

Improvements to Ceiling/Upper Air Forecasts from the 13km Rapid Refresh (RAP) and 3km High-Resolution Rapid Refresh (HRRR) Hourly Updated Forecast Systems



Patrick Hofmann¹, Ming Hu¹, Stan Benjamin², Steve Weygandt², Curtis Alexander¹, David Dowell²
 (1) Cooperative Institute for Research in Environmental Sciences,
 (2) NOAA - Earth System Research Laboratory

MOTIVATION

The focus of RAP and HRRR model development is providing short-range "situational awareness" guidance for aviation, severe weather, and renewable energy applications.

- **Areas of Improvement:** ceiling and upper air verification
- **New Applications:** HRRR based Rapidly Updating Analysis (RUA), and Real Time Mesoscale Analysis (RTMA)

MODEL OVERVIEW

NCEP RUC → Rapid Refresh (01 May 2012)

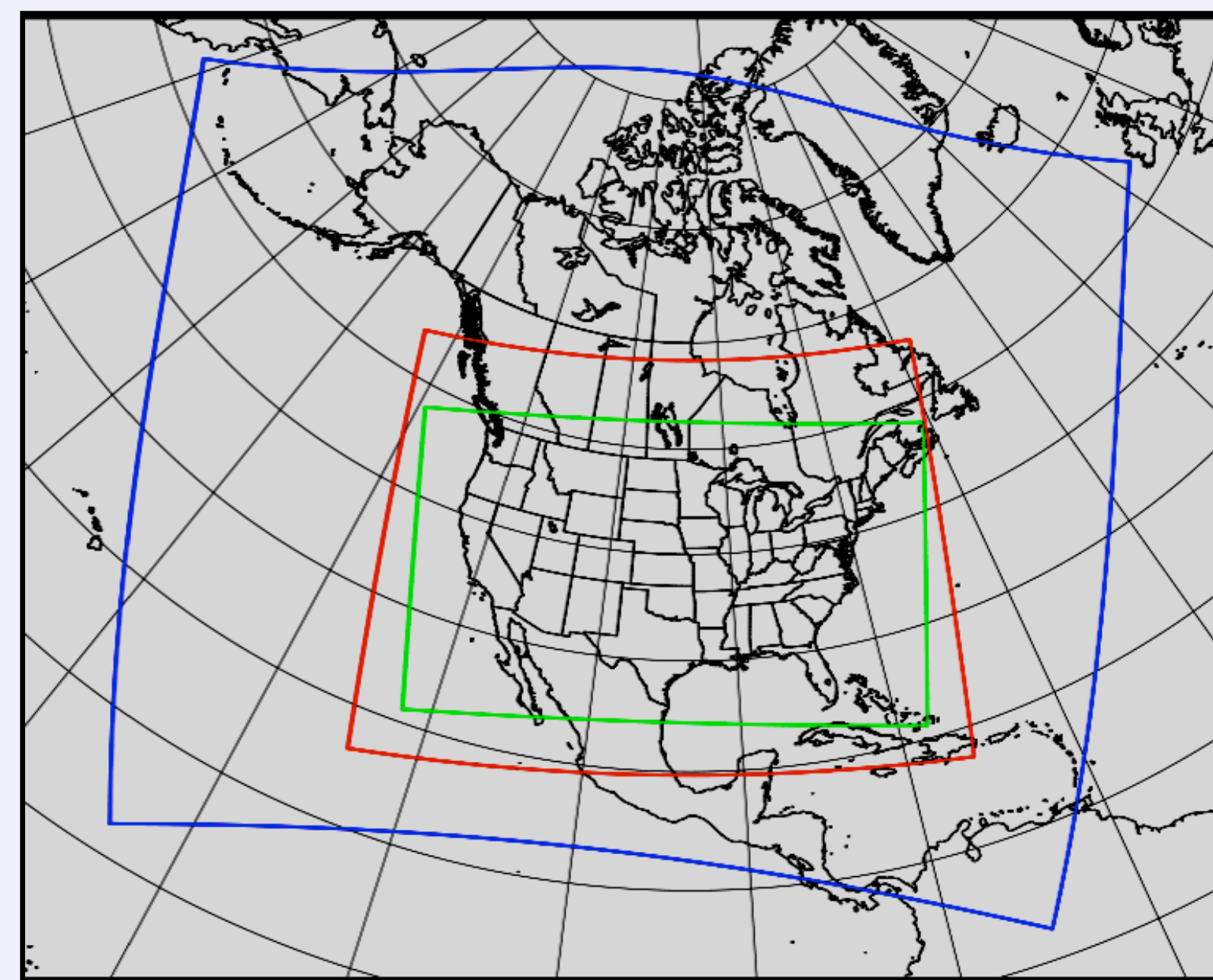
- Advanced community codes (ARW and GSI)
- Retain key features from RUC analysis / model system (hourly cycle -- radar DFI assimilation -- cloud analysis)
- RAP short-range guidance for aviation, severe weather, energy applications

GSD Rapid Refresh V2

- Real-time version 2 ("V2") producing significant improvement over RAP V1
- Implementation early 2013?

GSD HRRR

- Runs as nest within RAP V2
- Explicit convection
- Implementation 2015?

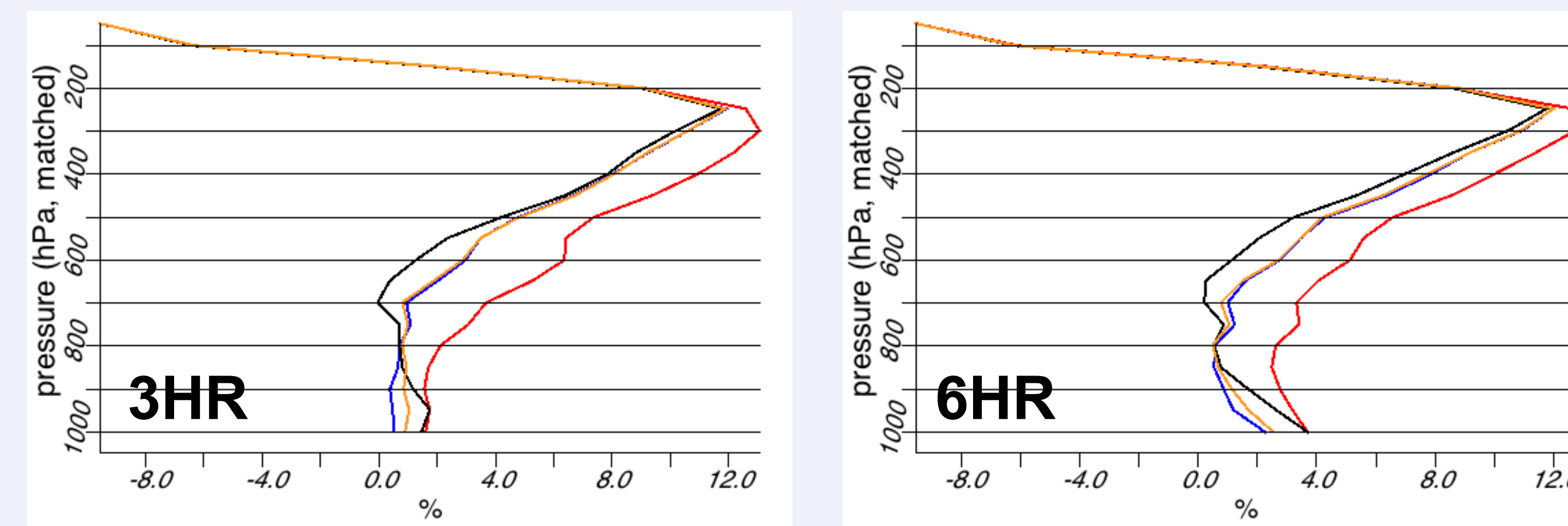


CLOUD BUILDING EXPERIMENTS

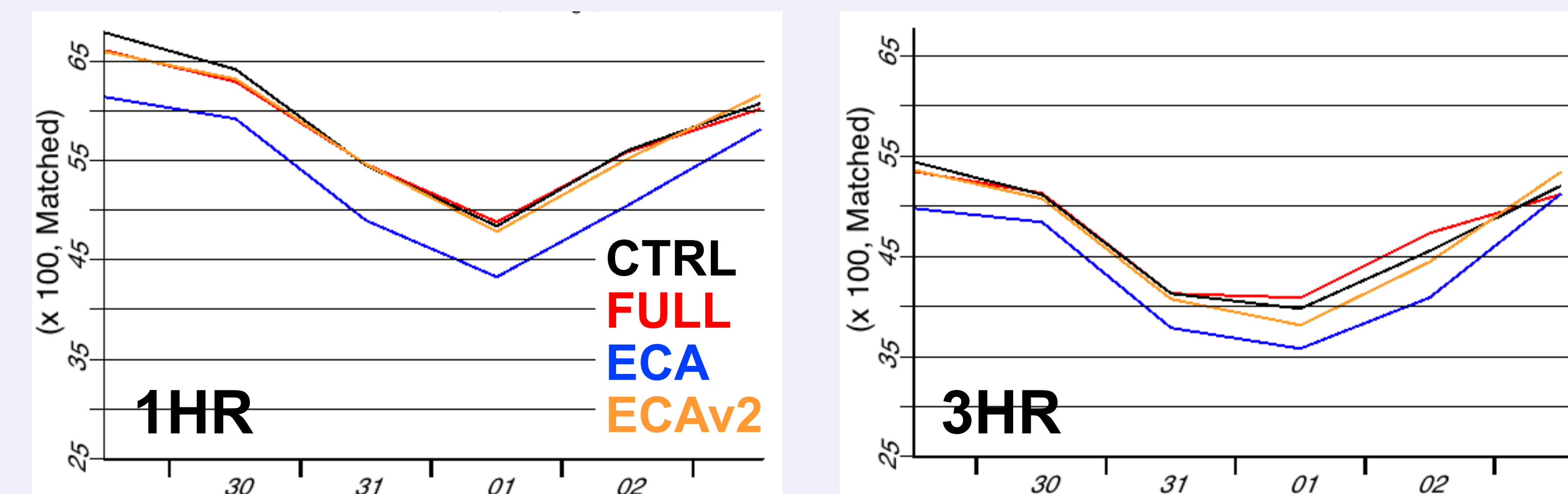
Retro Period: 29 May – 12 June 2011

- **CONTROL:** RAPV2, with cloud building below 1200m
- **FULL BUILDING:** Full column building using a cloud top pressure based cloud fraction
- **ECA BUILDING:** Full column building using effective cloud amount (ECA), which uses cloud emissivity as a proxy for true cloud fraction
- **ECA BUILDINGv2:** ECA BUILDING, but no clearing from partially cloudy regions

Upper-Air Raob Humidity Verification - Bias



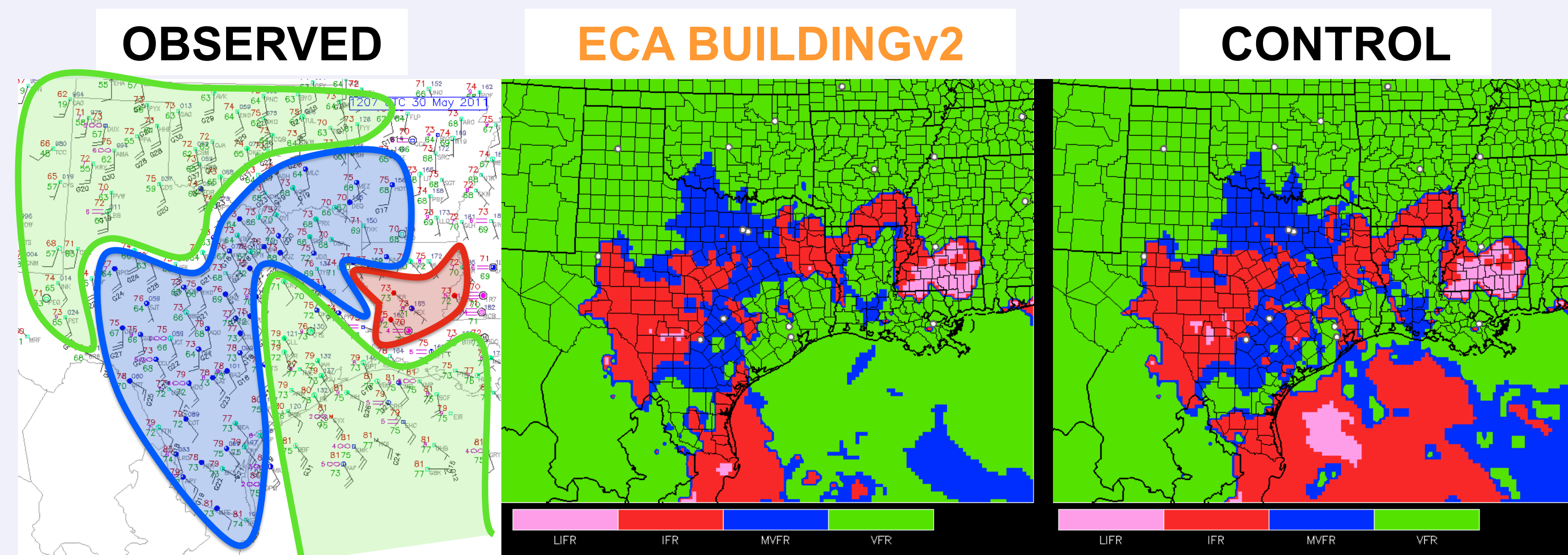
3000ft Ceiling Verification - True Skill Score



Results

- **CONTROL** avoids high moist bias by removing full cloud building
- **FULL BUILDING** maintains ceiling scores, but produces high moist biases in the forecasts.
- **ECA BUILDING** reduces moist bias, but degrades ceiling scores.
- **ECA BUILDINGv2** maintains reduction of the high moisture bias without degrading ceiling skill scores

Flight Rules Improvement
 3hr forecasts valid 12Z 30 May 2011



NEW HRRR APPLICATIONS

RUA (Rapidly Updating Analysis)

- 3-D hydrometeor fields for cloud water and ice mixing ratios are modified based on current radar observations, METAR ceiling, and GOES cloud retrieval data.
- RAP is the only current NCEP model/assimilation system to assimilate either GOES cloud data or METAR cloud data.
- GSI cloud/hydrometeor analysis gives a more physically consistent cloud field than the current GOES-only RTMA cloud field.

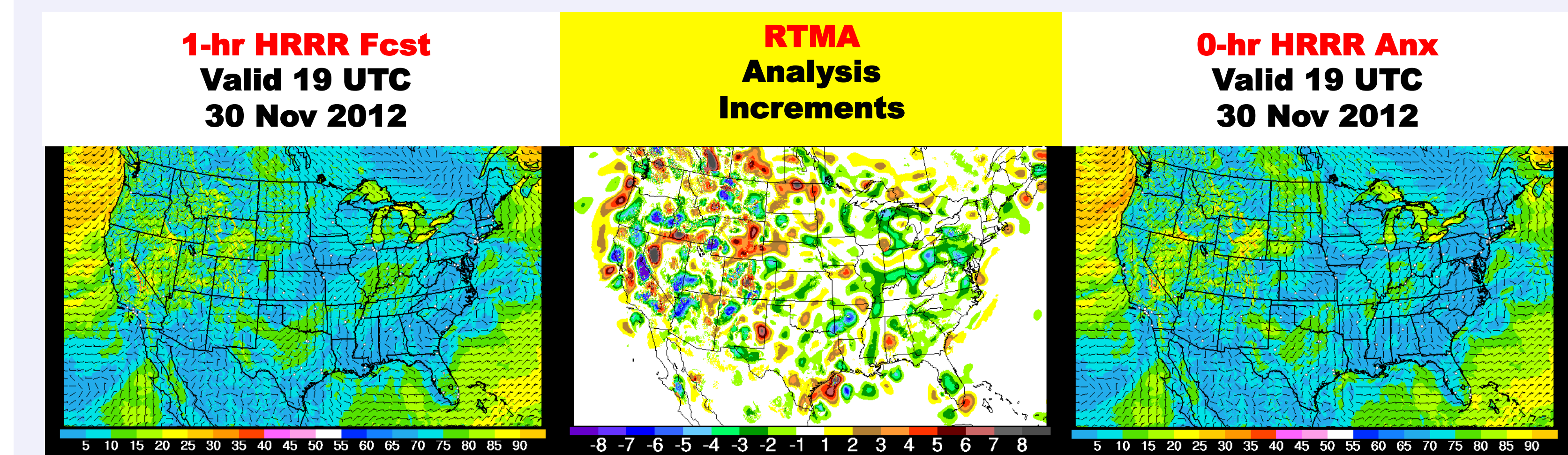
Composite Reflectivity



RTMA (Real-Time Mesoscale Analysis)

- 1hr HRRR forecast from previous cycle used as the background field.
- Gives more accurate initial surface fields for weather service forecasters and the Storm Prediction Center.
- These fields can then be used to better initialize the HRRR forecast.

10m Winds



SUMMARY

Completed RAP V2 Changes

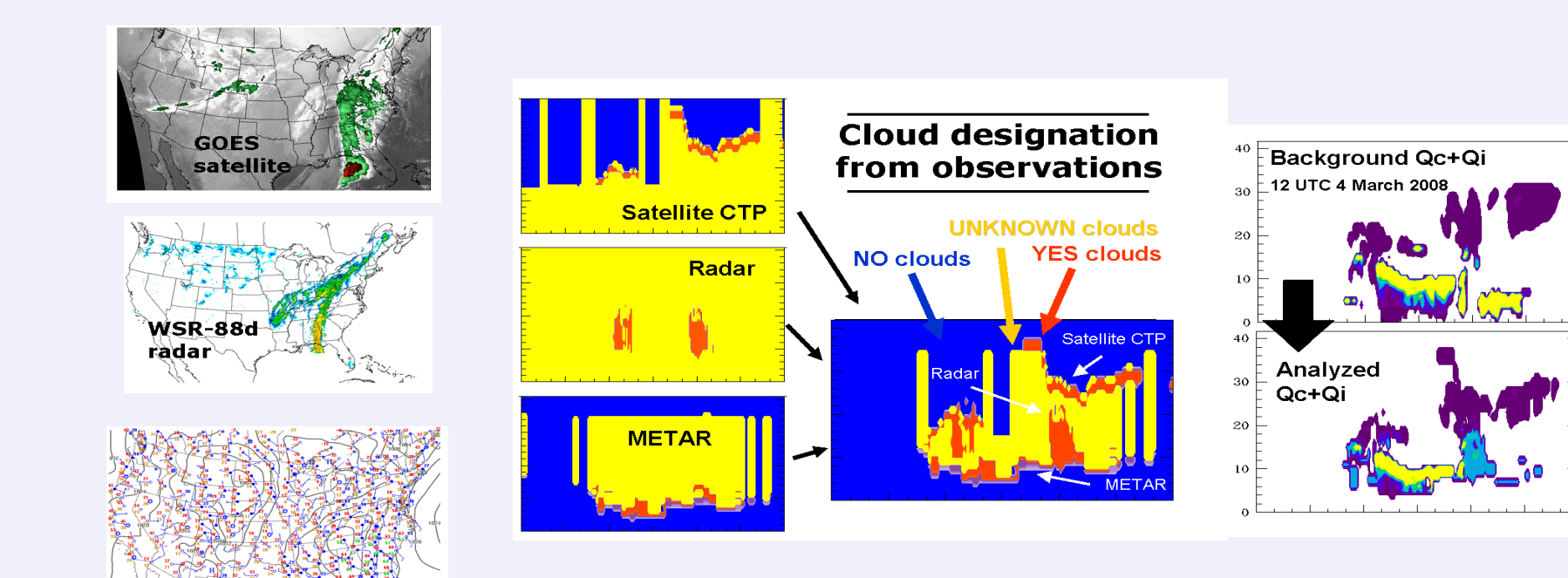
- Assimilation of surface moisture pseudo-obs in PBL
- Soil adjustment based on near-surface temperature / moisture increments
- Elevation correction, innovation limitation for PW observations
- Conservation of virtual potential temperature during cloud building
- GFS ensemble background error covariance specification
- Radiance bias correction
- Merge with latest version of GSI from NCEP community trunk
- Additional observations (radial wind, wind tower/nacelle, lightning)
- Improved cloud building

GSI 3km applications

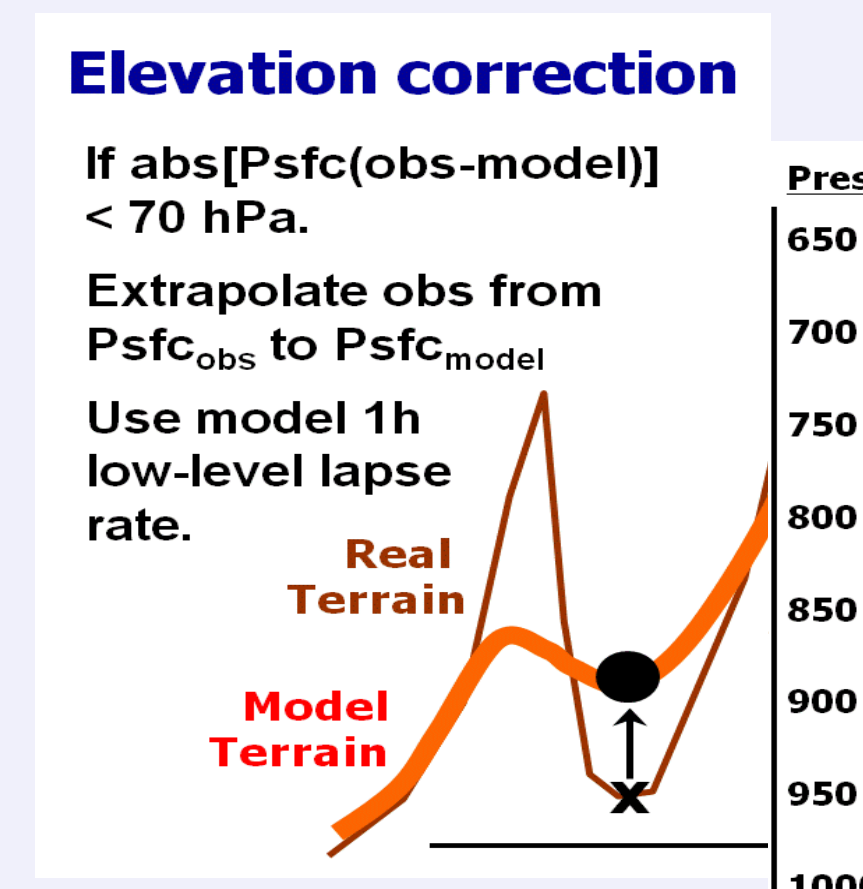
- RTMA-HRRR provides improved first-guess fields for NDFD
- RUA-HRRR results in more realistic initial model state, greatly improving reflectivity and hydrometeor fields

RAPID REFRESH ANALYSIS FEATURES

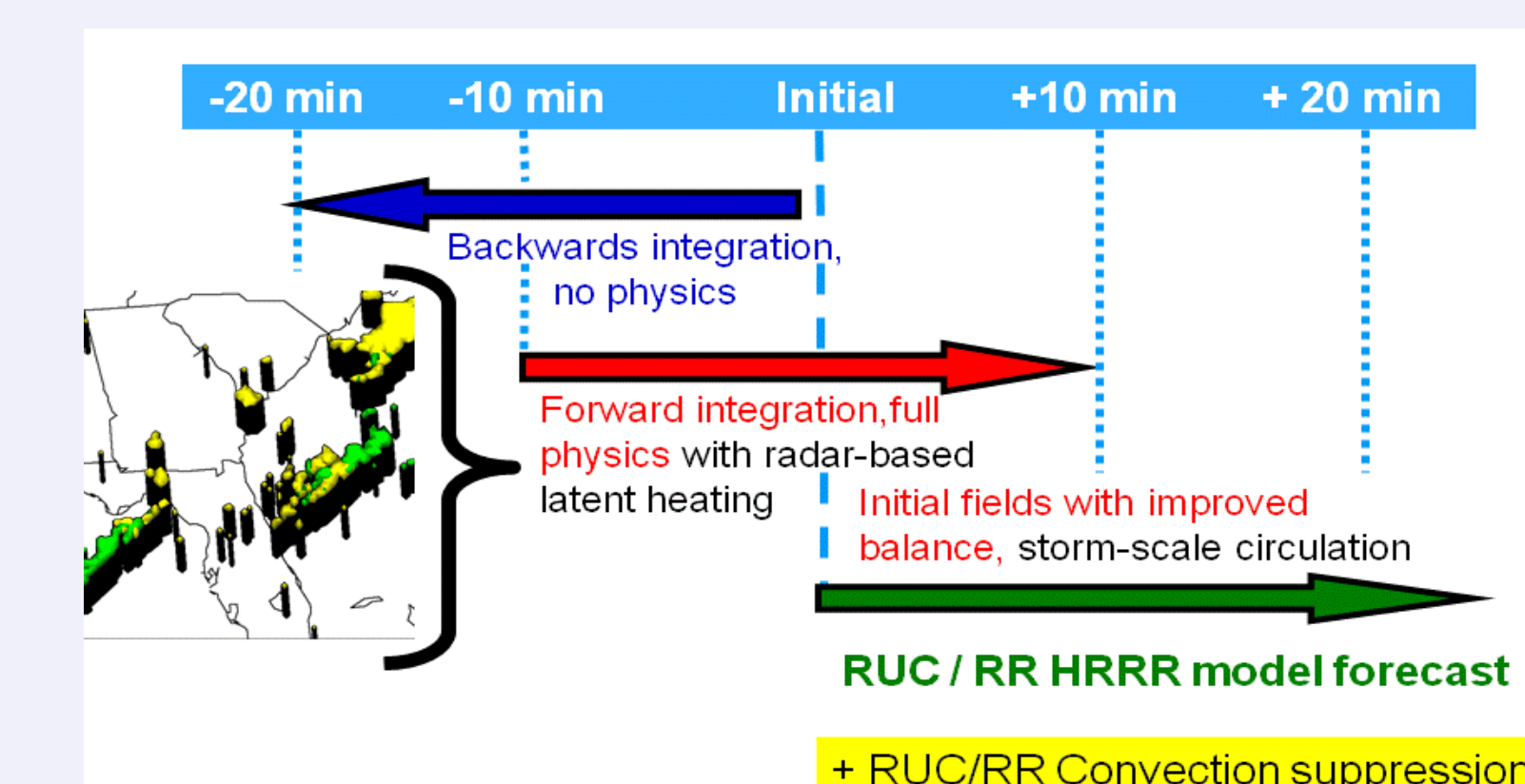
Cloud and hydrometeor analysis



Special treatments for surface observations



Digital filter-based reflectivity assimilation



PBL-based pseudo-observations

