nu-WRF model simulations and real time forecasts for MC^{3}E

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Prior to Field Campaign

- Conduct real time forecast (dry run) using NASA Unified WRF (nuWRF) at Goddard.
- Develop visualizations software (i.e., tracer transport) for real time forecast system

During Field campaign:

- Conduct real time forecast for aircraft missions and ground based observation

After field campaign:

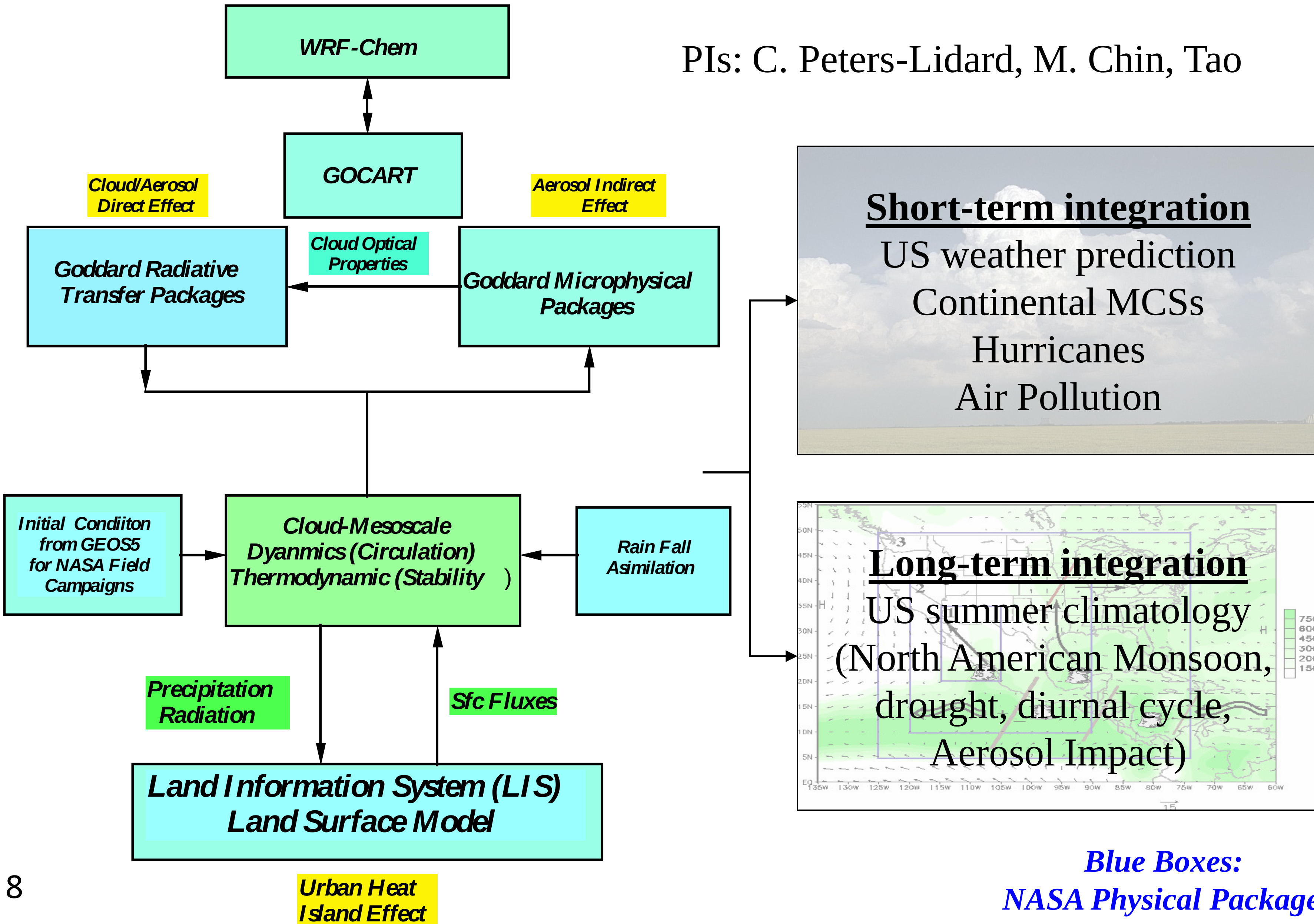
- Prepare documentation for the real-time forecast (i.e., identify cases for post mission simulations, describe the model performance)

Data for model validation (GPM rainfall/snowfall/LH retrieval)

- DSDs at various layers (gamma or exponential distributions for cloud water, rain, cloud ice, snow, and graupel), 3D liquid and ice water contents and median diameters, mixed phase information, particle number concentrations for cloud ice, snow, graupel and hail, aerial ratios (ice habits), and the liquid water fraction of melting snow, graupel and hail, over the life cycle of clouds and cloud systems.

NASA Unified (nu) WRF

PIs: C. Peters-Lidard, M. Chin, Tao



Blue Boxes:
NASA Physical Packages

Microphysics in GCE, nu-WRF, MMF and Stretched Global CRM

One-Moment (Warm Rain only, 2ICE, 3ICE-graupel, 3ICE-hail) (Tao and Simpson 1993, Tao et al. 2003, Lang et al. 2007)

One-moment 3ICE-graupel but improved - reducing 40 dBz aloft (Lang et al. 2011 – in press)

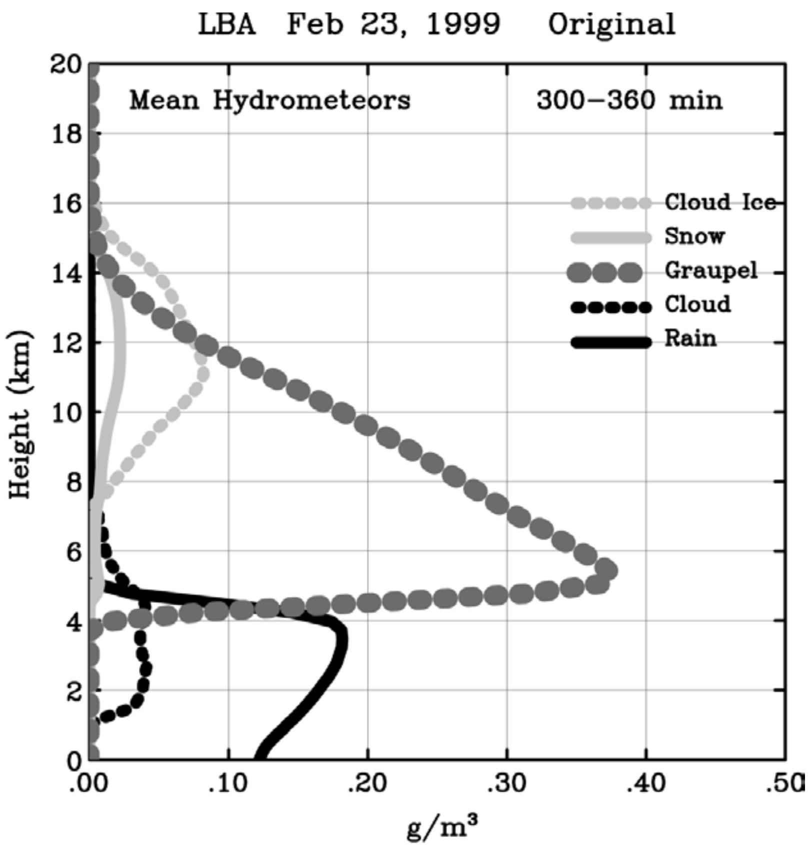
One-moment 3ICE-graupel - Temperature Dependent Drop Size Distribution (TDDD) (Matsui et al. 2009; Zeng et al. 2010)

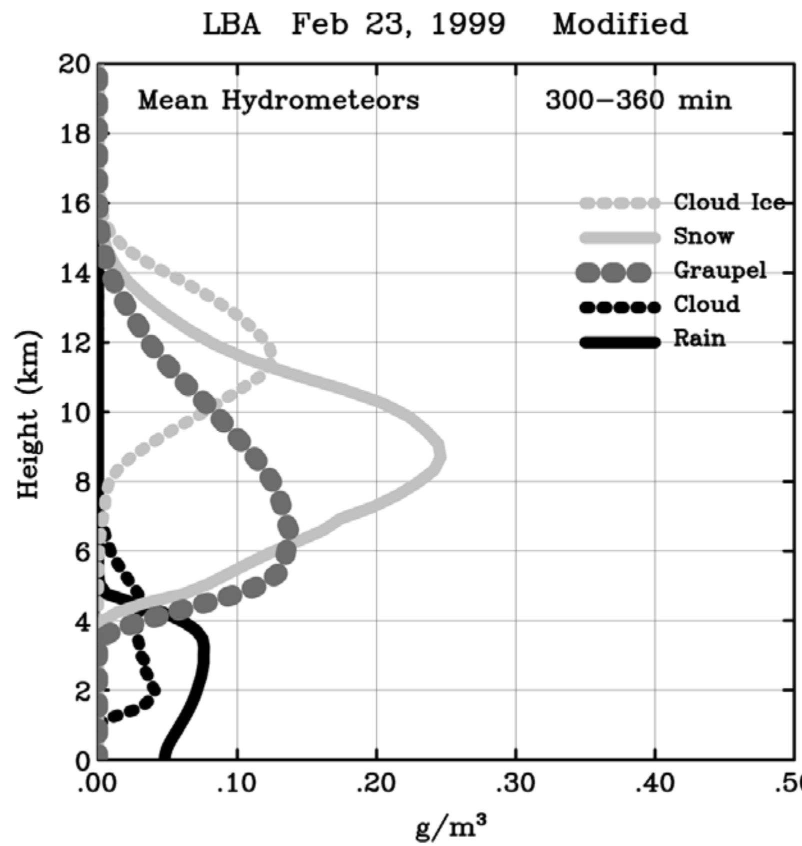
One-moment - 4ICE (cloud ice, snow, graupel and hail)

Two-moment - 2-liquid, 3ICE-graupel (based on spectral bin microphysics – could add more moments for chemistry, testing now)
30% more expensive than one-moment bulk scheme

Spectral bin microphysics (Tao et al. 2007; Li et al., 2009; Iguchi et al. 2011)
16 times or 1600% more expensive; 256 CPUs

Improved



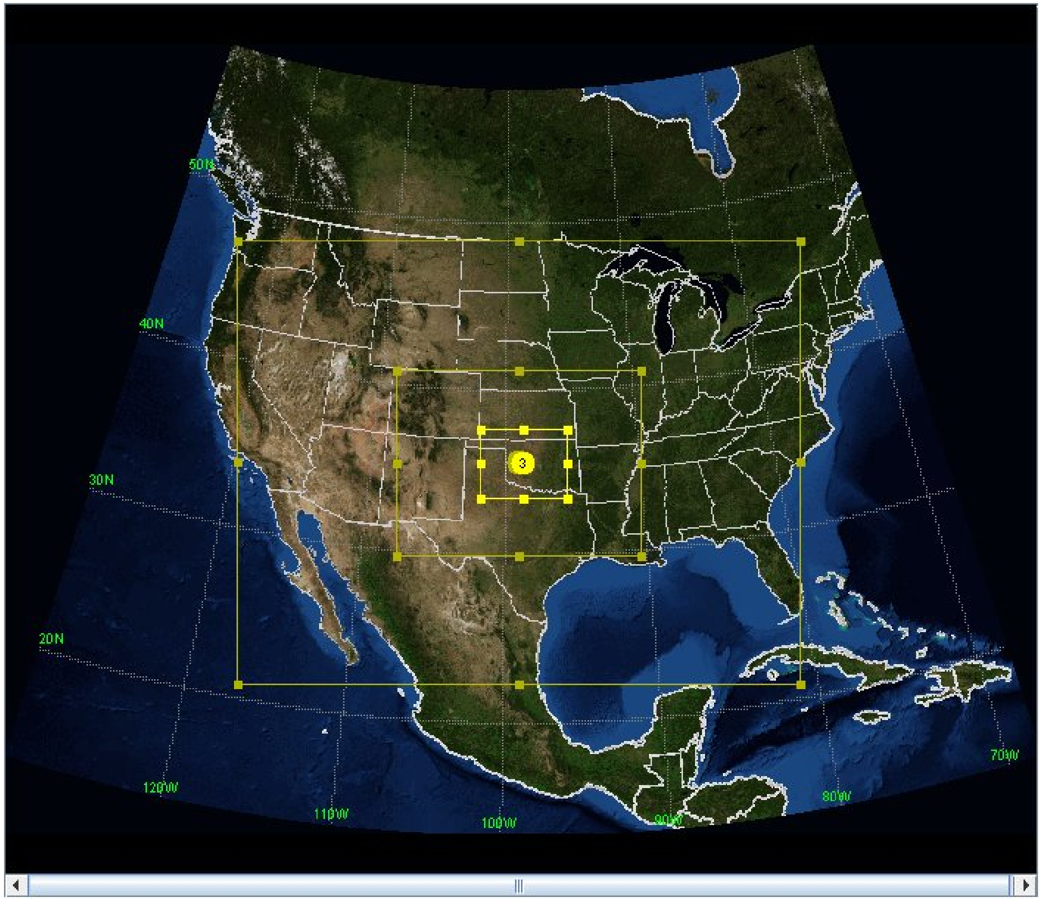


Reduce the graupel, but increase both cloud ice and snow

Lang et al. (2011)

Model Setup for MC^{3}E

- Three nested domain
  18km (212,167), 6km (276,210), 2km (294,234) grid spacing
  61 vertical layers
- Physics:
  Goddard Microphysics scheme
  Grell-Devenyi cumulus scheme
  Goddard Radiation schemes
  MYJ PBL
  Noah surface scheme
  Eta surface layer scheme
- Initial Condition
  Forcing data (NAM 218)
- Computational Cost: 320 CPUs, 1 and half hours wall clock time produces 24 hours forecast.

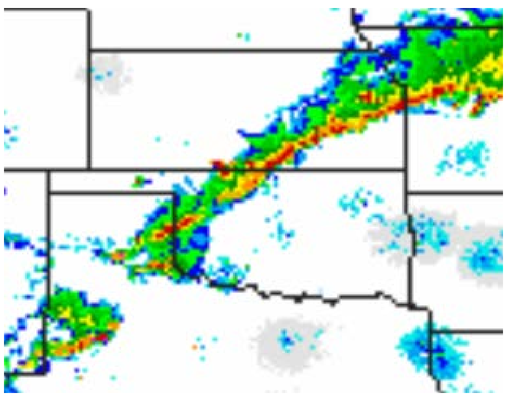


Post MC3E: conduct higher horizontal resolution, and test microphysics schemes and land surface models

Nu-WRF test cases for MC^{3}E

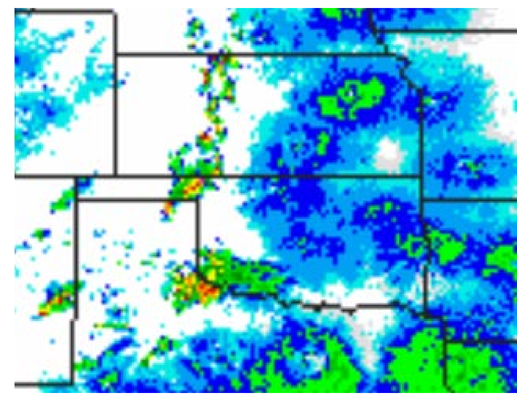
Case I: May 15-16, 2009
Case II: April 29-30, 2009
Case III: 01-02 Jan. 2011 Snow Storm

Other cases
East Coast Snow Storm (December 26-28, 2010), Typhoon Morakot (2009), AMMA (2006, 2008), Monsoon (aerosol, 2008), C3VP (2007) and many others

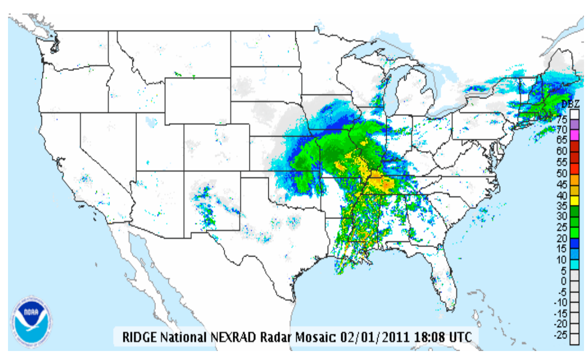


←-Case I

Case II →



Case III →

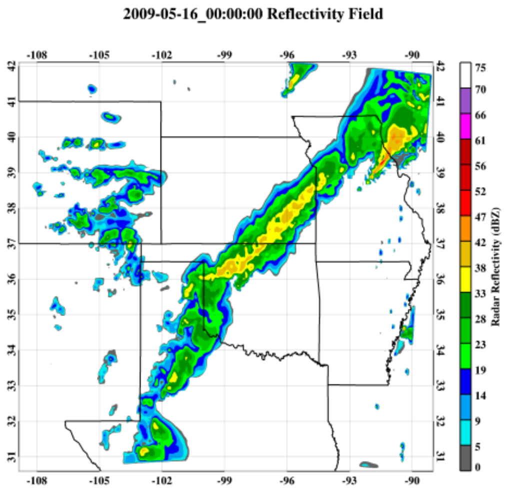


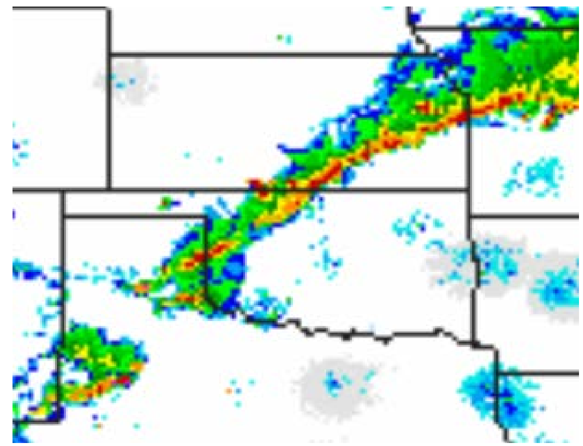
Case I: May 15-16, 2009

- Initialized at 00Z on May 15th

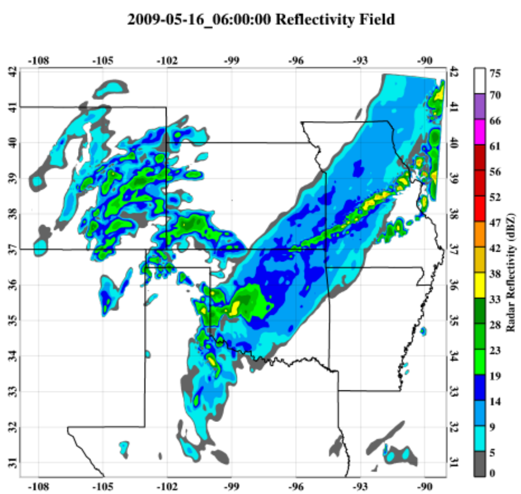
WRF | **Radar**

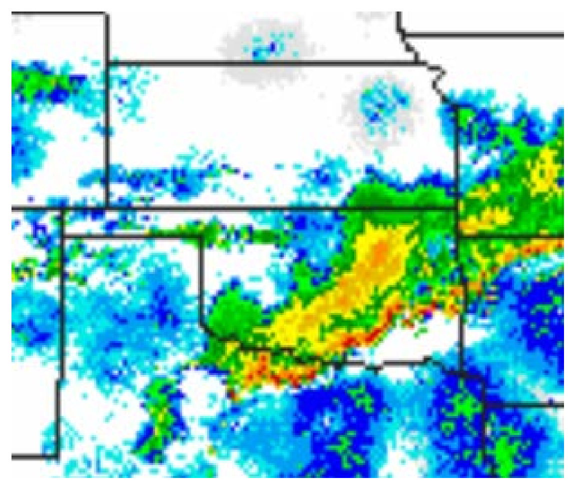
00Z, May 16

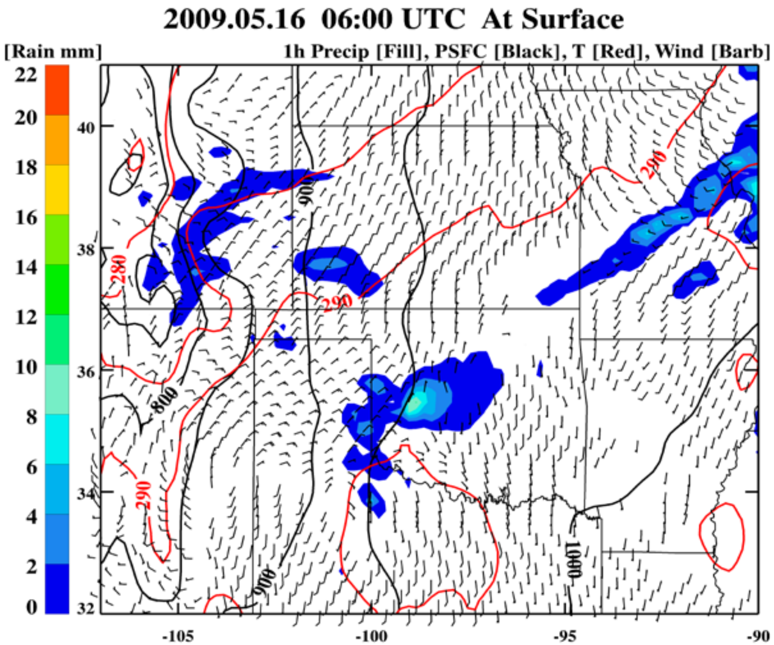


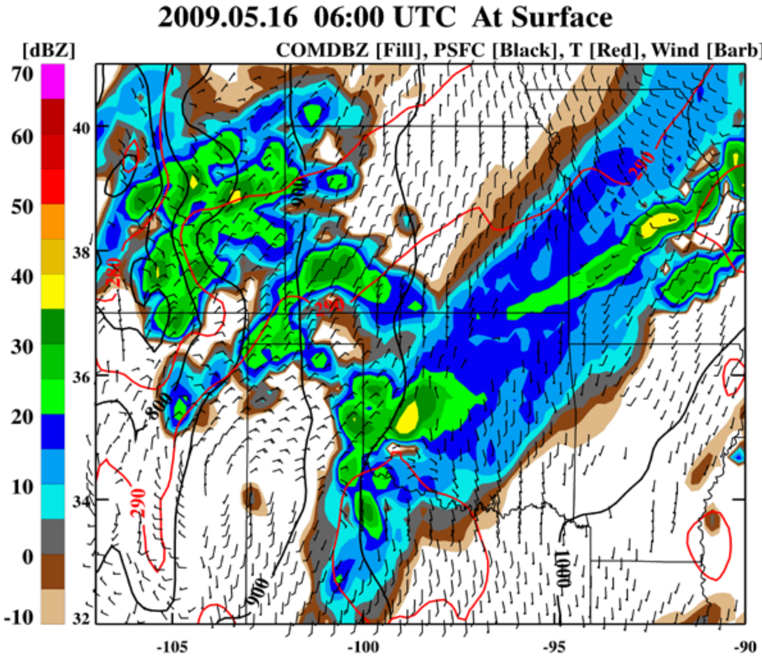


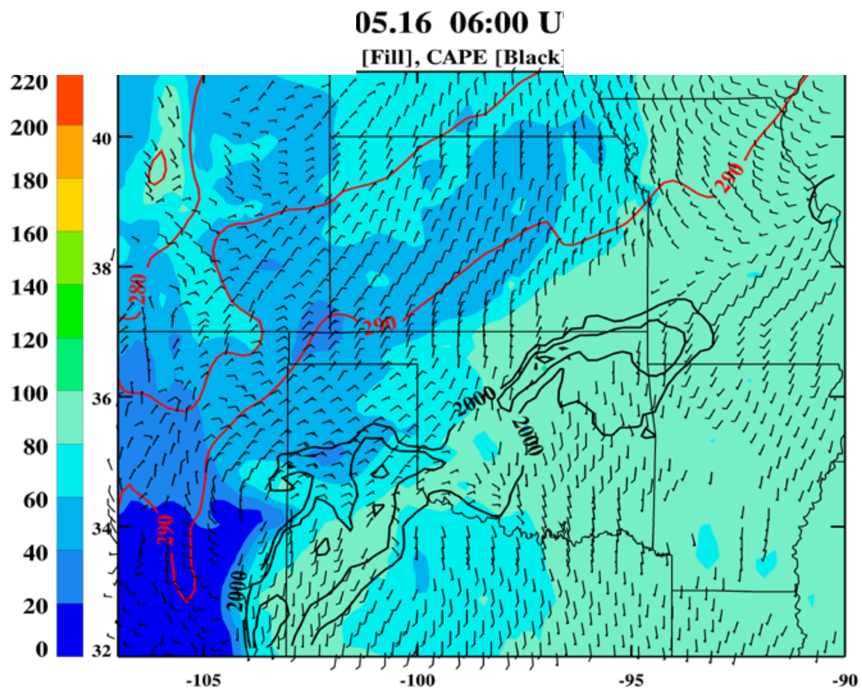
06Z, May 16

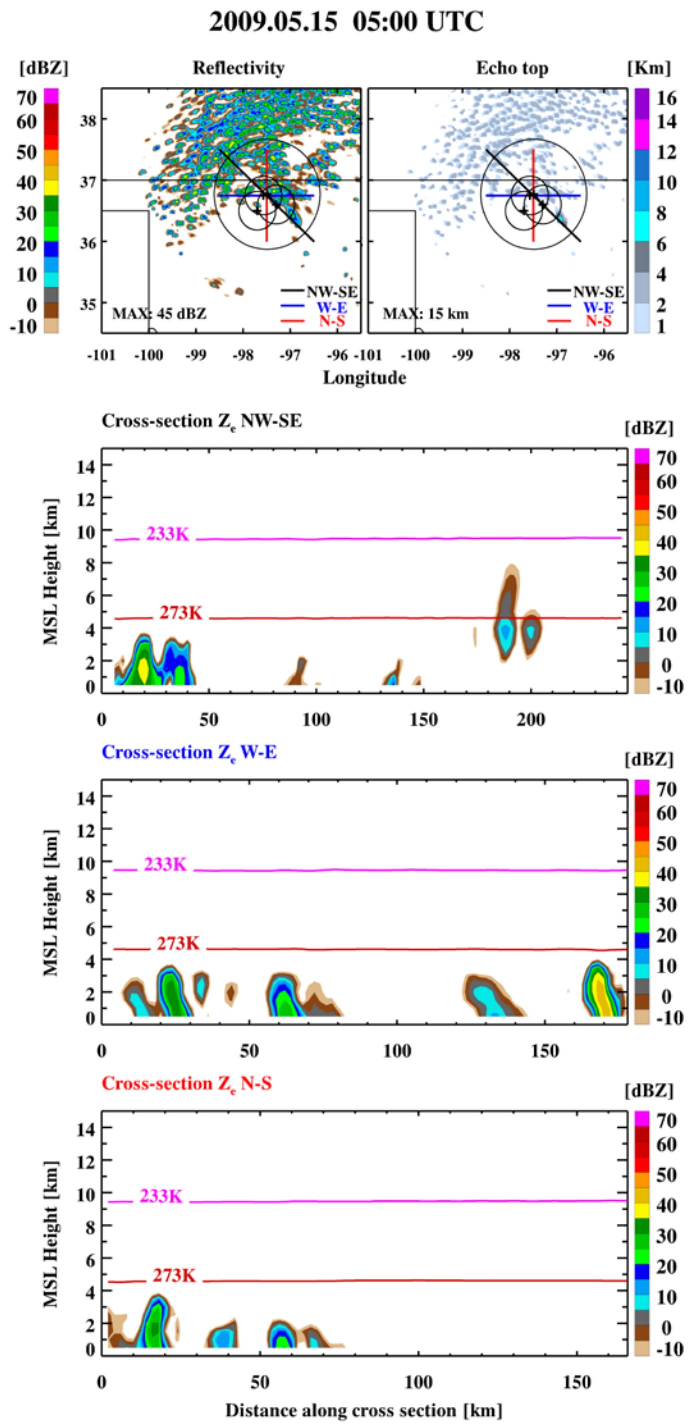


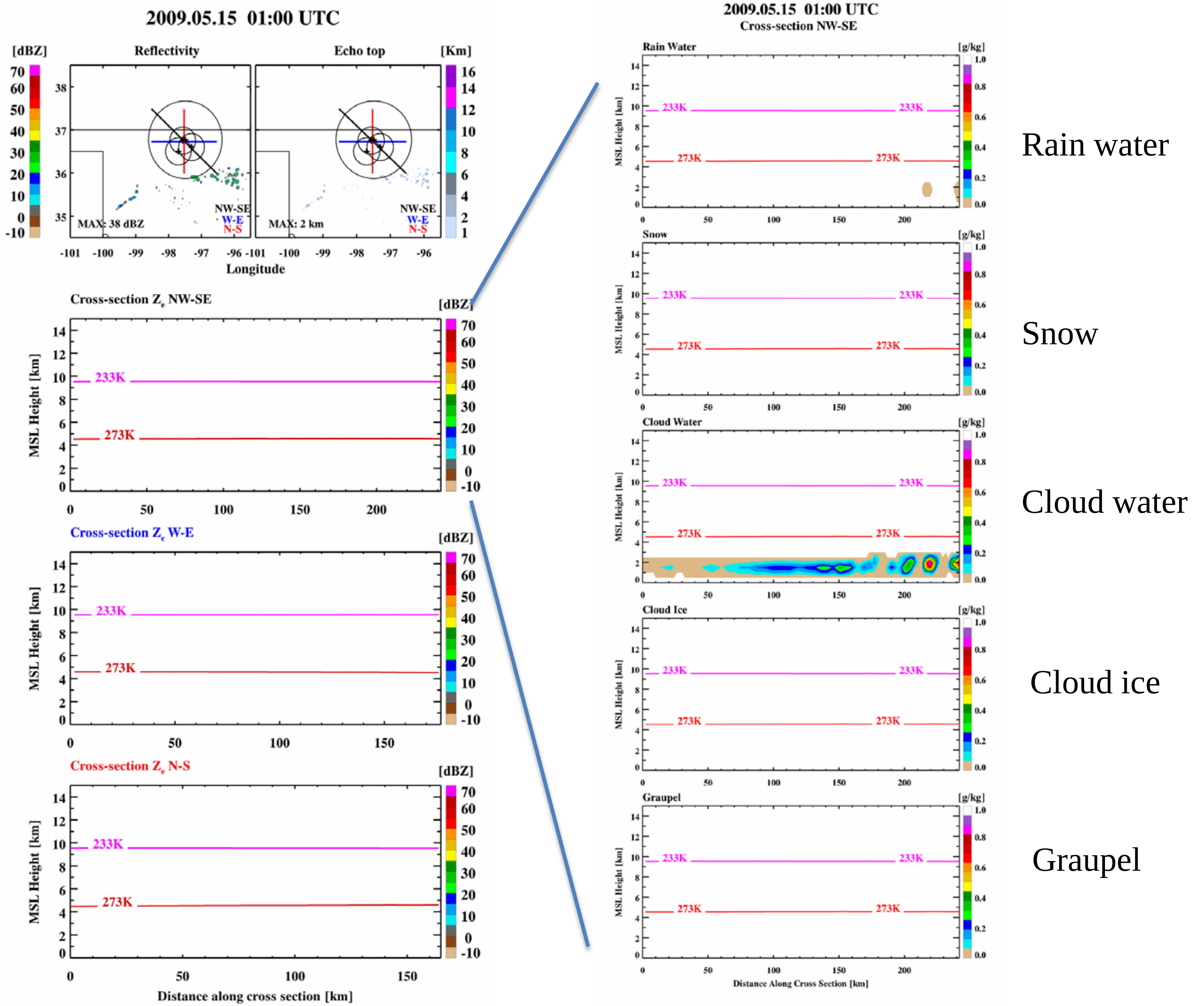



2009.05.16 06:00 UTC At Surface
[Rain mm]
1h Precip [Fill], PSFC [Black], T [Red], Wind [Barb]
22 20 18 16 14 12 10 8 6 4 2 0
40 38 36 34 32
-105 -100 -95 -90
280 290 800 900 1000


2009.05.16 06:00 UTC At Surface
[dBZ]
COMDBZ [Fill], PSFC [Black], T [Red], Wind [Barb]
70 60 50 40 30 20 10 0 -10
40 38 36 34 32
-105 -100 -95 -90
280 290 800 900 1000


05.16 06:00 U
[Fill], CAPE [Black]
220 200 180 160 140 120 100 80 60 40 20 0
40 38 36 34 32
-105 -100 -95 -90
280 290 2000


2009.05.15 05:00 UTC
Reflectivity
Echo top
[dBZ]
[Km]
MAX: 45 dBZ
MAX: 15 km
NW-SE
W-E
N-S
Longitude
Cross-section Z_e NW-SE
Cross-section Z_e W-E
Cross-section Z_e N-S
MSL Height [km]
233K
273K
Distance along cross section [km]

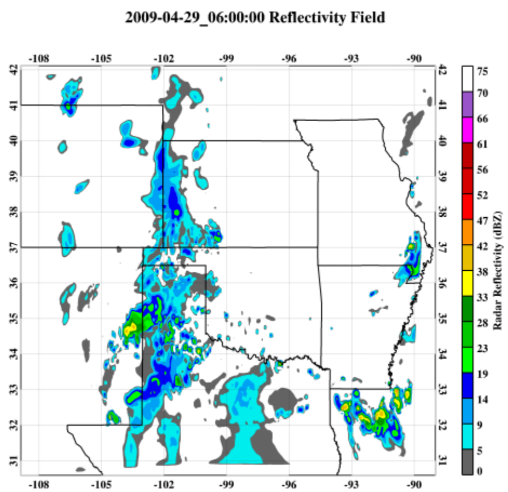

2009.05.15 01:00 UTC
Reflectivity
Echo top
[dBZ]
[Km]
MAX: 38 dBZ
MAX: 2 km
NW-SE
W-E
N-S
Longitude
Cross-section Z_e NW-SE
Cross-section Z_e W-E
Cross-section Z_e N-S
MSL Height [km]
233K
273K
Distance along cross section [km]
2009.05.15 01:00 UTC
Cross-section NW-SE
Rain Water
Snow
Cloud Water
Cloud Ice
Graupel
[g/kg]
Distance Along Cross Section [km]
Rain water
Snow
Cloud water
Cloud ice
Graupel

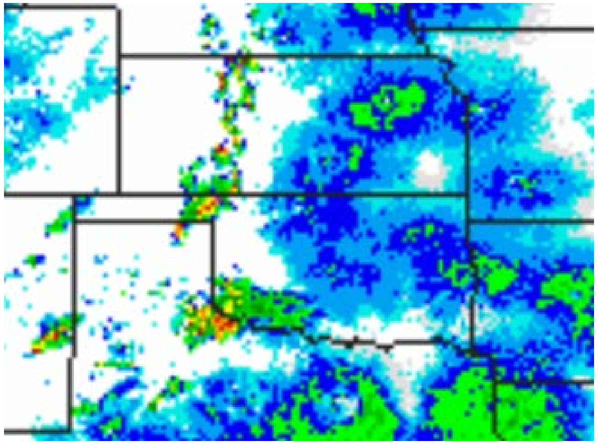
Case II: April 29-30, 2009

- Initialized at 12Z on April 28th

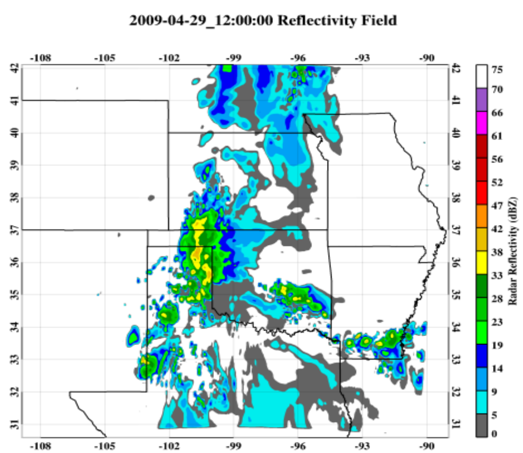
WRF | **Radar**

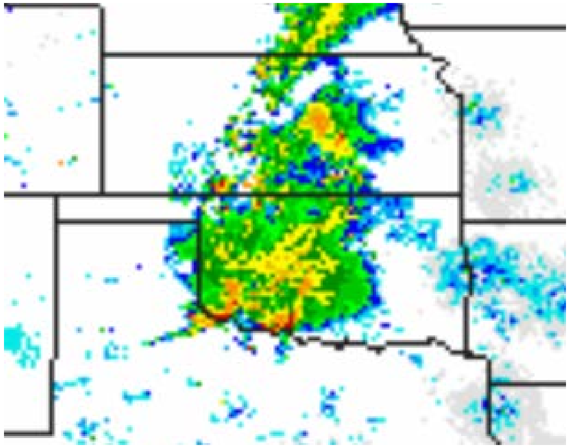
06Z, April 29





12Z, April 29





Time Line for Real Time

UTC	CDT	
02 Z	9 PM	Start download the NCEP data (need a few minutes)
03 Z	10 PM	Start NU-WRF 24-h forecast Requires 4 hour using 240 CPUs
07 Z	02 AM	Finish forecast and Start post processing Requires up 2 hour
09 Z	04 AM	Examine the results and archive the data
10 Z	05 AM	Modeled forecast data will be available to Team

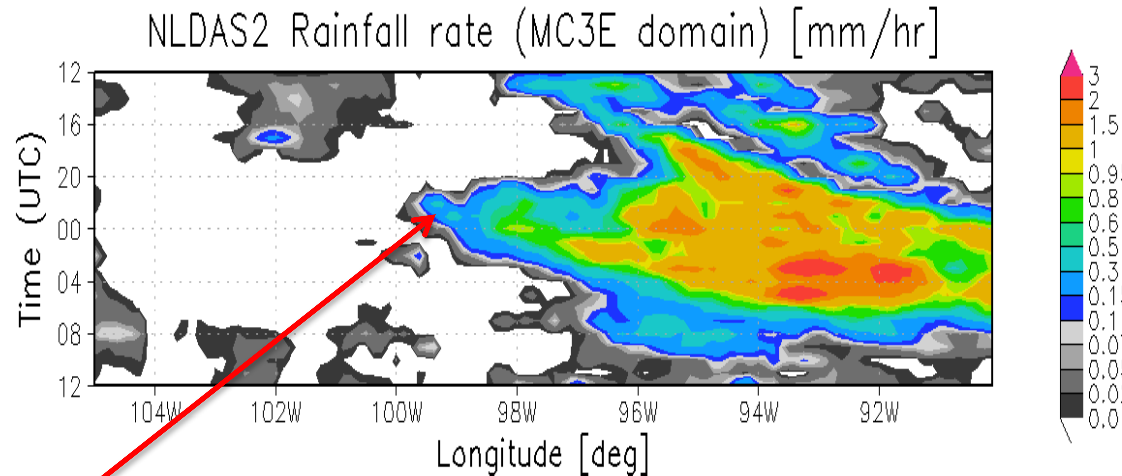
Forecasted Fields (visualization and regular plots)

Radar Reflectivity (vertical cross section)
Cloud fields (i.e, large precipitating ice) (vertical cross section)
Wind (vertical cross section)
Inert Tracer (vertical cross section + wind)
Echo top and CAPE (horizontal)
Surface rainfall, RH, temperature, wind
850 hPa (RH, temperature, wind)
700 hPa (RH, temperature, wind)
500 hPa (RH, temperature, wind)
300 hPa (RH, temperature, wind)

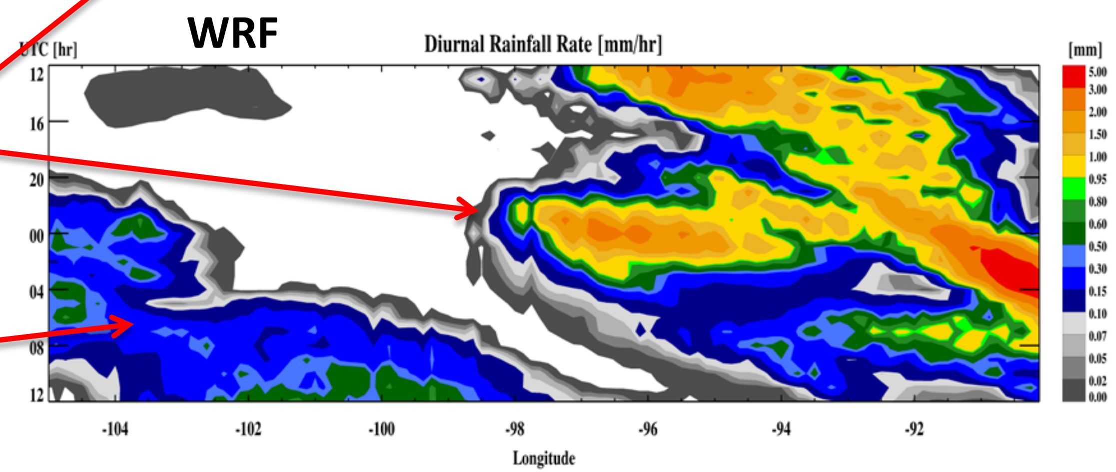
Hovemollar diagram

Lat: 37°N ~ 40°N

Period: 05/15/09 ~ 05/16/09.

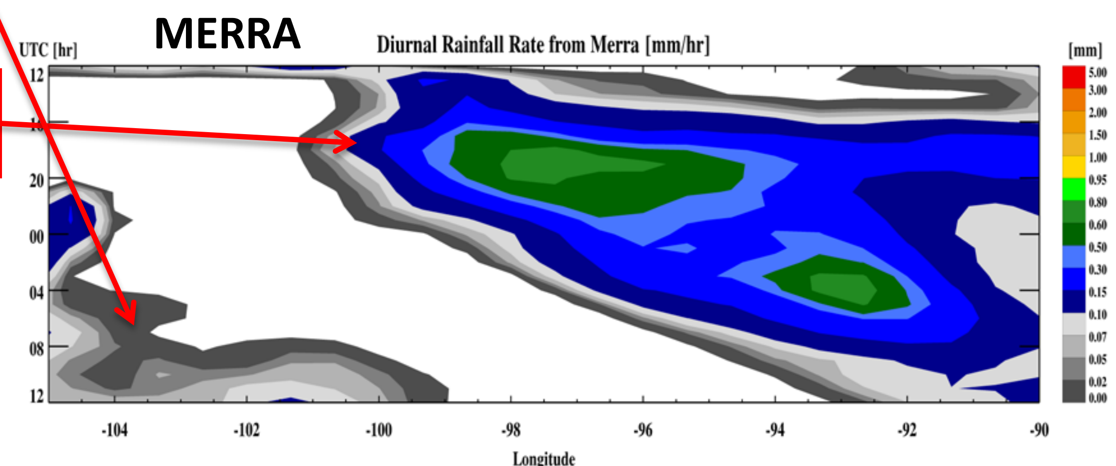


Afternoon onset (4pm LST) of moist convection that agrees with NLDAS and WRF



WRF overestimated rainfall near Rocky Mts. MERRA does better job.

Early onset (11am LST) of moist convection probably due to closure in RAS.



Climatologically, 40-dBZ penetrations above 10 km are rare even over land (Zipser *et al.* 2006; Liu *et al.* 2008)

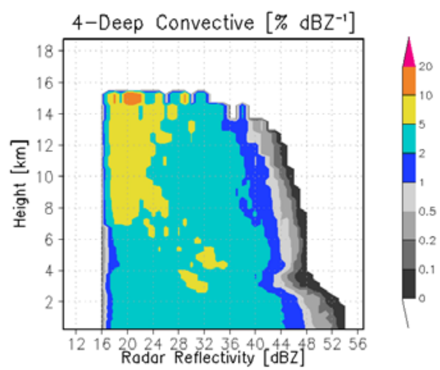
Reduce 40dBZ at high altitude

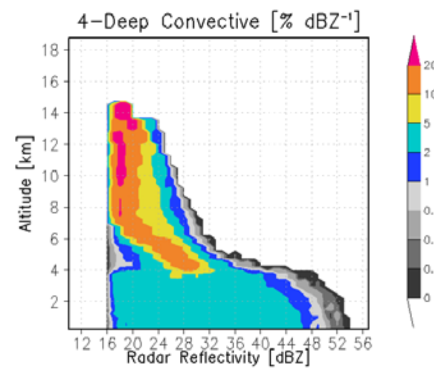
Long-term (multi-weeks) model simulations

TRMM

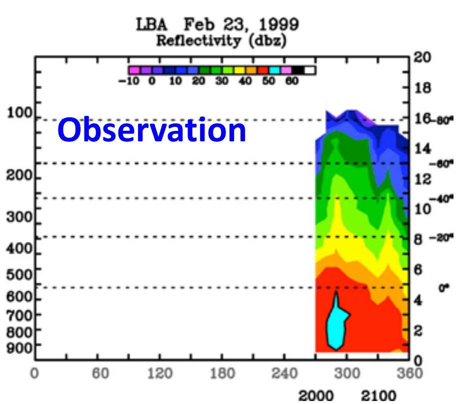
TDDD

Zeng et al. 2010

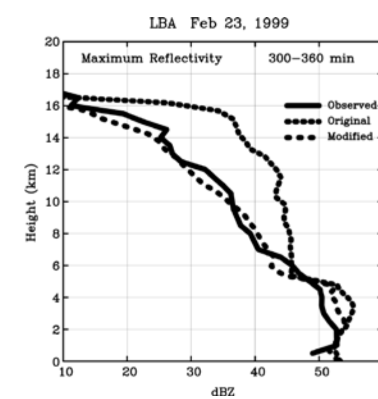




High resolution simulation of 23 Feb 1999 TRMM LBA MCS case



Improved



Improve riming, contact nucleation, immersion freezing and others (Lang *et al.* 2011)