Assimilation development activities on Regional and Local-Scale
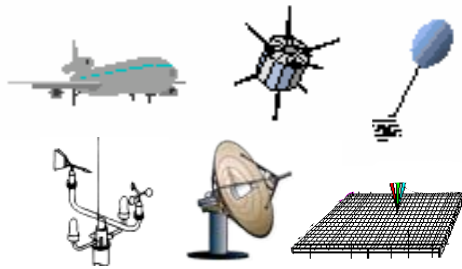
Stan Benjamin (GSD)
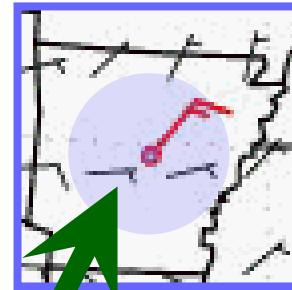
Thanks to Steve Weygandt, Tom Hamill

Operational Prediction Process
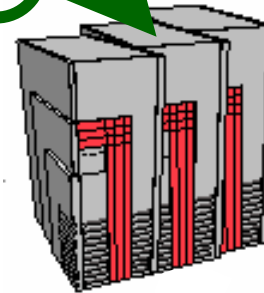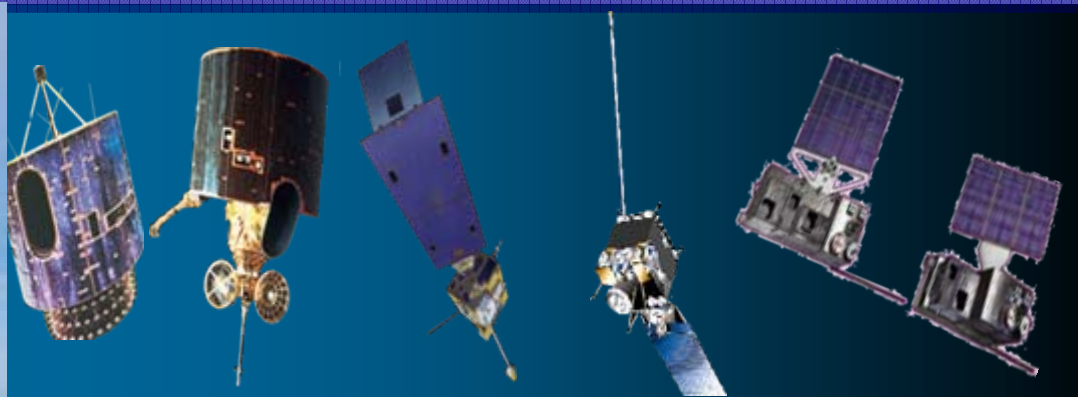
The Evolution of Observations

OLD

NEW

DATA ASSIMILATION:
Analysis Update Cycle

DATA ASSIMILATION:
Analysis Update Cycle

NEW

More frequent model updates

Better forecasts

Truth

Continuous Observations
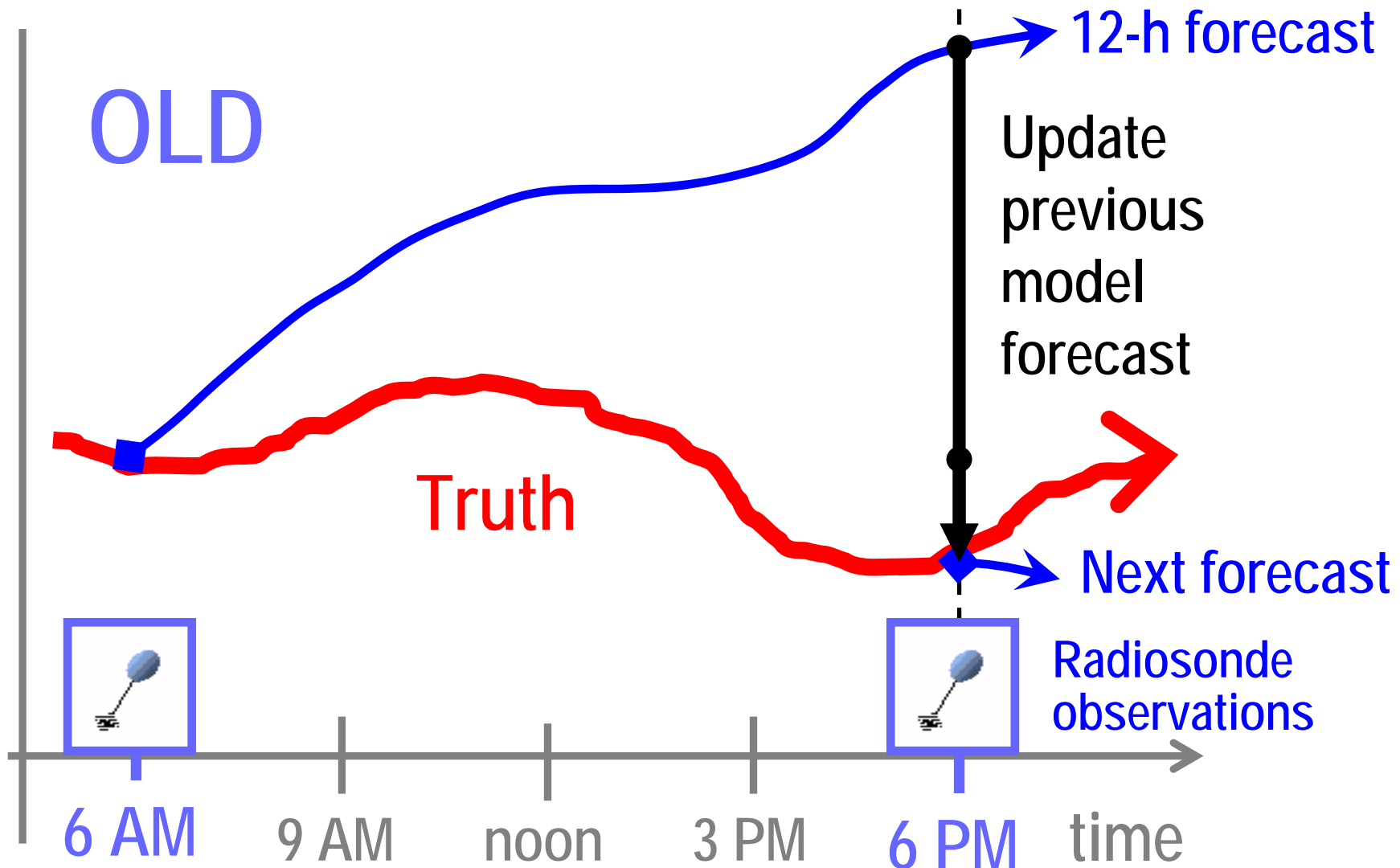
6 AM   9 AM   noon   3 PM   6 PM   time
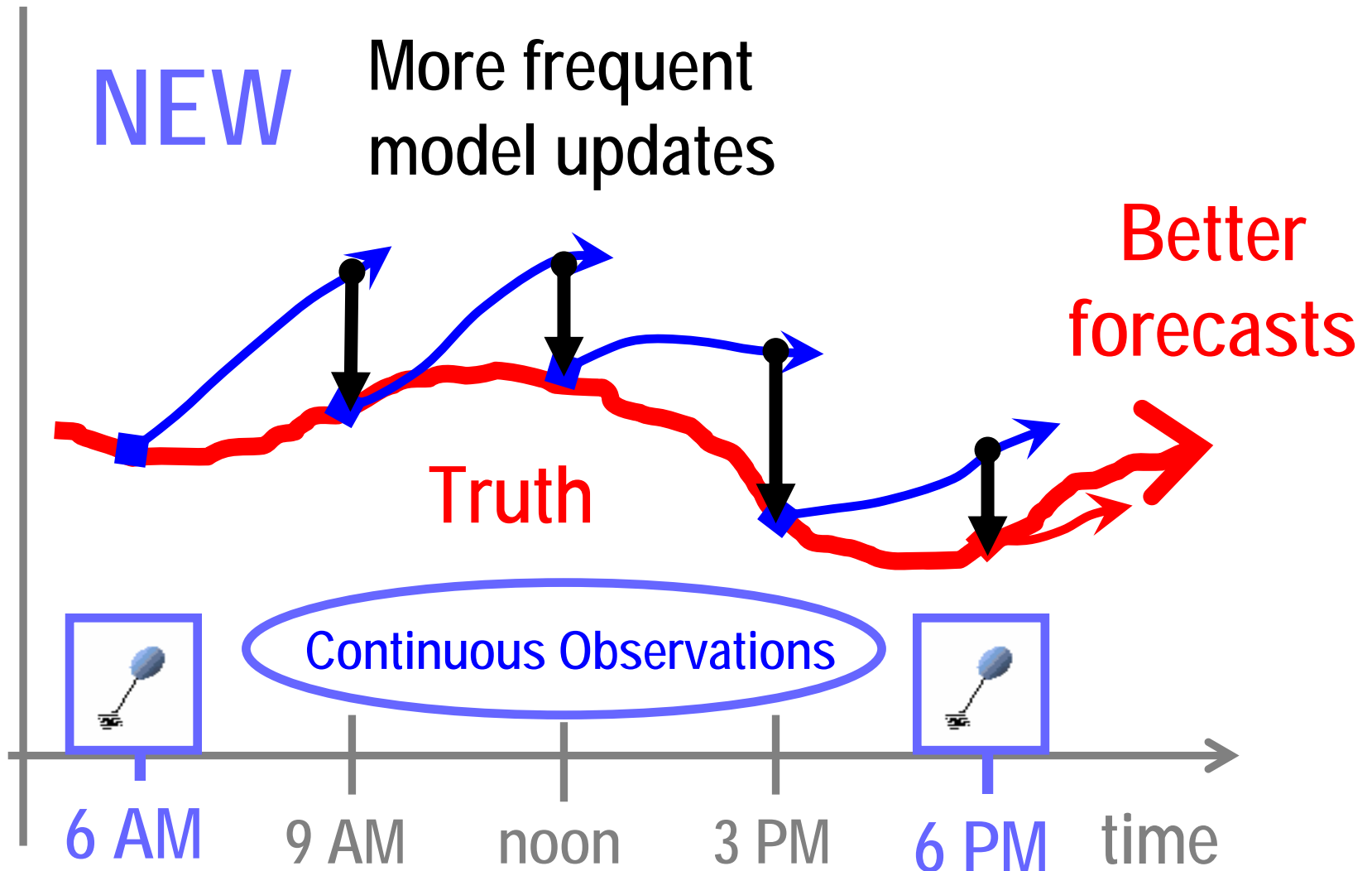
RUC vector (m/s) forecast error – 1200 UTC 8 Feb 2001 – 250 hPa

12h init 12z

9h init 03z

6h init 06z

3h init 09z

Assimilation of high-freq. obs decreases forecast

Benj. et al. (2004, MWR)

0.   5.   10.   15.   20.   25.

Regional <u>3-d</u> data assimilation

Summary of different techniques for model initial conditions

All use *previous model forecast* as *background*

- 3d variational analysis
    - RUC 3dvar (GSD - Weygandt/Benjamin/Devenyi)
    - Gridpoint Statistical Interpolation -
        - »used for NAM, GFS and future Rapid Refresh (GSD,NCEP, NASA)
- Ensemble Kalman filter assimilation
    - Research/development in ESRL - Hamill/Whittaker/Wang (PSD)
- 4d variational analysis
    - Will be available for WRF (no current work in ESRL)

3dVAR much less expensive than 4dVAR or EnKF

Simpler - LAPS (Local Analysis and Prediction System)
    - Modified Barnes analysis followed by application of balance constraint (GSD) (generally uses RUC background)
    - Nudging - MM5, WRF - (PSD applications - Wilczak, etc.)

NCEP Operational Model/Assimilation Systems
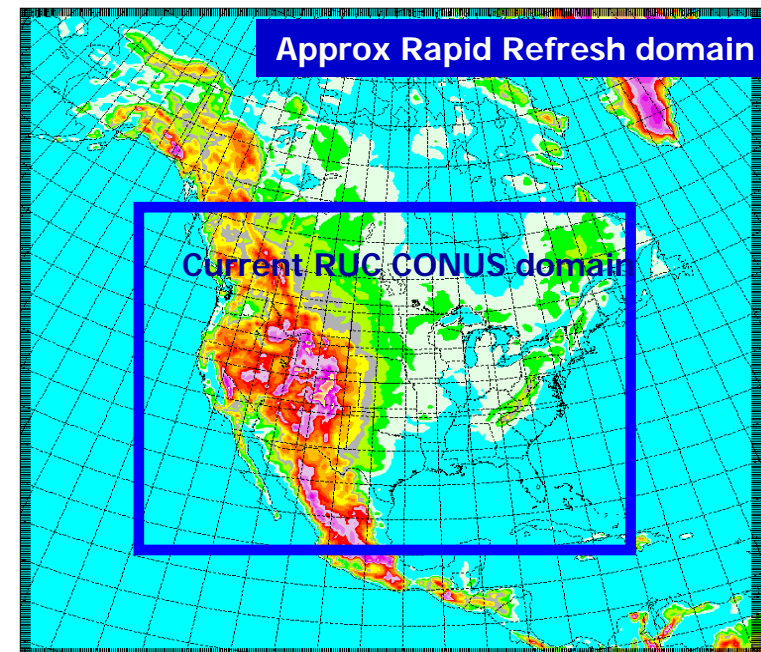
RUC – Rapid Update Cycle
- Assimilation **update every 1h**
- Developed largely at ESRL (GSD)
- Forecasts out to 12h (72h in GSD experimental version)
- Rapid Refresh - 2009

NAM (North American Mesoscale) –
- **6h update** frequency
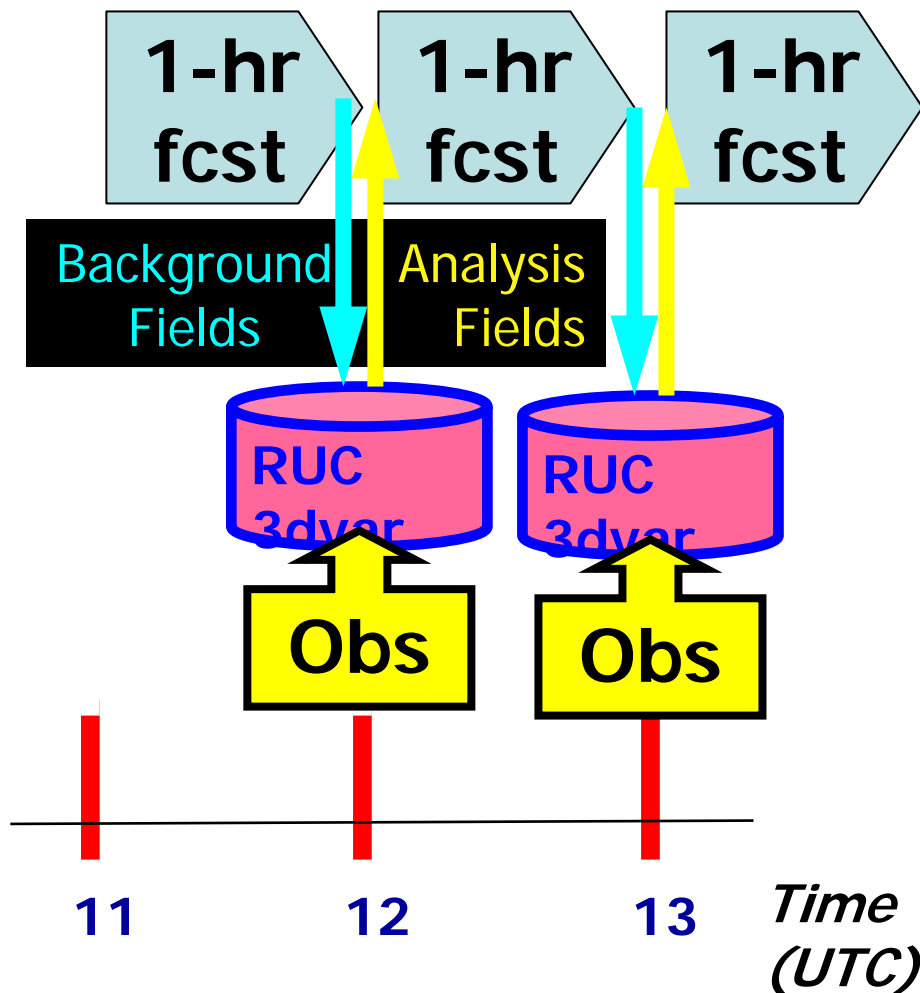- Forecasts out to 84 h

GFS (Global Forecast System) –
- **6h update** frequency
- Forecasts out to 240 h

Approx Rapid Refresh domain

Current RUC CONUS domain

RUC Hourly Assimilation Cycle

Cycle hydrometeor, soil temp/moisture/snow plus atmosphere state variables ($\theta, \Delta p, q_v, u, v$)


Hourly obs in 2008 RUC	
Data Type	**~Number**
Rawinsonde (12h)	80
NOAA profilers	30
VAD winds	110-130
PBL – prof/RASS	~25
Aircraft (V,temp)	1400-4500
TAMDAR (V,T,RH)	0-1000
Surface/METAR	1500-1700
Buoy/ship	100-150
GOES cloud winds	1000-2500
GOES cloud-top pres	10 km res
GPS precip water	~300
Mesonet (temp, dpt)	~7000
Mesonet (wind)	~ 600
METAR-cloud-vis-wx	~1500
Radar / lightning	2km

RUC Hourly Assimilation Cycle

RUC Hourly Assimilation Cycle

OO-HR RUCX - 1-HR RUCX 250 mb WIND SPEED DIF
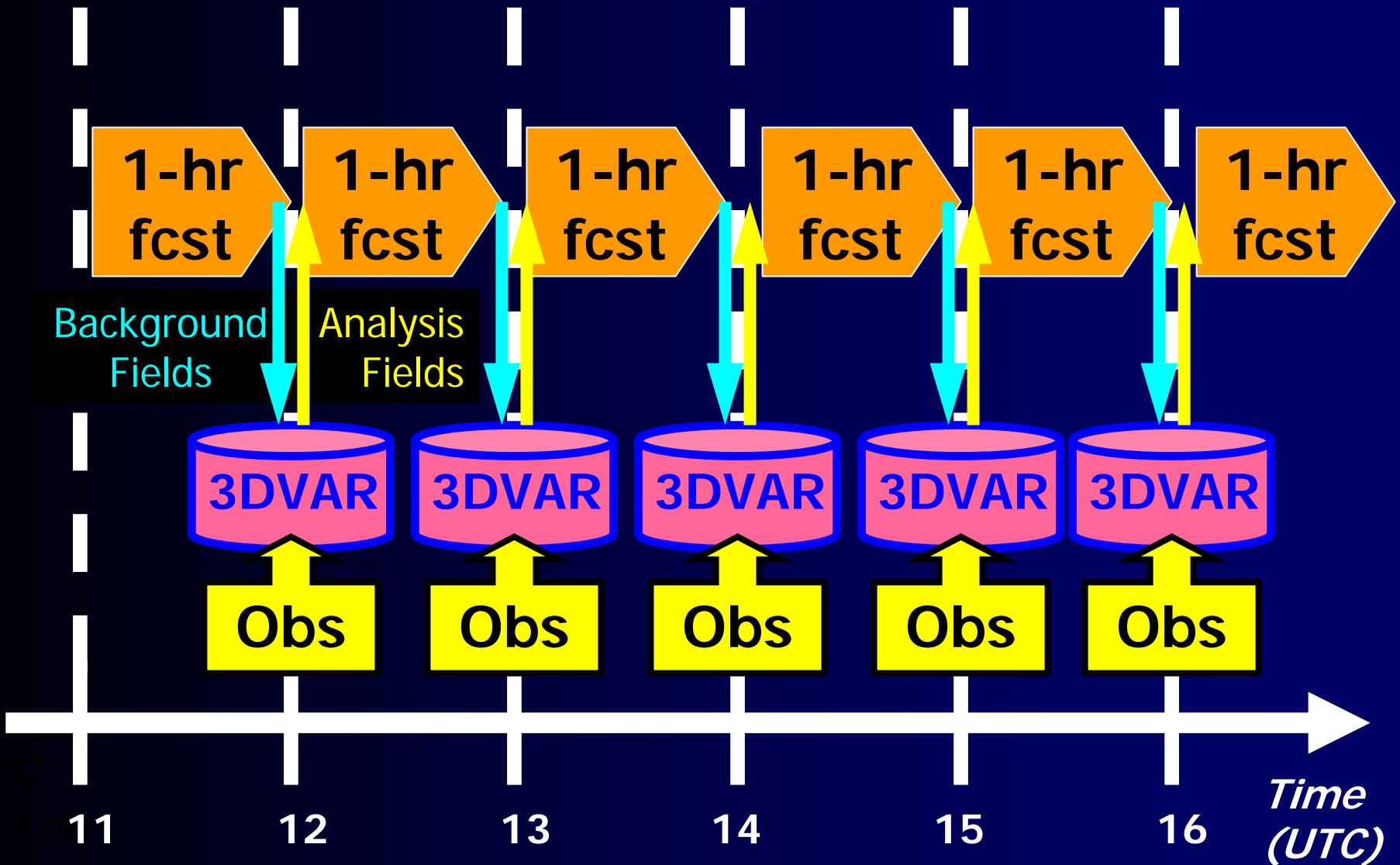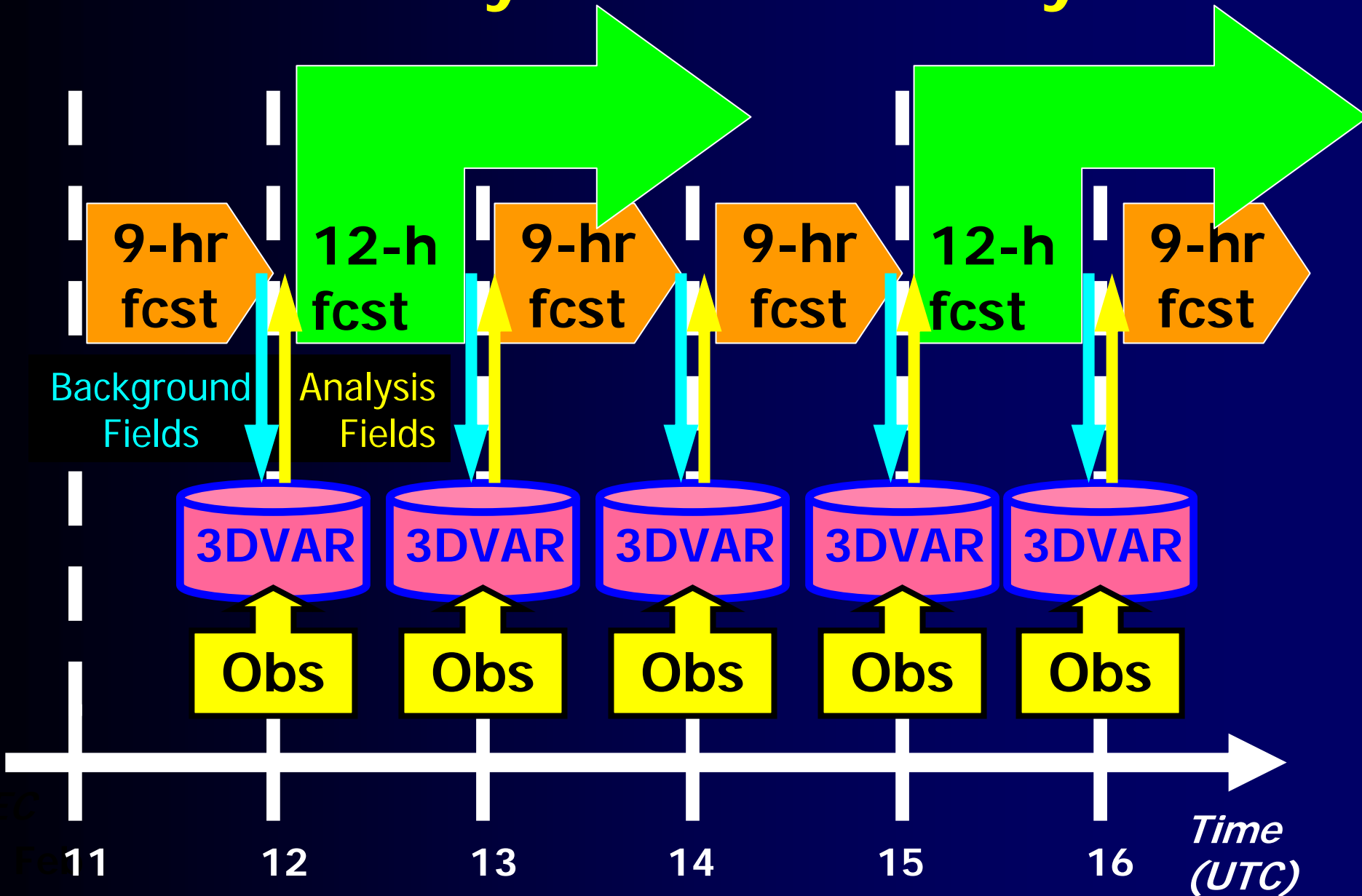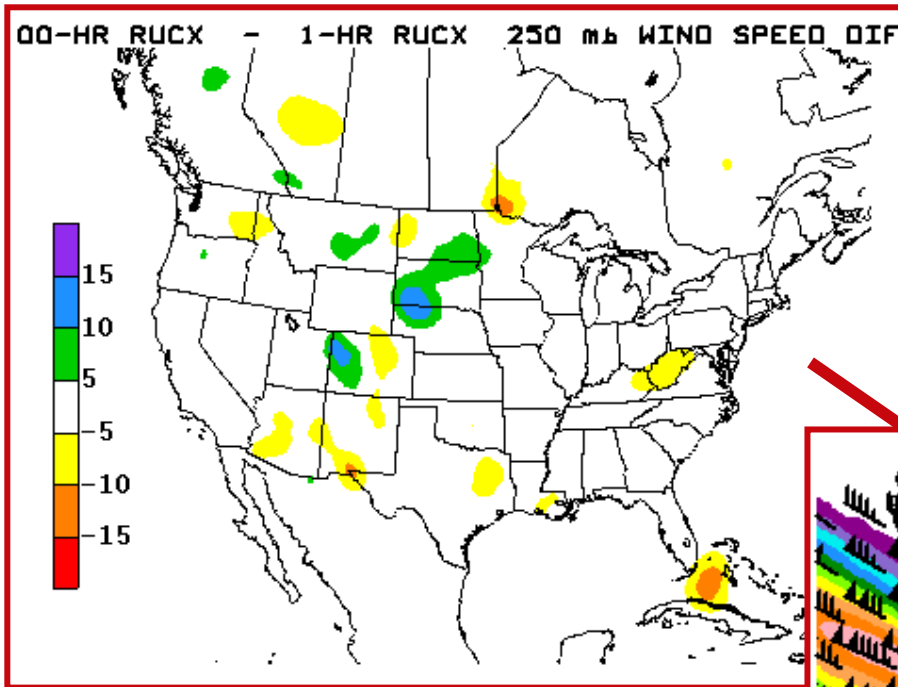
Analysis *increment (∆A)* - RUC 3dvar - 250hPa winds 06z correction to 1h RUC forecast from 05z

RUCX OO-HR FCST 250 MB WINDS (kt)

250 hPa winds
TODAY -0600z Thurs 4 Oct 2007
RUC model initial conditions
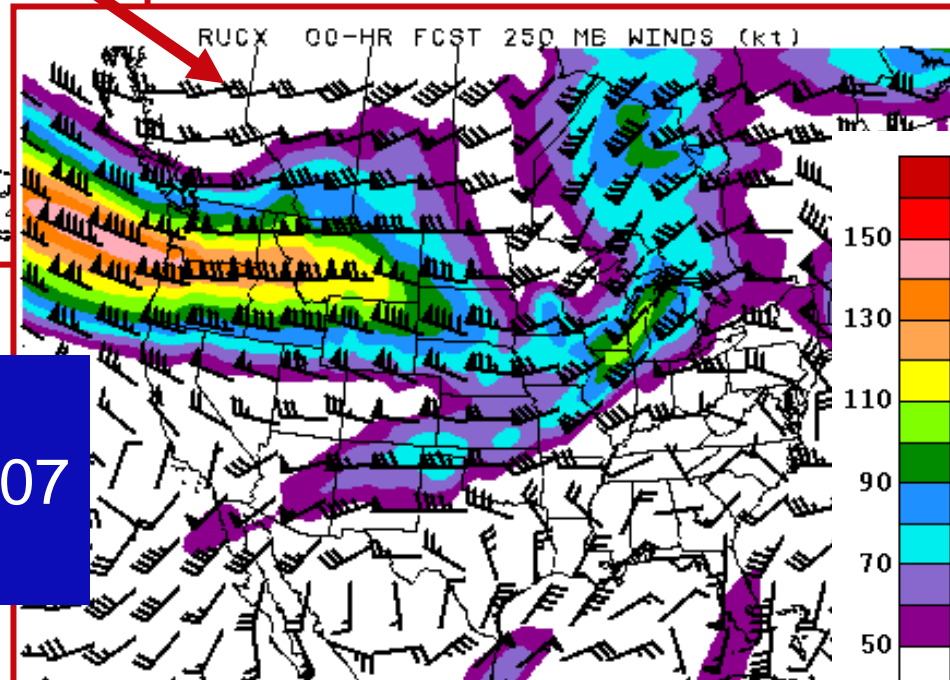
Analysis = Background + ∆A
Analysis increment - produced from 3dVAR minimization problem
  using observation errors, background error,
       spatial covariance of background error
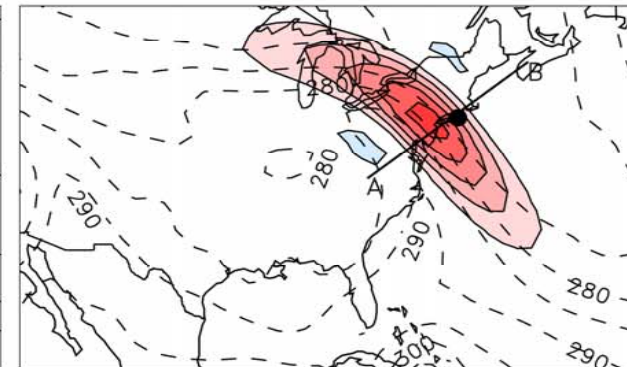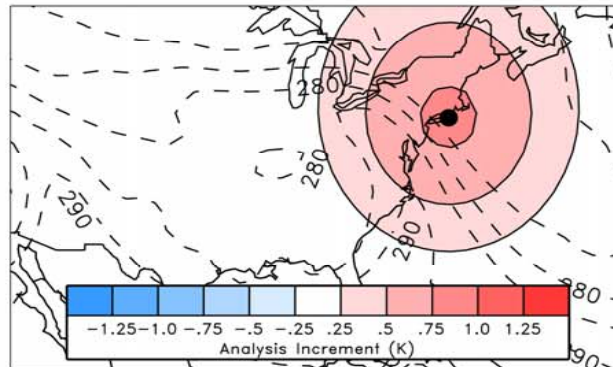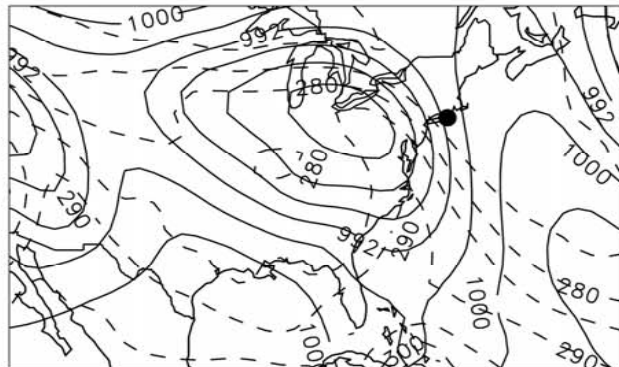
Ensemble-based data assimilation

- Parallel forecast and analysis cycles
- Ensemble of forecasts is used to estimate forecast-error statistics during the data assimilation
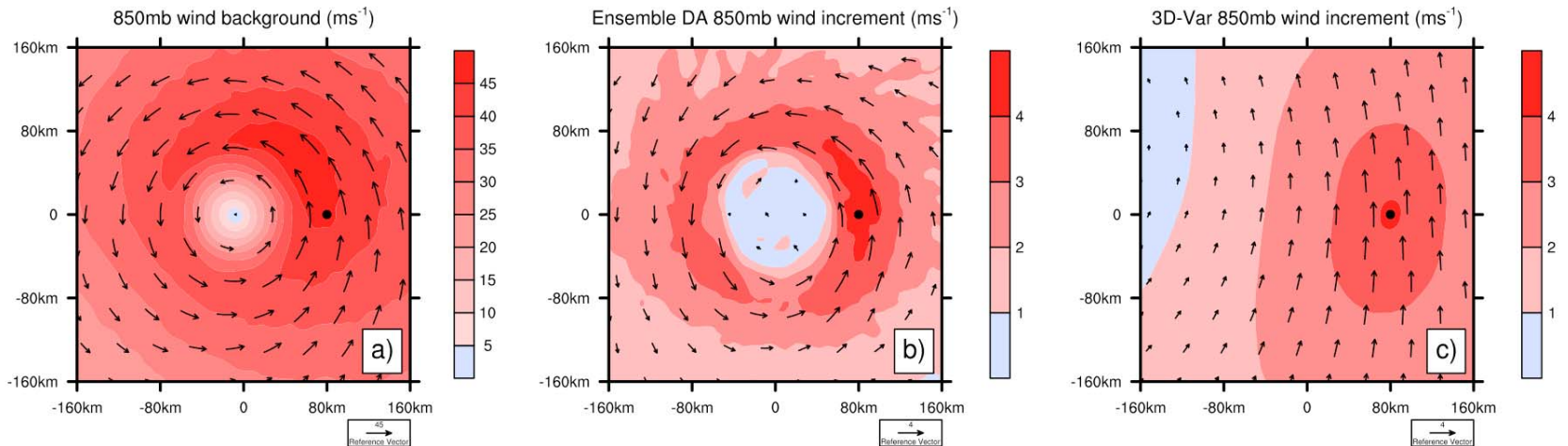
2-d surface regional data assimilation
Summary of different techniques

	Background
	RUC persistence

– Variational analysis

- Space-Time Mesoscale Anx Sys (STMAS) (GSD) - 15-min frequency, uses subhour observations ✓
- RUC (GSD) - integrated 2-d/3-d/PBL ✓
- Real-Time Mesoscale Analysis (RTMA) with GSI (NCEP, GSD) ✓

– Optimal interpolation

- MSAS/RSAS (GSD) ✓

– Nudging - via MM5 (PSD)

All use METAR, mesonet surface data, buoy

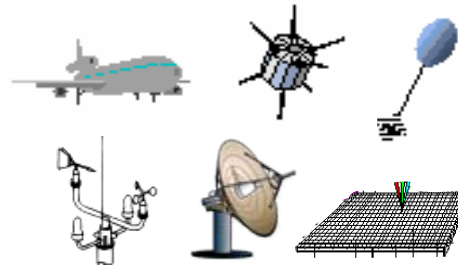*Surface-only assimilation not for model init, useful for nowcasting*

Observing System Experiments

Why? *Assess value added from <u>current</u> observing systems*

How?

Run model cycle with all observations

Remove specific observations, repeat cycle

Can test experimental observing systems
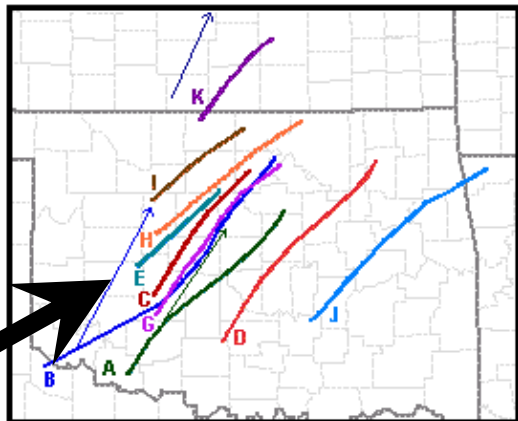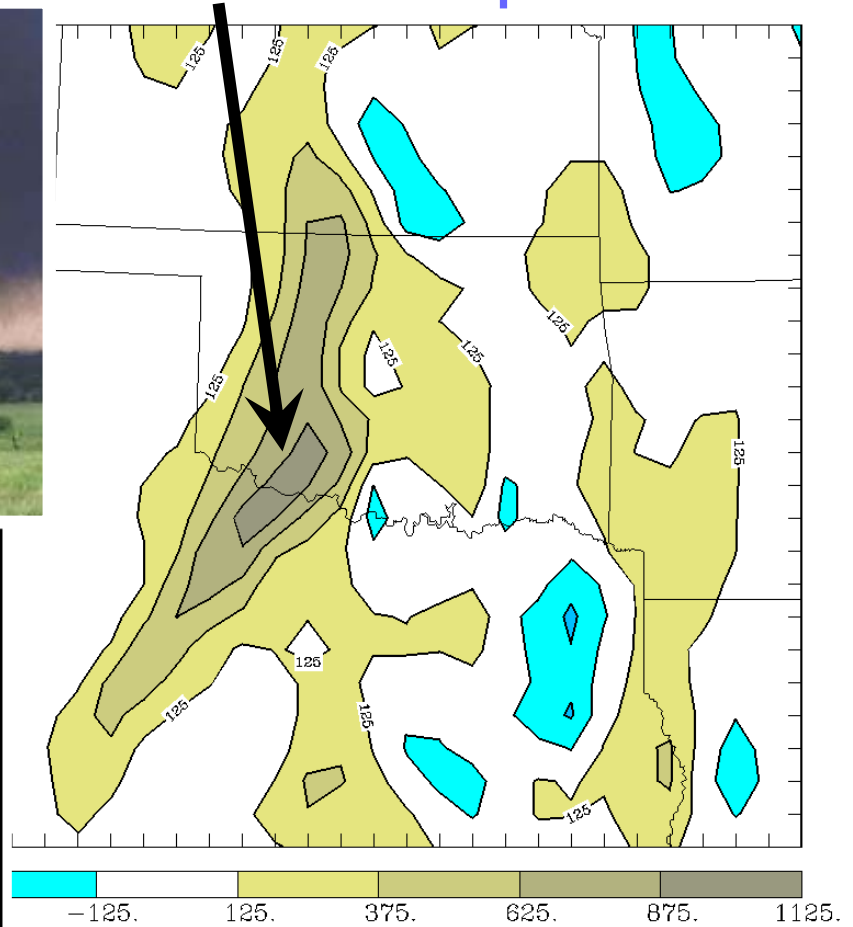
50+ tornadoes cause 42 deaths in Oklahoma

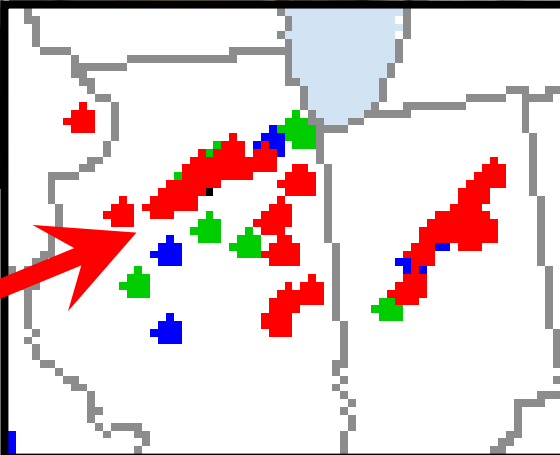More energy for thunderstorms 6-h forecast with **profiler data**

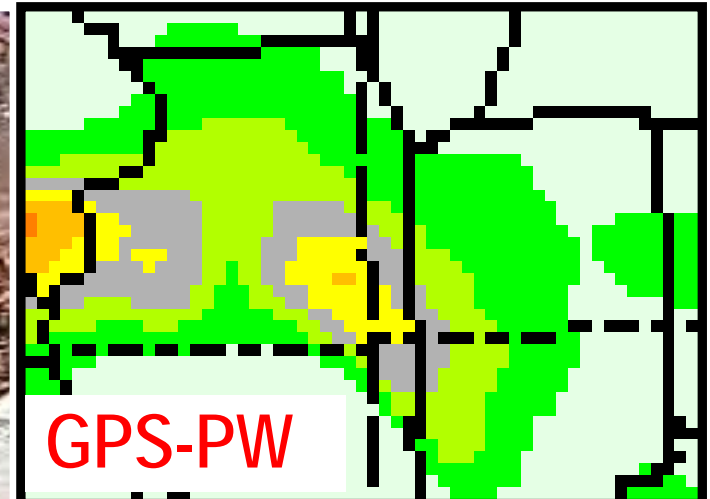Tornado paths

Tornado death toll rises to 8

Thursday, April 22, 2004 Posted: 9:43 AM EDT (1343 GMT)

UTICA, Illinois (CNN) -- The death toll from Tuesday evening's tornadoes rose to eight Wednesday afternoon, LaSalle County Coroner Jody Bernard
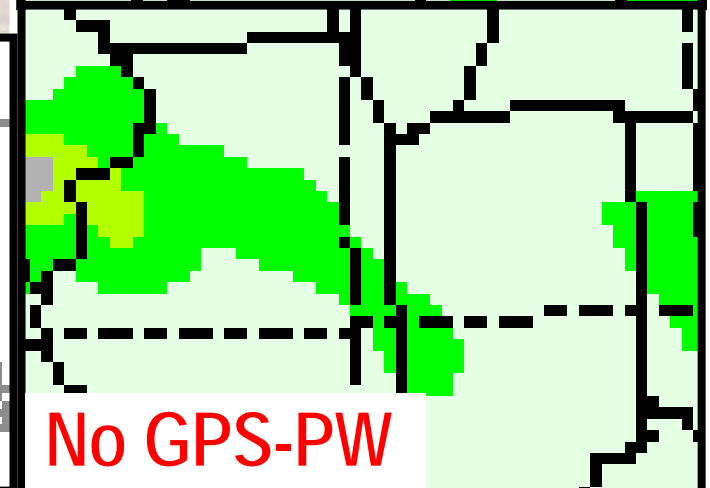
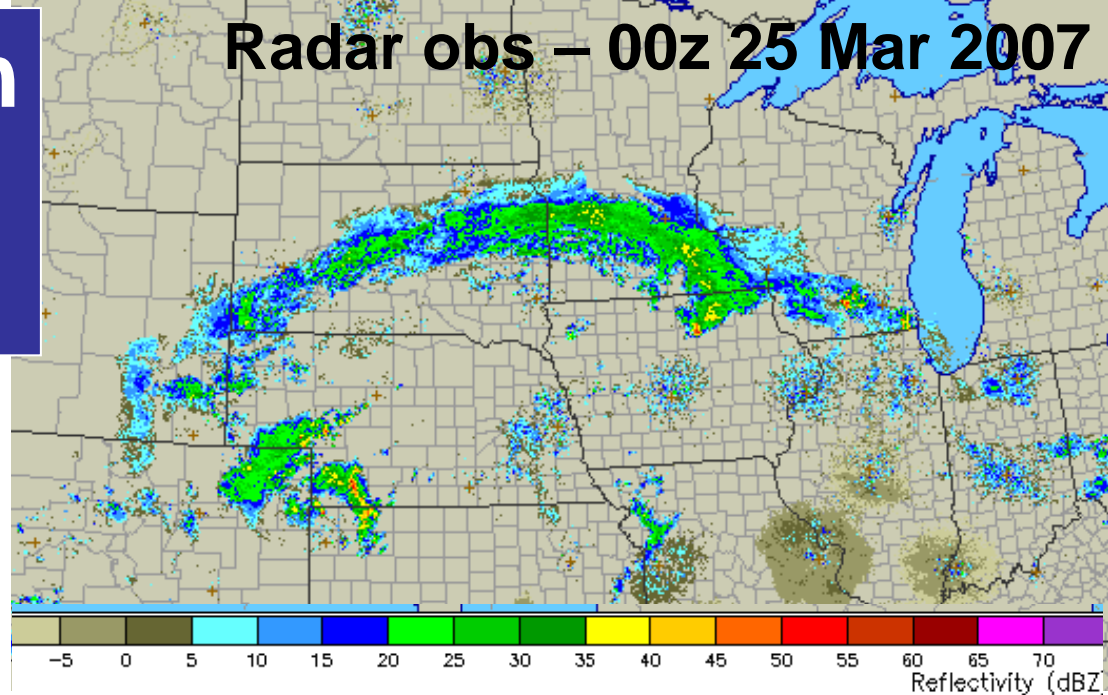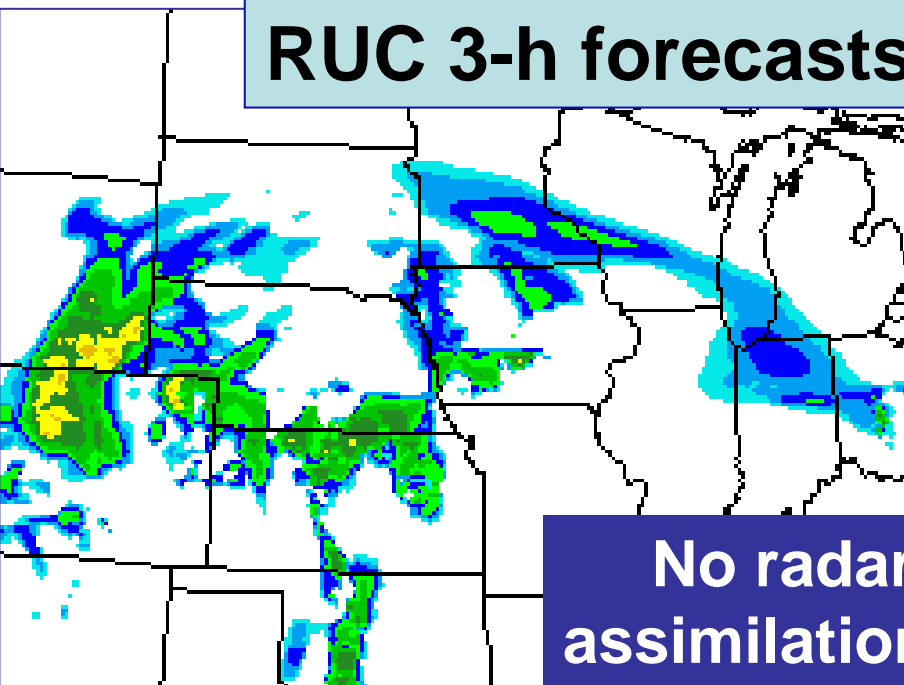More energy for thunderstorms 3-h forecast with **GPS-PW data**

GPS-PW

No GPS-PW

Tornadoes

Radar assimilation in RUC - winter storm example

Radar obs – 00z 25 Mar 2007

Reflectivity (dBZ)
−5 0 5 10 15 20 25 30 35 40 45 50 55 60 65 70
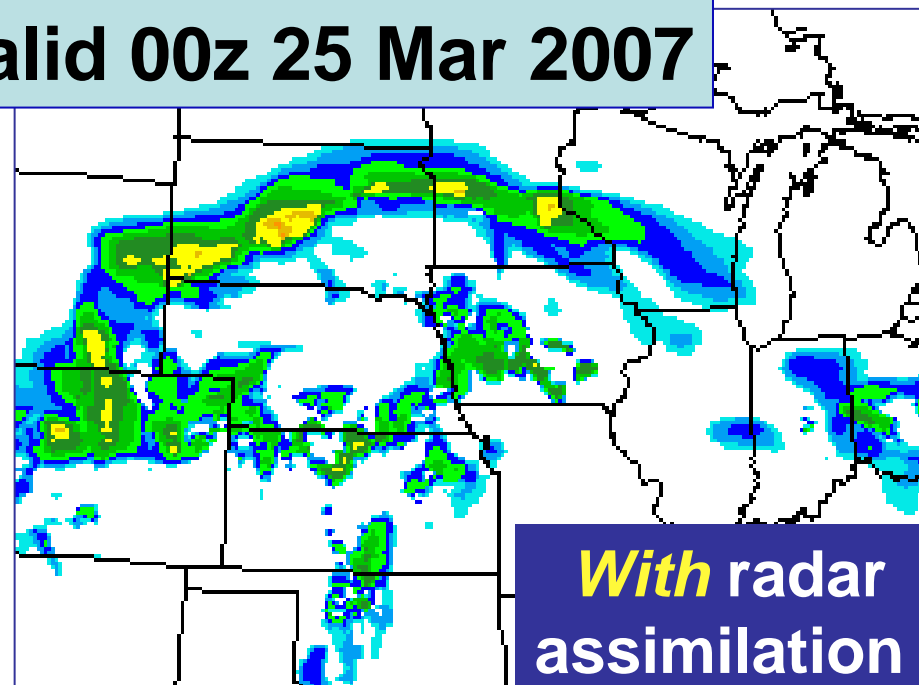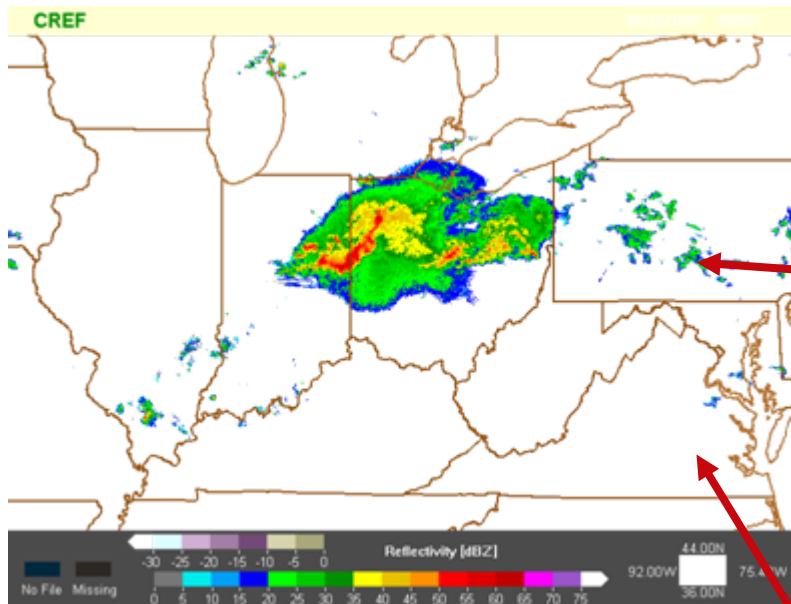
RUC 3-h forecasts valid 00z 25 Mar 2007
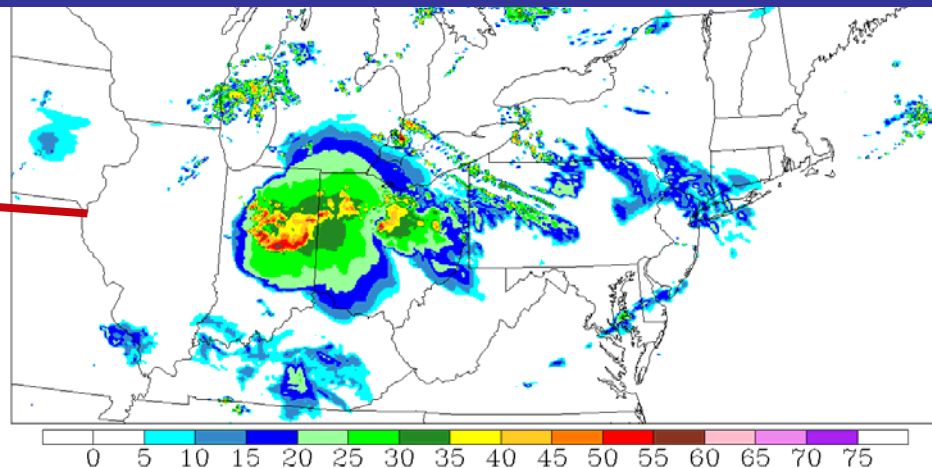
No radar assimilation

With radar assimilation

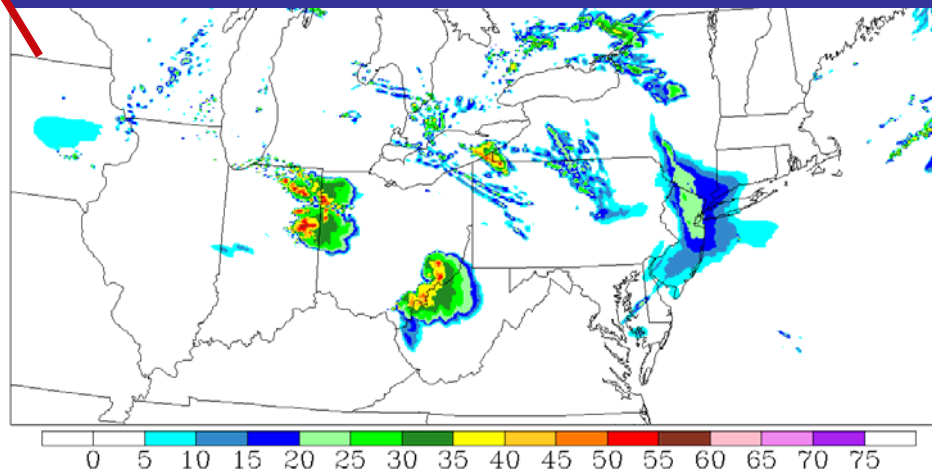# 3km forecasts from Radar-Enhanced RUC

Observed radar

6-h fcst - HRRR 3-km run initialized with radar-enhanced RUC

6-h fcst - HRRR but No-radar init - 3-km run

Radar-enhanced RUC essential for HRRR forecast success

6-h forecasts valid 00z 16 Aug 2007

Additional future ESRL data assimilation

• Satellite radiance assimilation (already in GSI for Rapid Refresh)

• Chemistry data assimilation (surface-based observations and satellite radiances) via GSI

- • work underway by Grell, Pagowski, Devenyi (GSD) to determine spatial background error covariances
- • interaction with GMD - Carbon Tracker, intercomparisons
- • Global application of GSI with chemistry data assimilation (with NCEP, NASA, others)

• Ensemble Kalman Filter assimilation

- • Potential application at NCEP
- • Ensemble Rapid Refresh planned for 2012

• Radar/lightning assimilation (digital filter initialization-DFI-RUC/RR, 4dVAR, EnKF, variational, balance (LAPS Hot))