Cloud/hydrometeor assimilation of NASA-LaRC GOES cloud products for RUC/Rapid Refresh

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GSD - Global Systems Division
Assimilation & Modeling Branch

- **Addition and initial testing of assimilation of NASA Langley GOES cloud products in RUC cloud/hydrometeor analysis**
- **Goal: to improve 1-12h cloud/icing/ceiling forecasts**

- **Generalize technique for GOES imager data, apply within GSI for Rapid Refresh**

Description, real-time products
http://ruc.noaa.gov
http://rapidrefresh.noaa.gov

18 Nov 2008

NCEP

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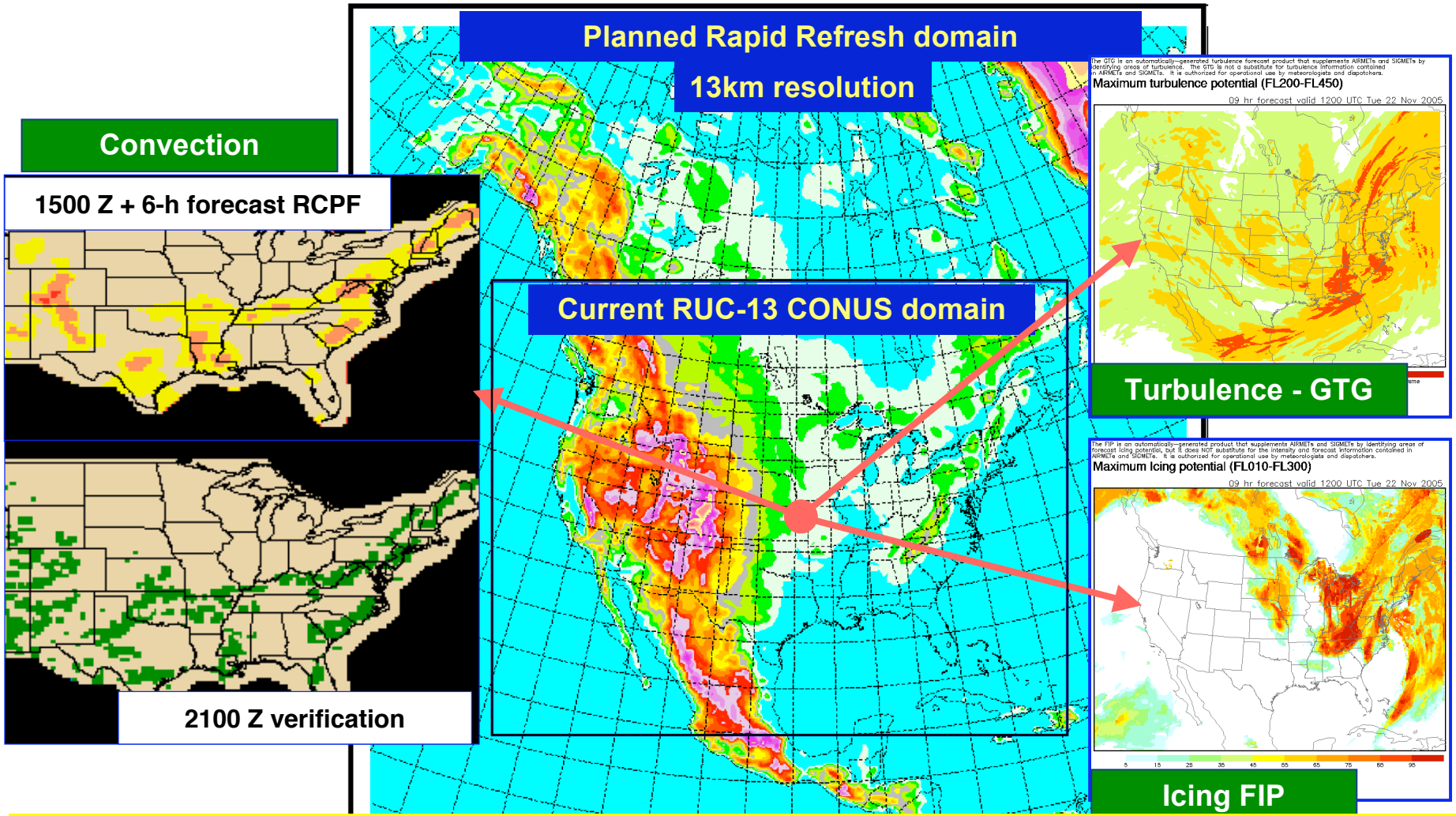
RUC/RR - backbone for high-frequency aviation products

Convective Weather, Icing Potential, Turbulence, Ceiling, Visibility, other aviation weather products



- Current GOES cloud-top product available only over CONUS
- Goal – Improve 3-d hydrometeor fields using GOES imager, use w/i GSI

Pre-implementation briefing - 4 Nov08

Louis Uccellini, NCEP director:

RUC upgrade – 2008

→*Implemented 12z Mon 17 Nov 08*

NOAA/ESRL/GSD/AMB
Stan Benjamin
Steve Weygandt

NCEP/EMC – Geoff Manikin

NCO/PMB – Xiaoxue Wang

Major components:

- RUC13 change package
  - assimilation - radar reflectivity, TAMDAR, mesonet winds
  - model physics – radiation, convection, LSM

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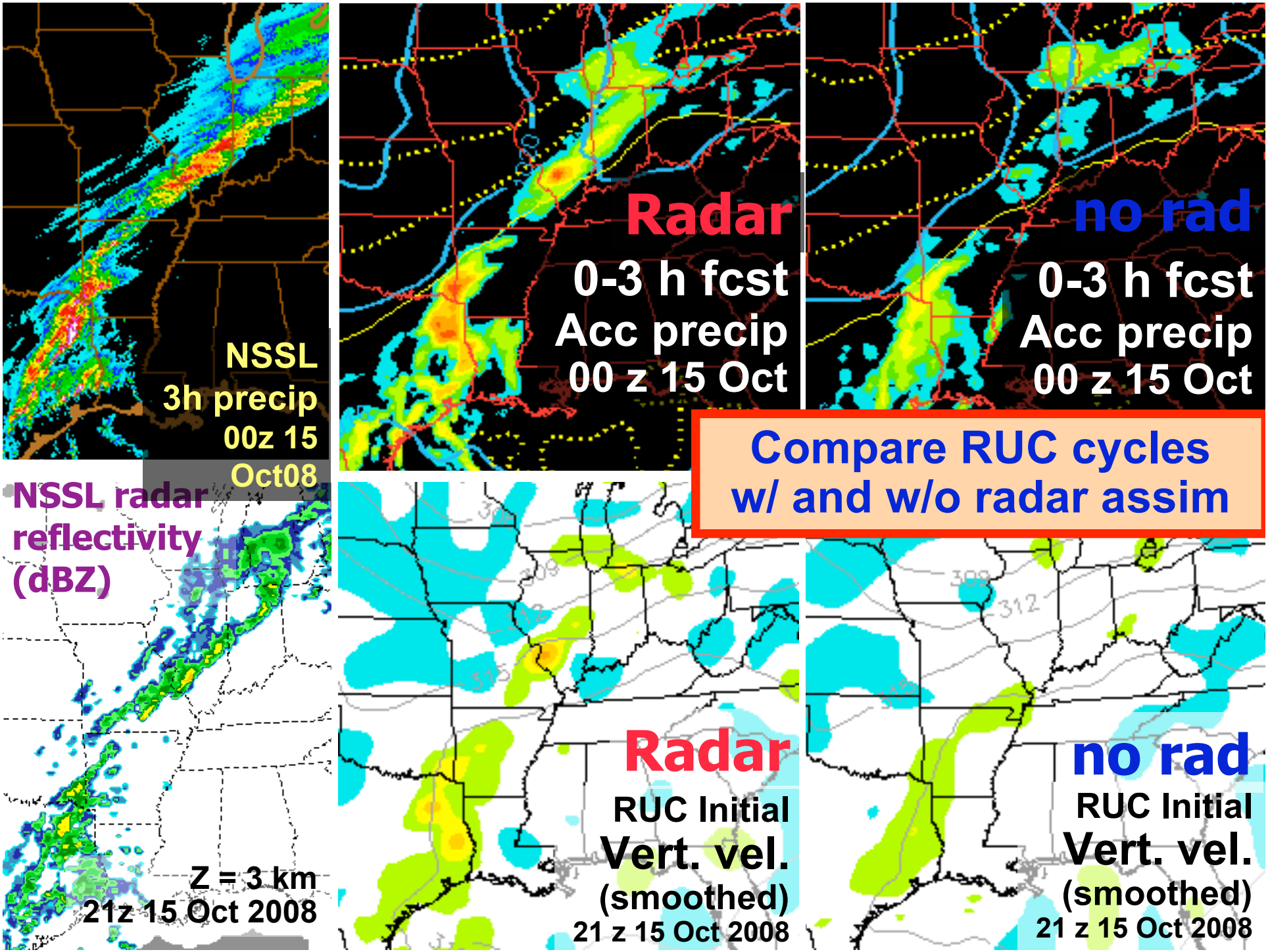
Changes for oper RUC upgrade

- Assimilation
  - Use of **radar reflectivity** in diabatic DFI in RUC model (also, hydrometeor assimilation component)
  - **Mesonet winds** using mesonet station uselist
  - **TAMDAR aircraft** observations
    (TAMDAR impact parallel RUC tests at GSD)

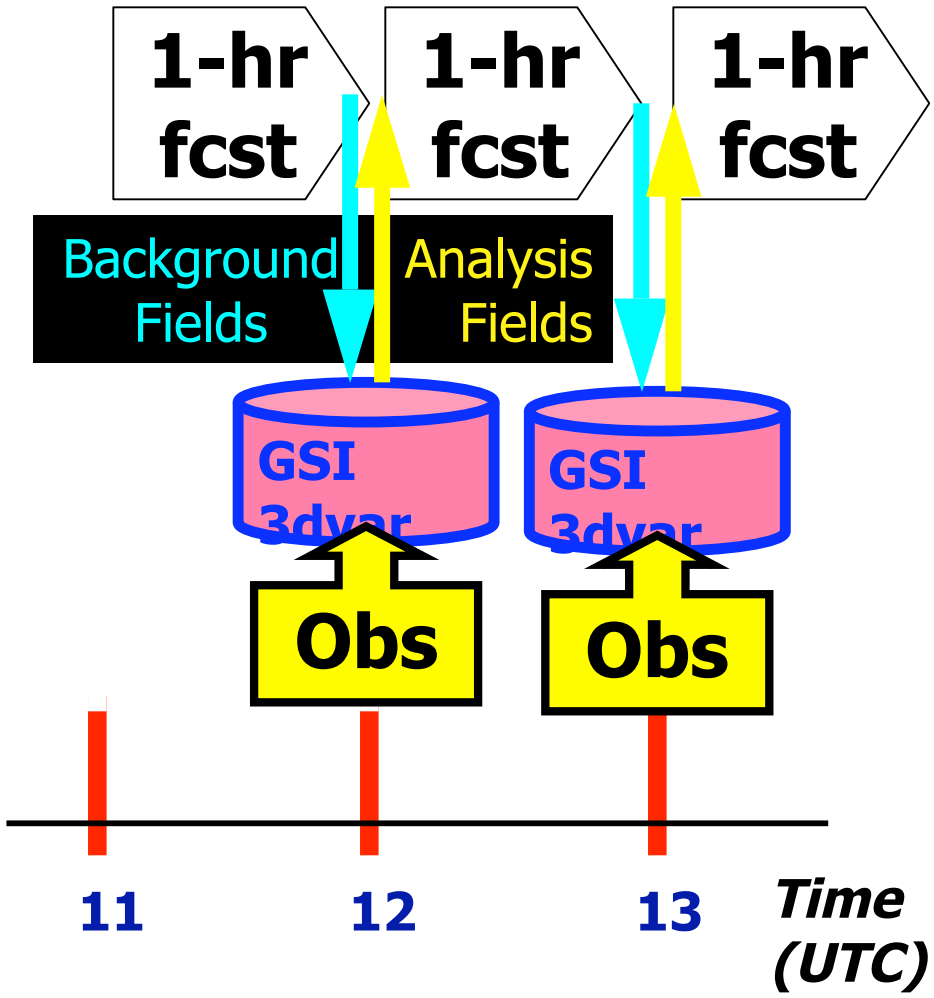
- Model physics
  - RRTM longwave radiation - eliminates sfc warm bias
  - Mod to Grell-Devenyi – decrease areal coverage
  - Mods to RUC land-sfc model
    - fresh snow density - nighttime temps over snow cover
    - limit on melting rate- allows warmer 2m temps
- Post-processing
  - add reflectivity fields, a few others, improved RTMA downscaling

RUC parallel web site:
http://www.emc.ncep.noaa.gov/mmb/ruc2/para


NSSL
3h precip
00z 15
Oct08
Radar
0-3 h fcst
Acc precip
00 z 15 Oct
no rad
0-3 h fcst
Acc precip
00 z 15 Oct
Compare RUC cycles
w/ and w/o radar assim
NSSL radar
reflectivity
(dBZ)
Z = 3 km
21z 15 Oct 2008
Radar
RUC Initial
Vert. vel.
(smoothed)
21 z 15 Oct 2008
no rad
RUC Initial
Vert. vel.
(smoothed)
21 z 15 Oct 2008

RUC/RR Hourly Assimilation Cycle

Cycle hydrometeor,
soil temp/moisture/snow
plus atmosphere state variables



Hourly obs

Data Type	~Number
Rawinsonde (12h)	150
NOAA profilers	35
VAD winds	120-140
PBL – prof/RASS	~25
Aircraft (V,temp)	3500-10000
TAMDAR (V,T,RH)	200-3000
Surface/METAR	2000-2500
Buoy/ship	200-400
GOES cloud winds	4000-8000
GOES cloud-top pres	10 km res
NASA-LaRC cloud top- full FOV	
GPS precip water	~300
Mesonet (temp, dpt)	~8000
Mesonet (wind)	~4000
METAR-cloud-vis-wx	~1800
AMSU-A/B/GOES radiances	
Radar reflectivity/ lightning	1km

RUC cloud/hydrometeor assimilation

Use GOES CT pres/temp, radar reflectivity, lightning, METAR (clouds, current wx ,vis) to modify water vapor, hydrometeor (qc, qi, qs, qr, qg) fields

- Rederive CTP from GOES CTT and RUC 1h forecast profile for CTP > 620 hPa (no CO_2 slicing used)

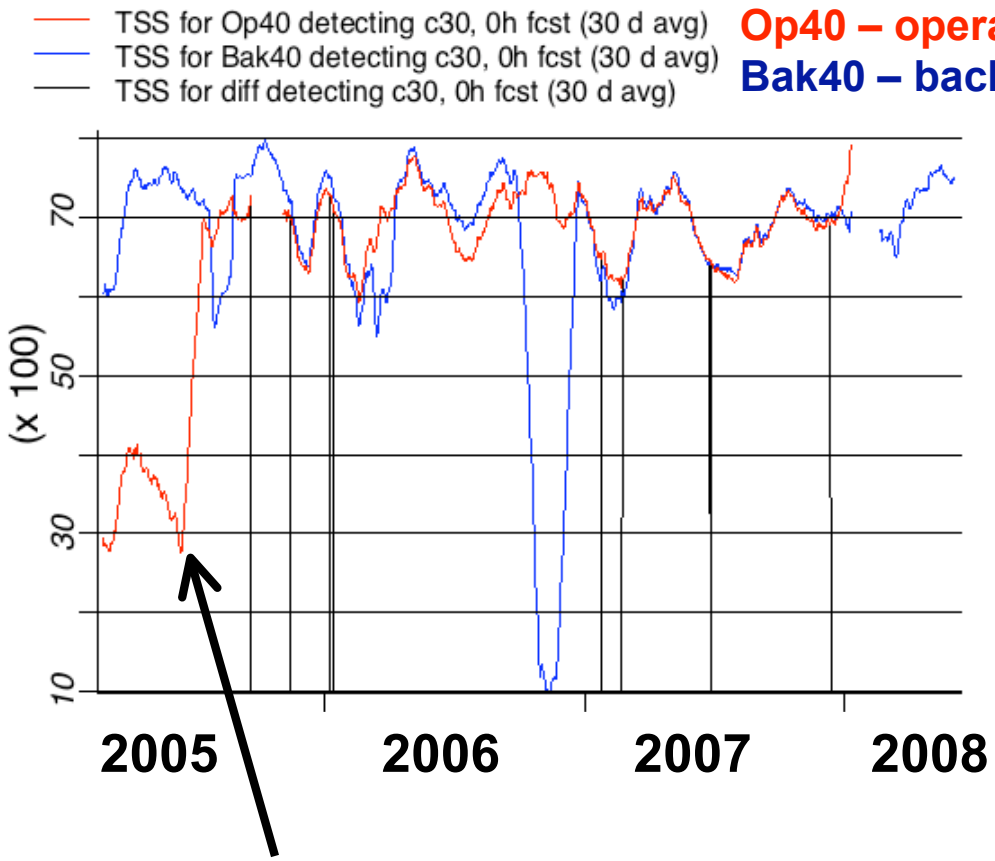
- Construct 3-d logical arrays (YES/NO/UNKNOWN) for clouds and precipitation from all info

- Clear/build (change qc, qi, qv) with logical arrays

- 3-d radar data to modify water vapor, hydrometeor fields

- Radar reflectivity NOT used for precip hydrometeor (qr, qs, qg) analysis, but instead for DFI-latent heat technique (later)
- Lightning data used as a proxy for radar reflectivity

0h RUC analysis - Effect of METAR cloud assimilation



Op40 – operational RUC at NCEP
Bak40 – backup RUC at GSD

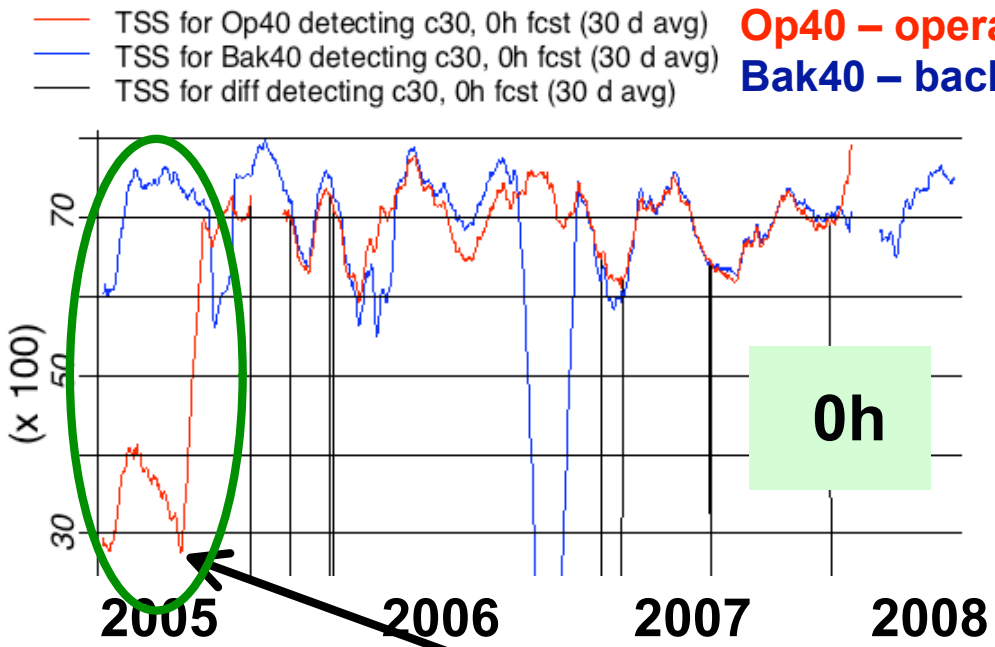
For 3000-ft ceiling

TSS – Total Skill Score
-Similar to CSI but for rare event

Ceiling – 1st level from ground up where $qc+qi>10^{-6}$ g/g

June 2005 RUC implementation at NCEP
- METAR cloud/vis obs added to RUC hydrometeor assimilation (using GOES cloud-top data since 2002)

3h - Effect of METAR cloud assimilation



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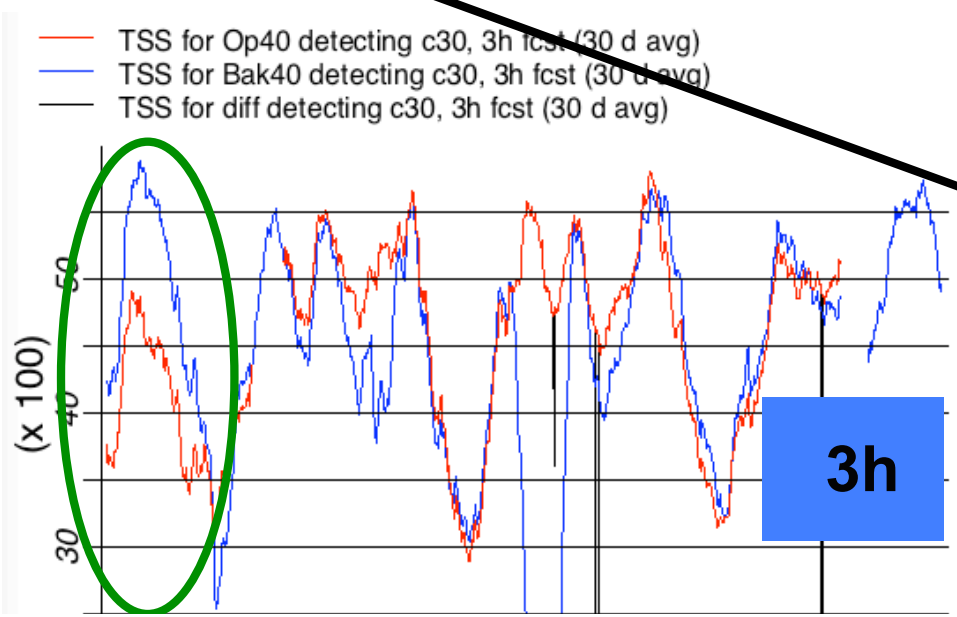

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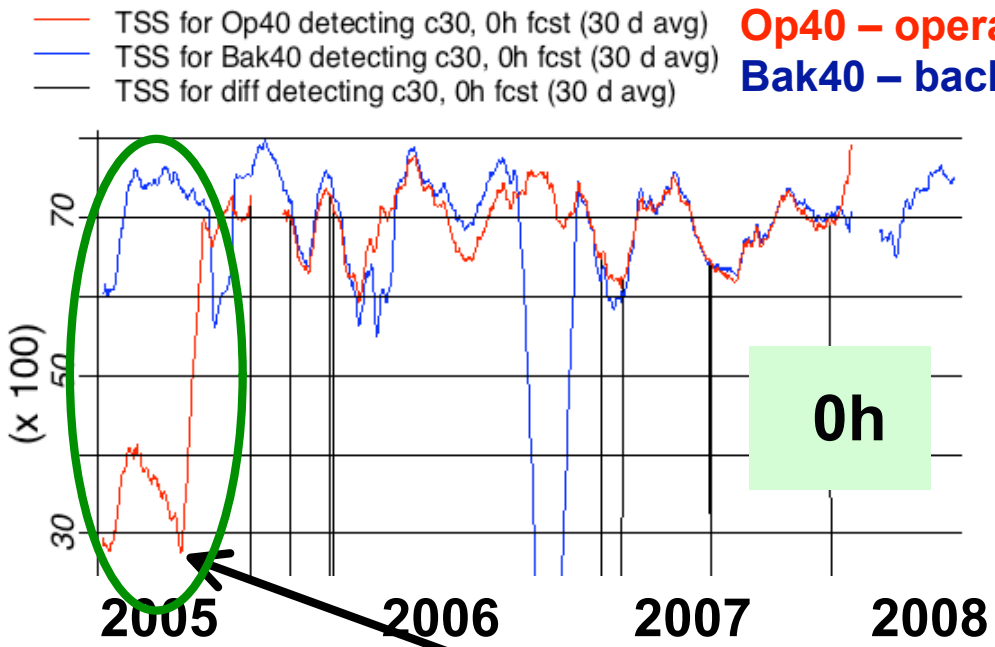
6h - Effect of METAR cloud assimilation



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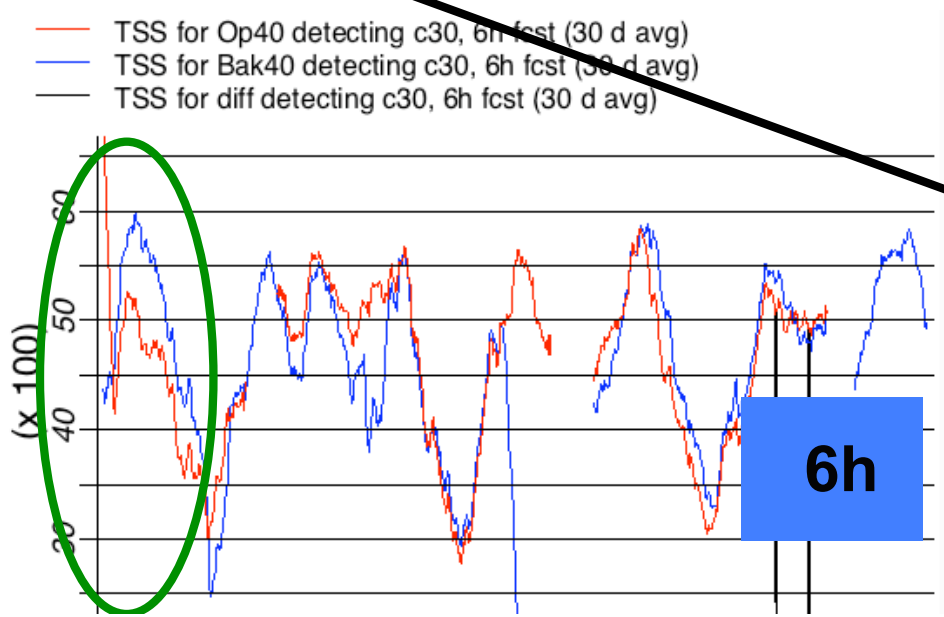

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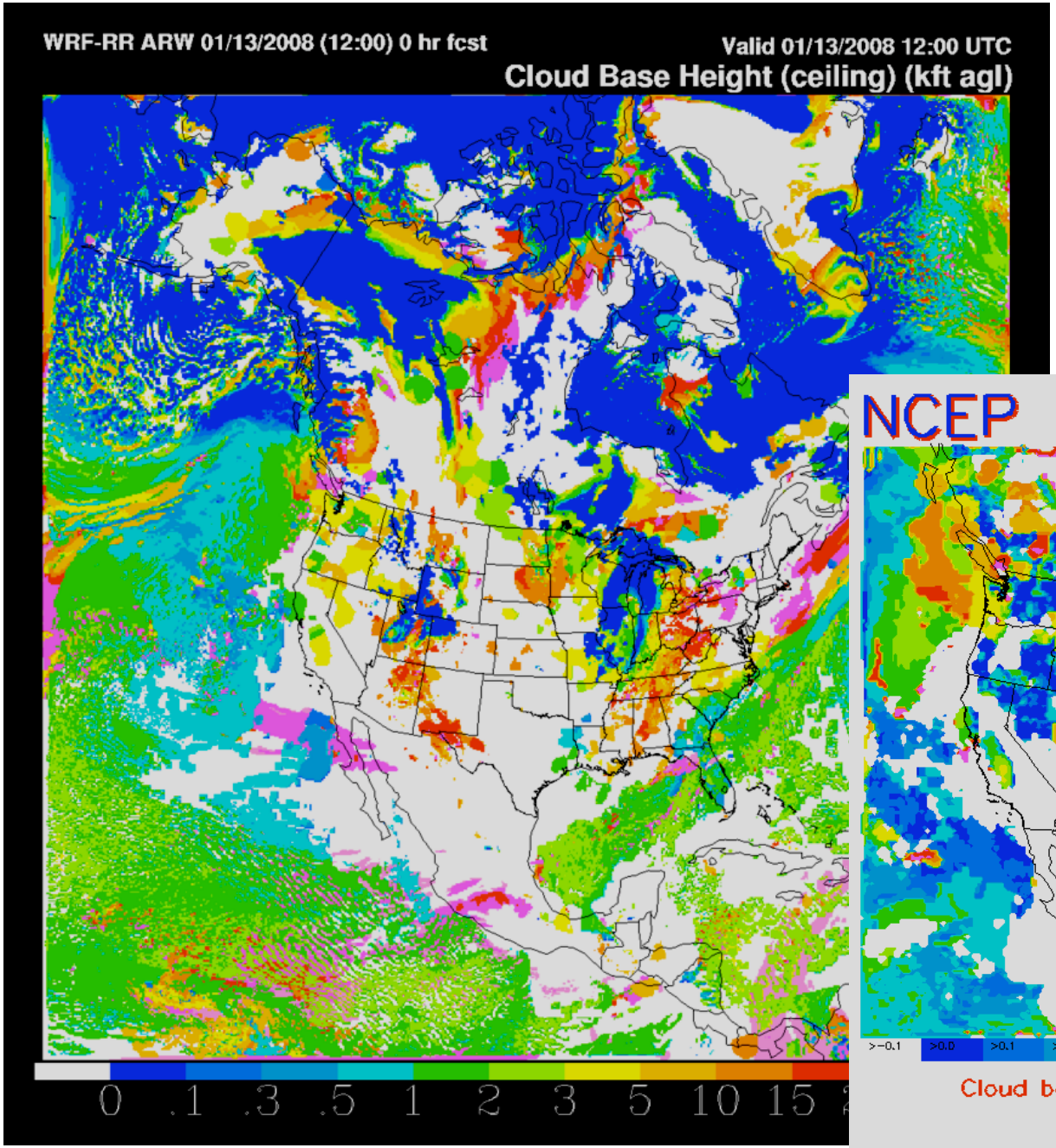
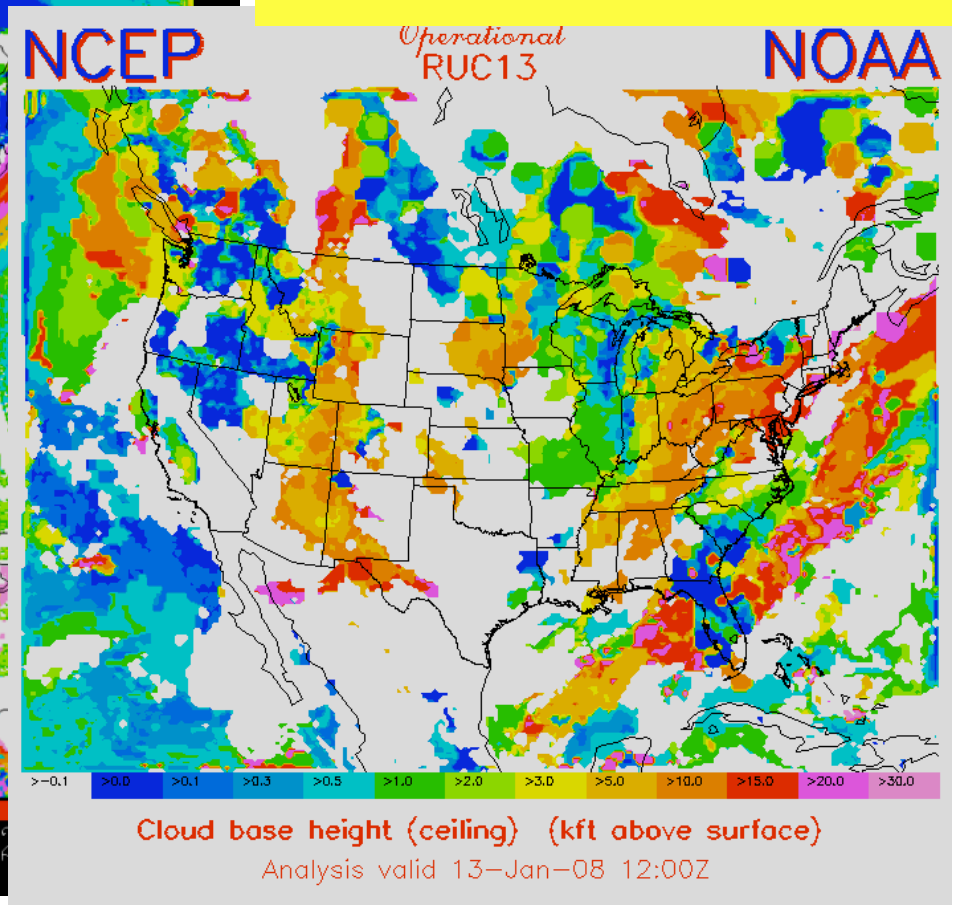


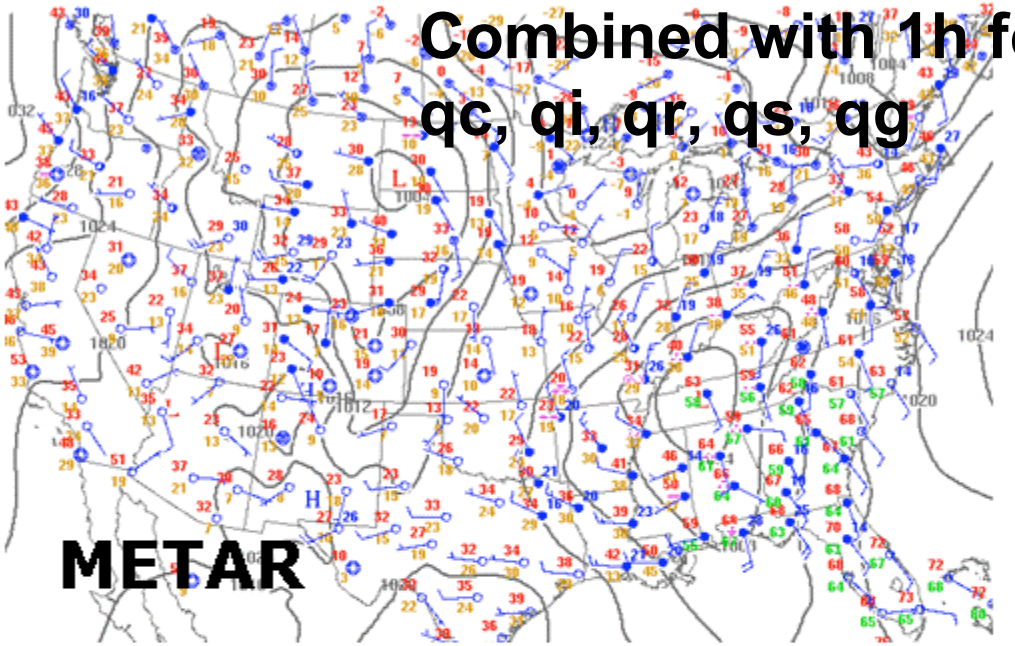
RR/RUC cloud anx in GSI working as of 1/12/08

- METAR cld/vis used
- GOES cld over CONUS

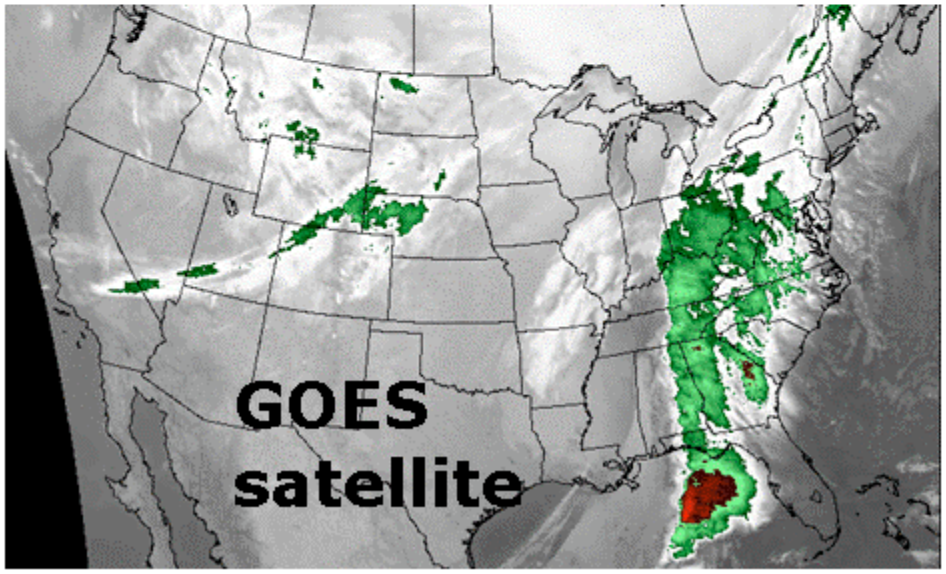


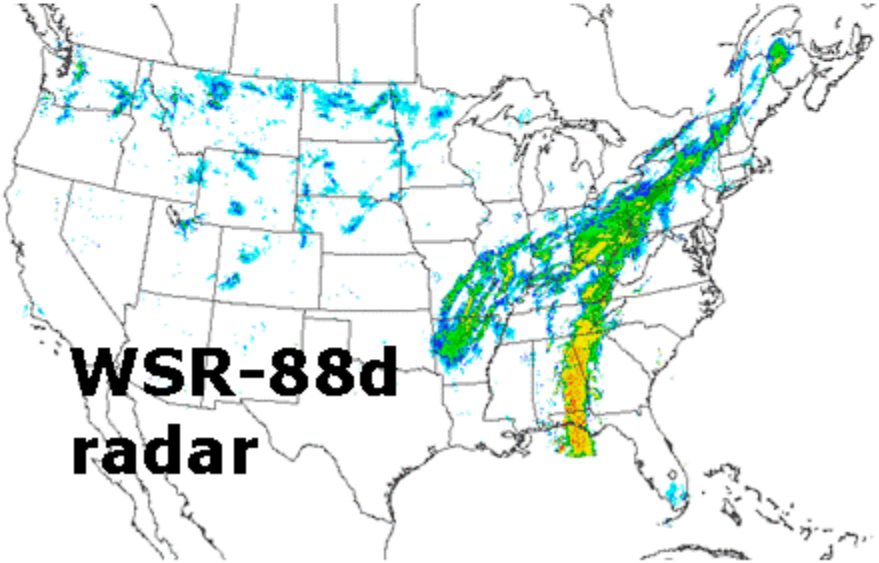
Cloud Observations from three sources

Combined with 1h fcst - 3-d fields of qc, qi, qr, qs, qg



12 UTC 4 March 2008

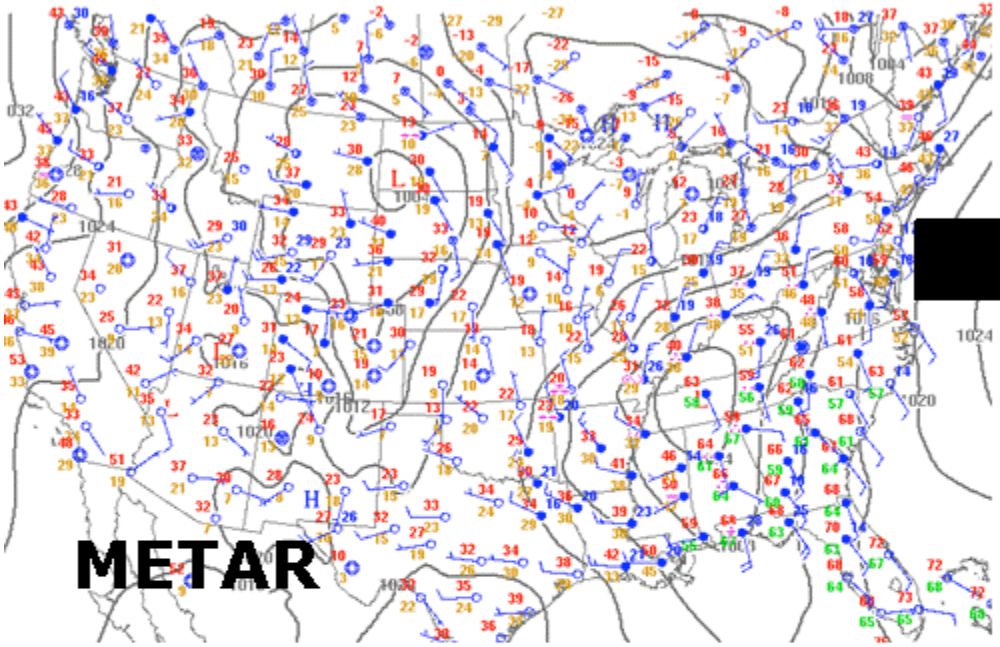


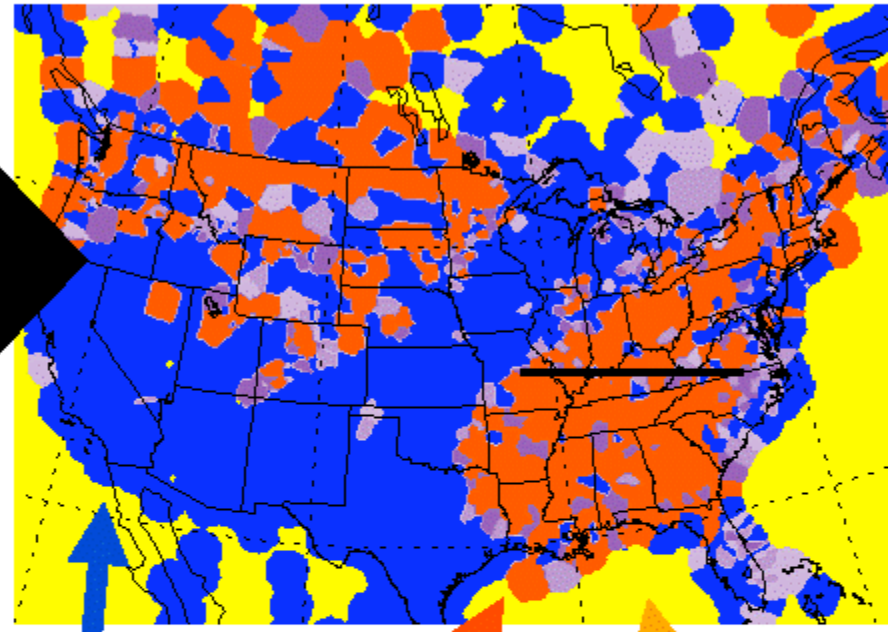


Processing METAR observations

Column "maximum" cloud

Yes > No > Unknown





12 UTC 4 March 2008

NO clouds

YES clouds

OVC

BKN

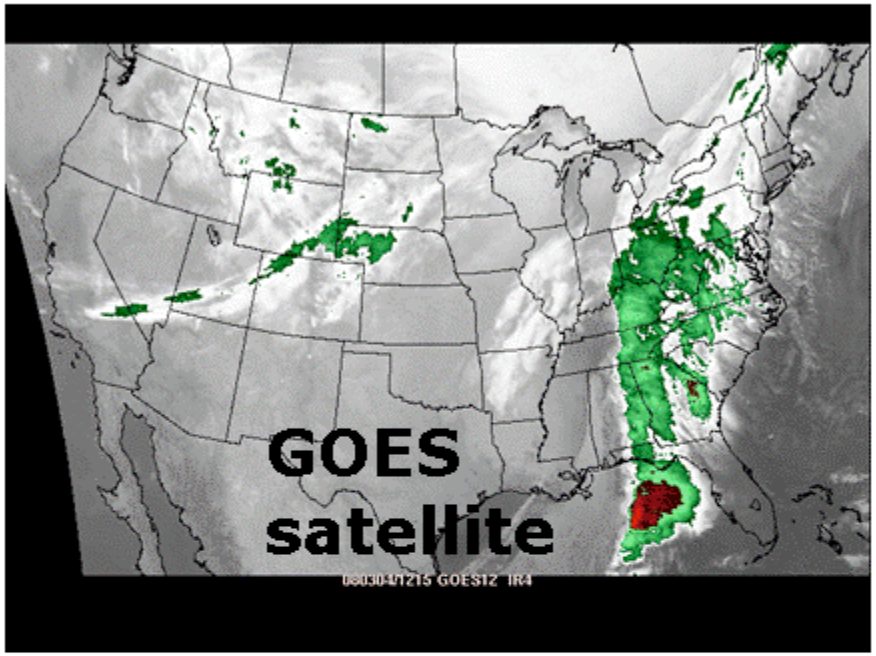
SCT

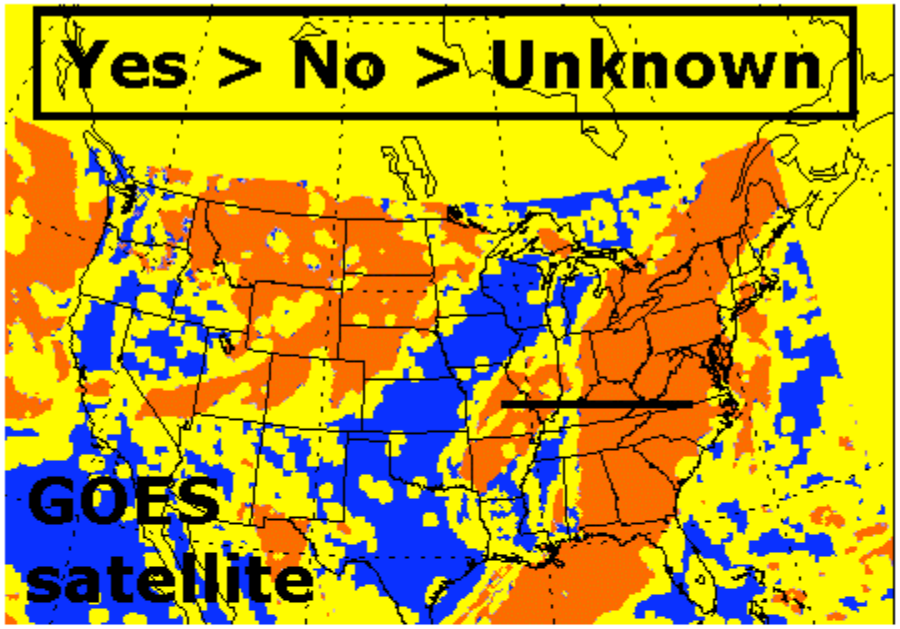
UNKNOWN clouds

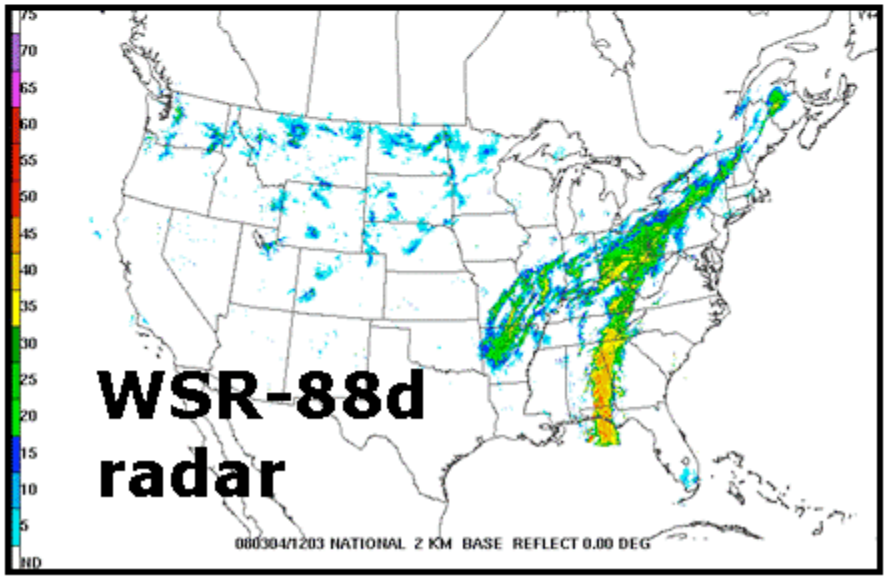
Cloud designation from observations

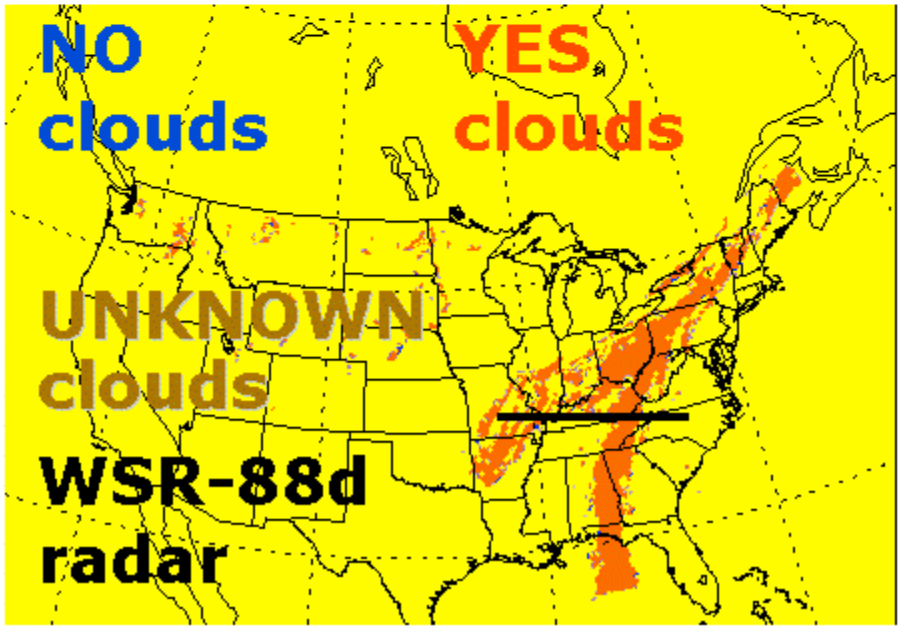
Specify 3-dimensional Yes/No/Unknown field

Observations → Column "maximum" cloud

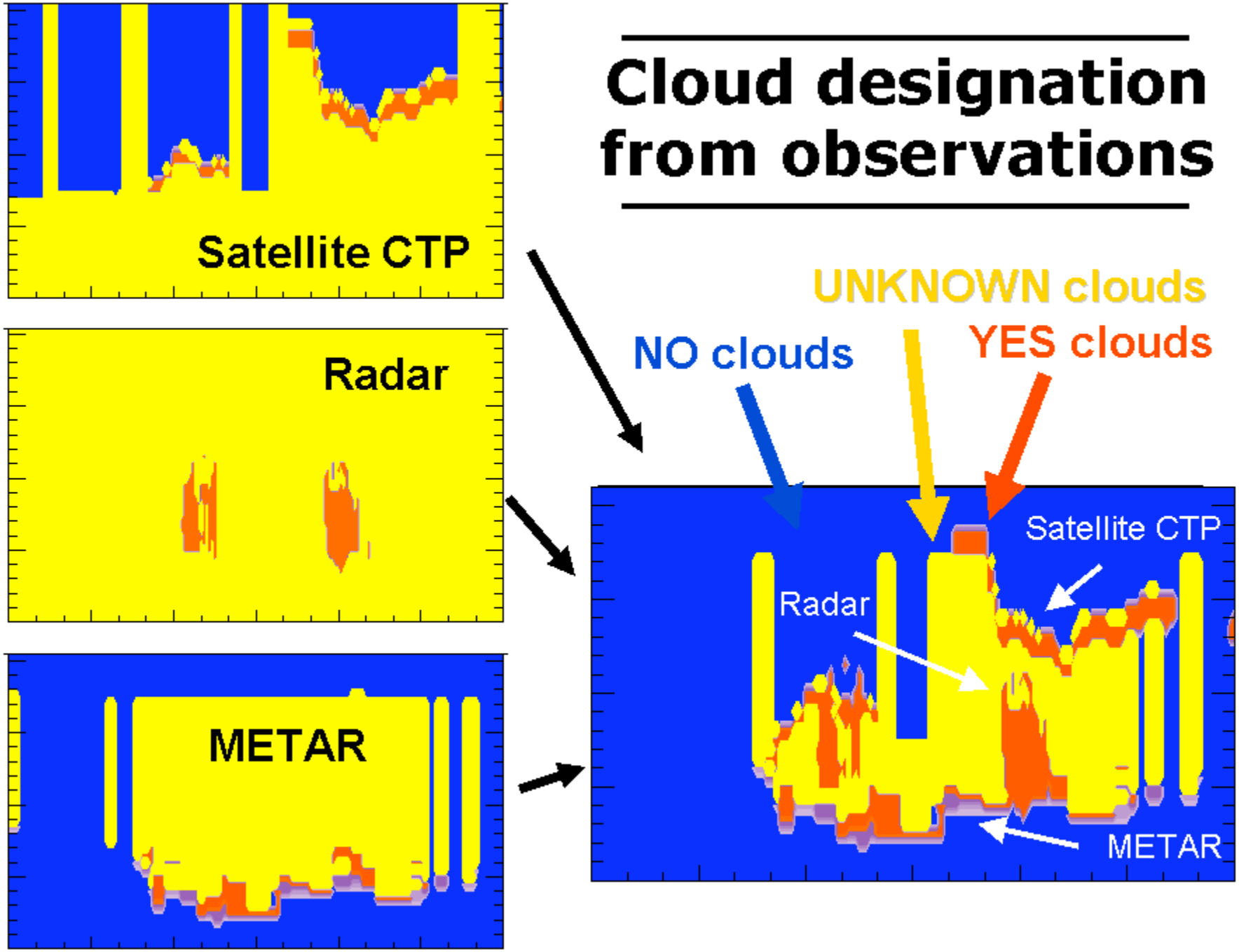




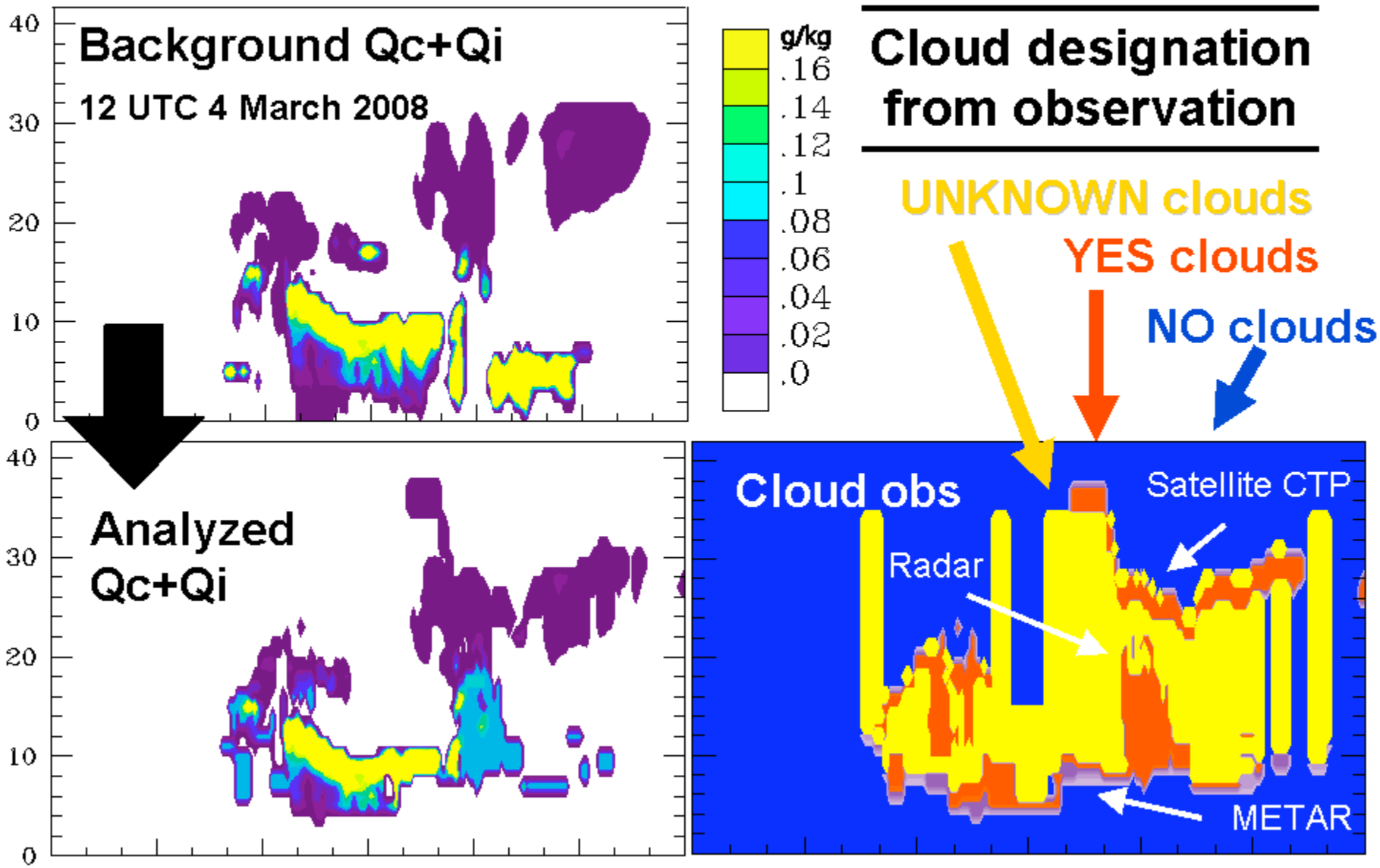




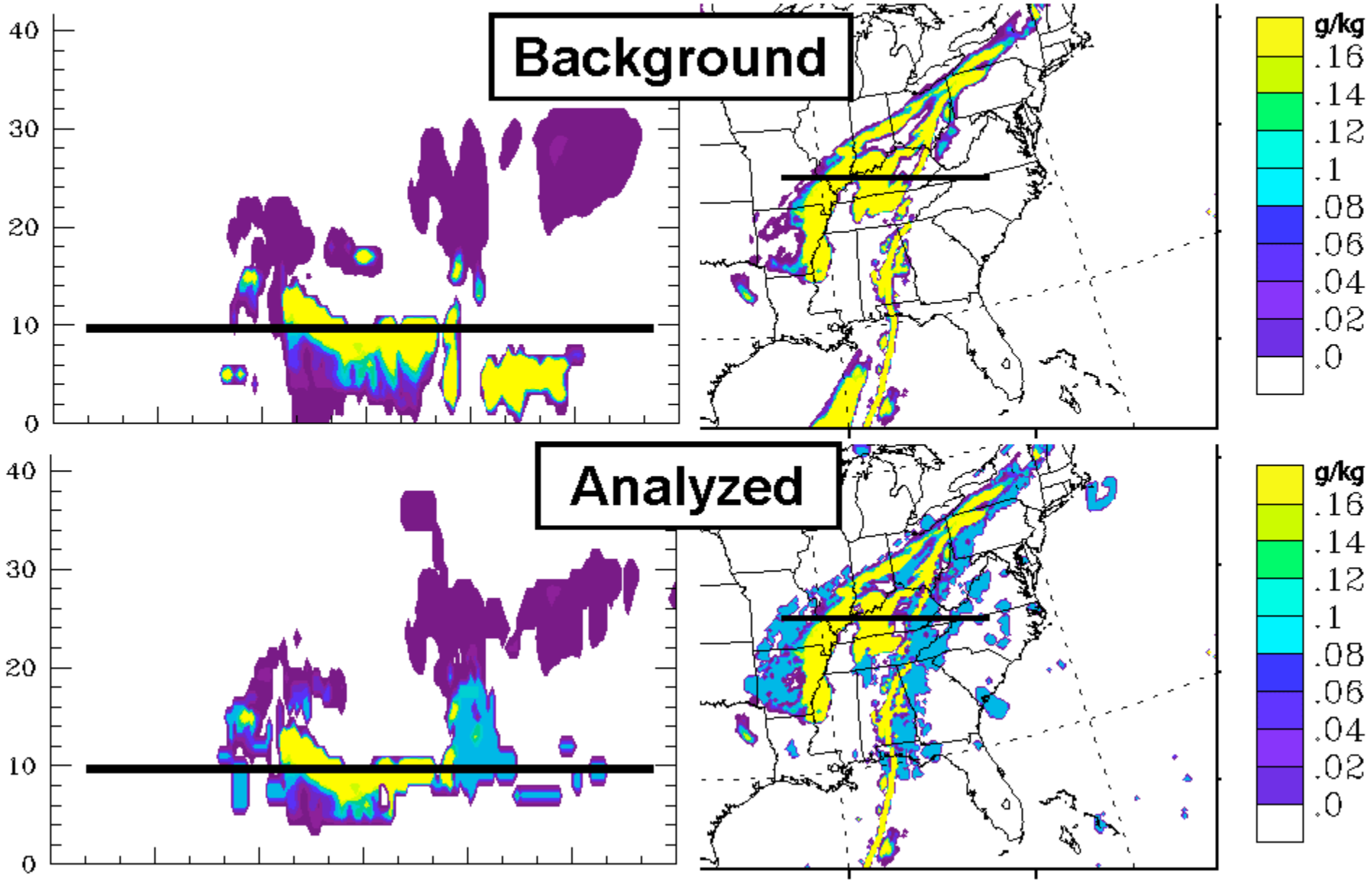
Cloud designation from observations



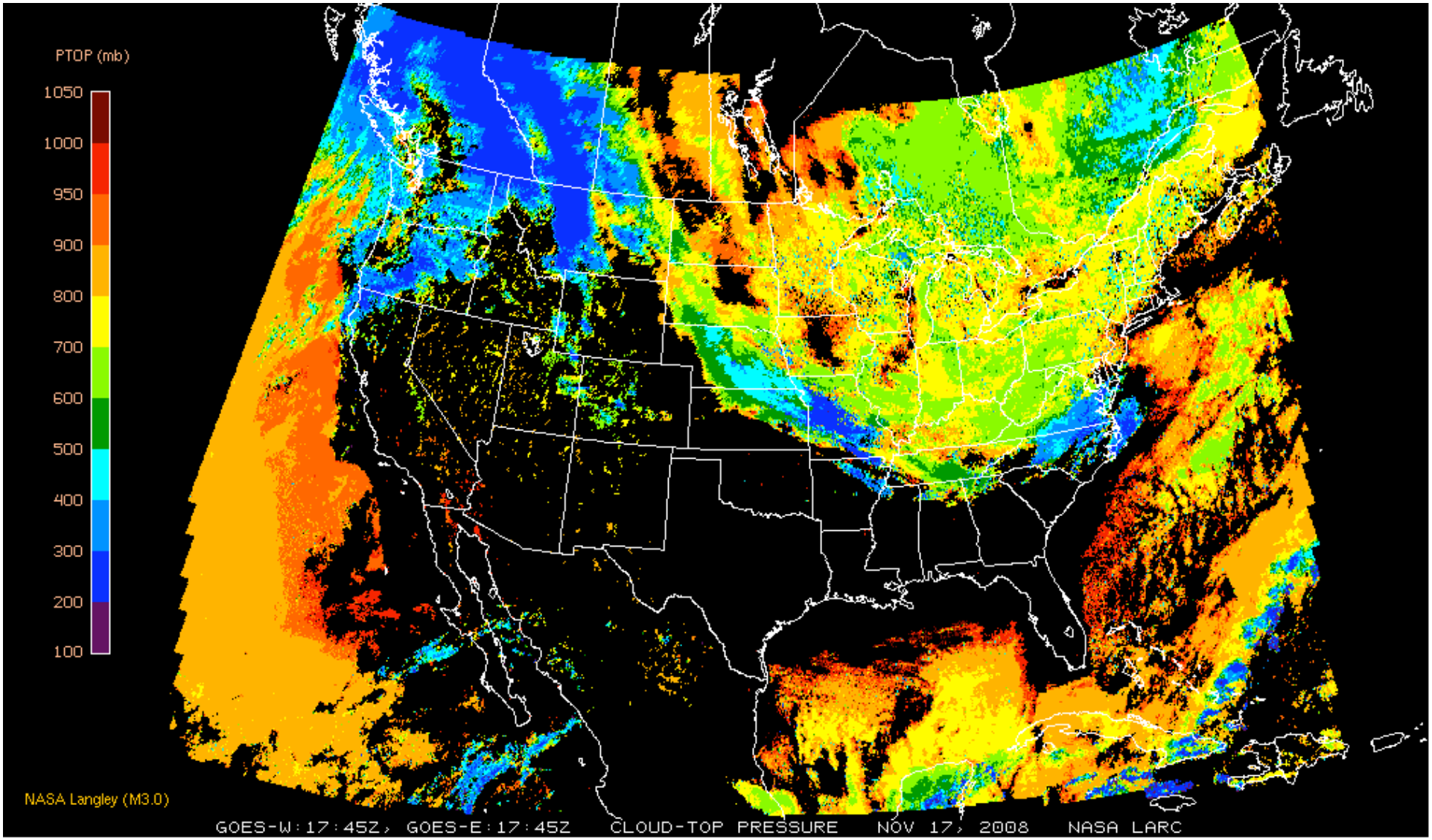
Modify background with cloud observations



Qc + Qi Cross-section and K=10



NASA LaRC cloud-top pressure - 18z 17 Nov 2008



RUC processing for NASA Langley cloud/hydrometeor assimilation

Use GOES CT pres/temp. similar to that for NESDIS GOES cloud product

Larger horizontal coverage

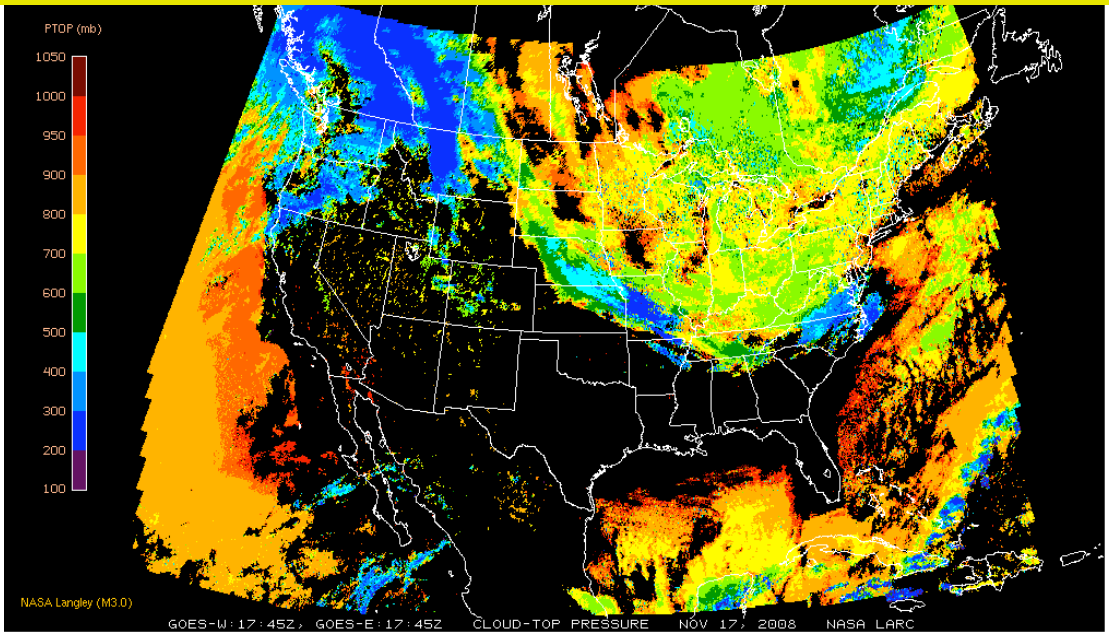
- NASA - about 60% coverage of RUC domain
- NESDIS - about 32% coverage of RUC domain

LaRC FOVs (GOES-E and GOES-W) mapped onto RUC grid points (up to 180 FOVs per RUC gridpt in GOES-E/W overlap zone over central US)

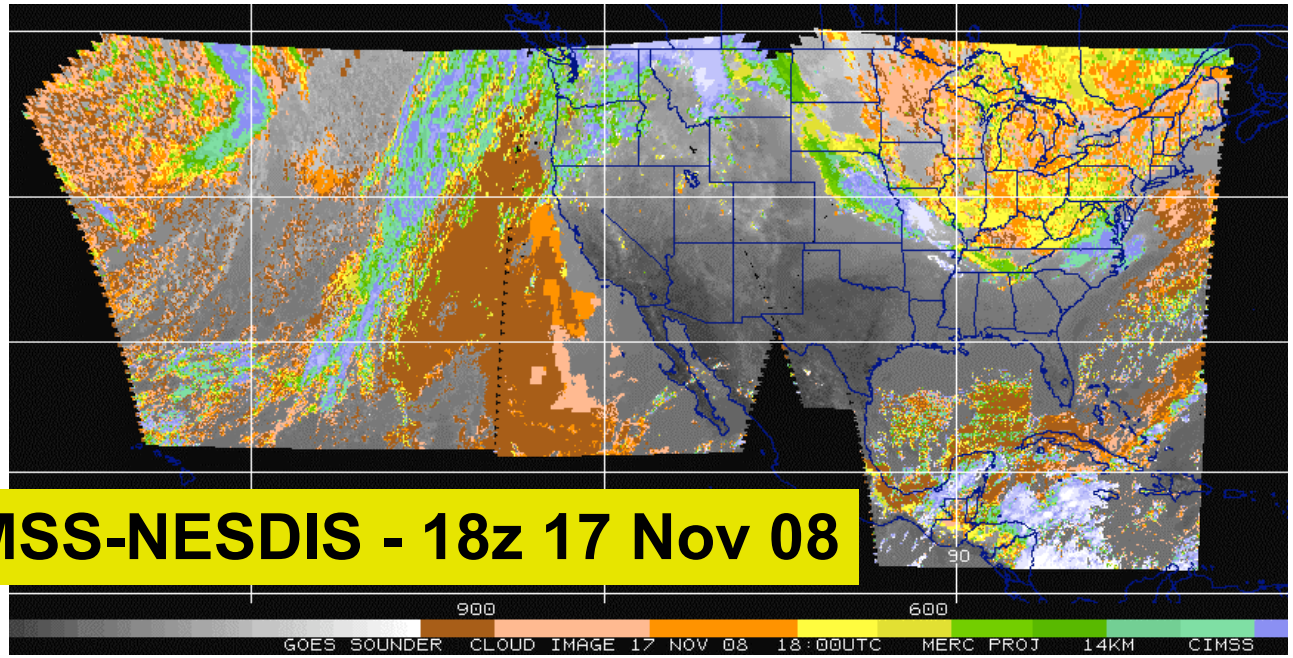
Values at RUC grid points from LaRC calculated via median value from FOVs

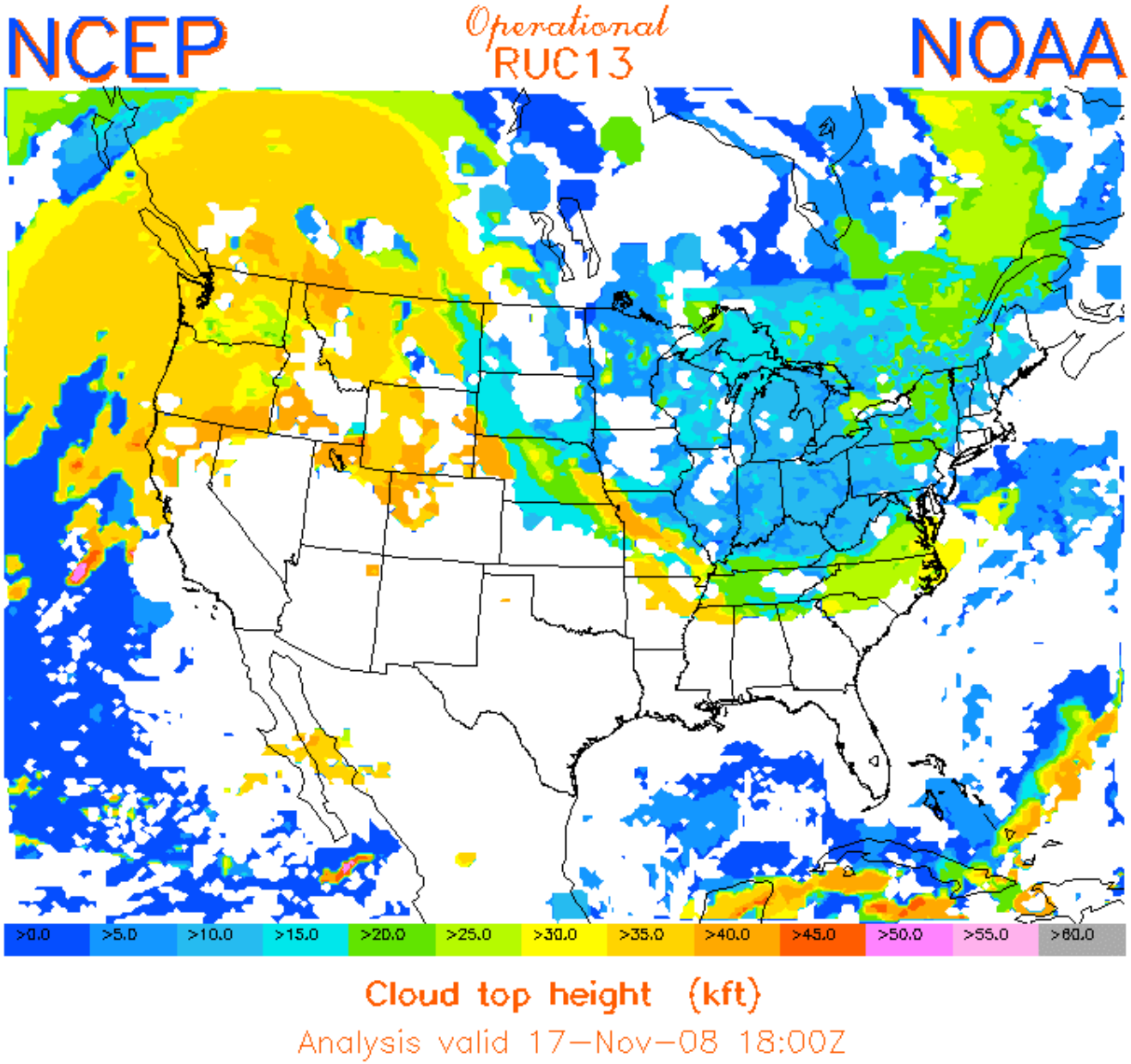
- cloud fraction
- cloud-top temperature
- cloud-top pressure
- liquid/ice water path

NASA LaRC cloud-top pressure - 18z 17 Nov 2008

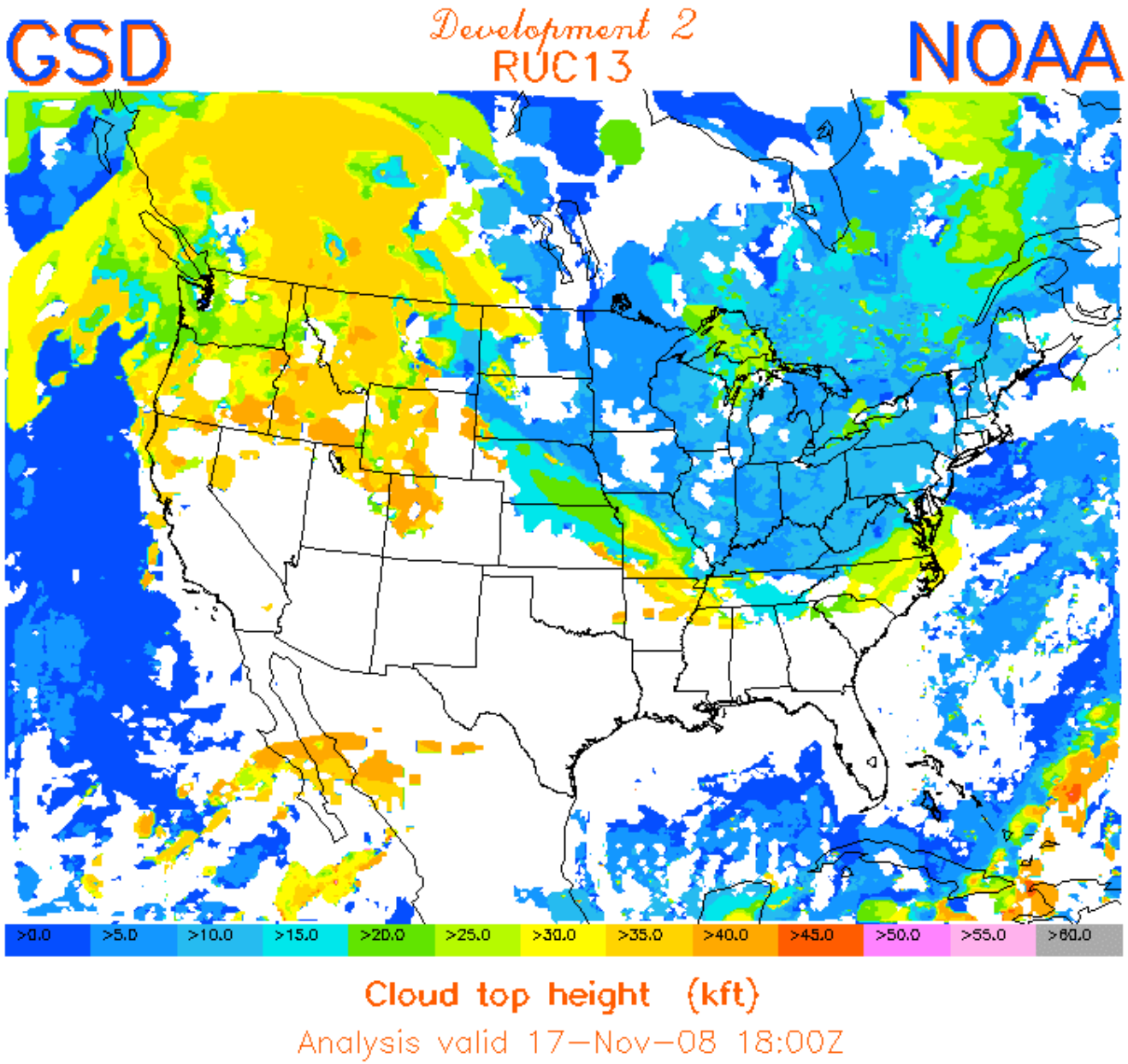


CIMSS-NESDIS - 18z 17 Nov 08





Oper RUC - uses NESDIS cloud-top data



Dev RUC - uses NASA LaRC cloud-top data

Assimilation of LaRC IWP/LWP data

Calculate

pressure thickness for cloud layer

dp = LWP * gρ / (autoconversion-cloud-build)

-(autoconversion ~ 0.2 g/kg cloud water

- at this value, cloud water starts to convert to rain water.

- build at 0.5 * this value

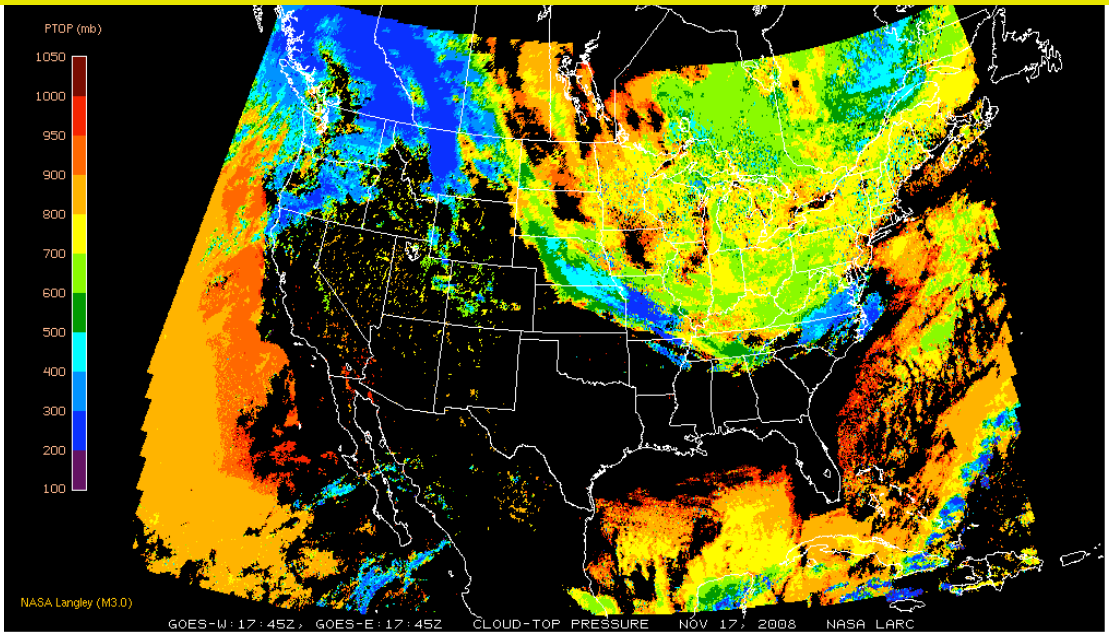
Pre-NASA conservative initial assumed thickness for build from GOES-top-down in RUC cloud analysis - 40 hPa.

Conservative approach with NASA LWP data

- build up to 100 hPa depth

- METAR ceiling overrides assumed depth

NASA LaRC cloud-top pressure - 18z 17 Nov 2008



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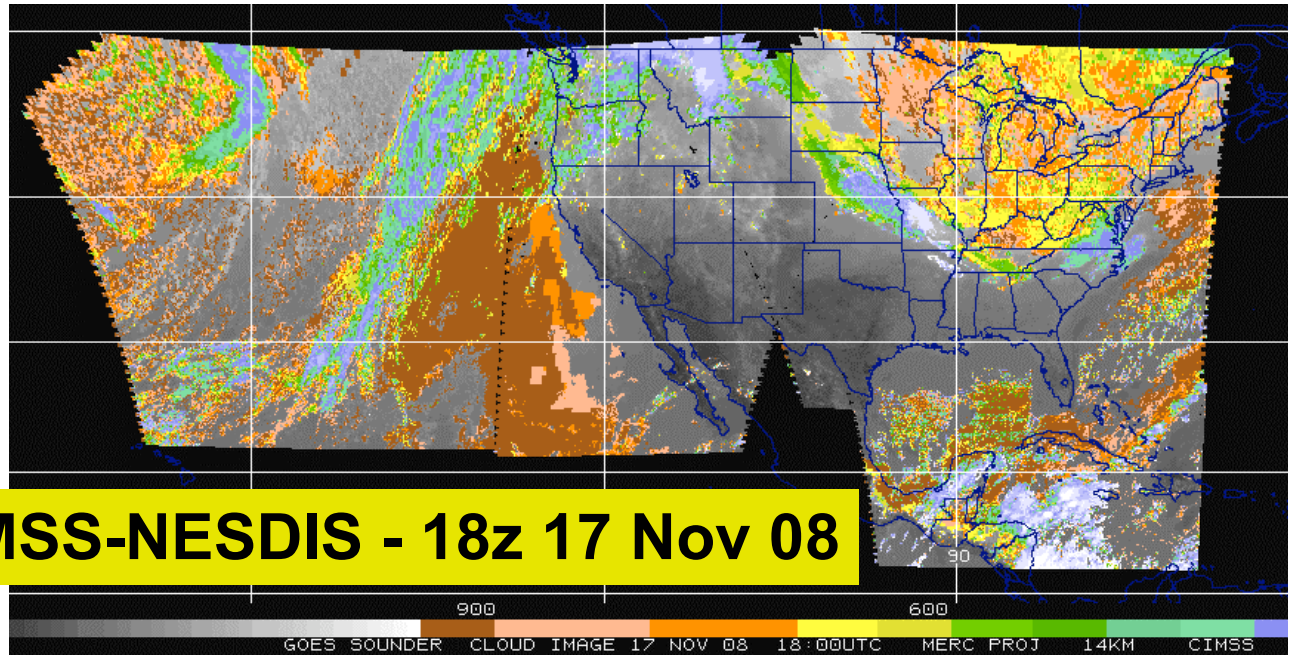

RUC cloud/hydrometeor assimilation

Use GOES CT pres/temp, radar reflectivity, lightning, METAR (clouds, current wx ,vis) to modify water vapor, hydrometeor (qc, qi, qs, qr, qg) fields

- QC logic for NESDIS cloud retrieval problems
  - low-level cloud
    - dependent on solar zenith angle, water/land (GOES cloud more accurate over water due to SST accuracy)
    - match marine stratus level in background, depending if level (k) can be found with $|T_{back}(k) - CTT| < 3K$
  - do not use CTT if $|CTT-T_{skin-back}|<3K$

- METAR cloud used only if consistent with GOES
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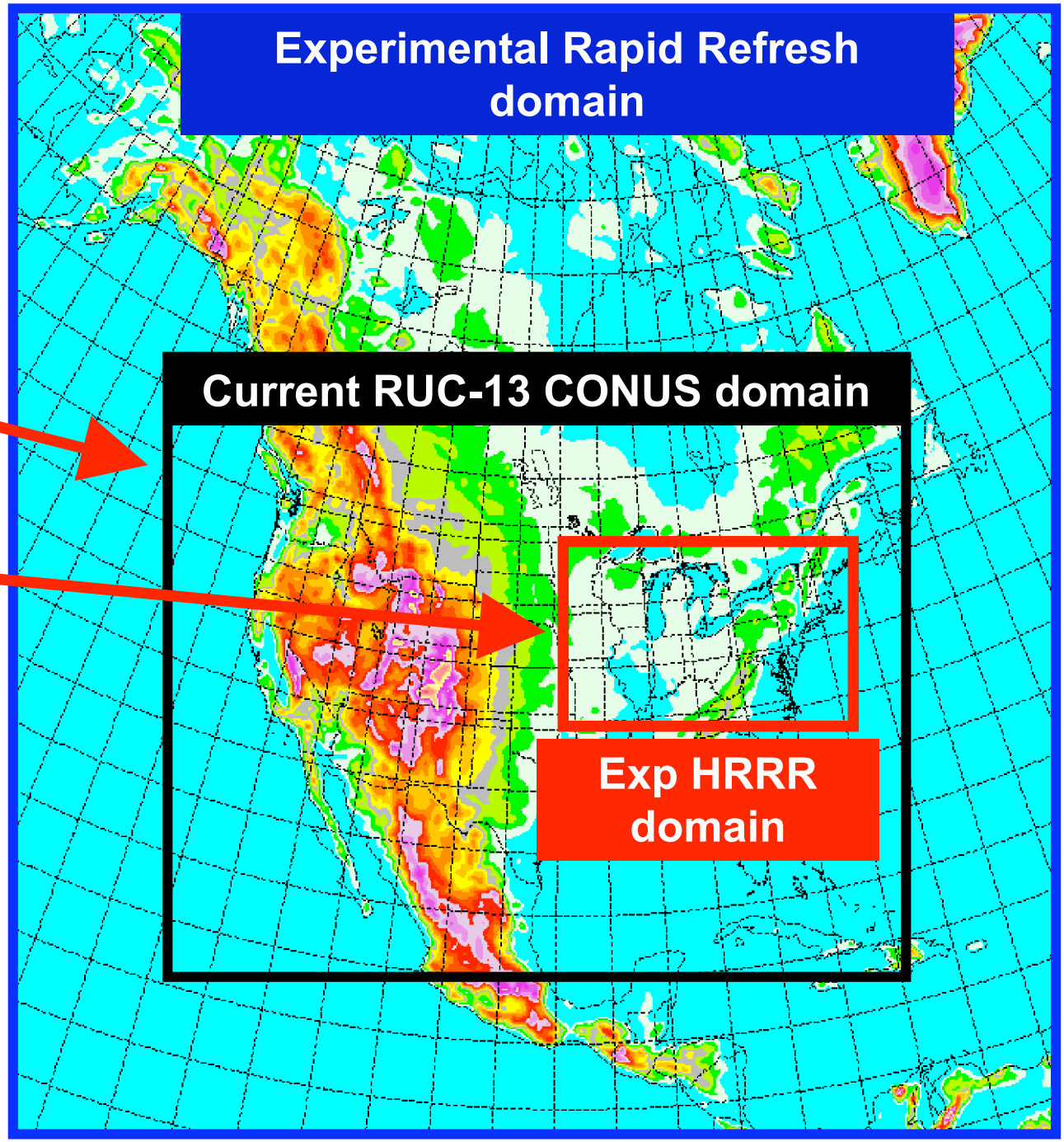
Adding Cloud/Hydrometeor Analysis in GSI

NOAA/ESRL/GSD

NASA ASAP - RUC-LaRC cloud assimilation status - Nov 2008

1. Assimilation technique developed, including assimilation of liquid/ice water path (ESRL/GSD)
2. Joint collaboration underway between ESRL and LaRC for evaluation.
3. Iterative revisions being developed in both RUC cloud analysis technique and LaRC retrieval processing, extensive evaluation in FY09
4. Major flaw in RUC cloud analysis uncovered?
5. RUC cloud analysis has been transferred to GSI analysis used in Rapid Refresh
   - Developments in cloud analysis with NASA/ESRL collaboration transferable to Rapid Refresh/GSI
6. Note: NASA processing must be transferred to NESDIS

NASA/LaRC cloud assimilation

- Will benefit experimental
- 13km RUC
- 13km Rapid Refresh
- 3km Hi-Res Rapid Refresh
  Storm-resolving (3-km) model init from radar-enhanced RUC or RR
- Updated every 60 min including latest radar data
- Proposed as part of NextGen