



Implementation and Evaluation of
WSR-88D Reflectivity Data
Assimilation for WRF-ARW via GSI and
Cloud Analysis

Ming Hu
University of Oklahoma

1. Previous work and Goal of visiting

- Previous work: Radar reflectivity in convective-scale assimilation and mode forecast system
 - Analyzed through a complex cloud analysis procedure
 - Horizontal resolution: 3-km or 1-km
 - Critical for capturing the behavior of individual cells in short-term forecast (2-3 hours)
 - Within ARPS system
- My visiting: Impacts of radar reflectivity in operational analysis and forecast system
 - Cloud analysis is used with GSI and WRF-ARW model
 - 9-km horizontal grid
 - Relatively larger scale weather system, such as storm cluster



2. Introduction to cloud analysis package

- Cloud analysis can
 - ❑ Build up hydrometers fields (cloud water, cloud ice, rain, snow, and hail)
 - ❑ Adjust in-cloud moisture and temperature in initial fields
 - ❑ reduce spin-up problem in short-term forecast
- Cloud and precipitation information
 - ❑ surface cloud observations (GOS, METARs)
 - ❑ radar reflectivity data
 - ❑ satellite data
 - ❑ Background (temperature, moisture)



2. Introduction to cloud analysis package - in-cloud temperature adjustment

- Latent heat scheme:
 - Based on latent heat

$$\Delta\theta' = \frac{\beta_{\theta} L_v (\Delta q_c + \Delta q_i)}{c_p \pi}$$

- Moisture adiabatic scheme:
 - Based on a moist-adiabatic temperature profile
 - Heating is applied only in updraft regions
 - The effect of entrainment is considered

3. Systems used in experiment

- GSI
 - Analyze conventional data and provide background fields for cloud analysis
- WRF-ARW
 - Forecast
- WRF2ARPS and ARPS2WRF
 - Exchange fields between WRF-ARW grid and ARPS grid
- 88D2ARPS
 - Process radar data: quality control and mapping reflectivity from radar coordinate into ARPS grid

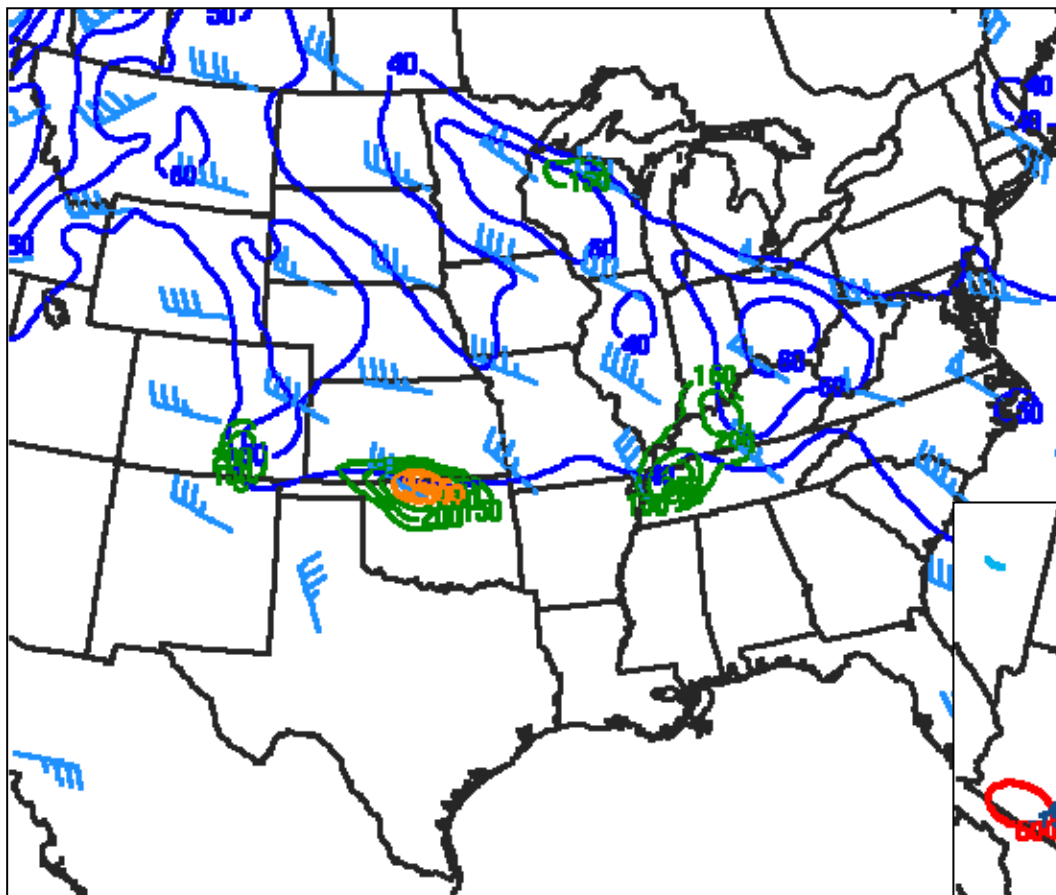




4. 23 May 2005 Central Plains Storm Cluster Case

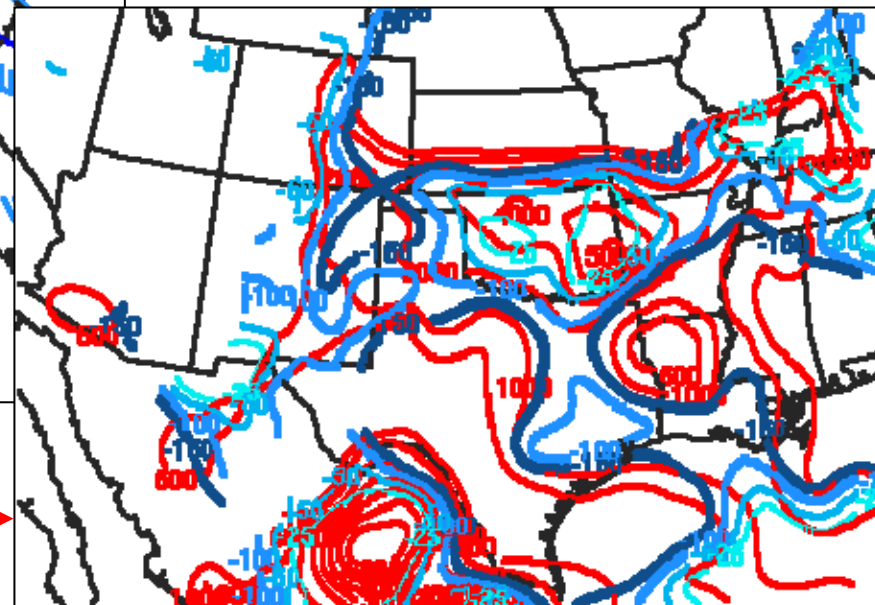
- **Initiation stage: 03Z**
- **Mature stage: 04~11Z**
- **Decay stage : after 11Z**
- **Dissipated by 13Z**

23 May 2005 Central Plains Storms -Environment (continued)



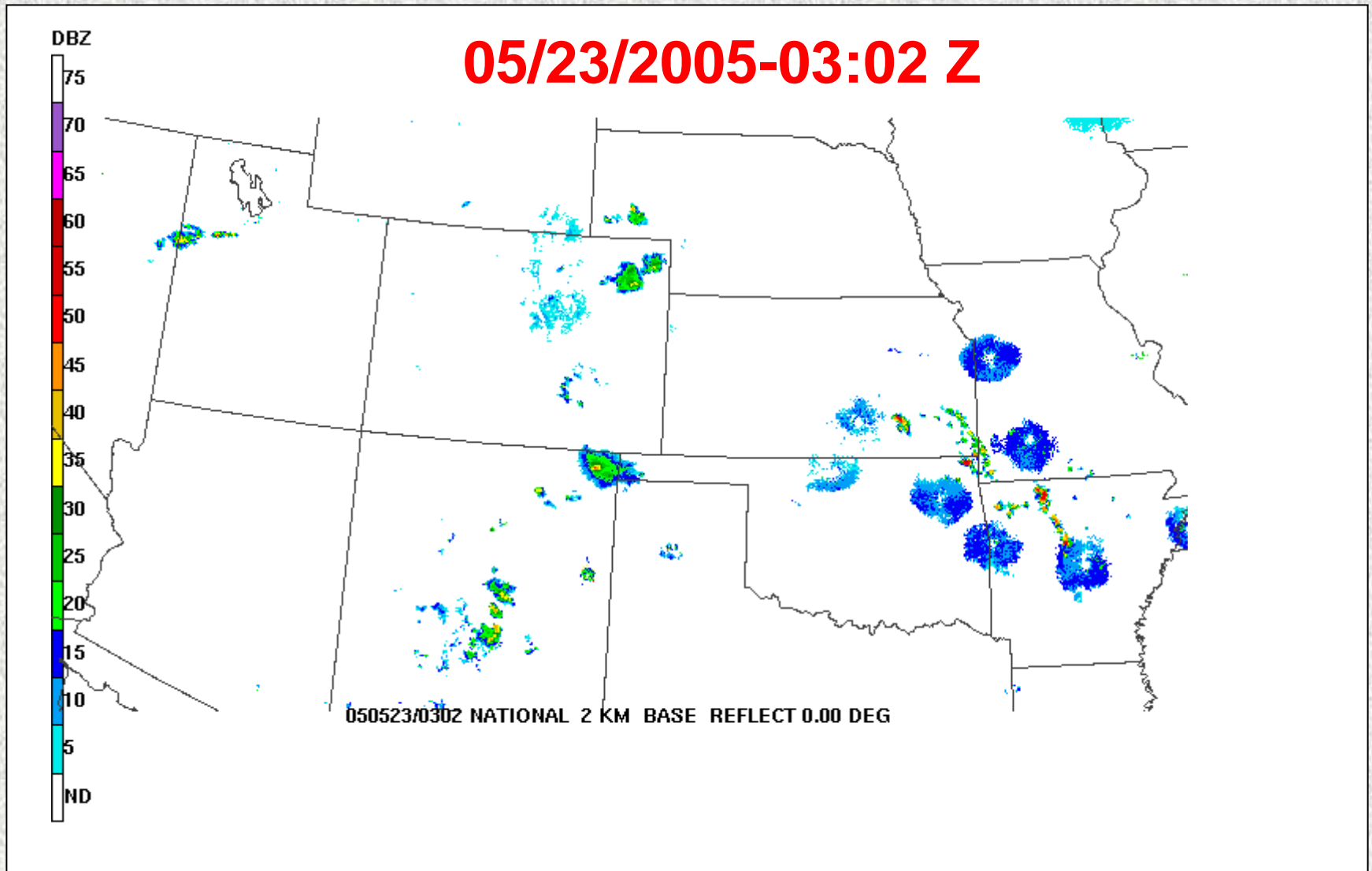
**SRH shear at
0000 Z
May 23, 2005**

**CAPE/CINH at 0000 Z
May 23, 2005**



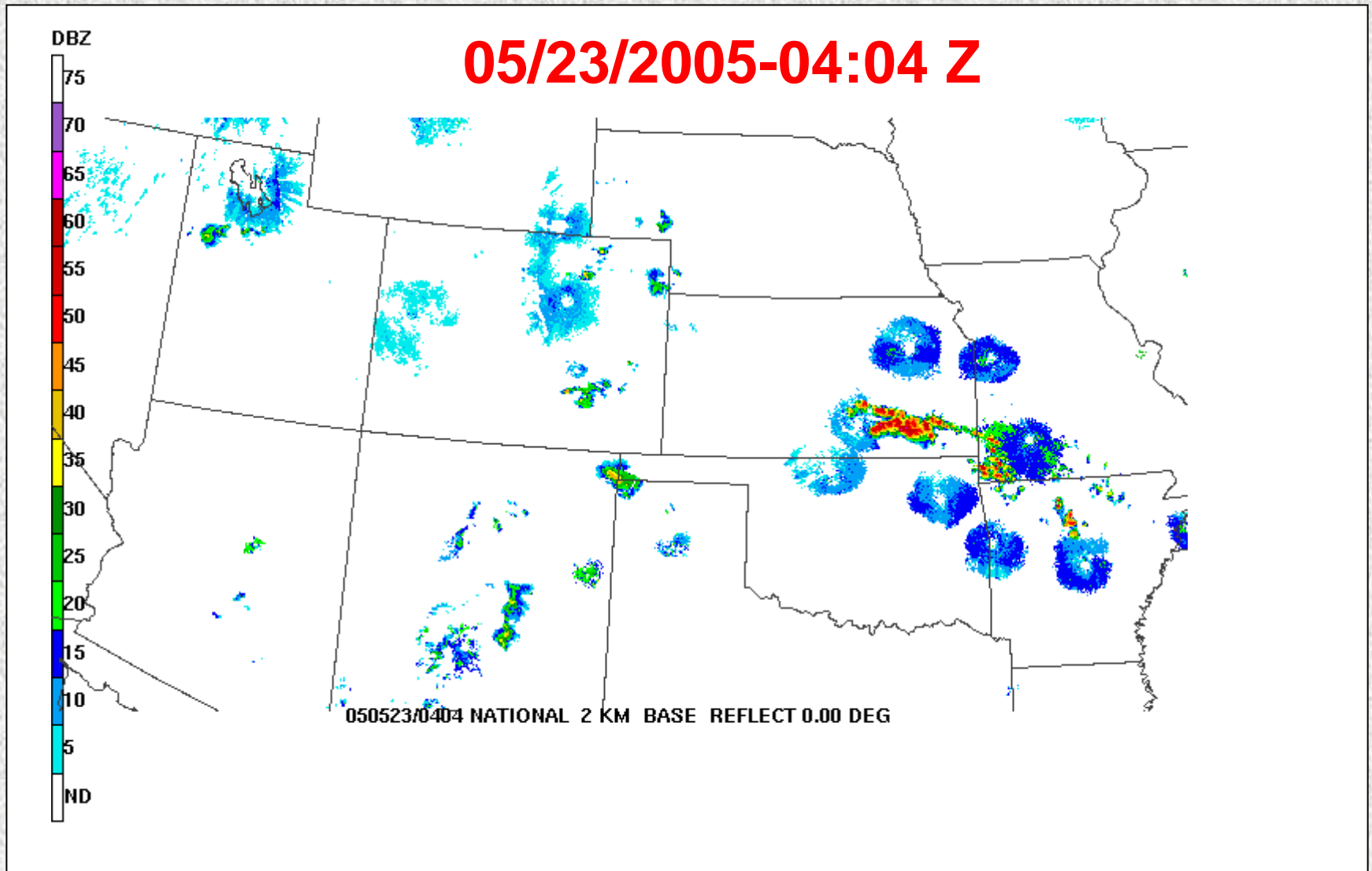
23 May 2005 Central Plains Storms

-Radar base reflectivity



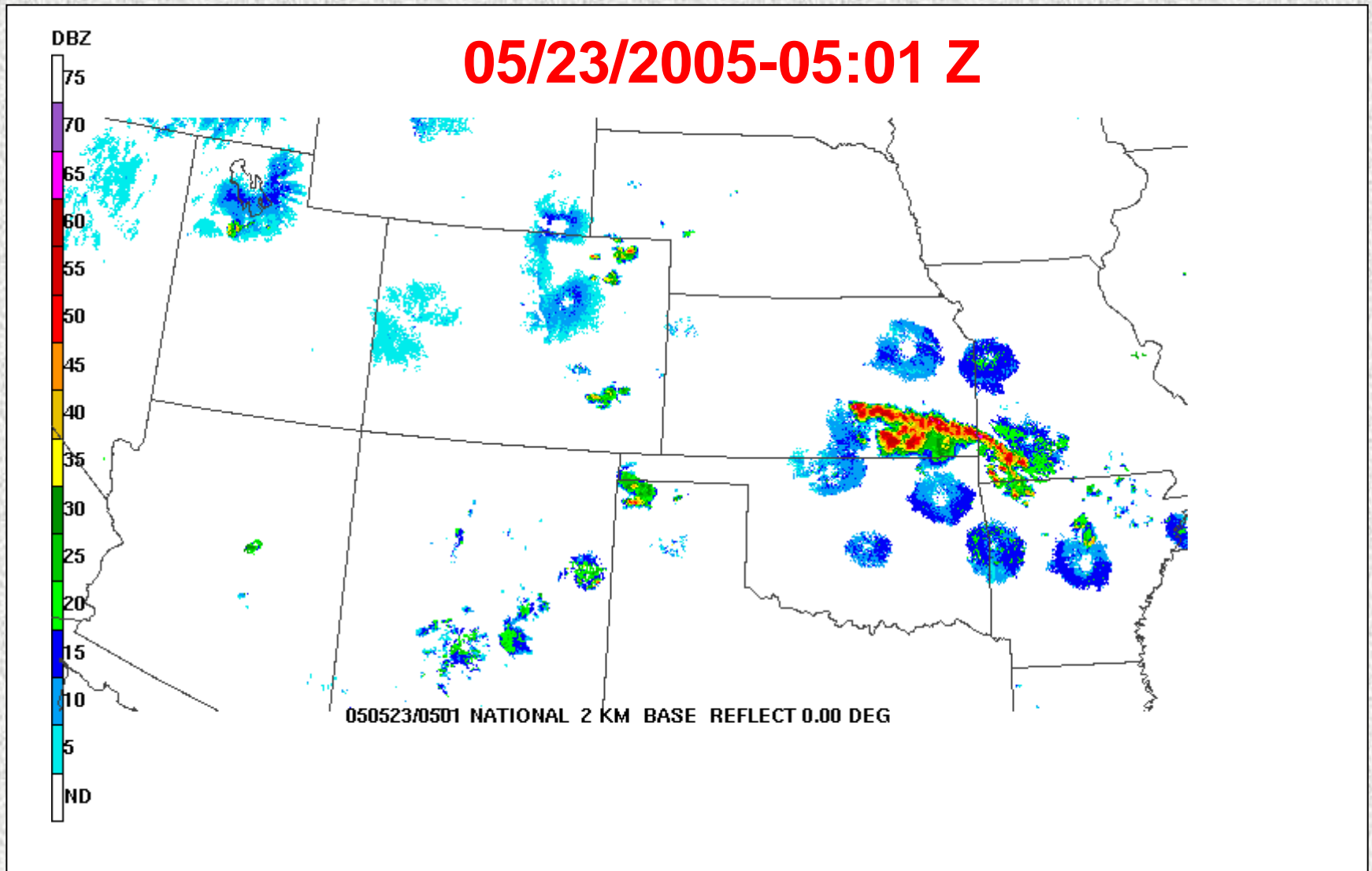
23 May 2005 Central Plains Storms

-Radar base reflectivity



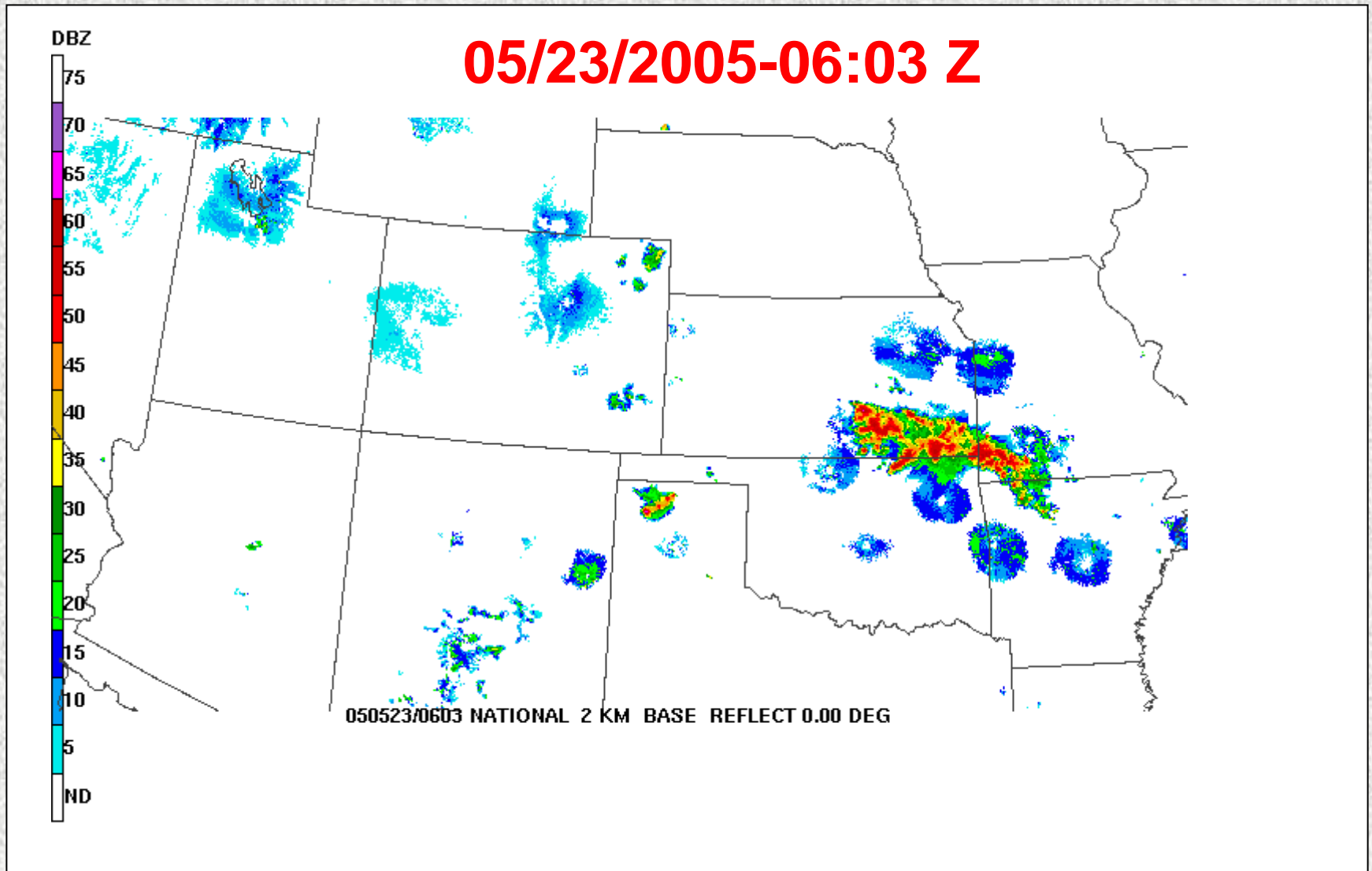
23 May 2005 Central Plains Storms

-Radar base reflectivity



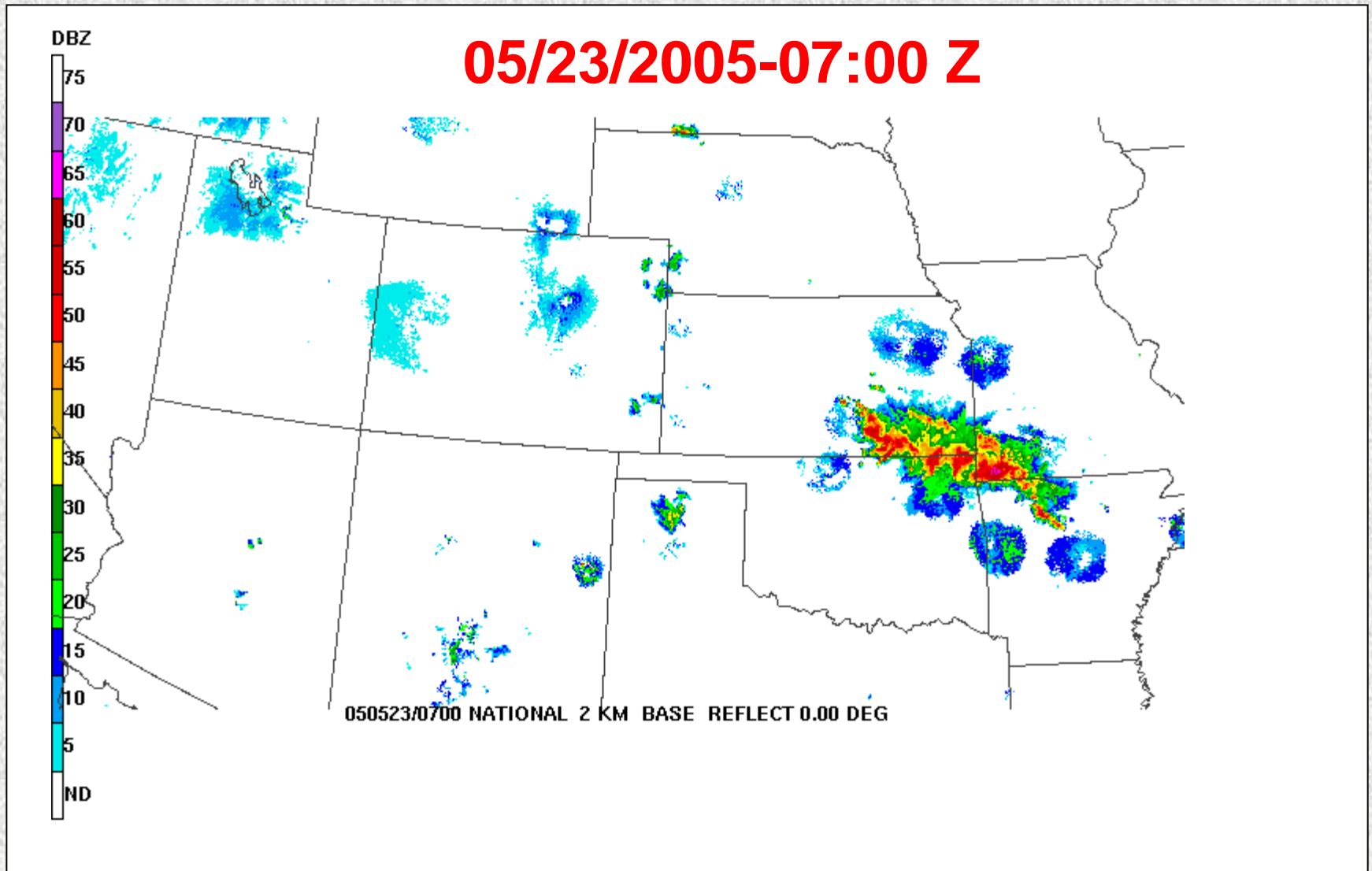
23 May 2005 Central Plains Storms

-Radar base reflectivity



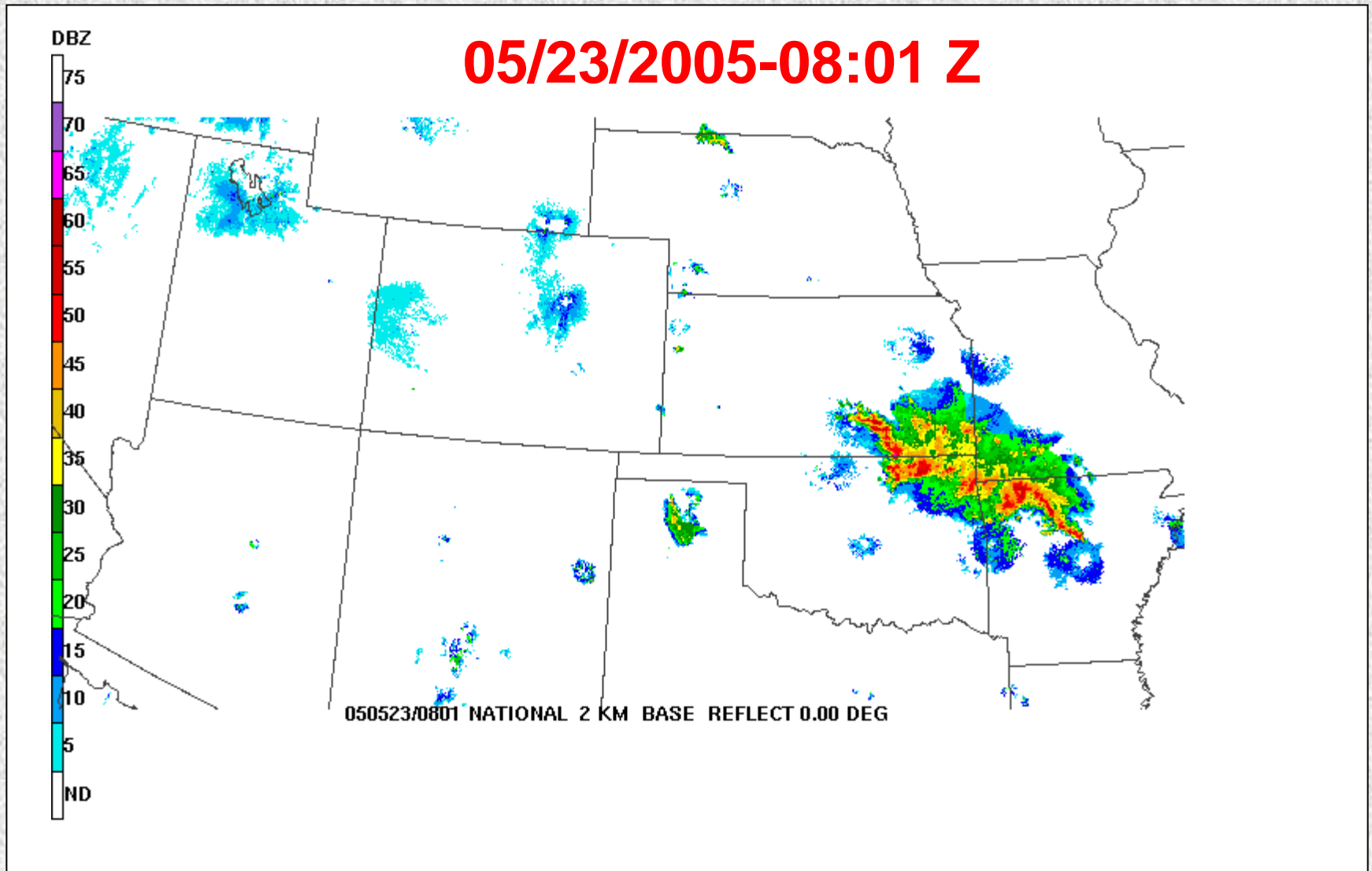
23 May 2005 Central Plains Storms

-Radar base reflectivity



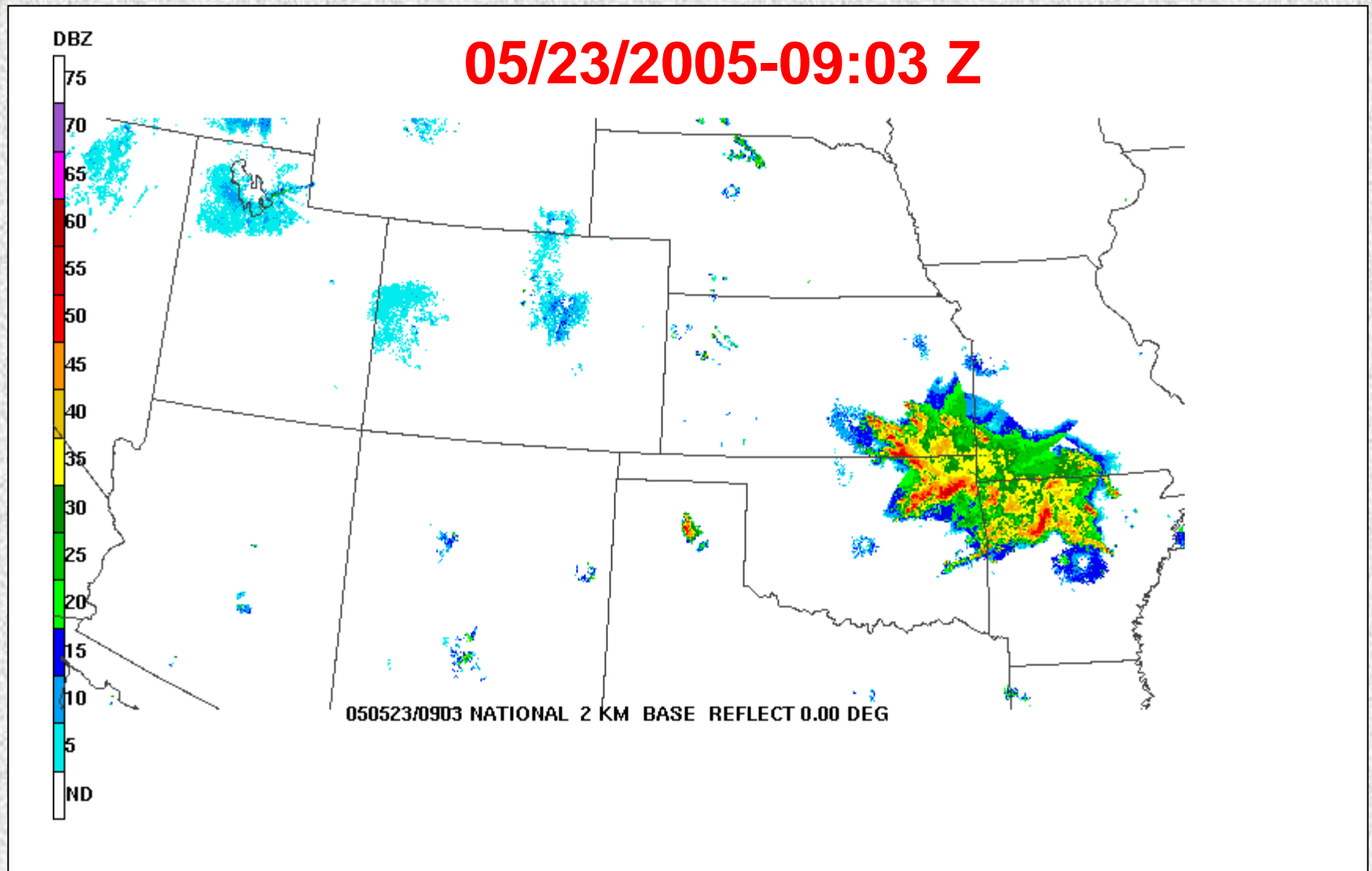
23 May 2005 Central Plains Storms

-Radar base reflectivity



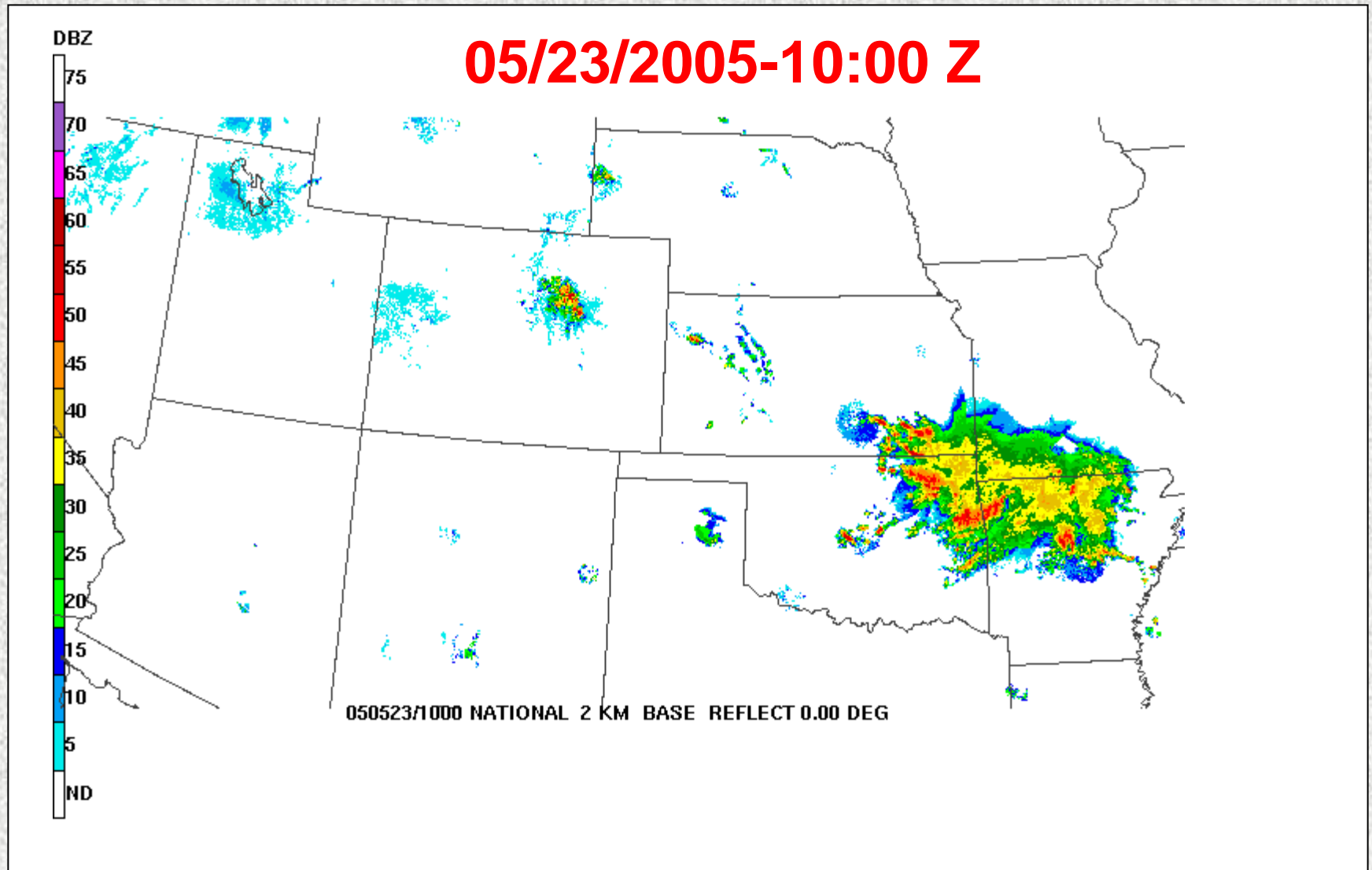
23 May 2005 Central Plains Storms

-Radar base reflectivity



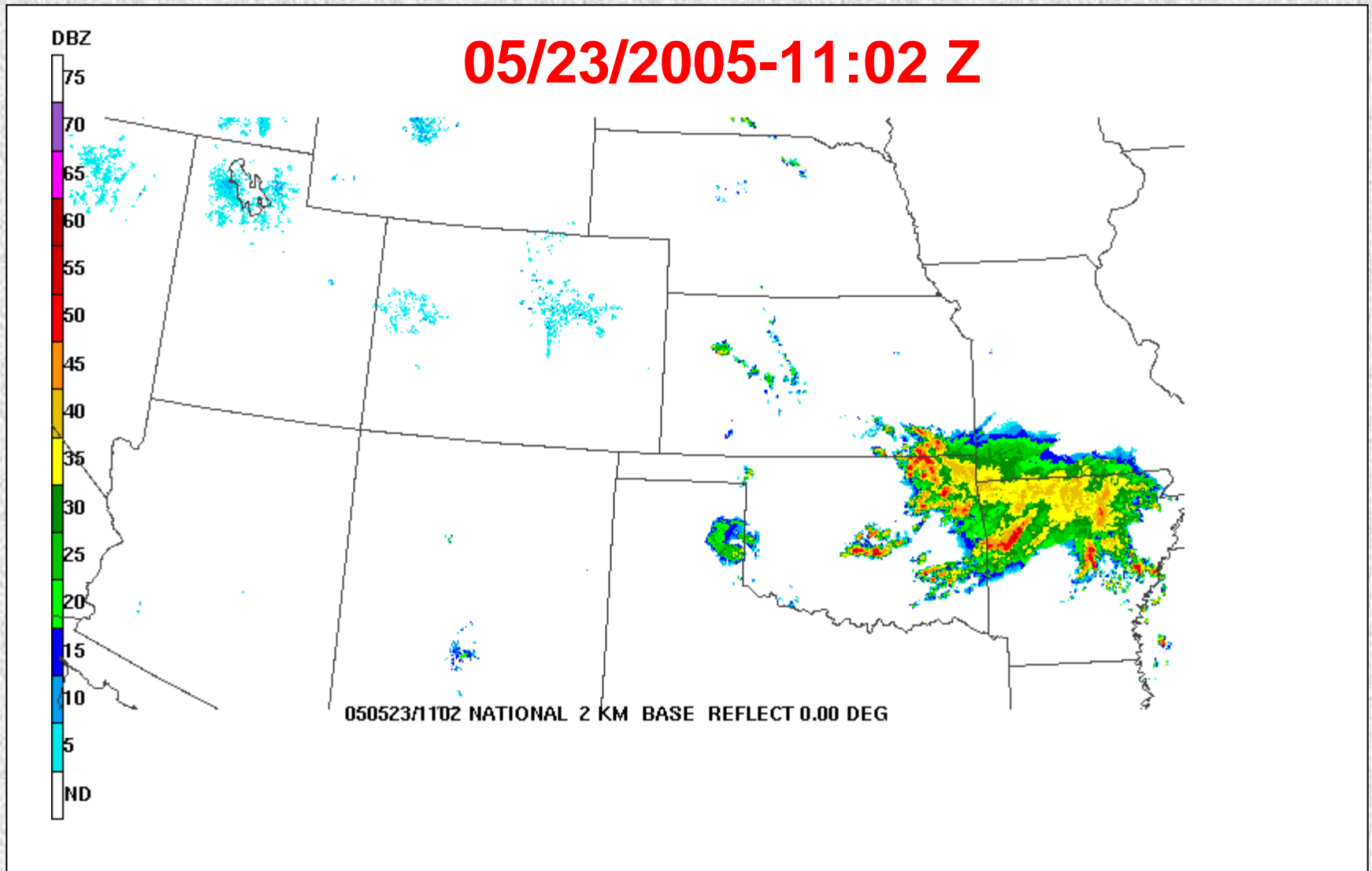
23 May 2005 Central Plains Storms

-Radar base reflectivity



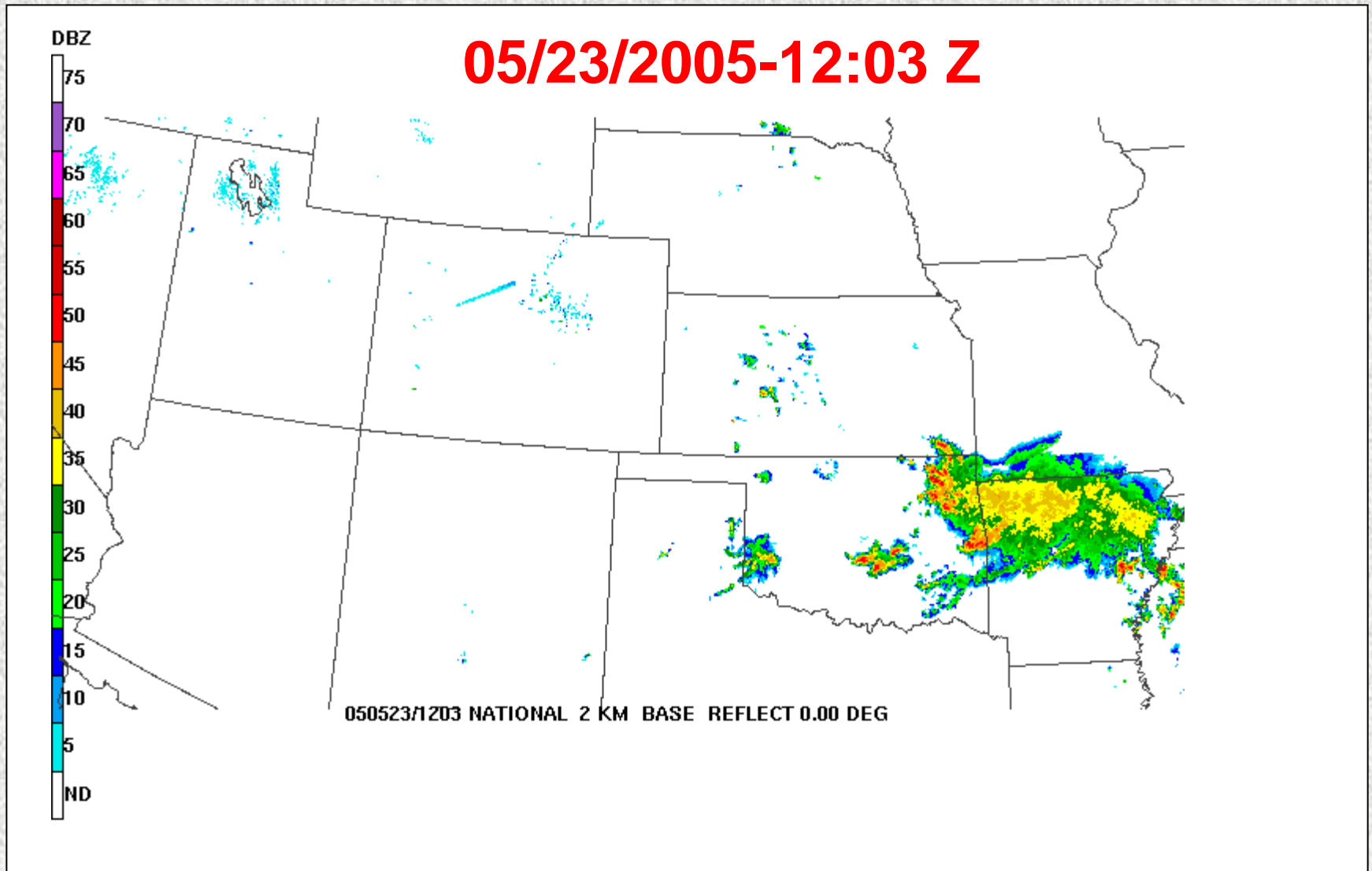
23 May 2005 Central Plains Storms

-Radar base reflectivity



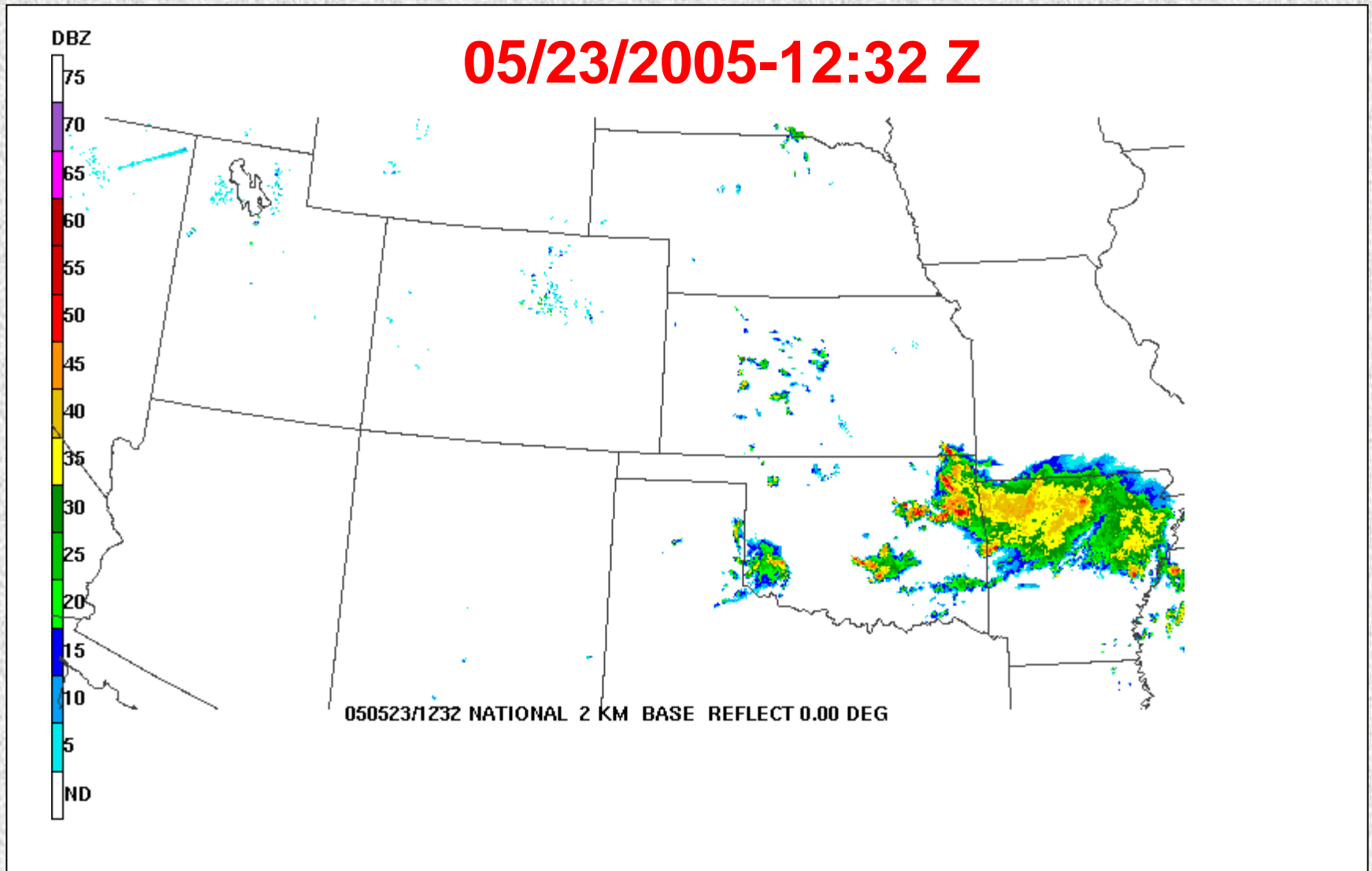
23 May 2005 Central Plains Storms

-Radar base reflectivity



23 May 2005 Central Plains Storms

-Radar base reflectivity





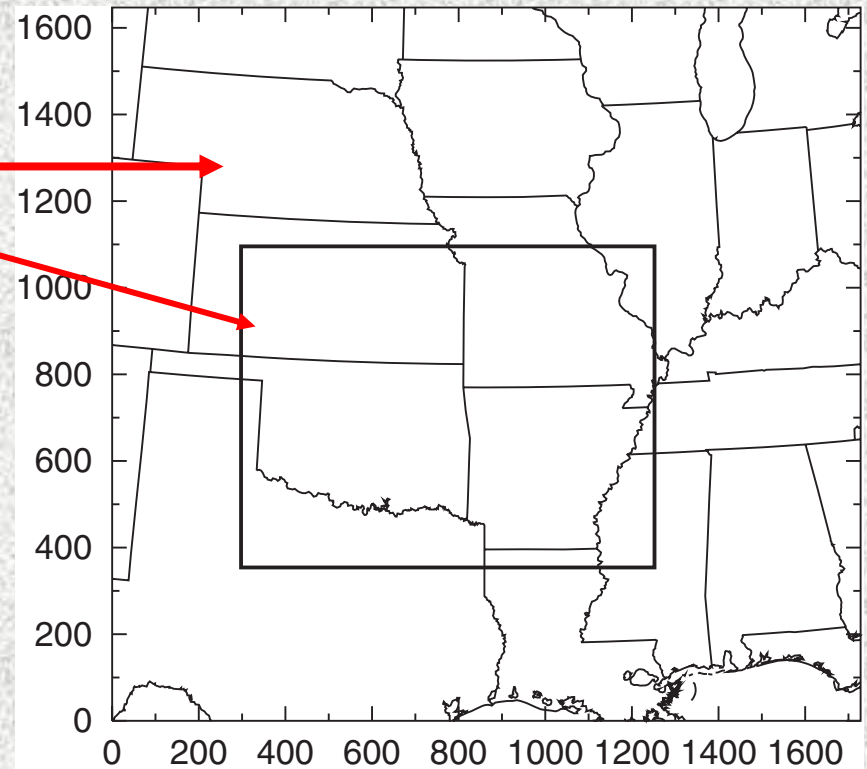
5. Experimental Design

Grid, domain, and initial time

- Horizontal 9 km and vertical 30 levels
- Domain
 - Background and boundary condition come from NAM model forecast
- Analysis conducted at 0600 UTC May 23, 2005
 - Background available
 - Storm are well captured by radars around

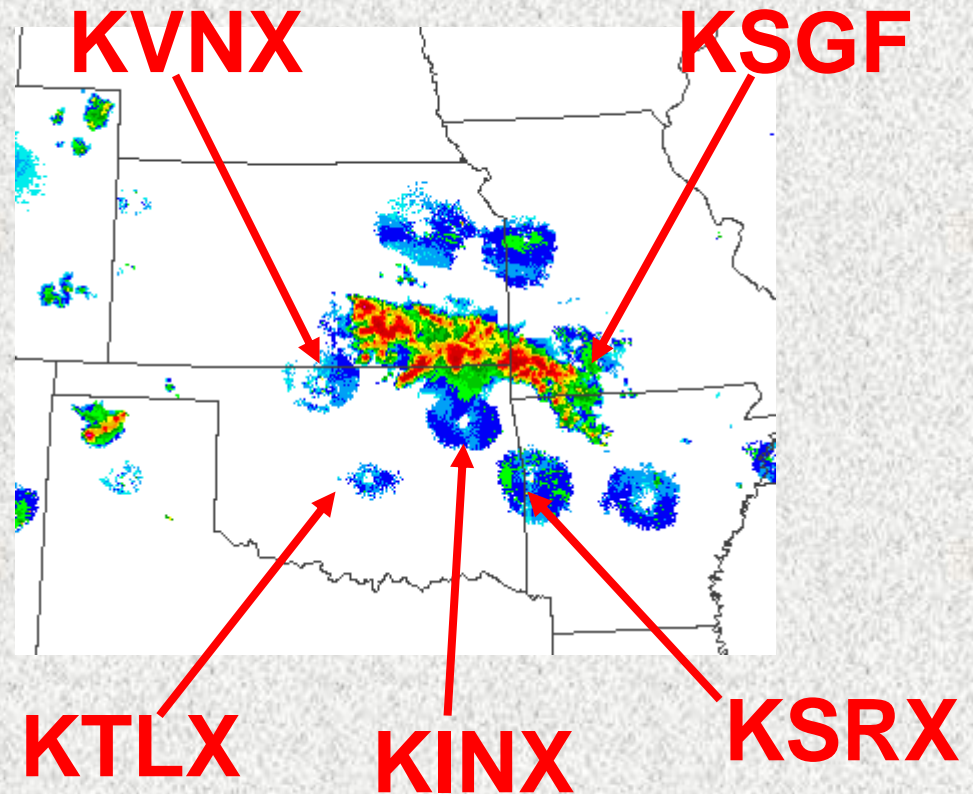
Computation domain

study domain

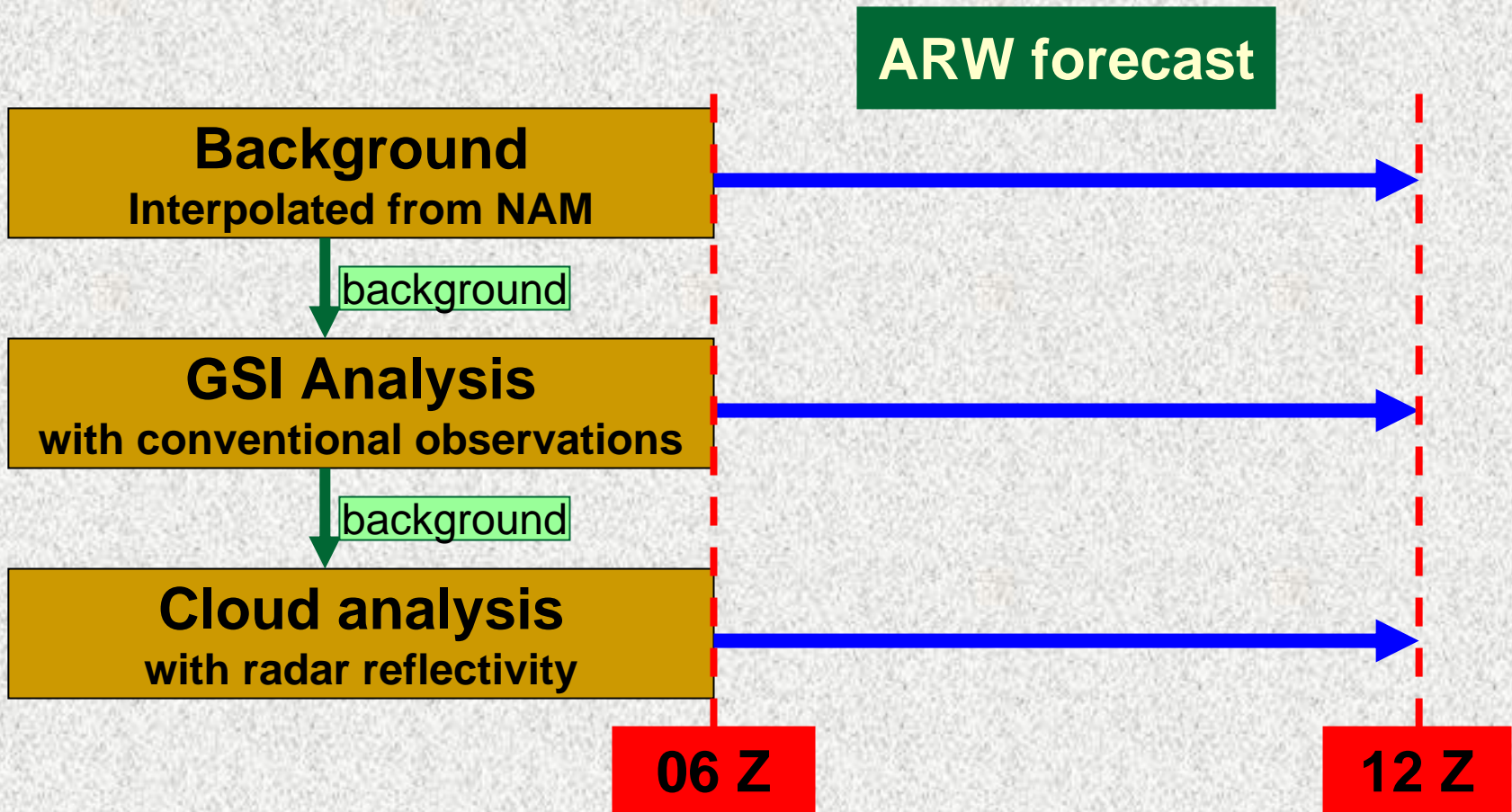


Radar base reflectivity at 0603 Z with radar data

- Reflectivity from 5 radars were used in the cloud analysis
- Only WSR-88D LEVEL-II data were used in the cloud analysis



Three Experiments

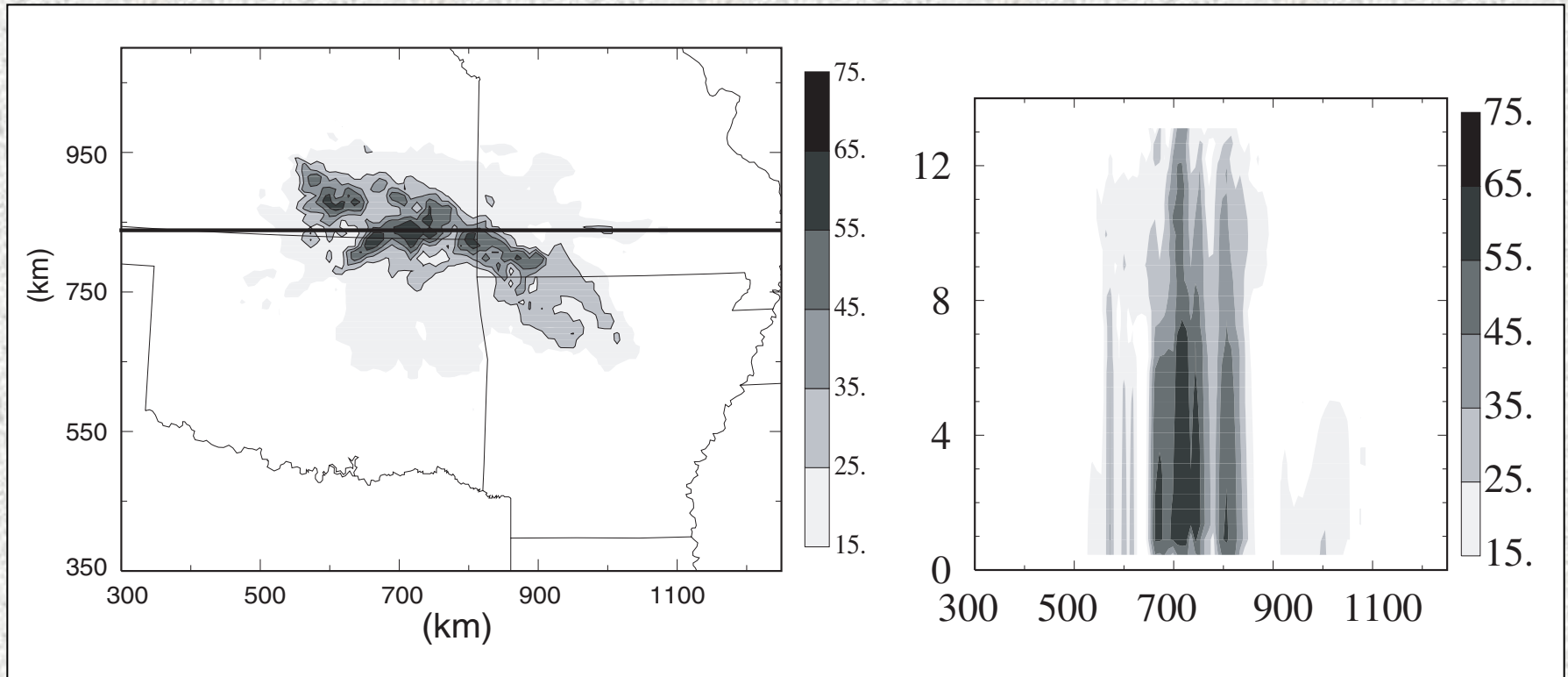




6. Experiment Results

- **Initial condition**
- **Forecast**

Effects of Cloud Analysis on Initial Conditions - observed reflectivity



**Observed composite reflectivity
from radars around storm cluster**

at 0600 Z

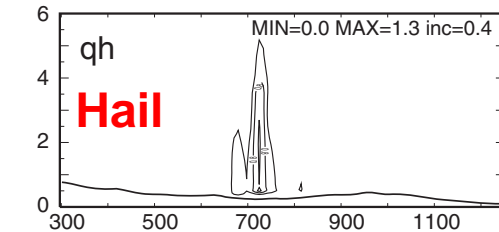
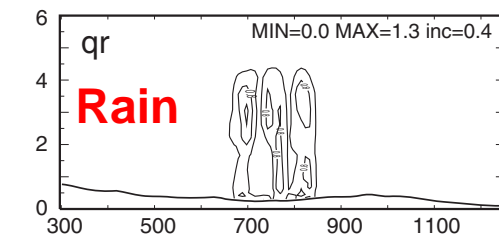
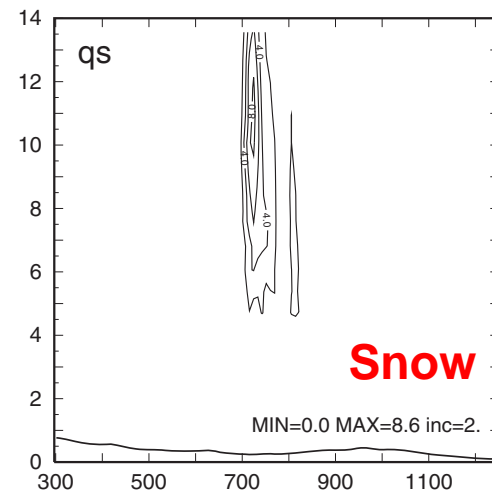
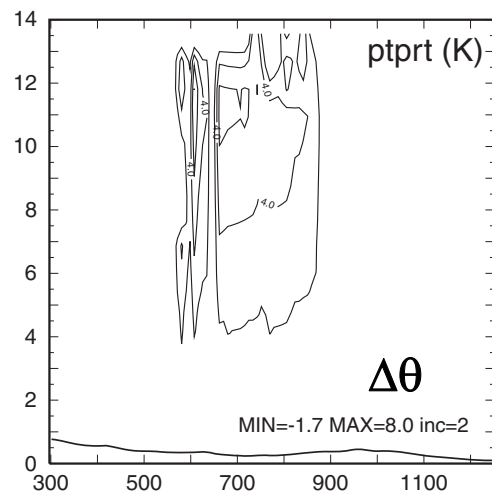
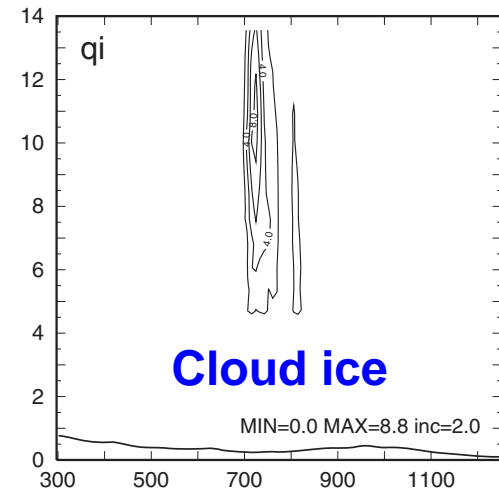
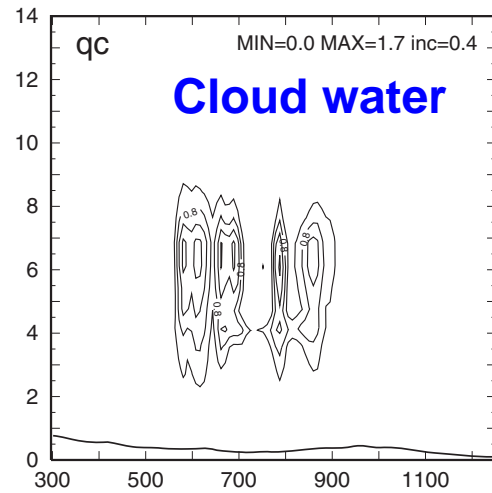
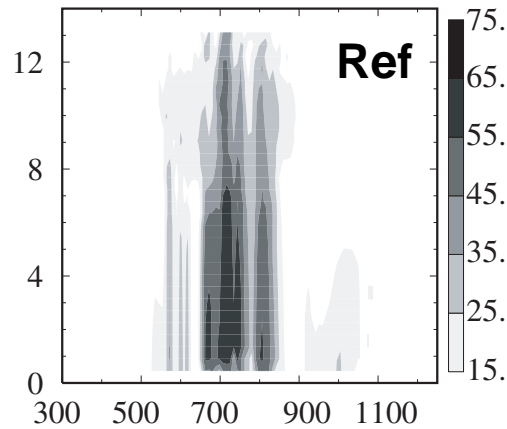
**Cross-section of
observed reflectivity**

at 0600 UTC



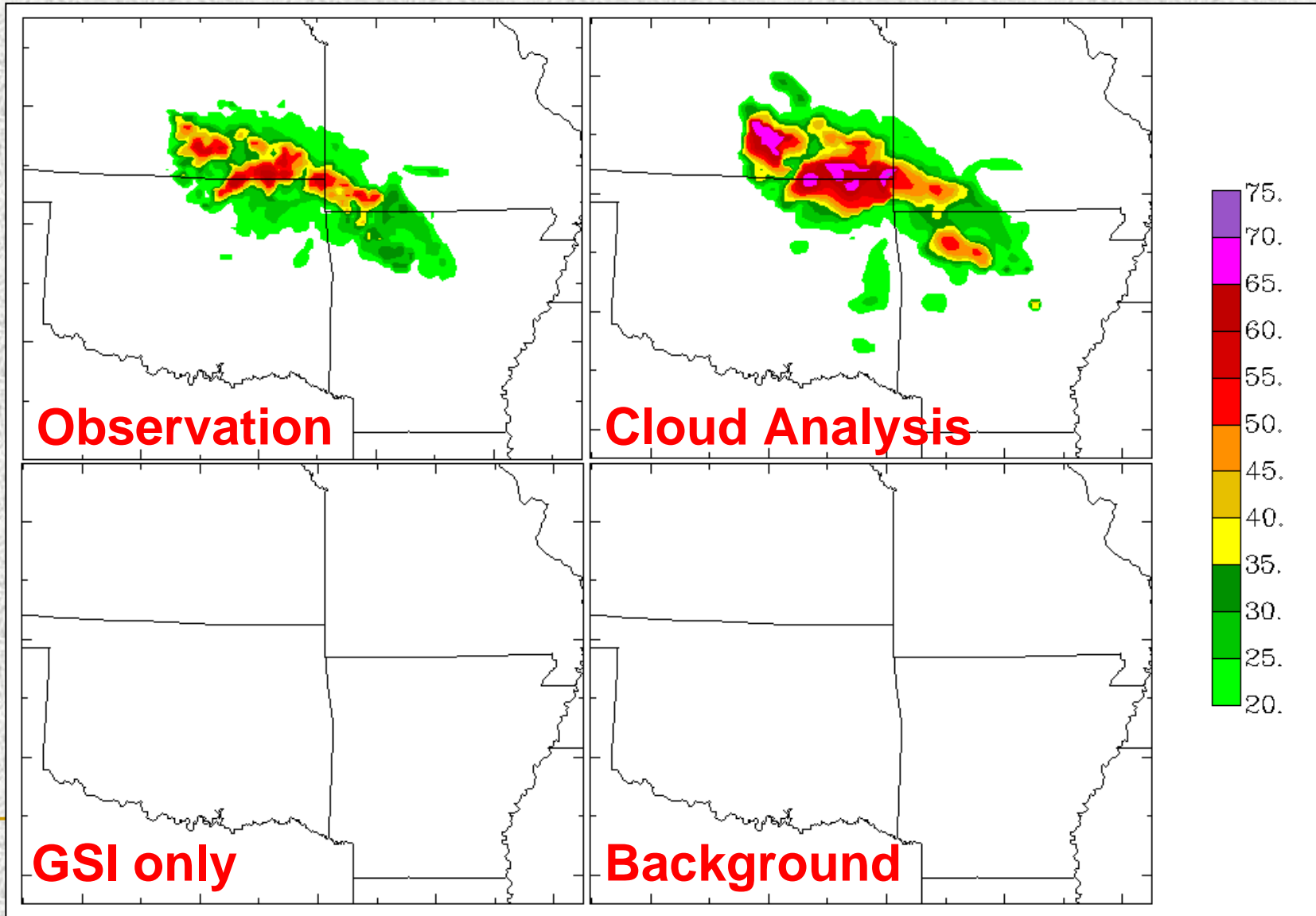
Effects of Cloud Analysis on Initial Conditions

-temperature, hydrometers analysis

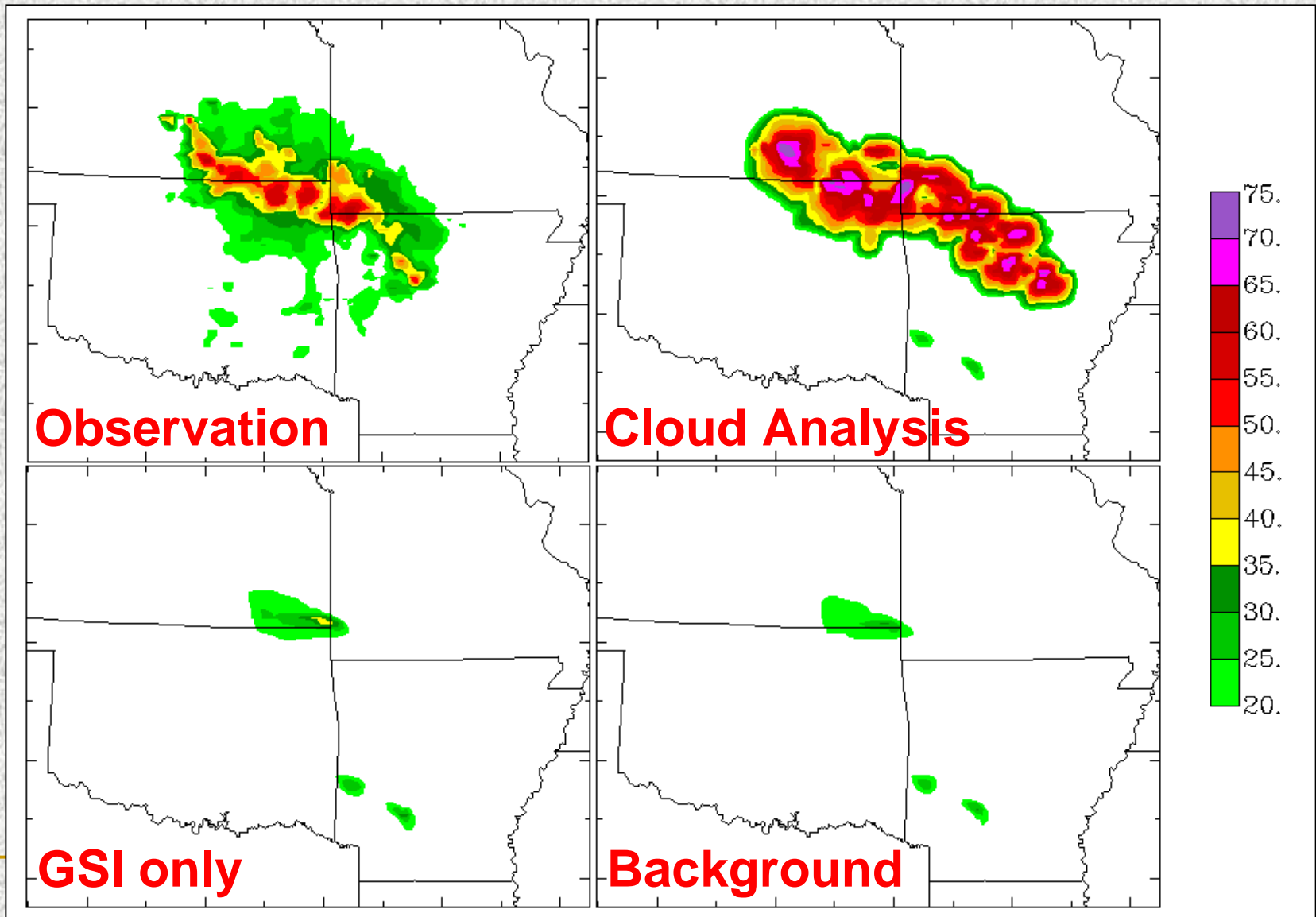


Evolution of Predicted Storms

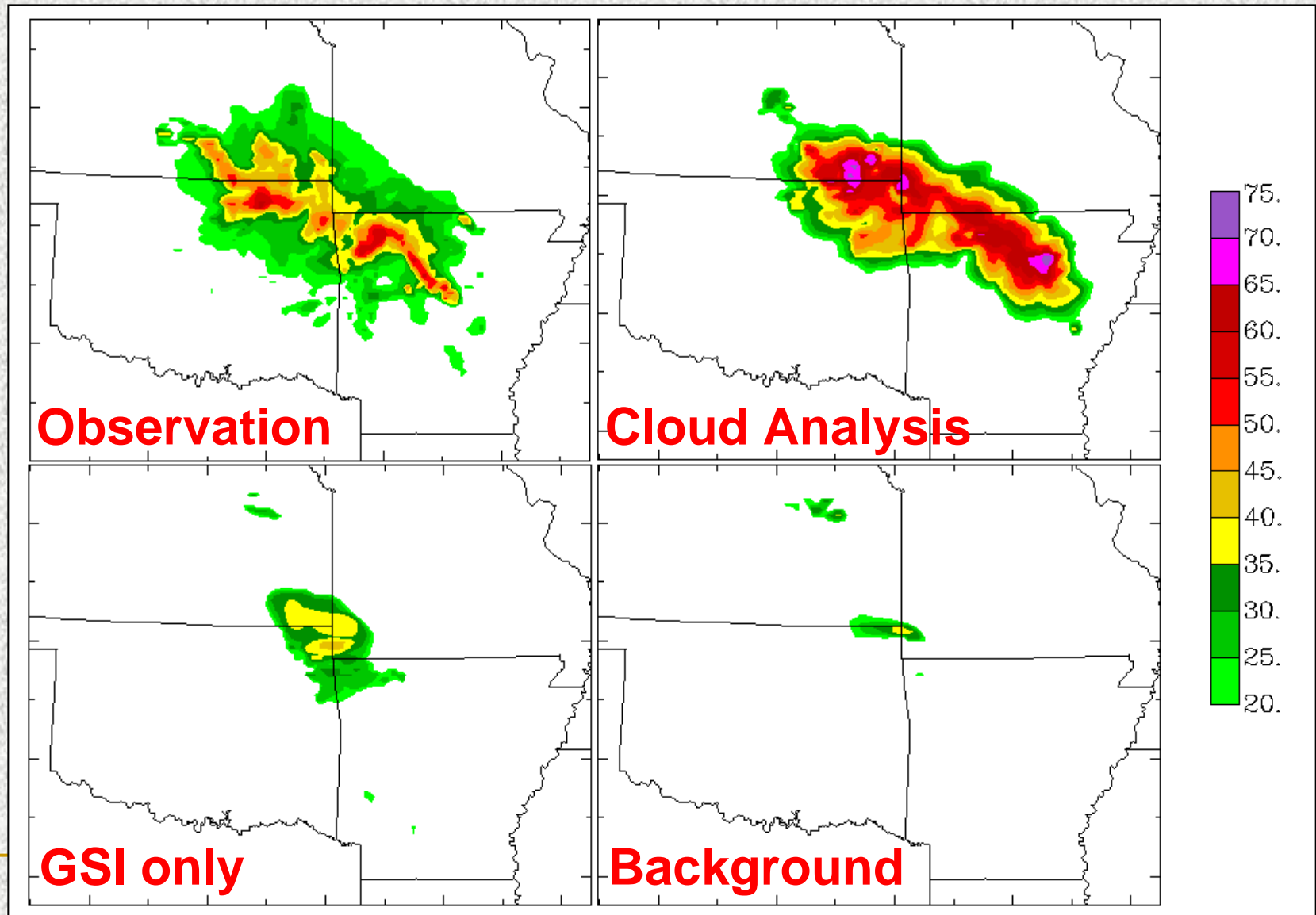
—composite reflectivity at half hour intervals from 06 Z to 12 Z



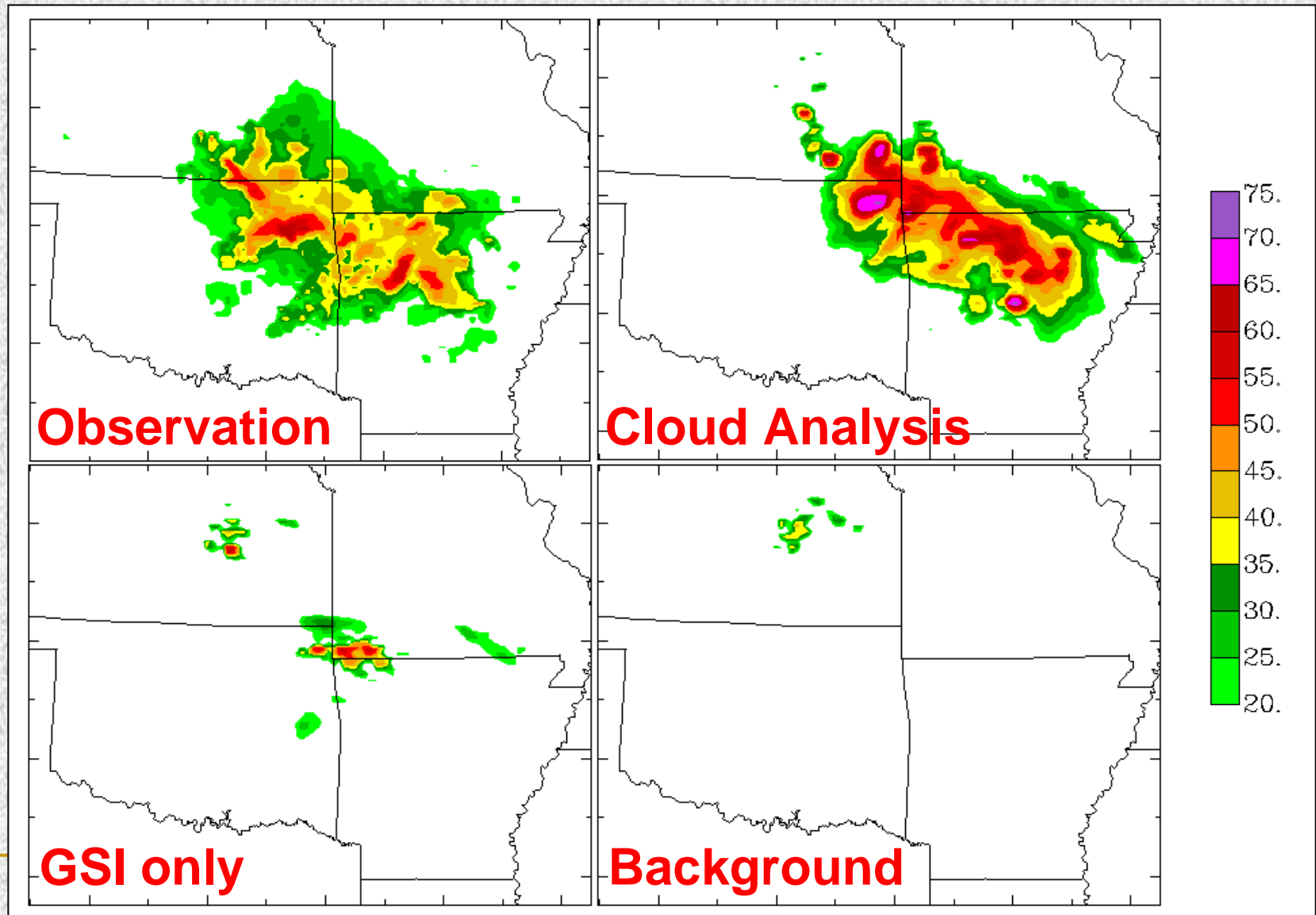
1 hour forecast (07 Z)



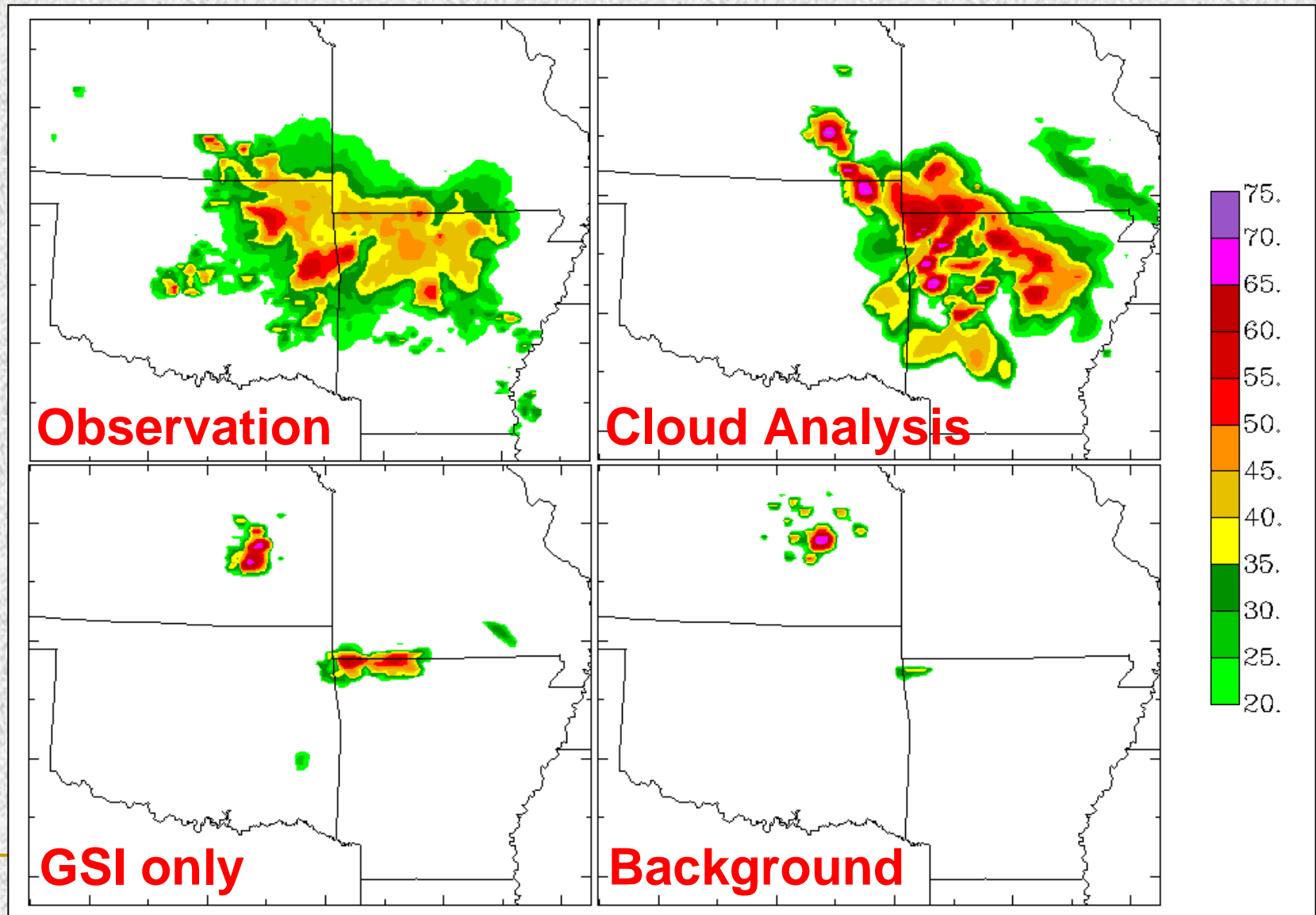
2 hour forecast (08 Z)



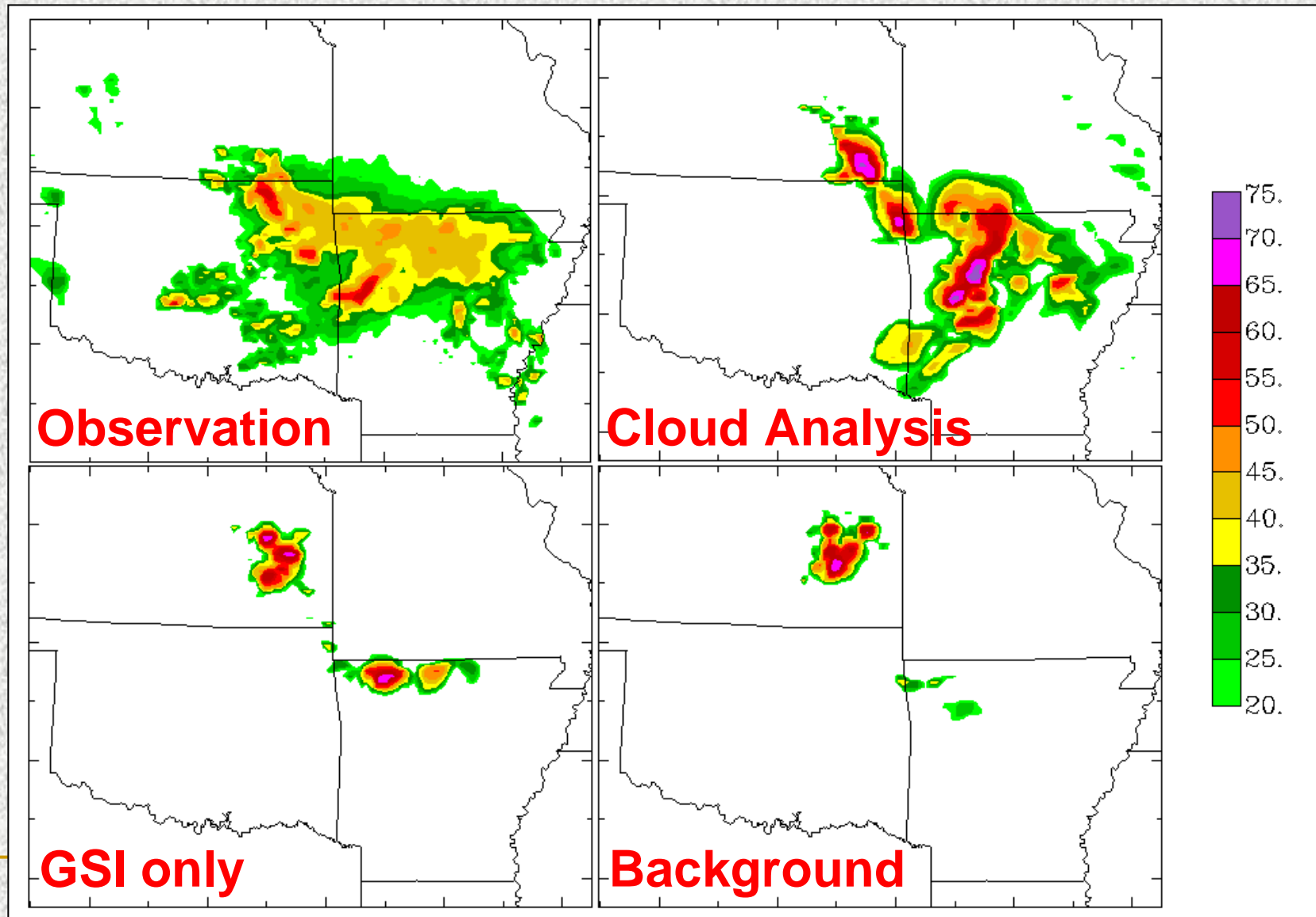
3 hour forecast (09 Z)



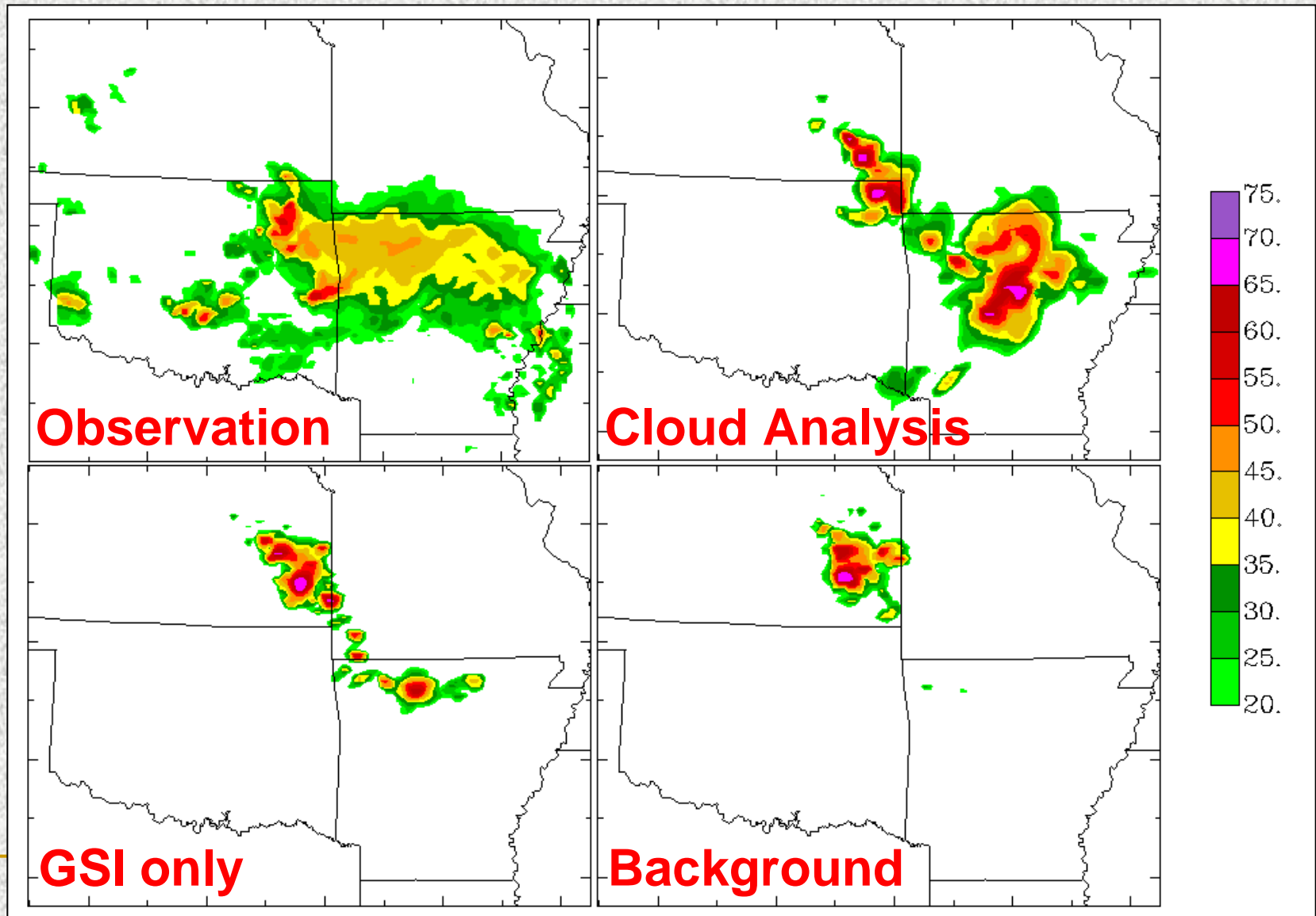
4 hour forecast (10 Z)



5 hour forecast (11 Z)

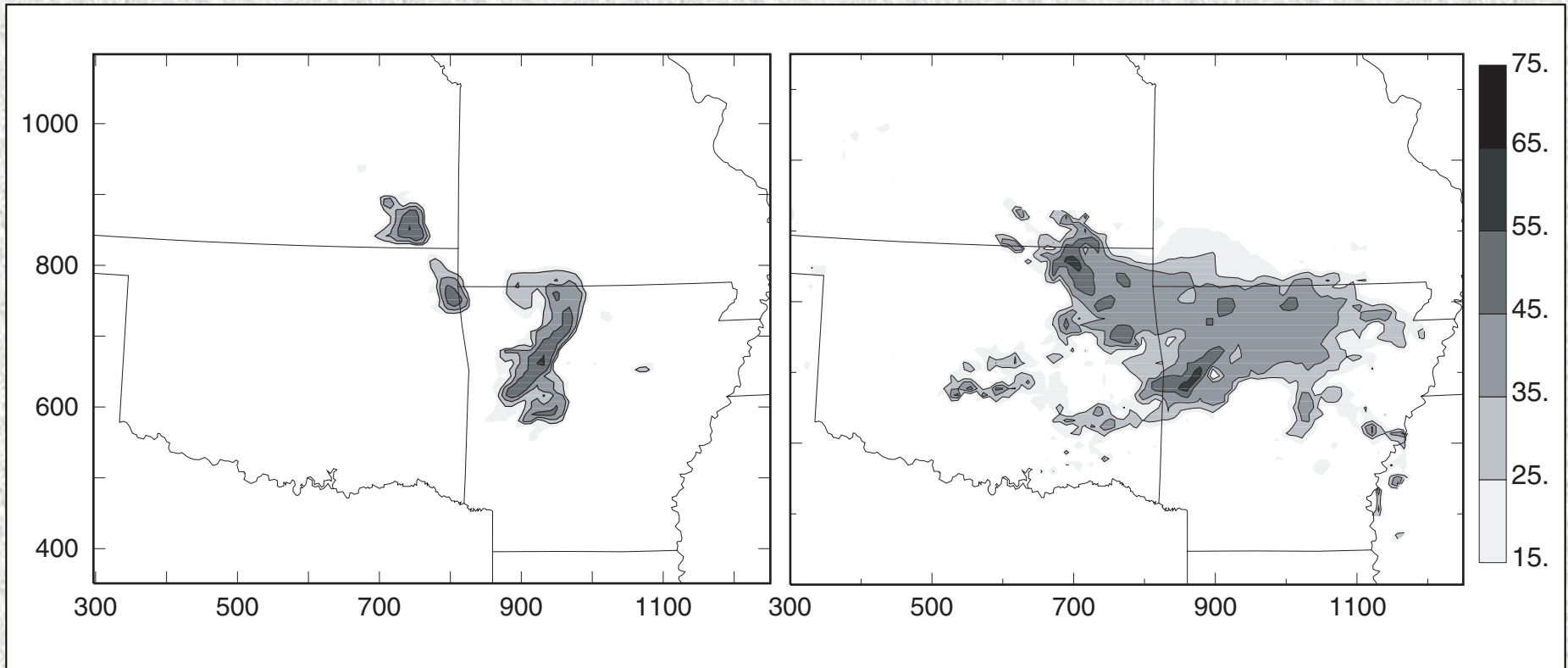


6 hour forecast (12 Z)



5 hour forecast valid at 11 Z

-Individual Cells comparison



Predicted low level reflectivity

Observed low level reflectivity

7. Summary

- Successfully build up storms in initial fields
- Significantly reduce spin-up problem and improve short-term forecast for storm cluster
- Predicted storm cluster sustains longer than observation
 - Need tuning cloud analysis to fit the larger scale system
 - ARW seems to keep storms lasting longer
 - The explicit microphysics was used in forecast

8 Work since visiting

- Cooperation with GSD scientists closely to incorporate both RUC and ARPS cloud analysis packages into GSI
 - Building GSI framework outside original GSI to add cloud analysis packages
 - Generating backgrounds for RUC and APRS
 - DATA prepare
 - NESDIS products, NSSL mosica reflectivity, METAR from prepbuf
 - Add RUC cloud analysis within GSI framework
 - Add ARPS cloud analysis within GSI framework



Plan in near future

- A generalized cloud analysis based on both RUC and ARPS cloud analysis for GSI analysis
- New schemes
 - Adjusting in-cloud temperature to suppress fake storms
 - Using cloud and precipitation type observations from Metar data
 - Lightning data



Acknowledgment

- The results of this presentation is fully supported by DTC.
- GSD's provide computer source (JET), GSI systems and helpful discussions.





Comments ?
