Assimilation Techniques (emphasizing radar) to improve convection

Mesoscale modeling improvements to support aviation applications

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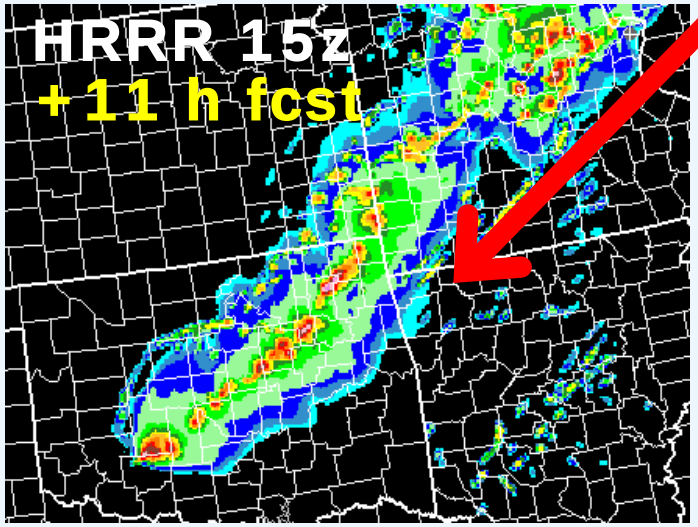
+ NCEP, NCAR, MIT/LL, NSSL,
NASA LaRC, OU/CAPS

March 22-14, 2010
Joint Interagency Weather
Research and Planning Meeting

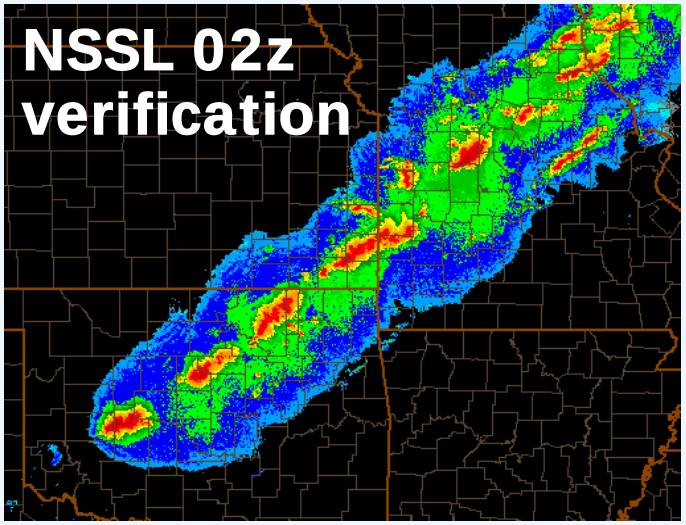
Improving thunderstorm predictions

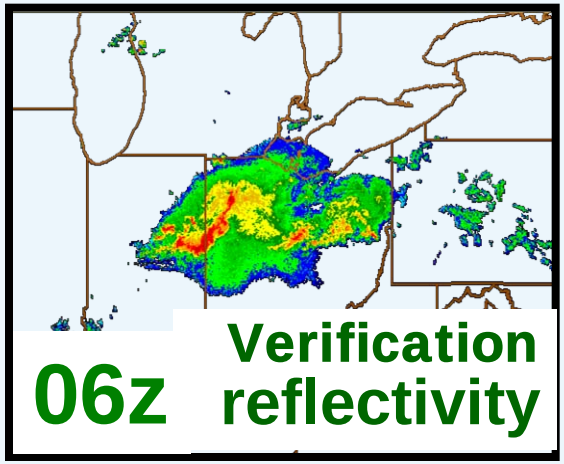
...a combined mesoscale and storm-scale data assimilation problem

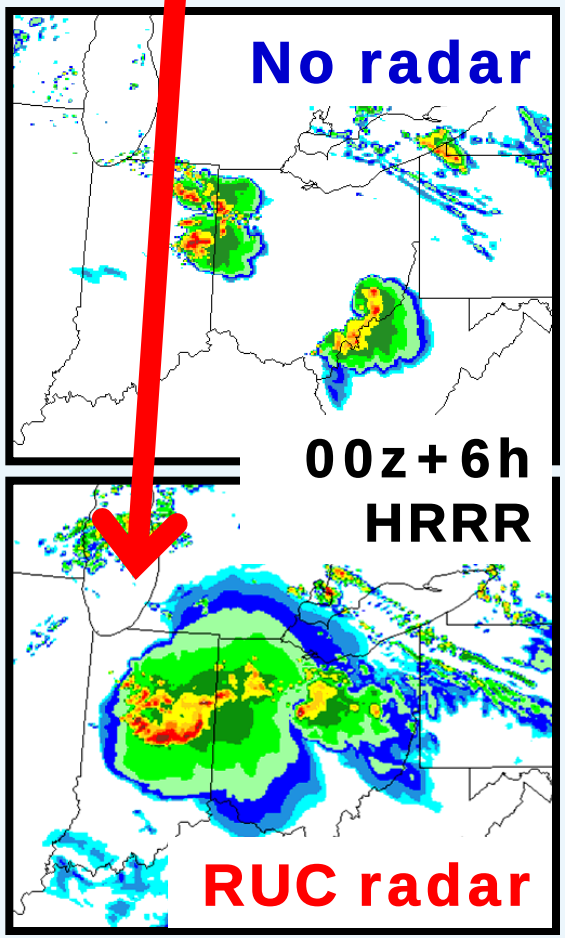


Excellent forecast of CI, storm evolution (NO radar assim)

Excellent forecast of MCS evolution (ONLY with radar assim)



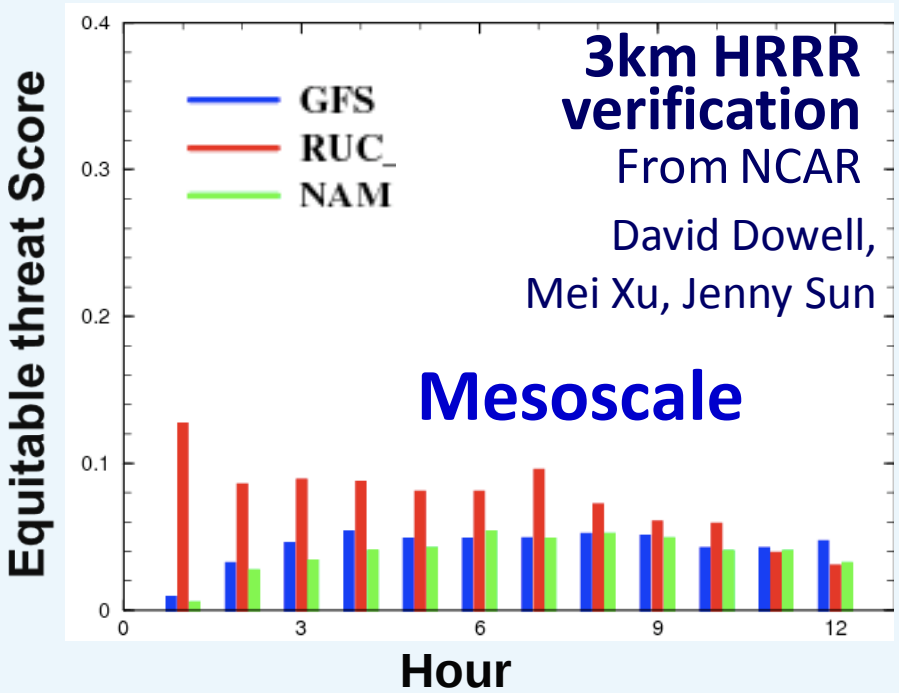




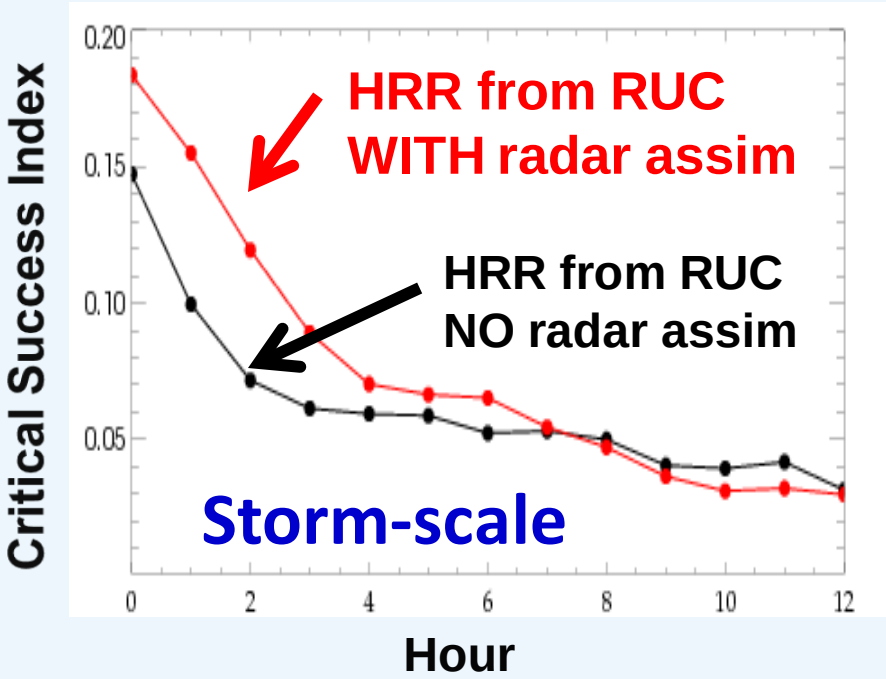
Improving thunderstorm predictions

...a combined mesoscale and storm-scale data assimilation problem

RUC grids provide improved initial conditions for HRRR relative to GFS, NAM, especially for 1-6 hr



Adding radar DFI assimilation to RUC convective environment further improves 1-6 h fcst skill

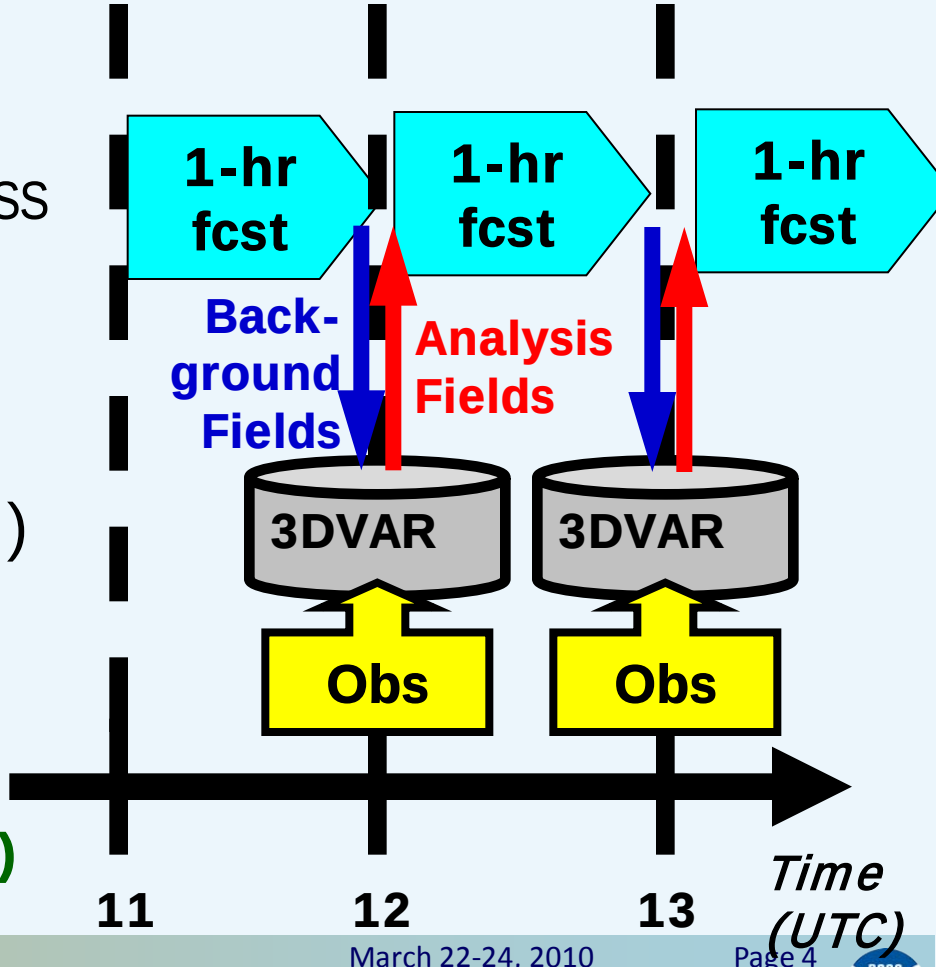


RUC / RR hourly updating

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

Data types used

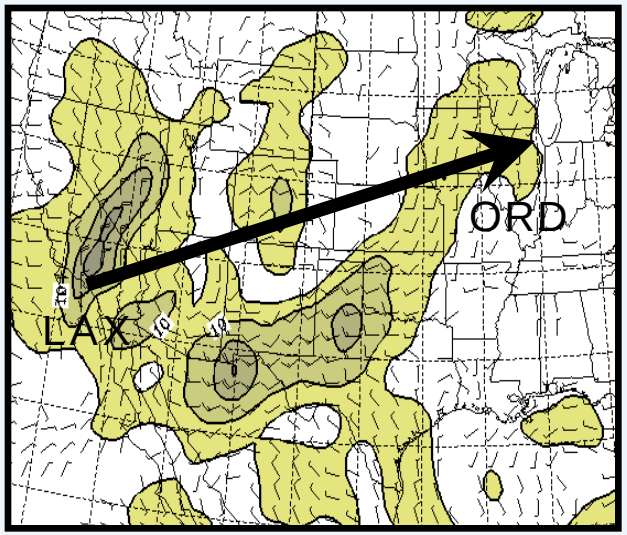
Rawinsonde (balloons)
Wind Profilers (405 MHz, 915 MHz) RASS virtual temperatures
VAD winds (WSR-88D radars)
Aircraft (ACARS, TAMDAR)
Surface (METAR , Buoy, Mesonet
Precipitable water (GPS, GOES, SSM/I)
GOES cloud-drift winds
GOES cloud-top pressure/temp
Radar reflectivity, lightning
Ship reports/dropsondes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



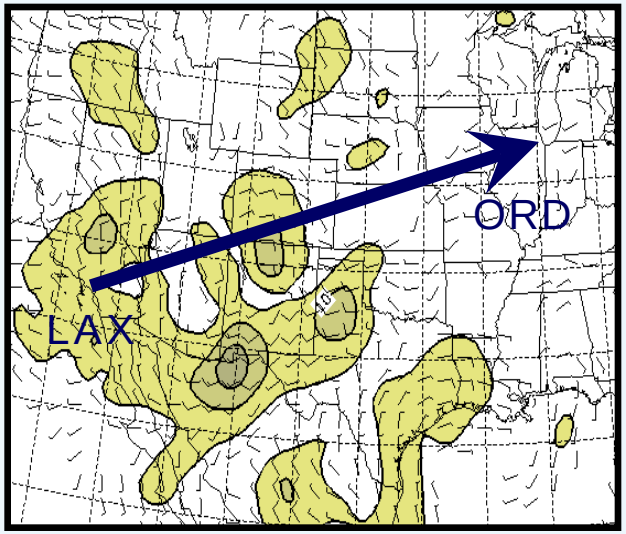
Benefits of Rapid Cycling NWP

Rapid update cycling improves short-range forecasts including upper-level winds

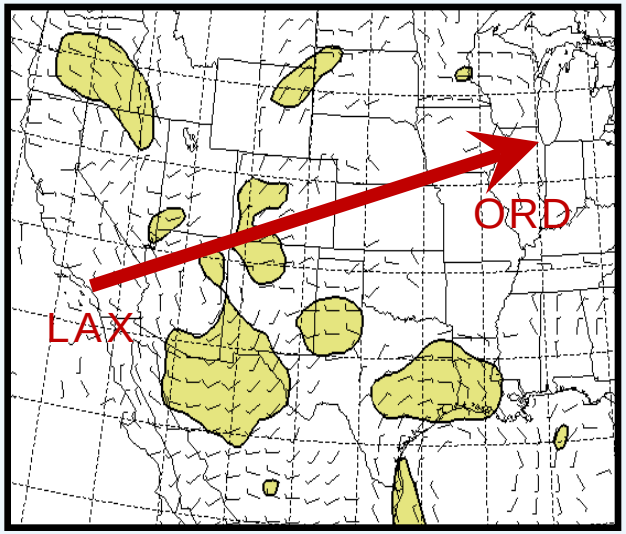
12-h fcst wind errors



6-h fcst wind errors



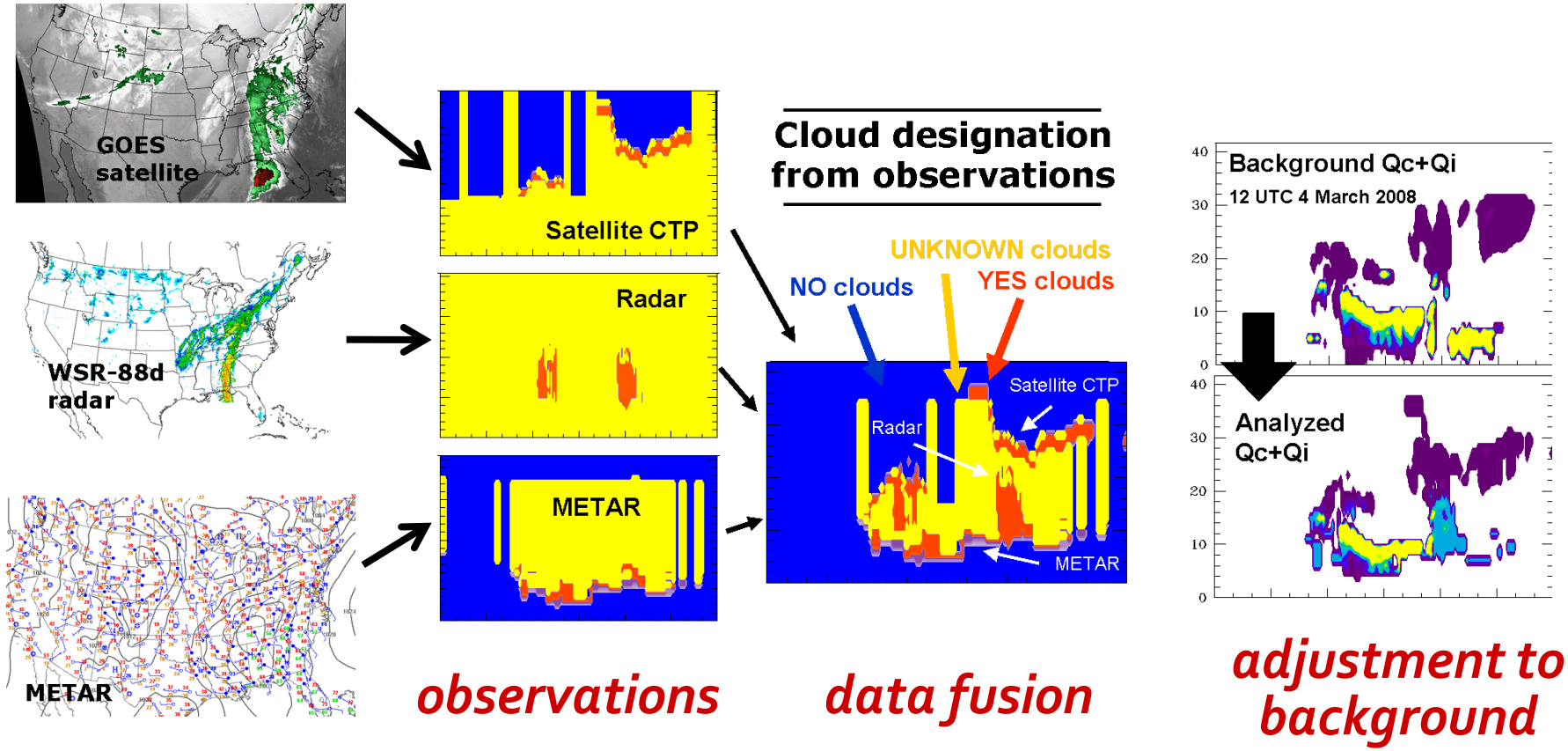
3-h fcst wind errors



RUC 250-hPa wind forecast errors

Cloud and Hydrometeor Analysis

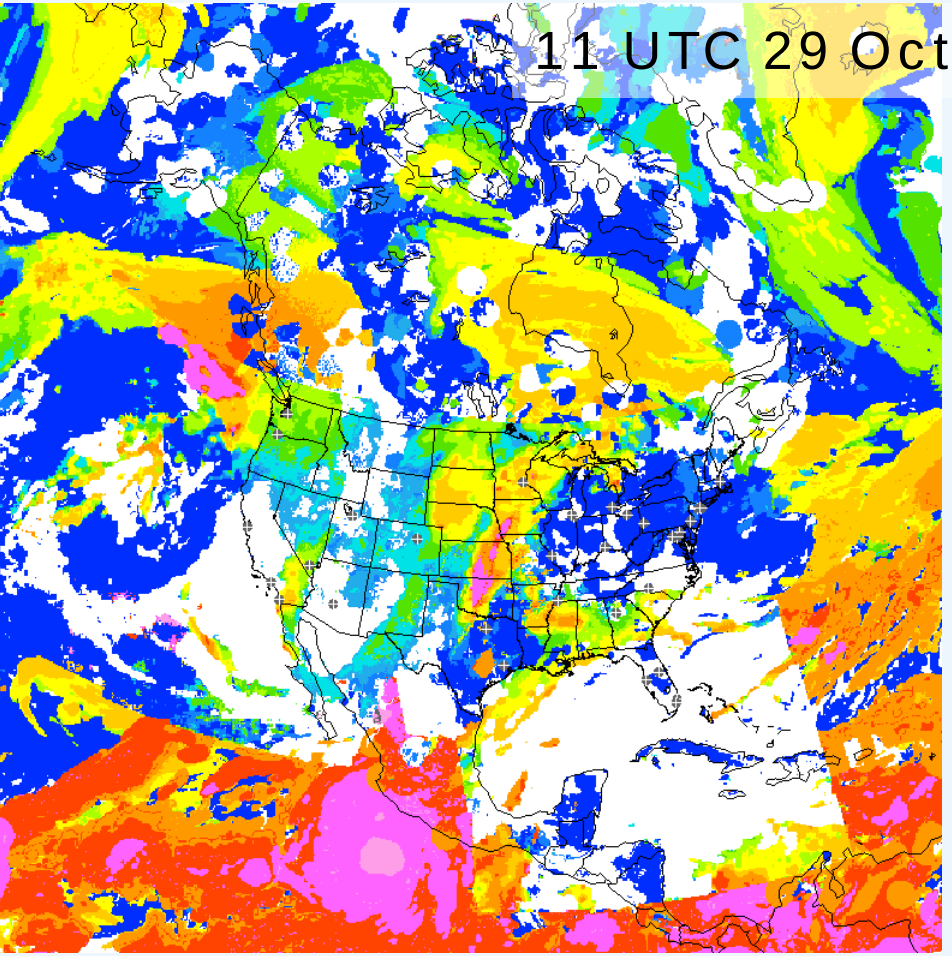
Incremental adjustment based on information from multiple observation types

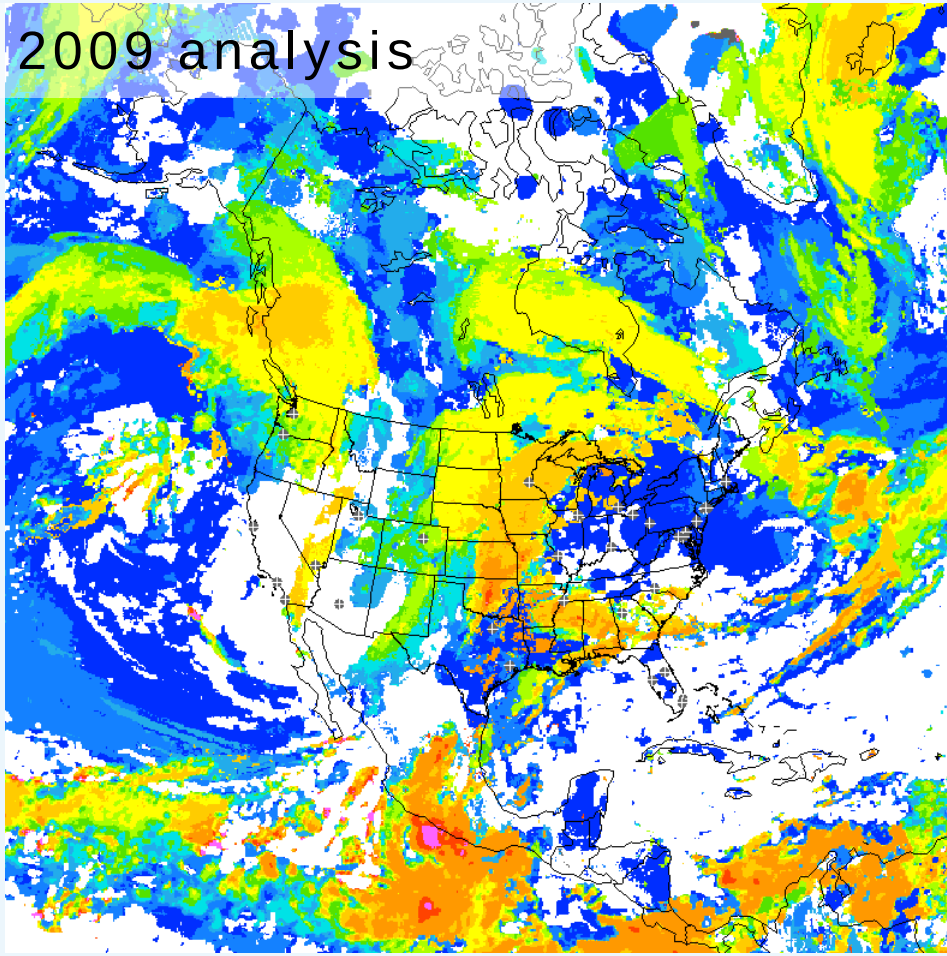


Using NASA Langley satellite cloud data

RR with NESDIS data-
currently only over RUC domain

RR with NASA data - over full RR domain





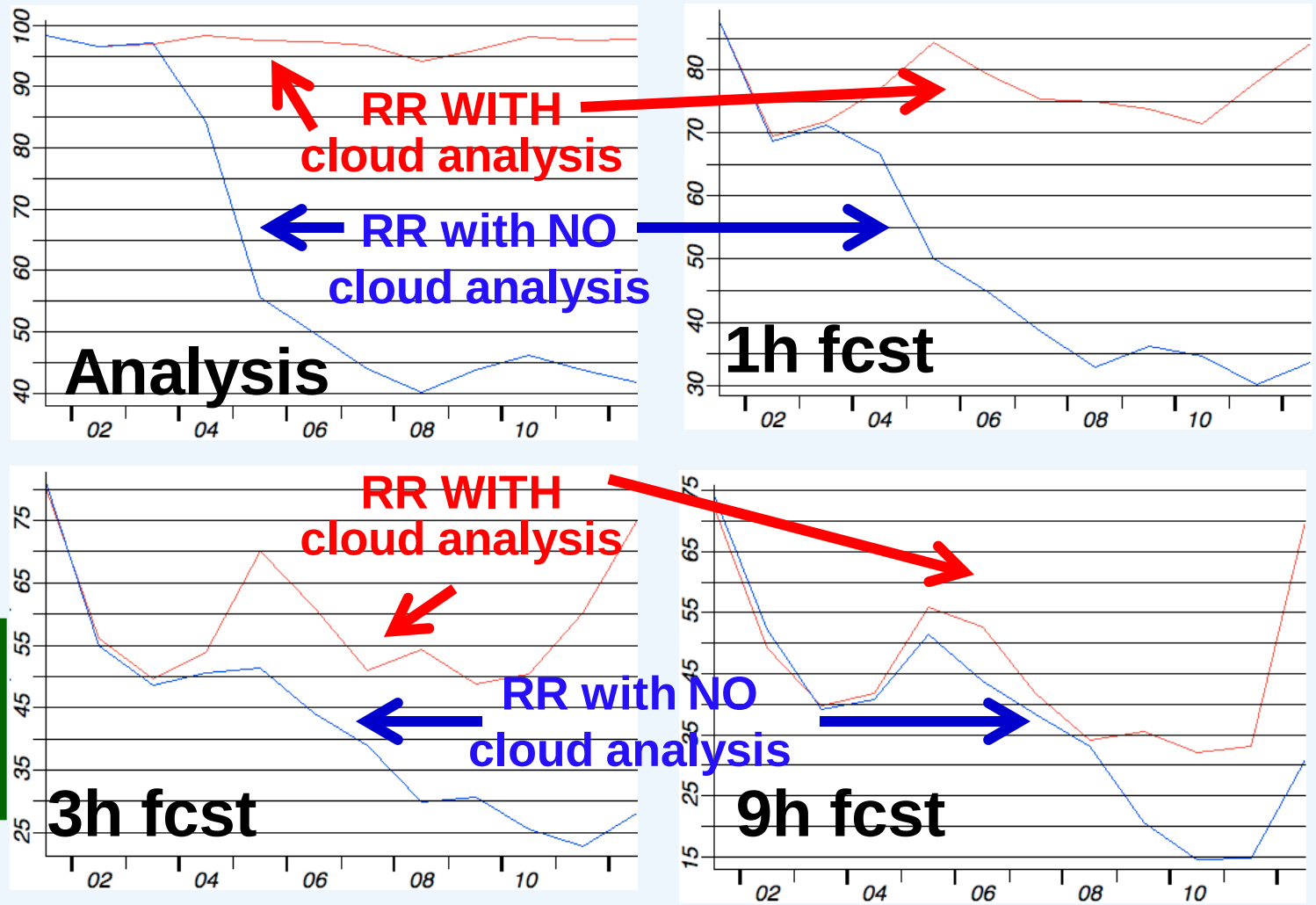
Cloud Analysis impact on RR

POD for 1000 ft. ceiling (IFR)

Large Improvement for 0-3 h fcsts

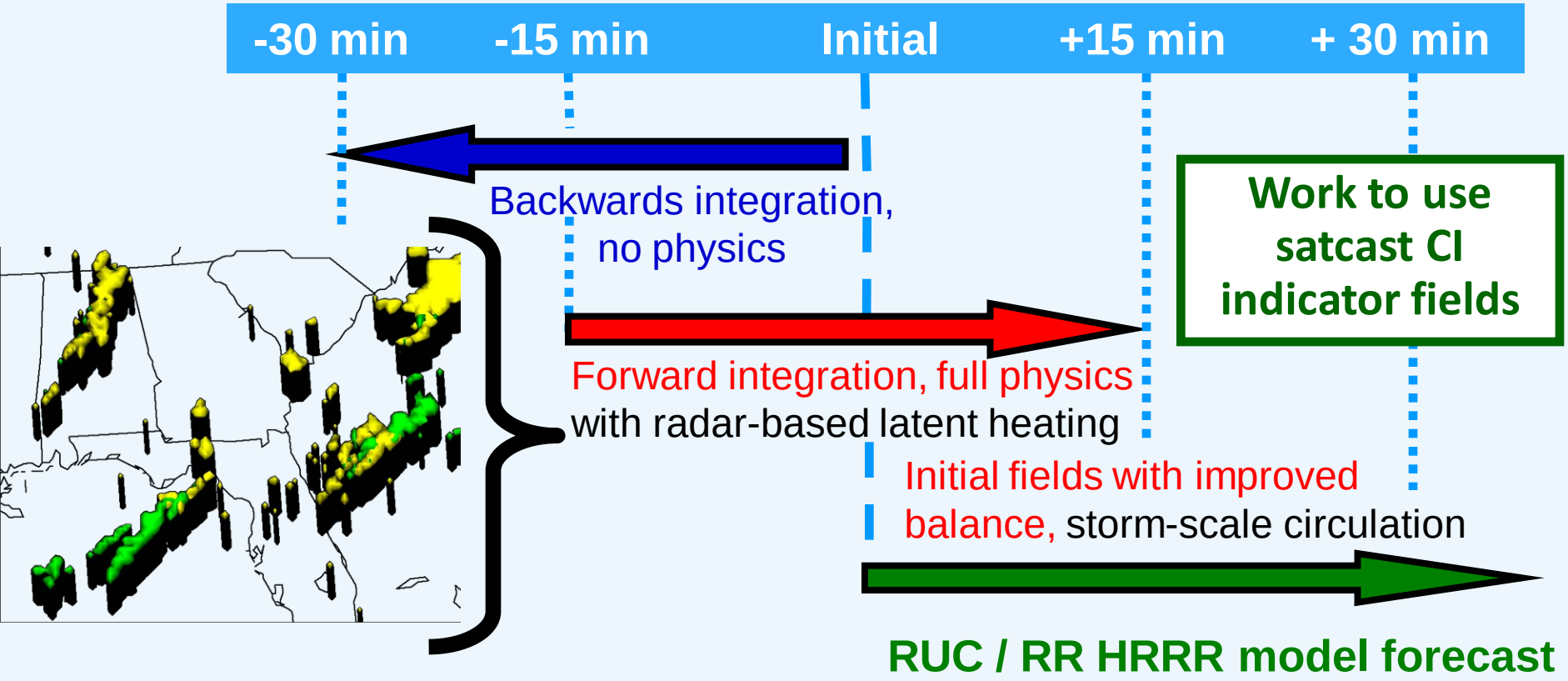
Smaller improvement 6-9 h, beyond

Work to variationalize cloud analysis



Radar Reflectivity Assimilation

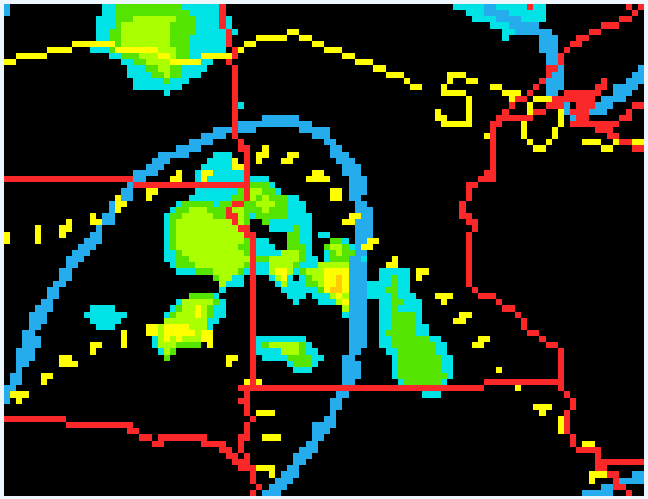
Digital filter-based reflectivity assimilation (radar-DFI) initializes ongoing precipitation regions



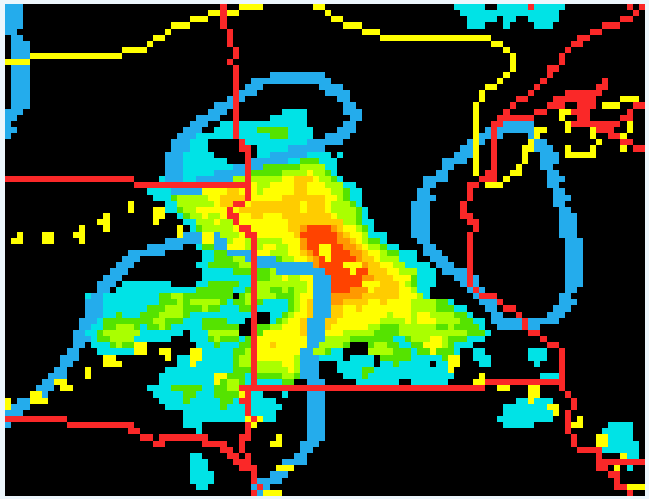
RUC Precipitation Forecasts

Digital filter-based reflectivity assimilation (radar-DFI) improving operational RUC forecasts

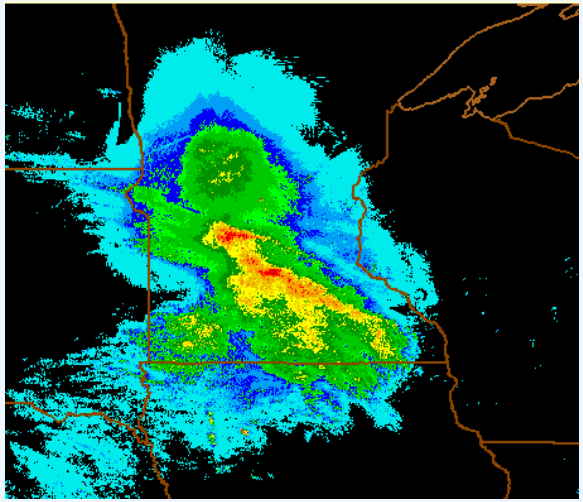
No radar assimilation



RUC radar assimilation



NSSL radar verification

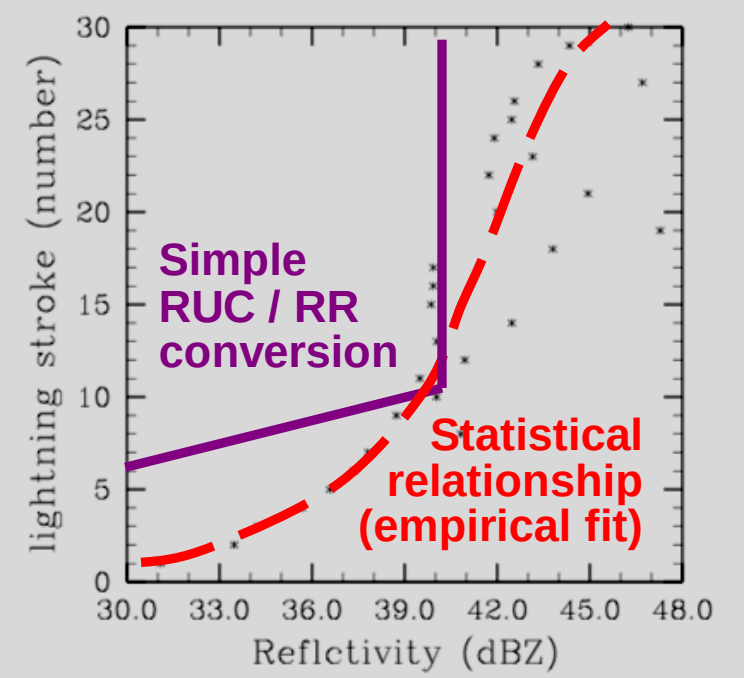


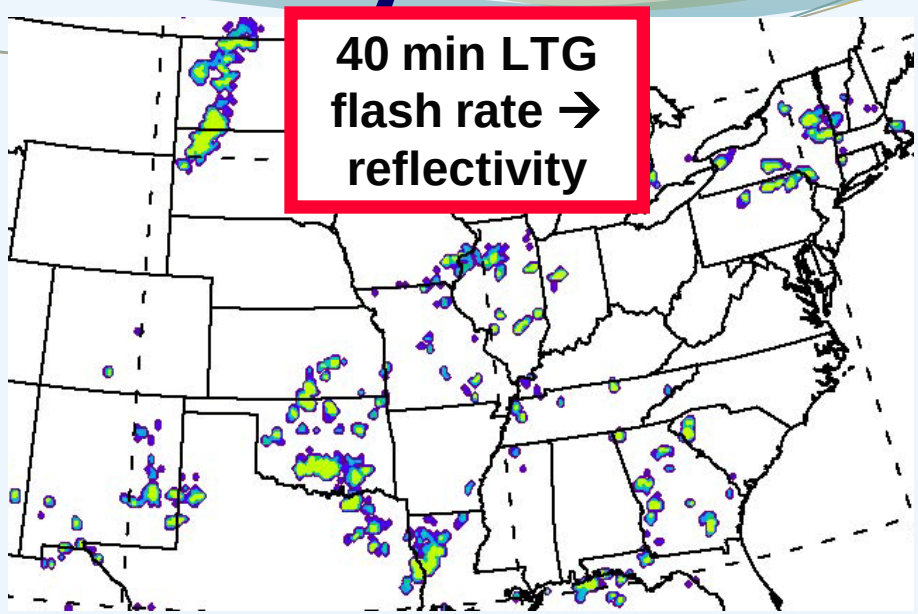
RUC 3-h precipitation forecasts

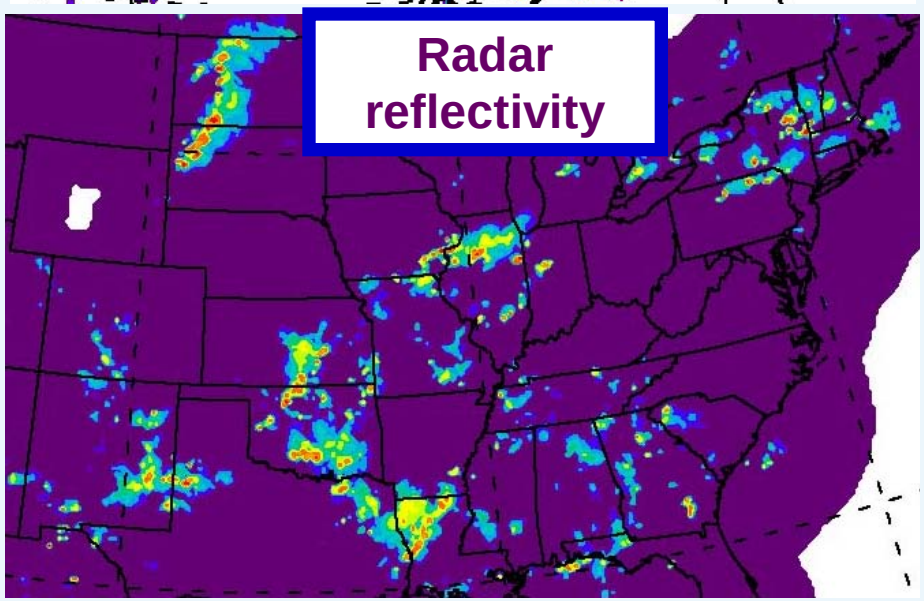
15 UTC 31 July 2008

Lightning data → Proxy Reflectivity

Lightning flash vs. maximum reflectivity





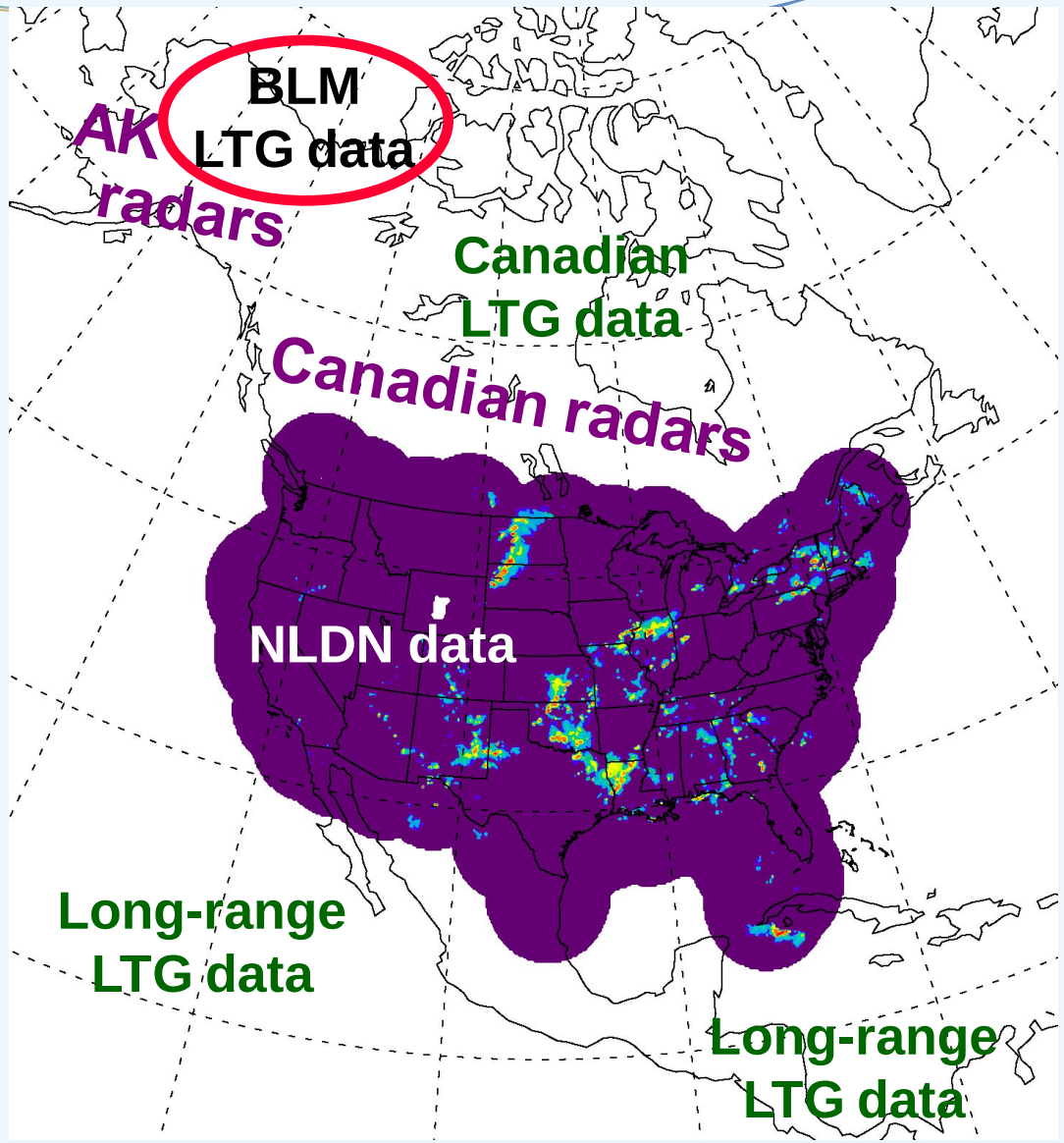


Lightning data → Proxy Reflectivity

Convert lightning data to reflectivity, obtain latent heating rate, use in diabatic DFI

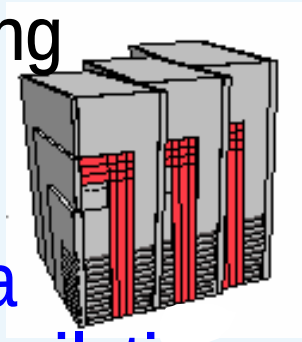
Provides capability to initialize precipitation systems over data sparse regions

Use lighting data in conjunction with radar and satellite data

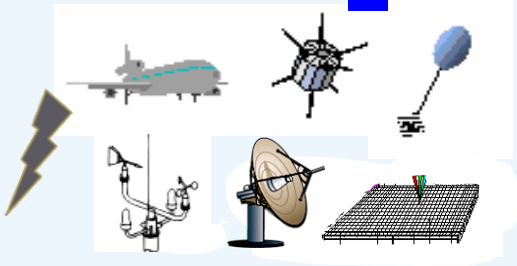


RUC / RR and HRRR models

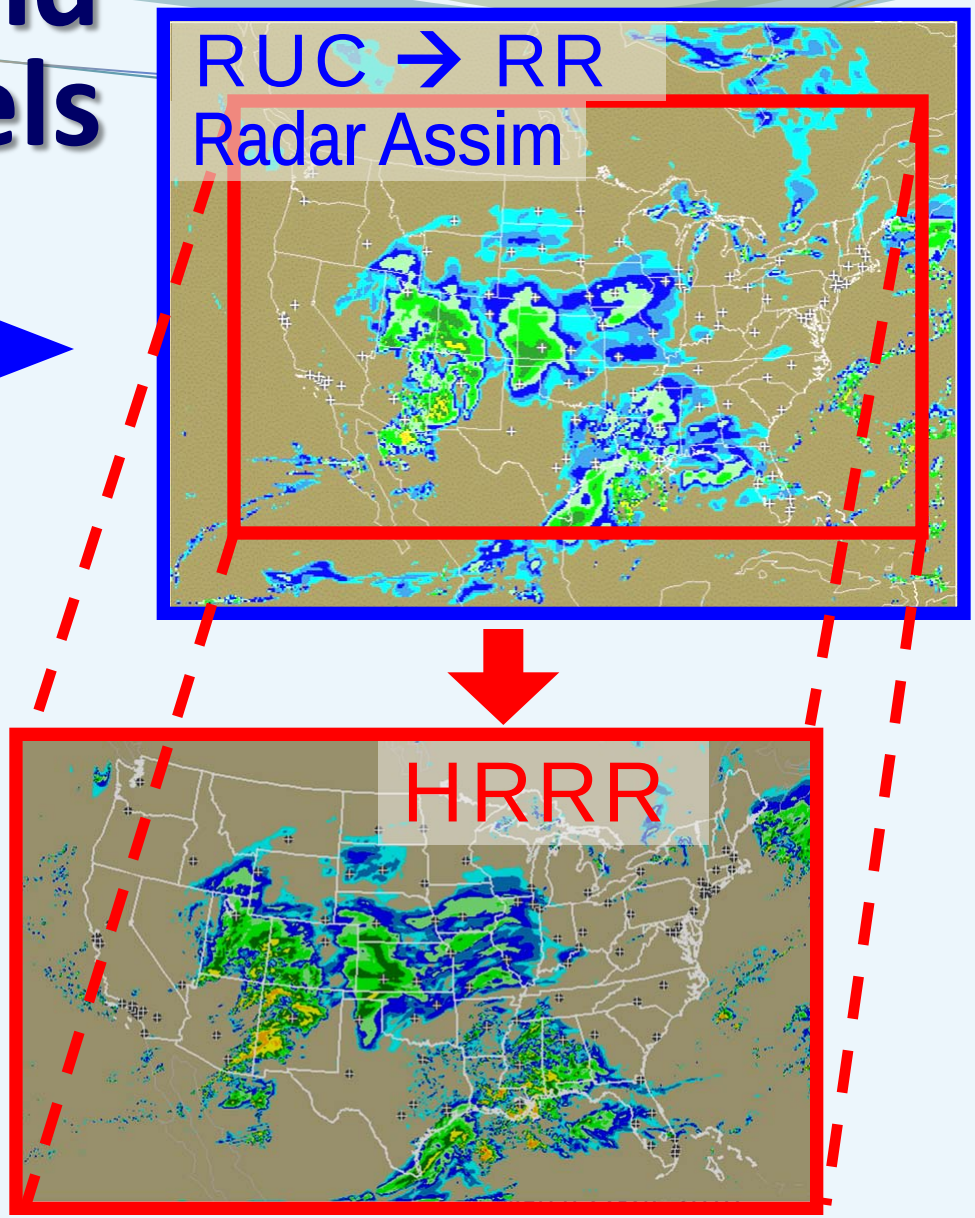
Hourly updating model



Data Assimilation cycle

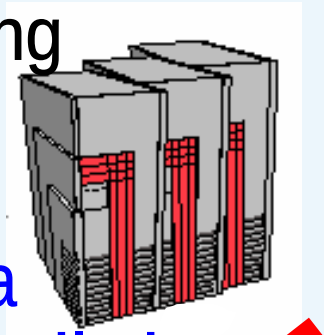


Observations

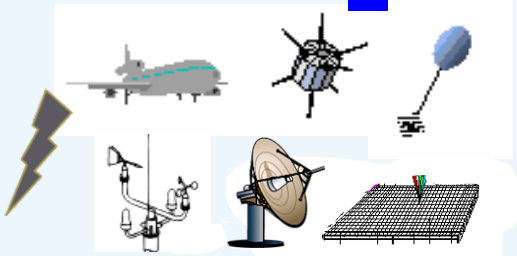


RUC / RR and HRRR models

Hourly updating model

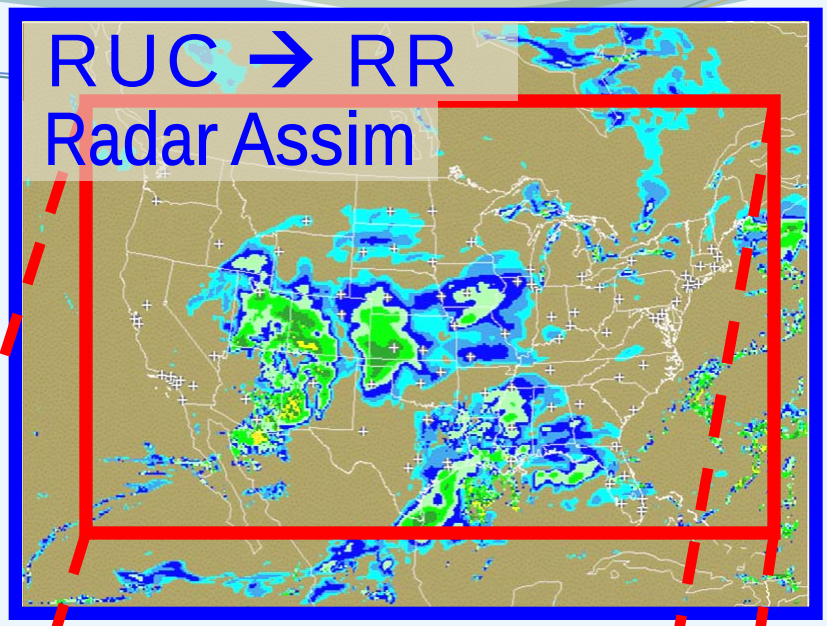


Data Assimilation cycle

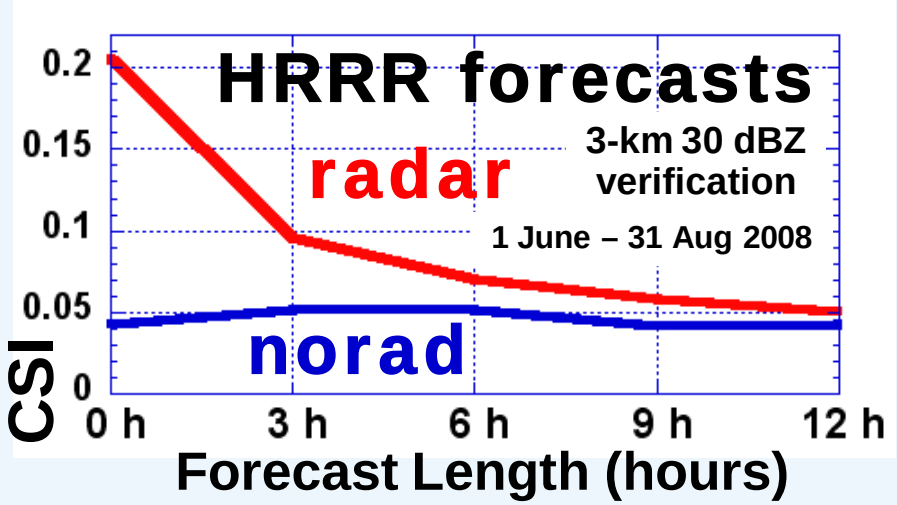


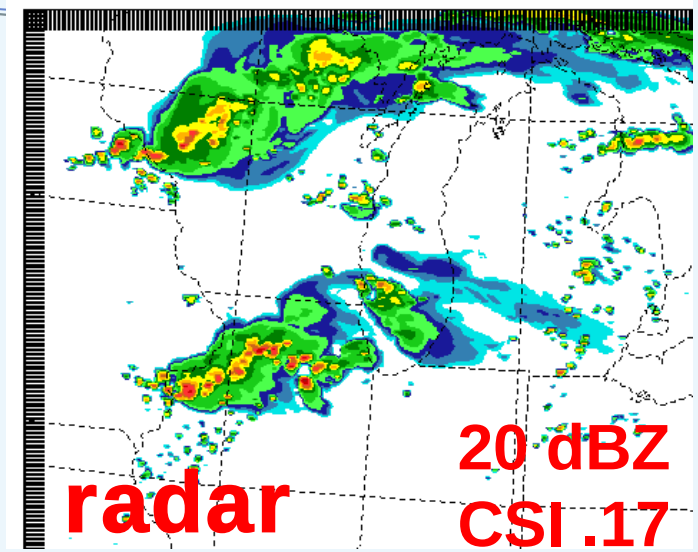
Observations

2nd pass 3-km radar DFI analysis

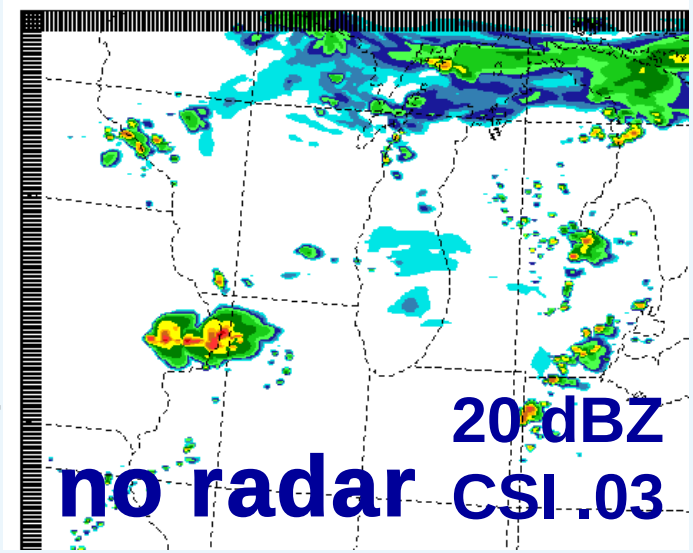


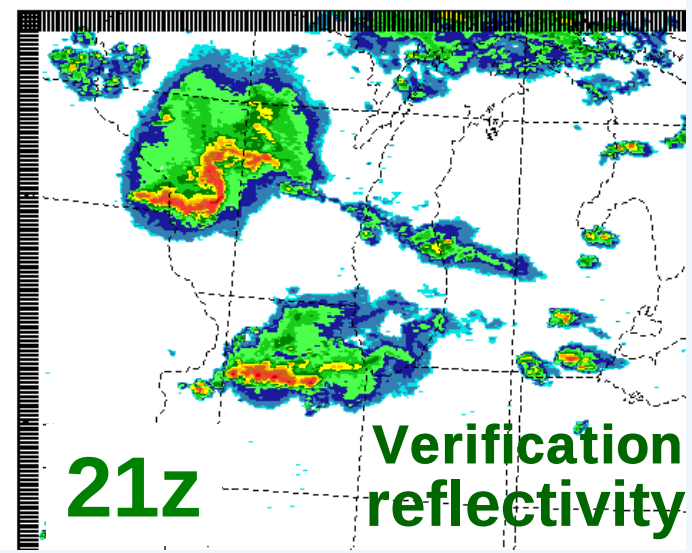
RUC radar-assim→ better HRRR fcsts



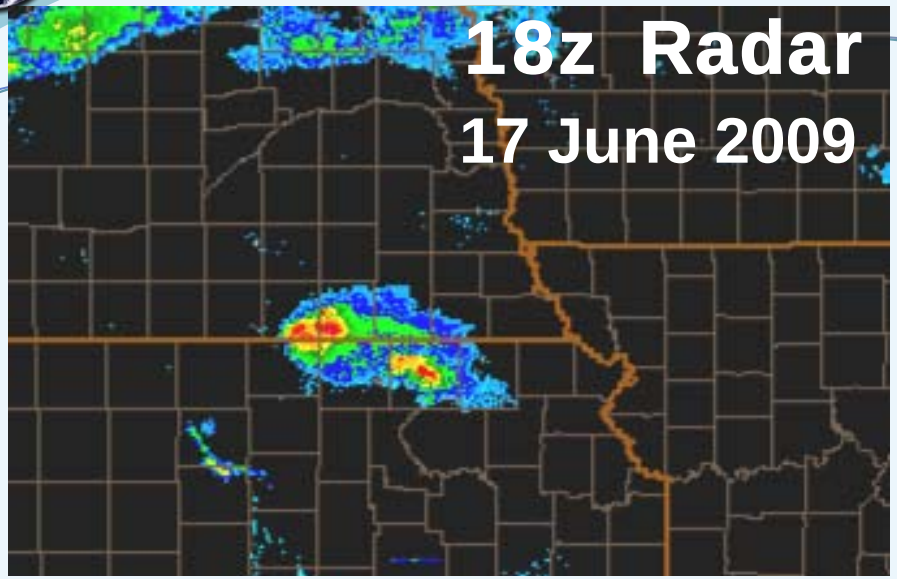


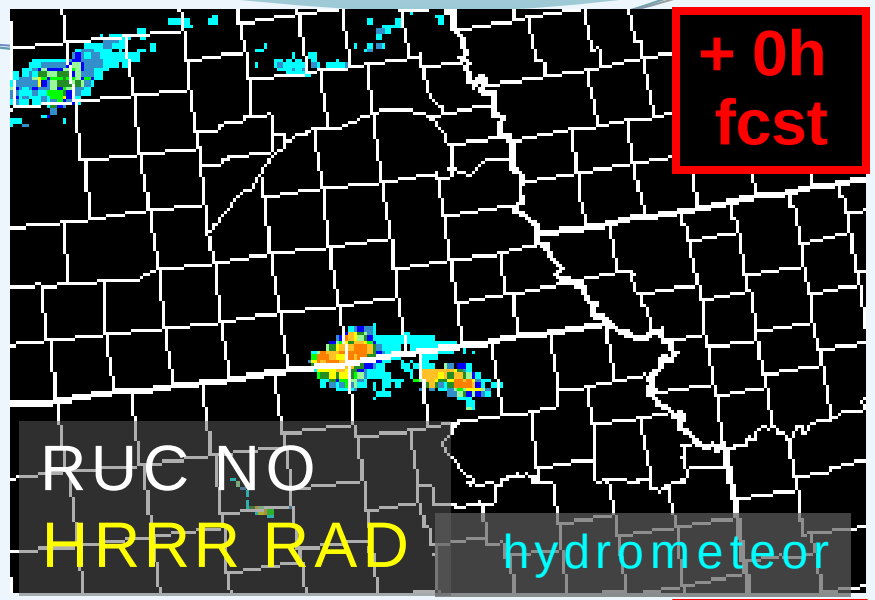
3-h fcst
valid 21 UTC
10 July, 2008

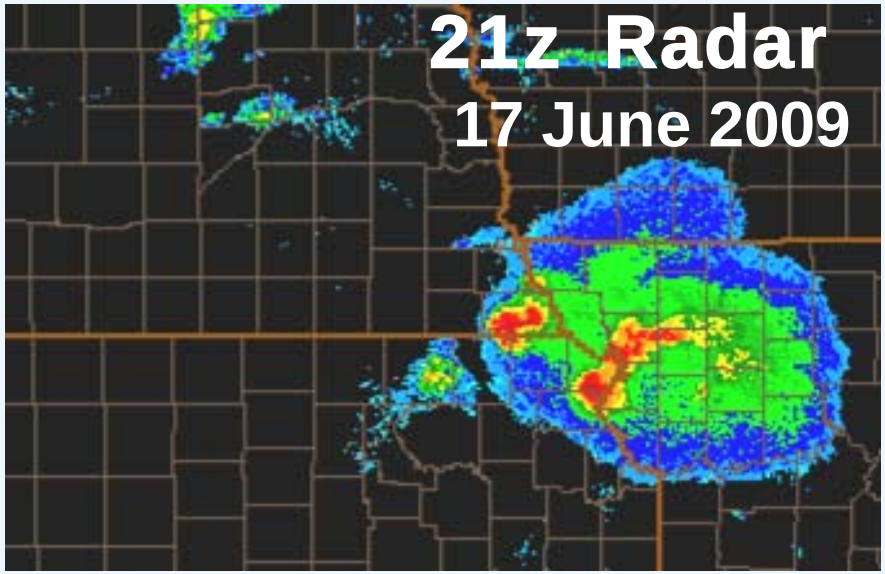


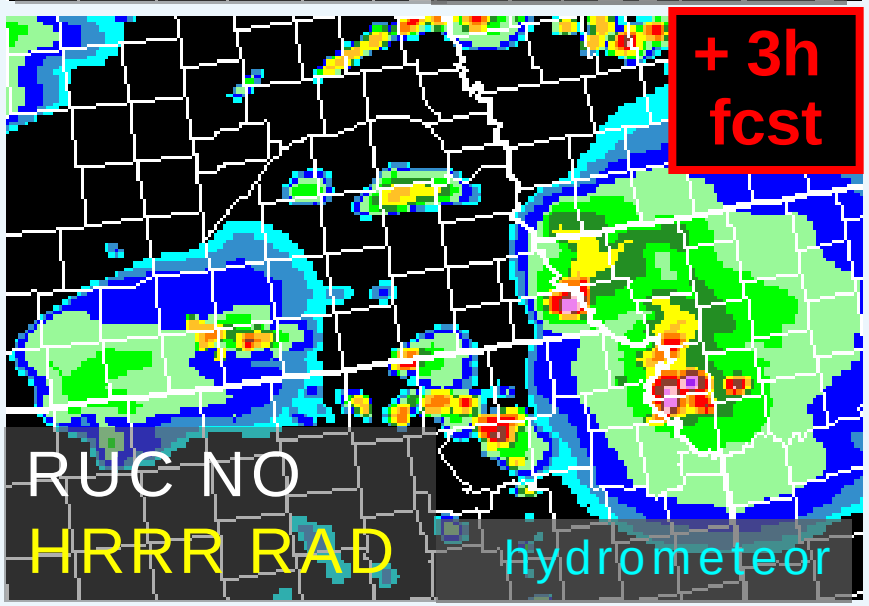


HRRR with radar DA on 3-km domain









Recent Advances in Data Assimilation

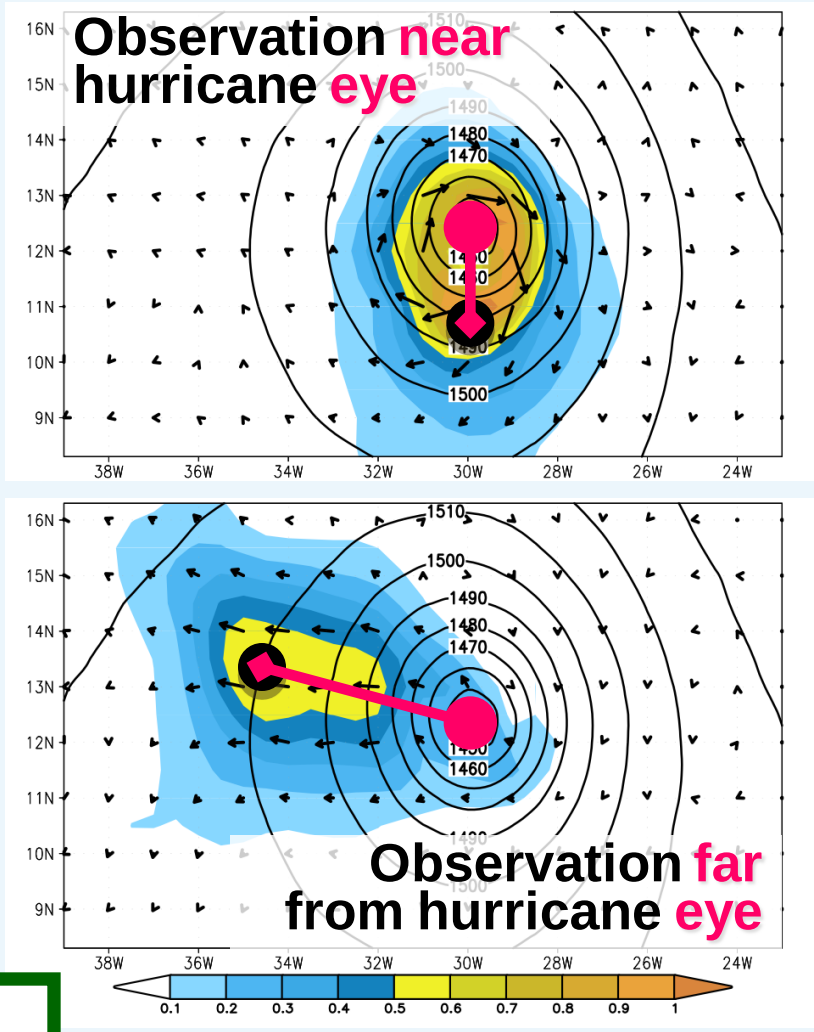
Ensemble Kalman Filter (EnKF) – ***Improved forecast error correlation structure → better analysis increments***

Advantageous for mesoscale features (hurricanes, frontal bands, thunderstorms)

Collaboration on global hybryd system using GSI framework

Work plan for RR EnKF system

Work on RR-chem data assimilation



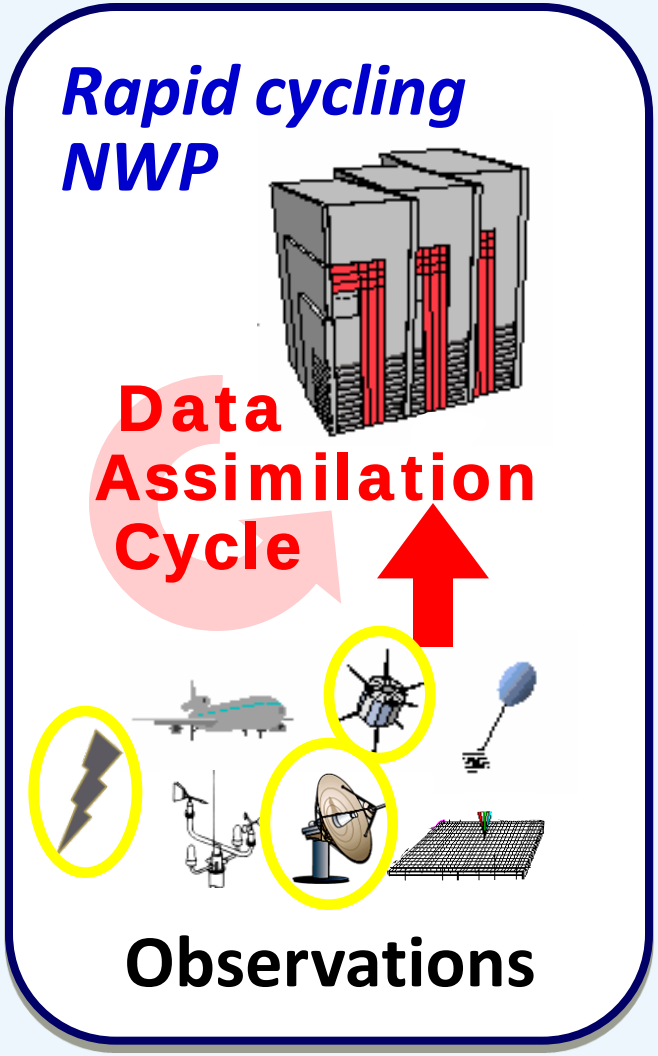
EnKF single obs increment examples

Maximizing forecast improvement from novel observing systems

Need data fusion between different observations:
Satellite, radar, lightning

Direct use of observations in assimilation systems instead of stand-alone retreivals

- Use of model information

-better use of observation / background error information

Increase collaboration between observation, assimilation groups