RUC / Rapid Refresh / HRRR: recent enhancements, future plans

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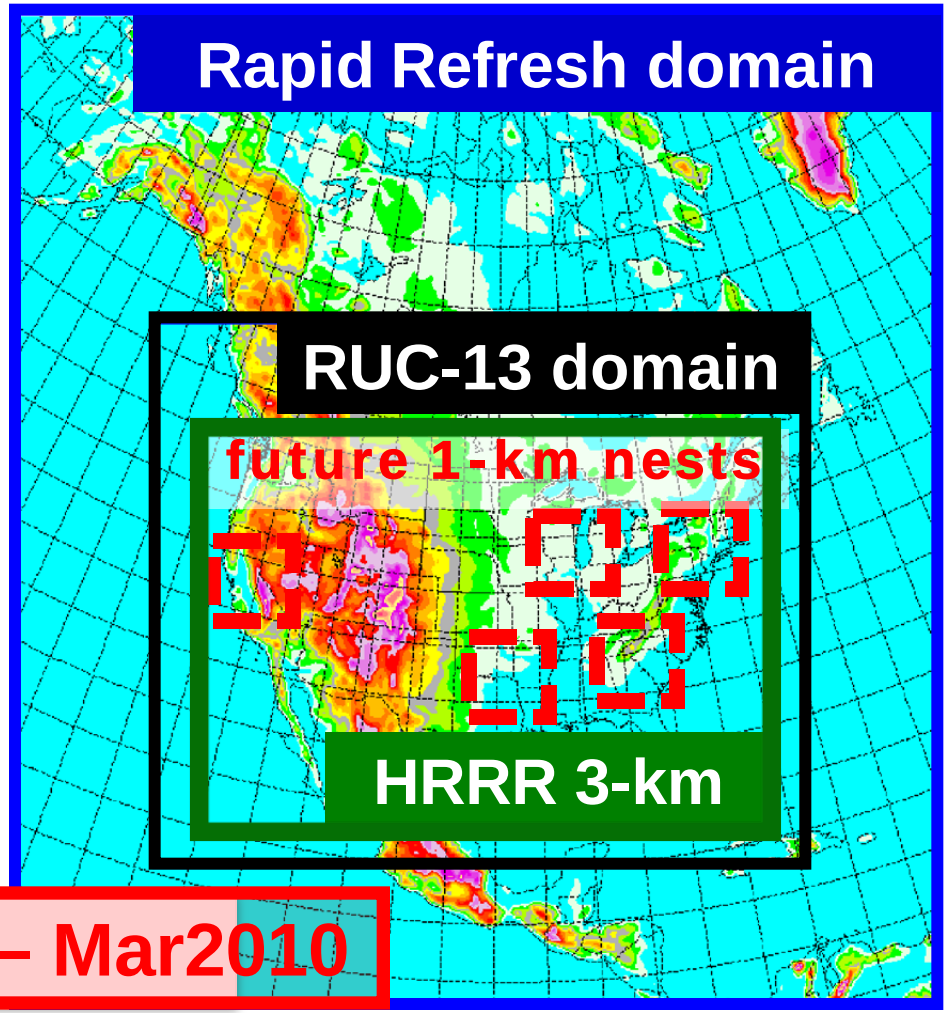
Earth System Research Laboratory
SCIENCE, SERVICE & STEWARDSHIP



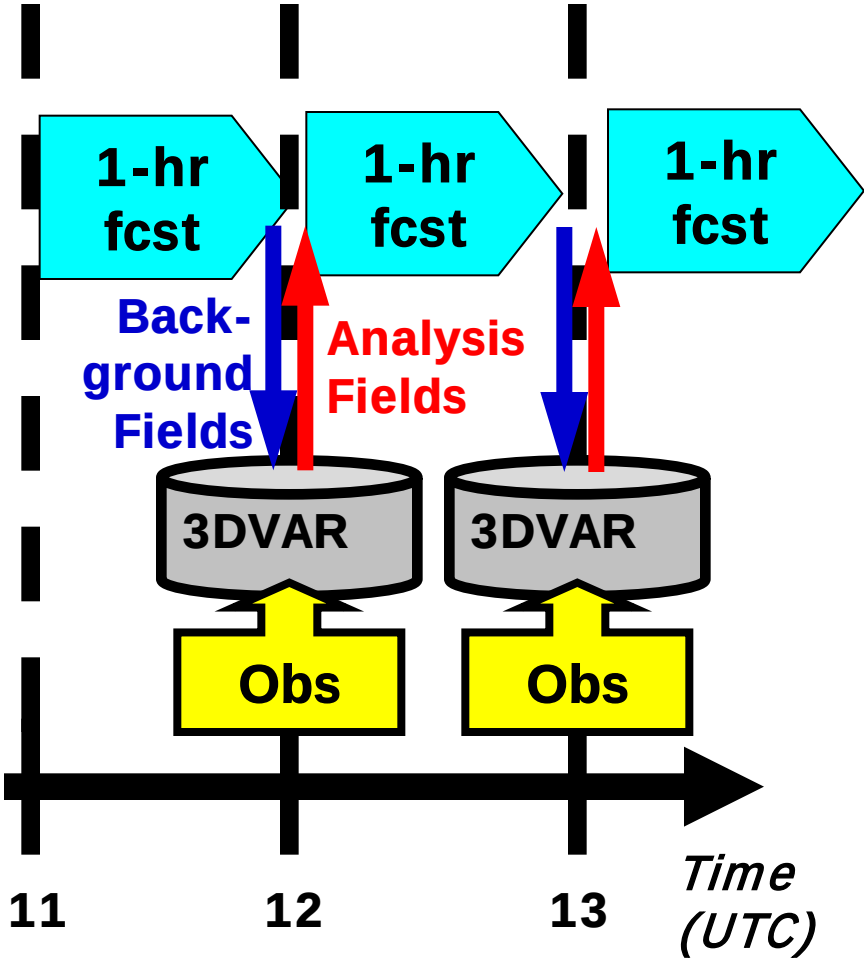
Avx Wx Res Planning Mtg – Mar2010

RUC / RR hourly updating

Use latest observations to obtain the freshest analysis and forecasts for aviation, severe weather, energy, and general forecast applications

Data types used

Rawinsonde (balloons)
Wind profilers (405 MHz, 915 MHz)
RASS virtual temperatures
VAD winds (WSR-88D radars)
Aircraft (ACARS, TAMDAR)
Surface (METAR, Buoy, Mesonet)
Precipitable water (GPS, GOES, SSM/I)
GOES cloud-drift winds
GOES cloud-top pressure/temp
Radar reflectivity, lightning
Ship reports/dropsondes
Satellite radiances (Rapid Refresh)
Upcoming: SATCAST or similar



HRRR status March 2010

Run configuration

- Hourly 3-km CONUS forecasts to 12-h (to 15-h spring 2010)
- Hourly mesoscale assimilation from RUC (1-way nest)
- Radar reflectivity assimilation via RUC DFI method, similar DFI-radar assimilation in experimental Rapid Refresh

Product dissemination

- Hourly native & pres-lev files + 15 min. VIL, echo-top, etc.
- File transfer to NCAR, MIT for CoSPA processing
- 12-h output available by ~ +2 h in 3-h “chunks”

Ongoing scientific research (radar DA focus)

- Strength of LH-based temperature tendency in RUC / RR
- Application of DFI-based reflectivity DA on 3-km grid
- Specification of storm hydrometeor fields on 3-km grid
- Assess diurnal and storm-type variations in DA success

RR status - March 2010

Transfer to NCEP underway

- RR versions of WRF-ARW and GSI running
- Real-time cycles within 1-2 weeks

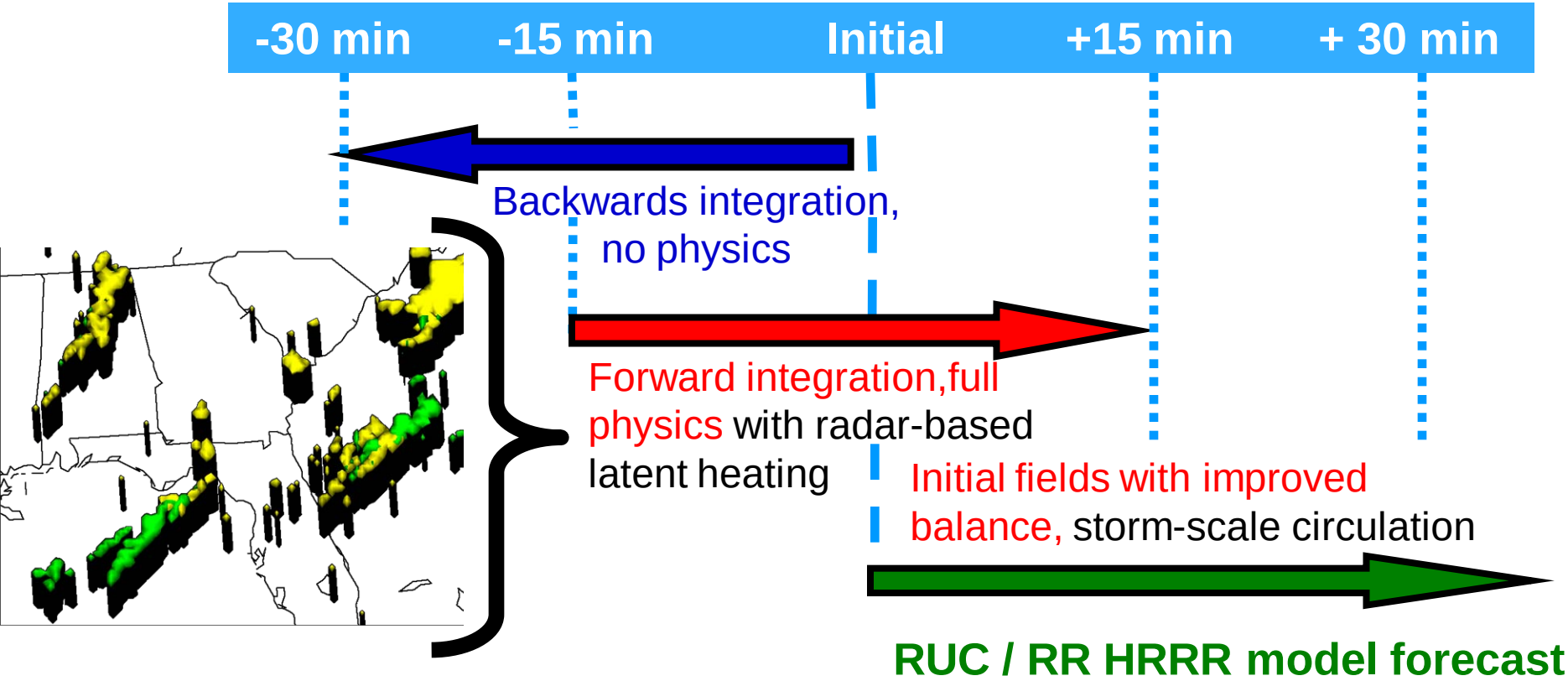
Forecasts equal or improved over RUC

- Wind, temperature, ceiling forecasts all improved
- 2m temperature forecasts improved

Run-time speed now equal to that from RUC

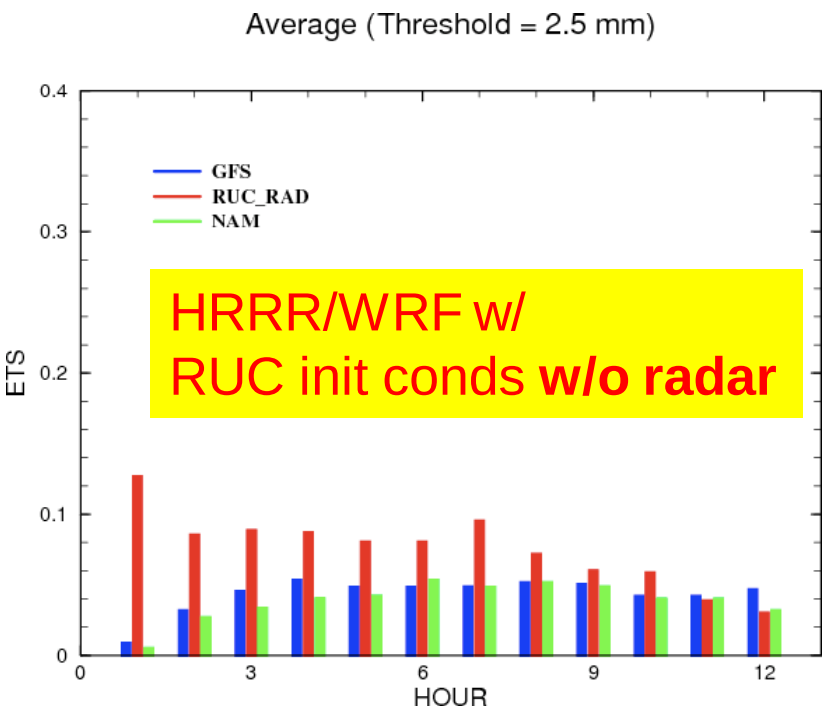
Radar reflectivity assimilation

Digital Filter-based reflectivity assimilation initializes ongoing precipitation regions

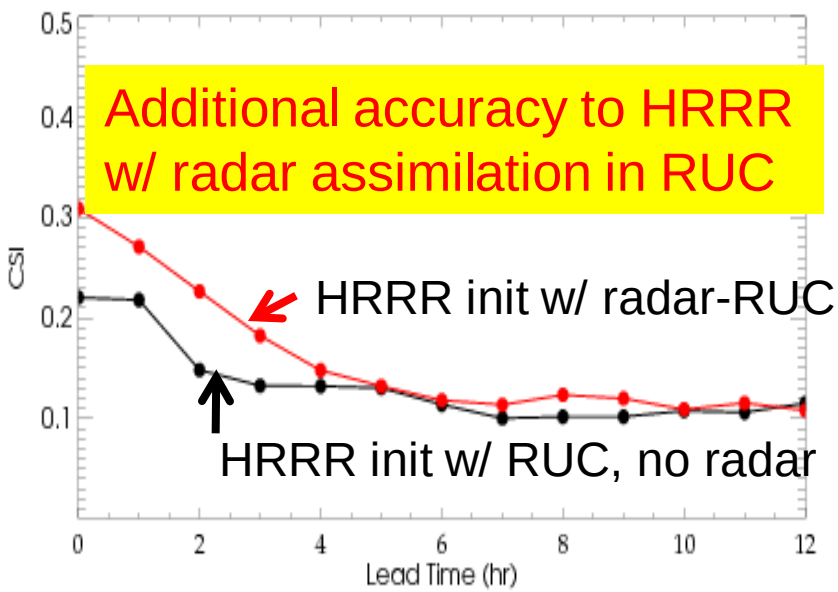


From NCAR report (16 Dec 09)

"Model Performance and Sensitivity"
(Mei Xu, David Dowell, Jenny Sun)
+ subsequent tests by ESRL
(Alexander, Weygandt) and NCAR
(Pinto validation

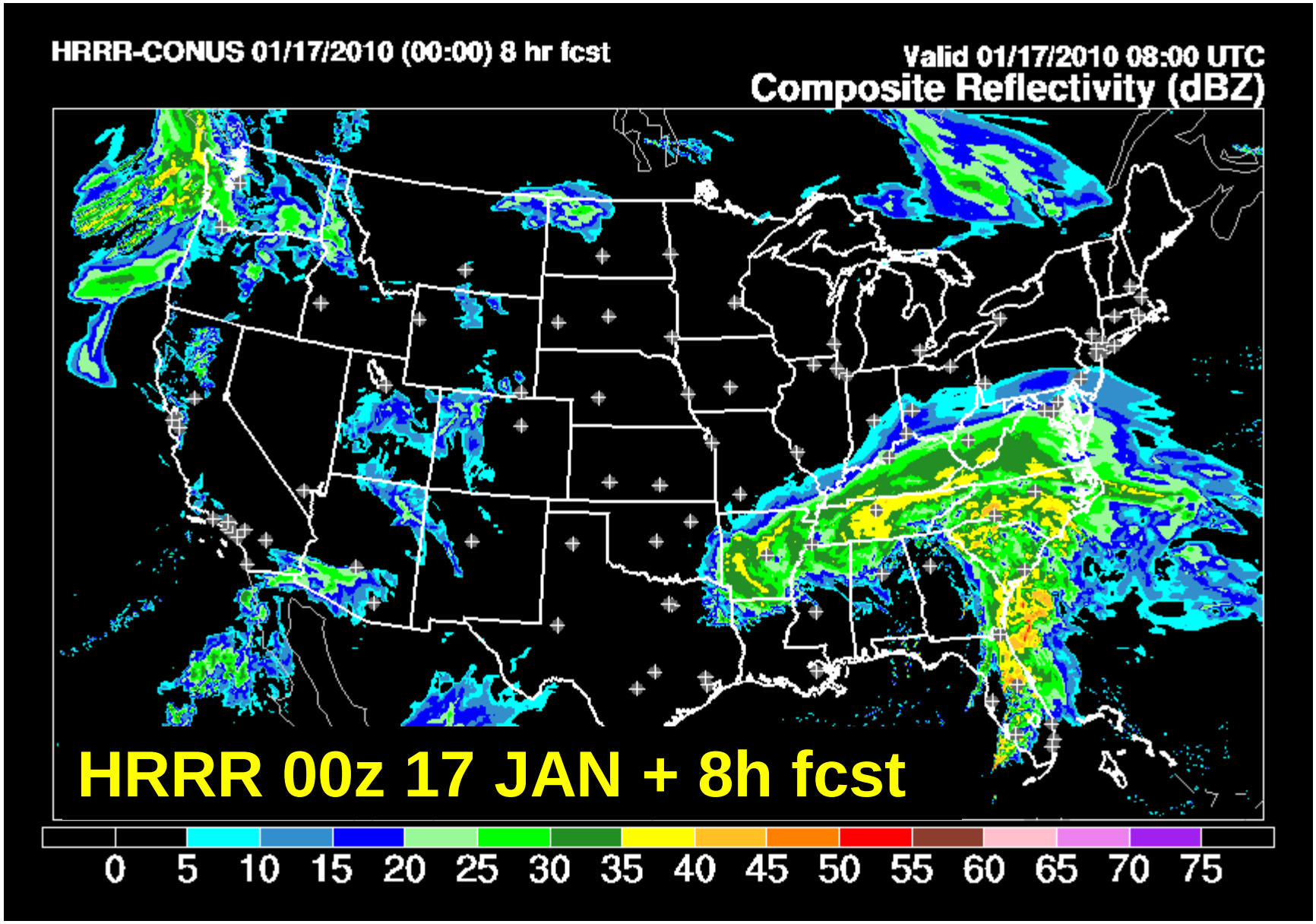


RUC grids provided much improved initial condition for HRRR than NAM or GFS grids, especially in 1-6h



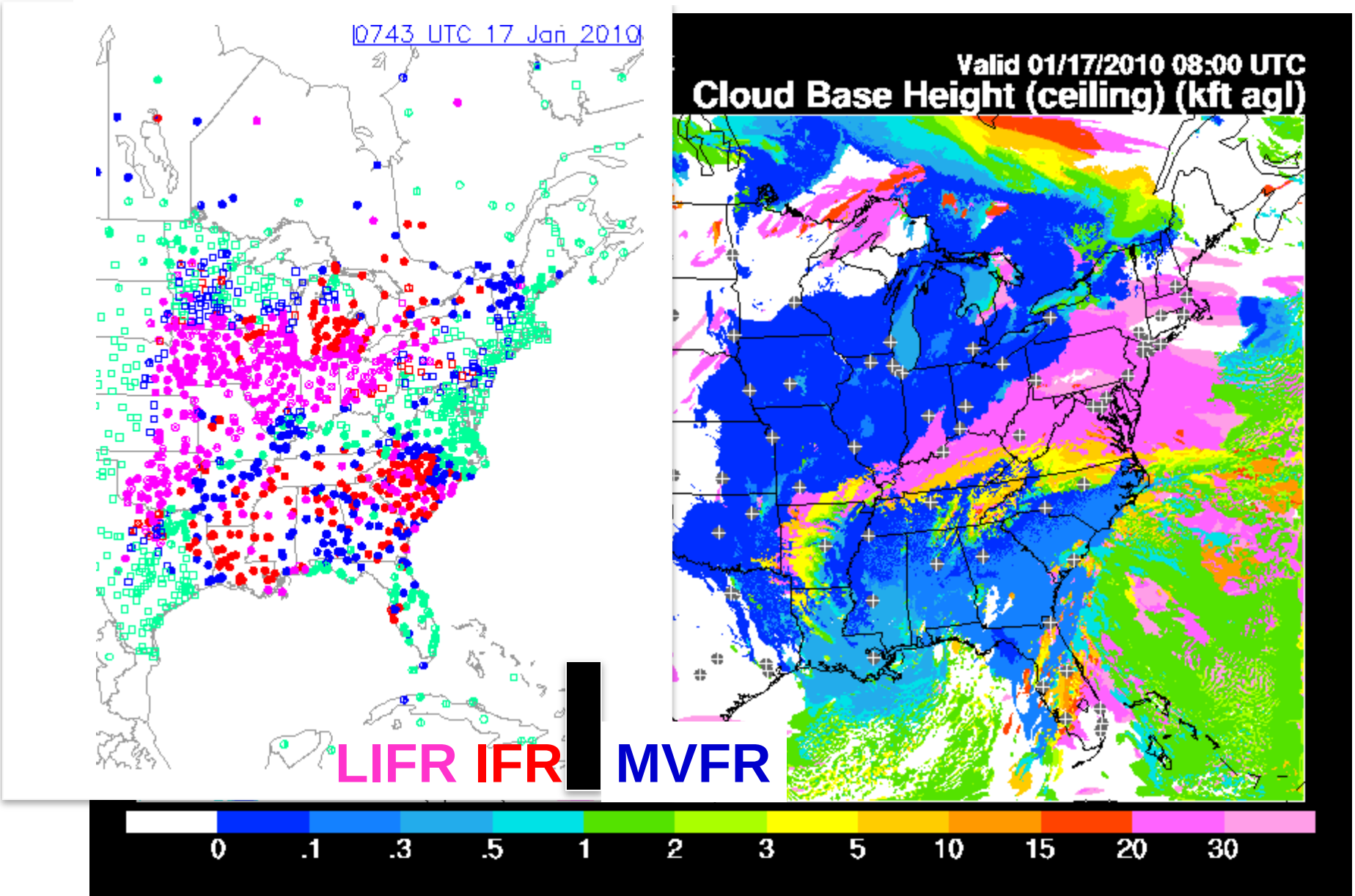
RUC-based HRRR skill
(even without radar assimilation)
due to effective analysis of convective environment using other observations
(ACARS, profiler, surface, cloud obs)
and digital filter initialization (focuses vertical motion for convection)
- RADAR ASSIMILATION FURTHER IMPROVES

HRRR – wintertime forecast applications

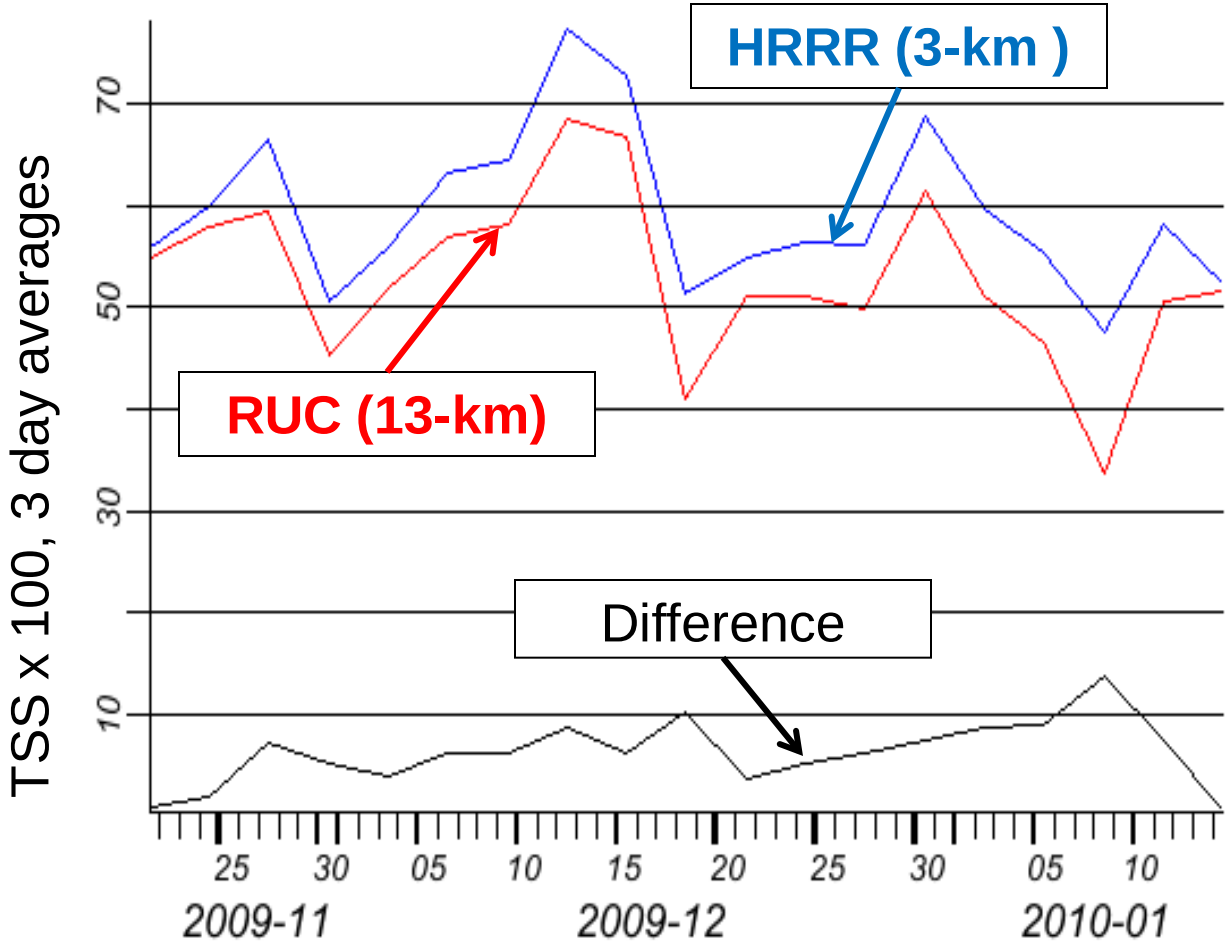


HRRR – wintertime forecast applications

Excellent skill for low ceiling / visibility



For 500 ft ceiling, 3-h forecasts, HRRR beats the RUC consistently



HRRR ceiling forecasts -- Skill pickup in complex topographic and near coastlines.

Moninger et al.
IOAS 9B.2
1:45 Wed.

RR version of WRF model

ARW core (currently WRF prev3.2 release)

Grell-Devenyi convection

Components in red match RUC

MYJ (NCEP/NAM) surface layer,

turbulent vertical mixing abv sfc layer, exps w/ MYNN

NCAR-Thompson microphysics (now 2-moment rain)

RRTM longwave radiation

Goddard shortwave radiation (includes cloud effects)

RUC Land-Surface Model (with recent enhancement to treat snow cover on sea ice)

Diabatic Digital Filter Initialization (DDFI) radar assim

Result: RR physics behavior similar to RUC – good for aviation applications and convective environment

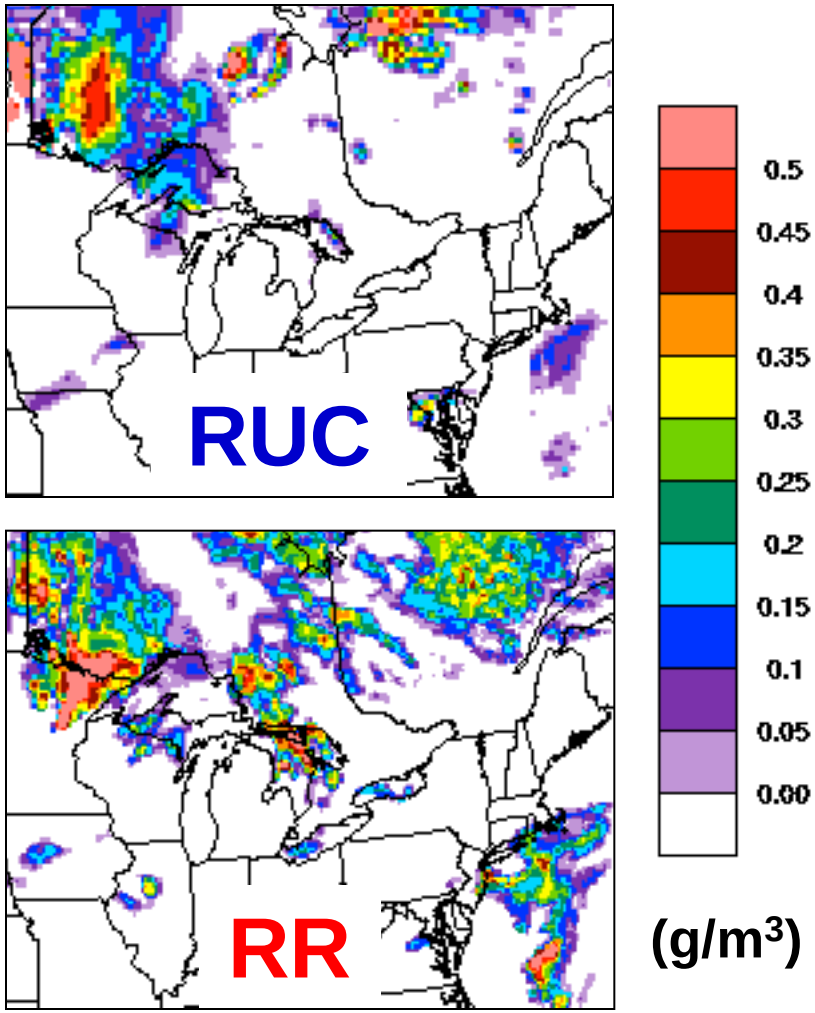
NCAR-Thompson Microphysics

RUC - Dec 2003 version

RR - new version in WRFv3.1 (mp_physics = 8) has many changes

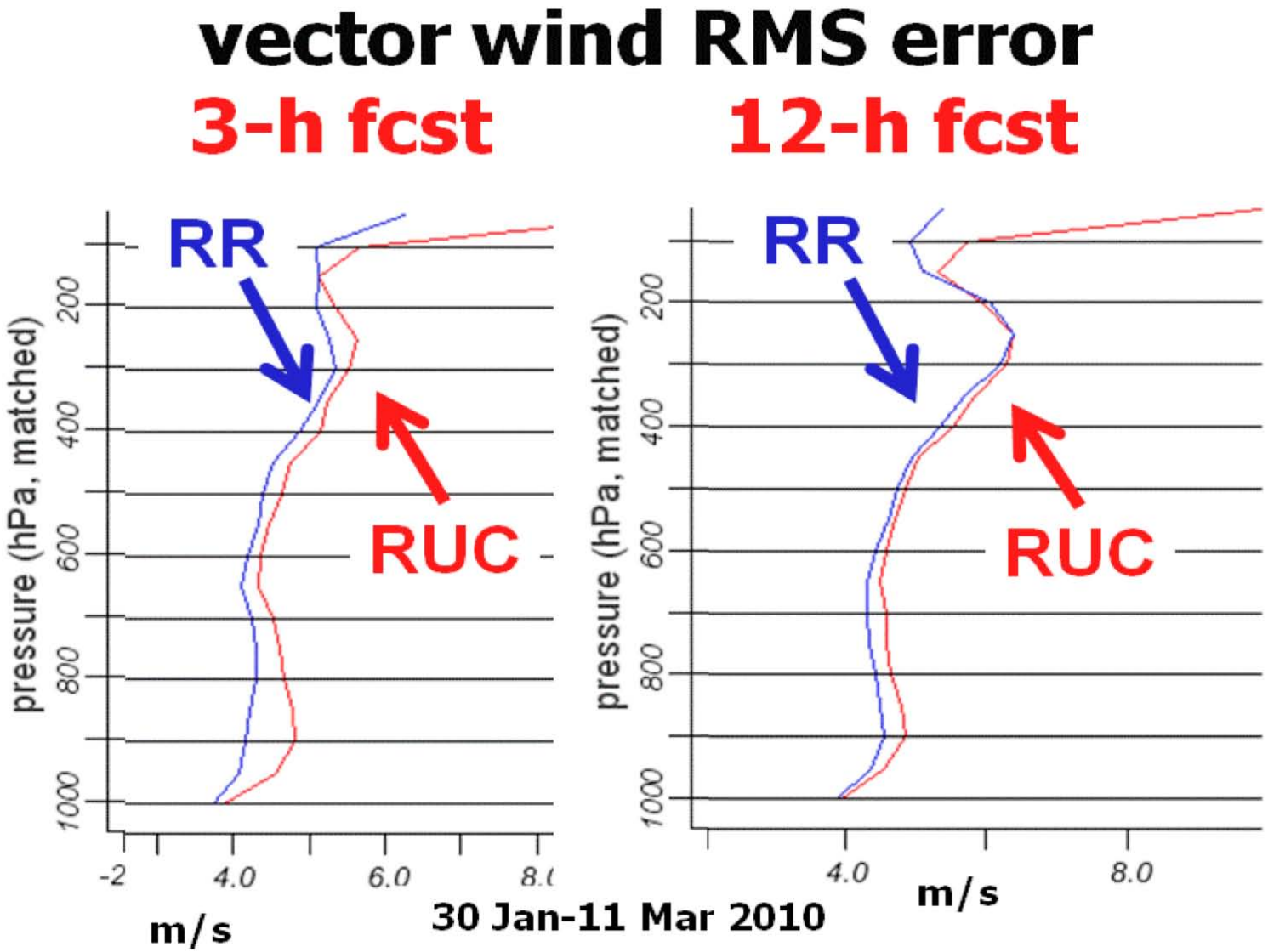
- **2-moment rain (mixing ratio, number concentration)**
  Better simulation of difference in drop-size distribution between rain from melting snow and rain from collision-coalescence
- **More ice supersaturation (up to water saturation)**

Subjective impression that RR has less graupel, more cloud ice & snow than RUC



Max supercooled cloud water
6-h fcst valid 03UTC 2 Nov 09

Rapid Refresh upper-air verification



WRF-Chem and RR

Primary WRF-Chem development and coordination occurring in ESRL/GSD

Current: introduce simple version of WRF-Chem (or derivative) into experimental RR-chem (and HRRR-chem) -- first step toward **integrated operational situational awareness for aviation, severe weather, energy, air quality forecasting**

CRITICAL FOR VISIBILITY, OBSCURATIONS,

- **Aerosol direct effect on radiation** (e.g. solar direct-beam irradiance, surface temp forecasts)

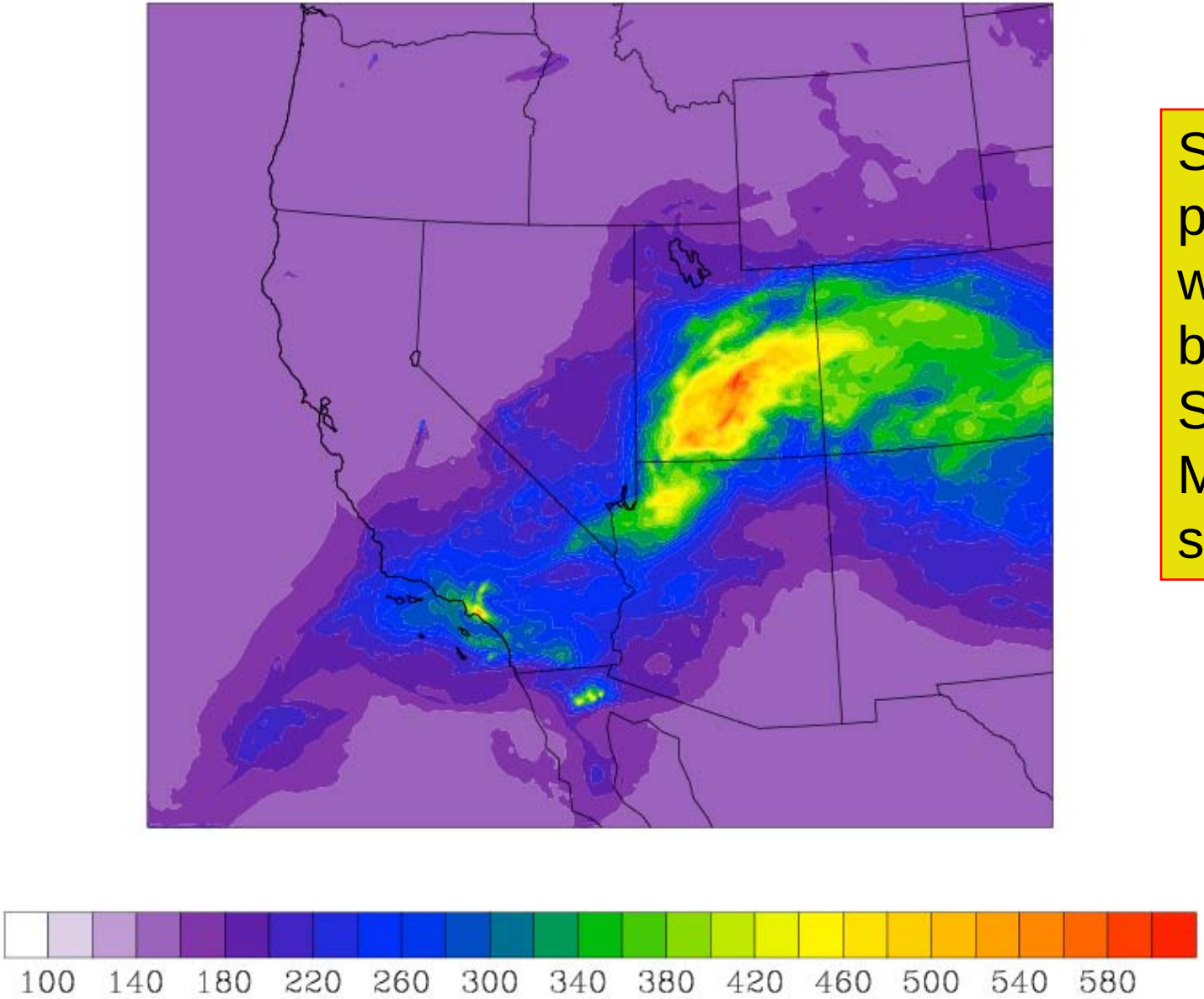
- **Improved warm-rain and ice nucleation in microphysics** (aerosol indirect effects) for better cloud/precip forecasts (impact on ceiling, visibility, icing, surface temp)

- **First step:** RR-Chem (+HRRR-chem) now running at ESRL

  * Once per day to 48h, uses real-time GOES-ABBA fire

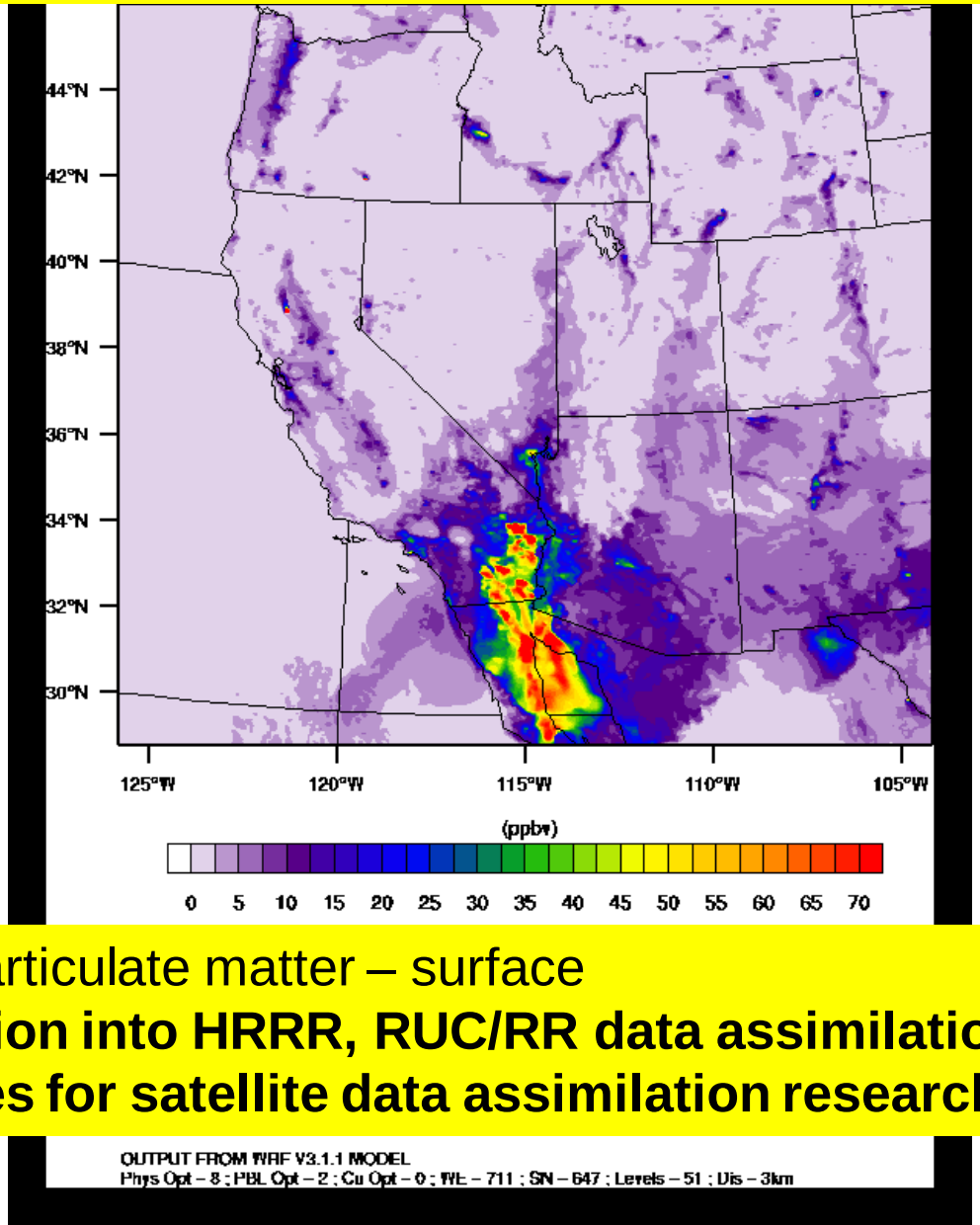
  * Aerosol cycling only

(HRRR-Chem Vertically Integrated Small Aerosol Concentration (relative units) 1200 UTC 2 Sep 2009



Sources are primarily wildfires, biggest in San Gabriel Mtns, southern CA

HRRR-chem – 3km, RUC/radar assimilation, real-time fire (GOES-ABBA), emissions



TODAY

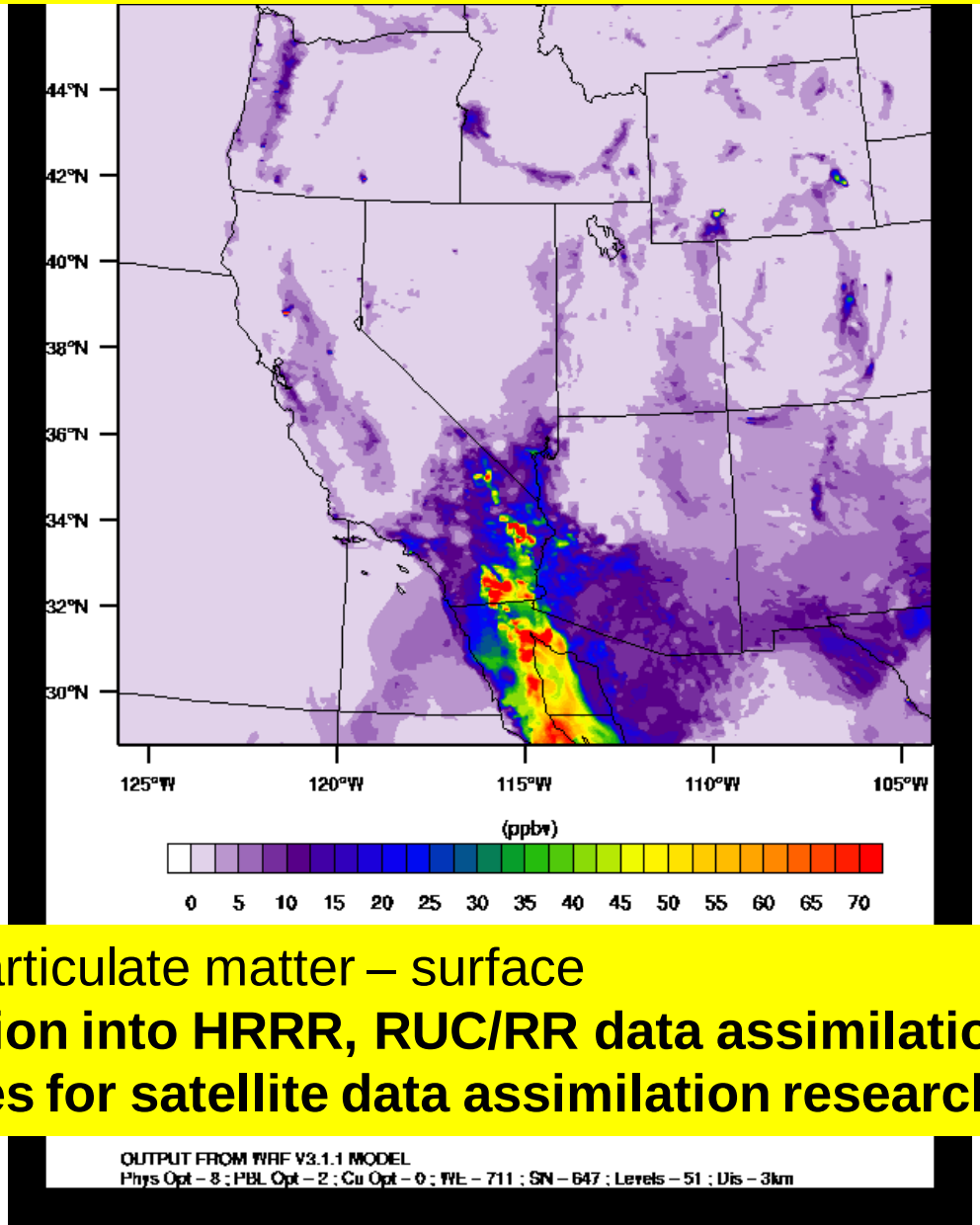
0h forecast
Initialized
06z 24 Mar

2.5 micron particulate matter – surface

Full integration into HRRR, RUC/RR data assimilation

Opportunities for satellite data assimilation research

HRRR-chem – 3km, RUC/radar assimilation, real-time fire (GOES-ABBA), emissions



TODAY

3h forecast
Initialized
06z 24 Mar

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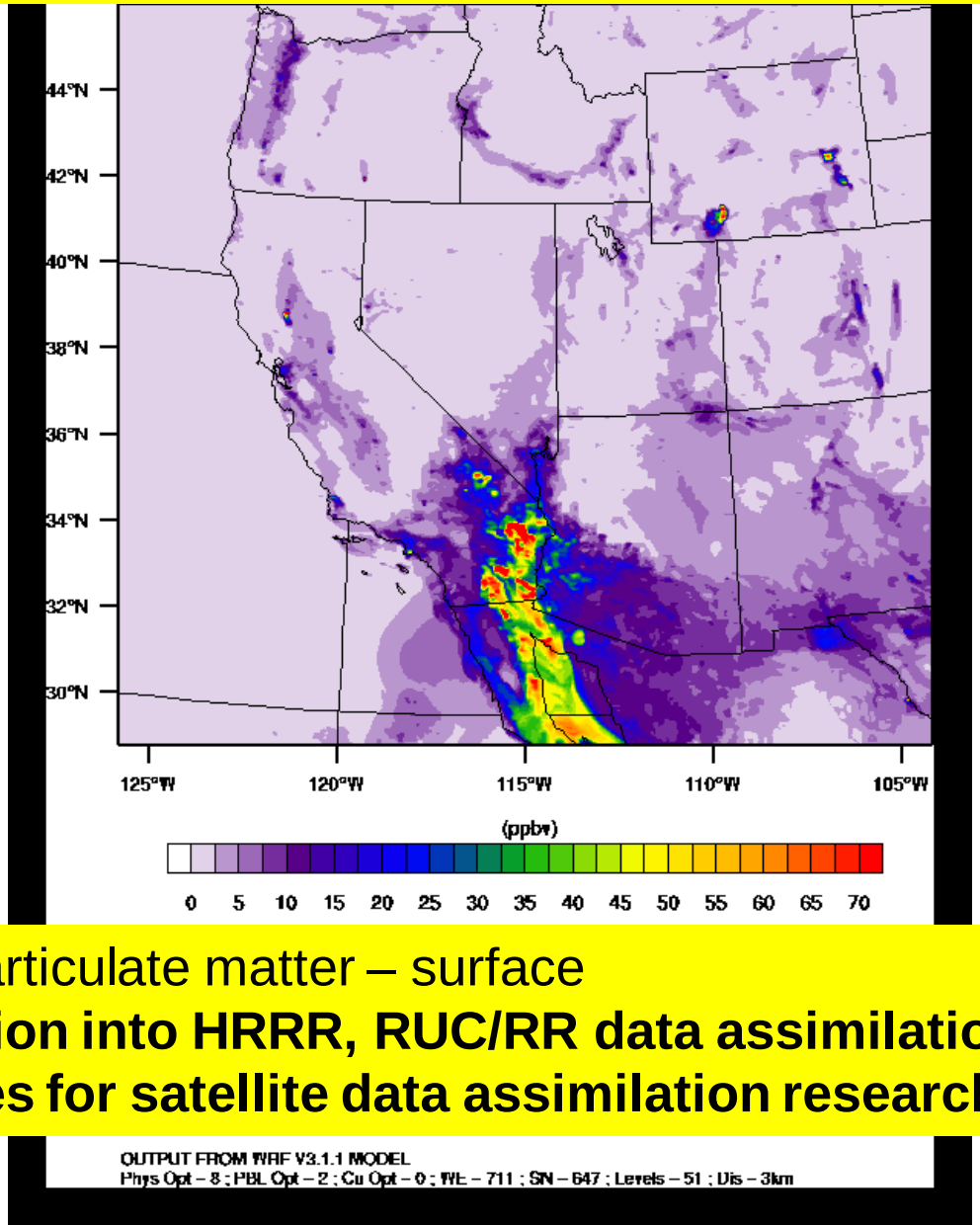

TODAY

6h forecast
Initialized
06z 24 Mar

2.5 micron particulate matter – surface

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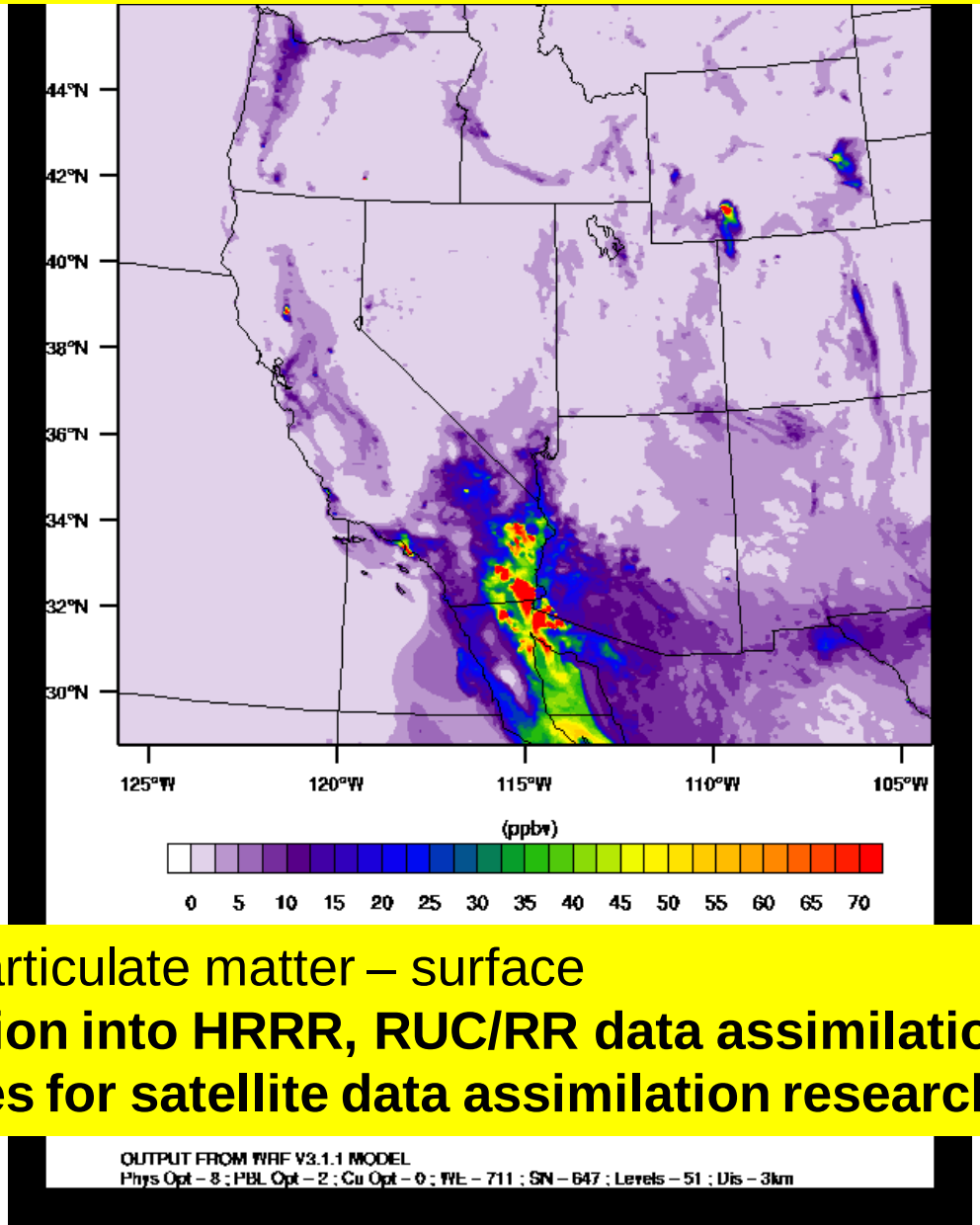
HRRR-chem – 3km, RUC/radar assimilation, real-time fire (GOES-ABBA), emissions



TODAY

9h forecast
Initialized
06z 24 Mar

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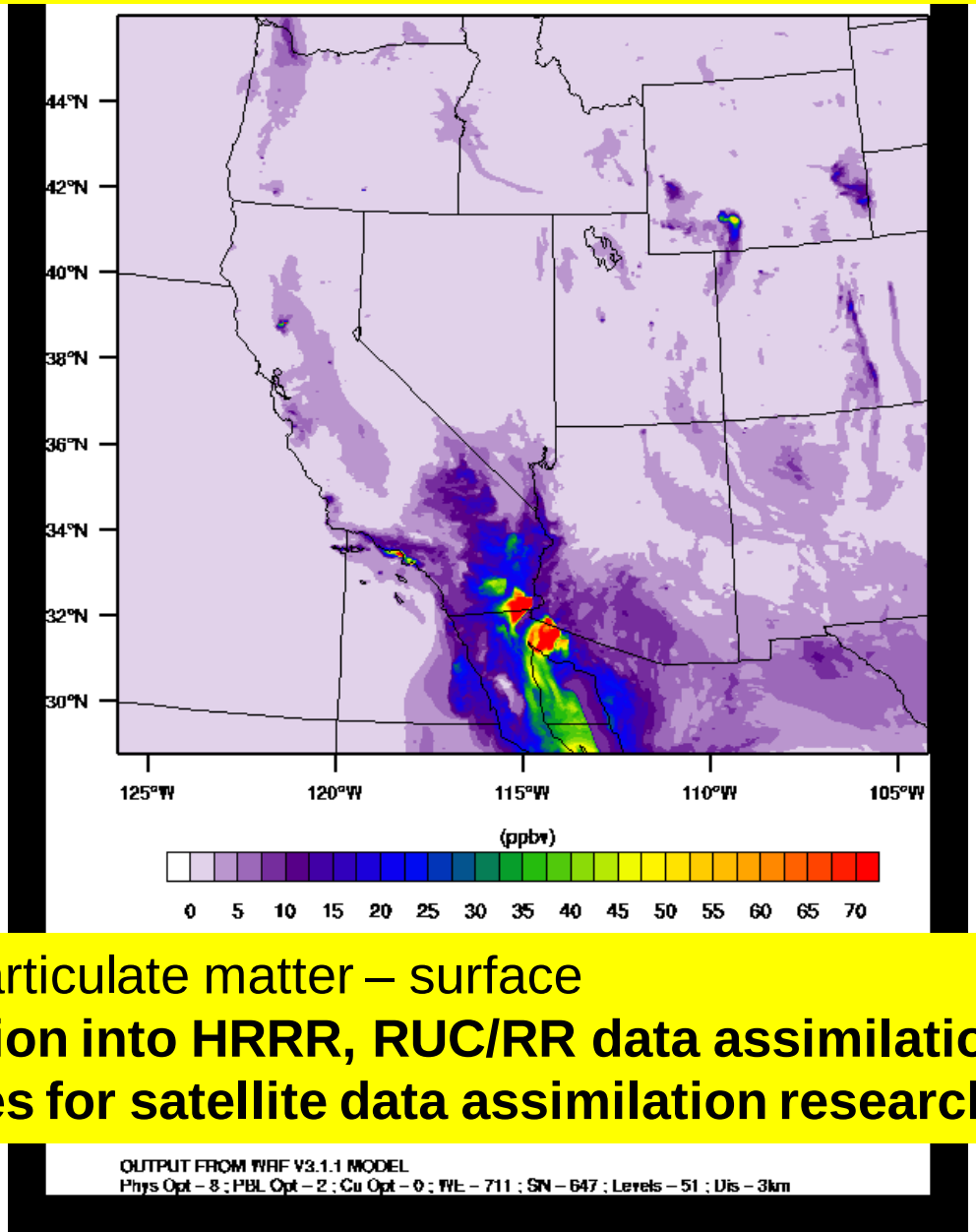


TODAY

12h forecast
Initialized
06z 24 Mar

2.5 micron particulate matter – surface

Full integration into HRRR, RUC/RR data assimilation

Opportunities for satellite data assimilation research

Coordinated Meso- and Storm-scale ensembles
The NARRE and the HRRRE

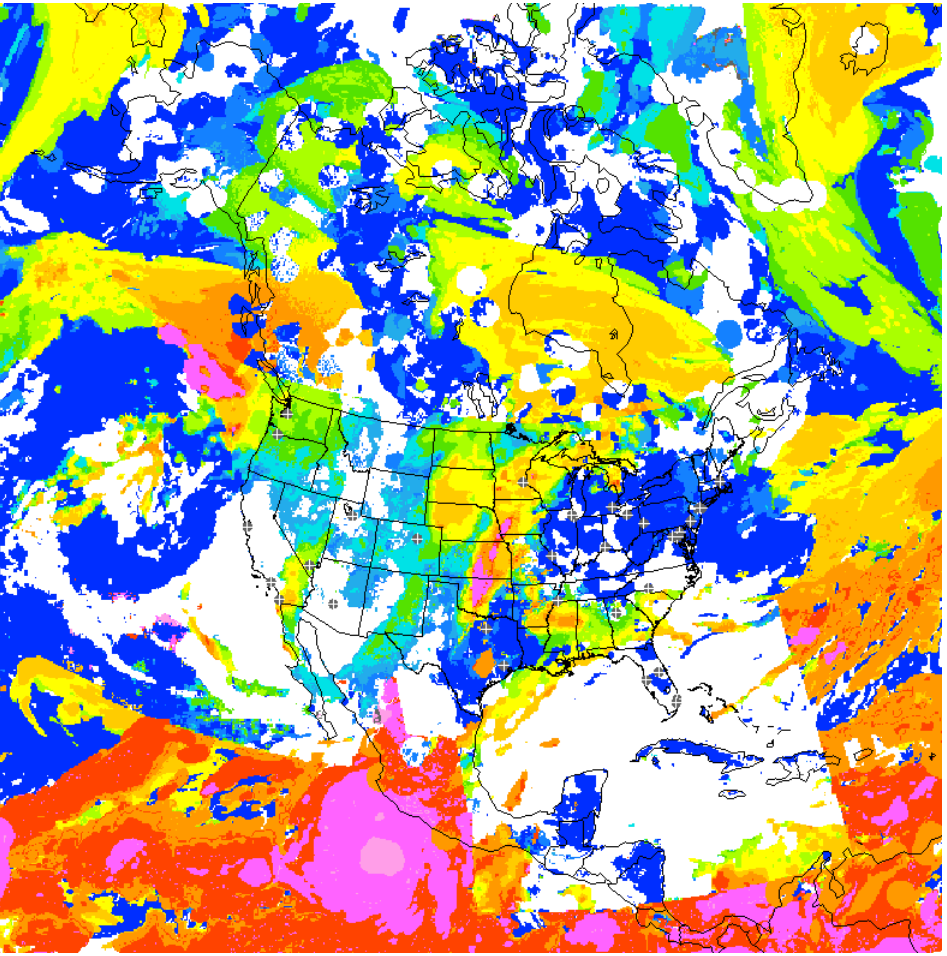
2013

NAM/Rapid Refresh ENSEMBLE (NARRE)

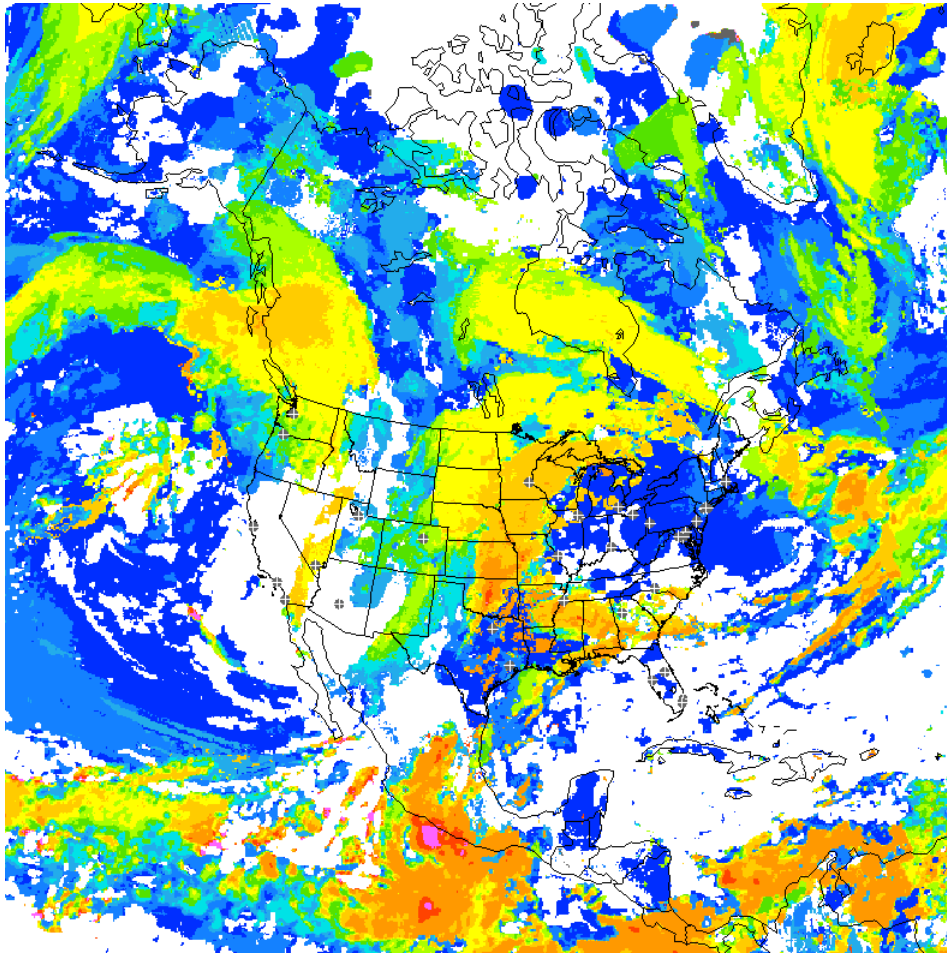
- NEMS-based NMMB and ARW cores & GSI analysis
- Common NAM parent domain at 10-12 km (even larger than initial Rapid Refresh domain)
- Initially ~6 member ensemble made up of equal numbers of NMMB- & ARW-based configurations
- Hourly updated with forecasts to 24 hours
- NMMB and ARW control assimilation cycles with 3 hour pre-forecast period (catch-up) with hourly updating
- NAM 84 hr forecasts are extensions of the 00z, 06z, 12z, & 18z runs.

Use of NASA Langley satellite cloud data

RR with NESDIS data-
currently only over RUC domain

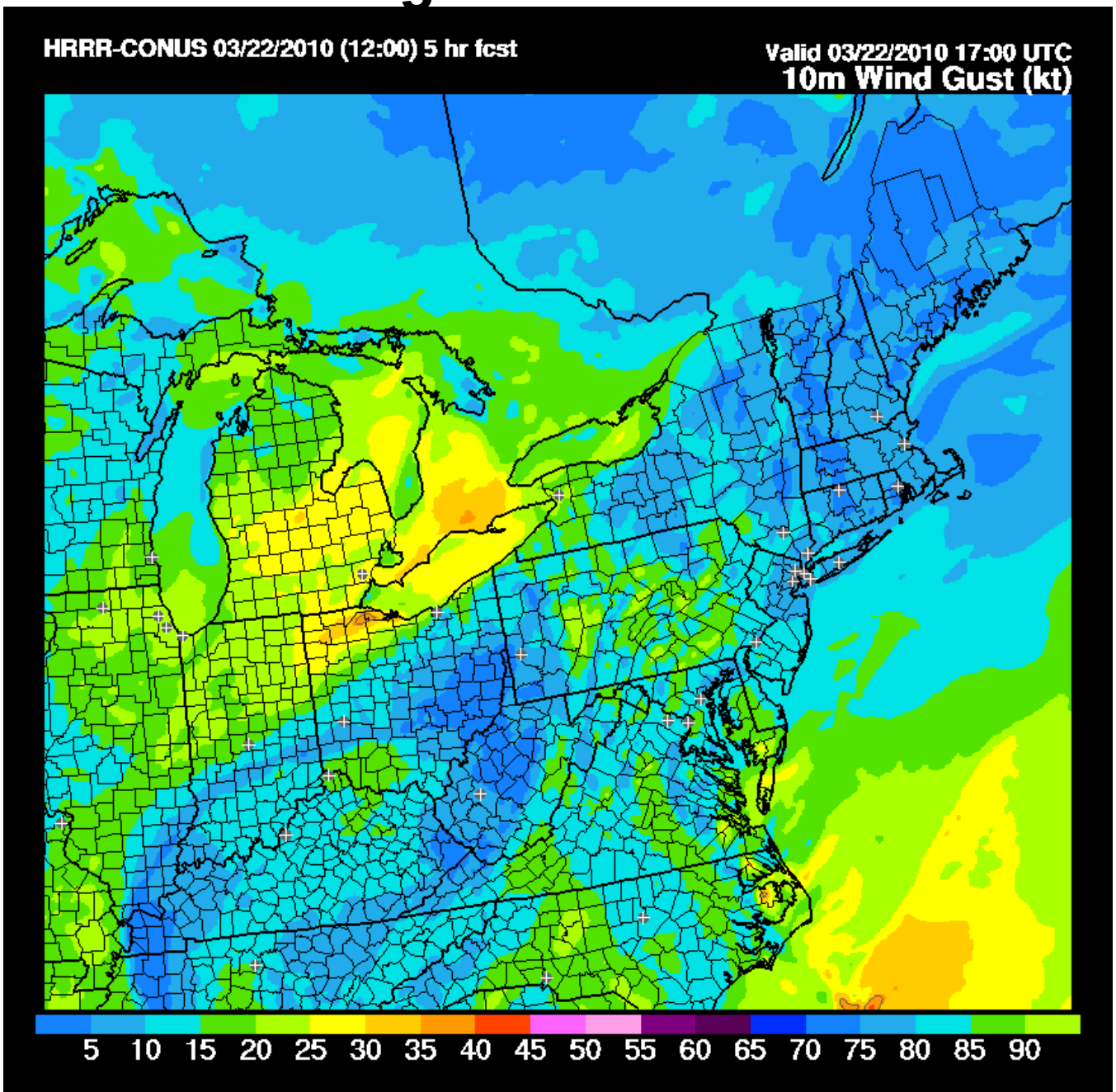


RR with NASA data - over full RR domain



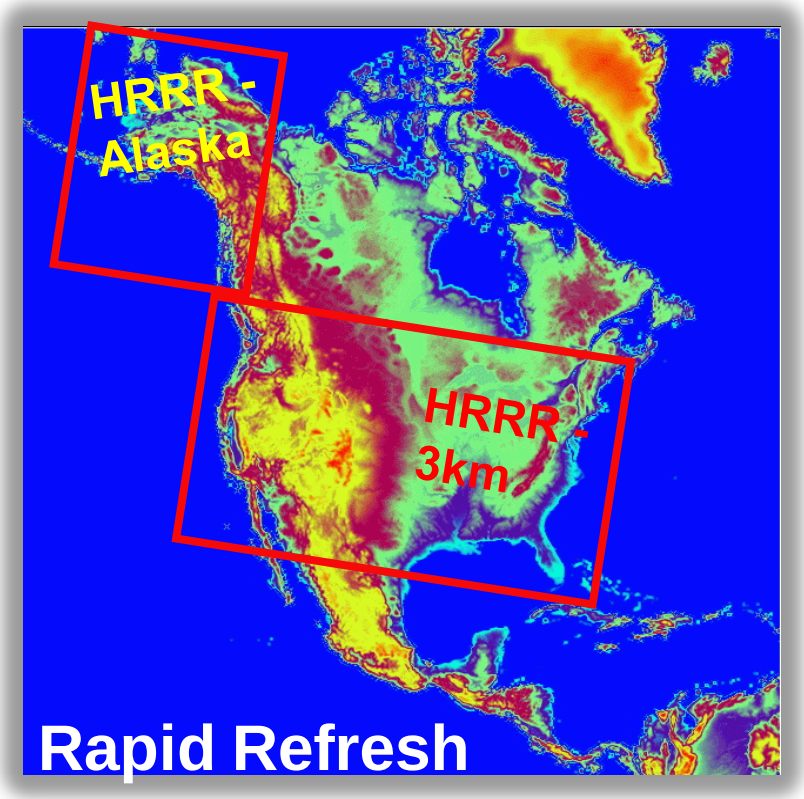
Analysis

HRRR 5h wind gust valid 17z Mon 22 Mar 2010



Future plans for ≤1h updated NWP

2010 – Rapid Refresh operational at NCEP
2012 – Operational (NCEP) CONUS-wide High Resolution Rapid Refresh nested inside RR
2013 – Ensemble RR - NARRe (~6 members, ARW, NMM cores)
2014 – Add operational Alaska HRRR
2015 – Ensemble CONUS HRRR - HRRRe (6 members)
2017 – Global Rapid Refresh (GRR)



Incorporation of inline chemistry – 2012-15

- Assimilation of radial wind, new satellite, phased-array radar, CASA, new regional aircraft, chemistry obs…
- Frequency from 60min➔30➔15min
- 1h EnKF + 1h hybrid 4dvar/EnKF
- Improved nowcast/blend/NWP
- Ensemble-based post-processing

Applications:
Aviation, severe wx, Hydrology, energy, air quality, fire weather, volcanoes/hazards, etc.

Firm NCEP plans

Plans in development

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Necessary links for NextGen research related to
-New observations
-Data assimilation
-Modeling

Add value to existing RR/HRRR
- Conduct within RR/HRRR framework (incl. WRF, GSI)
- To be useful to NextGen, products, obs, must be integrated to RR/HRRR (per Dave Johnson, NCAR, others)

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