The impact of assimilating radar and SCAN data on a WRF simulation of a Mississippi Delta squall line

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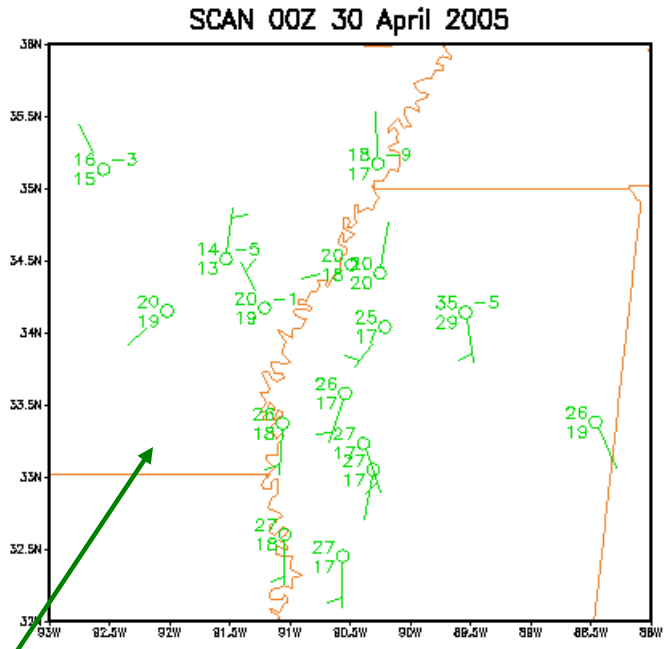
Outline

1. Description of squall line case study
2. Datasets
3. WRF model configuration
4. 3DVAR background error calculations
5. Simulation results
6. Conclusion

1. Case Study

A severe squall line entered northwest Mississippi, and propagated southeast from 00Z to 12Z on 30 April 2005. This storm caused strong winds, heavy rainfall, and a few tornadoes.



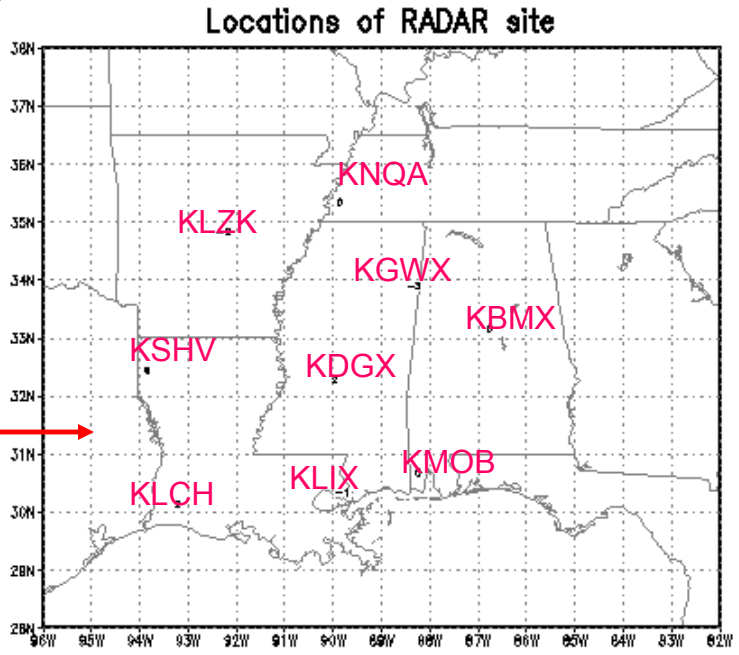
2. Data

- NAM 40-km is background field

- NCAR's Global Telecommunication System. Contains standard synoptic buoy, satellite-derived data, wind profiles.

- USDA's SCAN (Soil Climate Analysis Network). Contains 2-m and 10-m surface measurements, concentrated in eastern Arkansas and western Mississippi but also spread throughout the southern U.S.

- Radar. Provides 3D radial wind from 9 sites



3. WRF Model Set Up

3.1 Grid size 4 km

3.2 Grid points 350*350*35

3.3 3DVAR assimilation with cycling

18Z29 ----- 21Z29 ----- 00Z30----------12Z

3DVAR 3DVAR 3DVAR

{_____}{_____}

Data Assimilation Forecast

3.4 Experiments

1) *RADAR* – Radar, SCAN, and GTS data assimilation.

2) *SCAN* – SCAN and GTS data assimilation.

3) *GTS* – Only GTS data assimilation

4) *COLD* – Forecast starting at 18Z till 12Z 30, no data assimilation

4. 3DVAR Background Error (BE) Details

4.1 NMC method used(Parrish and Derber, 1992)

4.2 NAM used for WRF IC-BC

4.3 Time period, 1 April 2005 – 15 April 2005.

4.4 Two BE time periods are compared (12 h and 6 h)

BE12H based on time interval 12H (30 forecasts)

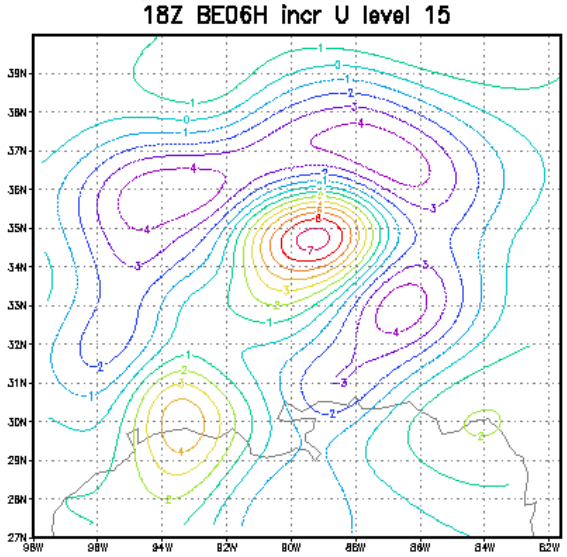
00Z---fcst---12H---fcst--- 24H
(1 Apr) DIFF
12Z---fcst--- 12H---fcst--- 24H
DIFF
(2 Apr) 00Z---fcst---12H---fcst---24H

BE06H based on time interval 06H (60 forecasts)

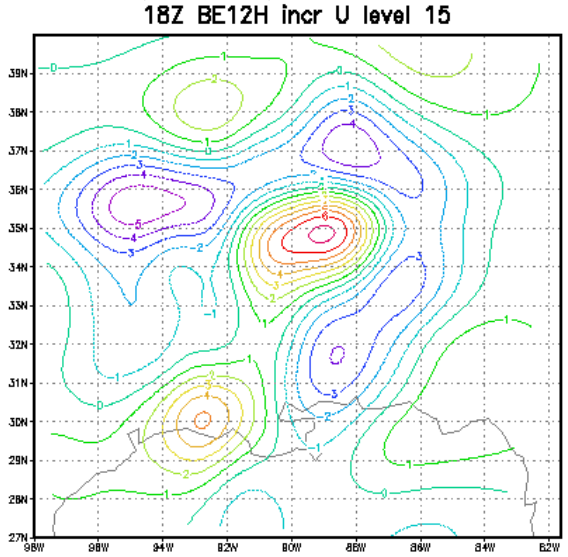
00Z--fcst--06H--fcst-- 12H
(1 April) DIFF
06Z--fcst-- 06H--fcst--12H
DIFF
12Z--fcst--06H—fcst--12H
DIFF
18Z--fcst-- 06H--fcst--12H
DIFF
(2 Apr) 00Z--fcst---06H—fcst—12H

Increment difference between BE06H and BE12H is small with combined radar, SCAN, and GTS. *Using 6- or 12-h BE will yield similar results.* Analysis increment differences with just SCAN and GTS have different patterns.

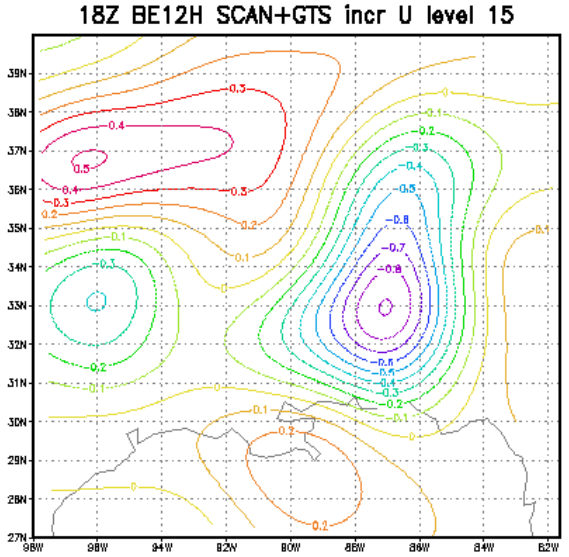
Radar, SCAN, & GTS



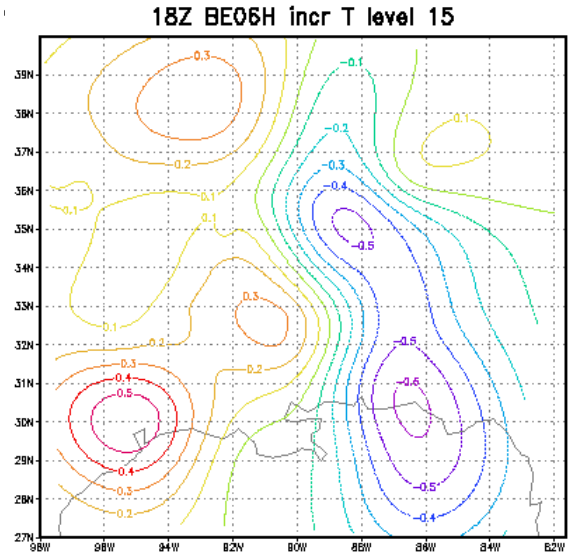
Radar, SCAN, & GTS



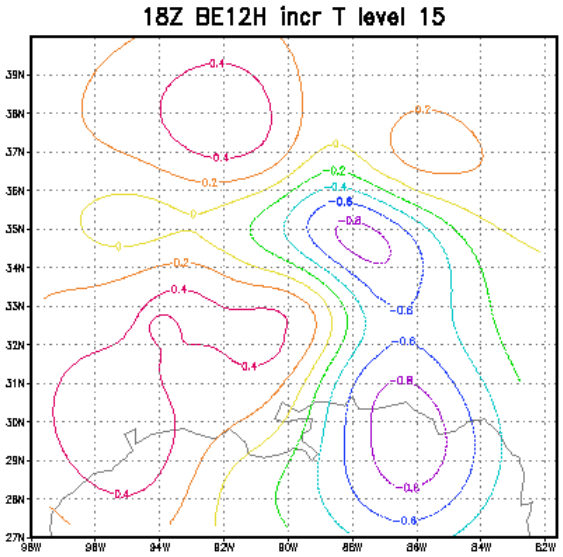
SCAN & GTS



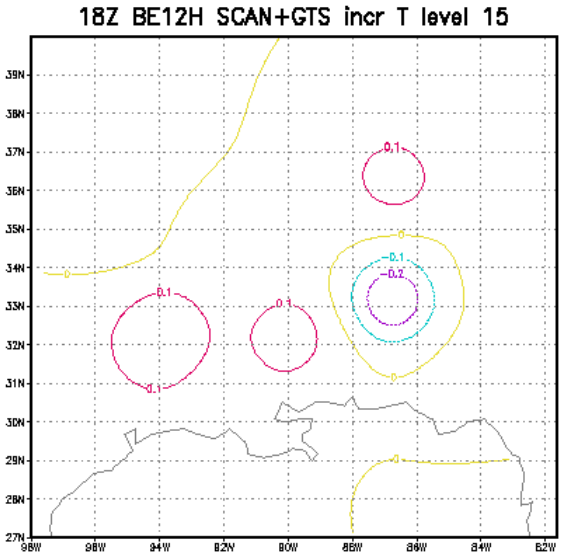
Radar, SCAN, & GTS



Radar, SCAN, & GTS

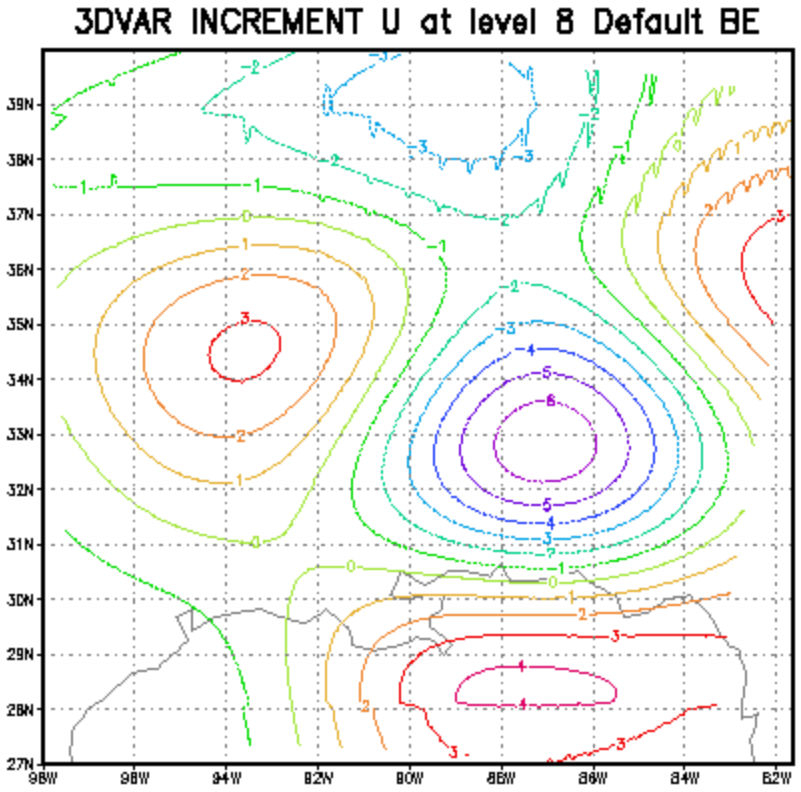


SCAN & GTS

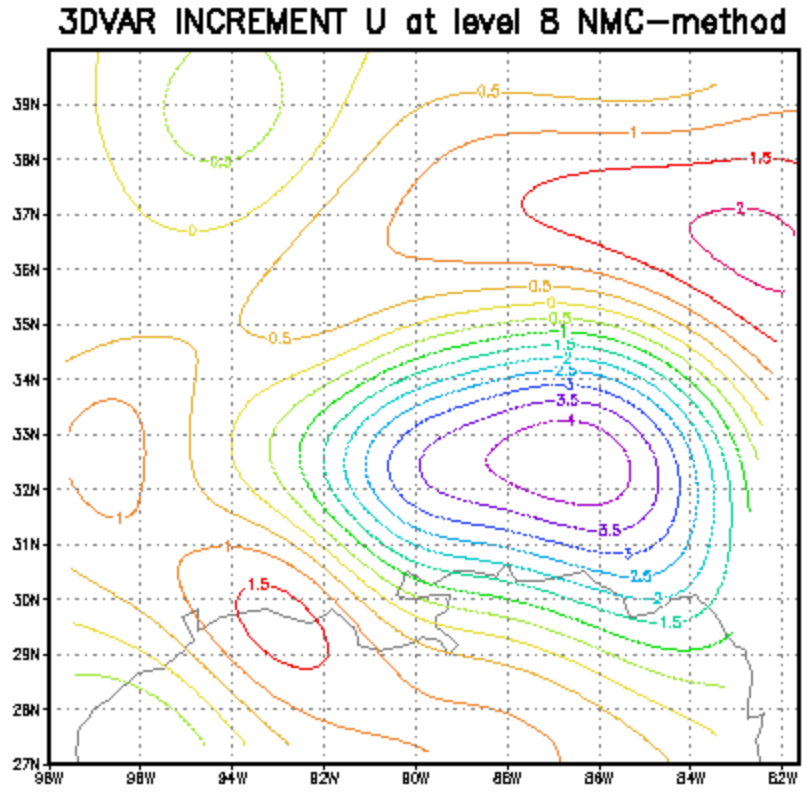


Comparison of default WRF BE to case study BE

Default WRF analysis increment



Analysis increments using
NMC method at 4-km



Also note noise in default WRF analysis increment

5. Results

5.1 Comparison of observed radar rainfall with WRF forecast.

5.2 Difference among WRF forecast rainfall using different combined observations:

RADAR + SCAN + GTS

SCAN + GTS

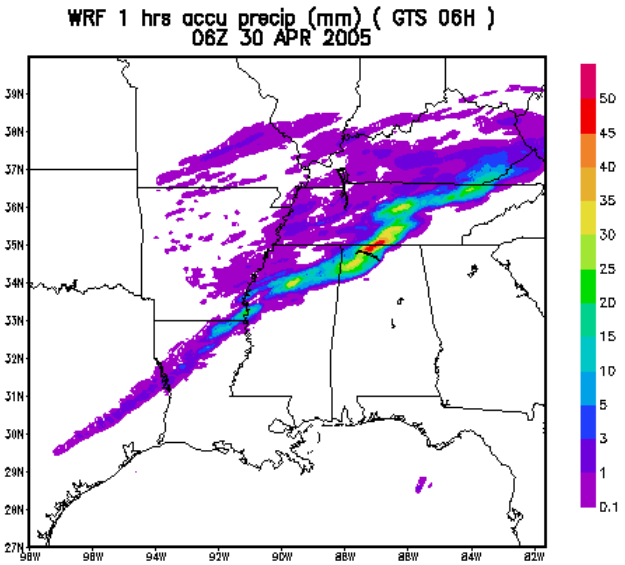
GTS

5.3 Comparison of BE12H forecasts to BE06H forecasts

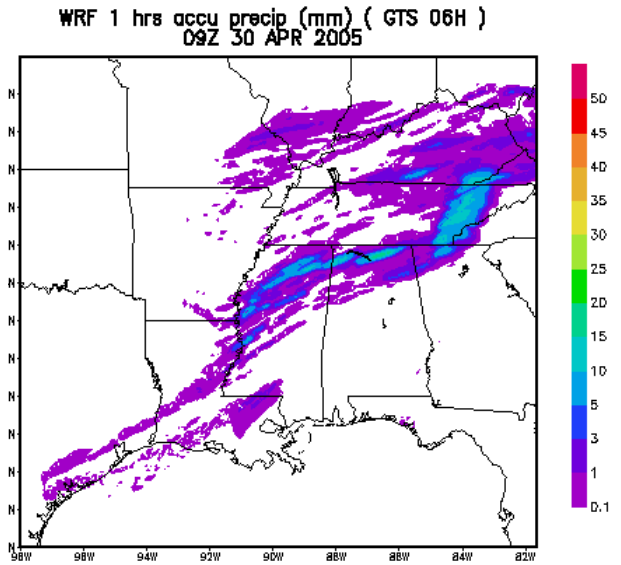
5.4 Model comparisons of NMC method to ensemble background errors.

GTS and SCAN results are very close. SCAN makes only minimum contribution.

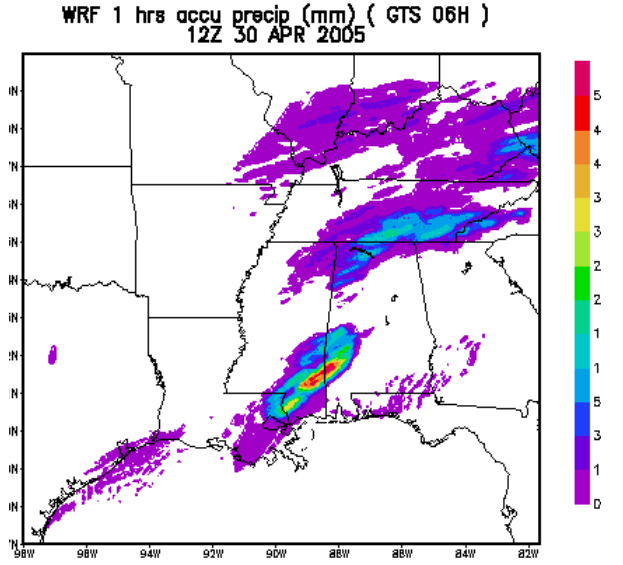
GTS



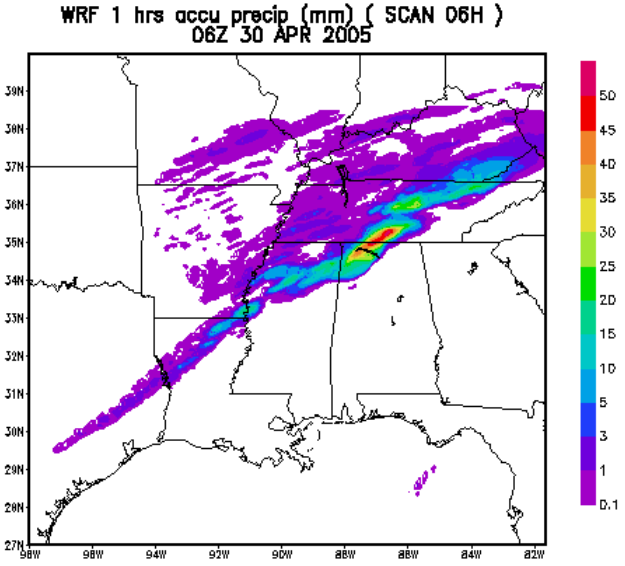
GTS



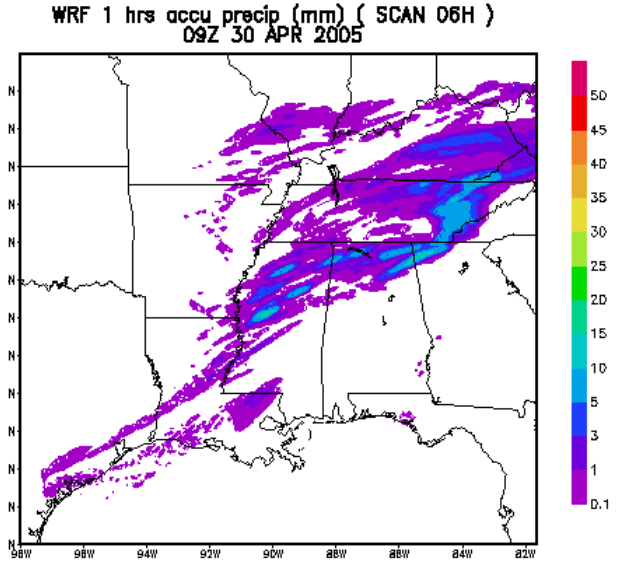
GTS



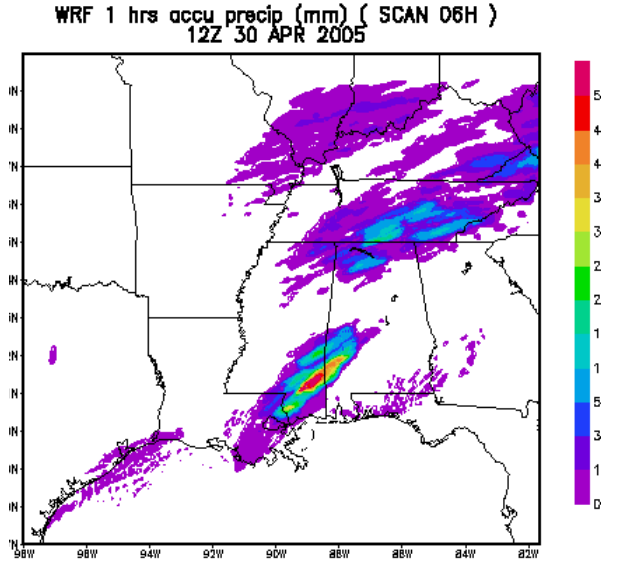
SCAN



SCAN

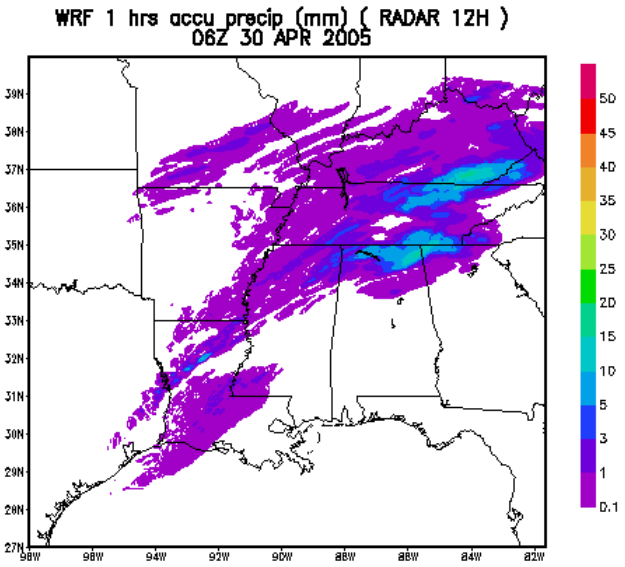


SCAN

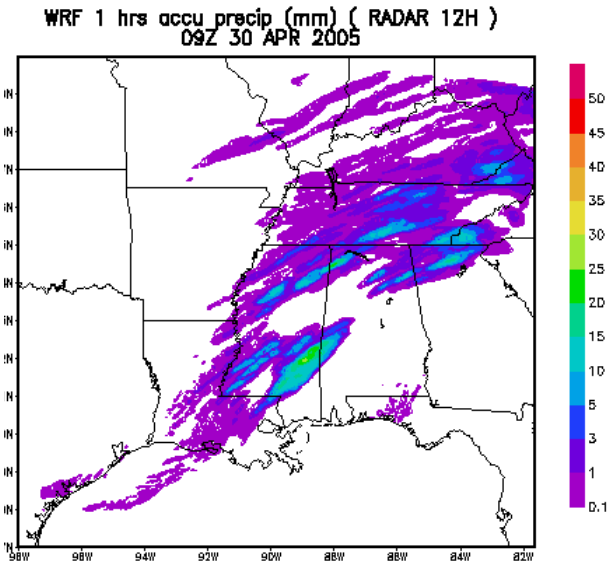


BE12H and BE06H results are close.

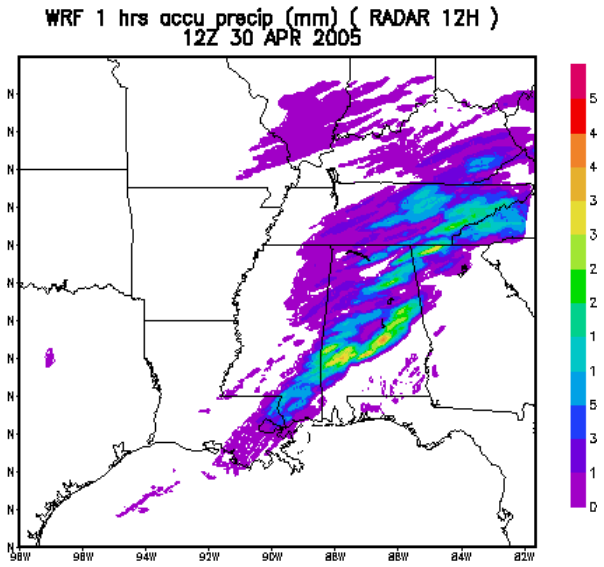
BE12H



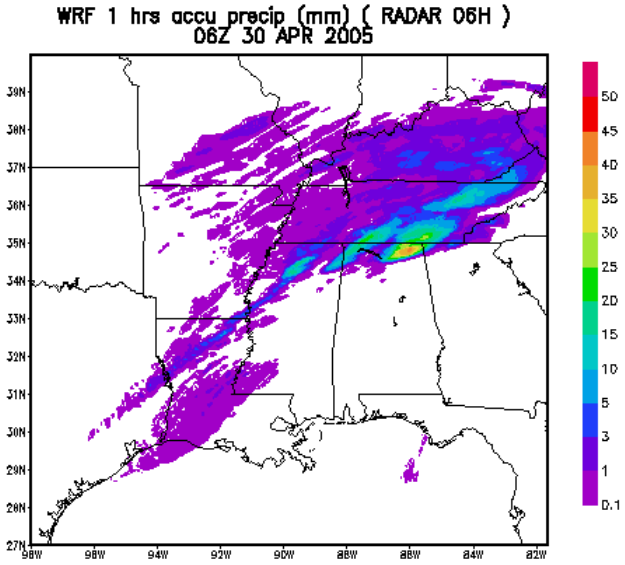
BE12H



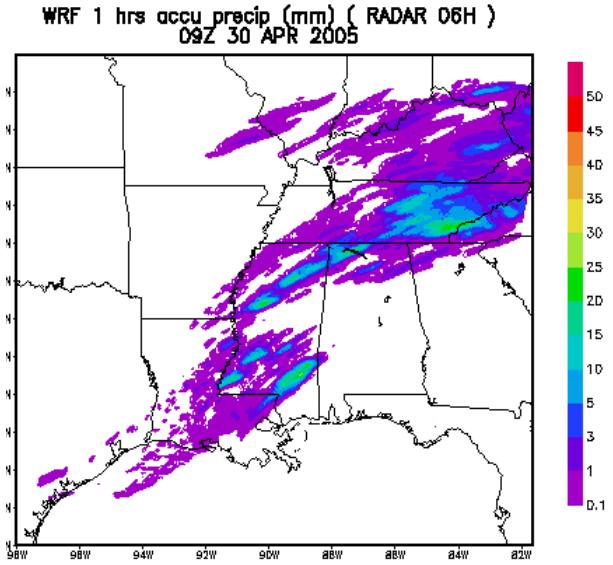
BE12H



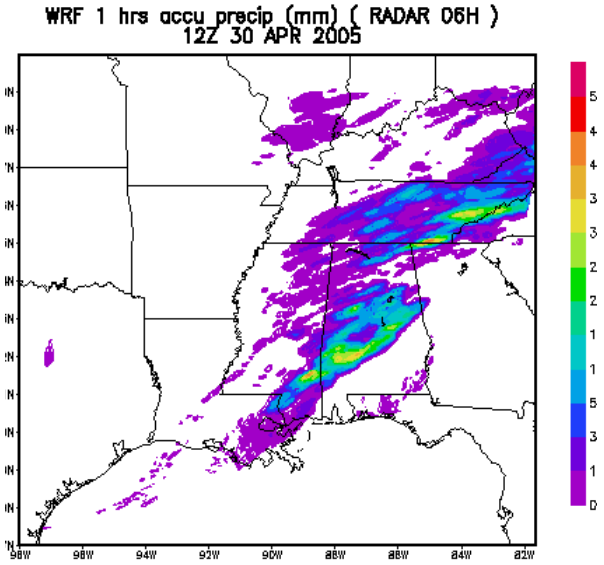
BE06H



BE06H



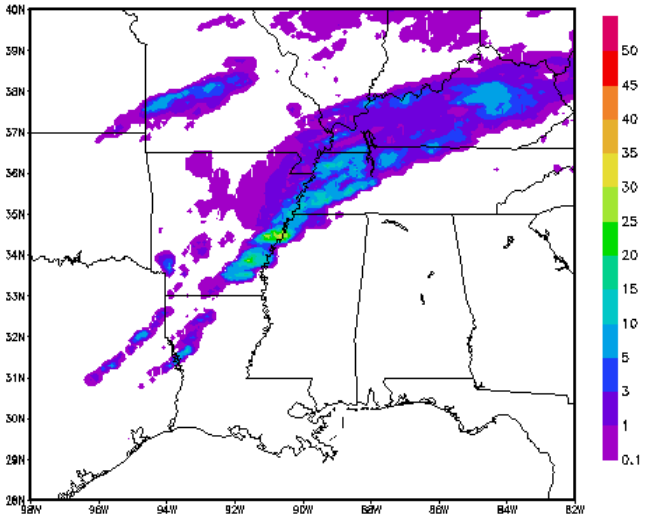
BE06H



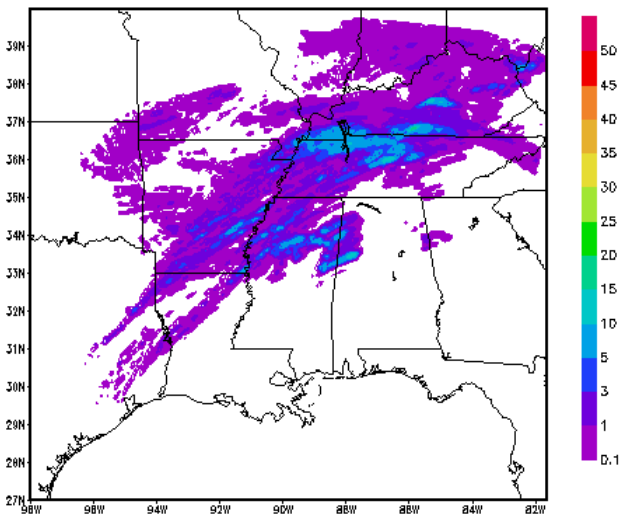
Comparison of Radar, GTS, and COLD runs

- Top left — Observed rain
- Top right — RADAR case
- Bottom left — GTS case
- Bottom right — Cold case

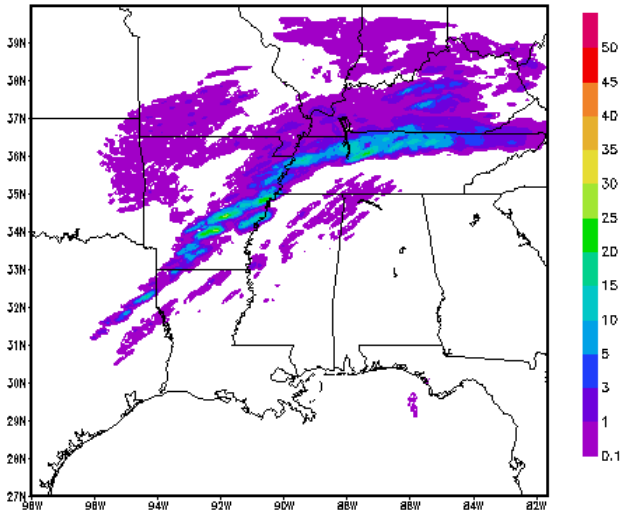
NCEP/CPC 1 hrs accu precip (mm)
valid 01Z 30 APR 2005



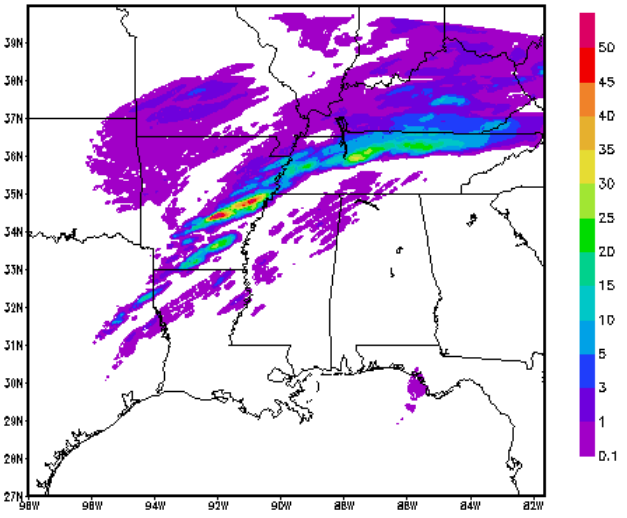
WRF 1 hrs accu precip (mm) (RADAR 12H)
01Z 30 APR 2005

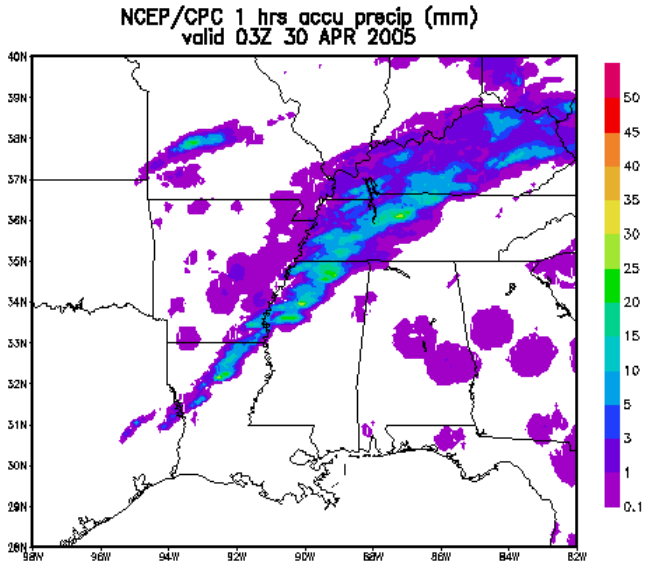


WRF 1 hrs accu precip (mm) (GTS 06H)
01Z 30 APR 2005



WRF 1 hrs accu precip (mm) (gts cold 18Z)
01Z 30 APR 2005




NCEP/CPC 1 hrs accu precip (mm)
valid 03Z 30 APR 2005
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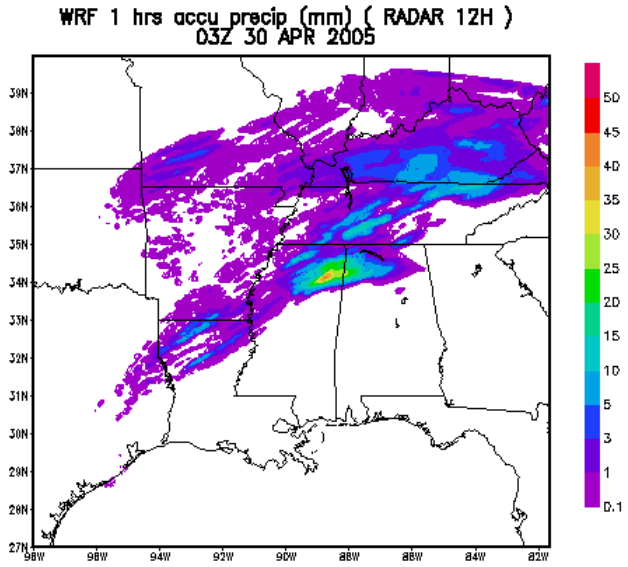
WRF 1 hrs accu precip (mm) (RADAR 12H)
03Z 30 APR 2005
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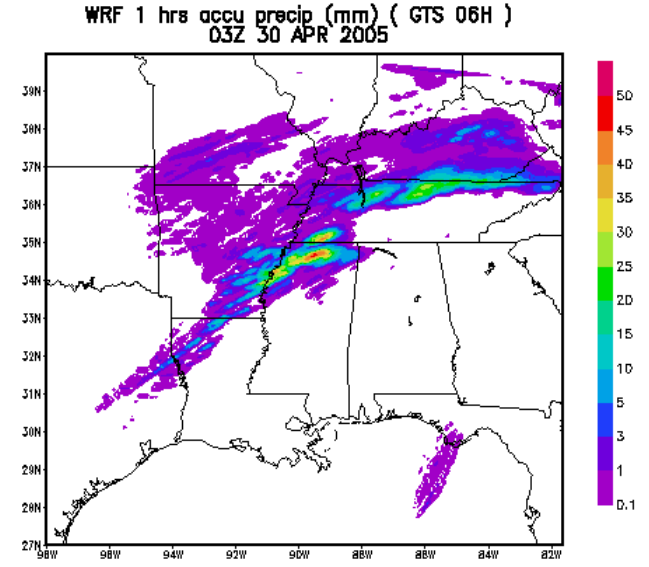
WRF 1 hrs accu precip (mm) (GTS 06H)
03Z 30 APR 2005
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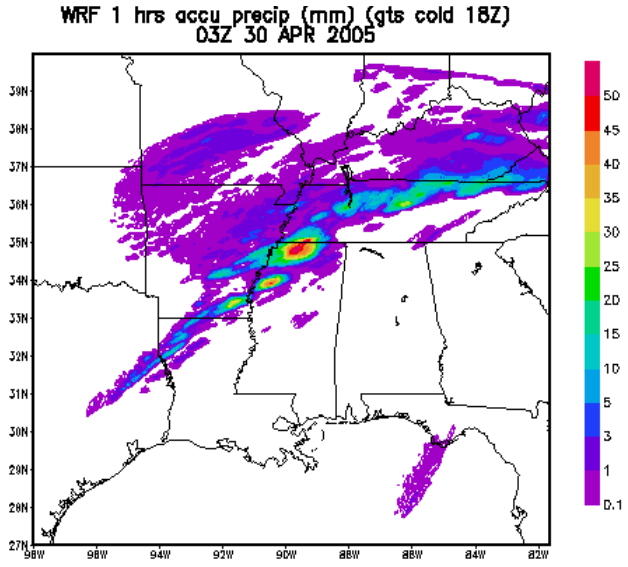
WRF 1 hrs accu precip (mm) (gts cold 18Z)
03Z 30 APR 2005
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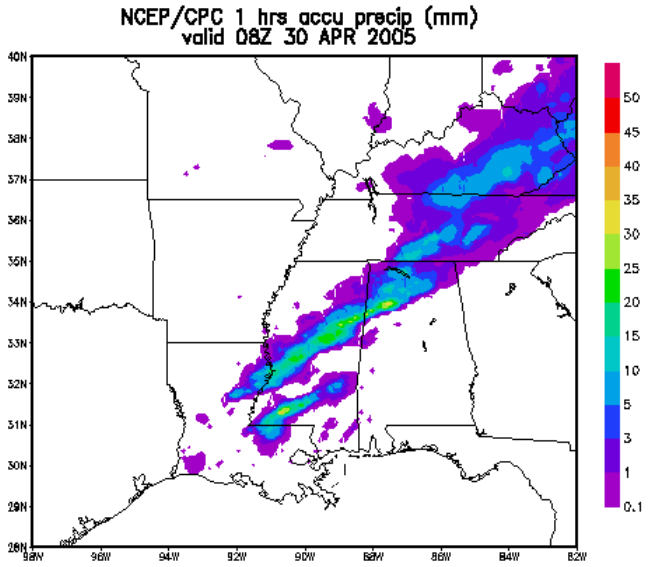
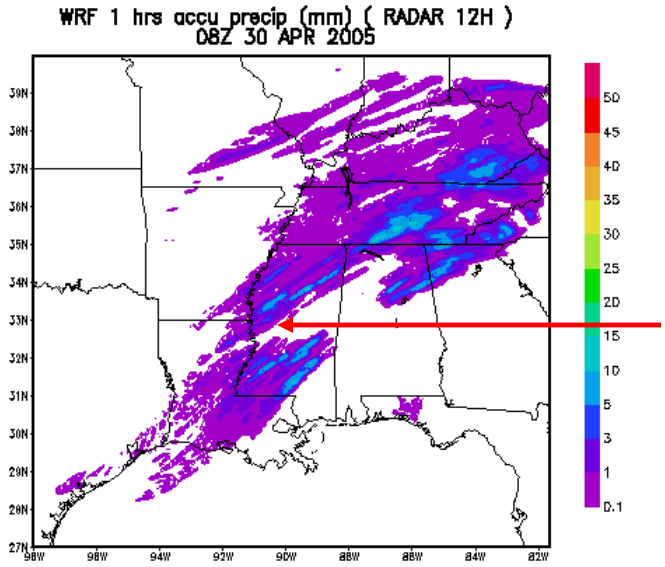
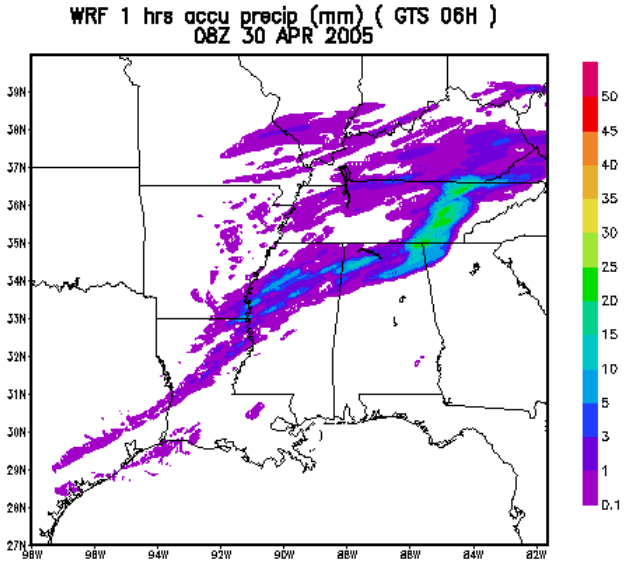
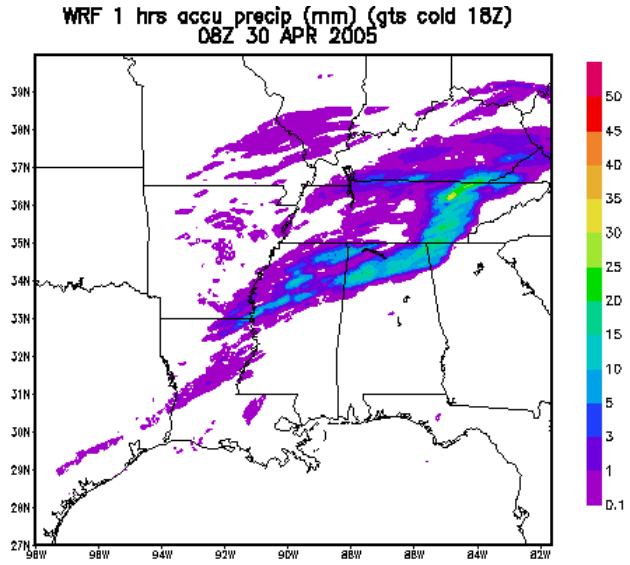
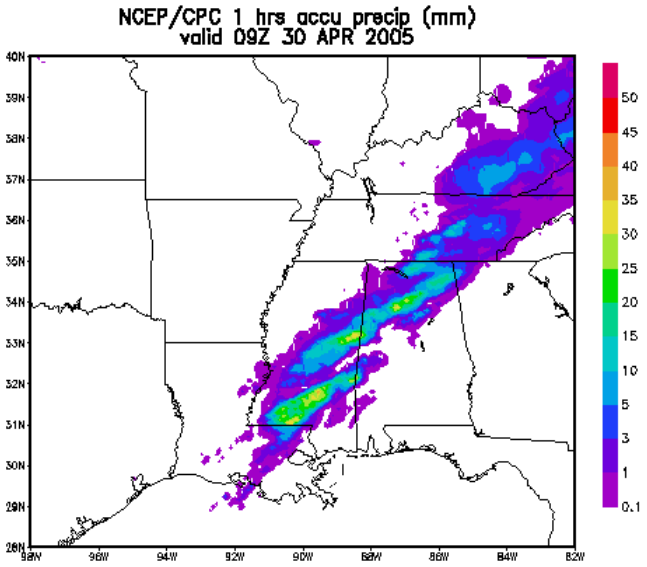


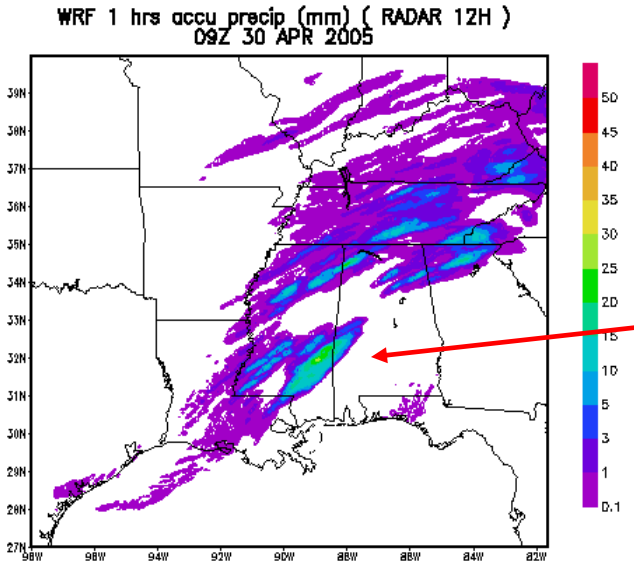


Even radar does not fully predict squall line

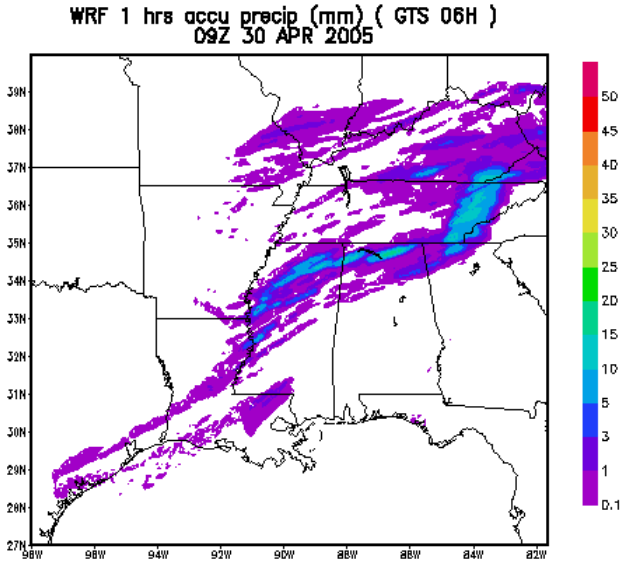


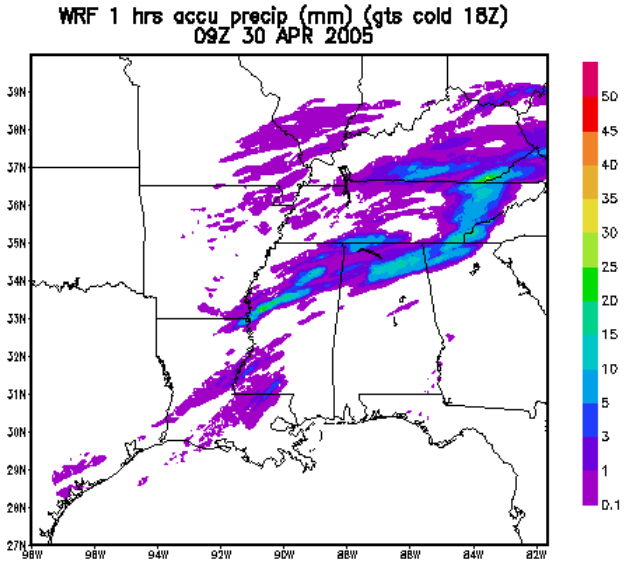


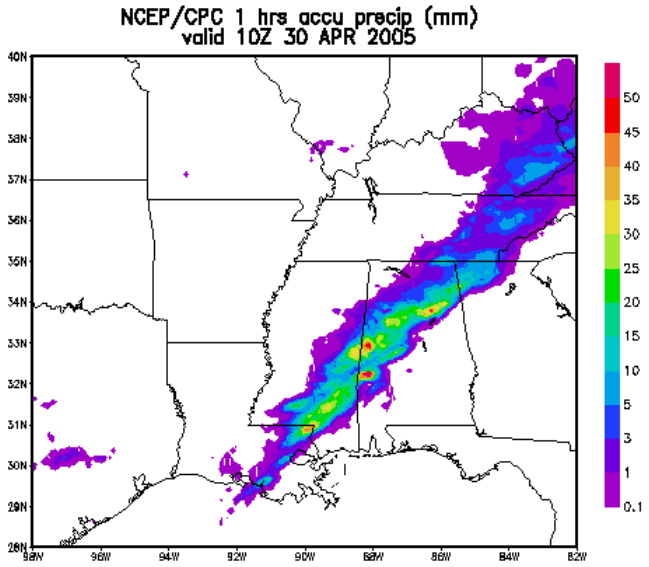




But radar predicts new squall line






NCEP/CPC 1 hrs accu precip (mm)
valid 10Z 30 APR 2005
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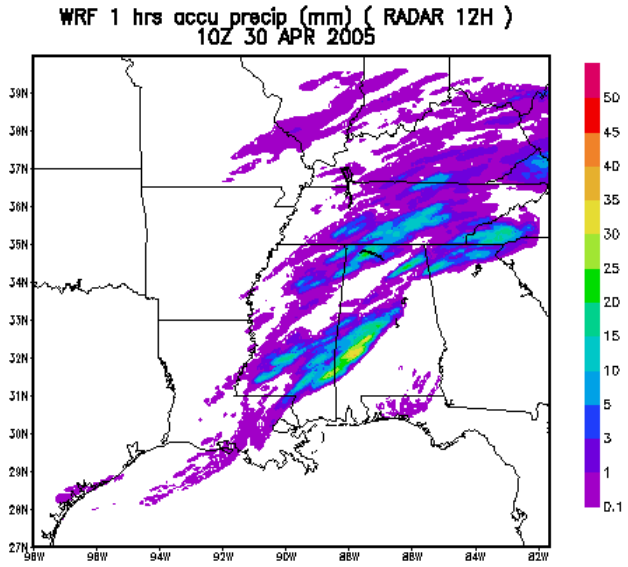
WRF 1 hrs accu precip (mm) (RADAR 12H)
10Z 30 APR 2005
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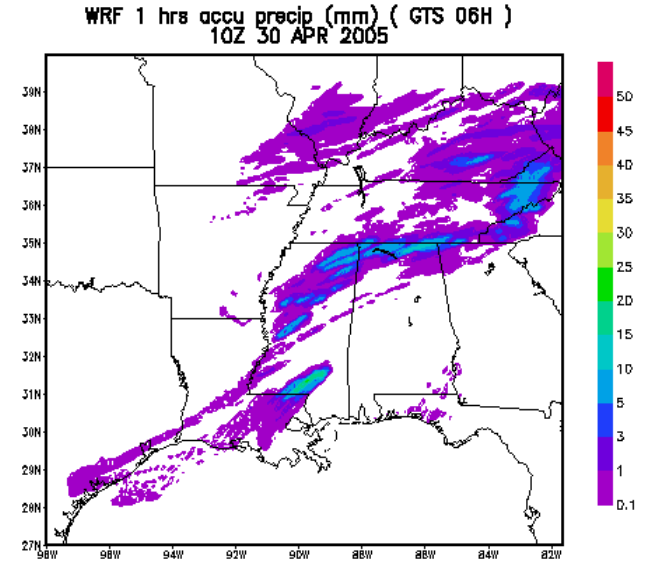
WRF 1 hrs accu precip (mm) (GTS 06H)
10Z 30 APR 2005
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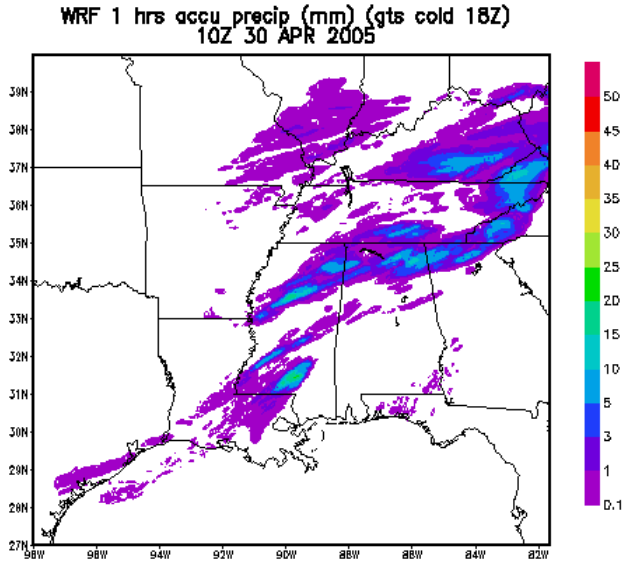
WRF 1 hrs accu precip (mm) (gts cold 18Z)
10Z 30 APR 2005
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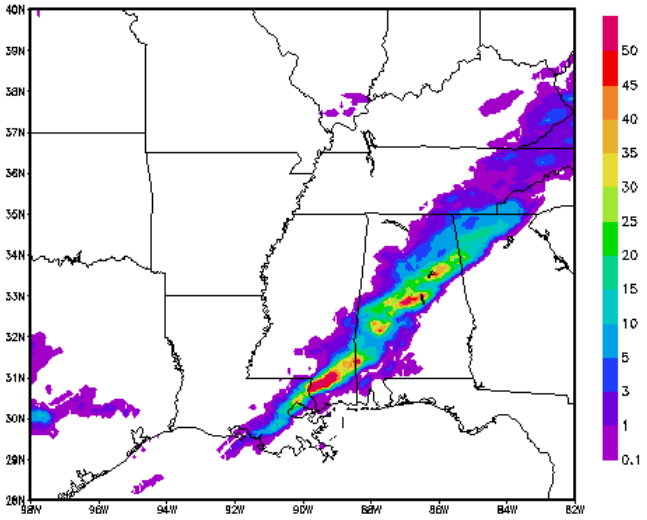
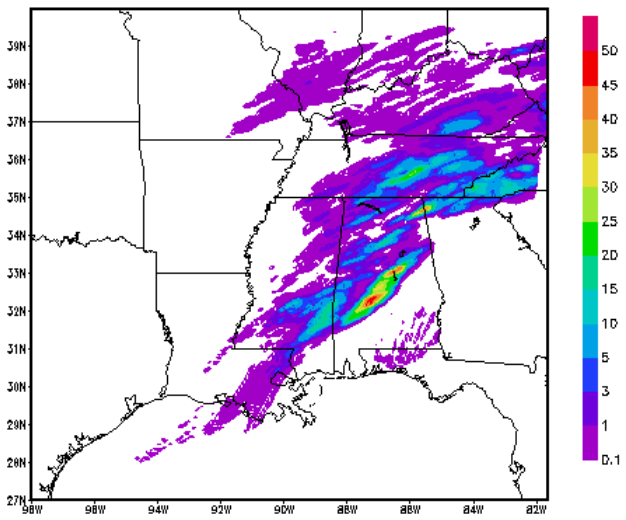
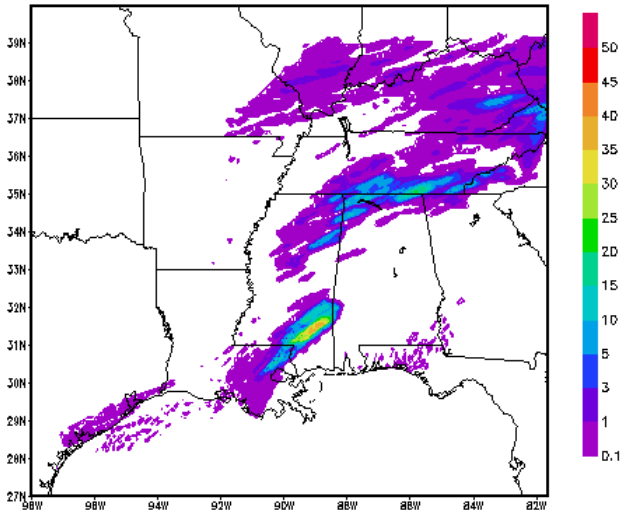
NCEP/CPC 1 hrs accu precip (mm)
valid 11Z 30 APR 2005



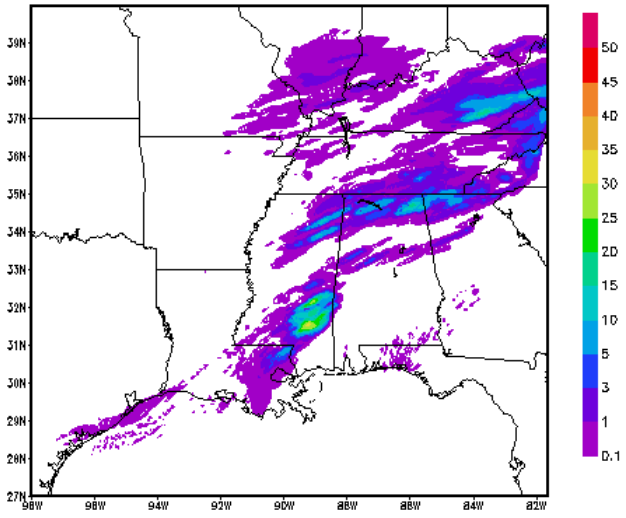
WRF 1 hrs accu precip (mm) (RADAR 12H)
11Z 30 APR 2005

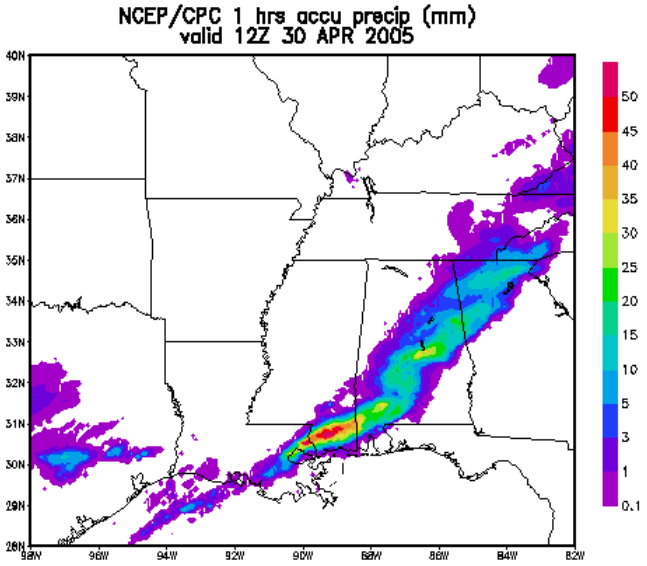


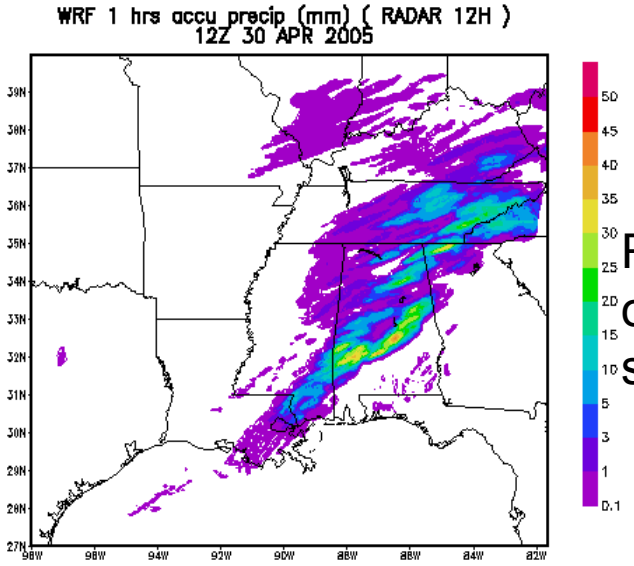
WRF 1 hrs accu precip (mm) (GTS 06H)
11Z 30 APR 2005



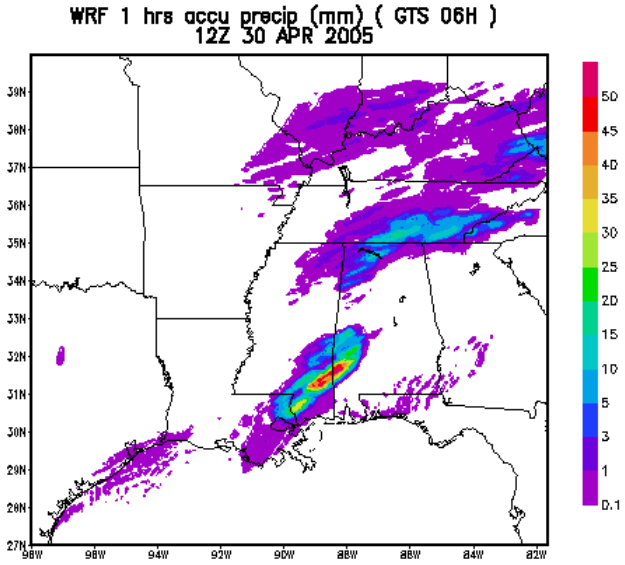
WRF 1 hrs accu precip (mm) (gts cold 18Z)
11Z 30 APR 2005

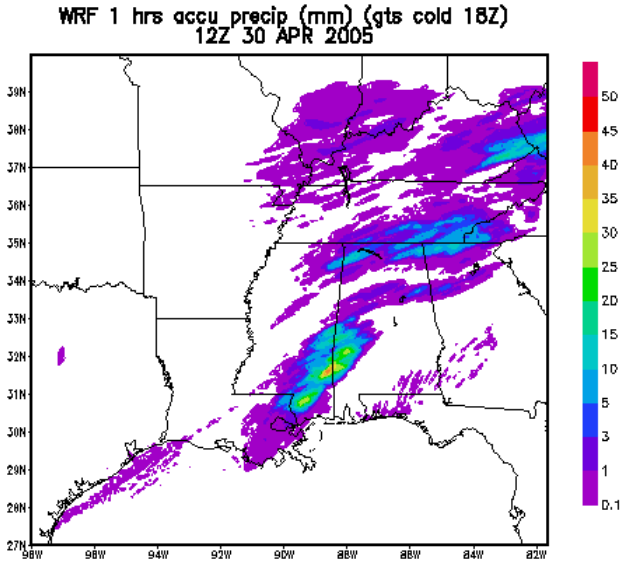






Radar depicts overall structure better





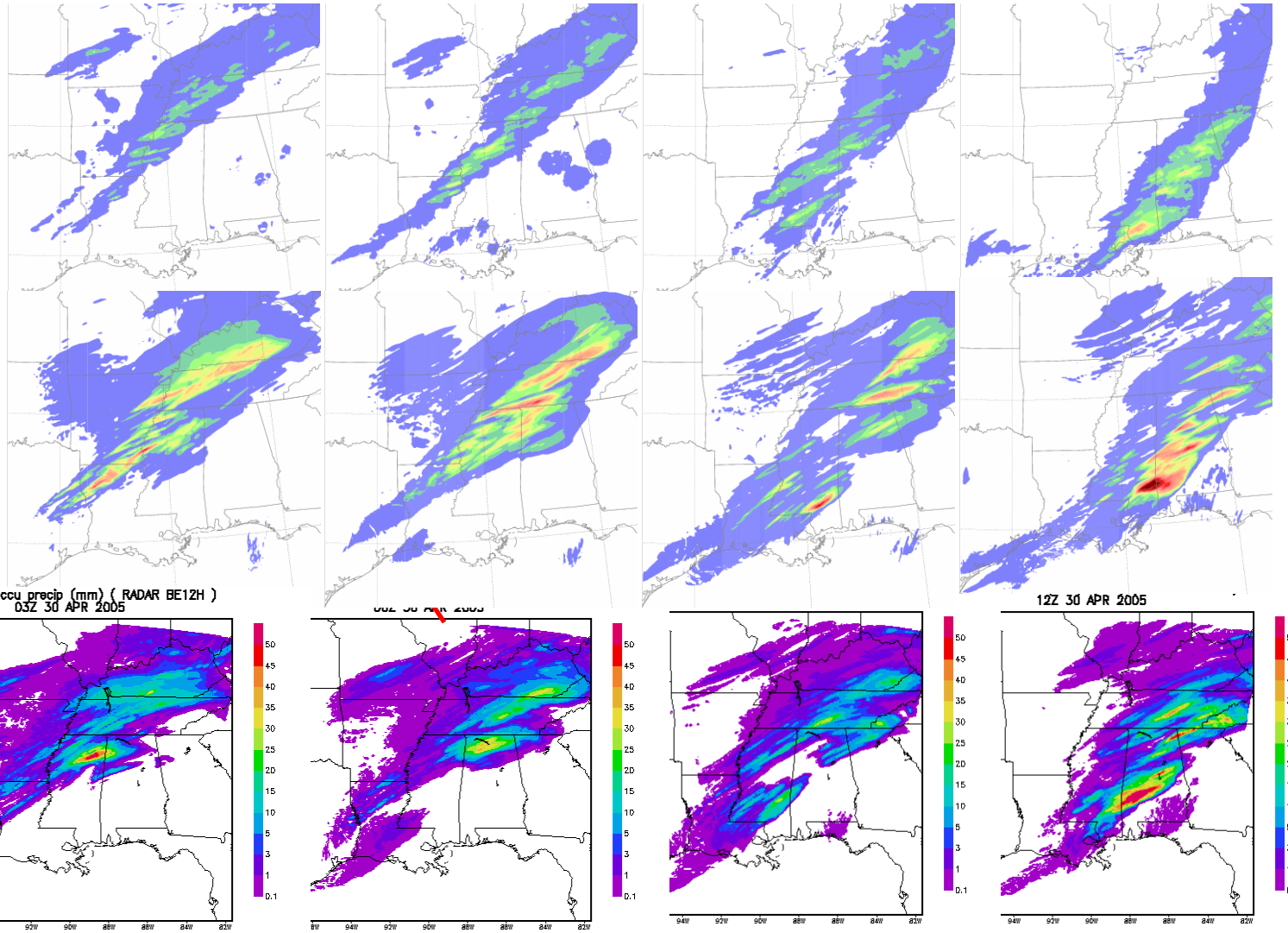
Model comparisons of NMC method to ensemble background errors.

Comparison of two forecasts, 3-h accumulated rain

Observed

With Ensemble Background Error

With NMC Background Error



Fcst time: 03 06 09 12

Results are somewhat different, but neither seems to be better or worse

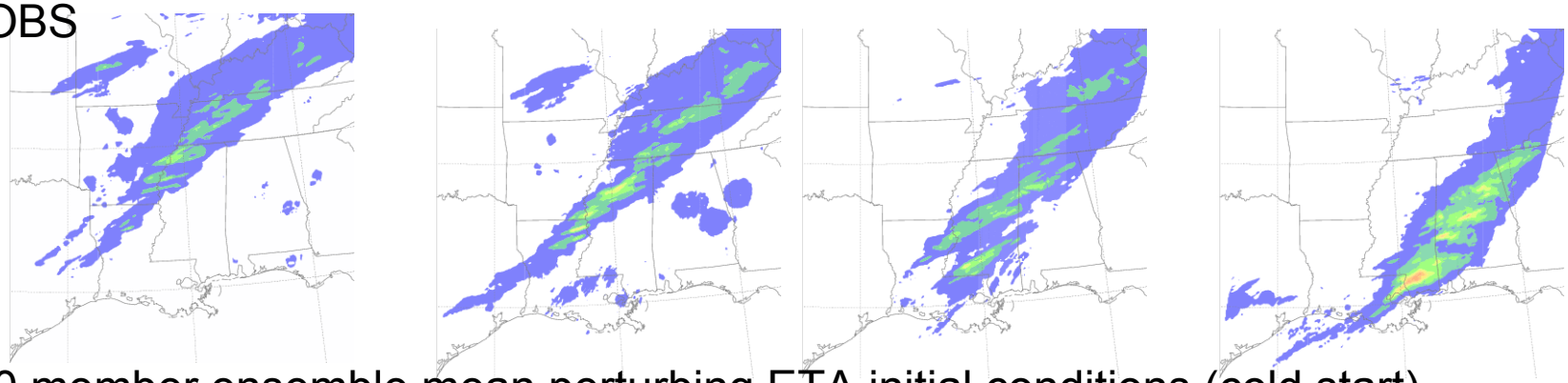
6. Conclusions

- 6-h and 12-h background errors (NMC method) yield similar results.
- Analysis increments from radar data different than those based on just using standard observations.
- Analysis increments for case study different than those based on WRF default background
- SCAN data provided small impact
- Radar data assimilation provided better squall line structure overall, and predicted the formation of a secondary squall. However, it did not predict the squall line structure entering Mississippi very well.
- Simulations using ensemble background error yielded somewhat different results, but not an apparently significant difference. This suggests using ensemble technique may be worth further study, since it is easier to implement and contains flow-dependent structure.

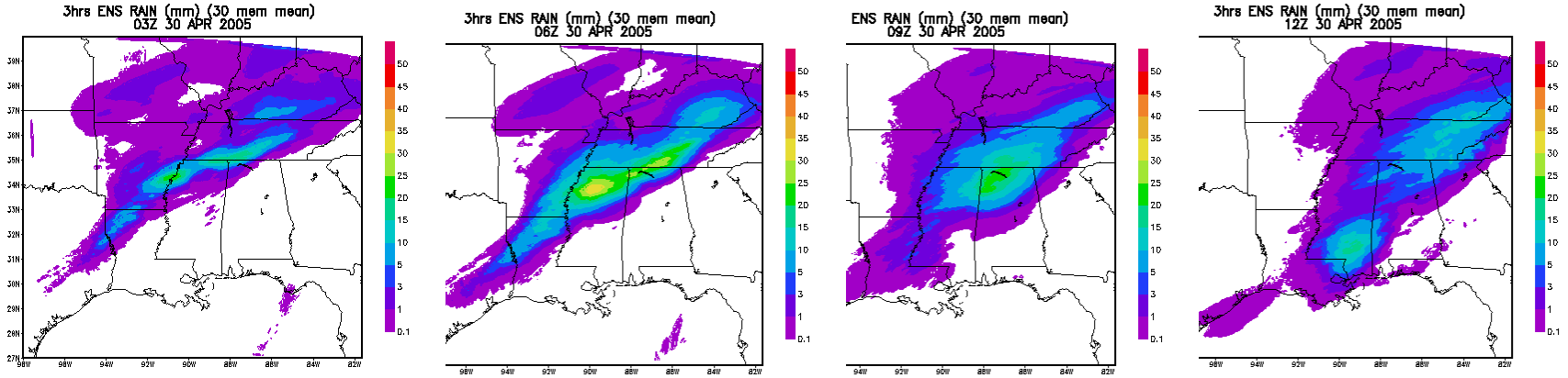
Bonus slides (not used in talk),
but available for potential questions

3 hours accumulated rainfall

OBS

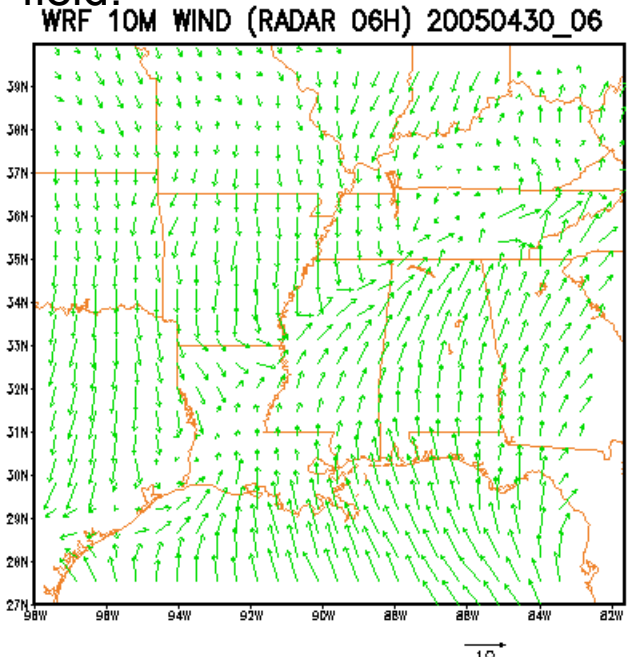


30 member ensemble mean perturbing ETA initial conditions (cold start)

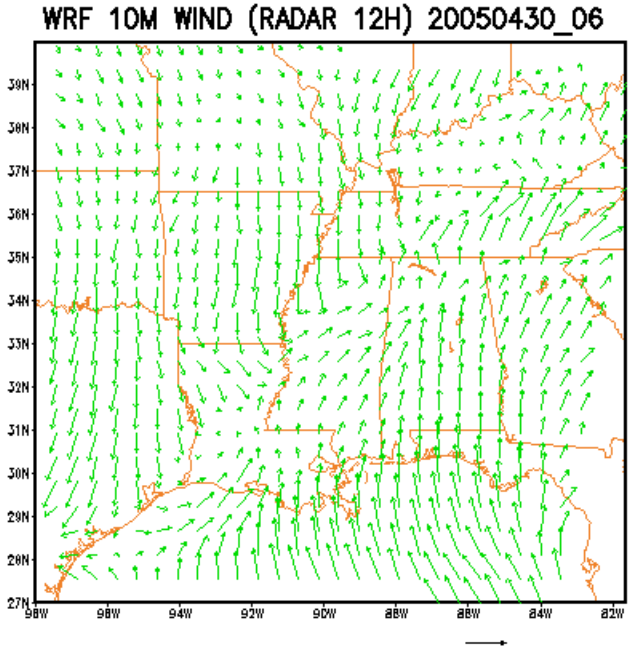


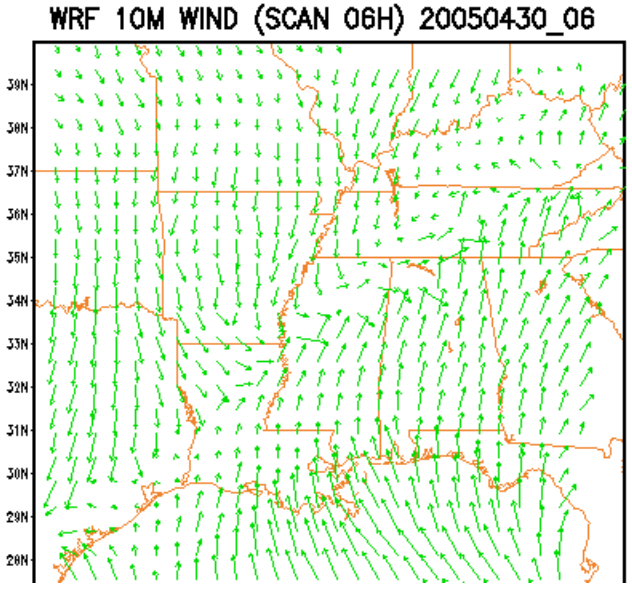
Leading time 03 06 09 12

Wind and convergence areas look close. The main differences will be from the added thermodynamic information from radar, and the 3D wind field.



RADAR





SCAN