MDE Product Development Team
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Executive Summary

Task 10.5.1: Infrastructure support related to operational running of the RUC and NAM operational modeling systems.9

- Testing continues at NCEP for 18h RUC/Canadian data, implementation now scheduled for 9 Mar.
- Improvement to snow cover, fix to 21 Jan RUC crashes will also be included.

Task 10.5.4 Develop, test, and implement Rapid Refresh configuration of the WRF modeling system.

- Fix to BC problem in RR, final major problem that we are currently aware of
- Rapid Refresh continues to provide results better than or equal to those from RUC.
- Overall performance of the RR is now generally suitable for implementation of the RR. Transfer to NCEP cirrus computer continues
- RR real-time cycle at ESRL/GSD running on fully dedicated processors providing much greater reliability.

Task 10.5.5: Develop, test, and implement 3DVARs for RR and NAM

- RR GSI – updating underway to latest NCEP version (Q1FY10 version)
    - commits to NCEP repository from RR are being readied, planned for March
    - further improvements to cloud analysis based on RUC development

Task 10.5.17: Infrastructure support for NAM, future RR, future HRRR, support for community WRF model

- WRFv3.2 nearing readiness. Contributions from NCAR to WRF model, especially on WRF physics, and from GSD on DFI and land-surface model.

Task 10.5.15: Develop methods for improved cloud/hydrometeor analysis in RR

- Ceiling forecasts from RR now generally exceeding those from RUC
- Issue with RR radar assimilation leading to clearing of snow hydrometeors resulting in warm surface temperature bias identified and fixed.

Task 10.5.24/19: Development/testing of HRRR

- CONUS HRRR reliability further improves with interaction between scientists and computer management team at NCEP.
- Improvements to RUC-based initial conditions.
- Summer 2009 retrospective experiments underway to evaluate radar assimilation impacts within RUC and HRRR on HRRR forecasts.
- Good performance from HRRR in winter season fields.
- HRRR showing excellent performance for IFR and LIFR ceilings, somewhat better still than those from RR and RUC.

AMS Conference: Over 10 papers presented by GSD, NCEP, and NCAR scientists related to RR and HRRR. A list will be provided at a later date.

Task 10.5.1 Infrastructure Support Related to Operational running of the non-WRF Rapid Update Cycle System in NCEP Operations

GSD

1. Operational RUC crash on 21 January 2010. Diagnosed by GSD to be related to an extreme frontal zone off the West Coast and behavior of the RUC vertical coordinate in this situation. The initial fix was simply to reduce the RUC model time step (implemented at 18z on 21 Jan), and the next day, a better fix was developed allowing the original longer time step, a simple modification in the coordinate (reduction in sigma layer thicknesses). This code change will be implemented to the NCEP RUC as part of the overall change package (next paragraph) now scheduled for 2 March 2010. This better fix via code change was implemented on 22 Jan to the GSD RUCs (backup (initializes HRRR) and development versions).

2. Upcoming RUC change package at NCEP – planned for 9 March 2010.
Preparation for upcoming RUC change package at NCEP, including extension to 18h, assisting EMC (Geoff Manikin) where current parallel version is being run **(http://www.emc.ncep.noaa.gov/mmb/ruc2/para/)**

Changes included:

- Extension from 12h/9h duration to 18h at all forecast times.
- Correction to cloud analysis code for warm clouds.
- Corrections to snow cover treatment (see next item)
- Decrease in sigma coordinate thickness – more robust for extreme frontal zone case of 21 Jan 2010 (see previous paragraph above).

Snow cover investigation and changes to operational code:

- Background: An important change was made to the RUC on 31 March 2009 to begin using NESDIS snow cover data to trim areal coverage from the RUC 1h forecast under certain conditions (2m temps > 2 deg C, no current precipitation in RUC1h forecast).
- Two discoveries were made, both resulting in deficiencies in evolution of snow cover in RUC and both necessitating code changes to be implemented as part of the upcoming change package:
    - Change snow cover update time to 23z (after new NESDIS IMSsnow data becomes available) instead of the previous setting for 19z (meaning, that snow cover clearing was 20h later than it needed to be).
    - Snow clearing code needed to be matched from land-points in IMSsnow data to nearest land-points in RUC.

NCEP

Geoff Manikin reports the RUC experienced several model failures on 21 January diagnosed by GSD to issues with an extreme mid-level frontal zone in association with an extreme jet stream core just offshore of southern California. The specification of the minimum thickness of model layers is set to 15 hPa in the model, and this can result in a major discontinuity if that value is invoked at a grid point next to a point where the thickness is extremely small. The time step of the model was reduced from 20 seconds to 15 on the afternoon of 21 January in a crisis implementation, and this resulted in an immediate cessation of crashes. This change, however, was made in the initial (mistaken) belief that CFL instability was the cause of the problem. The issue with the minimum thickness was discovered the following day, and a test change was made to a parallel run in which the minimum layer thickness was set to 10 hPa, with the time step reset to 20 seconds. The parallel run has experienced no problems since making these changes, but it was decided to wait and implement this change as part of the 18-hour extension package, currently scheduled for 9 March. In the meantime, the model takes slightly longer to run due to the shorter time step; the final forecast files of a 12-hour forecast are delayed by approximately 4 minutes.

Dennis Keyser reports that NCEP/NCO is investigating radiosonde sites that report an invalid instrument type. NESDIS hasn't yet responded to problems with the GOES 1x1 field-of-view cloud data (a few random files have data problems and GOES-East data often arrives too late to be used). NCEP plans to obtain all TAMDAR data from AirDAT as a MADIS alternative in order to add airframe type and company code to allow improved bias corrections to be developed. NCEP continues work toward moving the superior NRL-based aircraft QC code into production. Changes are being made to speed up the dump processing in order to reduce the extra time used by this new QC code. An updated version of the NCEP BUFR library software is being tested for implementation in FY2010. Efforts are underway to bring in new SSM/IS product data from the DMSP F-16 and F-17 satellites as a replacement to the SSM/I products which are no longer available. The Florida and Georgia DOT as well as the Aberdeen PG mesonet providers have been down for the past several months. The Colorado and Minnesota mesonet providers, which had been down most of November and all of December, returned in January.

Task 10.5.17 Infrastructure support for operational running of Rapid Refresh, North American Mesoscale, and HiResWindow (and future HRRR) at NCEP, including support for community WRF model

GSD

Excellent progress in Rapid Refresh development in January toward upcoming implementation at NCEP. More information under Task 5.4 report.

NCEP

Matt Pyle added the WRF digital filtering to the WRF-NMM dynamical core (it was already in place for the WRF-ARW core but heretofore untested at NCEP) for potential use with high frequency data assimilation. The filtered solution demonstrates significantly less noise over the first 3+ hours of the forecast, and appears to have little impact on the forecast noise at longer forecast ranges. Both of these test results are in line with the literature for digital filtering, and give confidence that it is working properly within the WRF-NMM. The impact on data assimilation has not yet been examined.

Since many obs-processing activities listed under Task 10.5.1 also pertain to the NAM, they are not duplicated here. For the NAM specifically, Dennis Keyser reports that some Alaskan radiosonde sites still need to move up their launch time so the NAM-GSI can use their data. The GOES-12 sounder has increased noise over the past few months, and an episodic filter wheel problem has developed. These problems may reduce the quantity and quality of GOES-12 radiances. On 12 January, NESDIS lowered the priority of NOAA-18, reducing the timeliness of radiances processed from this satellite. AIRS IR and AMSU-A radiances were not available from 1-4 January due to New Year's transition problems and then again from 9 through 27 January due to an instrument anomaly. MODIS winds were not available for 12 hours on 29 January due to a leap second processing problem. The following data types are monitored by the NAM-GSI: RASS virtual temperature profiles (NPN and MAP), Mesonet mass data, and MDCRS moisture data. Monitoring of NOAA-19 1b radiances will soon start. Reduced Level II 88D radar data dump counts on the IBM P6 (vs. the P5) are being investigated. NAM/NDAS and RTMA PrepBUFR files are being generated in parallel with 50 km ASCAT and WindSat scatterometer wind data (both non-superobed) and production NAM/NDAS dumps of METOP IASI radiances, GPS-RO data and SBUV-2 data are being created. These changes to obs monitoring are being tested in Eric Rogers' real-time parallel NDAS/NAM. Replacing the current synthetic wind data bogus with the GFS tropical cyclone relocation procedure (for medium to strong tropical cyclones) to update the global first guess fields input to the t-12 hour NDAS is being tested. 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 NAM/NDAS. The parallel RTMA for Guam is testing the use of low-level satellite-derived winds (added to parallel RTMA dumps on 25 January).

Yali Mao is translating the RUC-based FIP source code from C/C++ to FORTRAN to be eventually added to NCEP's product generation suite.

NCAR/MMM

CURRENT EFFORTS: NCAR hosted and led a WRF tutorial January 25–February 4, 2010. The tutorial covered model structure, preprocessing, and operation, and practical sessions let participants run model components and do test simulations. Over 60 people from 20 countries attended. The WRFDA and MET (Model Evaluation Tools) tutorials were be given in the second week (Feb. 1–5).

NCAR/MMM continued the preparation of the next major WRF release, V3.2. This is targeted for this spring. The Rapid Refresh version of WRF will be updated to V3.2 (per GSD), and GSD is contributing changes for DFI and land-surface model as part of the V3.2 modifications. Activities involved leading the WRF Release Committee meetings and code testing by MMM scientists and software engineers.

Dudhia (NCAR/MMM) completed work on cleaning up the use of pressure information by radiation and cumulus physics (described in previous report). The purpose is to improve efficiency by avoiding repeated computations of hydrostatic pressure needed by these schemes. The mods were added to the repository for V3.2.

Dudhia continued working with Steven Cavallo (MMM) on the improvement of handling top-of-atmosphere radiation in the RRTM longwave scheme. The revised code is nearly finalized, and problems were traced to two issues. First, the RRTM isothermal assumption above the model top was inaccurate, and a new climatological lapse rate profile has now been implemented. Second, in datasets that had no upper-level RH, the Ungrib pre-processor's assumed RH was too high for pressures above about 50 hPa. This was fixed.

Lastly, in preparation of the release, Dudhia worked on minor code changes to the Urban Canopy Model (UCM), the Lin microphysics scheme, the Morrison microphysics scheme, the NBA turbulence scheme, and the Pleim-Xiu LSM.

PLANNED EFFORTS: The support of the physics component of the WRF infrastructure and the implementation of modifications will continue. NCAR will continue to prepare the V3.2 release.

UPDATES TO SCHEDULE: NONE

Task 10.5.4 Develop, test, implement, and improve the Rapid Refresh.

GSD

Rapid Refresh primary and dev 1-h cycles continue to run on w/hJet at GSD. Performance with the "partial cycling" in the primary RR cycle continues to be superior to or equivalent to the GSD backup RUC over the CONUS.

A major step forward this month was the solution to the problem of spurious strong jets normal to the lateral boundaries developing in the course of the 1-h cycling. (Although this untoward behavior was largely suppressed by the partial cycling, its beginnings could still be seen on some occasions in the hours just before the new partial cycle was introduced.) The solution, implemented by Tanya Smirnova, was to modify the NCAR routine *update_bc* to account for a cycling frequency (hourly) higher than the frequency of availability of new lateral boundary conditions from the GFS (every 3 hours), and to make the external-model tendencies consistent with

the analysis increments from the GSI in the lateral-boundary blending zone of the RR. In addition, during the DFI step, the tendencies from the GFS at the lateral boundaries are replaced by zeroes. This latter procedure has always been done in the RUC DFI with no ill effects. The devRR cycle was cold started with the modified *update_bc* in late January and has shown no development of the spurious jets with continuous (not partial) cycling. Further, rerunning of the 10-d April 2009 retro period with continuous cycling showed no signs of development of the spurious jet. As of 12 February both the primary and dev RR cycles are running with the modified *update_bc*, partial cycling, and zero tendencies along the lateral boundaries during the DFI. These upgrades, with the zero tendencies during the DFI as a namelist option, will be passed on to the NCAR WRF developers for candidate inclusion into WRF for the upcoming 3.2 release.

After some further CONUS High Resolution Rapid Refresh (HRRR) testing is complete, we are planning to move the primary RR cycle to the 1224 nodes on nJet dedicated to running the 2010 summer convection forecasting exercise, and to initialize the HRRR from this RR cycle instead of the RUC. We are also considering running the primary RR to 15h or 18h at certain times of the day, depending on computing resources on nJet. When the RR becomes operational at NCEP, it will be run hourly to 18h (see Task 1 for discussion of progress toward the 18-h RUC.)

Tanya Smirnova continues to add RUC options to the NCEP WRFpost-processor (WPP). The recently implemented RUC algorithms for precipitation type applied to the RR are giving similar results to the RUC in areas of mixed, freezing and frozen precipitation. Discussions were begun at NCEP in early December in conjunction with the NCEP Production Suite Review meeting toward merging the GSD additions and enhancements into the new NCEP Unified post program (Unipost), which has replaced the WRF Post-processing Program for the global model and will become the standard post-processor for the NCEP regional models in 2010. Since then, Ming Hu has successfully compiled and run a recent version of the Uni Post on wJet (using Linux) and results from a test case are nearly identical to those from WPP. More recently he has obtained a copy of Unipost from the top of the NCEP subversion trunk and Tanya Smirnova is now converting the many RR options and enhancements made to WPP over the past year or more to run as part of the Unipost at GSD for both the RR and HRRR.

The Unipost also incorporates recently developed NCEP enhancements to post process wrfout files from the ARW when the ARW is run using the rotated lat-lon grid option. These will be tested at GSD on RR output generated from WRF using a slightly modified RR domain based on this grid once required library routines are received from NCEP.

Tanya Smirnova and Ming Hu continue to test pre-release versions of the WRF version 3.2 codes including the GSD enhancements discussed earlier to eliminate the spurious jets near the lateral boundaries. They are working with the NCAR WRF developers to resolve various issues involving DFI.

NCEP

Dennis Keyser reports that experimental Rapid Refresh (RR) PrepBUFR files containing 50 km ASCAT and WindSat data (non-superob) are being generated at NCEP and copied to a private ESRL directory on the NCEP ftpprd server. RR dumps of expanded (time-window) Level 2.5/3 88D radial wind data are also being copied to a public ftp directory. These and hourly lightning data are being tested in ESRL's experimental RR runs. At the request of ESRL, early (T+0:26 minute) parallel dumps were added for 0000 and 1200 UTC on 6 January. Future data tests will include Multi-Agency Profiler winds and METOP-2 radiances. EMC and GSD have requested the ROC start their hourly processing of Level 2.5 88D data 10 minutes earlier so more data will arrive before the RR cutoff. This is critical for the Alaska portion of the expanded RR domain, where the only source of radial wind data is the Level 2.5/3. Alaska Region and Pacific Region are engaged in discussions to provide NCEP with their Level II full resolution data as well.

Subtasks:

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

GSD
The partial cycling primary RR cycle continues to show performance that is equivalent to or better than the backup RUC running at GSD for wind and temperature when measured against rawinsondes. For mid January to mid-February, RMS vector wind errors at all levels at 3 and 12h from the RR primary 1-h cycle were consistently better than or equal to the RUC backup. The RMS temperature errors were similar to a bit better for the RR. There is a small high bias on wind speeds at most levels for the RR1h, and a small warm bias in temperature. The RMSE for RH is similar to the backup RUC below 500mb.

There continue to be issues with 2-m temperature forecasts in the interior valleys of Alaska where there is typically a very stable, cold air mass very near the surface due to persistent darkness. These issues relate in part to the poor fit by the GSI of METAR 2-m temperature reports, in part to the difficulty with current boundary-layer schemes in reproducing the extremely stable conditions in the first 100m or so above the surface (see task 8), and part due to the inability of the model terrain at 13km horizontal grid spacing to resolve the smaller valleys. Separately, a nighttime warm bias over the western CONUS reported on in the FY10Q1 report and due to deficient snow cover, still persists at some stations. We have not attempted to add snow cover to areas that were earlier discovered to be deficient in snow cover. (Recall that soil and snow properties are continuously cycled—they are excluded from the partial cycling.)

NCEP
Nothing to report. (Manikin)

10.5.4.2 1 Nov 2009 (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.

GSD continues to make many different types of RR files available to users (AWR RTs, NWS). We are currently producing 4 flavors of RR files (native level, pressure level, surface field, and precip fields) for each of 3 grids (full RR, Alaska 249, CONUS) and in grib1 and grib2 formats. Per a NWS Aviation Testbed meeting in November in Kansas City, the RR will produce two primary output files:

1. native level 3-d files plus all 2-d fields (land-surface, precip, others), including 2-d diagnostic fields
2. pressure level 3-d files plus all of the same 2-d fields

It was agreed (NWS, NCEP, AWRP PDTs) that these RR files will meet all known requirements.

As a result of discussions with Bob Sharman of the Turbulence PDT, we have added a few additional 2-d fields desired to streamline the generation of their G2G forecasts and have clarified procedures used for calculation of certain quantities by the WRF Postprocessor (WPP). Coordination between GSD and AWC to facilitate transfer of experimental RR grids to AWC is nearly complete and AWC has begun examining RR grids.

10.5.4.3 30 July 2010 (GSD, NCEP, NCAR)
Updated report on status of tactical planning for making RR-WRF ARW model code for 2013 in compliance with Earth System Modeling Framework (ESMF) in agreement with the Sept 2007 Rapid Refresh MOU between NCEP and GSD. Work in this area will commence in FY11.

At a December meeting between GSD and EMC teams, it was agreed to build an RR components from a common set of scripts (initial work by Eric Rogers) and the common NCEP unified post-processor program. On Thurs 14 Jan 2010, ESRL/GSD gained access to the NCEP Unipost code repository (thanks to Huiya Chuanand others at NCEP for this). As a result, work with the NCEP Uni Post is progressing well (see above discussion).

10.5.4.4 31 Mar 2010 (GSD, NCEP)
Complete pre-RFC 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.

An NCEP Charter document for the Rapid Refresh implementation was completed on 10 Dec 2009 and submitted to NCO via Geoff DiMego. Four presentations on RR were given at the 14th Conference on Aviation, Range and Aerospace Meteorology in Atlanta in January 2010.

Deliverables:

10.5.4.E1 20 Dec 2009 (GSD)
Report on Rapid Refresh testing at annual NCEP Production Suite Review meeting.

Stan Benjamin, Steve Weygandt and Ming Hu attended the NCEP Production Suite Review 8-10 December and gave an update on RR progress. This presentation can be found at
http://www.emc.ncep.noaa.gov/annualreviews/2009Review/presentations/Benjamin-Weygandt-RUC_C.ppt

Task 10.5.5 Develop, test, and implement improvements to the operational data assimilation supporting Rapid Refresh and North American Mesoscale runs.

GSD
With the Rapid Refresh running reliability due to the now fully dedicated processors and producing satisfactory performance scores, recent attention has focused on getting the RR package, including the RR version of GSI running in a parallel cycle on the NCEP developmental computers. Ming Hu has modified higher-level control scripts (with IBM features) from Eric Rogers and integrated with lower level specific task scripts from GSD and tested a 6-h cycle on the NCVEP machines. We are working to resolve a minor file access issues: accessing a real-time feed of the pressure-level GFS files for use as boundary conditions (we currently have the spectral coefficient files). One other fairly minor outstanding issue for running the RR cycle at NCEP is to convert the GSI I/O (for the ARW option) from netCDF to binary.

Work has also been proceeding in conjunction with DTC to get the RR-specific GSI enhancements (cloud analysis package and accounting for model vs. actual elevation differences in the surface observation assimilation) added to the shared NCEP/community repository. This has included work (mostly by DTC) to get the community GSI SVN trunk matched with the head of the NCEP trunk (nearly complete), get the platform specific modifications added into the shared repository (partially complete) and get the RR cloud analysis components into the trunk.

Ongoing comparisons continue to show satisfactory performance for the Rapid Refresh compared to the RUC for upper-air, surface and precipitation skill. A detailed summary will be provided in the February report associated with this subtask and deliverable 10.5.5.E2

NCEP

Manuel Pondeca has begun work on adding the assimilation of ocean surface ASCAT and WindSat winds as well as low-level satellite winds to the RTMA. He is also finalizing a journal article on the RTMA. These data have been added to Eric Rogers' NAM parallels as well. A 2.5km CONUS RTMA parallel is being run and is being downloaded for routine evaluation by NWS' Eastern & Western regions.

Dave Parrish is continuing work on the hybrid ensemble option in GSI. GEFS perturbations can now be read in (work by D Kleist), and this method is being adapted as the basis for reading SREF perturbations. Dual resolution capability is almost ready to use. This will allow ensemble perturbations to be used in GSI at their own resolution, which is normally lower than NMMB and GFS. In this way, the benefits resulting from the addition of ensemble information to the background error will incur only a modest additional computational cost to the GSI.

Eric Rogers continued parallel tests of the NEMS/NMMB model in the EMC NAM parallel system. Two NMMB parallels are now being run, the one a control run and the other an experimental run with model and/or analysis changes for inclusion in the control run. In January the Eulerian passive tracer advection of scalars was turned on in the control run, and in the experimental run the radiation parameterization was changed by halving the absorption coefficients for water and ice to 800 and 500, respectively, to try to reduce a cold bias in low-level temperatures in the control run.

Wan-Shu Wu worked on a study of the impact from using GPS-RO data in NDAS. This test used one of the latest versions of the GSI code, since the fixes for using this data in the regional mode had just been committed to the repository. It was found that the repository version could not generate a valid analysis in regional mode. Wan-Shu debugged the version and found an error in using the radar data. The bug had been introduced into the repository even though all the regression tests had been passed. The reason was that although the radar data have been used in the operational NDAS, they were not used in the regional regression tests because the global conventional information file was used. At her request, the current regression tests were changed to be as close as possible to what is run operationally in the regional. In order to do a clean impact test on the data, both the experiment and a control with the fixed version of the GSI were run at the same time. The results indicated that the GPS-RO data improved the temperature and the humidity fields but had no impact on the wind and surface pressure fields.

Deliverables:

10.5.5.E3 31 Dec 2009 (GSD, CAPS)

Further refinement to the radial velocity analysis component of GSI for Rapid Refresh configuration.

With some assistance from GSD, Yi Yang at CAPS conducted a controlled retrospective test for a Kansas MCS case from 15-16 June 2009. Comparisons were made between Rapid Refreshes run with no radar assimilation (the control), reflectivity assimilation, single-pass radial velocity assimilation, a 2-pass radial velocity assimilation (using a shorter error correlation length scale) and both radial velocity assimilation option in conjunction with the reflectivity assimilation. 3-h, 6-h, and 12-h precipitation verification score comparison indicate that as expected the biggest improvement over the control comes from the addition of the reflectivity assimilation. Consistent with similar tests conducted at NCEP, addition of the radial velocity data (with either 1 or 2 passes) yielded little additional improvement.

Discussion with Shun Liu and Dennis Keyser on the radial velocity data access issue has yielded progress. The very large size of the existing level II files (that made real-time transfer to GSD and use within the RR difficult) is because the files contain 3-h of radial velocity data. Work is underway at NCEP to produce smaller level II files

(containing data from a much narrower time window). Transfer and use of these files will alleviate the data latency issue with the level 2.5 files that precluded real-time use of them within the GSI for RR.

10.5.5.E2 28 Feb 2010 (GSD, NCEP)
Complete report on Rapid Refresh performance, including that from the GSI component of the RR, in comparison with the operational RUC.

A detailed comparison of RR and RUC was completed in preparation for a GSD internal review of the AMB group, including upper-level, surface and precipitation verification. Details are in slides 82-91 in (**http://ruc.noaa.gov/pdf/RR-RUC-TR_11_3_2009.pdf**) and summarized in 10.5.5.2.
Complete with 8 Dec 2009 presentation at NCEP Production Suite Review meeting:
http://www.emc.ncep.noaa.gov/annualreviews/2009Review/presentations/Benjamin-Weygandt-RUC_C.ppt

10.5.5.E3 1 May 2010 (GSD, NCEP)
Pending EMC, and NCEP Center initial recommendations, Requests for Change (RFCs) are filed to submit GSI code as part of Rapid Refresh software to NCO.

Task has been previously completed. Kefeng Zhu (CAPS/OU) is conducting additional his radial velocity experiments for the 16-17 June 2009 MCS case geared toward the next version of GSI for RR. One focus has been on the use of shorter correlation length scales. The experiments have been conducted using a Rapid Refresh retrospective setup running on the wjet supercomputer at ESRL. Additional details under subtask 10.5.5.1

Task 10.5.8 Improve physical processes in the WRF (RR and HRRR) and NAM models, especially including those that affect aircraft icing.

Subtasks:

10.5.8.1 30 Nov 2009 (GSD)
Complete systematic GSD evaluation of physics performance in GSD 1-hour RR cycles for initial RR implementation.

The overall performance of the RR WRF physics configuration was completed as part of the November (GSD Tech Review) and December (NCEP model review) meetings. The behavior of the physics (a critical component) appears to be very good, with the RR model now producing at least equal results to the RUC in all key areas (upper-level wind/temp – better, surface wind/temp/Td – about equal overall, precipitation – better for CSI, perhaps too high for bias, ceiling – better for MVFR and IFR conditions). Additional evaluations will be conducted up to the transfer of RR code to NCEP/NCO, but these results including the physics now appear adequate.

The Rapid Refresh will be upgraded to WRFv3.2 when it is released by NCAR in early spring 2010. WRFv3.2 will include some improvements to the Thompson microphysics and RUC land-surface model. An RR retrospective test of the MYNN vertical mixing (boundary-layer) scheme with enhancements to the mixing-length formulation is still planned. We are looking particularly for evidence of beneficial impacts on prediction of low level wind and temperature, and amplitude of the diurnal cycle of temperature, as compared to the MYJ currently used in all the GSD RR cycles.

10.5.8.2 30 July 2010 (NCAR/RAL)
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.

10.5.8.3 1 April 2010 (GSD)
Test and evaluate upgrades of RUCLSM to handle sea ice and snow cover on sea ice under wintertime conditions for FY11 Rapid Refresh upgrade.
The new version of the RUCLSM with the explicit prediction of sea ice temperature and its effects on sea ice albedo, as well as accumulation and ablation of snow on the sea ice, continues to run in the RR at GSD. So far, performance has been satisfactory. NCAR has submitted these enhancements to the WRF svn repository and they will be part of the WRF v3.2 release expected by late March 2010.

10.5.8.4 1 Aug 2010 (GSD)
Continue exploring possibilities for enhancing treatment of sea ice and tundra (including albedo changes and spring-time ponding) in Rapid Refresh domain toward a FY11 Rapid Refresh upgrade.

10.5.8.5 30 July 2010 (NCAR-RAL)
Evaluate the new aerosol based ice initiation scheme that was implemented into WRF during the previous year using available case studies, including ICE-L and IMPROVE II.

10.5.8.6 30 Aug 2010 (NCAR-RAL)
Develop a scheme to explicitly predict the number of cloud droplets based on an assumed aerosol/CCN spectrum. This includes testing various droplet activation schemes in the recent literature based on updraft, general turbulence characteristics, super saturation, and aerosol properties. These changes will enable improved prediction of the size distribution of water droplets, including when freezing drizzle will occur.

10.5.8.10 30 Sept 2010 (GSD, NCAR)
Begin testing at GSD of latest version of microphysics for Rapid Refresh upgrade in FY2011.

Deliverables:

10.5.8.E2 1 May 2010 (GSD)
Pending EMC, and NCEP Center initial recommendations, Requests for Change (RFCs) are filed to submit upgraded WRF model physics code as part of Rapid Refresh software to NCO.
10.5.8.E3 30 July 2010 (NCAR-RAL)
Provide an improved microphysics scheme to GSD for evaluation toward the FY11 Rapid Refresh upgrade.

CURRENT EFFORTS:
Trude Eidhammer added the option to let the initial aerosol concentrations vary based on land surface characteristics in the aerosol input files. Since background aerosol concentrations are taken from the 2.5 x 2 degree GOCART global model, aerosol concentrations can therefore be “smeared” out and local hot spots missed. We now allow for sulfate to be much higher in urban areas. Dust concentration is also allowed to be increased in the initial file if the surface wind is strong over typical dust emitting surfaces.

This effort will be merged in the future with GSD’s testing of the RR-chem and HRRR-chem.

PLANNED EFFORTS:
Continue testing the new aerosol scheme.

PROBLEMS/ISSUES ENCOUNTERED OR ANTICIPATED:
None

INTERFACE WITH OTHER ORGANIZATIONS:
GSD

UPDATES TO SCHEDULE:
None

Task 10.5.15 Develop improved methods of cloud and moisture analysis for use in the Rapid Refresh and NAM Modeling Systems.

GSD

GSD continues to monitor performance of the cloud analysis within both the RUC and Rapid Refresh. Work is also ongoing to get the RR GSI cloud analysis components ported to EMC GSI SVN repository. Also, GSD scientists met with John Derber and NCAR scientists to discuss ongoing work to transform the current RUC/RR cloud analysis to a variational-based cloud analysis. As some initial steps toward that goal, Stan Benjamin has begun testing an initial variational enhancement to the RUC cloud analysis. In this formulation, water vapor innovations are created based on existence of ceiling observations (resulting in RH=1.0 obs just above cloud base or ensuring sub-saturation below cloud base). The effects of this change were monitored for a few days and showed the desired result that they had statistical properties similar to those of conventional water vapor innovations). Recently these pseudo-innovations for RH from METAR ceiling obs have been introduced into the RUC 3DVAR variational water vapor solver. Very preliminary results suggest that they are producing slightly increased retention of assimilated cloud information within the RUC (as evidenced by improved IFR and LIFE ceiling verification).

Subtasks

10.5.15.2 5 Jan 2010 (GSD)

Complete improved version of 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.

A number of improvements have been made to the RR/GSI cloud analysis, including moving the cloud analysis after the variational solver, so that modifications made by the cloud analysis are retained within the final analysis fields. In addition, Ming Hu and Stan Benjamin have conducted a detailed evaluation and comparison of the RR/GSI cloud analysis with that from the RUC, and have identified and resolved a number of small differences between the RR and RUC cloud analyses that were degrading the RR cloud analysis skill scores. As a result, POD and TSS scores for both analyses and 1-h forecasts have improved recently for the RR and are now very competitive with the RUC (see Fig.4 below). These improvements were first introduced in to the RRdev cycle, and then ported to the RRprim cycle. Additional work by Ming Hu in late November has further improved the RR cloud analysis so that it is outperforming the RUC for IFR and MVFR ceiling forecasts.

We continue to assimilate experimental NASA Langley satellite-derived cloud-top data into the RRdev cycle. These data provide much more extensive coverage over Canada and Alaska, and the tropical Pacific and Atlantic Ocean regions of the RR domain. Qualitative evaluation of results indicates that introduction of these data help to reduce a high bias in high-level cloudiness of the tropical ocean regions.

Further improvements to the RUC/RR cloud analysis have been developed including, for the first time, allowance of partial cloudiness from the background 1h forecast in the vicinity of METAR stations. Also for the first time, innovations (observation-background differences) for clouds using the background grid column nearest to each METAR station are being used. This new code will be moved into GSI by March 2010.

On 15 Jan 2010, a solution was implemented to a problem with the RR cycled snow cover. GSD scientists had previously uncovered an issue with the Rapid Refresh cloud analysis inside GSI, in which snow hydrometeors are being erroneously removed, leading to less accumulated snowfall during the 1st hour of the model integration with the hourly RR cycling. This is the critical period for the cycled snow depth field in the Smirnova LSM used in the RR. This reduced snow depth, has in turn led to warm temperature biases over snowpack. This problem is now fixed.

10.5.15.3 30 Jan 2010 (GSD)
Complete improved diabatic digital filter initialization (DDFI) in the 13-km RR WRF model including assimilation of radar reflectivity data

Assessment of the RR DDFI reflectivity assimilation continues, including evaluation of retrospective case study results and summertime precipitation skill scores. Results look good overall, but some adjustment to the strength of the latent heating forcing may be made. Tests are now underway with the latent heating reduced by 50% in the development version of the RUC. HRRR tests will be performed using initial conditions from the devRUC compared to the usual configuration with the backup RUC. We hypothesize that this will result in less "shattering" of 2-3h HRRR reflectivity fields, an intermittent weakness in 2009 HRRR forecasts.

Deliverables:

10.5.15.E2 1 May 2010 (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.

10.5.15.E3 30 Aug 2010 (GSD)
Complete testing of revised cloud analysis for part of FY11 change package to Rapid Refresh

Task 10.5.24 Develop, test, and improve the 3-km WRF-based High-Resolution Rapid Refresh

Subtasks:

10.5.24.1 15 Jan 2010 (GSD, NCAR/RAL, NCAR/MMM)
Design the assimilation/modeling configuration for the HRRR during the 2010 summer convection forecasting (CoSPA) exercise.

As of late January, the HRRR is running with good reliability on 840 dedicated nJET cores. We are nearly complete with a change that will further enhance the delivery of HRRR guidance to CoSPA. This enhancement is to break up the 15-min VIL file (previously a single file with all output times from the entire 12-h HRRR run) into a series of 3-h files. These reduces the latency in the delivery of the VIL fields for the shorter hour forecast hours and also allows for transfer of at least some of the HRRR output in the event that the HRRR runs does not complete fully (as can happen when with slow I/O on one of the jet cores). An additional benefit is the ability to add extra surface fields to the 15-min output files. These fields will assist with high time and space resolution frontal and boundary detection. We are currently moving the RR to the faster (and also fully dedicated) nJET

cores to prepare for a switchover later this month to run the HRRR nested within the RR. The only other changes we anticipate for the HRRR is a possible extension to 15 hours forecast length and a possible addition of a 2nd pass radar reflectivity assimilation.

10.5.24.2 15 Aug 2010 (NCAR/MMM, GSD)
In collaboration with GSD, NCAR/MMM will work to evaluate convection-permitting (e.g., 3-km) forecasting by the ARW core for ultimate application in the HRRR. It will perform and evaluate convection-permitting forecasts using the radar-enhanced RR (13-km) grids from GSD for initial conditions, in order to identify strengths and weaknesses of the model at high resolution. This will include analyses, for selected cases, of the evolution of convective storm mode during first 1–3 hours of model transition from 13-km resolution to 3-km resolution. NCAR will collaborate with GSD in the process and submit a summary of results.

This work is ongoing in conjunction with NCAR personnel (including David Dowell, Jenny Sun, Mei Xu, James Pinto, Jimy Dudhia), with monthly meetings to exchange information. Issues that have been examined include domain size, grid-resolution, and choice of background grids, microphysics options, and surface temperature biases (related to model post-processing). In additional, as part of the 2009 retrospective verification, GSD has re-run specific cases (09 through 15 UTC, 29,30,31 July) and transferred files to NCAR and MIT/LL for CoSPA retrospective processing. NCAR's initial evaluation of these results showed an improvement to CSI for VIL forecasts by 20-40% for 1-5h forecasts when radar reflectivity assimilation was included compared to the operational HRRR runs last summer without radar data.

Deliverables:

10.5.24.E1 30 Sept 2010 (GSD)
Complete FY10 test (likely with full CONUS domain) with 3-km High-Resolution Rapid Refresh running every 1 h.

- Conduct real-time summer 2010 HRRR forecasts using 3-km WRF initialized with radar-enhanced Rapid Refresh over full CONUS domain, monitor performance, modify code/scripts as needed, maintain high reliability working with ESRL computer facility
- Coordinate with other AWRP users and other collaborators, including coordination of HRRR grid transfers
- Provide project management
- Lead writing of report on summer 2010 HRRR experiments

In late Oct. 2009, GSD began running in real-time an hourly cycled CONUS HRRR. The CONUS HRRR runs take about 50 min. of wall clock time on 840 cores. GSD worked with NCAR and MIT/LL too make sure cut down (2/3 CONUS) versions of the key HRRR output files were in place to allow uninterrupted product generation as CoSPA is switched to full CONUS. Following this checkout, the GSD 2/3 CONUS HRRR runs were discontinued. Work is ongoing to further optimize the HRRR code and scripts for reliability and runtime.

10.5.24E2 30 Sept 2010 (NCAR/MMM)
Collaborate with GSD on analysis of convection-permitting forecast cases for 3-km ARW initialized with RUC-RR radar-initialized DFI grids. Draft and deliver summary of conclusions and results.

Work ongoing with monthly meetings. See discussion in 5.24.2

10.5.24E2 30 Sept 2010 (NCAR/RAL)
Deliver report summarizing all HRRR experimental results on sensitivity to physical parameterizations, initial conditions and assessment of HRRR results for key case studies from high impact weather days.

10.5.24.E3 30 July 2010 (GSD)
Complete a report on initial applications of HRRR forecasts to icing, winter weather, and turbulence forecasts.

Task 10.5.19 Develop and refine techniques to assimilate radar radial velocity and reflectivity data through GSI and Rapid Refresh toward the HRRR.

GSD
GSD has completed a set of summer 2009 retrospective HRRR experiments to systematically evaluate the different radar assimilation configurations within the RUC / RR and the HRRR. The experiment grids have been transferred to NCAR for evaluation within CoSOA. Verification results provided by NCAR indicated this expected improvement in forecast with the RUC radar assimilation (compared to those without the RUC radar assimilation). Fig. 2 shows the CSI skill score comparison of the HRRR run from a RUC with the radar assimilation and a HRRR run from a RUC without the radar assimilation, averaged over seven runs during the morning of 30 July, 2000. As can be seen the improvement extends out through 6 hours. This improvement is in addition to the significant improvement in HRRR forecast initialized from the RUC (even without the radar assimilation) compared to initialization from other operational models. Taken together, these results document the important contribution of both the high frequency assimilation of mesoscale environmental information as well as storm-scale (radar and satellite) information).

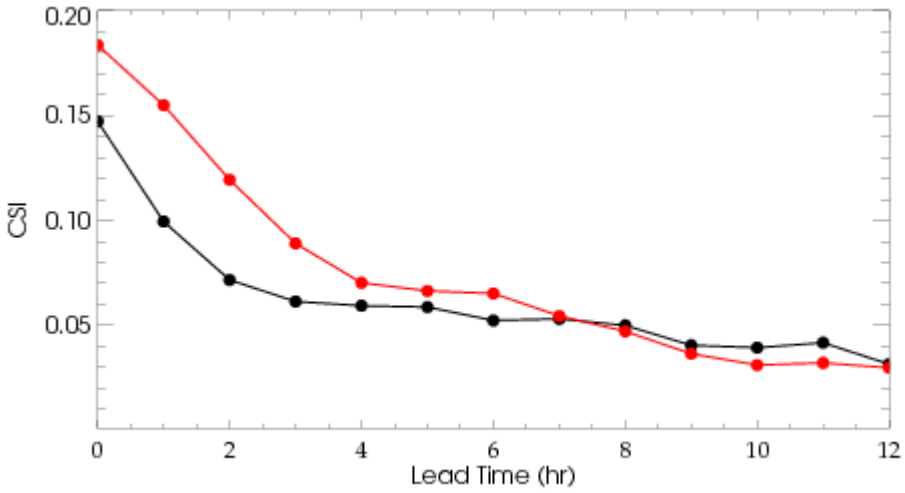

Fig. 1 CSI skill score comparison for the HRRR run from a RUC with the radar assimilation (red curve) with a HRRR run from a RUC without the radar assimilation (black), averaged over seven runs during the morning of 30 July, 2000.

NCEP
Shun Liu reports that a set of experiments were made to test the assimilation of radial wind twice with hourly intervals for the HiRes initialization. Three experiments were setup. In the first experiment, radial winds were assimilated twice with hourly intervals. In the second experiment, radial winds were not assimilated at all. In the third experiment radial winds were assimilated only at the beginning of the forecast. The results of these experiments are now being evaluated.

Shun Liu RFC'ed the 2009 radar bundle update to NCO for implementation. This update includes improving the radar data QC package, dumping VAD winds from the QC package and converting 3D mosaic products to GRIB

format. An update to include the PBL estimation algorithm in this version of QC package was also requested. Efforts are underway to test the PBL estimation algorithm and dump estimated the PBL values in BUFR format.

Deliverables:

10.5.19.E1 30 April 2010 (CAPS)
Provide new radial wind assimilation in 13km GSI designed specifically to improve HRRR initial conditions to be applied in summer 2010 HRRR exercise.

Experiments have been performed with the June 16, 2009 test case using the same domain and resolution as the 3-km HRRR grid of March 2009, which covers approximately the eastern 2 / 3 of CONUS. The HRRR used the same options as the current RR except that cumulus parameterization is turned off. Hourly assimilation cycles were performed over a 12 hour period, with the first analysis performed at 18 UTC, June 15, 2009, using 3-hour RR forecast from 15 UTC as analysis background. 12-hour forecasts were launched from each of the hourly analyses. For the verification, the HRRR forecast results were then interpolated to the same resolution as the RR but in much smaller domain which only covers the main part of the MCS.
In the last quarterly report, the GSS scores of HRRR and RR forecasts were reported where the HRRR runs assimilated only radar data. The HRRR using only radar data get higher scores in the first few hours of forecast than the RR with all the available data. The lower scores of in the later hours may be due to the lack of traditional data.

In the past month, the HRRR experiments were repeated in which both radar and conventional data are assimilated for a clean comparison with RR. The results were verified at the RR resolution by interpolating HRRR to the RR resolution, and at the HRRR resolution both interpolating the other way. Both verification domains cover the main part of the MCS. The GSS scores obtained in two different ways are very similar. As was found before, HRRR performed better than RR in the first few hours of forecast while RR gave higher scores on average for the remaining hours.

To find if the lower scores in the later forecasts of HRRR were due to possible undesirable effects of performing self cycling at the HRRR resolution where possible over-prediction of convective-scale features might be harder to suppress, we repeated the HRRR forecasts using the 1-hour RR forecasts as the background instead (RR_DFIRAD in Fig. 2), and compare them with those using self-cycled HRRR forecasts as background (HRRR_DFIRAD in Fig. 2). It can be seen the self-cycled scores are better (blue curves are generally above the green curves).

At the same time, we further tested the impact of digital filtering on the HRRR grid. Figure 2 shows the results of with the radar-enhanced TDFI used by the quasi-operational RR system (RR_DIFRAD), with standard TDFI contained in the official WRF release (RR_DFI), and with the DFI option switched off in the WRF integration (RR_NoDFI). The results show only minor differences with the use of different DFI options, suggesting perhaps digital filter procedure is less important on the 3-km HRRR grid, where direct forcing and development of convection can be better handled by the model than the 13-km grid, where cumulus parameterization is still important. More extensive evaluation may be needed for robust conclusions.

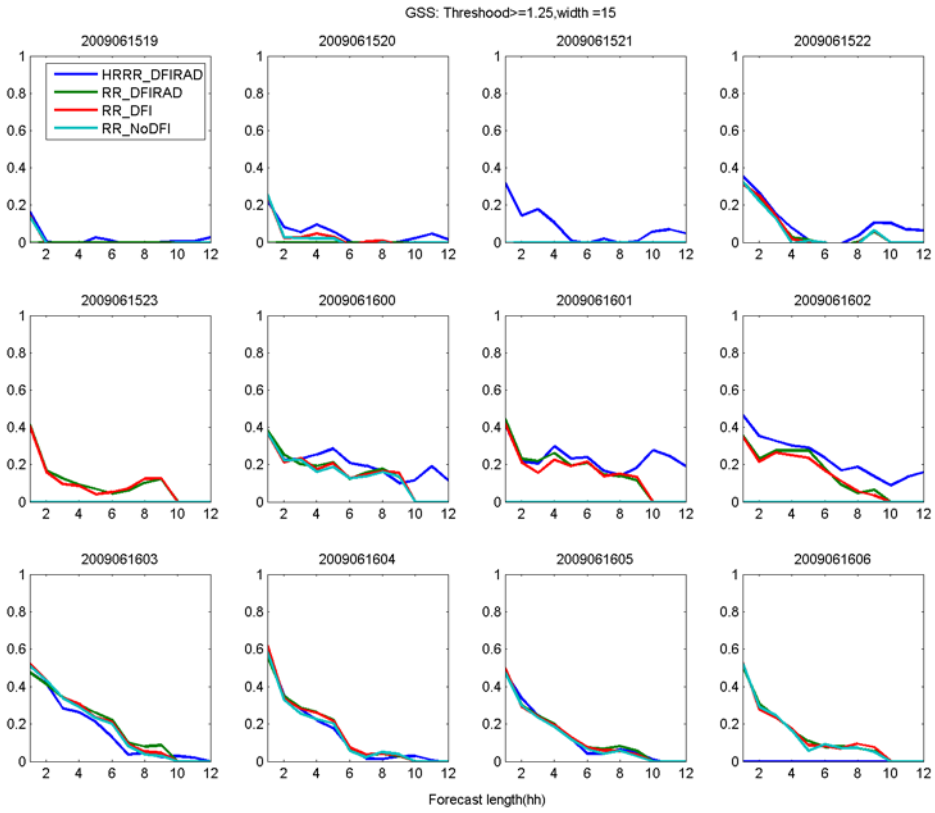

Fig. 2. GSS scores of HRRR forecasts with using different background fields and different DFI options. 'HRRR' represents the self-cycled run using the latest 1-hour HRRR forecast as the background except for the first analysis. 'RR' denotes the use of 1-hour RR forecast as the background. 'DFIRAD' represents the RR radar-enhanced DFI, while 'DFI' represents the DFI in official WRF release. 'NODFI' denotes no use of DFI in the WRF forecast. In the plots, some zero values are corresponding to missing scores due to WRF post-processing failure in the WPP step.

Deliverables

10.5.19.E4 15 September 2010 (Liu, Pyle, Parrish)
Demonstrate mini-NDAS data assimilation system using HRRR-like design constructed to precede HiResWindow runs or Matt Pyle's SPC runs using hourly updates with GSI.

CURRENT EFFORTS: (See also Liu activities under 10.5.5 above) In preparation for eventual regional data assimilation using ensemble information, the hybrid ensemble method (Wang et al, 2008) has been installed and tested in GSI. This is based on the formulation reported in Wang et al, 2008, and the development has been done in collaboration with Xuguang Wang. The code does not yet read ensemble perturbations. For testing purposes, ensemble perturbations were generated internally from random vectors sampled from the existing fixed background error. Initial hybrid ensemble code installed and tested in GSI. (Parrish)

PLANNED EFFORTS: Add interface to read existing regional ensemble perturbations from SREF. (Parrish)

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS: GSD, University of Oklahoma

UPDATES TO SCHEDULE: None

10.5.19.E5 15 Sept 2010 (CAPS, NCEP and GSD)
Report on the design and initial development of EnKF data assimilation for Rapid Refresh scale

Task 10.5.20 Develop ensemble-based probabilistic products for aviation users.

GSD
Doug Koch and Curtis Alexander conducted HCPF sensitivity tests and further examined the HCPF skill and documented the skill improvement by adding additional time-lagged ensemble members. In addition statistical reliability plots were created. Additional work has focused on developing a linear regression-based procedure for specify non-constant ensemble member weighting factors as a function ensemble member lead time. They have also conducted a retrospective evaluation of HCPF skill sensitivity to various parameters including the number of included time-lagged ensembles (documenting the HCPF improvement by adding older forecasts).

NCEP
Jun Du reports that the work related to the precipitation bias correction of the SREF system continues. Some effort was spent on investigation of a new method of smarter ensemble averaging. A poster presentation about a fog ensemble study was prepared for the AMS annual meeting by Jun Du and presented by Binbin Zhou. Binbin also gave an oral presentation at the AMS meeting to introduce NCEP's VSREF system to the community.