MODEL DEVELOPMENT AND ENHANCEMENT
PRODUCT DEVELOPMENT TEAM
TECHNICAL DIRECTION
(NOAA ESRL, NCEP, OU and NCAR)
FY 2010 –
Stan's corrections in this version – 12/14/2009, emailed to Warren.

General Instructions:

1. A detailed quarterly Progress Report will be submitted by the 15th of October 2009 and January, April, and July 2010 describing efforts performed in support of all Model Development and Enhancement Team (MDE PDT) tasked activities. A high level Monthly Progress Report will be submitted by the 15th of November and December 2009 and February, March, May, June, August, and September 2010 summarizing MDE PDT efforts towards goals and milestones, and include its financial status report.

Quarterly Progress Reports must contain efforts **by activity** presented as follows:

a. Current Efforts (quarter just completed)
b. Planned Efforts (for next reporting period)
c. Problems/Issues/Schedule Changes Encountered or Anticipated
d. Interface with other organizations (other than Core PDT member organizations)
e. Summary of funding status, planned versus actual expenditures

Monthly Progress Reports must contain a high level summary (about one page in length) of **overall MDE PDT activities** presented as follows:

a. Current Efforts (month just completed)
b. Planned Efforts (for next reporting period)
c. Problems/Issues/Schedule Changes Encountered or Anticipated

Monthly and Quarterly Progress Reports must also contain a tabularized listing of all deliverables and their status per the following sample table:

Table 1: "Month of Report" FY 10
Status of "Product Development Team" Deliverables

Legend: ☐ **Deliverable on schedule;** ☑ **Deliverable submitted;** ☐ **Deliverable overdue**

"Deliverable and Related Task"	Due Date	Status	Comment
		☐ ☑ ☐	

2. The MDE PDT Plan must be updated and delivered to the COTR to include activity planning for the seven year period from FY 2011 through FY 2017 **no later** than April 1, 2010.

3. Program Overview Meetings (POMs) will be conducted per the agenda to be supplied by the Program Office prior to the scheduled review.

4. All deliverables, technical reports, documentation to industry, press releases, and briefings must be reviewed and approved by the COTR, or designee, **prior** to **External** distribution. Approval must be received from the COTR or designee **prior to** exhibiting at conferences, symposiums, etc. The following statement shall be included in all research papers, journal articles, documents, announcements, etc.:

> *"This research is in response to requirements and funding by the Federal Aviation Administration (FAA). The views expressed are those of the authors and do not necessarily represent the official policy or position of the FAA."*

5. In tasks specifically stating "as authorized by the Program Office", authorization must be received in writing from the COTR, or designee.

6. The MDE PDT must not contact any FAA regional, headquarters, or air traffic control facility, in writing or orally, without first notifying the Program Office for approval.

7. Copies of all monthly and quarterly Progress Reports, technical papers, etc., must be submitted electronically to awrp@avmet.com

8. Costs not to exceed $2,445,000 must be expended in performance of the specific tasks of this Technical Direction.

9. Any funding identified as contingent funding may be funded if the indicated conditions are reached; as with all funding decisions, contingencies will be subject to Program Office consideration reflecting evolving priorities.

10. Although it is intended that funding allocated per fiscal year be expended within that specific fiscal year, consideration will be taken for tasks not completed due to unforeseen circumstances. Upon receipt of written notification from the Program Office, funding for uncompleted tasks will be carried over to the next fiscal year.

11. The MDE PDT must notify the FAA CO and their respective COTR, via e-mail, whenever any of the labs individually has reason to believe that the costs it expects to incur in the next 60 days, when added to all costs previously incurred in FY10, will exceed 80 percent of the amount allocated to them for MDE PDT tasking. The PDTs must also indicate whether exceeding the 80 percent level is a positive or negative variance based on their budget plan.

12. All travel must be approved in writing in advance by the COTR.

FY10 Specific Tasking

Task 10.5.1 Infrastructure Support Related to Operational Running of the non-WRF Rapid Update Cycle System in NCEP Operations **(ESRL $90K; NCEP $65K)**

This task will assure reliable and timely running of the NCEP Operational Suite and providing output grids of state-of-the-atmosphere (SAV) and aviation hazard products (AHP) to aviation users. NCEP/EMC will perform all tasks necessary for transitioning RUC changes (fixes/upgrades) submitted by ESRL/GSD to NCEP Central Operations (NCO) for implementation into NCEP's Production Suite (a.k.a. Operations). This includes code compilation, debugging, optimization, scripting, and testing. Testing includes both real-time parallel testing as well as retrospective parallel testing. Parallel test results are verified and summarized for briefing to NCEP management.

October 2009 through June (estimated) 2010

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

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

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

10.5.1.4 Maintain access to model verification data.

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

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

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

Task 10.5.17 Infrastructure support for operational running of Rapid Refresh, North American Mesoscale, and HiResWindow (and future HRRR) at NCEP **(ESRL $95K; NCEP $95K; NCAR $30K)**

This task will ensure uninterrupted running of the models, and continued availability of model datasets at highest resolution and smooth incorporation of incremental enhancements to the systems (configuration management). This operational infrastructure support covers RR, NAM and HiResWindow (SREF also has WRF components). In FY2011, this task will completely replace similar activities except for the legacy RUC modeling system.

This task will ensure reliable and timely running of the RR, North American Mesoscale (NAM) and HiResWindow components of the NCEP Operational run suite. The current non-WRF RUC is critically dependent on the NAM for its lateral boundary conditions, as will the WRF-based Rapid Refresh. The NAM and RUC/RR constitute the principal guidance tools for aviation users that are supported by the AWRP and feed into the Aviation Digital Data Service (ADDS) at the AWC as well.

NCEP/EMC performs all tasks necessary for transitioning

- RR changes (fixes/upgrades) submitted by ESRL/GSD and
- changes developed internally for NAM and HiResWindow,

to NCEP Central Operations (NCO) for implementation into NCEP's Production Suite. (a.k.a. Operations). This includes code compilation, debugging, optimization, scripting, and testing. Testing includes both real-time parallel testing as well as retrospective parallel testing. Parallel test results are verified and summarized for briefing to NCEP management. Substantial attention is also given by EMC staff in the matters of observation processing and quality control for all the model runs.

The following activities continue throughout the year.

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

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

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

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

10.5.17.5 Maintain access to model verification data. (NCEP)

10.5.17.6 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 and/or unified model post-processor. (NCEP)

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

10.5.17.8 June 2010. Deliver a WRF Users' Workshop and a tutorial on the ARW core (NCAR) and a tutorial on the NMM core for the user community. (NCAR/MMM)

10.5.17E1 Perform ingest, quality control and preparation of both existing and new observations in support of the operational RR, NAM, and HiResWindow runs. (NCEP, ESRL)

10.5.17E2 Perform configuration management for RR, including thorough documentation, and respond promptly to any code malfunctions or performance issues. (ESRL, NCEP)

10.5.17E3 Monitor RR, NAM & HiResWindow performance, respond to any problems detected by ESRL, NCEP, or any users, diagnose source/cause of the problem, develop solution, test changes and coordinate with NCO on implementation. (ESRL, NCEP)

10.5.17E4 As requested by other PDTs, incorporate new AHP calculations into Operational WRF Model post-processor and product generator (NCEP, ESRL).

Task 10.5.4 Develop, test, implement, and improve the Rapid Refresh **(ESRL $250K; NCEP $75K)**

The effort in FY 2010 for the Rapid Refresh will focus on final testing at NCEP and ESRL of the Rapid Refresh (RR) replacing the RUC assimilation/model system, including the initial RR implementation at NCEP. The transition from the RUC to the RR is evolutionary, not revolutionary, by using model physics

and assimilation techniques in the RR similar to those in the RUC that have proven beneficial to aviation weather forecasting.

The Rapid Refresh will include a major increase in domain coverage from the current CONUS RUC domain to a North American domain, not quite as large as the NAM domain, but still covering Alaska, Canada, Puerto Rico, and the Caribbean region. The consequential trade-off in resolution by configuring the RR in the enhanced North American domain is not drastic, with an estimated resolution that is essentially the same as for the 13-km RUC CONUS domain.

A version of the GSI system is the center of the Rapid Refresh analysis code in the RR operational implementation planned for mid 2010. In FY10, ESRL will complete real-time and limited retrospective runs with the full WRF model in an hourly assimilation cycle.

In FY10, work will be completed on transferring all RUC-specific capabilities into the WRF post-processor. This task will include an extensive evaluation of the complicated interaction of all of these RR components (assimilation, model dynamics, model physics, post-processing) via extensive case studies and real-time and retrospective evaluation periods.

ESRL and NCEP will make available experimental RR products in FY2010 and interact extensively with RUC/RR users, **including other AWRP PDTs**, on its performance. Considerable effort will be necessary to communicate information on the RR system to users in the FAA, NWS, and specifically at AWC and SPC. This will include documentation (papers, web forums, and in-person presentations).

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

10.5.4.2 Nov '09 (ESRL, NCEP): Continue to solicit input from In-flight Icing, Turbulence, National Ceiling/Visibility, and Convective Weather PDTs and NWS forecasters in Alaska and Puerto Rico, on performance of pre-implementation Rapid Refresh.

10.5.4.3 Jul '10 (ESRL, 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.

10.5.4.4 May '10 (ESRL, 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.

Task 10.5.5 Develop, test, and implement improvements to the operational data assimilation supporting Rapid Refresh and North American Mesoscale runs **(ESRL $170K; NCEP $120K; OU $80K)**

The Gridpoint Statistical Interpolation (GSI) package is currently used for the experimental Rapid Refresh (scheduled to replace the RUC at NCEP in 2010), as well as NCEP's operational Global Forecast System (GFS) and the North American Mesoscale (NAM) model runs. This task will provide the necessary continued development and enhancement for the 3DVAR-based GSI analysis capability.

In FY 2010, GSD and NCEP will continue development of the GSI assimilation system. The major objective for GSD in FY10 will be to finalize adaptations of RUC-specific analysis components to the GSI framework to create a Rapid-Refresh specific GSI suitable for use with 1-h cycling with surface and other observation types. Specific RUC capabilities include 1) cloud/hydrometeor analysis for stratiform clouds and parameterized convective clouds including use of METAR cloud/weather/visibility information and NESDIS cloud top pressure data (see also task 5.15), 2) use of surface observations including specification of appropriate horizontal and vertical correlation length scales, and 3) appropriate balancing for the RR mesoscale 1-h cycling application yielding forecast improvement down to 1-h lead time.

In addition, detailed evaluation of the experimental RR forecast system will continue over OCONUS

regions with a particular emphasis on Alaska and Puerto Rico. Ensuring a close analysis fit and short-term forecast skill for surface observations will be a significant challenge in the arctic regions, where unique land surface challenges exists (glaciers, tundra, arctic night, etc.). Additional interrelated development work described in other tasks includes: 1) radar radial velocity and reflectivity assimilation (task 5.19) and diabatic Digital Filter Initialization (5.15)

10.5.5.1 Nov '09 (OU, NCEP)
Refine the radial velocity analysis component of GSI and determine the optimal decorrelation scales for different analysis passes.

10.5.5.2 Feb '10 (ESRL)
Report on statistical evaluation of pre-implementation Rapid Refresh forecasts initialized with the GSI, including examination of upper-level winds, surface fields, and precipitation.

10.5.5.3 May '10 (NCEP and ESRL)
Report on testing of 2DVAR GSI assimilation of high spatial and temporal mesonet surface data using analysis grids with 2.5-km or finer resolution.

10.5.5.4 Jun '10 (NCEP)
Establish hourly cycled NDAS-like assimilation system on NOAA R&D computer at NCEP (machine called "vapor") using GSI and NMMB within NEMS to be adapted to a NEMS- and ARW-based RR by GSD.

10.5.5.5 Jul '10 (NCEP)
If authorized by NCEP Director, implement initialization of HiResWindow runs using CAPS/Shun Liu improved techniques for radial velocity analysis in GSI together with Diabatic Digital Filter use of 88D reflectivity Mosaic.

10.5.5.6 Jul '10 (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 satellite channel bias correction, improved use of WSR-88D radial wind and/or satellite radiances and/or retuned co variances to the GSI for FY2011 change package to the NAM.

10.5.5.7 Aug '10 (ESRL)
Report on testing of FY11 version of GSI for FY11 Rapid Refresh upgrade.

10.5.5E1: Dec '09 (ESRL and OU)
Further refinement to the radial velocity analysis component of GSI for Rapid Refresh configuration.

10.5.5E2: Jan '10 (ESRL, NCEP)
Complete report on Rapid Refresh performance, including that from the GSI component of the RR, in comparison with the operational RUC.

10.5.5E3: May '10 (ESRL, 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.

10.5.5E4: Aug '10 (ESRL and OU)
New version of GSI including revised radial wind assimilation for FY11 RR upgrade.

10.5.5E5: Sep '10 (NCEP)
Subject to NCEP Director approval implement NEMS/NMMB version of GSI (e.g. strong constraint, revised bkgs+obs errors) in NAM/NDAS.

Task 10.5.8 Improve physical processes in the WRF (RR and HRRR) and NAM models, especially those that affect aircraft icing. **(ESRL $60K; NCAR $60K)**

ESRL will continue evaluation of physics parameterizations in the GSD developmental RR cycle. Inspections by NWS forecasters and others in Alaska plus GSD's own verification have helped GSD identify matters of particular concern. Discussions from Alaska and other polar (arctic and Antarctic) modelers have shown that having at least 2 layers of snow in the land-surface model is important to obtain reasonable forecasts of near-surface conditions. This aspect of the WRF version of the RUC LSM is considered to be strength of that scheme. Known deficiencies in the ability of present PBL and surface-layer schemes to accurately describe extremely stable conditions just above the surface also need addressing. Collaboration with microphysics and boundary layer experts outside of ESRL will continue as part of the effort to address these matters.

Since parameterization of precipitation-producing deep convection will continue to be necessary in the RR for several more years, ESRL will continue to develop and test new designs for improving the Grell-Devenyi convection scheme, as has been found necessary in the past.

NCAR installed a new ice initiation scheme into WRF-Thompson microphysics scheme to create ice crystals on dust/mineral aerosol category and will test this new scheme in a number of sensitivity tests and case studies to evaluate its behavior and compare to observations.

Once installed in WRF, test and evaluate the scheme in case studies and compare to observations. The new code will incorporate the new code into WRF-HRRR after successful testing.

The following efforts will be pursued and results evaluated to make decisions on the final makeup of the 2010 NAM upgrade package – emphasis is on the impact to high-resolution forecast guidance:

1. Compare different convective schemes, including runs with no calls to any convective scheme (so-called explicit runs), as well as running with only the shallow component of some convective schemes.

2. Examine benefit (versus cost) of advecting separately each hydrometeor category, as well as testing different microphysical parameterizations.

3. Examine benefit (versus cost) of using different positive-definite advection schemes, especially those that conserve mass of passive scalar quantities (e.g., moisture, various forms of condensate, and TKE).

4. Examine impact of using the full set of GFS physics in the NMMB.

10.5.8.1 Nov ‘09 (ESRL)
Complete systematic ESRL evaluation of physics performance in GSD 1-hour RR cycles for initial RR implementation.

10.5.8.2 Jul ‘10 (NCAR)
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 Apr ‘10 (ESRL)
Test and evaluate upgrades of RUCLSM to handle sea ice and snow cover on sea ice under wintertime conditions for FY11 Rapid Refresh upgrade.

10.5.8.4 Aug ‘10 (ESRL)
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 Jul '10 (NCAR)
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 Aug '10 (NCAR)
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.

10.5.8.7 Sep '10 (ESRL, NCAR)
Begin testing at ESRL of latest version of microphysics for Rapid Refresh upgrade in FY2011.

10.5.8E2: May '10 (ESRL, NCEP)
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.

10.5.8E3: Jul '10 (NCAR)
Provide an improved microphysics scheme to ESRL for evaluation toward the FY11 RR upgrade.

Task 10.5.15 Develop improved methods of cloud and moisture analysis for use in the Rapid Refresh and NAM Modeling Systems **(ESRL $60K)**

Improving performance of operational mesoscale models and *initial cloud and moisture fields* are the key data assimilation development that will spur improvements in the prediction of icing, ceiling and visibility, and convective storms. All operational models (RUC/RR/HRRR and NMM in NAM and HiResWindow) predict clouds and precipitation, and they need detailed information on the water vapor field, the location, coverage, and hydrometeor composition of observed clouds and observed precipitation at the start of the forecast period--thus the need for cloud and moisture (and precipitation) analyses.

ESRL will further examine special considerations regarding initialization of clouds over Alaska and other arctic regions using satellite data (possibly POES data) and METAR data. GSD will also review the possibility of including the GOES fog / low-level 3.9 micron product, which may help to improve the horizontal definition of low cloud coverage in important low-ceiling/visibility conditions.

ESRL will further test the use of radar data to specify latent heating within the diabatic digital filter initialization (DDFI) for the WRF model to be used in the Rapid Refresh. The radar-enhanced DFI assimilation technique was shown in FY07-09 to be very effective for the RUC. In FY10, GSD will evaluate and improve the performance of the DDFI to ensure that it produces effective initial 3-D cloud and hydrometeor fields. All work on using the radar-enhanced DDFI for the 3-km HRRR is covered under task 5.19.

10.5.15.1 Jan '10 (ESRL)
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.

10.5.15.2 Jan '10 (ESRL)
Complete improved diabatic digital filter initialization (DDFI) in the 13-km RR WRF model including assimilation of radar reflectivity data

10.5.15E1: May '10 (ESRL)
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.

10.5.15E2: Aug '10 (ESRL)
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 **($320K ESRL; $185K NCAR)**

This task will specifically treat development and testing of the 3-km HRRR model itself. Development and testing work on assimilation of radar data at the 3-km scale will occur under Task 5.19.

ESRL started work on a multi-year effort in FY08, in collaboration with CAPS, NCAR, and NCEP, toward a demonstration ***High-Resolution Rapid Refresh (HRRR)*** to run at **3-km** resolution with **hourly updating** in continuing cycling and assimilation of 3-d radar reflectivity and radial wind data. The MDE-PDT has collaborated with the Convective Weather PDT in the application of the HRRR to the Advanced Storm Prediction Algorithm, where it plays a dominant role especially for forecasts > 2h in duration.

The key objective for FY10 will be the summer 2010 convection forecast exercise over a CONUS-wide domain with other PDTs (Convective Weather, in particular) in which the HRRR plays a dominant role. This will build on the HRRR forecasting experiments conducted in 2008 and 2009, including real-time HRRR forecasts from ESRL and extensive experiments by ESRL, CAPS, and NCAR to improve data assimilation and modeling configurations. The 2010 HRRR summer exercise will be initialized from a version of the radar-enhanced Rapid Refresh run at ESRL/GSD instead of the radar-enhanced RUC used in 2008 and the first half of 2009.

The 2010 HRRR is proposed to run over the full lower 48-state CONUS domain. ESRL will continue to lead development, testing and demonstration of the HRRR in FY2010 in collaboration with NCAR, CAPS/OU, MIT/LL, and NCEP. This effort aims toward a HRRR implementation at NCEP as a nest inside the Rapid Refresh by 2012, with domain size dependent on NCEP computing resources.

<u>BACKGROUND</u>
<u>Multi-year requirement for HRRR</u>
Accurate, rapidly updated (at least hourly) forecasts of convective storms are probably the greatest need for improvement in aviation weather services. Summertime convection is the foremost weather-related problem for U.S. aviation weather and the National Airspace System.
<u>How to fulfill the requirement</u>
Improved forecasts of convective storms, critical for aviation and many other national needs, require

- Horizontal resolution in the **1-3km range** to resolve convective storms. Resolution of 5 km is borderline, and resolution of 6-13km is clearly inadequate.
- **Hourly updating** using current conditions, including radar data, since convective time scales are less than 1h.
- New forecasts produced within 30-45 minutes of initial time.

<u>High-Resolution Rapid Refresh (HRRR) characteristics / evolution</u>
(In addition to those shown above under "How to fulfill the requirement"):

- Perform data assimilation focusing on 3-d radar reflectivity, using current Rapid Refresh or RR DFI-00h grids as background (already incorporating data including all other observations on a coarser resolution), with later (FY11+) sharpening of initial HRRR grids by adding 3km assimilation procedures
- Cycle frequency: Run HRRR cycle at least hourly, increase to 30 min
- Forecast duration: at least 12h every hour.
- Output frequency: at least every 15 min.

Effort will focus on the improvements to and actual operation of the real-time HRRR run. ESRL will have a primary responsibility for scripts, scheduling, and computer resources for these runs, monitoring, modifying as necessary, and maintaining the highest level of reliability possible, subject to computer maintenance issues. ESRL will also have a primary role for interaction with to facilitate continued improvement of the HRRR.

A number of evaluations for real-time runs and retrospective experiments will be carried toward and during the summer 2010 HRRR/CoSPA exercise. NCAR and ESRL will collaborate on HRRR sensitivity studies for physical parameterization schemes, and model configurations. These sensitivity tests are essential for a better understanding and enhancing of model performance—for example, reducing model forecast biases—and for designing model ensembles. In addition, they will also provide valuable insight on how the HRRR will benefit the convective, turbulence, icing, and ceiling and visibility research teams.

10.5.24.1 Jan '10 (ESRL, NCAR, NCAR/MMM, CAPS, MIT/LL)
Design the assimilation/modeling configuration for the HRRR during the 2010 summer convection forecasting (CoSPA) exercise.

10.5.24.2 Aug '10 (NCAR/MMM, ESRL)
In collaboration with ESRL, 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 ESRL 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 ESRL in the process and submit a summary of results.

10.5.24.3 Sep '10 (ESRL, NCAR)
Complete 2010 HRRR summer exercise using modeling and assimilation modifications determined in 2010 exercise. Collaborate on analysis of HRRR tests and deliver summary of results.

10.5.24.4 May '10 (NCAR)
Conduct sensitivity runs with respect to physical parameterization schemes and initial conditions for multiple high-impact weather days, collaborating with ESRL. Examine possible reasons for forecast success (or not) for these cases with regard to storm location, timing, intensity, and structural organization.

10.5.24.5 Jul '10 (ESRL)
Analyze and evaluate the results with regard to sensitivity for prediction of turbulence, icing, and winter weather (including ground de-icing) conditions. Collaborate with relevant PDT members on evaluation of results. The CONUS HRRR now in planning for FY10 will be particularly strongly tied to the Turbulence PDT and allows a HRRR-based GTG, especially for mountain-induced turbulence.

10.5.24E1: Sep '10 (NOAA/ESRL)
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

10.5.24E2: Sep '10 (NCAR)

Collaborate with ESRL 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.

10.5.24E3: Sep '10 (NCAR)
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.

10.5.24E4: May '10 (NOAA/ESRL)
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 **(OU $180K; ESRL $100K; NCEP $50K; NCAR $40K)**

This task will address the radar assimilation development and testing specifically for the 3-km HRRR. The HRRR allows radar-initialized fully explicit convection modeling with real-time hourly assimilation. It was found that the DFI-output grids from the RUC and Rapid Refresh using radar reflectivity assimilation at 13-km have been quite effective in convective storm retention for 3-km HRRR forecasts, adding at least 2-h to reflectivity forecast skill, especially by removing any smoothing (previously considered necessary) of the 3-d latent heating fields based on 3-d reflectivity. The change to use of DFI-RUC grids instead of RUC-analysis grids effectively reduced forecast availability by almost 60 min.

ESRL will develop and test modifications to application of the 13-km DFI and 13-km mapping of the reflectivity (refinements to beam blocking, extension for offshore reflectivity, lightning, etc.) regarding impact on subsequent HRRR forecasts. ESRL will also conduct tests for 3-km application of the DFI, application of multiple radar times within DFI at both 13-km and 3-km resolution, variational techniques for reflectivity assimilation, and combinations of both reflectivity and radial wind. OU will focus on radial wind assimilation in these developments and tests, closely collaborating with GSD. (NCEP)

In FY 2010, NCEP will continue the efforts to refine use of Level II and 2.5 88D radial wind data in its GSI analysis system.

10.5.19.1 Dec '09 (ESRL, NCAR, OU)
Select initial case studies from summer 2009 for 3-km HRRR data assimilation case studies.

10.5.19.2 Aug '10 (ESRL, NCAR)
Run case studies from 2009-2010 using 3-km HRRR on ESRL jet computer using different RR-based initial conditions

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

10.5.19.3 Sep '10 (OU)
Complete new 3-km GSI data assimilation experiments toward improved assimilation of radial wind.

10.5.19.4 Sep '10 (ESRL)
Develop and test improved DFI assimilation of radar reflectivity at 3-km using observation-based specification of latent heating within WRF-DFI developed by ESRL and NCAR in FY09.

10.5.19E1: Apr '10 (OU)
Provide new radial wind assimilation in 13km GSI designed specifically to improve HRRR initial conditions to be applied in summer 2010 HRRR exercise.

10.5.19E2: Sep '10 (ESRL, OU, NCAR)

Report on results from improved version of 13km/3km radar assimilation techniques for demonstration in FY10 exercise.

10.5.19E3: Aug '10 (ESRL, OU, NCAR)
Provide additional report on radar assimilation results for HRRR from winter 2007-08 case studies under the lead of ESRL with contributions from each organization.

10.5.19E4: Sep '10 (NCEP)
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.

10.5.19E5: Sep '10 (OU, NCEP and ESRL)
Report on the design and initial development of hybrid ensemble-3DVAR system

Task 10.5.20 Develop ensemble-based probabilistic products for aviation users **(ESRL $180K; NCEP $140K)**

Efforts will be continued to improve the Short-Range Ensemble Forecast (SREF) system at NCEP with its annual upgrade and continued development of both grid-based and site-specific SREF products for aviation interests in accord with recommendations and suggestions by AWC, the AWRP PDTs and NWS' Alaska and Pacific Aviation Weather Units. Six WRF members were added to the operational SREF running at NCEP in FY06, 3 based on WRF-ARW and the other 3 on WRF-NMM. Each set of three consisted of a control run with no initial condition perturbation plus a pair of runs using Bred Mode perturbation applied with positive and negative sign. The primary challenge of this implementation was getting the WRF (version 2.0) members to fit into the designated run slot and, eventually, coarser resolutions were chosen to accomplish this.

ESRL and NCEP will have developed an initial component of an aviation-targeted Very Short-Range Ensemble Forecast (VSREF) in 2009 that is updated hourly with members from hourly RUC or Rapid Refresh forecasts, recent NAM and SREF member forecasts, and even longer-range GFS and GEFS member forecasts. VSREF will extend the SREF structure toward rapid-updated probabilistic aviation products. A first component of the VSREF will be to adapt the RUC/NAM Convective Probabilistic Forecast (RCPF). Consistent with the initial GSD/EMC work toward the VSREF, the NWS Science and Technology Infusion Plan desire to support 6-dimensional databases: a variable; 3-D space; time; and with probabilistic bounds.

10.5.20.1 Jan '10 (NCEP)
Complete 'research quality' version of upgrade to SREF (e.g. higher resolution, NEMS members and more physics diversity or stochastic physics) for consideration in November 2010 SREF upgrade package.

10.5.20.2 Feb '10 (NCEP)
NCEP visits AWC to conduct continued training and education on SREF applications, receive feedback on existing guidance, and to acquire new requirements (fully depending on FAA funding).

10.5.20.4 Aug '10 (NCEP)
Based on case-study testing and refinement of the research-quality code, deliver the upgrade SREF codes to NCO for November 2010 SREF upgrade package.

10.5.20.5 Mar '10 (ESRL and NCEP)
Improve preliminary (developed in FY09) procedure appropriate for aviation users from Very Short-Range Ensemble Forecast (VSREF) system using high-resolution RR and NAM existing runs toward a future High-Frequency Probabilistic Forecast (HFProb) generator to be used in NextGen, including common post-processor, obs-based statistical post-processing, optimized member weighting

10.5.20.6 Jul '10 (ESRL and NCEP)

Further calibrate probabilities and potential echo-top (improve statistical reliability) ensemble cumulus information.

10.5.20E1 Aug '10 (ESRL and NCEP)
Demonstrate products from experimental VSREF probabilistic forecasts updated hourly.

Task 10.5.9 Assimilate turbulence observations directly into the Rapid Refresh and NAM models. **(unfunded)**

The MDE PDT will conduct initial comparisons of the EDR observations between RUC (or RR) gridded EDR and TKE observations using a database similar to that developed at GSD for monitoring aircraft wind, temperature, and relative humidity and their systematic differences (bias, mean absolute) with 1-h forecasts from different versions of the RUC and experimental RR. This work will be coordinated with the work of the Turbulence PDT, where ongoing comparison evaluations of EDR observations vs. GTG grid values continue.

NCEP continues to routinely receive and process aircraft turbulence data from all the equipped aircraft that report through ACARS. These data pass through ARINC and are put into the MDCRS format, which has space for turbulence as well as moisture (WVSS-II). Data assimilation is an essential tool for extracting useful information from these reports.

These proposed observation-model comparisons proposed above are a prerequisite for attempting assimilation of turbulence observations, requiring a forward model from multivariate 3-d model fields to EDR (or DEVG) and their adjoint. GSD and NCEP must connect the observed turbulence observations, which NCEP has been ingesting since 2003, to the GSI assimilation code (being used for the RR and NAM) as a passive two-dimensional variable for updating.

10.5.9.1 Mar '10 (ESRL)
Work toward initial capability to compare TAMDAR and other EDR measurements with RUC/RR gridded data via aircraft-model data base similar to that used previously for monitoring aircraft wind/temperature/moisture observations broken out by aircraft tail number.

10.5.9.2 Mar '10 (NCEP)
Connect observed turbulence metrics to the processed PREPBUFR file used by the GSI analysis.

10.5.9.2 Aug '10 (NCEP, ESRL)
Incorporate turbulence metric as passive 2D variable in GSI analysis.

10.5.9E1 Jul '10 (ESRL)
Complete initial capability to compare TAMDAR and other EDR measurements with RR gridded data via aircraft-model data base similar to that used previously for monitoring aircraft wind/temperature/moisture observations broken out by aircraft tail number.

MDE PDT FUNDS ALLOCATION for FY10

Task #	Task Description	($K) NCAR	NCEP	ESRL	OU	Total
10.5.1	Infrastructure support for operational running of the RUC at NCEP		65	90		155
10.5.17	Infrastructure support for running WRF RR, NAM, and HRW models	30	95	95		220
10.5.4	Develop, test, and implement the Rapid Refresh configuration of the WRF model (WRF-RR)		75	250		325
10.5.5	Develop, test, and implement improvements to the operational 3DVAR for Rapid Refresh and NAM		120	170	80	370
10.5.8	Improve physics in the WRF model, especially including those that affect aircraft icing	60		60		120
10.5.15	Develop improved methods for analyzing clouds and water substance for use in the WRF modeling system			60		60
10.5.6	Develop, test, and evaluate the performance of the nonhydrostatic WRF modeling system					
10.5.24	Test WRF Rapid Refresh model at 3-km resolution toward High-Resolution Rapid Refresh (HRRR)	185		320		505
10.5.19	Develop ability to assimilate WSR-88D radial velocity and reflectivity data into the WRF modeling system	40	50	100	180	370
10.5.20	Examine utility of ensembles for conveying probability and confidence to aviation users		140	180		320

10.5.9	Assimilate turbulence observations (EDR data) directly into the WRF model		0	0		0
		315	**545**	**1325**	**260**	**2445**