MODEL DEVELOPMENT AND ENHANCEMENT RESEARCH TEAM

Monthly Report for July 2008
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Executive Summary

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

- Testing continues at NCEP for RUC upgrade package code (radar reflectivity assimilation, TAMDAR, radiation, Grell/Devenyi upgrade). Implementation planned for fall 2008, possibly by Sept 2008. Real-time comparisons continue in http://wwwt.emc.ncep.noaa.gov/mmb/ruc2/para.
- New forum post at http://ruc.fsl.noaa.gov/forum/f2/Welcome.cgi/read/1832
- GOES PW 1x1 near-term change for RUC, higher-resolution GOES PW data but only over water.

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

- Updated web-page with hourly cycled RR at http://rapidrefresh.noaa.gov .
- One-hour cycle using WRF version 3.0, DFI, and latest regional GSI version (March 2008) now running reliably at GSD and without severe daytime cold bias seen earlier.
- ***Rapid Refresh now planned to run out to 18h duration hourly.***

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

- Further modifications incorporated in July into RR version of GSI

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

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

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

- HRRR changes in last quarter: Now running 1h earlier, also using DFI-output (showing large improvement), and being moved to different queue for better reliability.
- 15-min VIL output from hourly HRRR available at: http://ruc.noaa.gov/hrrr/vil
- New HRRR reflectivity "matrix" web-page at: http://ruc.noaa.gov/hrrr/reflectivity.cgi

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

GSD

Updates on two change packages to operational RUC:

a. **Small change package for GOES 1x1 PW**
b. **Larger upgrade (~September) change packages to RUC**

a. GOES 1x1 PW change

This near-term change will occur within the next 2 weeks. Background: NESDIS is waiting for a RUC change to cease production of 3x3 field-of-view (FOV) precipitable water (PW) data, which the operational RUC currently assimilates. Thus, this change will be for modifications to the RUC analysis to allow use of the much denser 1x1 FOV PW data. NCO is now working on these changes (developed previously at GSD and tested there and at EMC).

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

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

The RUC upgrade continues in parallel testing at NCEP. Real-time comparisons continue to be available at http://wwwt.emc.ncep.noaa.gov/mmb/ruc2/para. Both GSD and NCEP/EMC have used this web site on a daily basis to compare forecasts between the operational RUC and parallel RUC (with upgrade). NCEP/NCO has implemented their radar reflectivity processing with super-hi-res data, a prerequisite for the RUC upgrade.

A new update on the RUC upgrade was posted on the RUC web forum on Tues 12 August 2008 -- see http://ruc.fsl.noaa.gov/forum/f2/Welcome.cgi/read/1832

Current planned implementation date – fall 2008, possibly as early as September 2008

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED: None, updates on planned implementation will soon be announced.

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

Dennis Keyser reports that an implementation on 8 July replaced the “old science” (based on 5x5 matrix of fields-of-view[f-o-v]) GOES cloud data with the improved “new science” form (based on single 1x1 f-o-v data). Two problems with the “new science” GOES cloud data are random files (2-4 per day) where NESDIS encodes 1 or 2 reports at the beginning with missing lat/lon and a bogus satellite id, and the later arrival of the eastern GOES data which can reduce the number of obs in the RUC dump files for some cycles (NESDIS has been contacted on both issues). Tests of RUC using GOES 1x1 f-o-v PW data are underway. An obs-processing change package which includes turning on the 1x1 GOES and establishing a Rapid Refresh data processing system started running in NCO parallel production in early July and is scheduled for implementation in late August. Radar processing of new Build 10 data (see Task 08.5.17) is effecting the generation of 88D mosaics used in the parallel RUC. Some radiosondes are not receiving the proper instrument type due to obsolete entries in the NCEP/NCO upper-air dictionary. NCO has filed a Request For Change (RFC) to correct this and it should be implemented in August. Parallel testing of TAMDAR aircraft temperature and wind data is also currently underway. At the request of ERSL/GSD, efforts are being made to get TAMDAR airframe type and company code (currently not provided in either the ESRL MADIS or AirDAT feed) to allow for improved bias corrections.

Geoff Manikin reports that in the fall of 2007 EMC began running a parallel version of the RUC model, with the primary feature of this code being the assimilation of radar reflectivity data. Geoff Manikin has worked with Shun Liu to generate hourly reflectivity mosaic files to be ingested by the RUC, and the assimilation of the mosaic data is linked to the digital filter initialization to specify the 3-d profile of latent heating. Other changes include the assimilation of TAMDAR data and mesonet wind data from a list of approved providers, a change in the longwave radiative scheme from Dudhia to RRTM, a modification to the snow component of the land-surface model to decrease excessively cold 2-meter temperatures over fresh snow at night, another change to the snow model to allow for warmer temperatures during warm

advection events over snow cover, and a modification to the convective scheme to decrease widespread coverage of light precipitation. Daily comparisons of operational and parallel forecasts along with a statistical evaluation continue. NCO has taken over the processing of the radar data, and while getting this started has been rather slow it should be fully running by late August. Updated code for the RUC system was turned over to NCO during July, and they will begin their parallel testing in early August with implementation scheduled for September. In addition, an upgrade to the operational RUC should be made in August to switch to reading 1x1 GOES precipitable water since this month NESDIS has shut off their 5x5 data. With help from Dennis Keyser, the analysis code is being updated to handle a larger volume of GOES precipitable water data. GSD/EMC discovered that the new precipitable water feed has a high moist bias so code is being prepared to deal with that. A late August implementation of the new system is likely.

Subtasks

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

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

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

08.5.1.4 Maintain access to model verification data.

Deliverables

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

CURRENT EFFORTS:

PLANNED EFFORTS:

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS:

UPDATES TO SCHEDULE:

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

ESRL/GSD
During July, work continued toward making GSD's Rapid Refresh (RR) 1-hour cycle more reliable and more efficient. As described in the FY08 Quarter 3 report, the RR is now running with major upgrades to both the WRF model component (version 3.0) and GSI analysis component (March 2008 release) of the real-time hourly cycled RR at GSD.

With assistance from Dennis Keyser and others at EMC, the problem associated with the unreliability of the real-time RR PrepBUFR (and satellite radiance) observation data feed from NCEP has been resolved. The processing to create these files for the operational RUC is now running in parallel within NCO at NCEP (planned operational implementation on Aug. 19) and PrepBUFR files are now being obtained from an NCEP ftp site. Dezso Devenyi is comparing the observation counts for GSI runs with these new files and the ones GSD was obtaining previously (from the less reliable feed), with a planned switchover for the GSD real-time RR to follow next week.

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

We have also started using the 6th order diffusion option, motivated by the desire to reduce the likelihood of model crashes due to violation of CFL criterion in regions of strong vertical motion.

Taken together, these changes have made the 1-h cycle run much more reliably on wJET. A 12h forecast on wJET is now usually completed in about 3200s using 128 processors (120 for the model, 8 for the "quilted" I/O). The GSI, usually takes about 720s using 64 processors.

We have also explored use of the adaptive time step option in WRF 3.0, in which the time step is increased (or decreased) during the run according to the maximum value over the domain of the Courant number in the preceding large time step. A further modification that we see as crucial to increasing the efficiency of the model is being designed at present. This is the capability to call the Thompson microphysics less often than every large model time step. (We think that calling the microphysics every other large time step, i.e., every 2 min, will speed up the wall time of the forecast by up to 5%without degrading the forecast.) This capability exists in the RUC, but not presently in the WRF-ARW.

Occasional model crashes arising from strong vertical velocity along the southern boundary of the domain remain a serious issue, particularly where the main cordillera of the Andes in Columbia intersects this boundary. An NRC post-doc, Joe Olson, has modified the WPS to smooth the model terrain more heavily near the lateral boundaries than in the interior of the domain. This appears to help in some situations, but this crash problem remains under investigation. Ming Hu made another change to help this problem, increasing the width of the relaxation zone along the lateral boundaries from 5 to 10 points, which has significantly decreased the frequency of the crashes. Ming is also working with Tanya Smirnova to determine if the DFI plays a part in these crashes. A change was also made to the post-processing to add CONUS (domain #130) and Alaska (domain #249) output grids and graphics products. In additions, modifications to the WRF-ARW model physics necessary associated with the radar initialization procedure are currently under test. This is discussed further under Task 15.

Note: As of Tues 12 Aug, NCEP has agreed with AWC and SPC that the Rapid Refresh will run hourly out to 18h. GSD and NCEP will be working together on this new parameter, but in general, this will be very beneficial for aviation weather forecast users.

PLANNED EFFORTS: Continue to closely monitor RR forecast performance and continue to experiment with procedures to speed up execution of both the GSI and the model and remedy the sporadic boundary related crashes.

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED: None

INTERFACE WITH OTHER ORGANIZATIONS: DTC, NCEP, NCAR

UPDATES TO SCHEDULE: None.

NCEP

NCEP has established a retrospective NAM Data Assimilation System (NDAS) test system using GSI and WRF-NMM for the full NAM domain at 32 km on the NCEP node of the NOAA R&D computer (known as haze). This month (June) a replacement system (vapor) is now being used. Accounts are being setup on vapor for GSD Rapid Refresh developers so they can use this system as a template and adapt it to perform hourly updates and digital filter and transition it to use WRF-ARW for rapid prototyping of the Rapid Refresh at and with NCEP.

Subtasks

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

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

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED: None

INTERFACE WITH OTHER ORGANIZATIONS: NCEP, NCAR, NWS regions

UPDATES TO SCHEDULE: None

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

With the increased reliability of the RR 1-h cycle (see discussion above), we are working with the NWS regions (especially Alaska) to make R/T gridded data available. They have had a number of specific requests (fields, sub-domains, etc.), which we are working to accommodate (including creating output grib files on the Alaska 249 domain and converting files to grib2 to reduce the size).

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

(see discussion above). The domain parameter settings that were causing a problem for the icing team has been fixed and we are beginning real-time feeds.

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

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

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

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

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

Deliverables

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

Work to improve the RR 1-h cycle on the GSD supercomputer has been complemented by collaborative work with EMC to facilitate a rapid transfer of code and scripts to the NCEP supercomputing environment. Toward that end, EMC scientist Yoshi Sato has generously provided his NAM retrospective infrastructure (code, scripts, etc.), which will provide a reference framework for the NCEP computing environment. Also, Several GSD scientists have obtained accounts on the new NCEP research computer (vapor), where initial NCEP testing of the RR will occur.

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

NCEP
Wan-Shu Wu tested the variational quality control in the regional data assimilation test system. Since the gross check limit for each type of observation was an important parameter in variational quality control, the gross check limits were adjusted along with other quality control coefficients. The impact on the free forecasts was small. She also modified the low resolution system to test the sensitivity of the vertical grid of the model. In the current test, the vertical grid was set to be similar to that of the global system in NCEP, including more levels in the middle and upper troposphere than the NDAS while keeping the total number of vertical levels at 60. The density of the levels below 700 mb was reduced compared with the operational NDAS. The transition level from constant sigma to constant pressure was also moved from 420 mb to 70 mb. The profile of background error used in the analysis was interpolated to the new levels. The preliminary results showed positive impact on the free forecasts.

Shun Liu worked on modifying the GSI codes so that GSD's cloud analysis package can be compiled on the NCEP IBM machine and tested for possible use in regional applications of WRF-NMM.

Dave Parrish continues work on improving the regional GSI tangent linear normal mode constraint (TLNMC), and has formulated a new solution method. This is based on solving for the normal mode balance increments using a nested multi-grid technique, which in a computationally feasible manner allows any regional domain to be imbedded in a series of successively coarser grids until the coarsest grid covers the entire global domain. The solution is obtained by iterative relaxation and transfer of corrections between grids, with an exact solution obtained spectrally on the coarsest grid. Coding is in progress and should be completed by the end of August.

Manuel Pondeca reports that the GSI was used to develop the 2DVar Real Time Mesoscale analysis for

the Hawaii and Puerto Rico 2.5-km resolution NDFD grids. Work completed included prescribing adequate terrain-following background error covariance in the GSI as well as improving the assimilation of temperature observations found near the coastal boundaries between water and land masses. The CPU time needed to run the GSI-2DVar for the CONUS Real Time Mesoscale Analysis was also cut by a factor of 2.5 thanks to improvements made by David Parrish to the GSI anisotropic recursive filter. GSI-2DVar work underway includes exploring the use of potential temperature as an analysis variable (Pondeca) and adding the other variables to the analysis, e.g. height of planetary boundary layer, visibility, wind gust etc (Yonqiu Zhu). Yoshi Sato and Pondeca performed extensive testing of ensemble-based (from NCEP's Global Ensembles) background error covariance matrices for both regional and global GSI-based assimilation systems. However, the forecast scores were only barely improved over the default system using isotropic background error covariance. It is suspected that this might be due, in part, to lack of adequate spread in the Global Ensemble. Further investigation is underway by comparing the Global Ensemble input data with the ensemble fields generated within a Kalman Filter data assimilation system.

GSD
Work continued to improve the reliability and performance of the GSI within the RR 1-h cycle. Ming Hu and Tanya Smirnova found and fixed a key bug in the coupling of the soil moisture between GSI and the WRF ARW. This resulted in a dramatic improvement to the low-level temperature field. Examination of rawinsonde statistical verification for 12-h forecasts from the RR 1-h cycle vs. the operational RUC (for the month of July) indicated temperatures and winds are better for RR than RUC except near the tropopause, but relative humidity is worse for RR than RUC. Examination of the 00-h forecast statistics indicates that the GSI is not fitting moisture observations as closely as the RUC. The assumed errors for the background and observations have not been adjusted for the RR, and we will be considering changes to these values as we continue to monitor the performance of the real-time RR cycle. Dezso Devenyi has been working to add a capability within the GSI to ingest newly available aircraft observations and has received assistance from Dennis Keyser and Jack Woolen of NCEP.

Subtasks

08.5.5.2 Report on testing of 2DVAR WRF-GSI assimilation of high spatial and temporal mesonet surface data using analysis grids with 5-km or finer resolution. (31 Dec 07)

See discussion above for summary of ongoing work.

08.5.5.3 Further refine the radial velocity analysis component of GSI in response to model resolution changes. Examine data impact at higher assimilation frequencies and higher spatial resolutions. Consider issues on data quality, super-obbing, and optimal de-correlation scales. (31 Jan 08)

08.5.5.5 Based on case-study testing and refinement of the research quality code, deliver result in an 'experimental' code for an upgrade package (e.g. improved use of WSR-88D data and satellite radiances and co-variances) to the WRF-GSI for FY2009 change package to the NAM-WRF. (31 Jul 08)

INTERFACE WITH OTHER ORGANIZATIONS:

Subtasks

08.5.5.1 31 December 2007 (GSD and CAPS) COMPLETE
Progress report on testing and evaluation of the generalized cloud/hydrometeor assimilation (including GOES cloud-top data and METAR cloud/visibility/weather data) within a cycled GSI on the full Rapid-Refresh domain.

Based on recommendations received from John Derber and Russ Treadon (at a GSD/EMC GSI meeting at NCEP in June), Ming Hu is completing minor modifications to portions of the generalized cloud analysis to conform to specific EMC coding practices. This will facilitate submission of the cloud analysis option package to EMC for inclusion in the next GSI release.

08.5.5.2 31 December 2007 (NCEP and GSD)
Report on testing of 2DVAR GSI assimilation of high spatial and temporal mesonet surface data using analysis grids with 5-km or finer resolution.

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

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

See discussion above about ongoing statistical comparisons of the RR 1-h cycle vs. the operational RUC upper-level winds (over the matched CONUS radiosondes stations).

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

Deliverables

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

CURRENT EFFORTS:

PLANNED EFFORTS:

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED: None.

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

CURRENT EFFORTS:

PLANNED EFFORTS

Deliverables

08.5.5.E1 30 March 2008 (NCEP)
Subject to NCEP Director approval implement upgrades to WRF-GSI used in NAM/NDAS.

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

08.5.5.E3 30 September 2008 (NCEP and CAPS)
Deliver enhancement package for radial velocity data analysis for further implementation testing.

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

NCAR/MMM

NCAR conducted the second WRF tutorial of the year in Boulder on July 14-18, with over 70 people attending. The tutorial covered model structure, preprocessing, and operation and practical sessions provided opportunities to run components and make simulations.

On July 21–22, NCAR/MMM put on a WRF-Var tutorial, with 52 people attending. This was the first-ever separate WRF-Var tutorial. It covered the entire WRF-Var system, from observation preprocessing, to operation, to background error generation. Four hours of practice session were given, allowing users to work through all aspects of the system.

NCAR prepared code for the next release, WRF V3.0.1. A fix was made to avoid use of the Pleim-Xiu LSM if the user has non-standard numbers of land categories (which can lead to blow-ups). Also, the Lin microphysics scheme was fixed to define properly the graupel
ventilation factor, a bug responsible for some strange behavior reported by users. The 3.1.0 minor release is planned for early August.

Jimy Dudhia of NCAR worked with Brian Reen (Penn State) to improve the PBL height computations by the MYJ PBL scheme. This is being made available to WRF users as a download of this module.

Dudhia worked with Mukul Tewari and Fei Chen (NCAR/RAL) to allow snow albedo to be based on land-use type as an option. Currently it uses satellite-derived maps of this field which are low-resolution. There will be a new switch to select this option. Dudhia also worked with visitors of Chen on a new multi-layer urban model and its addition to the MYJ PBL option.

Dudhia worked with visitor Joe Galewsky (U. New Mexico) for a week, and did idealized testing with WRF, including generalization of the sea-breeze case to read levels from the namelist.
The sea-breeze case was corrected for situations where a v-component of the wind may be added.

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

GSD

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

GSD and DTC

The test of the impact of changing the vertical distribution of vertical levels in the WRF-ARW was planned and executed in a collaborative effort between GSD and DTC. The particular impacts examined are on forecasts of 2-m temperature and dew point and 10-m wind, as well as low ceiling and visibility. Of particular concern are situations having low-level warm advection over snow-covered ground, a condition that has caused systematic daytime cold biases in 2-m temperature forecasts (subtask 1, below). The hypothesis is that higher resolution in the lowest ~500m above ground will improve these forecasts beyond what has already been achieved by alterations to the RUC LSM (subtask 1). Results are currently being evaluated and will bear on the final RR configuration of model levels near the surface.

Subtasks
08.5.8.1 31 Dec 2007 (GSD)

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

Code modifications and testing have begun by GSD to call the microphysics parameterization in the WRF-RR-ARW less frequently, at multiples of the long (non-acoustic) time step. Initial testing in which the microphysics was called every other long time step, and the changes over the single long time step

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

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

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

A two moment scheme for rain was completed and tested on various cases. This improved scheme is available to ESRL for testing in the WRF Rapid Refresh. We participated in the WMO Cloud Modeling Workshop this July which allowed us to interact with scientists working on the some of the same microphysical modeling issues that we are. In particular, this was useful for planning the implementation of an aerosol scheme into the model. In addition, work continues on the freezing drizzle cases from Cleveland. A paper summarizing these results is in preparation. These cases will be used to evaluate the improvements to the microphysical scheme.

Deliverables
08.5.8E3 May '08: Improved microphysics scheme to ESRL for evaluation in WRF Rapid Refresh. (NCAR)

Deliverables

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

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

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

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

Subtasks

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

08.5.15.2 30 Jan 2008 (GSD) COMPLETE
Develop and evaluate performance of diabatic digital filter initialization (DDFI) in the RR WRF model without use of radar data

Although this was reported as complete in previous months, we note that this work was described in a paper by Steven Peckham, Tanya Smirnova, Stan Benjamin, John Brown (all from ESRL/GSD), and NCAR/MMM colleagues at the 9th Annual WRF Workshop in late June (go to paper 1.3) . An issue with the DDFI occasionally causing the RR 1-h cycle to crash was recently isolated and resolved, by shortening the time-step in the backward integration

08.5.15.3 30 March 2008 (GSD and CAPS)
Further refine the generalized cloud analysis for the target RR resolution, model physics scheme and use of additional data. Perform forecast test evaluations to document the impact of the cloud analysis refinements.

Ming Hu introduced the generalized cloud analysis into the latest GSI version (March 31, 2008) and has conducted systematic tests within the RR retrospective test environment. This version is now running in the RR 1-h cycle at GSD. Ming is completing minor modifications to the coding to make the cloud analysis code consistent with EMC coding practices. This will facilitate submission of the cloud analysis option package to EMC for inclusion in the next GSI release.

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

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

The components for RR reflectivity assimilation are in place with the release of WRF version 3 including diabatic digital filter initialization and cloud analysis capability within GSI (upgraded to latest GSI version during the quarter). Testing and refinement of DDFI within 1-h cycle and of various cloud analysis options (including reflectivity assimilation) continue. An option to use a shorter time step during the DFI has been implemented to prevent occasional crashes during the backward portion of the DFI (noted in Task 4).

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

Deliverables

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

08.5.15.E2 30 Aug 2008 (GSD)
Complete testing of GSI generalized cloud analysis for Rapid Refresh and deliver code to NCEP as part of Rapid Refresh package delivered to EMC, pending availability of NCEP testing capability.

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

NCEP

Dennis Keyser reports that a crisis change was implemented on 11 July to correct a program memory problem that caused hurricane Bertha to not be recognized in the t.c. vitals quality control processing nor in the subsequent tropical cyclone first guess relocation processing. There appears to be an improvement in the receipt of some of the Alaskan radiosonde data, as sites like Shemya (70414) are now usually available before the NAM data cutoff. NCEP contacted Alaska in late winter about this issue, but there is still a need for some sites to move their launch time so their data can be received in time for the NAM-GSI. Since the beginning of April, Level II reflectivity (and radial wind) data from an increasing number (at least 100) WSR-88D radar sites are unavailable due to their switch from Build 8 to Build 10 software and the inability of NSSL's qc code to deal with the super-res format of Build 10. Level 2.5 winds are used when Level 2 winds are unavailable. NCEP/NCO is working on a recombination code to ingest these data and convert them back to a Build-8 look-alike format. During two separate periods in the last half of July, some Level 2.5 radial wind superobs have been unavailable to the NAM-GSI due to errors in the uncompression code (NCO is investigating). Since early May, AIRS radiance data counts have been lower than average due to late posting of files associated with hardware issues with NESDIS' processing machines. This should improve later this year when NESDIS ports their AIRS system to new Linux machines. AIRS AMSU-A radiances have not been available to the NAM-GSI since mid-April when AMSU-A channel 4 went bad. Efforts are underway to modify the GSI to allow the remaining AMSU-A channel data to be used. Some radiosondes are not receiving the proper instrument type due to obsolete entries in the NCEP/NCO upper-air dictionary. NCO has filed a Request For Change (RFC) to correct this and it should be implemented in August. The following data types are now monitored by the NAM-GSI: RASS virtual temperature profiles, QuikSCAT 0.5 deg. scatterometer wind superobs, TAMDAR (via ESRL MADIS feed) and Canadian AMDAR aircraft temperature and wind. Efforts to speed up the dump processing of NEXRAD Level II data are being explored. Cooperative Agency Profiler (CAP) and RASS data are not yet available through an alternate ERSL MADIS feed.

Eric Rogers reports that the final 30 days of testing of possible model/analysis modifications for the fall 2008 NAM change package are underway. Once completed, code will be RFC'ed to NCO. WRF-NMM model changes being tested (which address model biases) include a new shallow convection algorithm, changes to the radiation parameterization (doubling the absorption coefficients for water and ice), changes to the land-surface physics, and changes to vertically mix and diffuse each hydrometeor species separately. Assimilation/analysis changes include a new version of the GSI analysis, assimilation of TAMDAR/CanadianAMDAR/METOP data, and "partial" cycling (using GDAS atmospheric first guess for the first GSI analysis in each NDAS cycle).

Shun Liu worked with NCO to test the radar build-10 data decoder and super-resolution data recombination algorithm. A few bugs were found and reported to NCO. He also worked with NSSL to compare super-resolution data and legacy resolution data from NCOs' decoder and NSSL's decoder.

Matt Pyle reports that on August 6th, NCO implemented changes to the operational HiResWindow runs a) to properly generate precipitation type and total cloud field percentage within the WRF-ARW and b) to change product generation to set the GRIB model/process ID to 112 for NMM and 116 for ARW so the two models' output could be distinguished.

Subtasks

08.5.17.1 Maintain four-per-day North American Mesoscale runs and provide SAV and AIV guidance.

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

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

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

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

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

Deliverables

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

CURRENT EFFORTS:

PLANNED EFFORTS:

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED:

INTERFACE WITH OTHER ORGANIZATIONS: GSD & NCO.

UPDATES TO SCHEDULE:

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

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

PLANNED EFFORTS:

PROBLEMS / ISSUES ENCOUNTERED OR ANTICIPATED: None

INTERFACE WITH OTHER ORGANIZATIONS: NESDIS, GSD & NCO

UPDATES TO SCHEDULE: None

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

GSD
A modification was made in early June to the HRRR initialization from the RUC, now directly using the DFI-initialized grids. This change has significantly improved the effective radar reflectivity assimilation for the HRRR. This was possible only after a redesign of the RUC post-processing and scripts (see 5.19.E1 text). A set of cases was first tested by GSD with this change. A comparison of 1h HRRR reflectivity forecasts before (lower right) and after (upper right) is shown below. Subsequently, this change was implemented into the real-time HRRR processing.

Currently, the RUC-DFI data is only available from the GSD "development-13" experimental RUC, not the "backup-13" RUC generally made available to outside users. A transfer to the backup RUC has started but not completed for the code and script changes required for output of the RUC-DFI grids (also valid at

00h but requiring a number of changes to avoid confusion with the different RUC analysis grids, also valid at 00h).

Ongoing monitoring of the HRRR runs with this enhancement continues to indicate that the HRRR forecasts with the direct use of the DFI-initialized RUC grids depict well the evolution of ongoing convection. Statistical verification of forecast reflectivity for the HRRR initialized with the RUC DFI fields vs. a corresponding 3-km grid initialized from the operational RUC (with no radar assimilation) indicates a significant forecast improvement in the HRRR from the radar assimilation on the parent RUC grid.

Subtasks

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

A key case study period examined so far is 10 July 2007. In addition, GSD has conducted some exploratory HRRR re-runs for a few of the several interesting cases that occurred during the first week of June 2008. Another period of active weather across the northeast corridor occurred from 20-23 July 2008. MIT/LL is compiling a more comprehensive list of key days from the summer 2008 season

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

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

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

At CAPS, work continues on GSI assimilation experiments that could contribute to a later HRRR formulation including radar radial velocity assimilation on the 3-km grid. Aimei Shao continued the assimilation and forecast experiments with tropical cyclone Erin (over Oklahoma in August 2007). Except for the previous two sets of experiments, a set of experiments with assimilation cycles was added to evaluate the impact of assimilating reflectivity alone. In addition, the impacts of the different background error de-correlation length scale in GSI and some other parameters including the positive-definite moisture variable advection in WRF model were examined.

The results show that the covariance de-correlation scale has a significant impact on the forecasts. A scale that is ¼ of that used by conventional data and typically used by the regional GSI analysis for radar radial velocity data is found to be too large for the 3-km analysis – incoherent structures develop in the flow fields of the storm in this case. Improper length scale of background error decorrelation may worsen the forecast. A background error decorrelation scale of about 3~4 grid intervals seems to be work better and additional tests will be needed to determine the optimal scale. In addition, assimilation and forecast experiments with a smaller domain size shows significant boundary condition impact, therefore the original large domain (about 2/3 of CONUS) will be used by future experiments. One-km resolution nested-grid forecasts are being performed to see its impact on the intensity and structure of predicted Erin.

In July, a new visiting scientist, Dr. Yi Yang, joined CAPS to work on the FAA project. His initial goal is to

repeat the experiments of Aimei Shao with the newly released WRF version 3.0 and the latest version of GSI, and to use RUC instead of NAM analyses as the analysis background and boundary conditions. Initial porting problems to a supercomputer, Ranger, at the Texas Advanced Supercomputing Center were solved with the WRF Preprocessing (WPS) software, and forecasts starting from RUC analysis directly were performed using different microphysics options. It is found that the microphysics have significant impact on the forecast of Erin. For this particular case, the Lin microphysics scheme produces clearly better forecast than the WSM6 or the newer Thompson scheme. Further precipitation verification will be performed.

The latest version of GSI has been compiled successfully on Ranger. Some problems were encountered running GSI which seem to be related to the version compatibility of static files used by GSI. Yi Yang is working with Ming Hu of GSD to solve the problem.

08.5.19.4 30 Sept 2008 (GSD)
- Develop new stand-alone 3-km processor from raw 3-d reflectivity tiles to 3-km HRRR domain, similar to software developed for 13-km RUC
- Develop and test code at 3-km for assimilation of radar reflectivity using observation-based specification of latent heating within WRF-DFI.

Deliverable

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

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

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

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

Task 08.5.24

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

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

Real-time ftp transfer of HRRR grids to NCAR and MIT/LL since mid April. VIL fields with 15-min output added to HRRR grids and also ftp'd to NCAR (accomplished in mid-May). Modification made to HRRR scripts to speed up processing time by 1 hour, resulting in improved HRRR guidance. In order to do

this, the backup RUC was changed to run out to 13h (instead of 12h) on an hourly basis, so that each HRRR run can be started as soon as the new RUC analysis (or post-DFI) file is available, using lateral boundary conditions (BCs) from the *previous* RUC forecast. This trade-off in using older (less accurate) BCs was considered acceptable to get the new HRRR forecast out 45-60 min faster.

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

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

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

Additional improvement to speed up processing of RUC radar assimilation fields used to drive the HRRR, resulting in further substantial improvement in the HRRR. Real-time verification of HRRR reflectivity forecasts is ongoing. Real-time monitoring of HRRR forecasts has revealed some issues related to the limited HRRR domain size and propagation of convective systems into the HRRR domain.

5.24.2 NCAR-MMM

Evaluate HRRR forecasts with different initializations using GSD HRRR runs

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

Deliverables

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

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

- Conduct real-time summer 2008 HRRR forecasts using 3-km WRF initialized with radar-enhanced RUC over Northeast US Corridor domain
- Coordinate with other AWRP users and other collaborators
- Provide project management
- Lead writing of report on summer 2008 HRRR experiments

(See subtask 08.5.24.1)

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

Collaborate with GSD on analysis of results. Draft and deliver summary of results. Evaluate techniques for convection-resolving (e.g., 3-km) forecasting by the Rapid Refresh (ARW core) in preparation for development of high-resolution RR (HRRR). Perform and evaluate RR convection-resolving forecasts on test cases using radar-enhanced RUC or Rapid Refresh grids from GSD to identify strengths and weakness of model at high resolution. Evaluate effects of transition from 13-km parameterized convection to 3-km resolved convection in 0-3h forecasts and in lateral boundary conditions from the RUC or Rapid Refresh using the Grell-Devenyi parameterization.