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Adaptation of the Gridpoint Statistical Interpolation (GSI) for hourly cycled application within the Rapid Refresh

Ming Hu[1,2], Stan Benjamin[1], Steve Weygandt[1], Haidao Lin[1,3], Curtis Alexander[1,2], Patrick Hofmann[1,2], David Dowell[1]

1 NOAA Earth System Research Laboratory/Global System Division
2 Cooperative Institute for Research in Environmental Sciences, Colorado University at Boulder
3 Cooperative Institute for Research in the Atmosphere, Colorado State University

Earth System Research Laboratory
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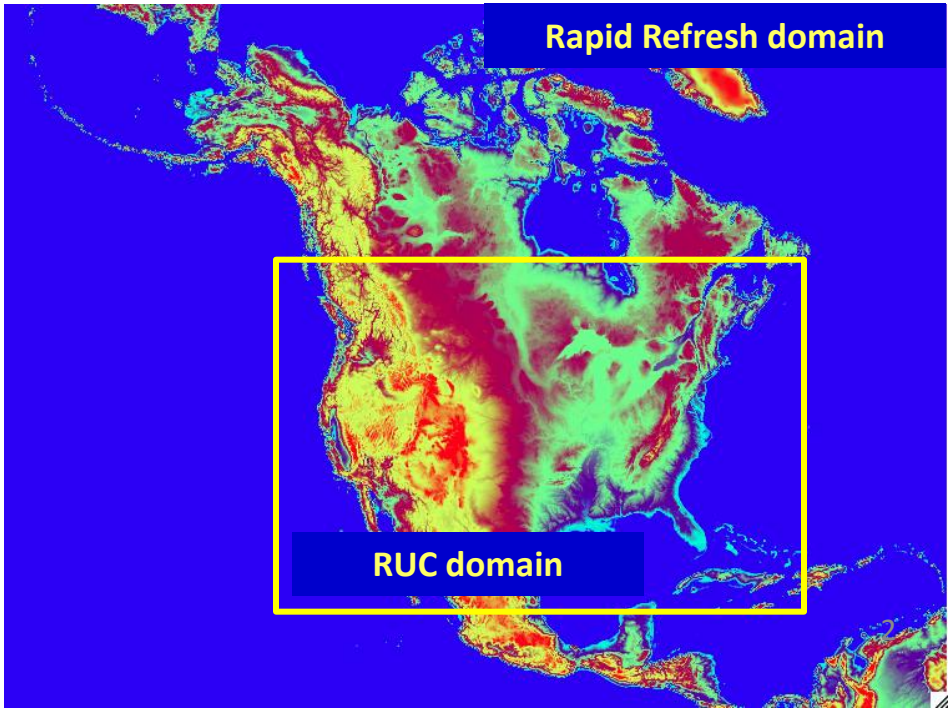
RUC Becomes Rapid Refresh (RAP)

RUC

- Non-WRF RUC model
- RUC 3DVAR analysis
- Continuous cycling
- CONUS Domain

Rapid Refresh

- WRF-based ARW
- GSI analysis
- Partial cycling
- Expanded 13 km Domain
  - ~2.8 times bigger
  - Includes Alaska
  - Rotated Latlon



John Brown's talk in session 3B1

RUC and RR

- 24/Day = hourly update
- Forecasts to 18 hours
- 13 km horizontal
- Cloud analysis, Radar DDFI, Surface data analysis

RAP: An operational system(since May 1st, 2012) built upon community forecast and analysis systems with lots of enhancements and tunings

Why use GSI for Rapid Refresh?

- NCEP, NASA GMAO supported "full" system
  - Developed mainly by NCEP for operational data analysis
  - Advanced satellite radiance assimilation with JCSDA
  - NASA GMAO work to create GSI-based 4DVAR
  - GSI used by NCEP for GFS, NAM, and RTMA
- Community analysis system
  - Many community developers and users (GSD, NCAR/MMM, …)
  - DTC work to make GSI available to research community
  - Community-wide SVN code management

The 3rd GSI summer tutorial: 21-23 August 2012 at NCAR, Boulder, CO

- Other applications
  - Use of GSI observation processing for ESRL EnKF work
  - Transition to GSI by Air Force Weather Agency

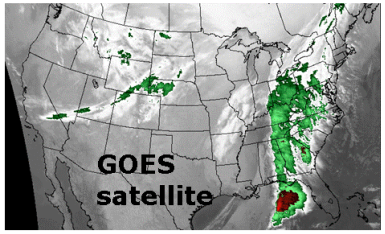
GSD contributions to GSI

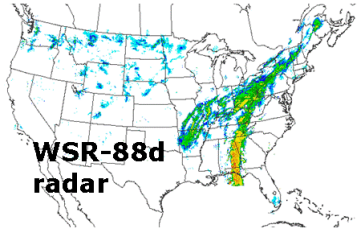
- Porting of GSI to from NCEP IBM to ESRL Linux
  - Many IBM-specific coding features, especially I/O
  - Much work by ESRL IT team to get robust Linux GSI
  - NCEP libraries on Linux
- Coupling of GSI to WRF ARW
  - Testing and evaluation of many GSI features for ARW
  - Completion of several GSI ARW code stubs
  - Adaptation of GSI and ARW modules to accommodate hourly cycling

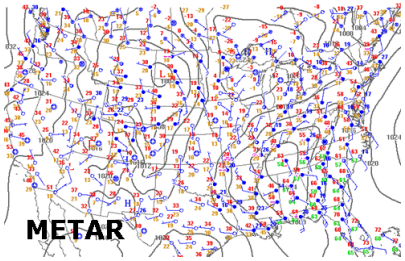
Adding Rapid Refresh (RUC) specific features to GSI:

- Cloud analysis (satellite, METAR, radar obs)
- Assimilation of radar and lightning data
- RUC-design modifications for surface assimilation

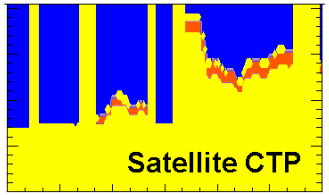
RUC/RR Cloud analysis schematic

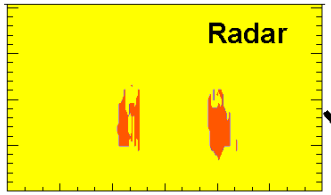


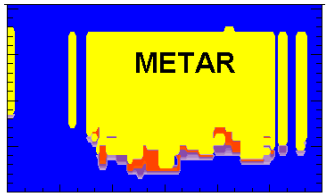




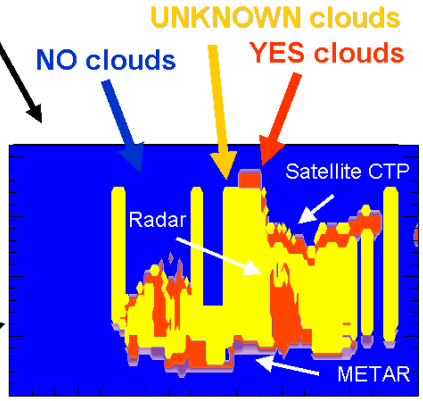
observation

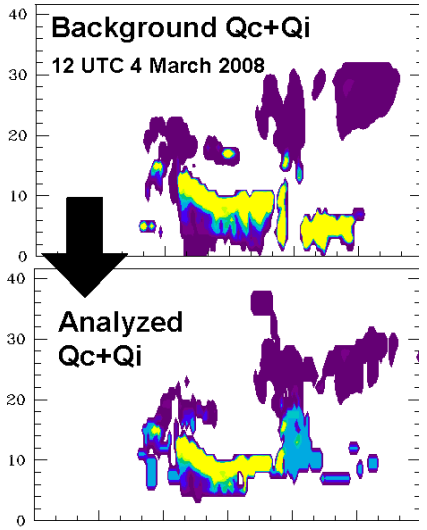






Cloud designation from observations



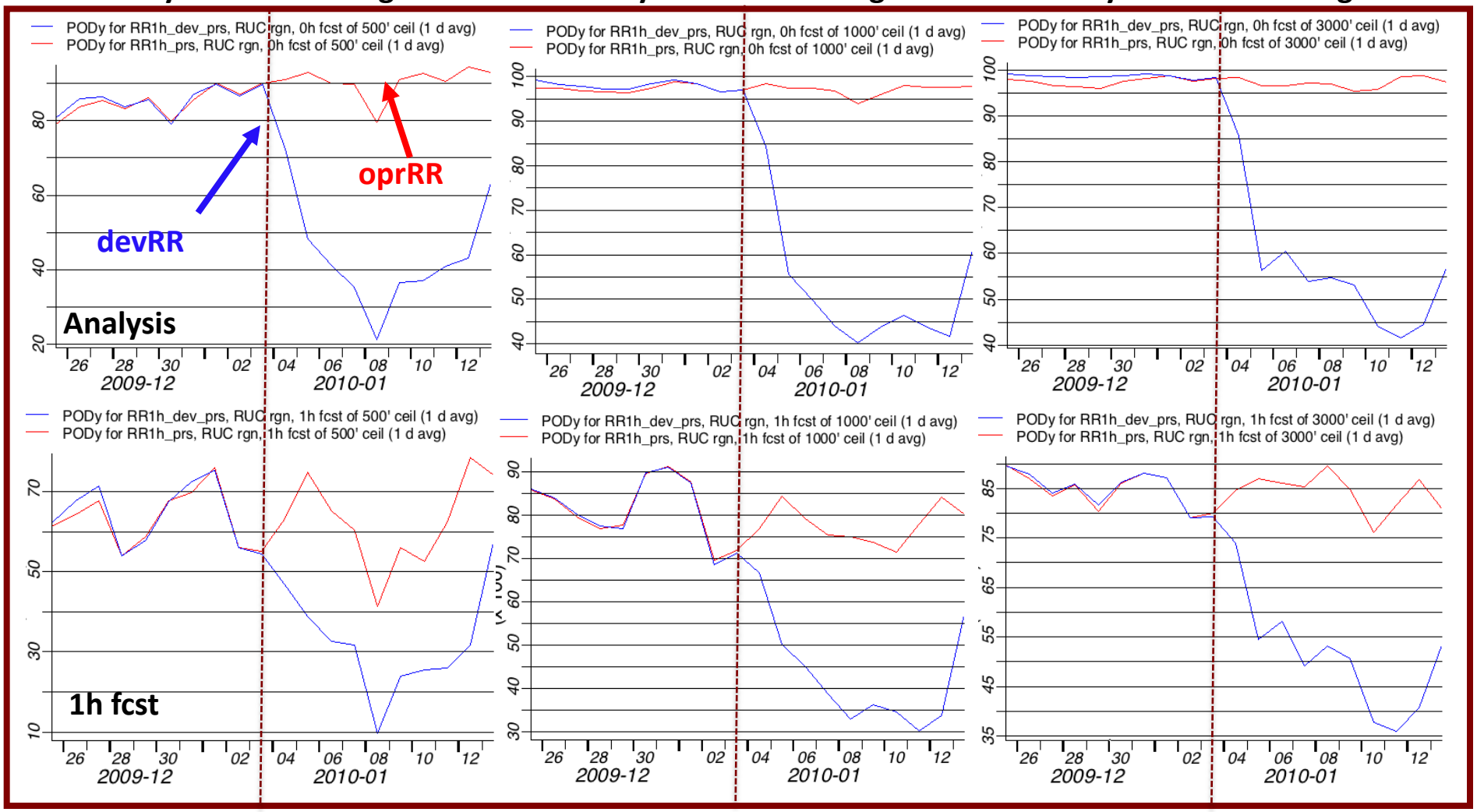


- Uses METAR, satellite, radar, lightning data
- Updates RR 1h-fcst RR hydrometeor, water vapor fields
- Generates latent heating from radar and lightning data

RR Cloud analysis

Cloud Analysis Verification: PODy analysis and 1-h forecast

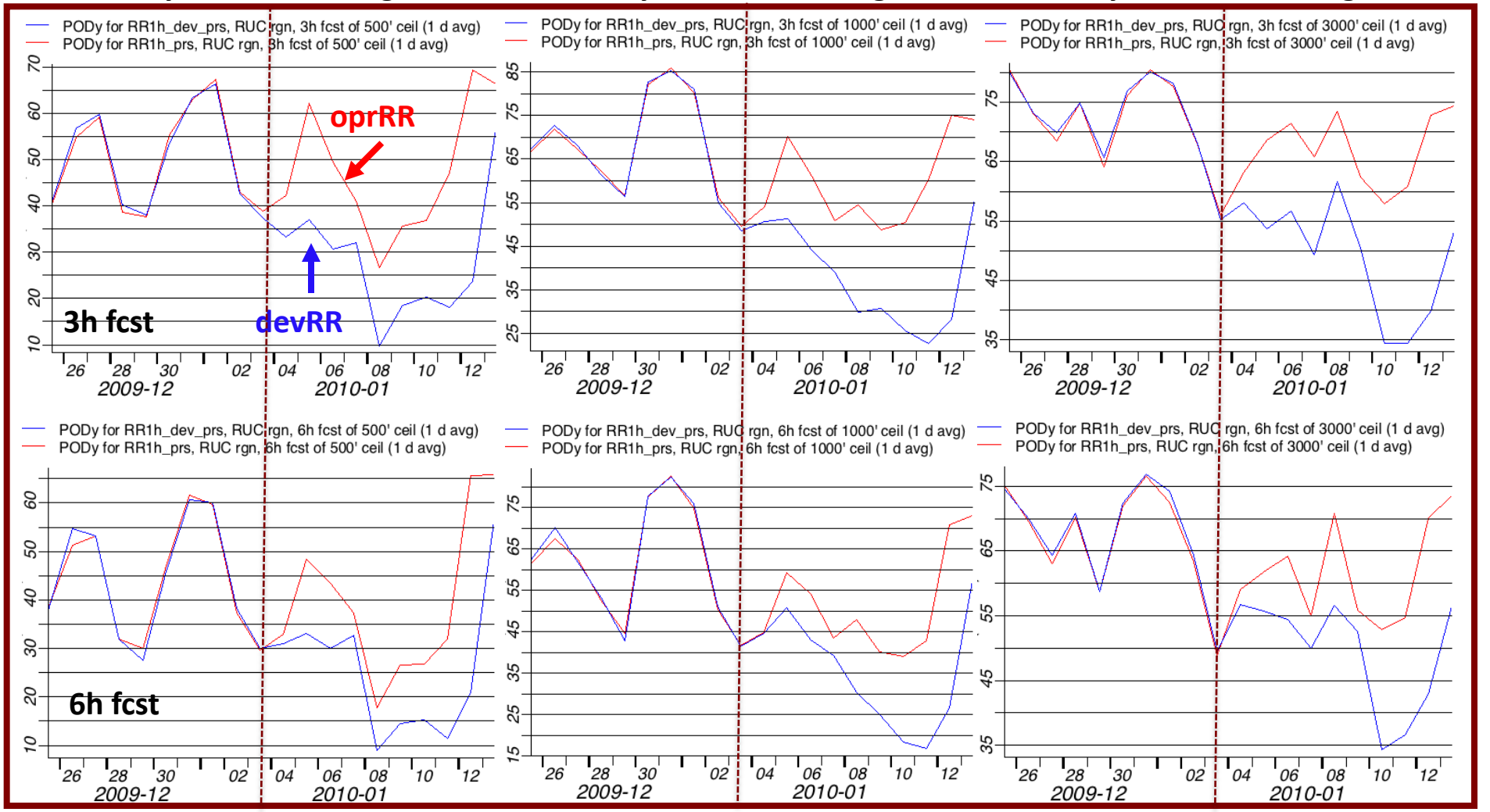
PODy 500 feet ceiling | **PODy 1000 feet ceiling** | **PODy 3000 feet ceiling**



RR Cloud analysis

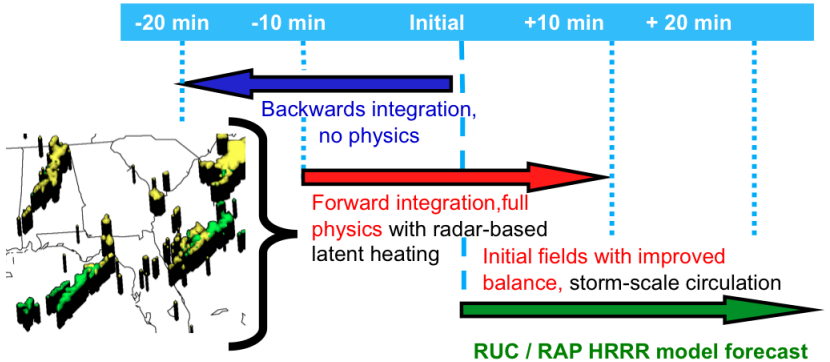
Cloud Analysis Verification: PODy 3- and 6-h forecast

PODy 500 feet ceiling | **PODy 1000 feet ceiling** | **PODy 3000 feet ceiling**



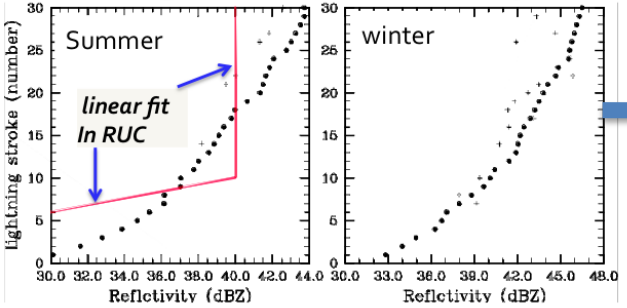
Radar and lightning data assimilation in RR

Digital Filter-based reflectivity assimilation initializes ongoing precipitation regions

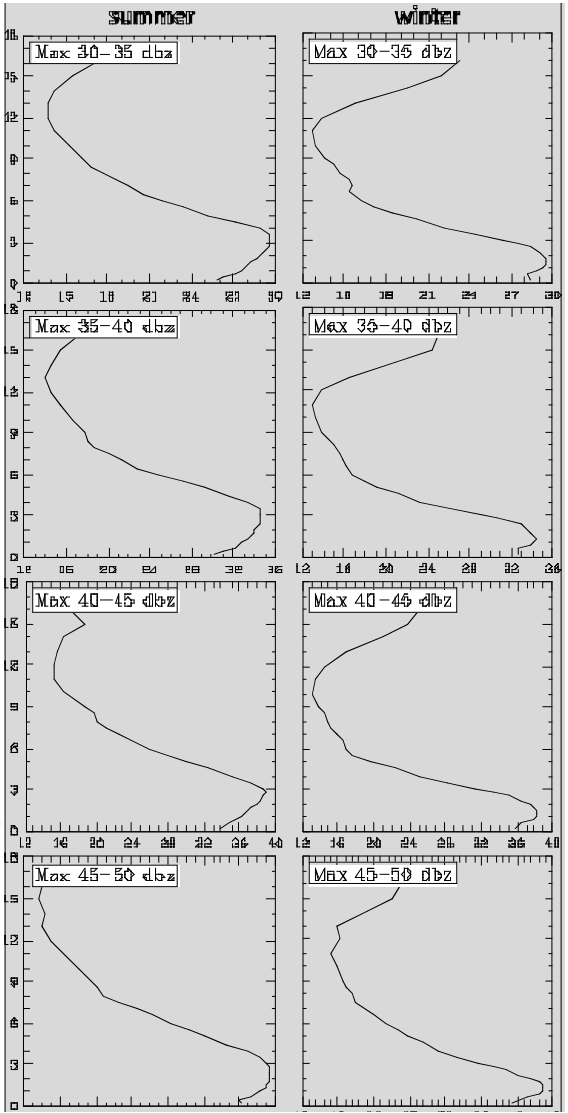


Important for storm initialization and forecast in RR/HRRR

Use of lightning data to augment 3-d reflectivity



Lightning flashes per RR grid box vs. column maximum reflectivity



Average vertical profile of reflectivity as a function of the composite reflectivity in 5 dBZ bins from 30 to 50

Great lightning coverage from GLD360: more details in our poster for "2012 NOAA Satellite Science Week"

Further Enhancements in cloud analysis for RAPv2

1. Avoid building cloud using METAR ceiling observations with haze and dust observations in
2. Use NASA LaRC cloud product along with the NESDIS product
3. Use PBL in the calculation radar reflectivity TTEN
4. **Building of low-level clouds from GOES data**
5. **Conserve the virtual potential temperature during moisture adjustment**.
6. Avoid building cloud into inversions if guess is very dry
7. Bug Fixes

These enhancements are based on the real-time tests and the RUC applications. Please see Patrick's talk tomorrow (2E1.3) for more details on enhancement 4 and 5

Surface data analysis Enhancements for RAPv2

1. **Assimilation of surface moisture pseudo-obs in PBL**
2. **Soil adjustment based on near-surface temperature / moisture increments**
3. **Elevation correction, innovation limits for GPS-TPW obs**
4. Linear variation of observation error inflation below surface for q, t.
5. QCed wind measurements from towers and wind-generator nacelles are now included in analysis
6. Limit the low level moisture analysis increment over ocean

For up-air observations

- Add additional QC for PBL profiler
- Add aircraft observation rejection list to toss bad aircraft temperature, wind, and moisture observations.
- **Closer fit to sounding**

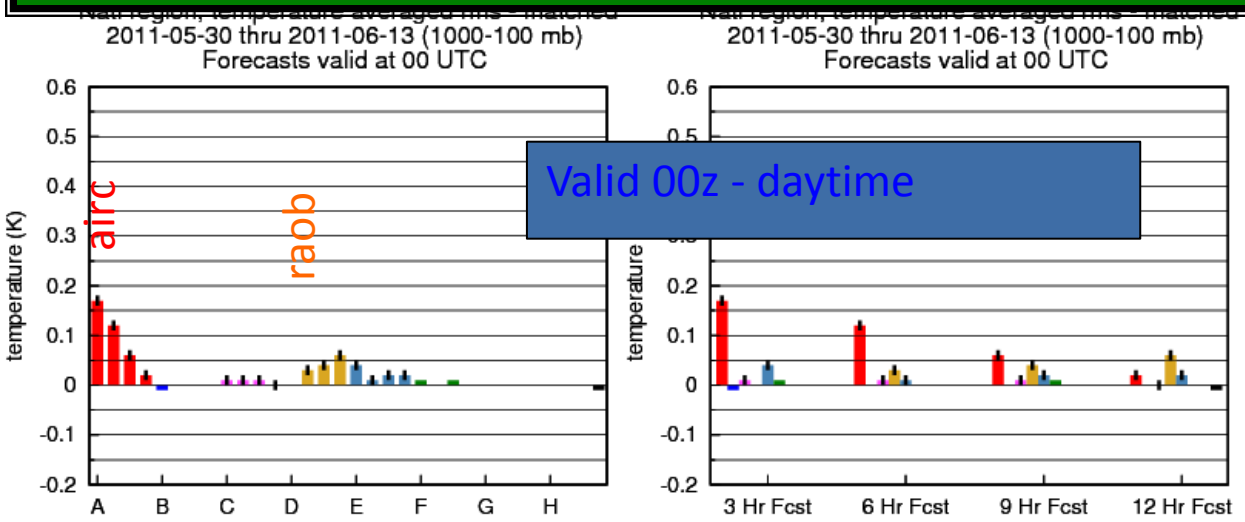
Please see Patrick's talk for details on 1,2, 3, and closer fit to sounding

These enhancements to RAPv2 have been committed to GSI trunk and will be available for community users in new community GSI release version 3.1.

Other tuning and testing for RR GSI

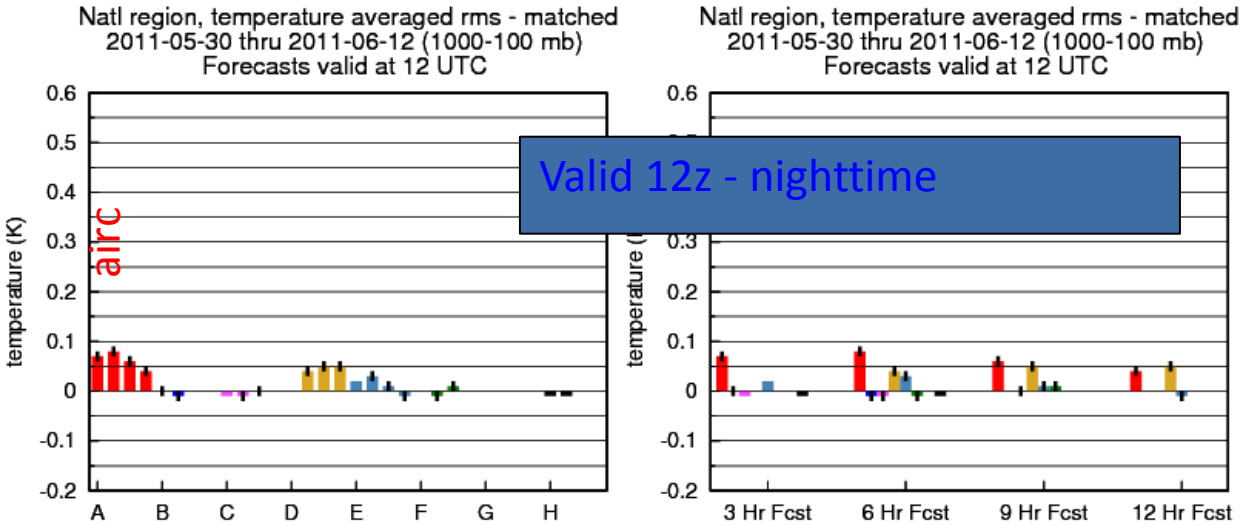
- Tune existing background error covariance for RR
- Apply and test new observations
  - lightning, Nacelle and tower wind, NASA cloud products, Sodar profilers
- Comparison of RR(RAP) GSI on top of different trunk GSI revisions
  - RAPv1 GSI is based on GSI trunk r9374 (2010-09-23)
  - Current RAPv2 GSI is based on GSI trunk r16882 (2012-01-05)
  - RAPv2 on top of the trunk is under testing
- Data usage: data window, data errors, QC
- Check the impact of the data in Rapid Refresh

From RAP data impact study



Valid 00z - daytime

A - withhold aircraft obs - Exp v6 - c
B - withhold all profiler obs - Exp v7
C - withhold VAD winds - Exp v11 - c
D - withhold rawinsonde obs - Exp. v
E - withhold surface obs incl METAR
F - withhold GPS-Met PW obs - Exp
G - withhold AMVs - Exp v10 - contr
H - withhold radar refl- Exp v8 - cont



Valid 12z - nighttime

Temperature

national - 1000-100 hPa

#1 = Aircraft
#2 = RAOBs

Aircraft more at 3h, RAOB-12h

Details see Stan Benjamin's talk at WMO Workshop on Impact of Observations on NWP
" Impact of upper-air and near-surface observations on short-range forecasts from NOAA hourly assimilation cycles (RUC and Rapid Refresh)"

Summary

- GSI has been successfully adapted in RR(RAP) application
- Benefit from the GSI development and research community
- Great contributions to GSI community from RAP development
  - Cloud analysis package
  - Surface data analysis enhancements
  - Radar and lightning data analysis
  - Test and evaluation GSI for application in rapid assimilation cycles with WRF-ARW

Future work

- Future development
  - Process toward variational cloud analysis
  - Generate background error covariance based on RR(RAP) forecast
  - Enhancement satellite radiance data assimilation
  - Apply and improve RR(RAP) GSI for HRRR applications

- Evolve toward a variational/EnKF hybrid approach

RAP 2Way Hybrid Assimilation Cycles (under development)