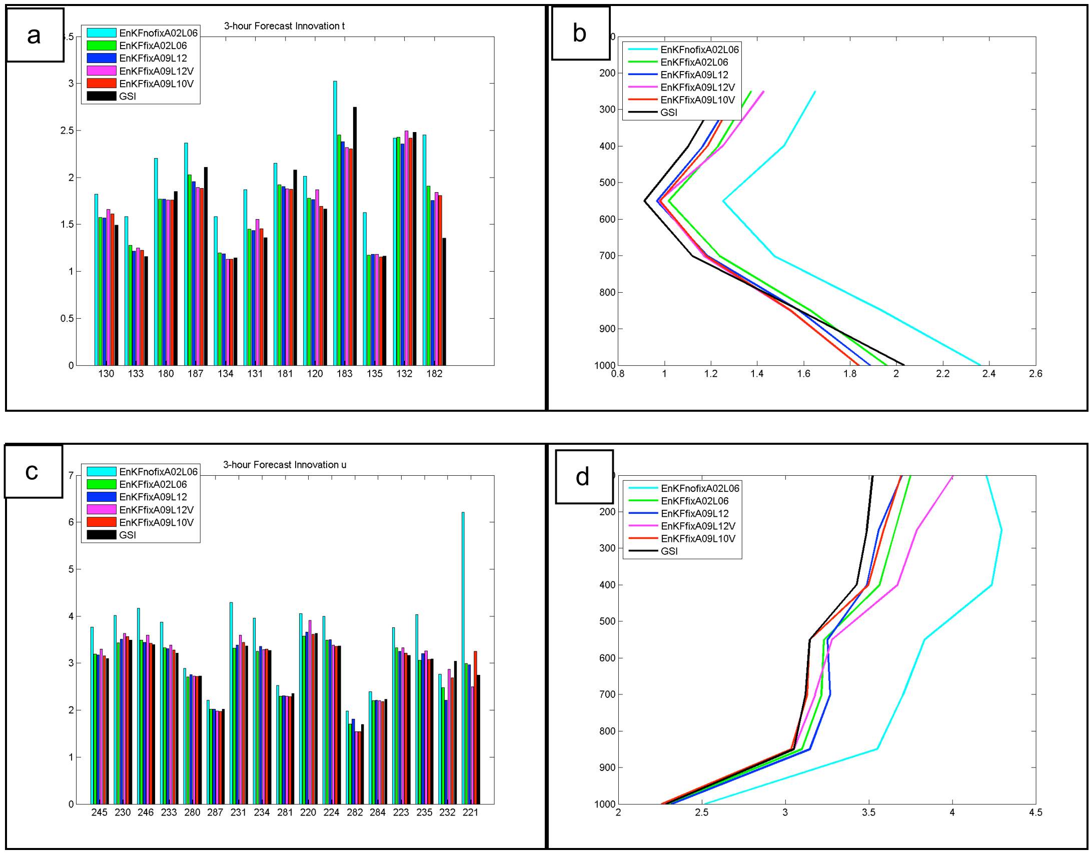

Figure 2. Averaged 3-hour forecast innovation for different observation types (a) temperature and (c) x-component wind. (b) and (d) the same as (a) and (c) but displayed in vertical. The first two experiments were conducted last month. The experiments EnKFfixA09L12 (blue), EnKFfixA09L12V (magenta) and EnKFfixA09L10V (red) are the experiments described in the above.

In December, we conducted single observation test for EnKF. In order to use the same innovation as GSI, the background value at a given point was read manually from the diagnostic files. To eliminate this manual step, we ran GSI twice. The first was to get the background by giving a fixed state value at observation location. Then we set the real observation value equal to the acquired background plus the prescribed innovation. All of these procedures are now controlled by the Workflow Management System (WMS) available on JET.

A new single-observation test was conducted to test the above workflow. The ensemble mean 3-h forecast, which was obtained after 6 days' data assimilation cycles, was used as the background for both the EnKF and GSI. Fig. 3 illustrates the analysis increment for temperature and wind after assimilating a single temperature observation at 700 hPa at 35.23 $^{\circ}N$ and 262.56 $^{\circ}W$, with a 1K-observation increment and an observation error of 0.8K. The left two columns are increments (analysis minus background) of the GSI, and the right two columns are increments of the EnKF. While the maximum of U increment from GSI is 0.105m/s, and that of V is 0.102m/s, U and V increments from EnKF have a max value of 0.172 m/s, 0.651m/s respectively. The magnitude of temperature increment of EnKF is 0.248k, smaller than 0.339K from GSI. The patterns of the increments are also different between EnKF and GSI. This difference is believed to be due to the flow-dependent ensemble covariance in EnKF.

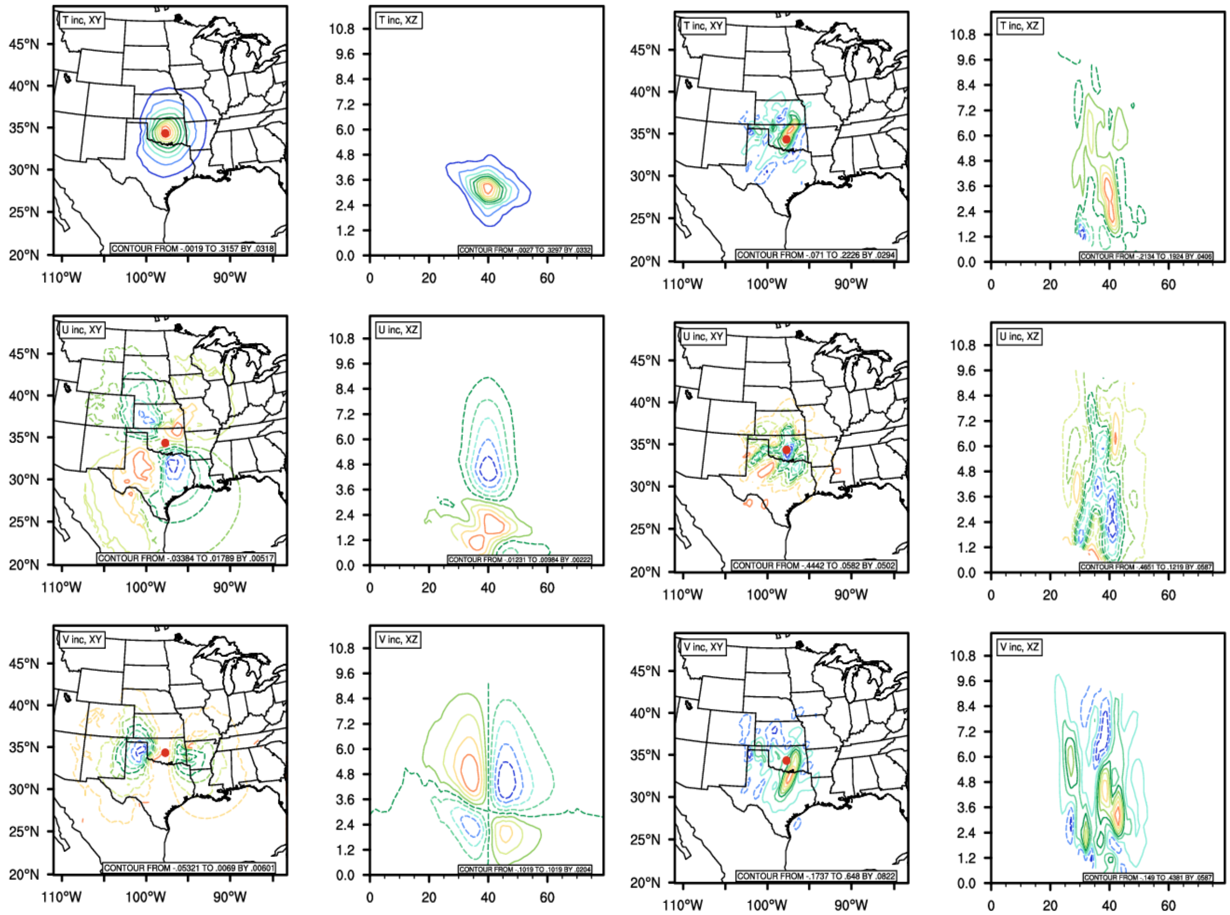

Figure 3. Distribution of increments (analysis minus background), left two columns are from GSI, while right two columns are from EnKF. The first and third columns are at 700 hPa, the second and forth are cross section. The first row is temperature increment, the second is U, and the third is V.

NCEP

Work continued on fixing the non-meteorological profiles generated occasionally by the NAM's GSI analysis. Extra constraints from the rawinsonde temperature observations were added into GSI analysis. The pointer problem with increasing array size was solved. The code was verified with analysis statistics and plots. Methods were tested to properly add the extra rawinsonde humidity constraint into the analysis. Compared with the other humidity variables, i.e., relative humidity, the specific humidity interpolation seemed to work best. These changes are being tested to make sure that they produce no negative impact and that they fix the problem of non-meteorological profiles. The GSI changes to limit the usage of Level 2.5 radar data over CONUS and to increase the ob-errors for Level 3 data were tested with an off line parallel and were found to produce no significant impact on the short term forecasts. The radar changes were then incorporated into the official parallel. A regional hybrid variational-ensemble data assimilation paper to be presented in the AMS meeting was prepared (given by Parrish), and work was done to incorporate the new NEMSIO library into GSI. (Wan-Shu Wu)

Since New HiRes Level 3 data became available at NCO, Shun Liu has worked on checking the difference between the new and old Level 3 data in the analysis. The new Level 3 data has a slightly larger RMS compared to the old. The codes for assimilating radar data in regional GSI have been modified, and the changes include adding subtypes to Level 2, Level 2.5 and Level 3 radar; limiting the use of Level 2.5 data in CONUS domain (still fully used in Alaska); and increasing the observation error for Level 3 data over CONUS. Work continues on interpolating 3D reflectivity mosaic to the NMMB model grid. (Shun Liu)

Work on combining the results from the Lanczos-based estimate of the GSI-2DVar analysis error with those from routine-cross validation runs has begun. The goal is to improve the amplitude of the analysis error, which is always overestimated due to the low-dimensionality of the space of calculations. Revisions for the RTMA manuscript submitted to Weather and Forecasting are complete. (Manuel Pondeca)

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

GSD

A considerable amount of testing occurred in January for different versions of the Thompson microphysics scheme (v3.2, v3.2-corrected, and v3.3) and for the MYNN boundary layer scheme. Currently, the RR uses the v3.2-corrected version of the Thompson scheme both at GSD and NCEP. Joe Olson continues testing of the Mellor-Yamada-Nakanishi-Niino PBL scheme on the RR and a smaller High-Resolution Rapid Refresh (HRRR) look-alike domain. Further robustness was added by eliminating impacts of the surface layer at altitudes well above the boundary-layer height and replacing the existing MYNN formulation with the Bougeault-LaCarrere formulation for the dominant mixing length in the free atmosphere. Overall, these mods have shown good promise of improving MYNN wind forecasts in the boundary layer without degrading temperature forecasts and without causing poorer wind forecasts aloft in individual case studies. A retrospective RR test to compare performance of this scheme to the current MYJ is planned.

NCAR

Subtasks:

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

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

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

Deliverables

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

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

PROBLEMS/ISSUES ENCOUNTERED OR ANTICIPATED: None

INTERFACE WITH OTHER ORGANIZATIONS: GSD

UPDATES TO SCHEDULE: None

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

GSD
The RR with the frozen GSI version (including the cloud analysis) showed further improvements in skill in January 2011 (Fig. 4 below). This further improvement is largely attributed to the modification to the cloud analysis (see Task 5.5) at the end of December 2010.

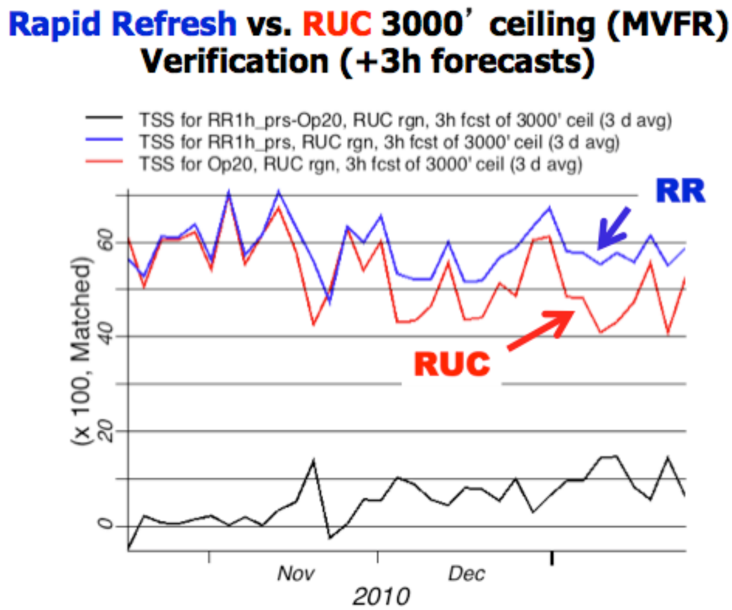

Figure 4. Verification of MVFR ceiling forecasts at 3h duration from the RUC and Rapid Refresh from Oct 2010 through Jan 2011. (TSS – Total Skill Score - higher score is better)

In early February, Ming Hu re-tested the GSI for 3-km application on the CONUS HRRR domain. Previously (spring 2010), he had encountered memory issues on the jet chips, making this application difficult. The new chips have expanded memory, the tests were successful, allowing us to proceed using the GSI cloud analysis to generate a 3-km radar latent heating based temperature tendency field for use in testing 3-km DFI radar assimilation in the HRRR (see task 5.24).

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

GSD
Curtis Alexander has completed work to create sample grib2 HRRR 15-min output files for VIL and other fields. This was completed, by creating full ARW model output files at 15-min intervals and then running two different versions of the UNIPOST utility. The first one creates the 15-min grib2 files, while the second is only run hourly to create the standard hourly HRRR output files (wrfnat, wrfprs, wrftwo). The use of UniPost for sub hourly processing and the conversion from grib1 to grib2 worked well. Note, this conversion step is necessary because at present UniPost only write grib1 output files. Work is underway at NCEP to directly write grib2 files from UniPost.

A significant coordinated group effort has lead to the completion and verification of an extensive set of RUC-HRRR and RR-HRRR retrospective experiment runs designed to yield HRRR forecast improvements over the 2010 season and guide final decisions for the HRRR implementation configuration for the 2011 season. Two retrospective test periods have been considered (June 3-9, 2010 and July 14-24, 2010). HRRR experiments, first required cycled retrospective runs of the 13-km RUC and/or the 13-km RR, followed by 3-km CONUS HRRR runs nested within the parent RUC or RR runs. Several key elements have been absolutely essential to our ability to get these experiments completed and analyzed. These include the additional jet computer cores (the HRRR shadow system), expansion of the jet disk drive system, development of an easy to use robust quantitative verification system, and enhancement of the RUC, RR, and HRRR retrospective scripts.

A variety of different experiments have been conducted to evaluate solution to known HRRR deficiencies (low bias in SE, MCS propagation issues, etc.) and to test planned system enhancements (switch from RUC to RR as parent model, use of 3-km DFI-based radar reflectivity assimilation). Specific tests have looked at: 1) strength of the latent heating within the DFI-radar assimilation for the RUC, 2) removing the 6th order diffusion within the HRRR, differences in formulation of the microphysics within the HRRR, 4) initialization of the HRRR from the RR (with radar assimilation) as opposed to the RUC, 5) and initial tests of the a 3-km DFI-based radar assimilation within the HRRR. Analysis of the results in ongoing, but based on our results we have removed the 6th order diffusion in the HRRR (yielding improved performance for small-scale storms in the SE and fixing a dew point instability in the mountainous regions of the west). In other areas, preliminary results suggest: 1) a small amount of improvement in HRRR skill beyond 4h lead time for the weaker strength latent heating in the RUC, 2) a small amount of improvement beyond 4h for RR vs. RUC initialized HRRR, 3) better initial growth of storms (especially small-scale storms) from use of a 3-km DFI-based radar assimilation procedure.

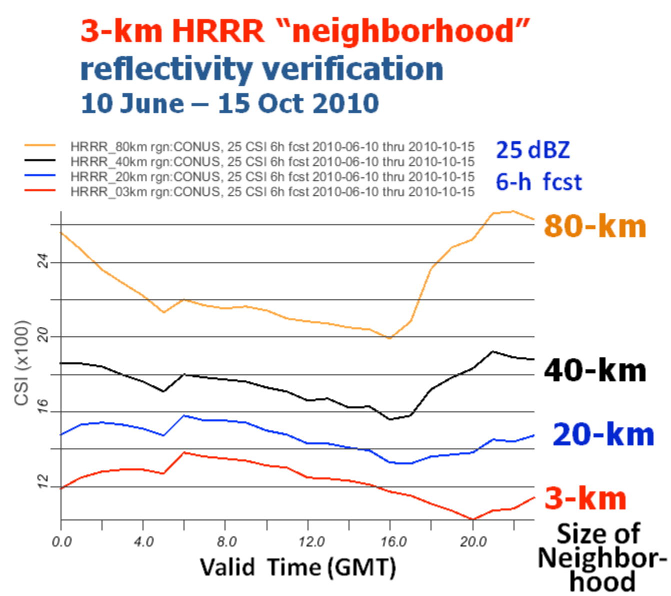

Fig. 5.   A sample reflectivity of verification statistics from the database. Shown is the average CSI as a function of forecast valid time for all 6-h forecasts from the 3-km HRRR for the period from 10 June – 15 Oct. 2010. The CSI skill is shown for verification on small "neighborhood" (3-km) and for successive larger "neighborhoods" (20-km, 40-km, 80-km). Focusing on the convective initiation (CI) time of 1700-1900 GMT (1-3 PM EDT), one can see that although skill is low on the 3-km verification relative to other times, skill grows rapidly for verification over larger neighborhoods. This clearly indicates that while the HRRR does not pinpoint CI locations to within 3-km, it performs well at located CI within 40-km to 80-km.

NCAR

Task: Evaluate convection-permitting forecasting by the ARW core for ultimate application in the HRRR

CURRENT EFFORTS: Jimy Dudhia of NCAR submitted a report on the 2010 convection-revolving ARW simulations for the Spring Forecasting Experiment. He worked with Greg Thompson (NCAR/RAL) to investigate the causes of reflectivity differences seen in the 3-km high-resolution ARW runs of the 2009 tests and the 2010 tests using different versions of the Thompson microphysics scheme. The work identified the main code changes, centered on graupel production, that were responsible for the performance differences.

PLANNED EFFORTS: New RR-initialized, high-resolutions will be planned and conducted in Spring 2011.

UPDATES TO SCHEDULE: NONE

Task 11.5.19 Develop and refine techniques to assimilate radar radial velocity and reflectivity data through GSI and Rapid Refresh toward the HRRR

Not funded in FY11, an unfortunate slow-down to HRRR development.

Task 11.5.20 Develop ensemble-based probabilistic products for aviation users

Not funded in FY11.