Progress Toward WRF Applications in the 13km Rapid Refresh (RR) and its 3-km Nest, the High-Resolution Rapid Refresh (HRRR)

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Description, real-time products
http://rapidrefresh.noaa.gov

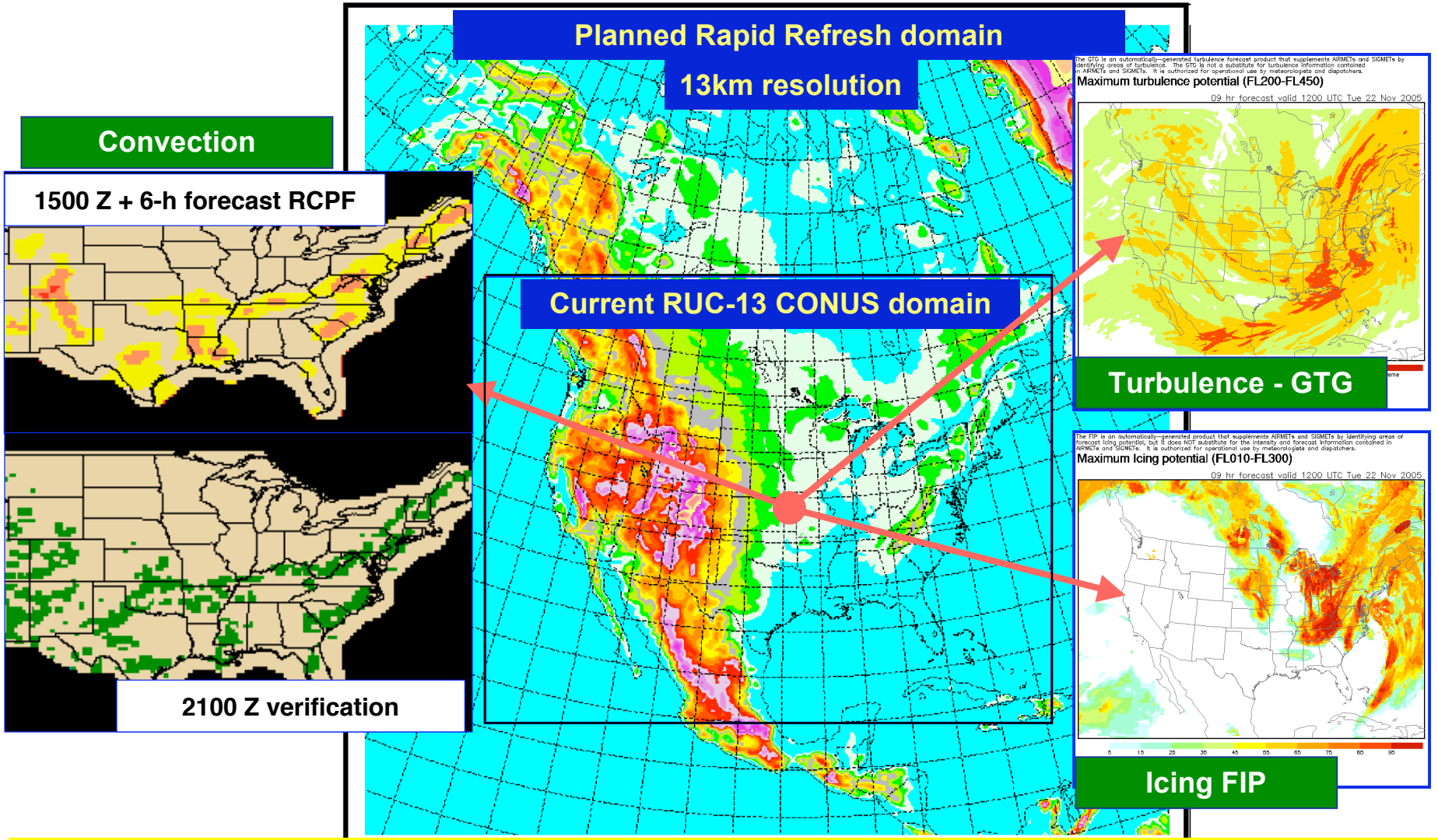
Tues 24 June 2008

NCEP

Earth System Research Laboratory
SCIENCE, SERVICE & STEWARDSHIP

RUC/RR - backbone for high-frequency aviation products

Convective Weather, Icing Potential, Turbulence, Ceiling, Visibility, other aviation weather products



- 1-h assimilation cycle with latest obs improves short-range forecasts

RUC to Rapid Refresh

- CONUS domain (13km) → North American domain (13km)
- RUC model → WRF model (RR version) (ARW dynamic core)
- RUC 3DVAR → GSI (Gridpoint Statistical Interpolation) (incl. RR enhancements)

NCEP/GSD Agreement on Rapid Refresh - signed 12 September 2007

- **2009 – Initial Rapid Refresh – Phase 1**
  - **Model - WRF-ARW, Rapid Refresh physics**
  - **Data assimilation – GSI with RR-developed enhancements**
  - **To be "submitted" for operations by Sept 2009, implemented replacing RUC by early 2010**
- **2012 – Ensemble Rapid Refresh – Phase 2**
  - **6 members, 3 each using ARW and NMM**
  - **Model (ARW, NMM) and GSI will use ESMF framework, not WRF framework**
  - **Model/assimilation systems from NOAA/ESRL and NCEP**

RR version of WRF model

ARW core

Physics *(those from RUC are in red)*

Grell-Devenyi convection (Grell – paper 10.2)

MYJ (NCEP/NAM) surface layer and
turbulent vertical mixing above surface layer

Thompson-NCAR microphysics

Diabatic Digital Filter Initialization (DFI)
- similar to that in RUC model (Peckham et al.-1.3)

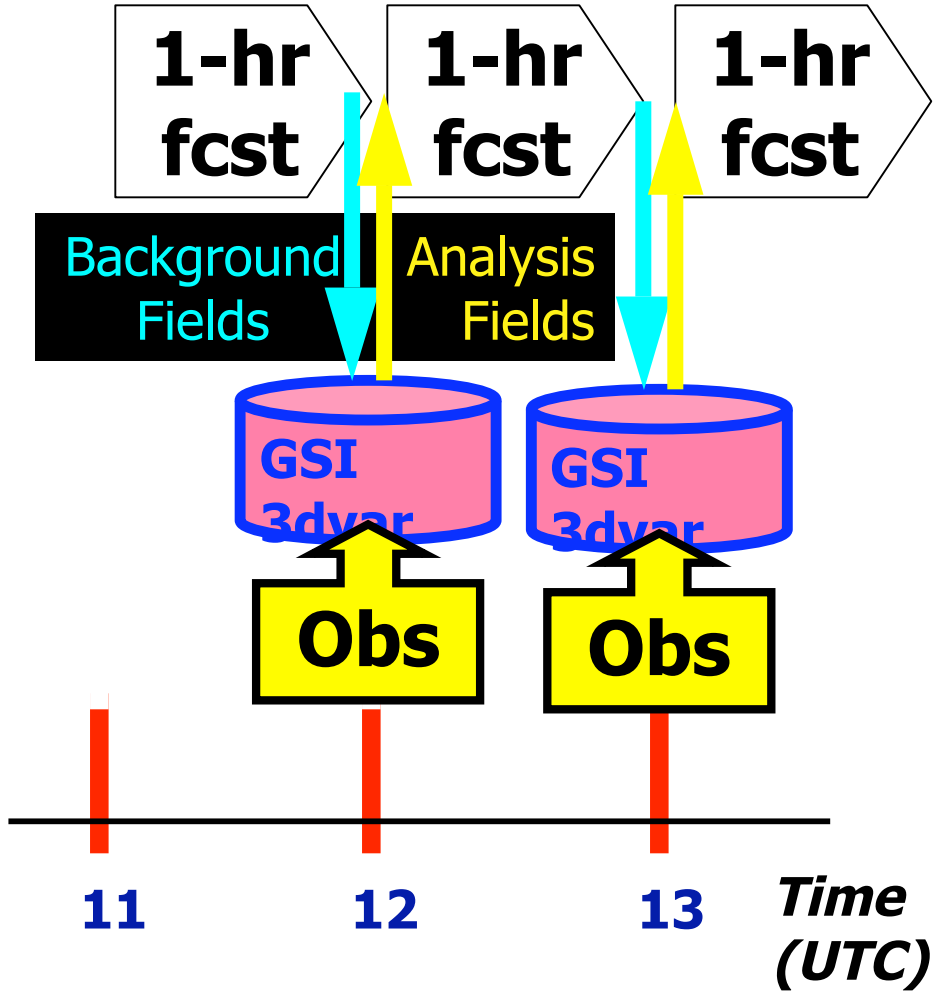
Radiation (RRTM longwave, Dudhia shortwave)

RUC Land-Surface Model (diversity from Noah LSM in anticipation of ensemble RR by 2012)

Result: Physics behavior similar to that of RUC, preferred for aviation applications and convective environment

RR Hourly Assimilation Cycle

Cycle hydrometeor, soil temp/moisture/snow plus atmosphere state variables

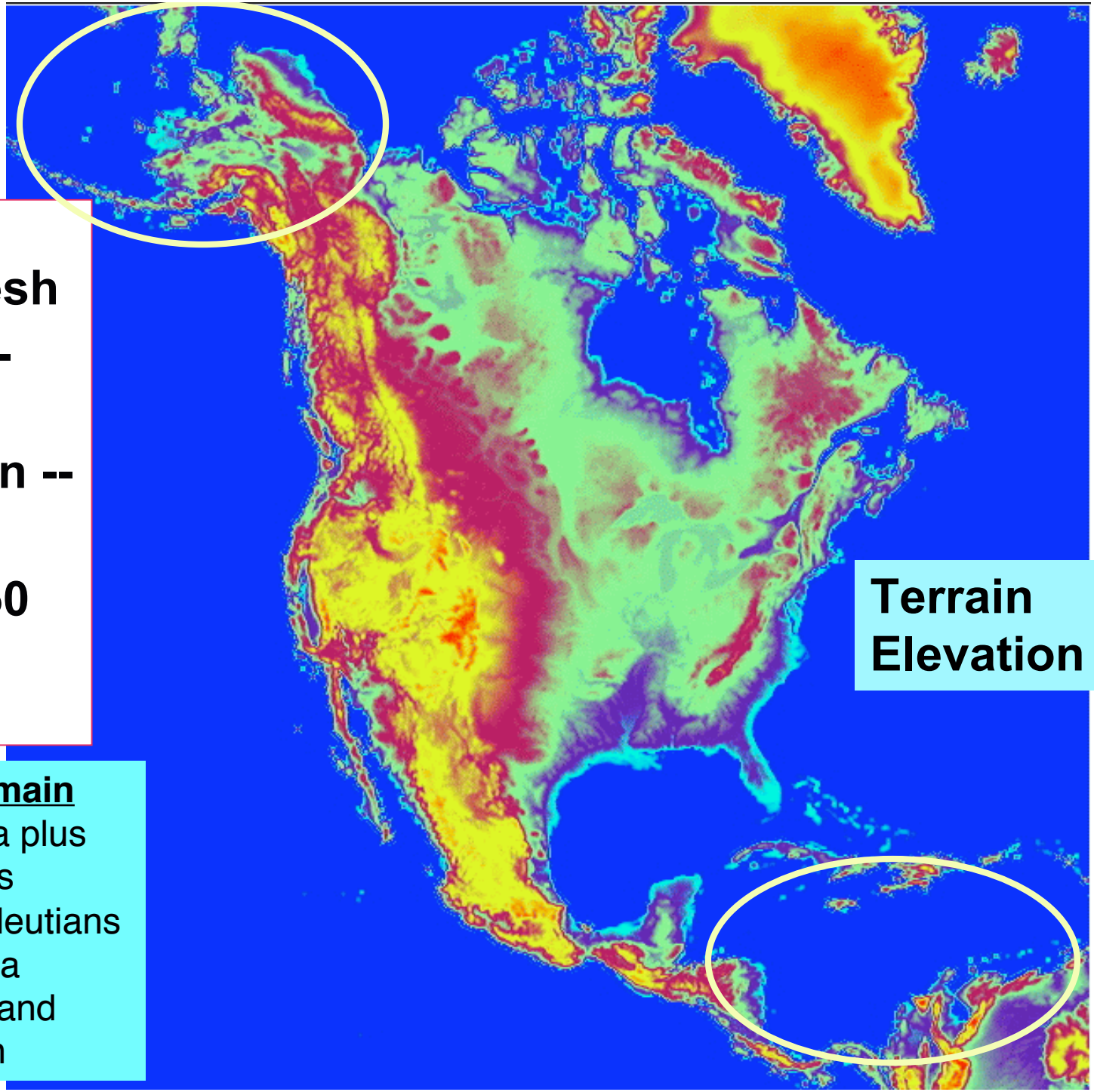


Hourly obs

Data Type	~Number
Rawinsonde (12h)	150
NOAA profilers	35
VAD winds	120-140
PBL – prof/RASS	~25
Aircraft (V,temp)	3500-10000
TAMDAR (V,T,RH)	200-3000
Surface/METAR	2000-2500
Buoy/ship	200-400
GOES cloud winds	4000-8000
GOES cloud-top pres	10 km res
GPS precip water	~300
Mesonet (temp, dpt)	~8000
Mesonet (wind)	~4000
METAR-cloud-vis-wx	~1800
AMSU-A/B/GOES radiances	
Radar reflectivity/ lightning	1km

Rapid Refresh *domain* - *Final* configuration --

649x648x50 grid pts



Terrain Elevation

Constraints on domain

- Continental Alaska plus coastal margins
- Dutch Harbor in Aleutians
- Isthmus of Panama
- US Virgin Islands and most of Caribbean

RR vs. RUC grid points

Horizontal

- **RUC** **451 x 301** **- 13km**
- **RR** **649 x 648** **- 13km**

(about 3x increase)

Vertical

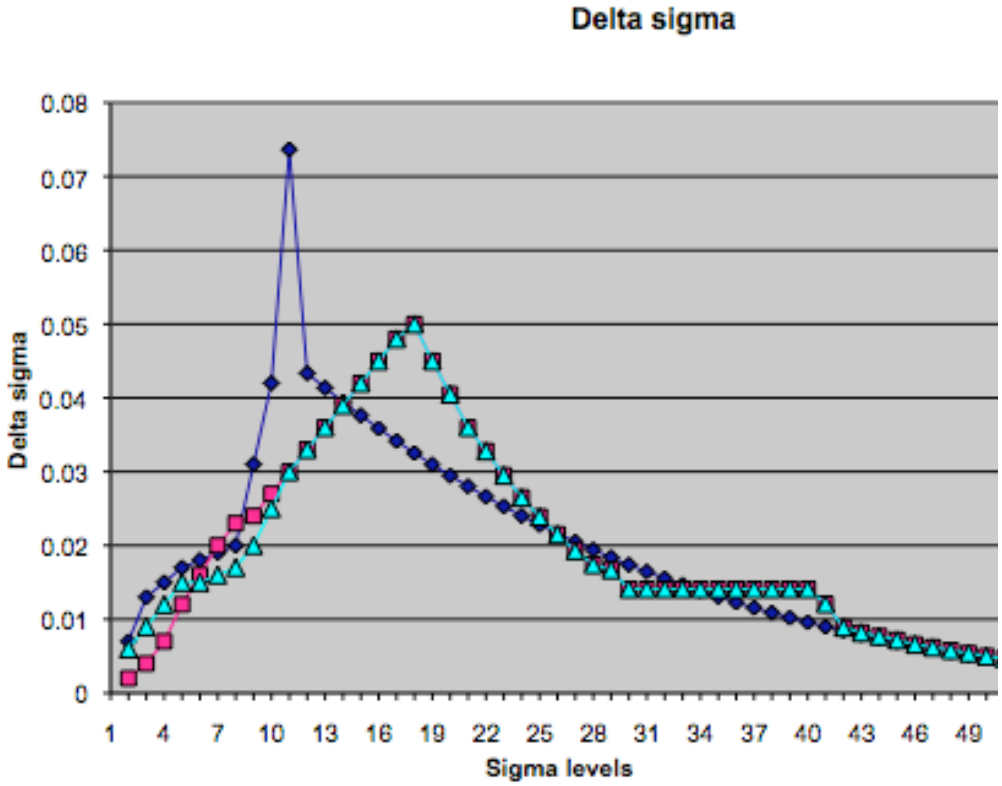
- **RUC** **50 hybrid θ-σ levels**

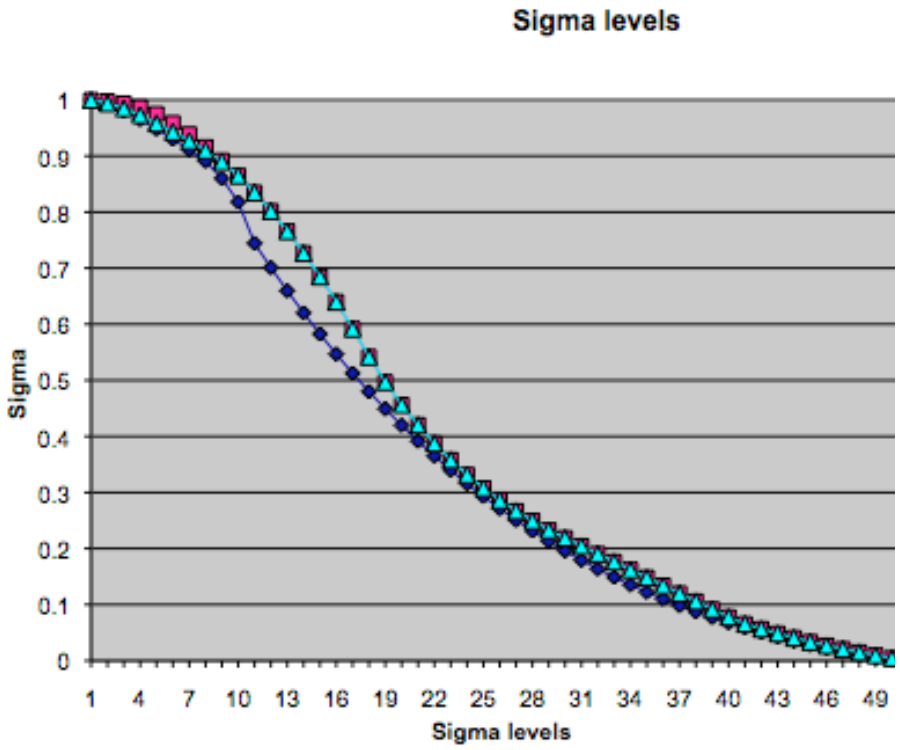
Top at 500K (40-60 hPa)

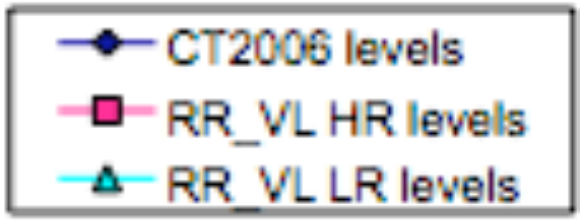
- **RR** **50 σ levels**

Top at ~5 hPa

Tests on vertical stratification for Rapid Refresh – DTC - Jamie Wolff, Louisa Nance







Current status - RR testing
June 2008

- **RR PrepBUFR + satellite ftp'd from devccs/NCEP**
- **Cold start version - full domain – now using WRFv3.0**
- **1h cycle running over full RR domain – WRFv2.2.1+**
  - All observations (NA prepBUFR + satellite data)
  - Sample files being made available
  - Refinements ongoing
    - Cloud/hydrometeor analysis
    - Upcoming - Surface assimilation, possibly background error covariance

RUC Home

Current and forecast weather

13km Rapid Refresh-1h cycle
13km Rapid Refresh-cold start - Alaska zoom
CONUS 130
3km HRRR
RUC GRIB viewer

Soundings:
RR-cyc - Interactive (Java)

Questions / Announcements

Forum-latest news
FAQ
Real-time RUC grids

Organization

AMB Staff
Sponsors
ESRL/GSD

Description

RR-Oct07
RR Change Log
RUC/RR/FIM Pubs

Other Information

Obs counts-NCEP RUC
RUC Backups
NCEP product status
NCEP obs processing
NCEP status messages

ESRL / GSD Home

Search GSD

Rapid Refresh Information

Rapid Refresh/RUC Development Group -- NOAA /OAR / ESRL / Global Systems Division / Assimilation and Modeling Branch

The Rapid Refresh (RR)

The next-generation version of the RUC

- ***An experimental (to become operational) NOAA/ NCEP hourly updating operational weather prediction system comprised primarily of***
  - ***A numerical forecast model***
  - ***An analysis/assimilation system to initialize that model.***

The Rapid Refresh uses a

- ***a RR-configuration of the WRF model***
- ***a RR-configuration of the Gridpoint Statistical Interpolation (GSI) analysis system.***

- ***Developed to serve users needing frequently updated short-range weather forecasts, including those in the US aviation community and US severe weather forecasting community.***
- ***The Rapid Refresh is the next-generation version of the 1-h cycle system, planned to replace the current RUC in NCEP operations by early 2010.***

The Rapid Refresh (RR) uses a version of the WRF model and the Gridpoint Statistical Interpolation (GSI) analysis largely developed at NCEP/EMC.

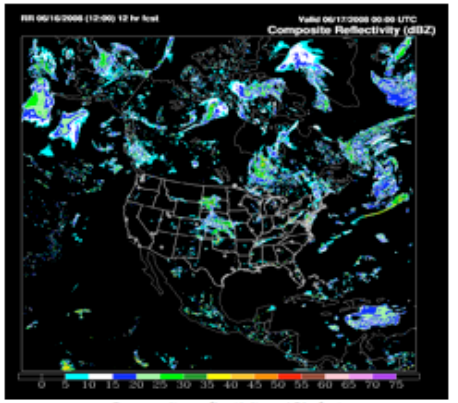
The High-Resolution Rapid Refresh (HRRR)

A 3-km hourly updated nest inside of the 13km Rapid Refresh (currently nested inside the 13km radar-enhanced RUC run at GSD)

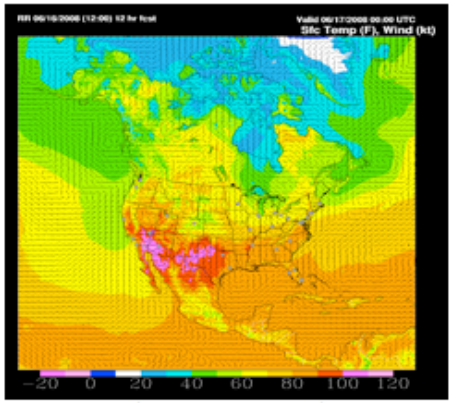
- ***Real-time products from 3km HRRR***

The HRRR uses

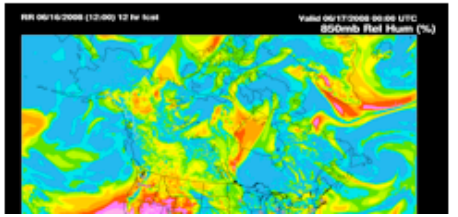
13km Rapid Refresh-1h cycle



Composite reflectivity - 12h fcst



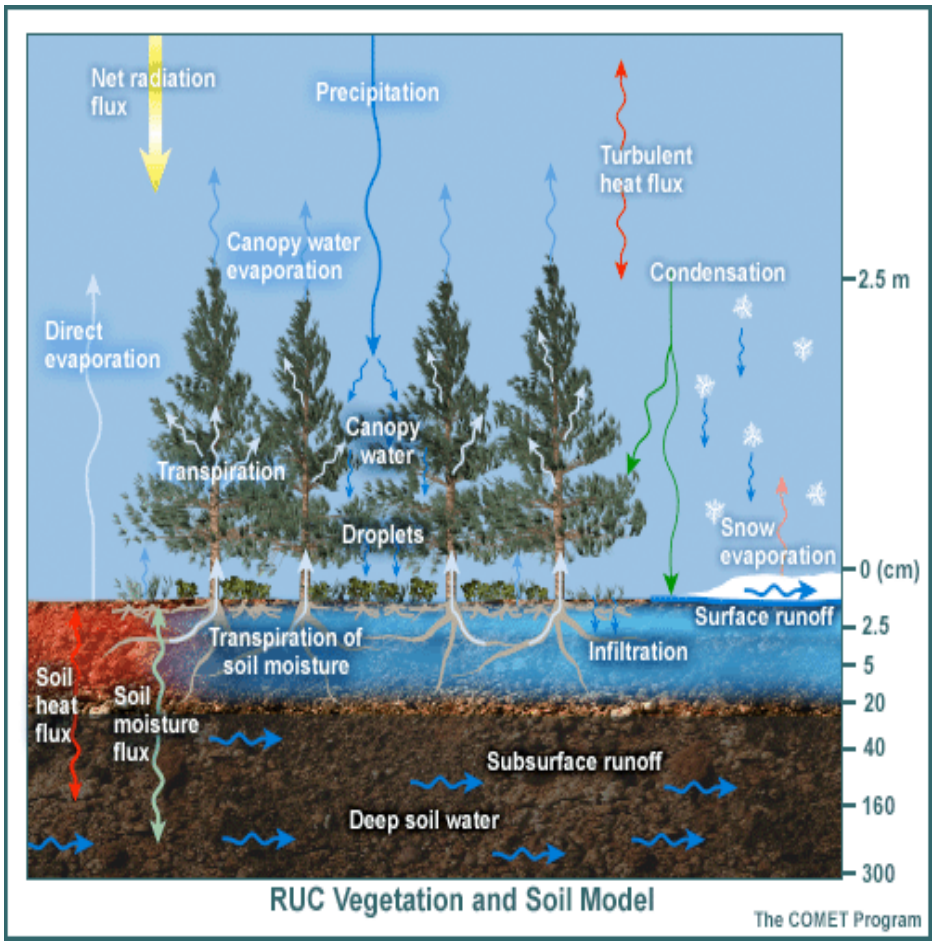
Surface Temperature - 12h fcst



Main accomplishments toward RR

- **GSI adapted for GSD Linux computer with WRF-ARW background**
- **Addition of cloud-hydrometeor analysis to GSI**
- **DFI added to WRF (v3.0)**
  - RUC-like design, accumulation in wrf.F90 - usable for other dynamic cores. (initial application w/ ARW core)
- **Updated versions in WRFv3.0 of**
  - Grell-Devenyi scheme (option 5 for convection)
  - RUC-Smirnova scheme
- **WPS changes such that RUC native data (including hydrometeors and LSM fields) can be used easily by community WRF users**

Changes to RUCLSM snow model in WRF version 3 based on SnowMIP2 experiment



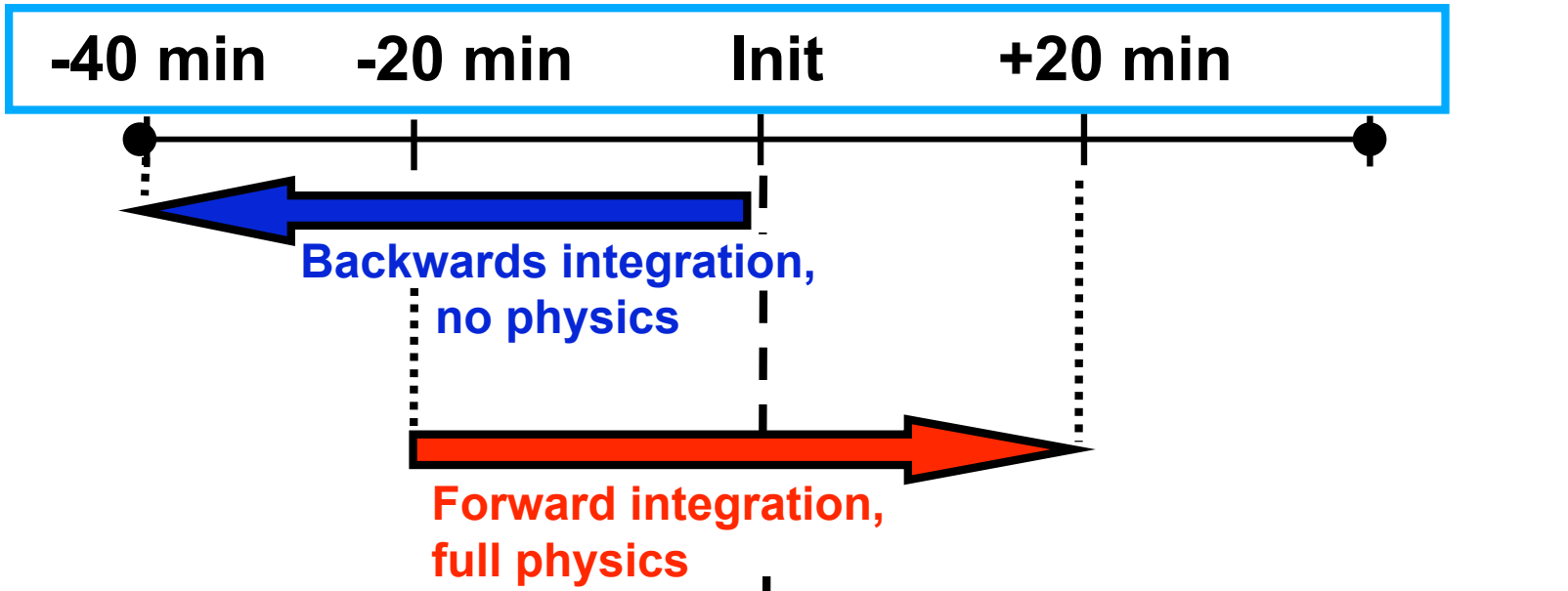
Increased density of snow on ground to ≥100 kg/m3 (from ≥50 kg/m^3) to reduce cold bias over fresh snow cover when temps are ≤ -15C.

Patchy snow - when snow depth is below some threshold value albedo and skin temperature are weighted average between snow-free and snow-covered portions of the grid box

Soon to be committed to the WRF Repository - introducing additional iteration for energy budget solution if melting rate exceeds possible maximum rate for given conditions; different treatment of open and forested areas.

Diabatic Digital Filter Initialization (DDFI), used in RUC
- Application into WRF - **completed for ARW, in WRFv3.0**

(Tanya Smirnova, Steven Peckham, Stan B., John Brown)



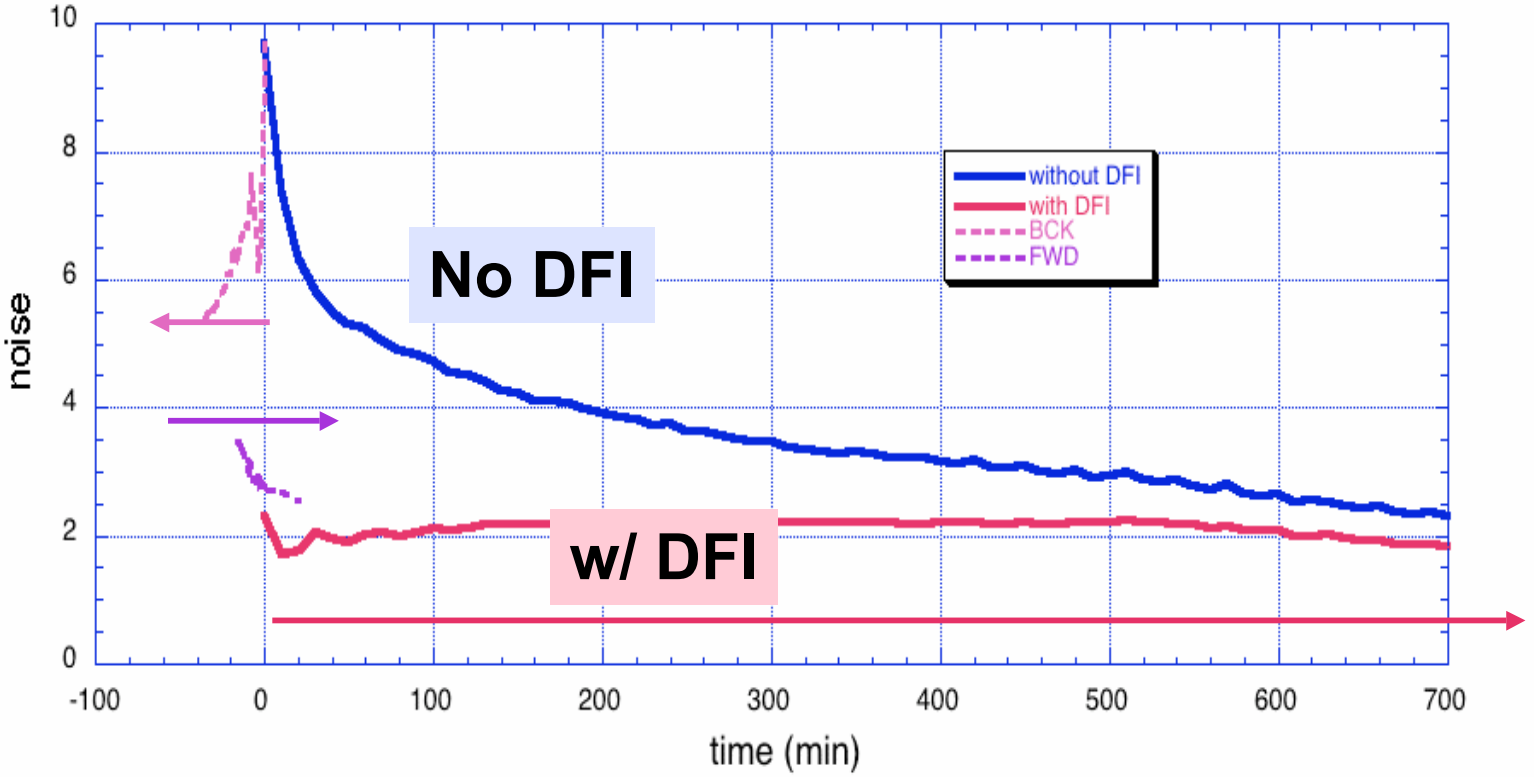
Function of DFI: Remove high-frequency oscillations (particularly, gravity waves) from the initial state for the forecast

⇒ creates smoother background for next analysis

Quieter forecasts in WRF using DFI

Noise = mean absolute sfc pressure tendency (hPa/h)

$$\left| \frac{\partial p_{sfc}}{\partial t} \right|$$

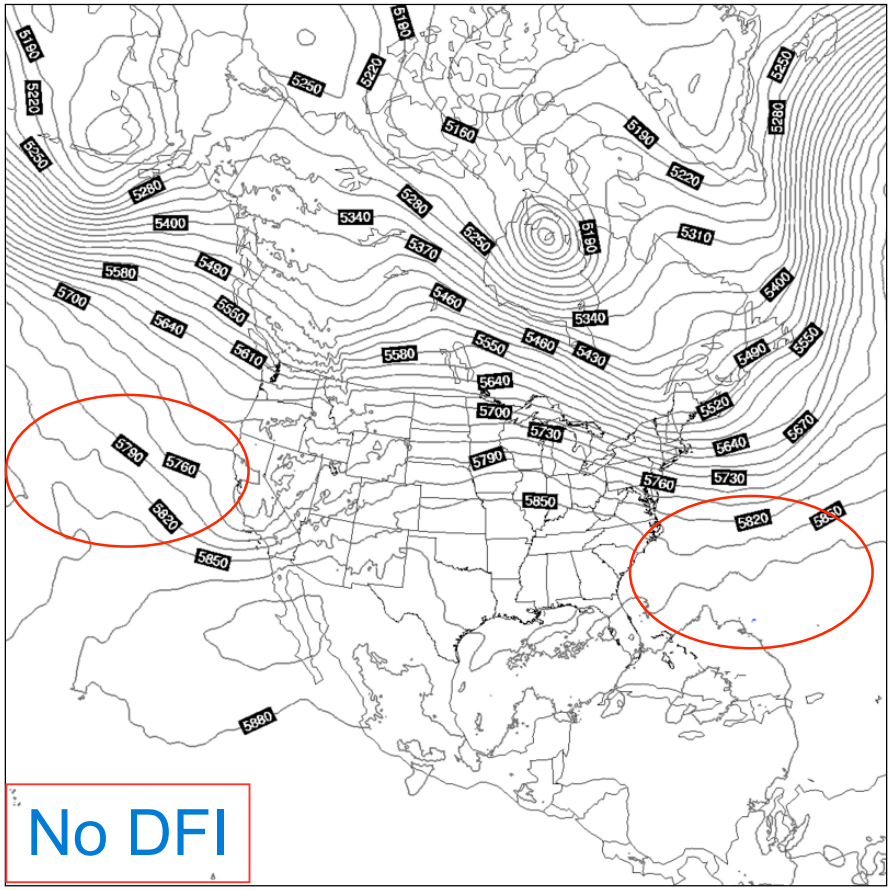


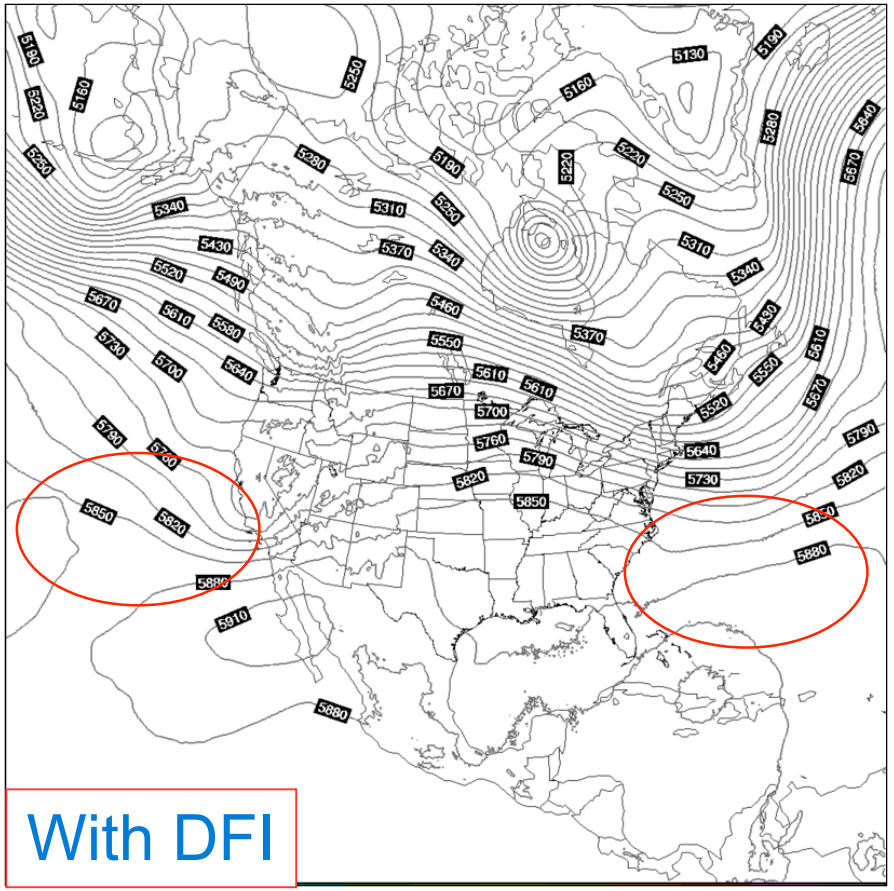
Using WRF-13km Rapid Refresh over N. American domain

Successful for reducing noise in 1h WRF fcst, as with RUC

500mb Height 3-h Fcst for 03Z 30 Oct 07
Rapid Refresh WRF

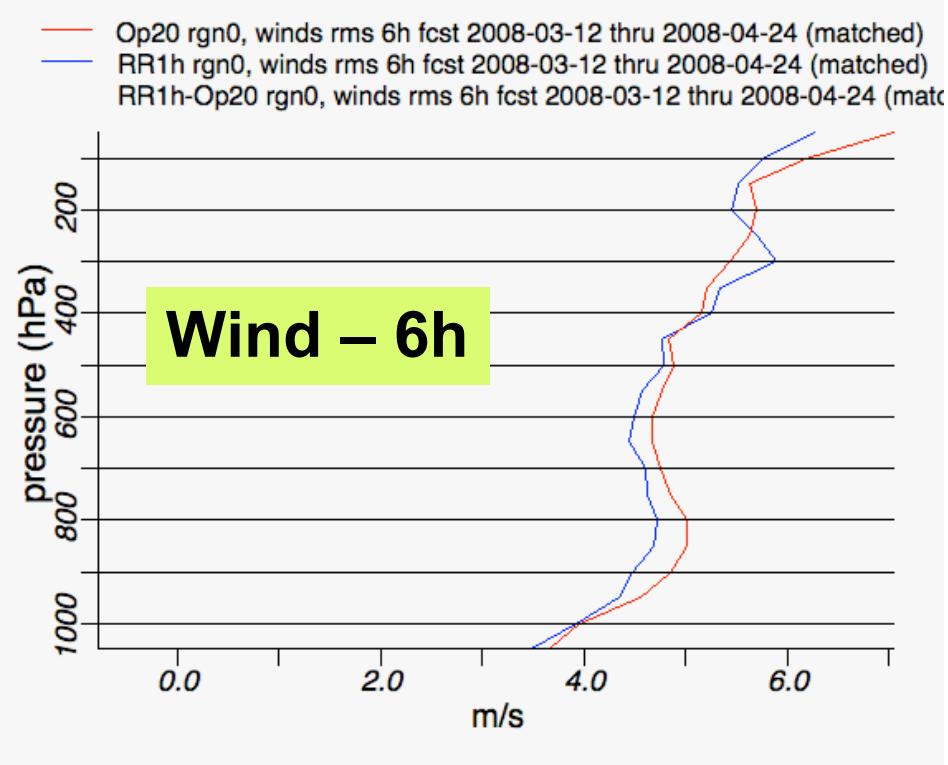
Away from terrain and convection,
height contours are smoother with DFI

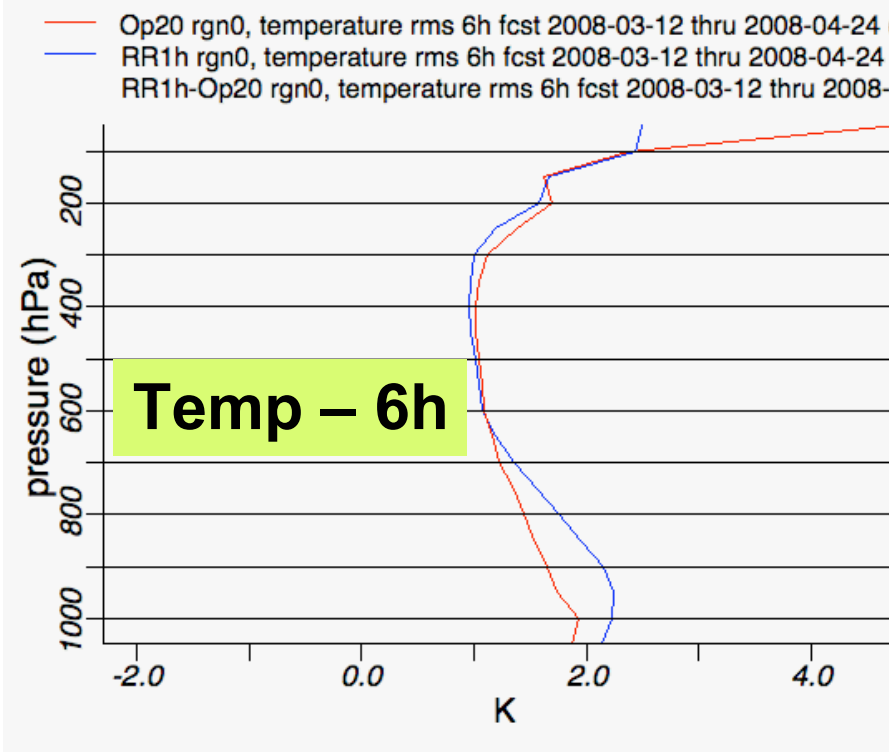




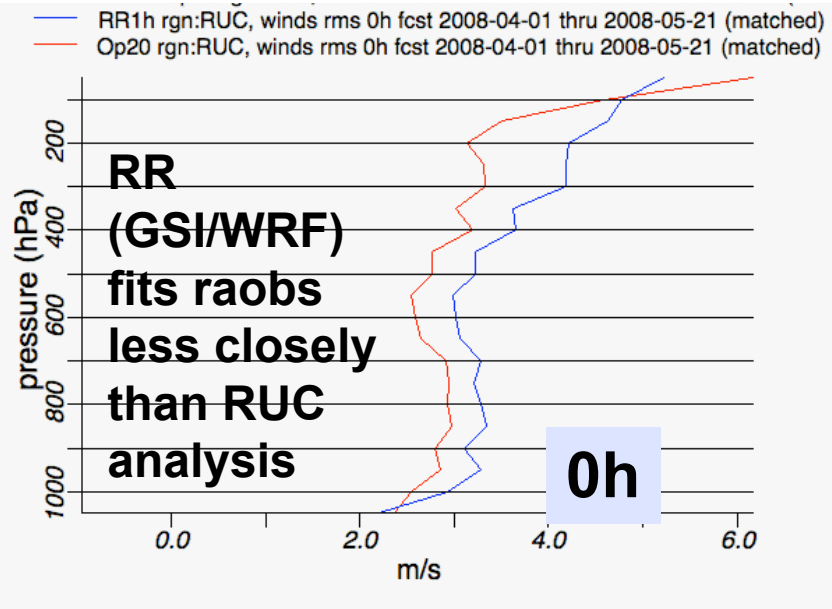
Rapid Refresh status

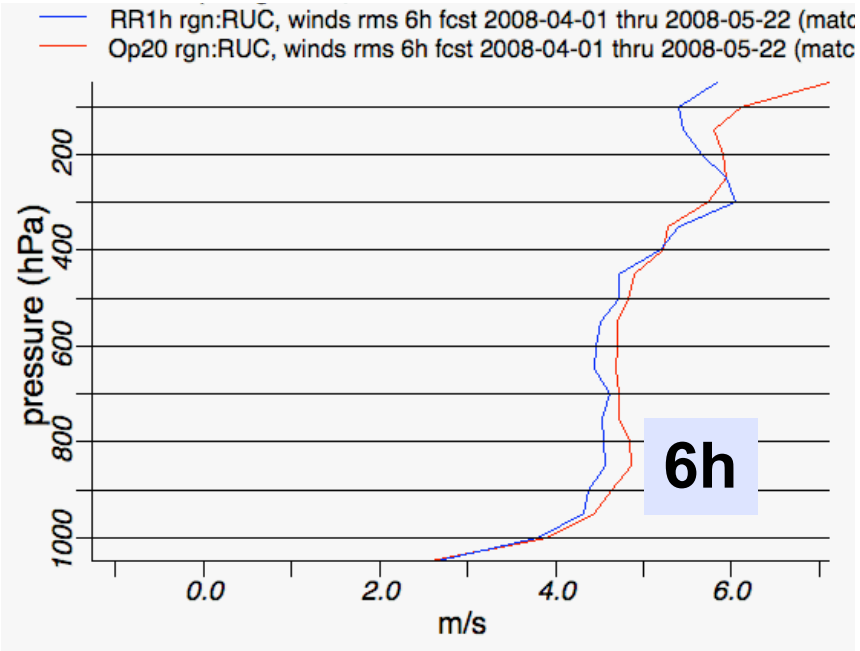
- **RR 1-h cycle 6-h forecast skill matching RUC1-h forecast skill over CONUS for winds (!), not yet for temperature and RH**

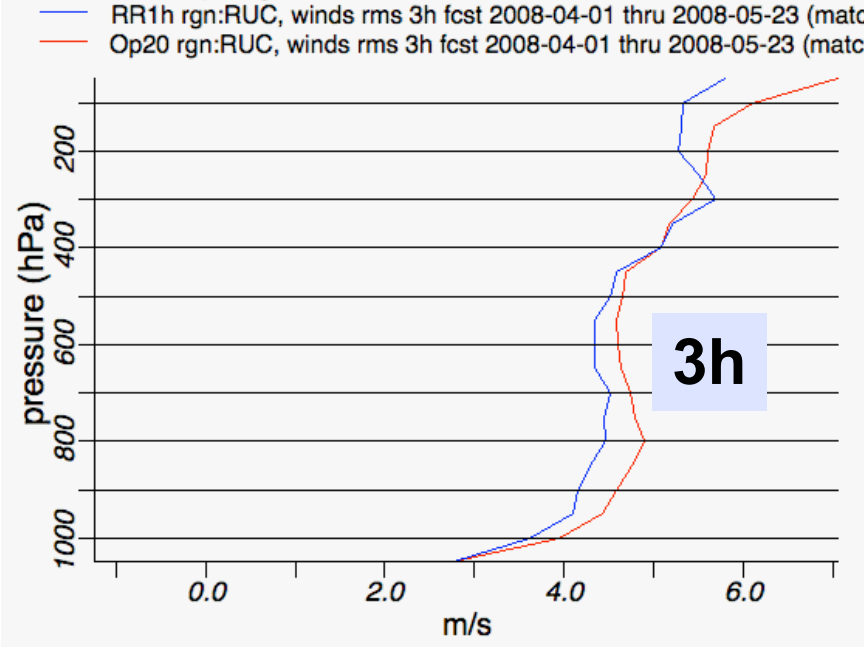


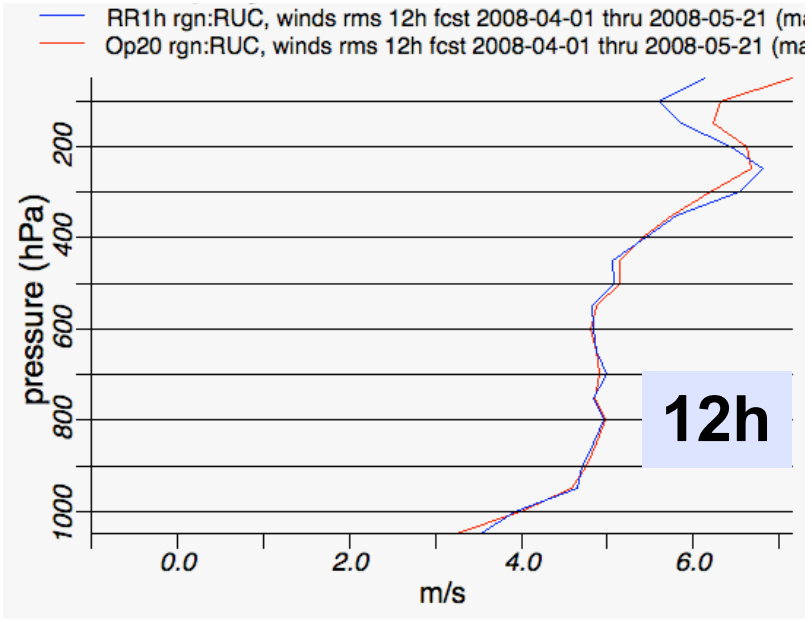


RR vs. RUC – winds

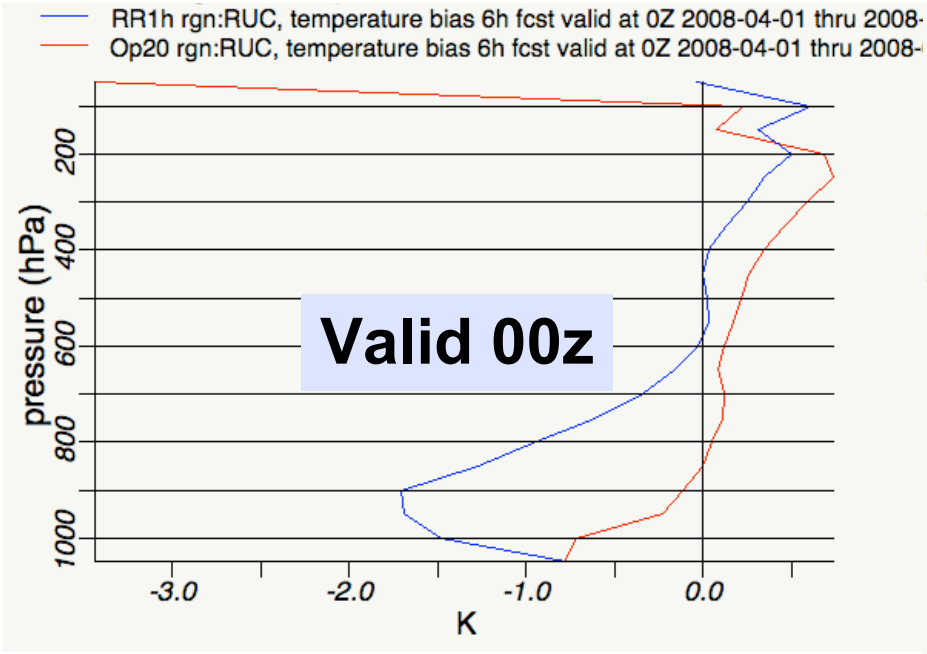


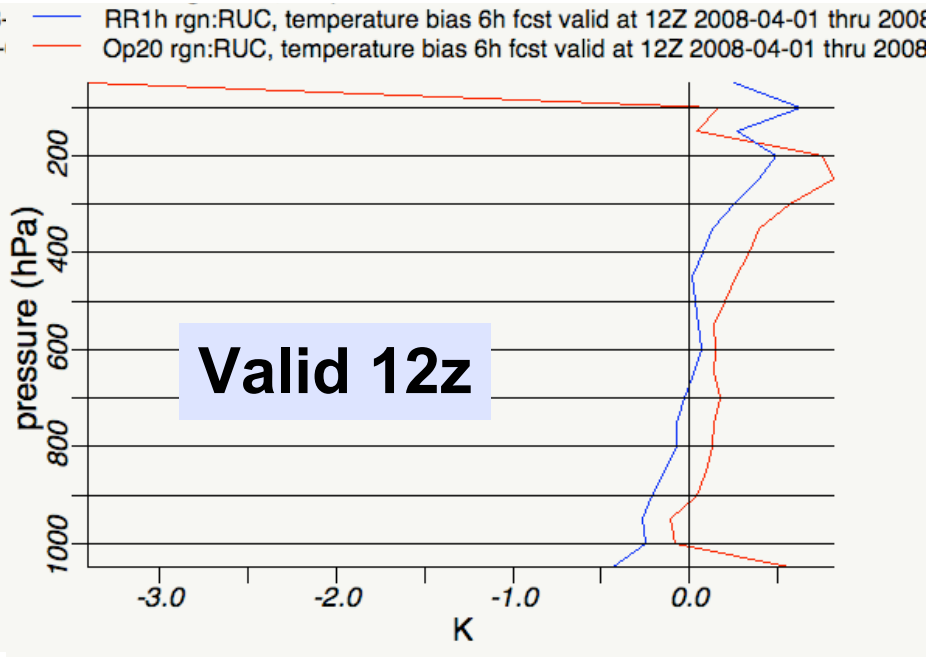


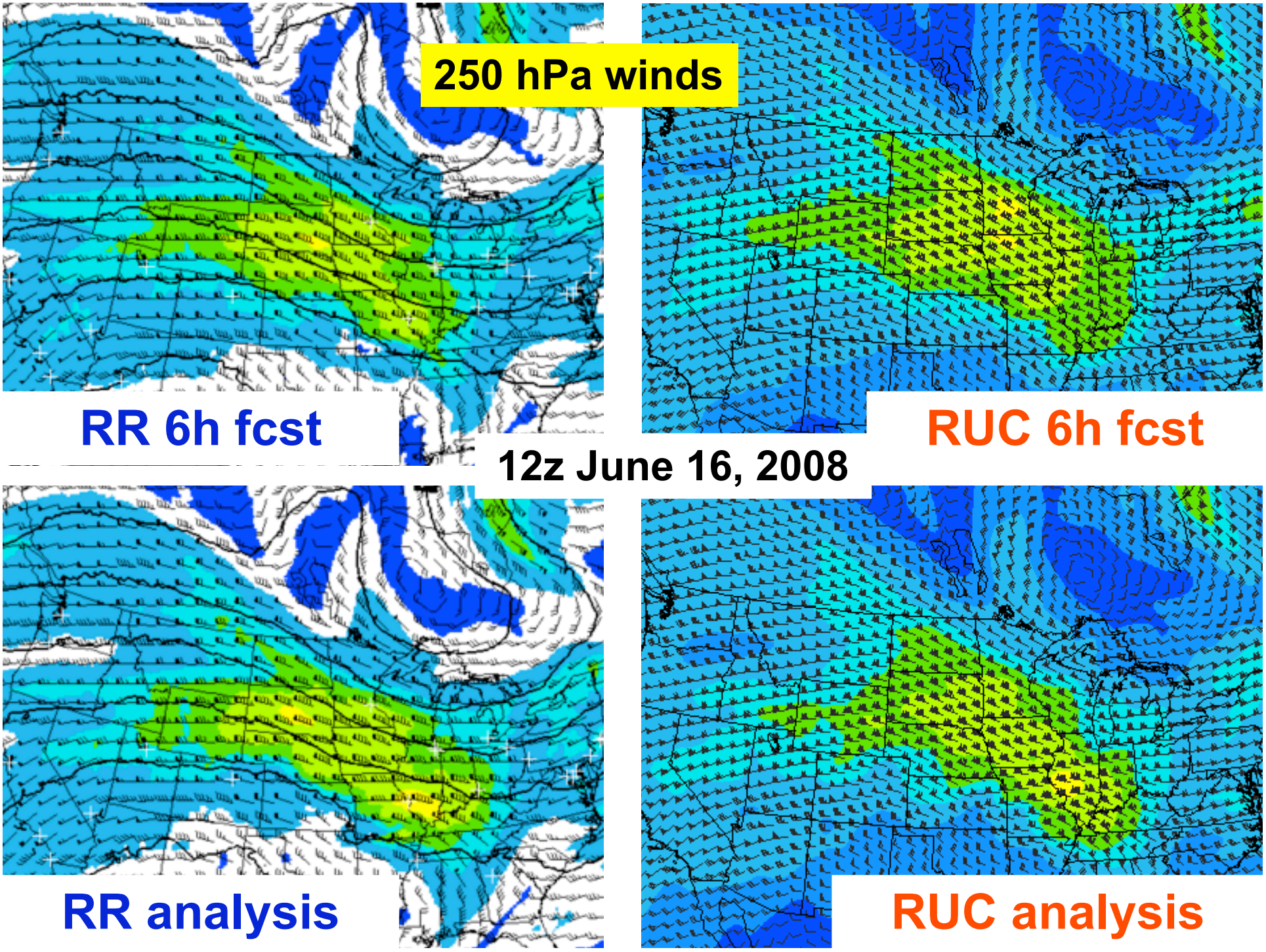


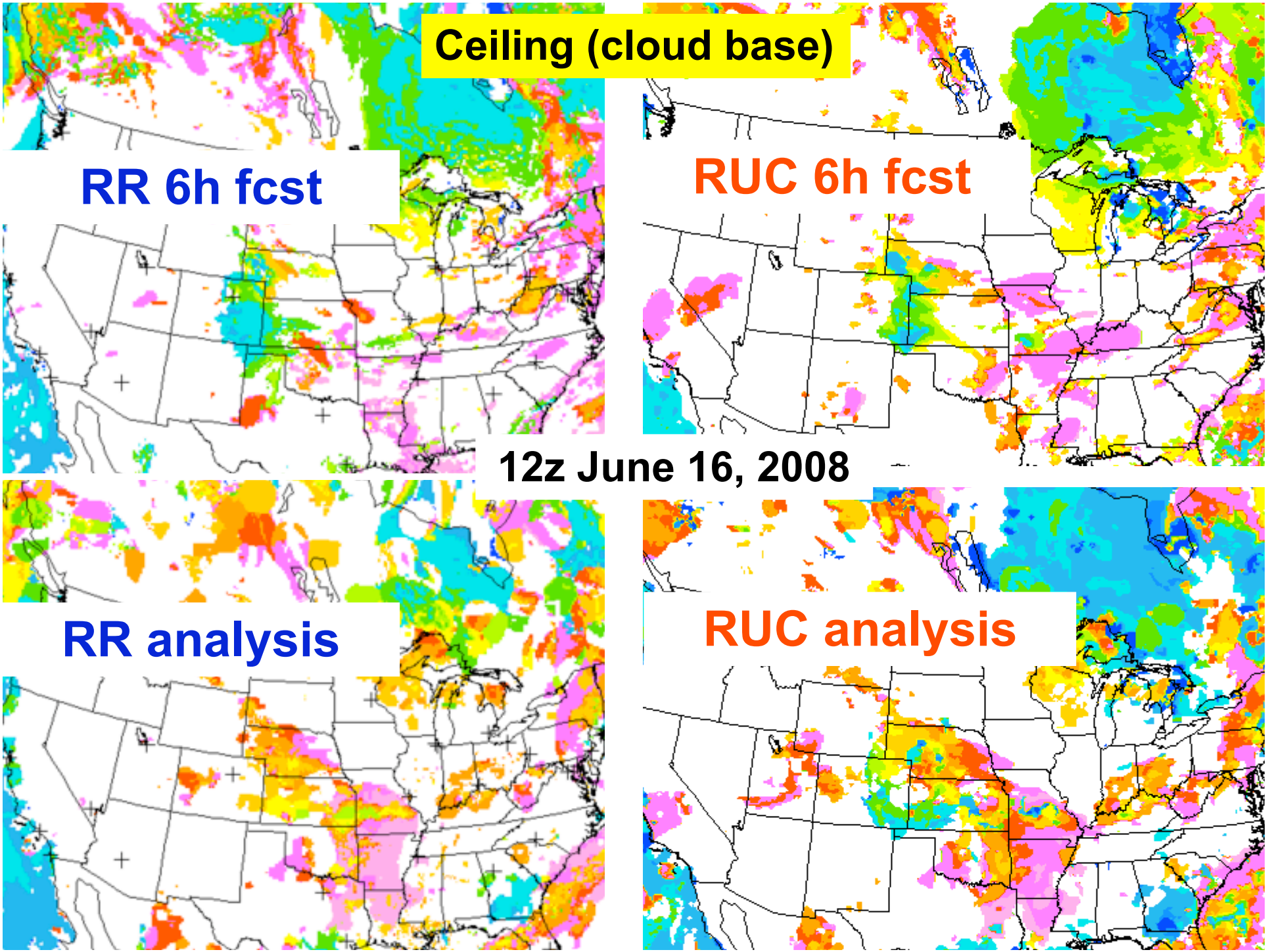


RR vs. RUC – temp bias (F-O)

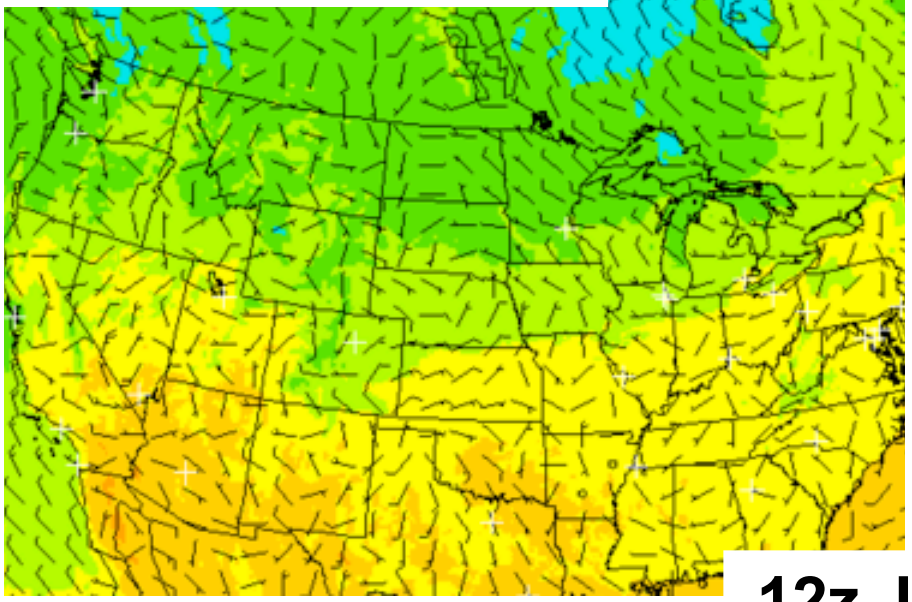




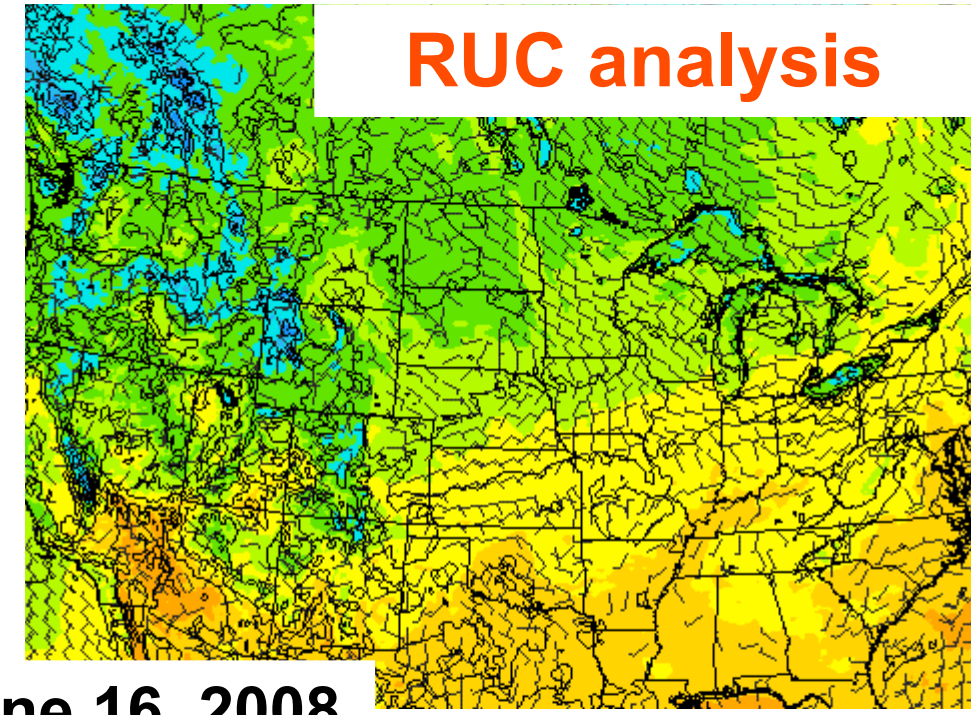

250 hPa winds
RR 6h fcst
RUC 6h fcst
12z June 16, 2008
RR analysis
RUC analysis


Ceiling (cloud base)
RR 6h fcst
RUC 6h fcst
12z June 16, 2008
RR analysis
RUC analysis

RR analysis

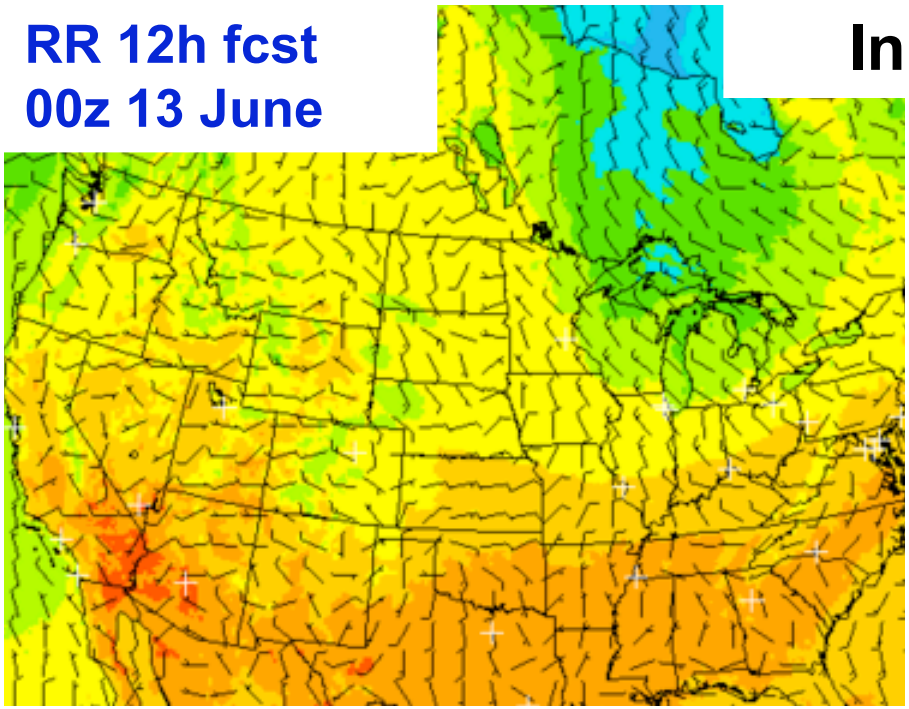


RUC analysis

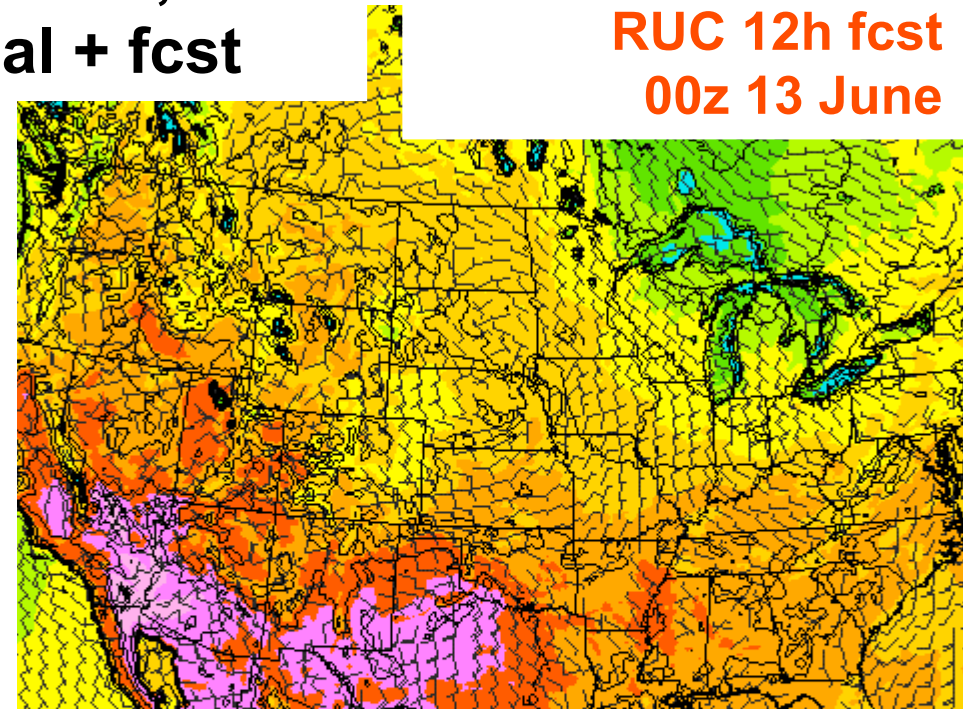


12z June 16, 2008
Initial + fcst

RR 12h fcst
00z 13 June



RUC 12h fcst
00z 13 June



Remaining development and testing for RR

ANALYSIS - GSI

- **Cloud-hydrometeor analysis with existing RUC-RR obs**
  - Include GOES, NPOESS imager data
- **Forward model for surface observations**
  - Pseudo-innovations through PBL
  - Coastline effects
- **Buddy check QC**
- **Mean innovation QC**

MODEL – WRF-ARW

- **Solve daytime cold bias**
- **Change ARW so that microphysics can run on multiple dynamics time steps**
- **LSM cycling – design interaction with obs, LDAS**

Overall run time

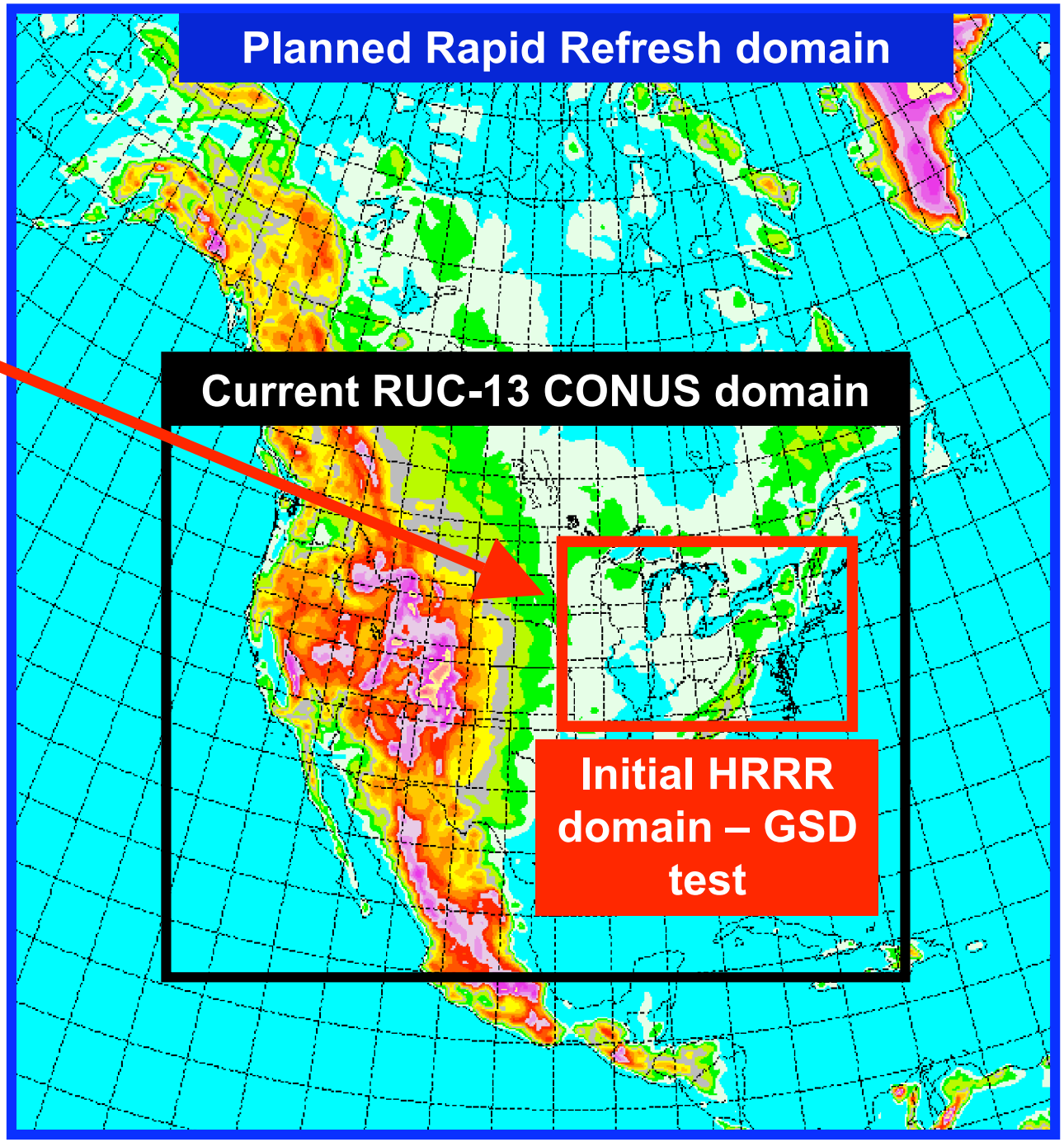
High-Resolution Rapid Refresh (HRRR)

- Storm-resolving (3-km) model, ARW, same physics as RR but no GD convection

- Initialized hourly with radar-enhanced RUC (current tests)

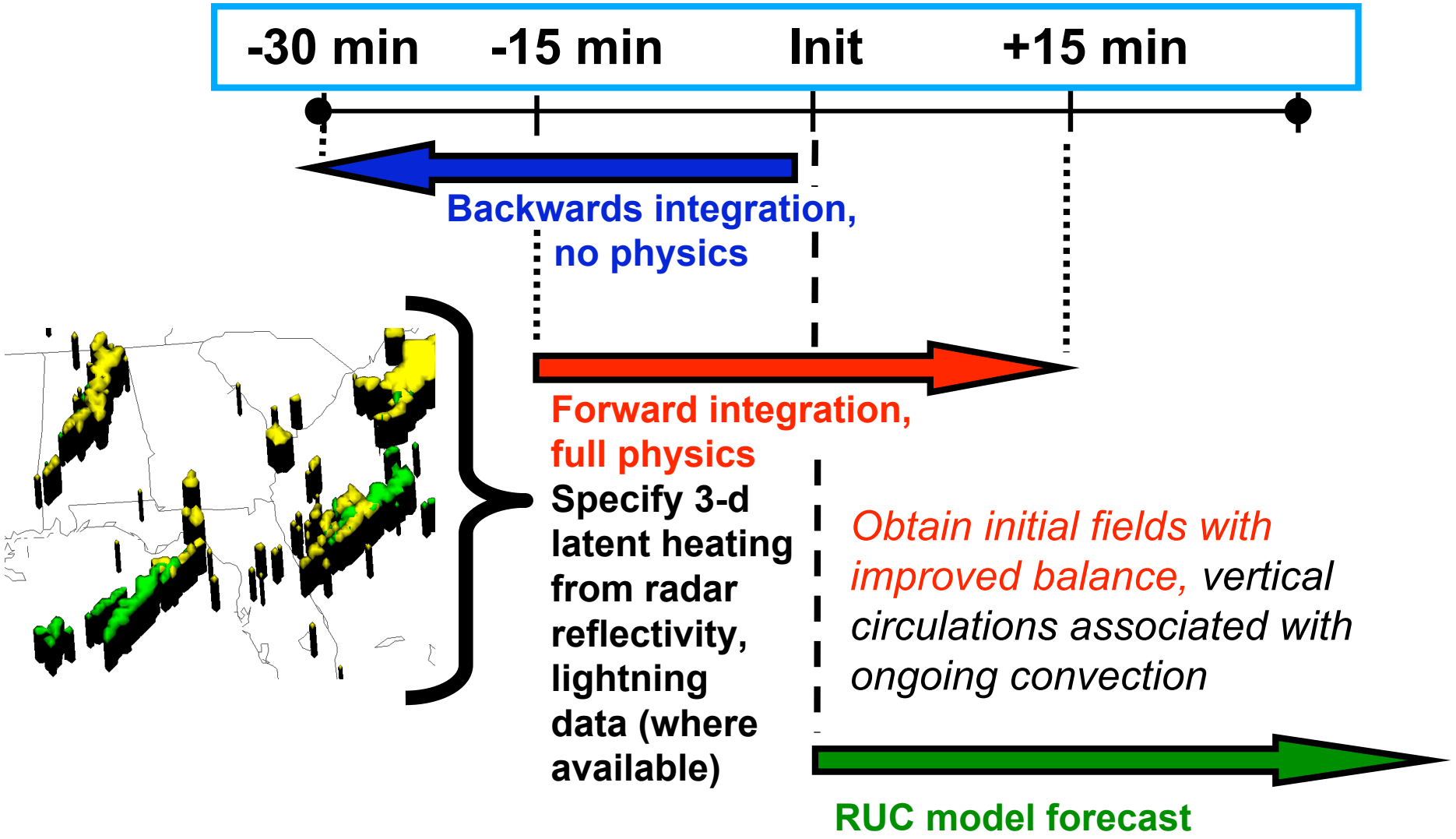
- Will run as 1-way nest inside Rapid Refresh

- Expandable based on NOAA computing resources



Diabatic Digital Filter Initialization (DDFI)

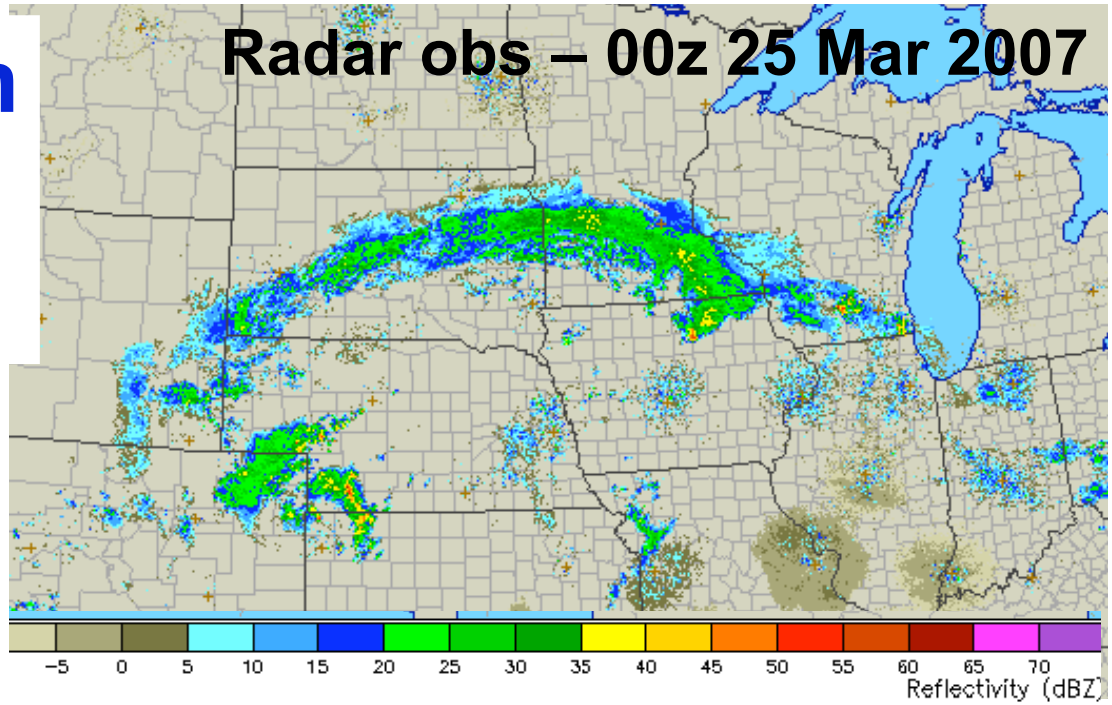
New - add assimilation of radar data



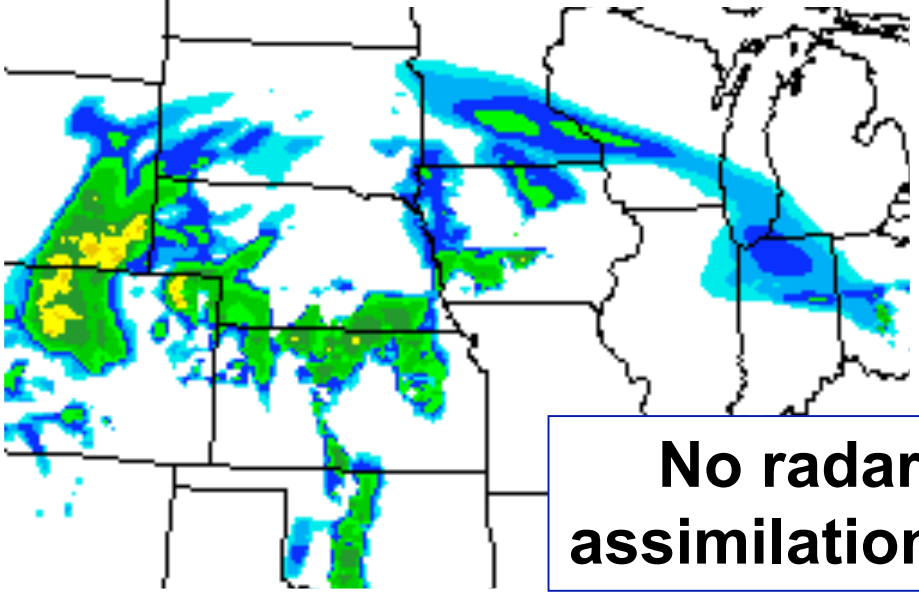
Radar reflectivity assimilation in RUC

Radar assimilation in RUC - winter storm example

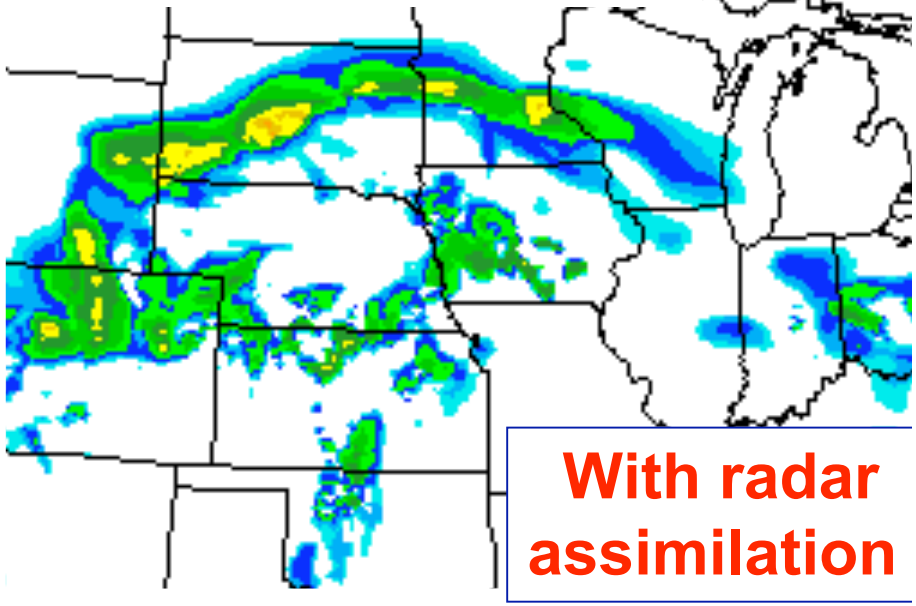
Also, added simulated radar reflectivity field to RUC output



RUC 3-h forecasts valid 00z 25 Mar 2007



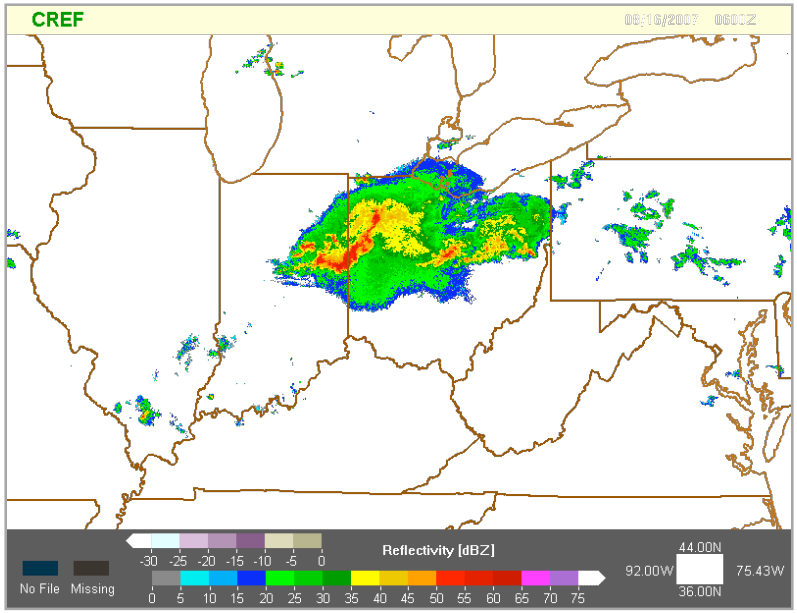
No radar assimilation



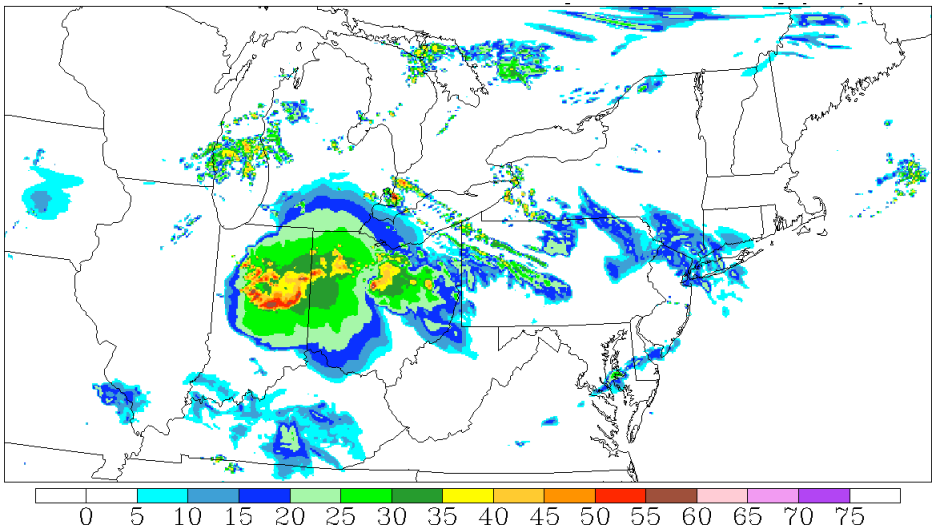
With radar assimilation

6h HRRR forecasts init w/ RUC (w/ and w/o radar

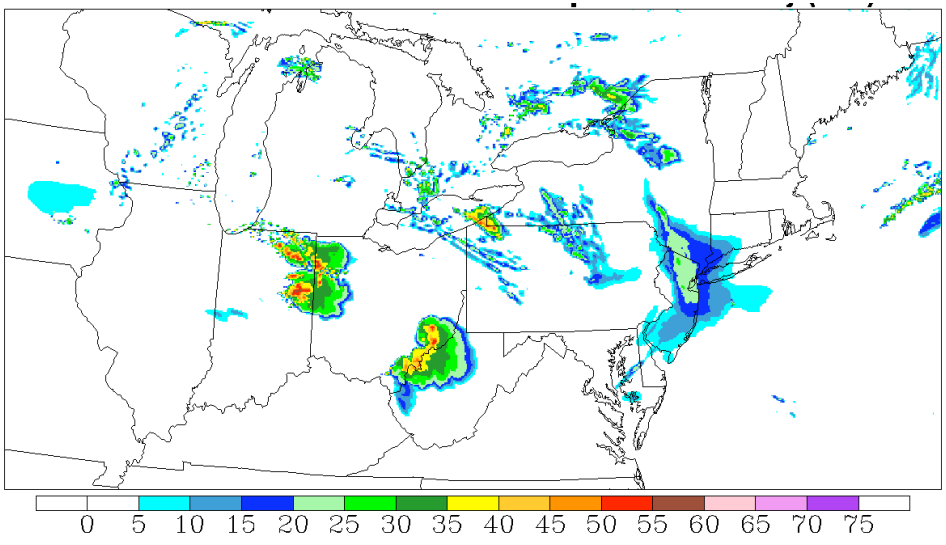
NSSL verification



HRRR 3-km run initialized From radar-enhanced RUC



No-radar init HRRR - 3-km run



1. HRRR already in testing
2. Radar-enhanced RUC essential for HRRR forecast success

6-h forecasts valid
06z 16 Aug 2007

Rapid Refresh, HRRR Summary

- **Rapid Refresh – 1h model/assim replacing RUC**
  - Uses
    - WRF-ARW, RUC-like physics, GSI assimilation
  - In real-time testing at NOAA/ESRL/GSD
  - Planned for implementation at NCEP by early 2010, testing at NCEP in 2009
- **RUC**
  - Upgrade in Sept 2008
  - Assimilation of radar reflectivity via DFI
- **High-Resolution Rapid Refresh**
  - 3-km WRF model run hourly
  - Uses radar-enhanced RUC as initial conditions

    (radar-enhanced Rapid Refresh by fall 2008)

http://rapidrefresh.noaa.gov