RUC and WRF Experimental Model Forecasts for NEHRTP

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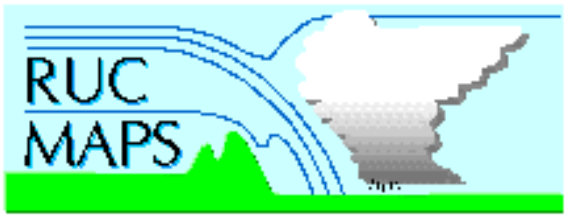
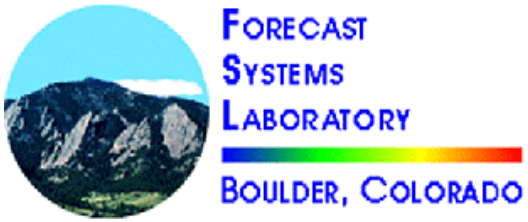




Experimental model, data assimilation activities for NEHRT Program

Goal – improved sfc forecasts through:

- Identification of systematic problems

verify/evaluate forecast →

refine models/assimilation →

improve operational models →

better ensemble forecasts

Model/Assimilation system attributes:

- High-resolution model runs
- Frequent assimilation of all observations including: surface, satellite, radar, GPS

Surface T, Td Forecast Factors

Numerical Model

- Radiation
- Land Surface Model
- Planetary Boundary Layer
- Moist Physics (Clouds/Precipitation)

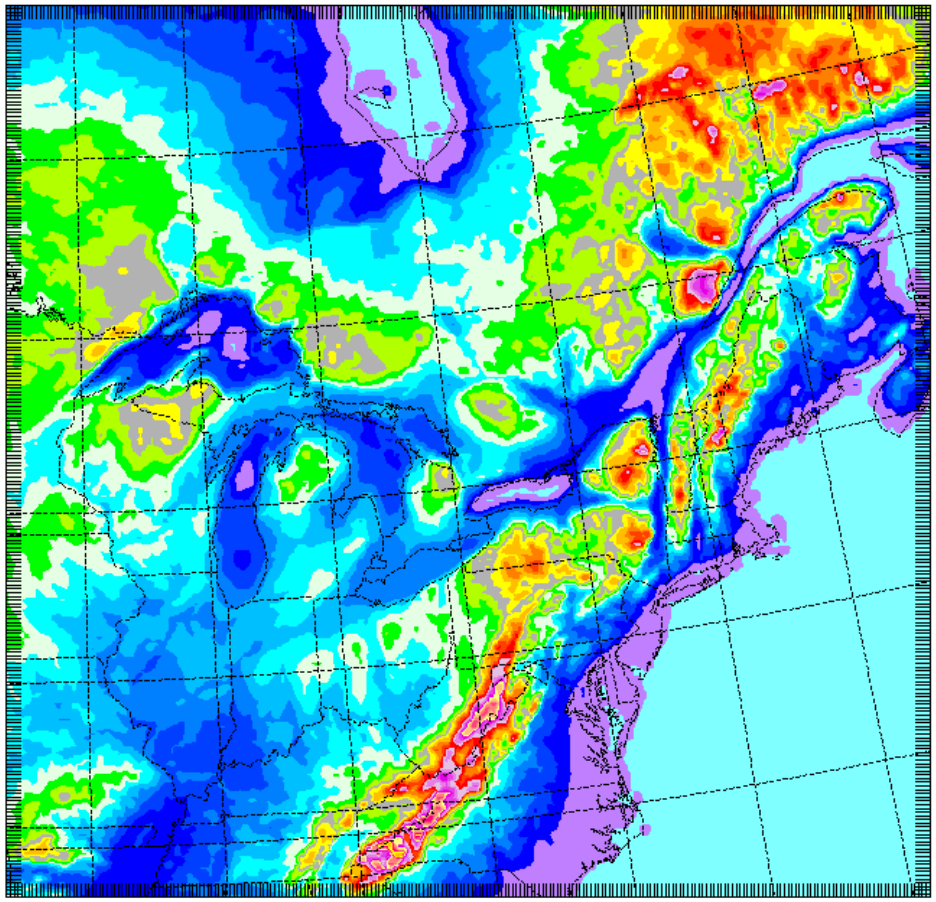
Data Assimilation System

- Surface observations
- Satellite data
- Radar data

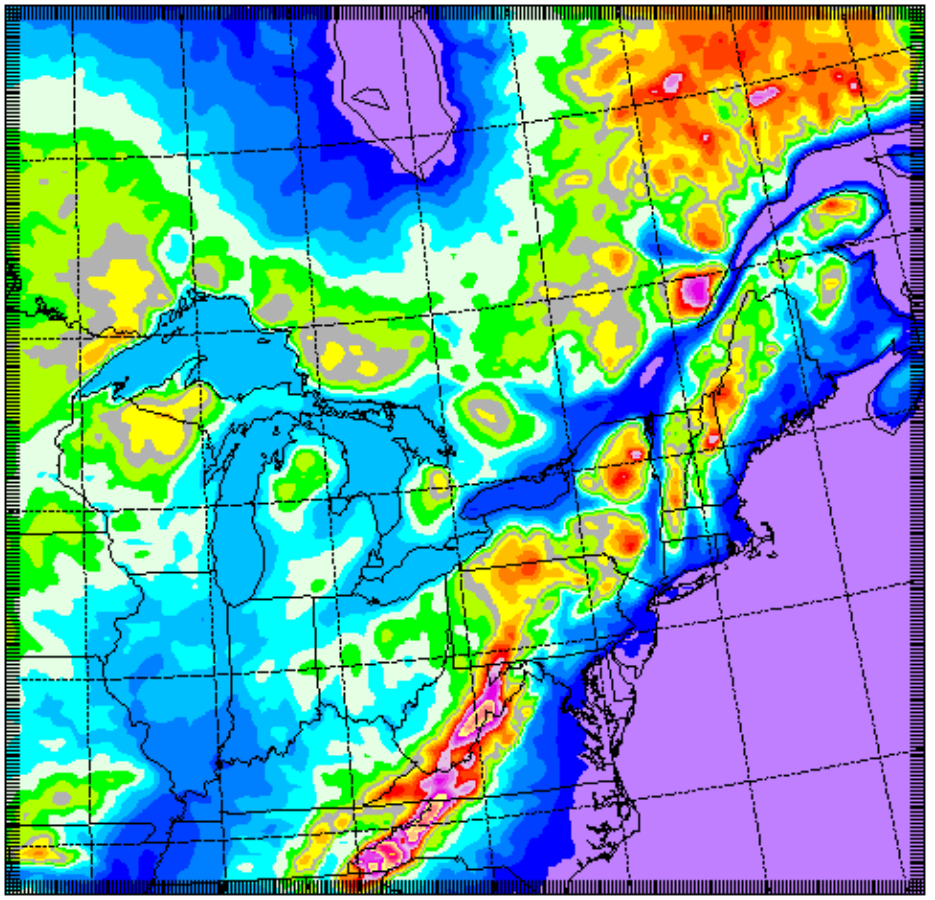
2003 FSL NEHRT RUC & WRF Model Runs

- 10-km regional domains centered over New England
- 48-h forecasts made every 12 h.
- Initial, boundary conditions from FSL 20-km RUC
  Full hydrometeor fields (qc, qi, qr, qs, qg)
  Full land-sfc fields (6-level soil T,Q; snow depth,T; canopy water)
- Boundary conditions from FSL 20-km RUC
- Obs used in FSL RUC 20-km update cycle:
  (raob, profiler/VAD, ACARS, surface, GPS, satellite, radar, lightning)
  Full cycling of hydrometeor, land-surface fields
- RUC10 forecasts to NWS Eastern, Central regions
- Re-ran 2002 period, model changes into oper RUC

2003 NEHRT RUC & WRF Domains



2003 RUC10 Terrain



2003 WRF10 Terrain

FSL Rapid Update Cycle Model

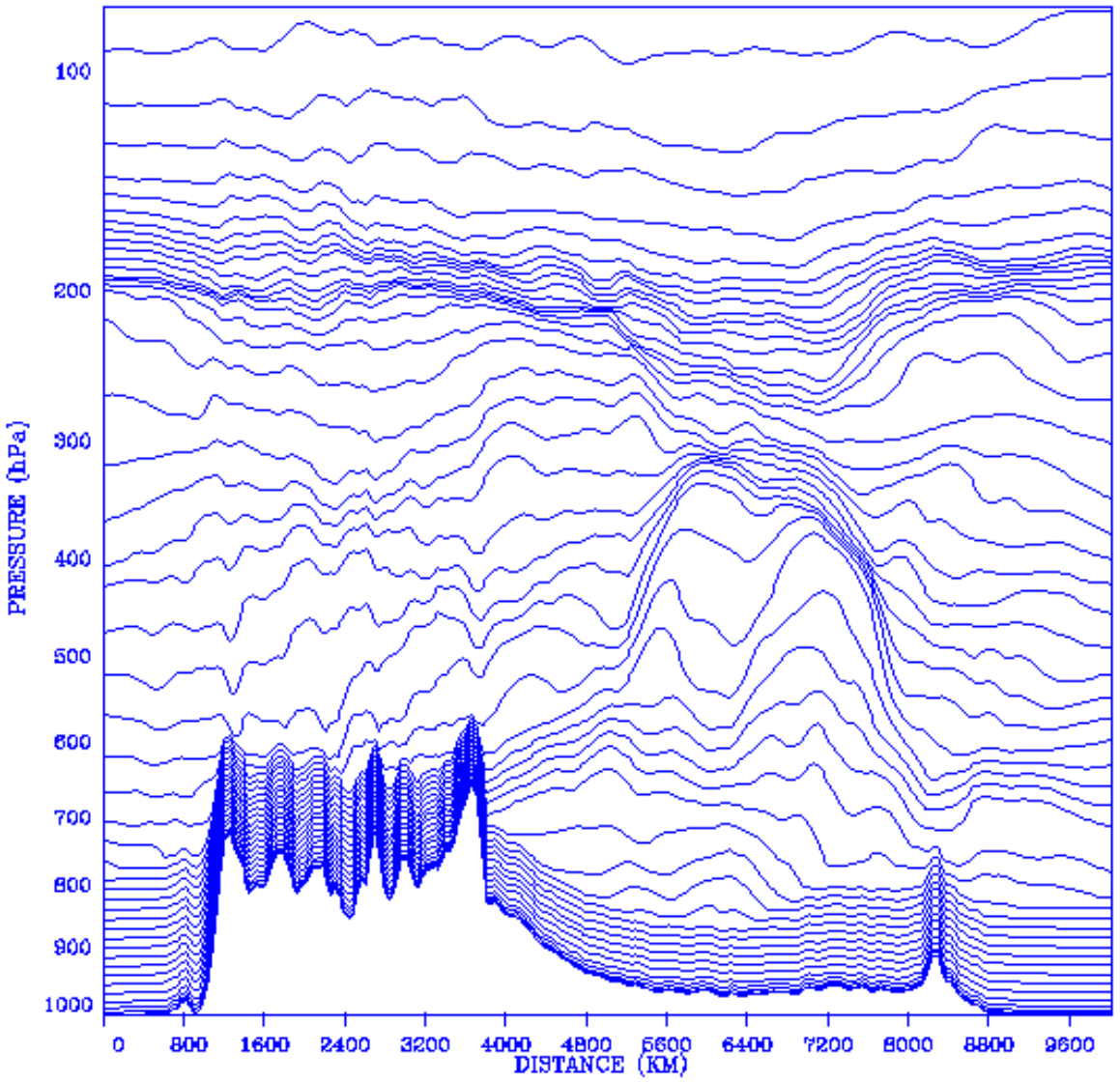
Vert Coord	Hybrid sigma-isentropic
Stable clouds, precipitation	NCAR mixed-phase (cloud water, rain water, snow, graupel, ice, ice particle number. concen.
Sub-grid precipitation	Grell-Devenyi ensemble scheme (108 closures, mean fed to model)
Turb / PBL	Burk-Thompson
Land-surface	RUC LSM - 6-level soil/veg model, 2-layer snow model (Smirnova)
Radiation	Dudhia LW/SW scheme (RRTM LW in testing)

RUC hybrid isentropic/sigma coordinate

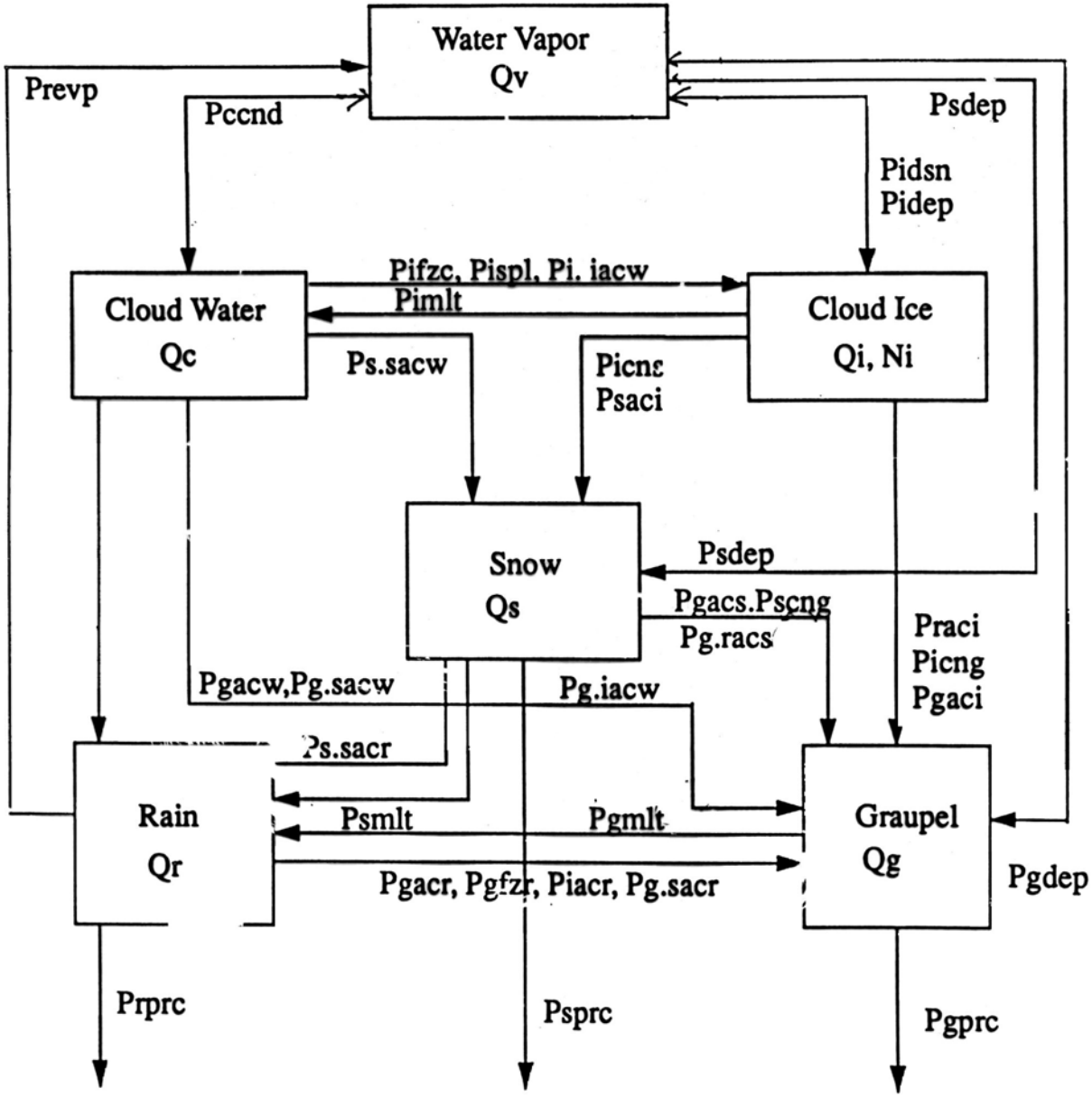
- Adaptive vertical resolution
- Less “vertical” transport
- Adaptive obs influence regions

20km RUC
50 levels

1200 UTC 14 Jan 2002



NCAR mixed-phase microphysics

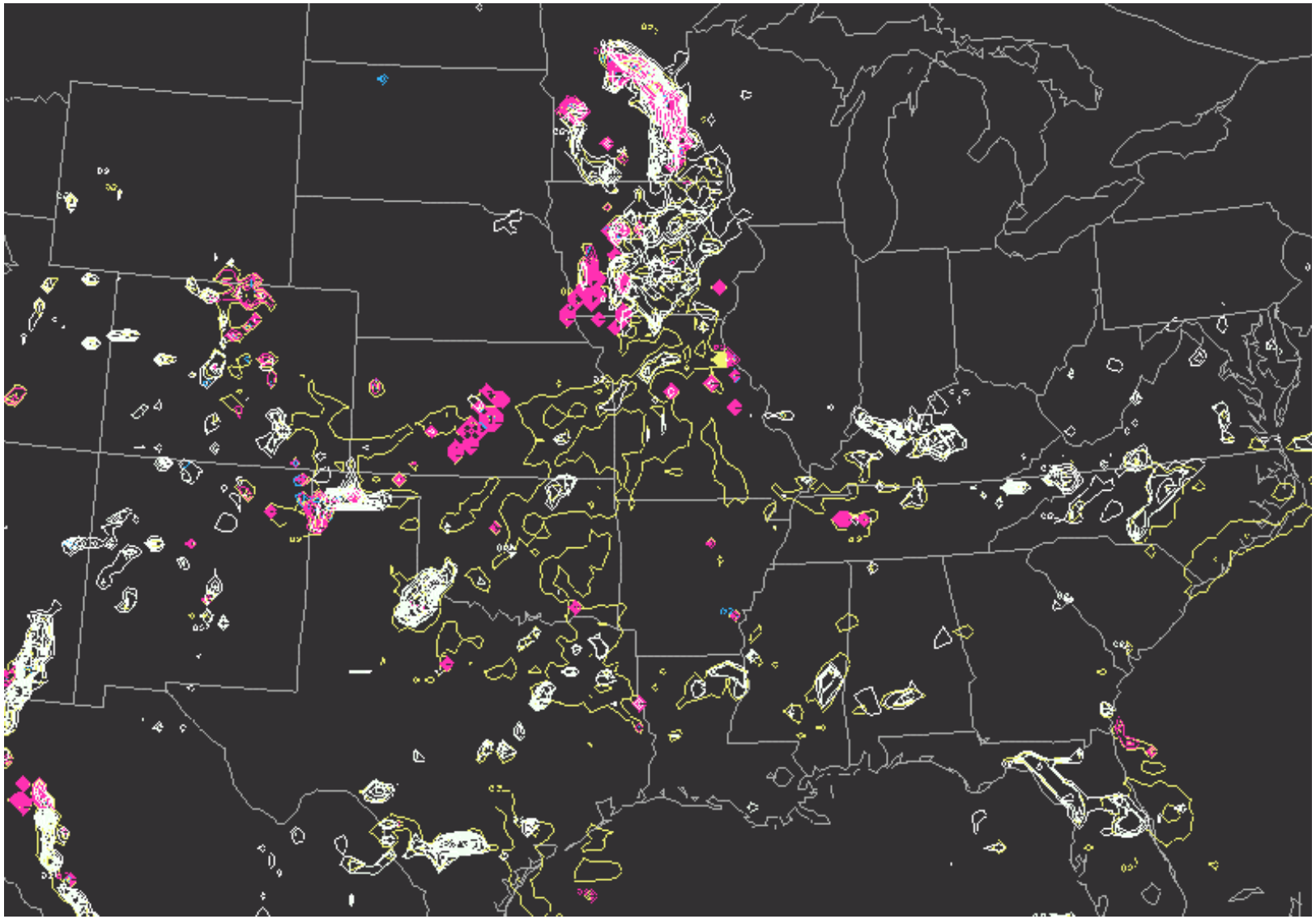


Grell-Devenyi Cumulus Parameterization

- **Uses an ensemble of closures:**
  - Cape removal
  - Moisture convergence
  - Low-level vertical mass flux
  - Stability equilibrium
  - Updraft/downdraft timelag
- **Includes multiple values for parameters:**
  - Cloud radius (entrainment)
  - Detrainment (function of stability)
  - Precipitation efficiency (function of shear)
  - Convective inhibition threshold

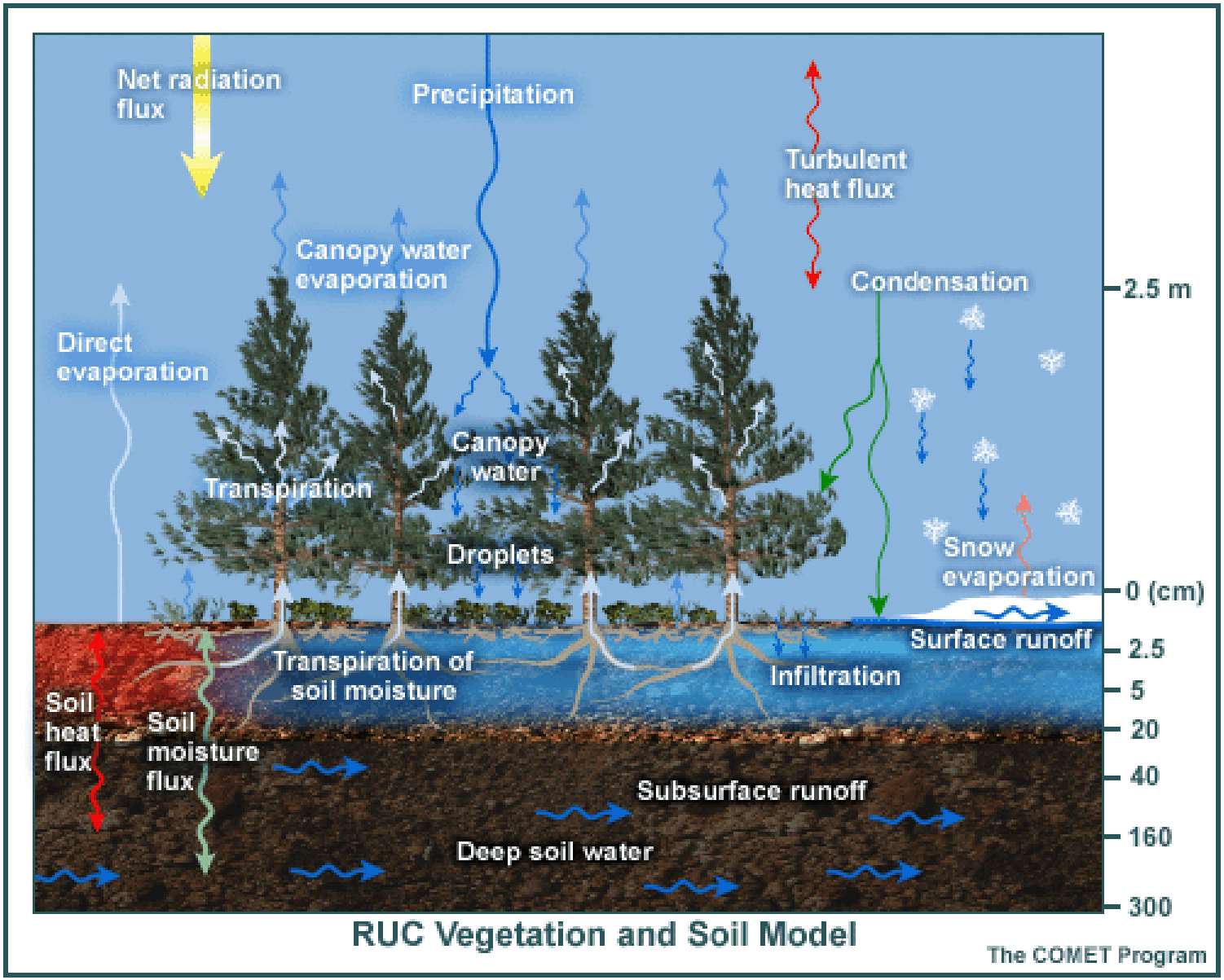
Currently feeding mean quantities back to model

Closures groups in RUC Grell-Devenyi ensemble cumulus scheme



9-h fcst valid 21z 10 Jul 2002

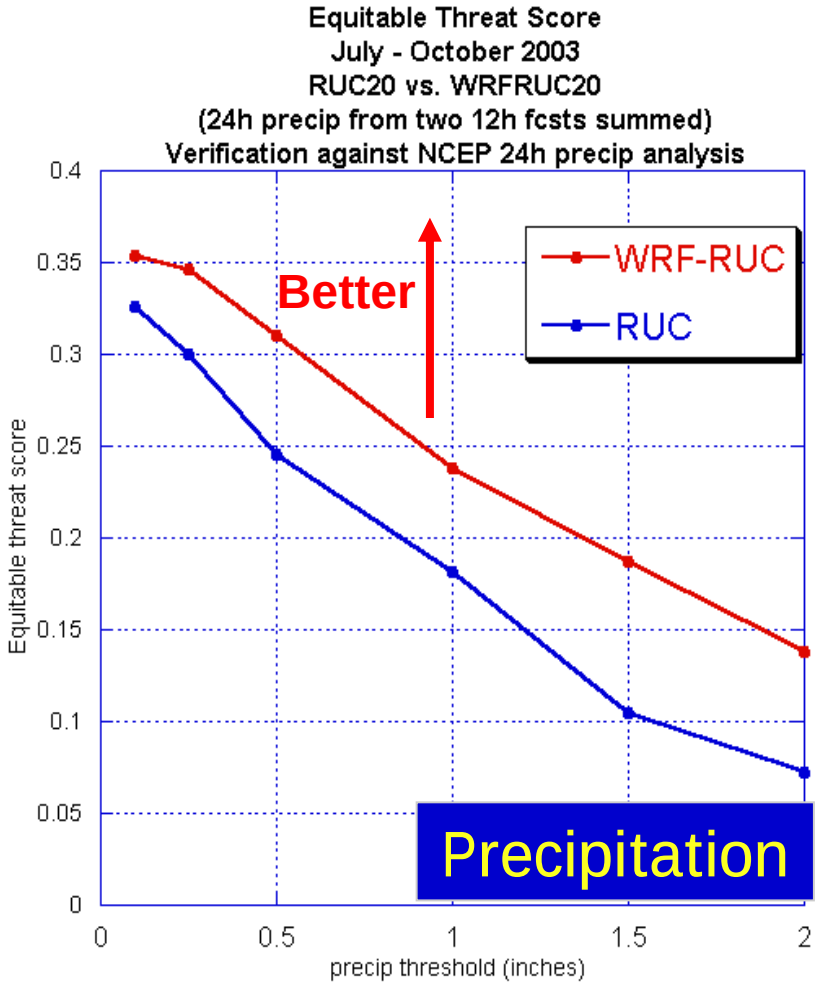
RUC Land-Surface Model (Smirnova)

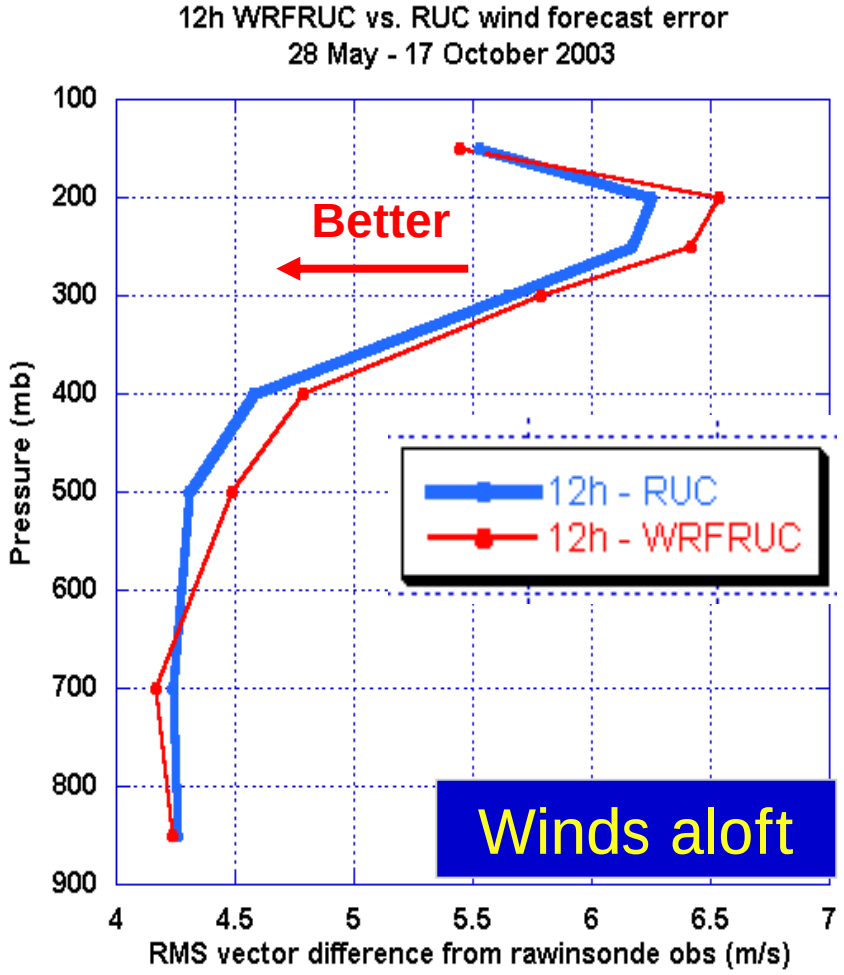


FSL-RAPB NCAR EM WRF Model

Vert Coord	Sigma hydrostatic-p
Stable clouds, precipitation	NCEP 5-class (qv,qc,qr,qs,qg)
Sub-grid precipitation	Betts-Miller-Janjic
Turb / PBL	Mellor-Yamada-Janjic (Eta)
Land-surface	RUC LSM - 6-level soil/veg model, 2-layer snow model (Smirnova)
Radiation	Dudhia shortwave RRTM longwave

RUC vs. WRF-EM-RUC forecast skill 20-km - CONUS Summer-fall 2003





- RUC winds aloft better
- WRF precipitation better

FSL RUC Assimilation

Updates	Intermittent 1-h cycle
Analysis	3DVAR on θ/σ surfaces ($\psi/\chi/Z$, θ, $\ln Q$)
Sfc Obs / PBL Structure	Use surface obs through PBL Lapse-rate checks
Noise	Adiabatic digital filter initialization
Clouds / moisture	Cloud analysis (GOES cloudtop pres, radar reflectivity, METAR clouds)

Incremental analysis assumes small changes to a smoothly varying field

Data for 20-km RUC at NCEP

Data Type	~Number	Freq.
Rawinsonde	80	/12h
NOAA profilers	30	/ 1h
VAD winds	110-130	/ 1h
Aircraft (V,temp)	1400-4500	/ 1h
Surface/METAR	1500-1700	/ 1h
Buoy/ship	100-150	/ 1h
GOES precip water	1500-3000	/ 1h
GOES cloud winds	1000-2500	/ 1h
GOES cloud-top pres	~10km res	/ 1h
SSM/I precip water	1000-4000	/ 6h

Experimental Data at FSL

Data Type	~Number	Freq.
GPS precip water	~200	/ 1h
Mesonet	~3000	/ 1h
PBL – prof/RASS	~20	/ 1h
Radar refl / lightning	4 km res.	

RUC surface obs assimilation

If abs[Psfc(obs-model)] < 70 mb.

Extrapolate obs T,Td,Z from $Psfc_{obs}$ to $Psfc_{model}$

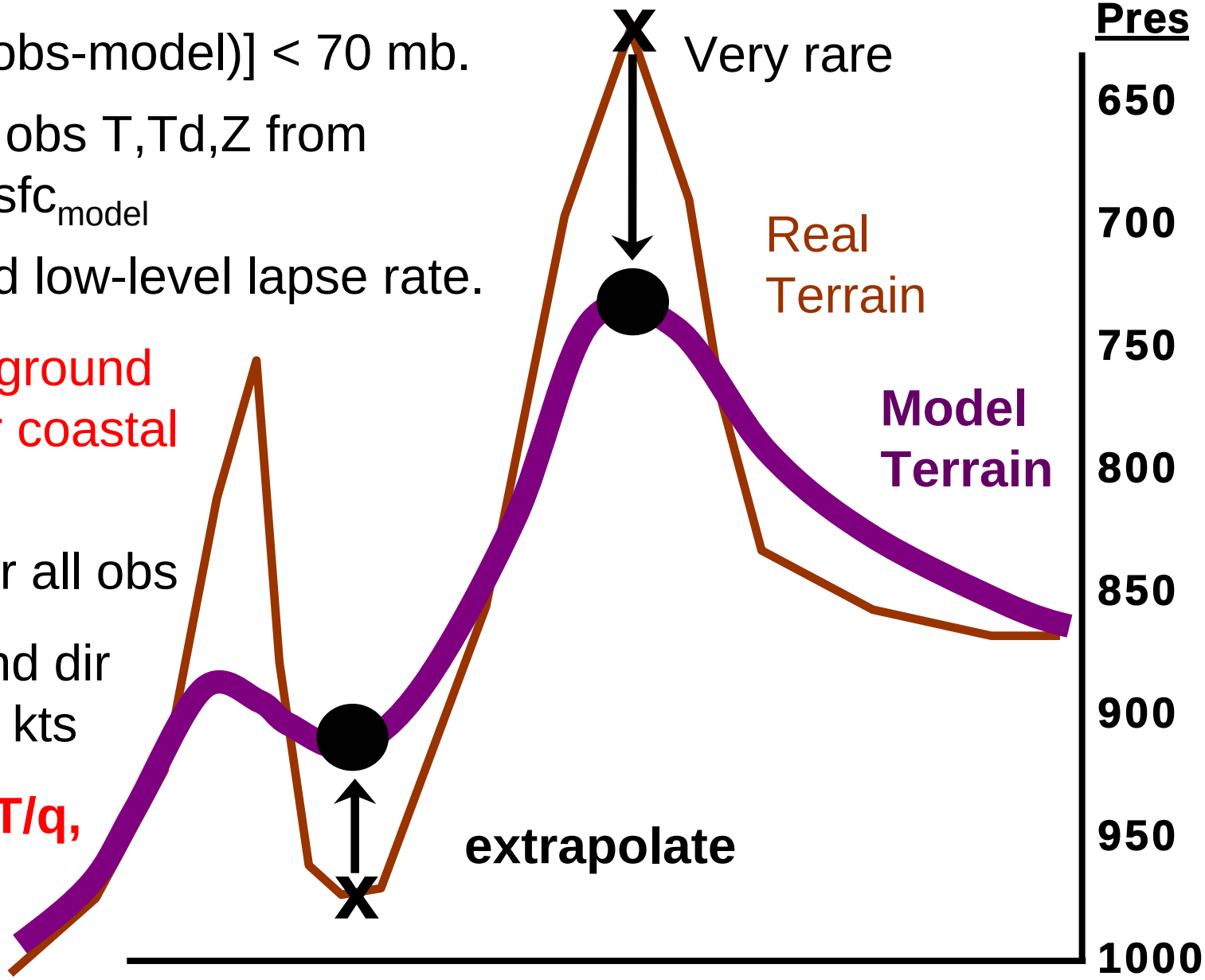
Use bckgrnd low-level lapse rate.

Match background land-use for coastal stations

Use wind for all obs

Bckgrnd wind dir for wind < 5 kts

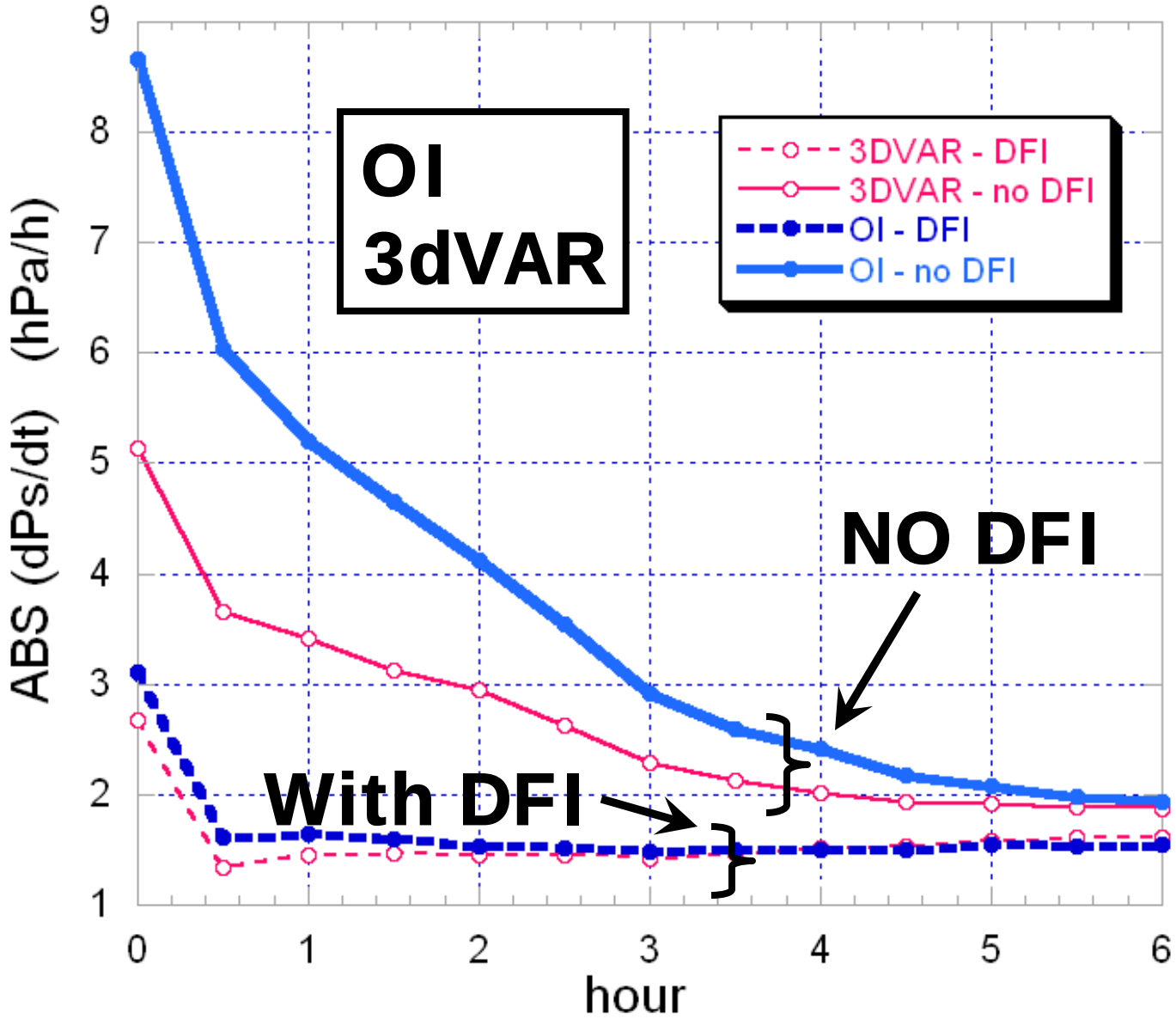
Derive 2m T/q, 10m winds



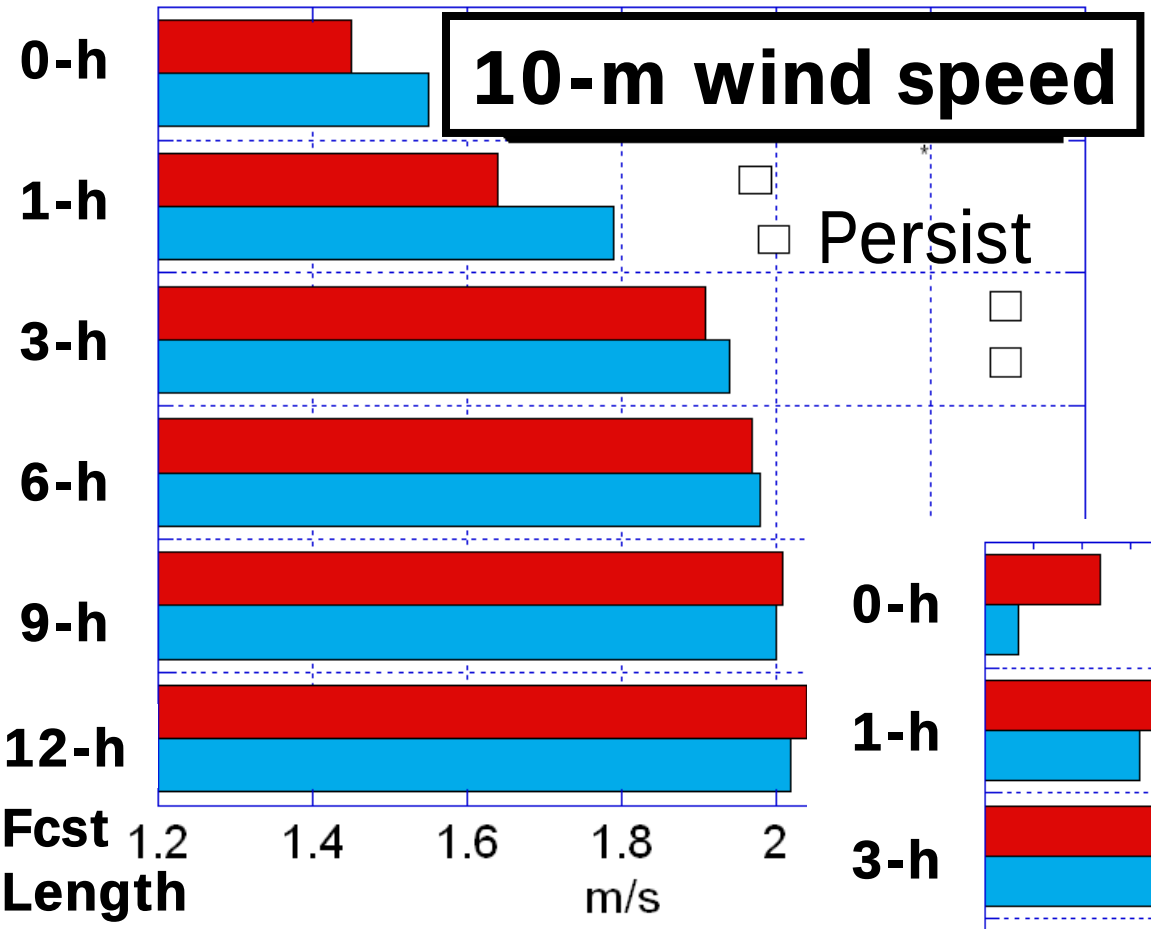
Use of Digital Filter Initialization

RUC uses adiabatic DFI (Lynch and Huang 1992)

Noise level For OI and 3dVAR with and without DFI



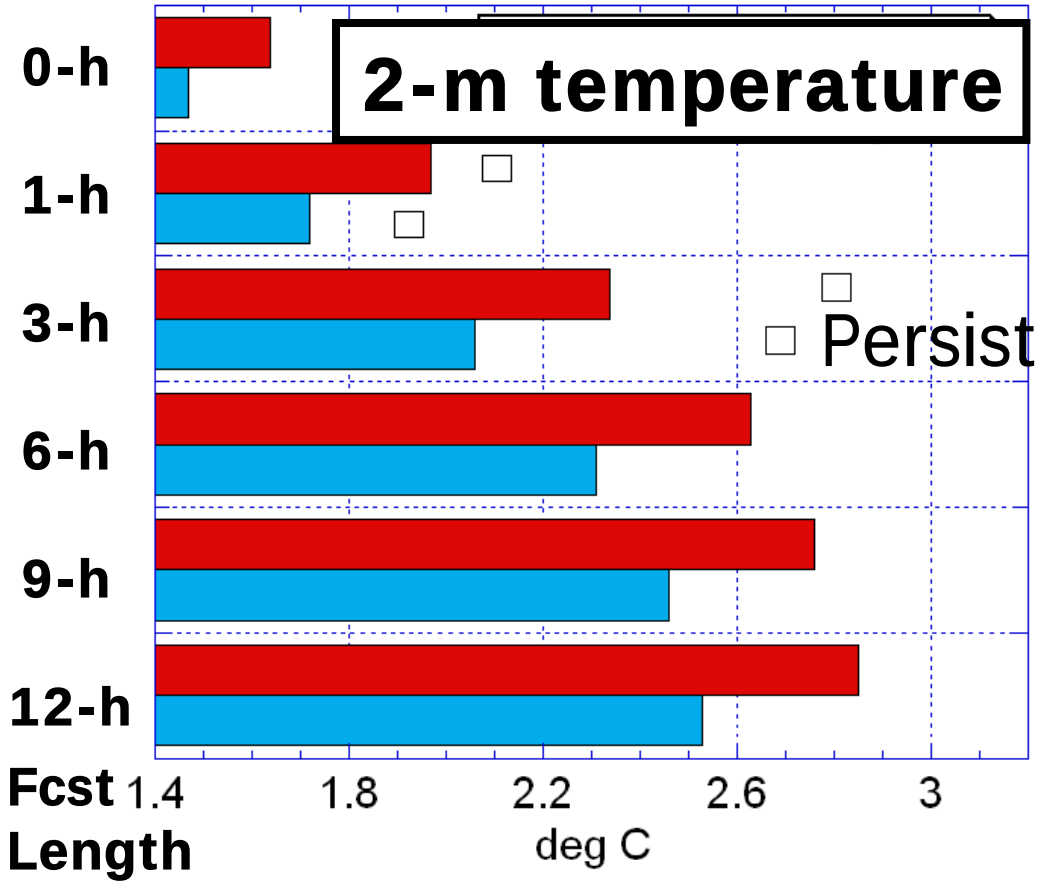
1200 UTC
19 Dec 2002



Verify RUC sfc fcst against all U.S. sfc obs

SUM (Apr–Sep)

WIN (Oct–Dec)



RUC improves *surface* wind, temp skill down to 1-h fcst

Much better than 1-h, 3-h persistence forecasts

RUC Cloud Analysis

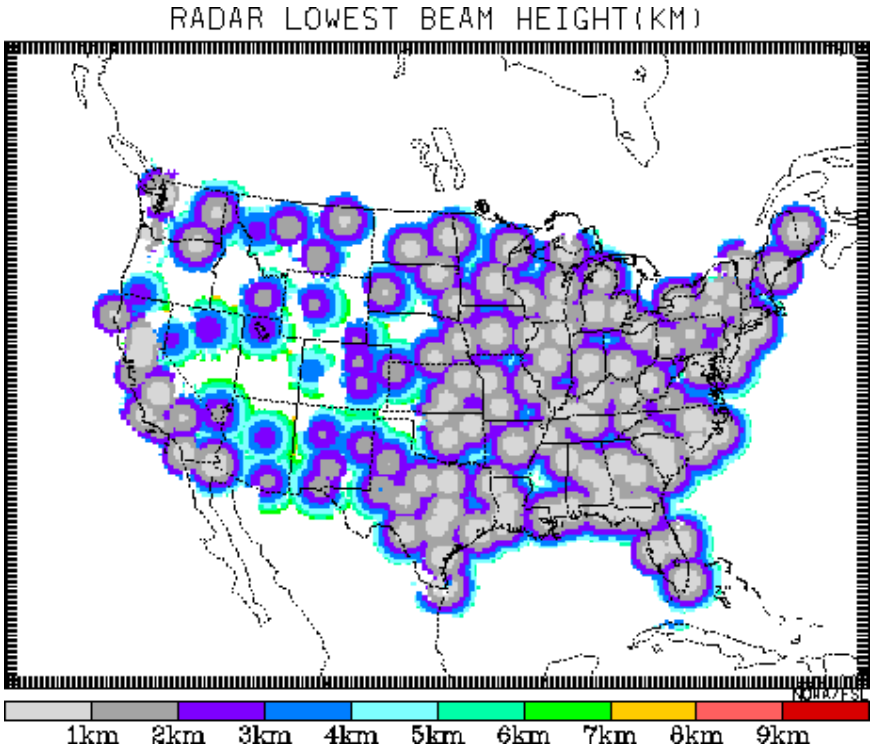
Use satellite, radar, lightning, surface data to modify moisture fields (vapor, hydrometeors)

- Construct 3-d logical arrays (YES/NO/UNKOWN) for clouds and precipitation from all info
- Clear/build (change qc, qi, qv) with logical arrays
- Safeguards for pressure-level assignment problems (marine stratus, convective clouds)
- Use nationwide mosaic radar data to modify water vapor, hydrometeor fields
- Lightning data used as a proxy for radar reflectivity
- Feedback to cumulus parameterization scheme

Use of radar reflectivity

Two different radar data sources

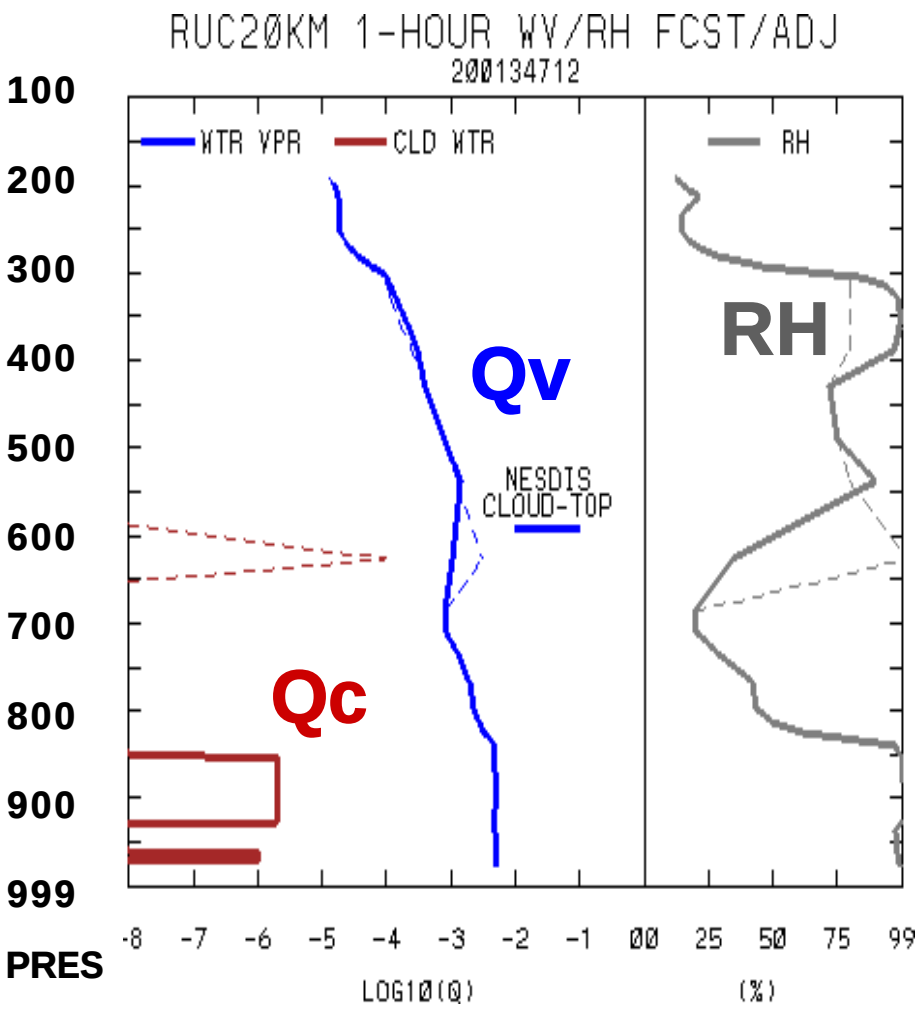
- WSI 2-km data
- NWS 10-km radar coded message
  Includes radar coverage information



Don’t remove precip that radars aren’t seeing

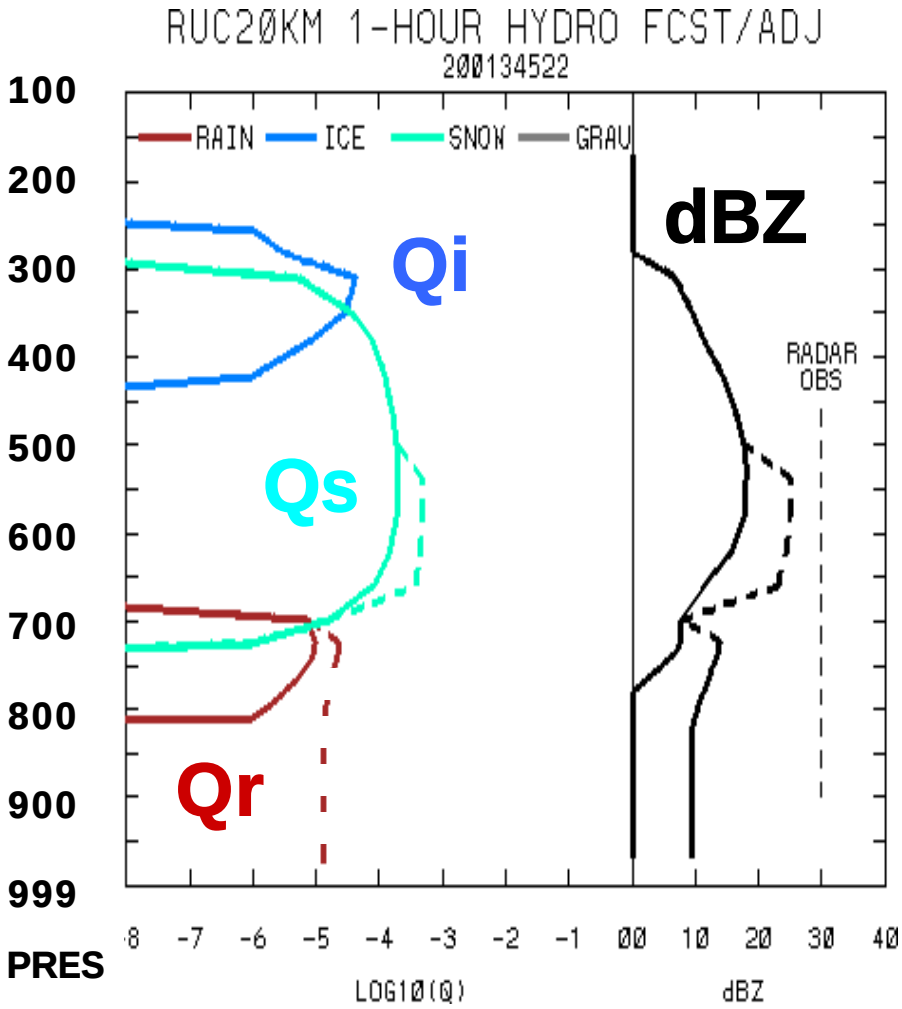
- Data void regions (orographic precipitation)
- Cold season shallow precipitation

GOES cloud top pressure

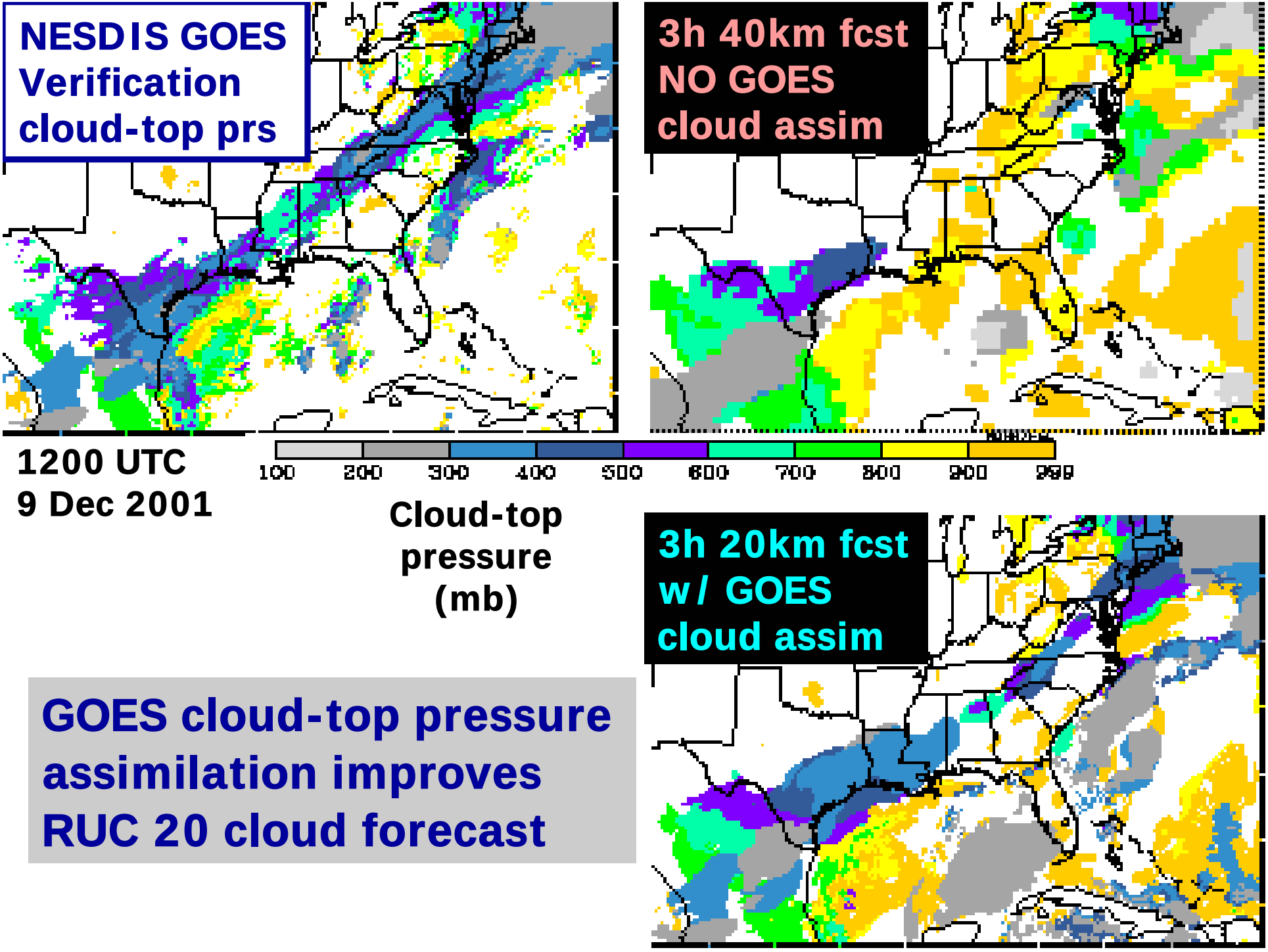


Cloudwater, water vapor and relative humidity before (—) and after (----) GOES Cloud-top pressure adjustment

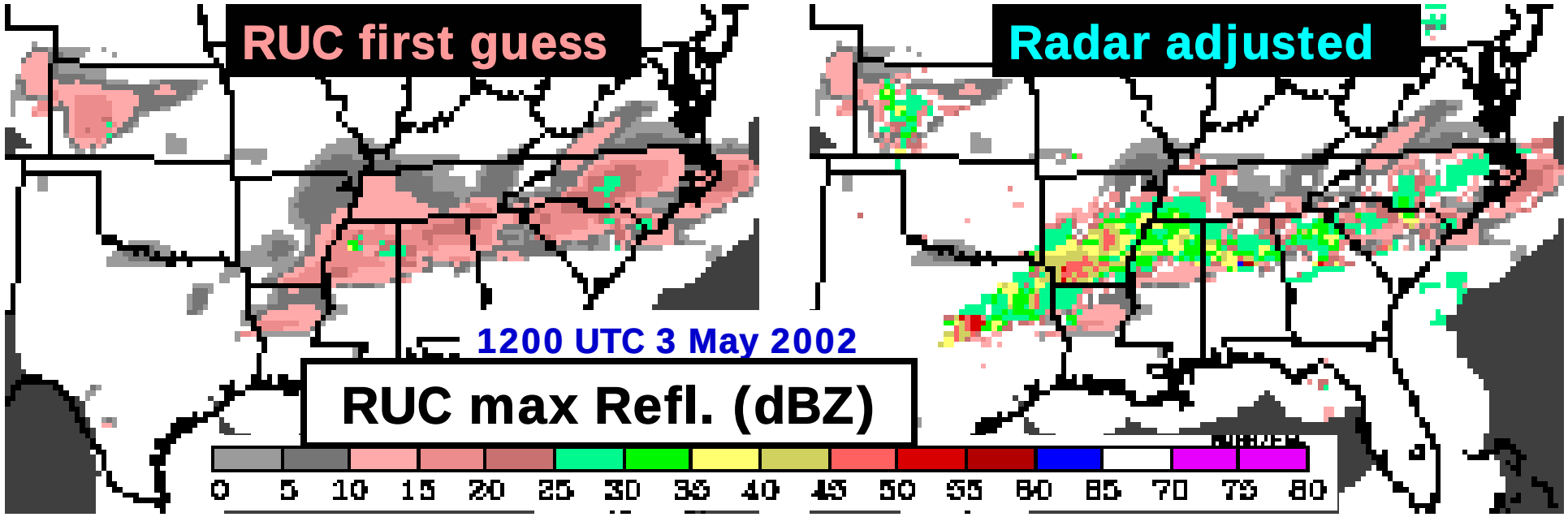
Radar/lightning data



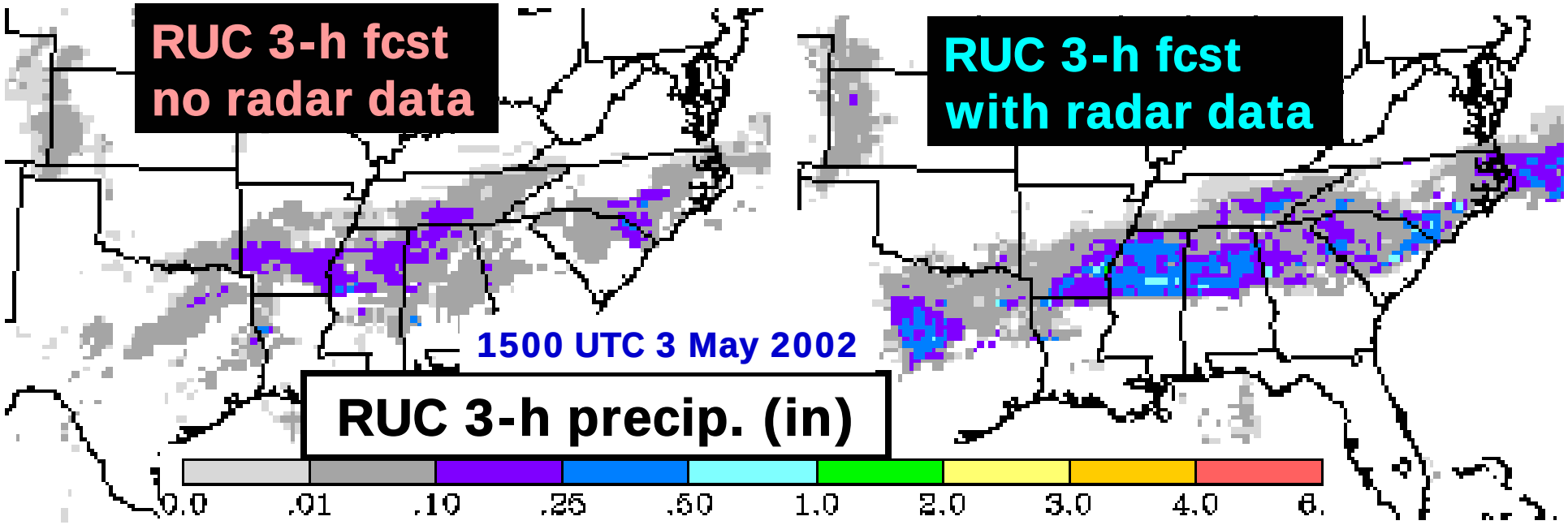
Rainwater, snow, cloud ice and reflectivity before (—) and after (----) GOES radar/lightning adjustment

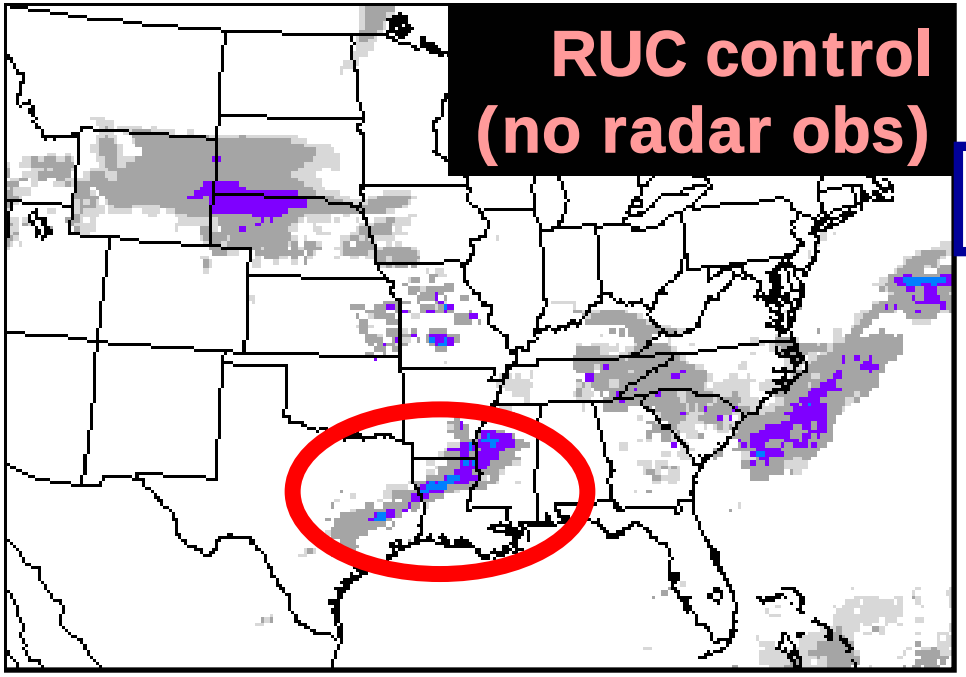


GOES cloud-top pressure assimilation improves RUC 20 cloud forecast

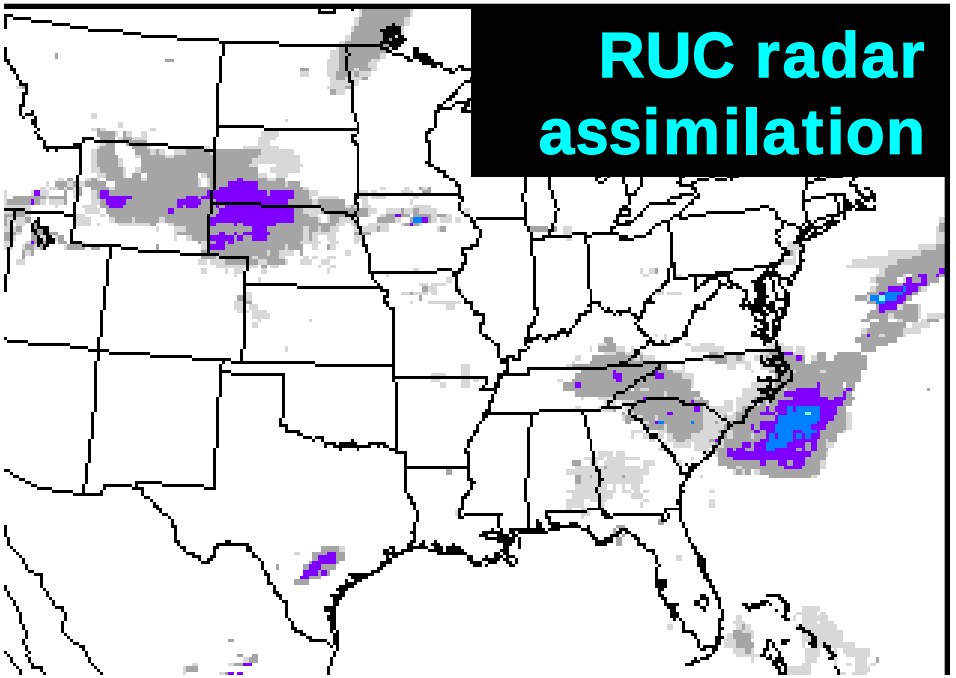


Radar data impact example

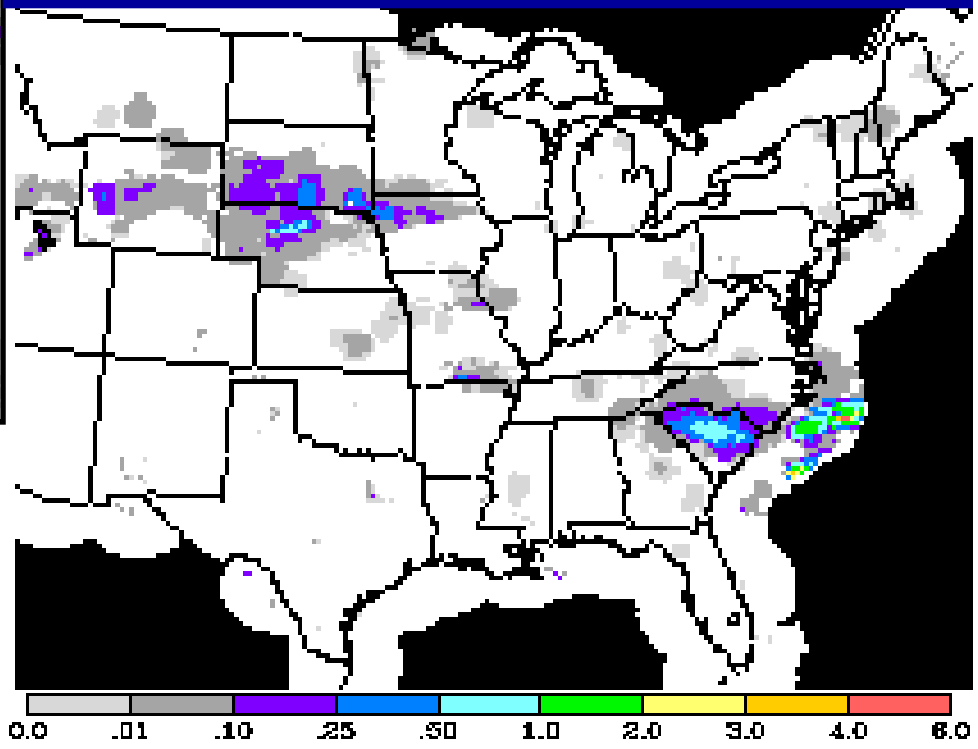




3-h fcst accum. precipitation



3-h Stage II verification precip



3-h accumulated precipitation ending 1500 UTC 1 May 2002

Assimilation of METAR cloud obs

- Nearest station up to 120 km distance
- Maps info to 3-d cloud, precip. Y/N/U fields
- Clear/build changes qc, qi, qv

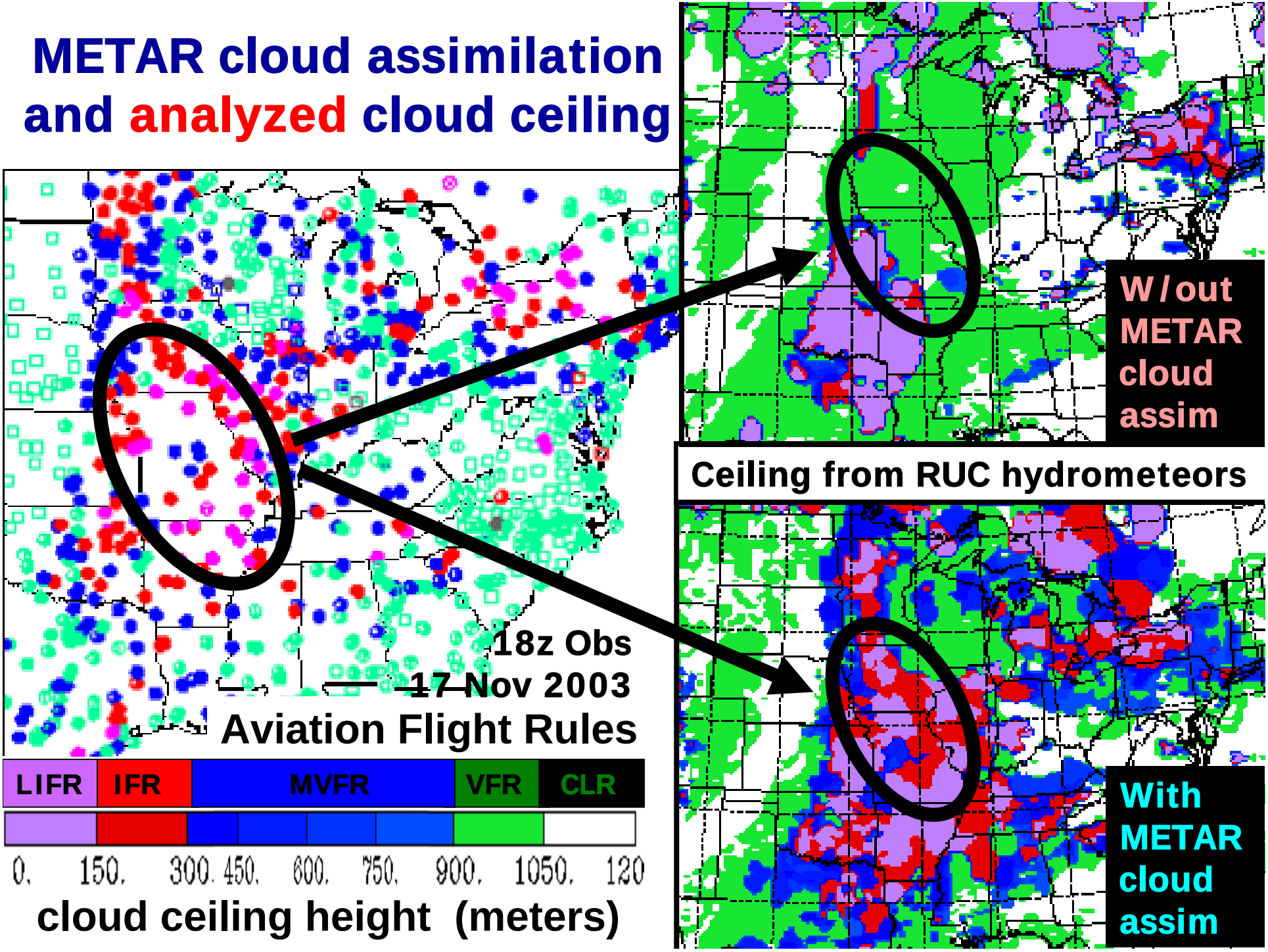
Build for BKN / OVC / Vertical Visibility

- 50 mb thick layer
- 150 mb thick for precip + GOES clouds
- Can build multiple broken layers

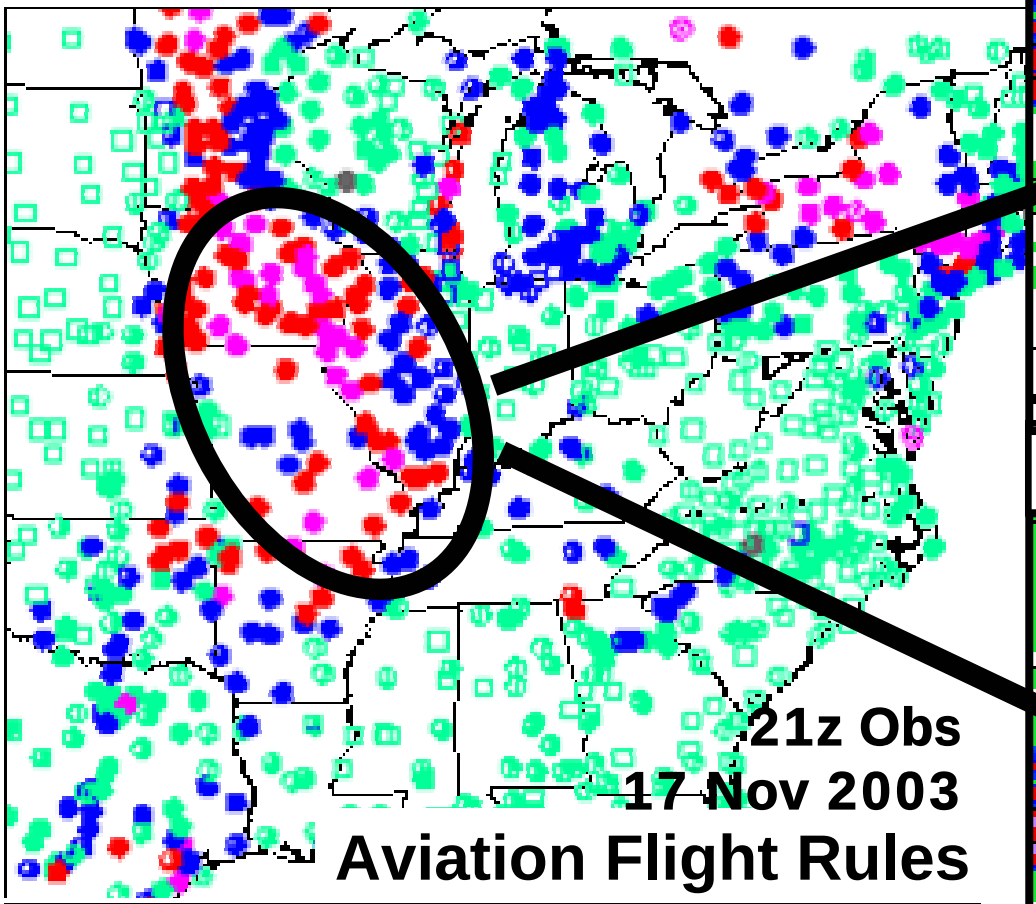
Clear

- Up to cloud base (if needed)
- to 12 kft for CLR report

METAR cloud assimilation and analyzed cloud ceiling



METAR cloud assimilation and 3-h fcst cloud ceiling

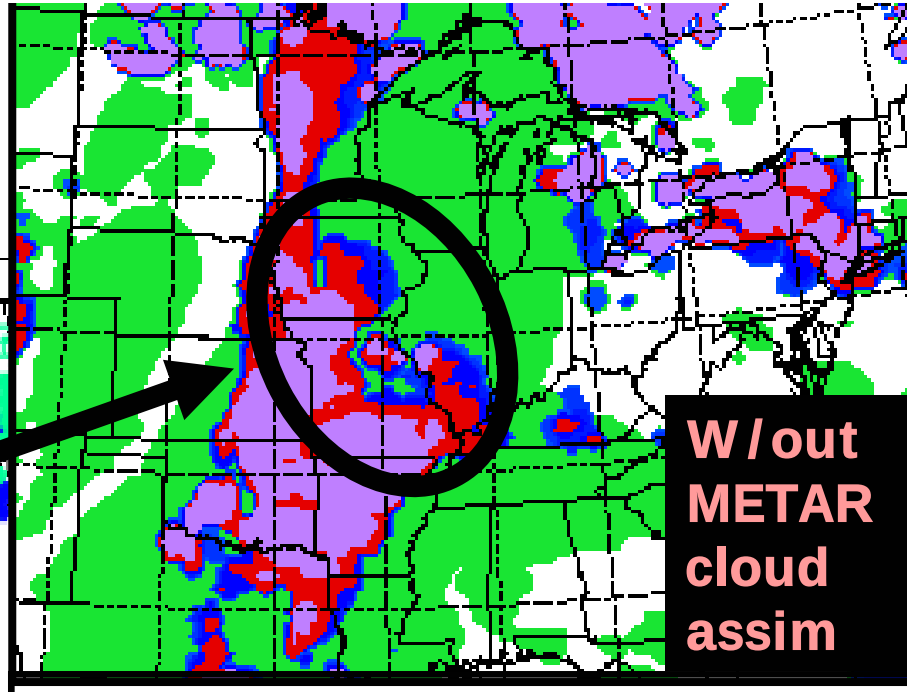


21z Obs
17 Nov 2003
Aviation Flight Rules

LIFR | IFR | MVFR | VFR | CLR

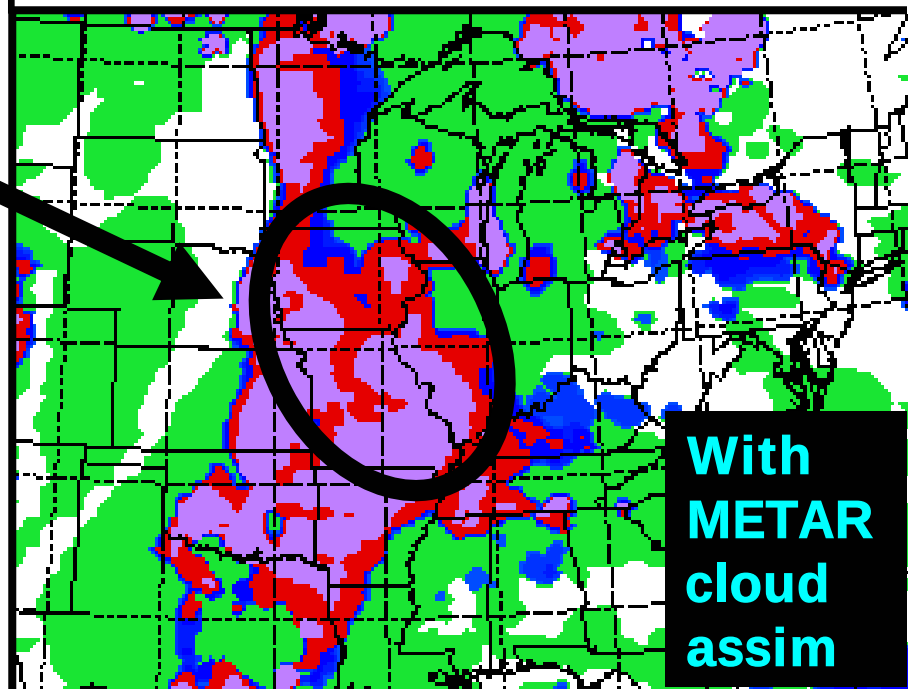
0. 150. 300. 450. 600. 750. 900. 1050. 120

cloud ceiling height (meters)



W/out METAR cloud assim

Ceiling from RUC hydrometeors



With METAR cloud assim

2004 FSL NEHRT RUC & WRF Model Runs

- 20-km CONUS domains (1-h cycle for RUC)
- 13-km CONUS domains (1-h or 3-h cycle for RUC)
  (13-km WRF depends on computer resources)
- 48-h forecasts made every 12 h.
- WRF initial, boundary conditions from RUC
  Full hydrometeor fields (qc, qi, qr, qs, qg, qn)
  Full land-sfc fields (6-level soil T,Q; snow depth,T; canopy water)
- Improvements to RUC analysis (surface obs assim, cloud analysis using satellite/radar/lightning/METAR obs)
- RUC13 forecasts to NWS Eastern, Central regions
- Evaluate 2003 problem days → model improvements
- Website: http://highrestemp.noaa.gov