A Study of MODIS Retrieved Total Precipitable Water Data and Their Impact on Weather Simulations

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Outline

- Observations
- Two case studies and Preliminary Results
- Summary

MODIS Data

- Moderate Resolution Imaging Spectroradiometer
- Aboard Terra (2000) and Aqua (2002)
- 36 spectral bands: 0.405-14.387 μm
- Resolutions: 250m, 500m, 1000m (radiances)
- Sun-synchronous near polar-orbiting
- Mean altitude : 705 km (equator)
- Width of swath : 2300 km (Terra), 2330 m (Aqua)

MOD05 Total Precipitable Water (TPW)

IR

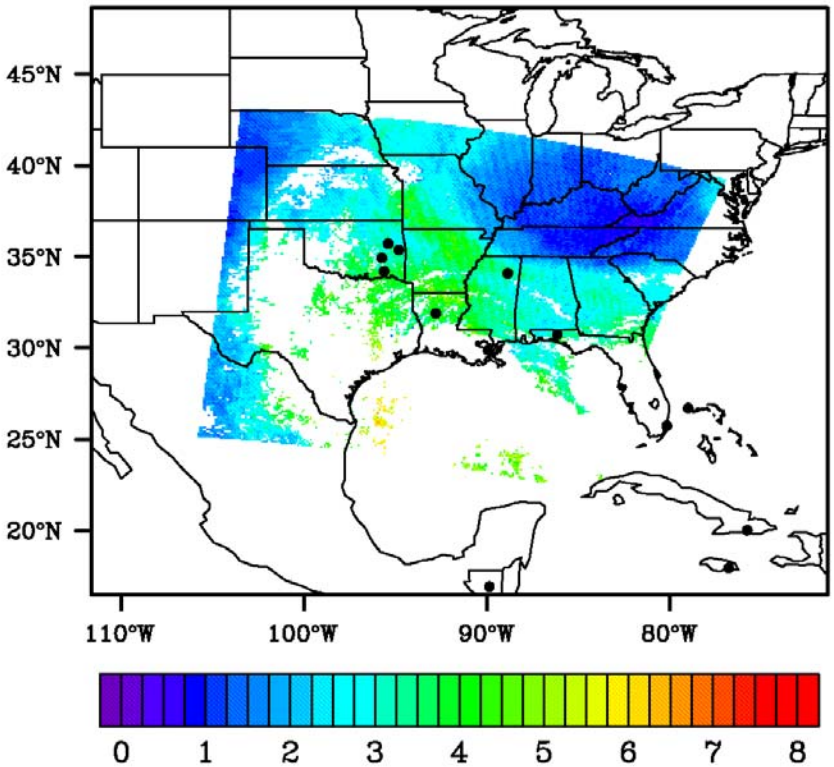
- The original retrieved IR products are vertical temperature and dew point profiles in 101 levels which are then used to calculate TPW.

nIR

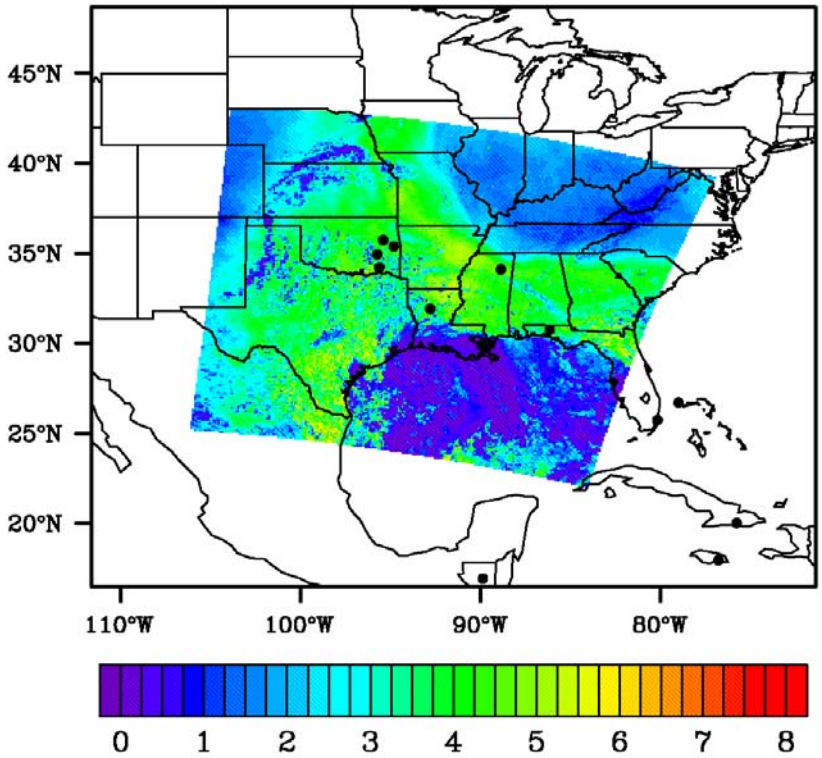
- The quality relies on observed water vapor attenuation of nIR solar radiation which is reflected by surfaces and clouds. (data available day time only)
- The accuracy of the data is strongly related to the estimation of surface reflection. (larger error over ocean)

MOD05 Total Precipitable Water (TPW)

(September 5, 2002)

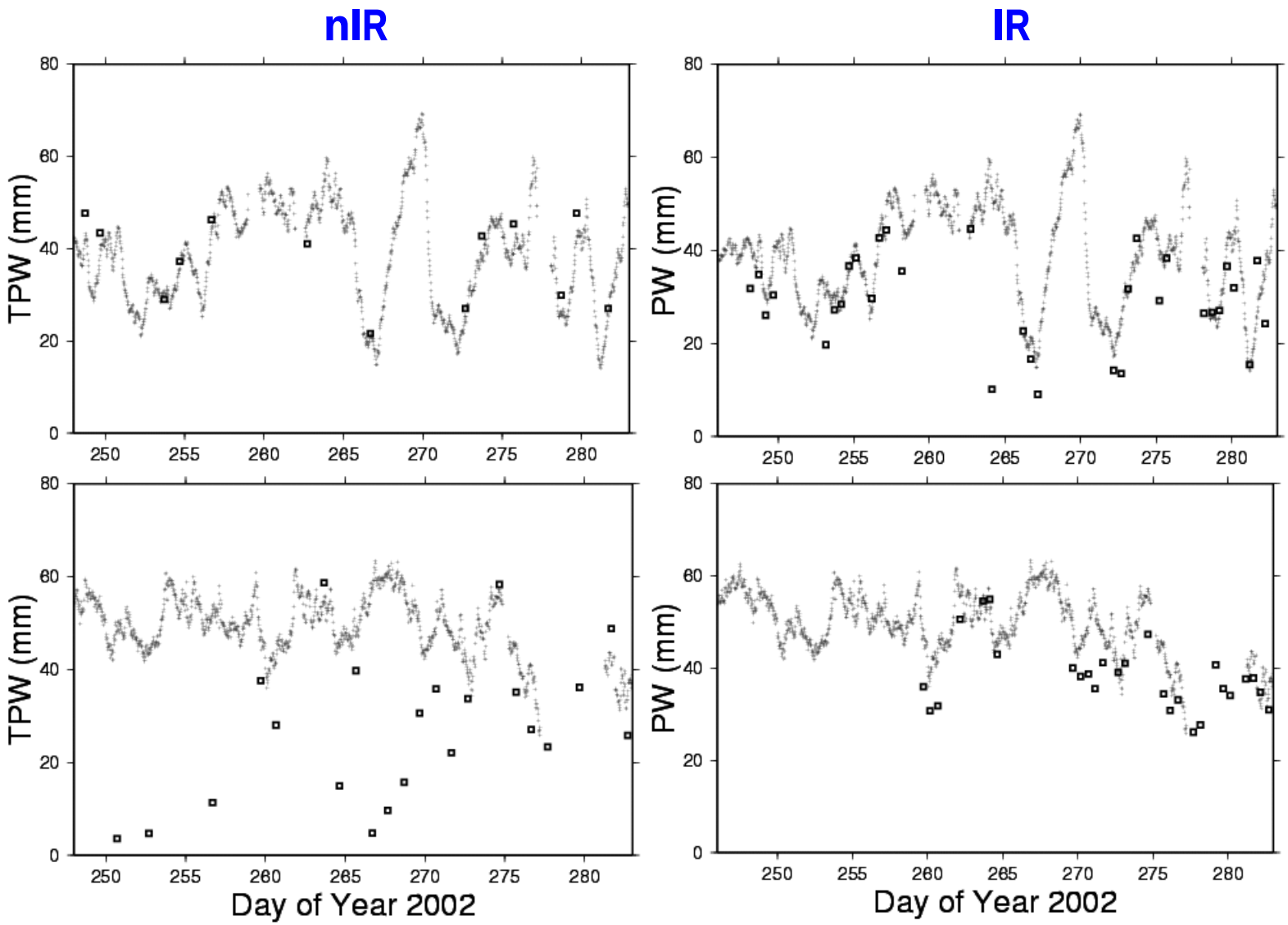


MODIS InfraRed (IR) TPW (cm).
This image shows a 50% retrieval rate.

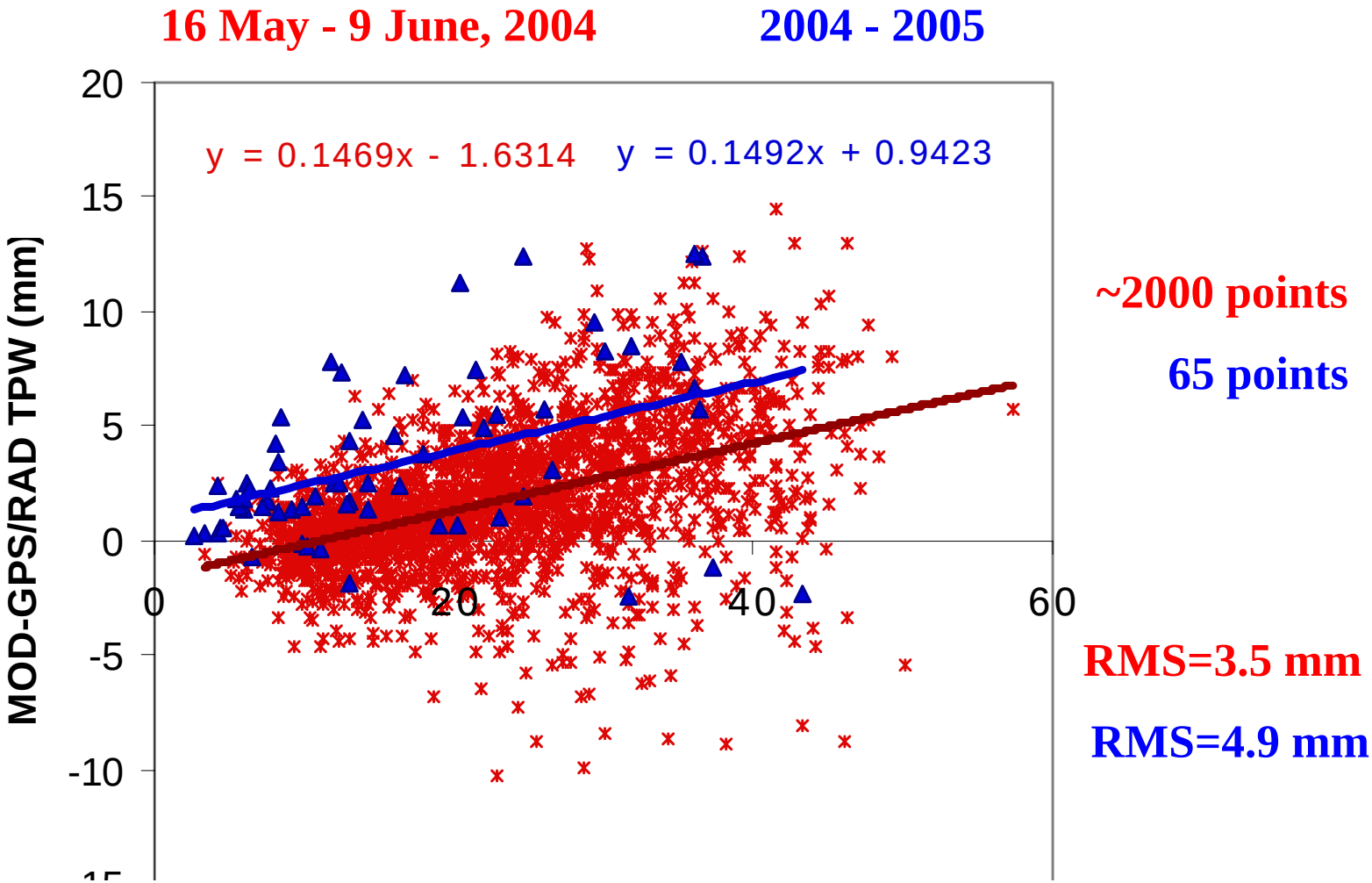


MODIS near InfraRed (nIR) TPW (cm).
This image shows an 85% retrieval rate.

MOD TPW vs. GPS TPW

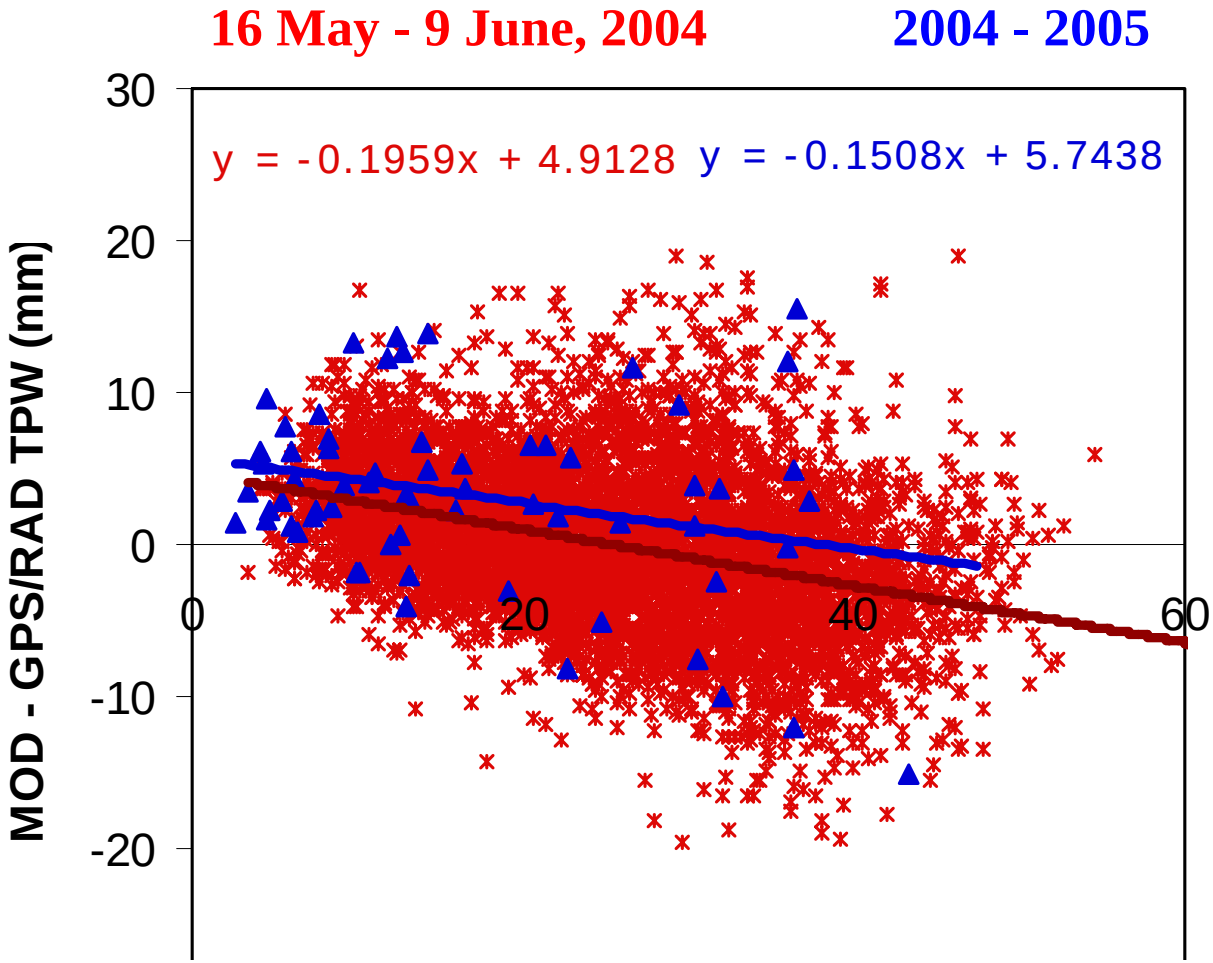


MOD nIR TPW vs. GPS/RAD TPW (US)



Kleidman et al. (2000), nIR TPW: Error – 2 to 5 mm
Dry atmos. – underestimated

MOD IR TPW vs. GPS/RAD TPW (US)



~6000 points

66 points

RMS= 5.0 mm

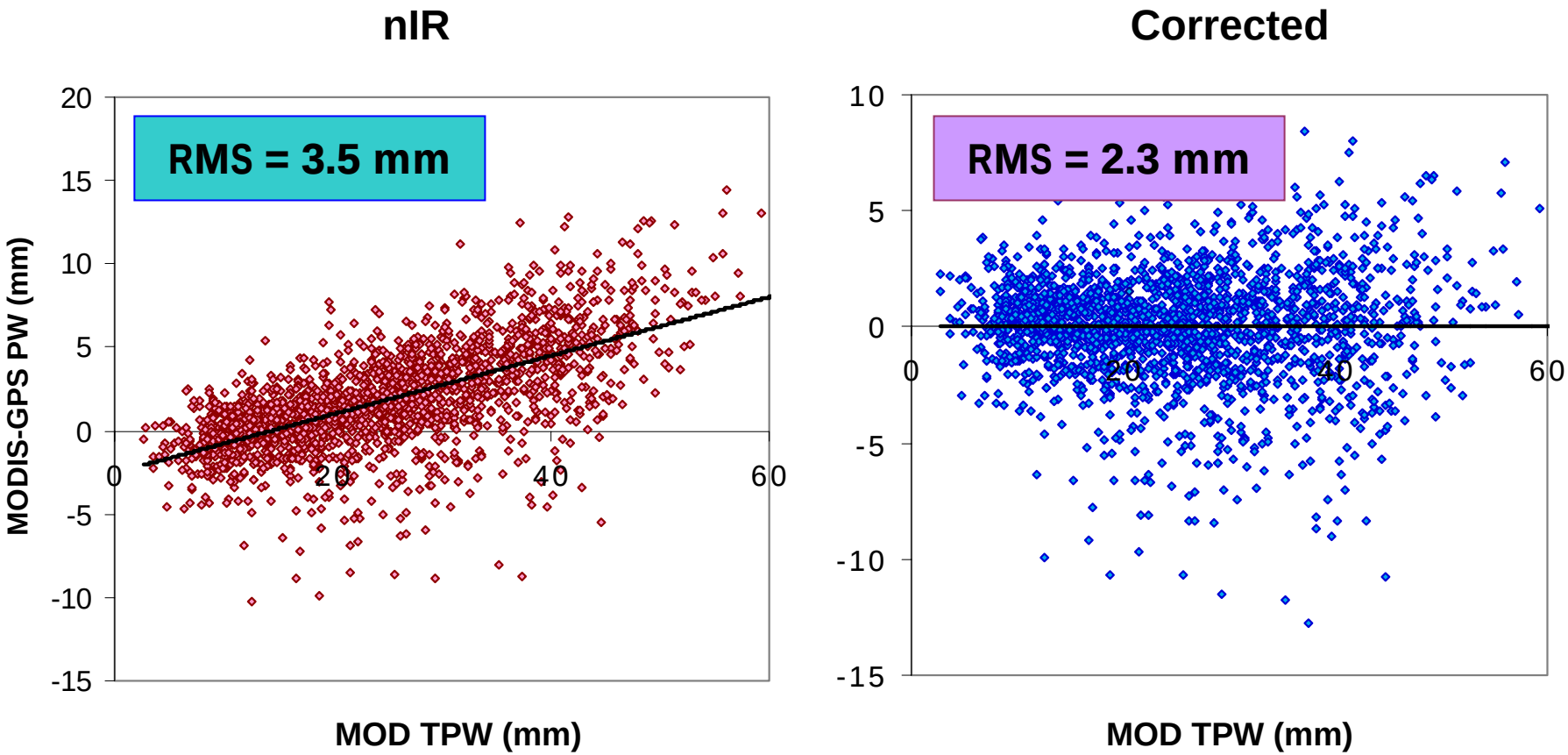
RMS=6.8 mm

Seemann et al. (2003), IR TPW: Error – 4.1 mm

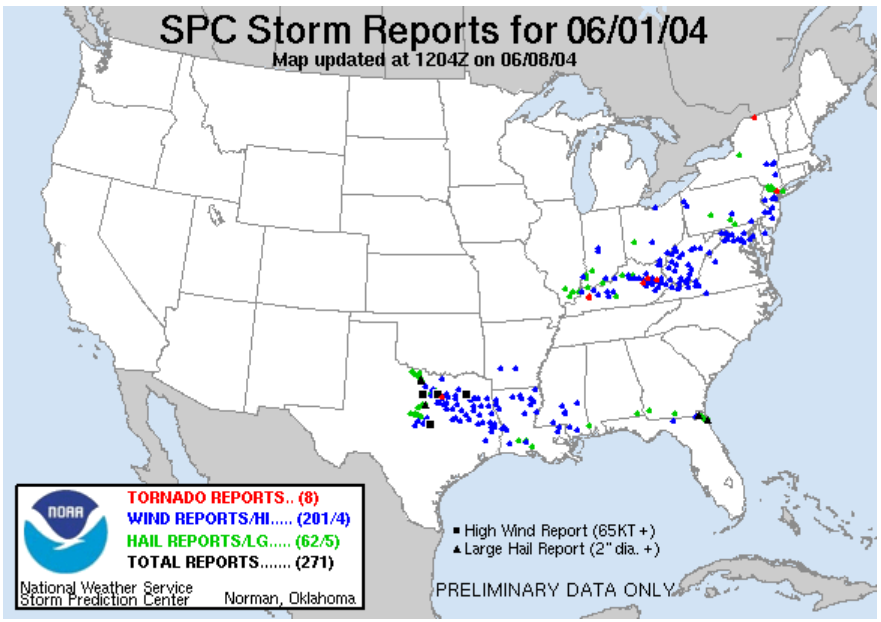
Dry atmos. – overestimated by 3.7 mm

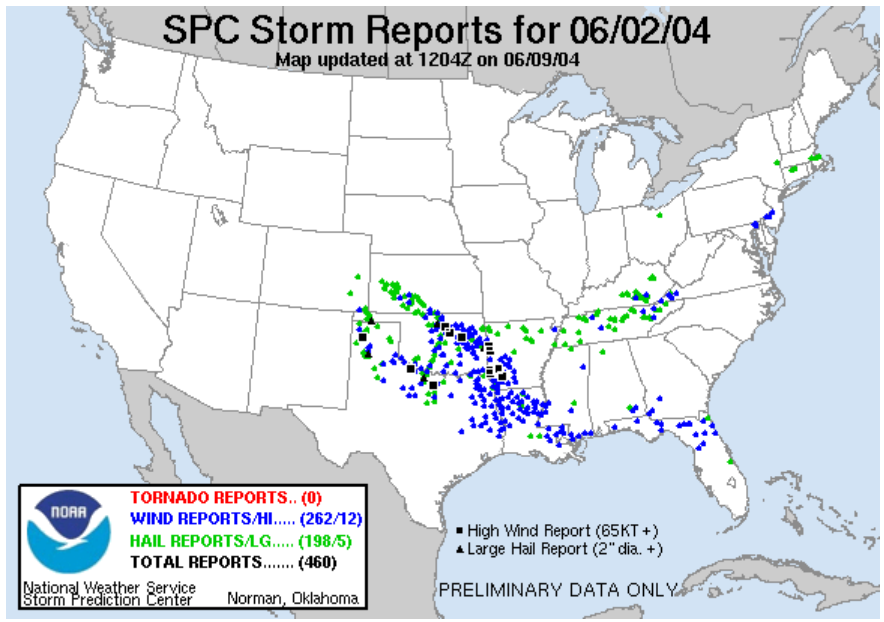
Moist atmos. – underestimated by 1.2 mm

Corrected MOD vs. GPS/RAD (US)



Case 1: Thunderstorm, 2004

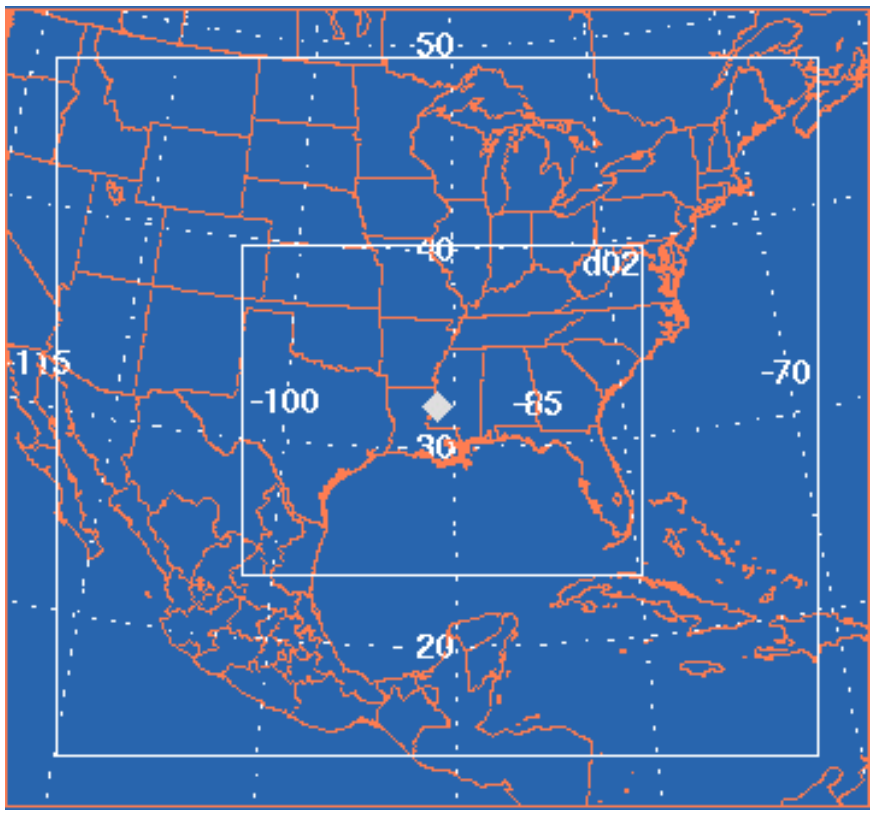




Severe thunderstorm activity on June 1 and 2, 2004 in Oklahoma, Texas, Arkansas and Louisiana. (recommended by Jack Kain; Curtsey Storm Prediction Center NOAA)

Model Configuration

Weather Research and Forecast Model



Global Reanalysis: AVN 1° x 1°

Domain 1 - 30 km

2 - 10 km

Physic: Purdue microphysics

New Kain-Fritsch

RRTM long wave

Dudhia short wave

YSU PBL

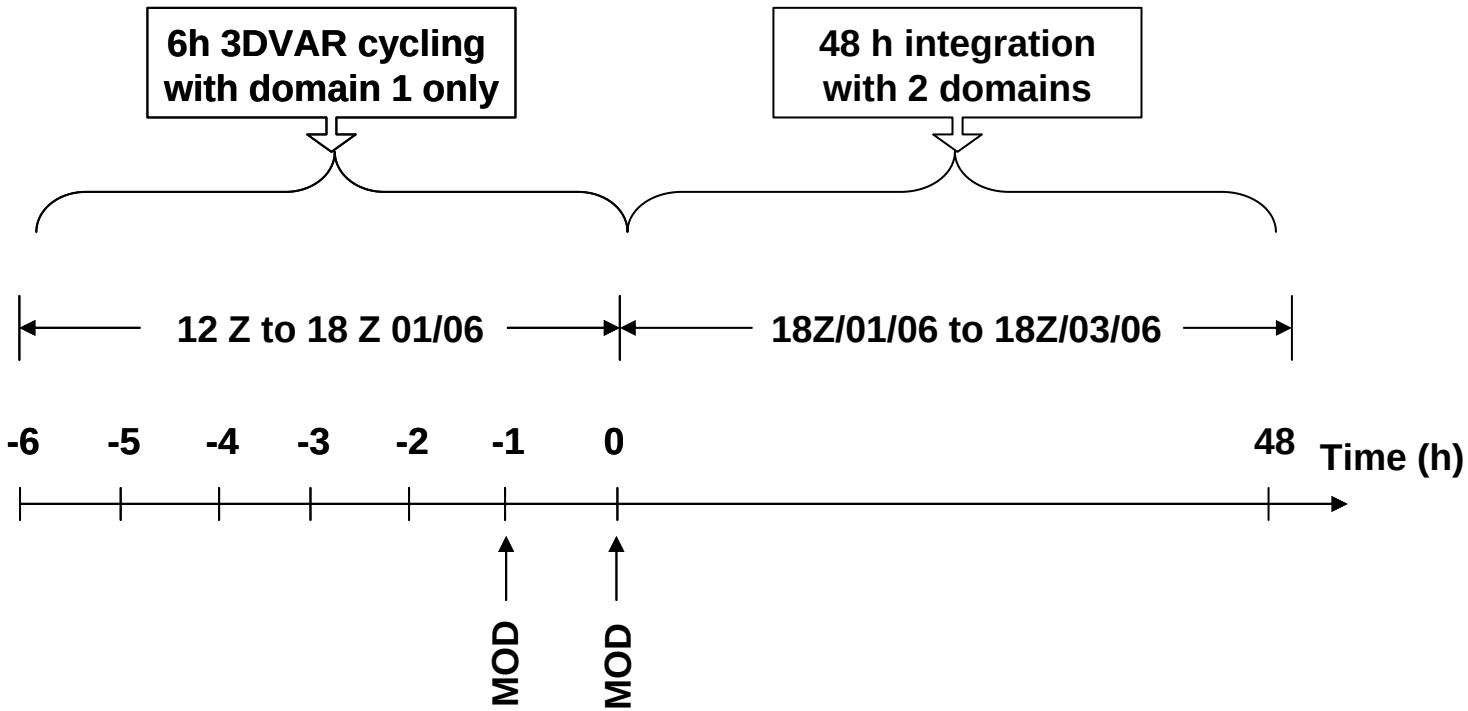
Experiments

(18 Z June 1 – 18 Z June 3, 2004)

	Assimilated data	*Error*
CNTL	None	
MOD	MODIS nIR TPW	4.0 mm (TPW)
CMOD	Corrected nIR TPW	2.5 mm (land) 4.0 mm (ocean)

Data Assimilation

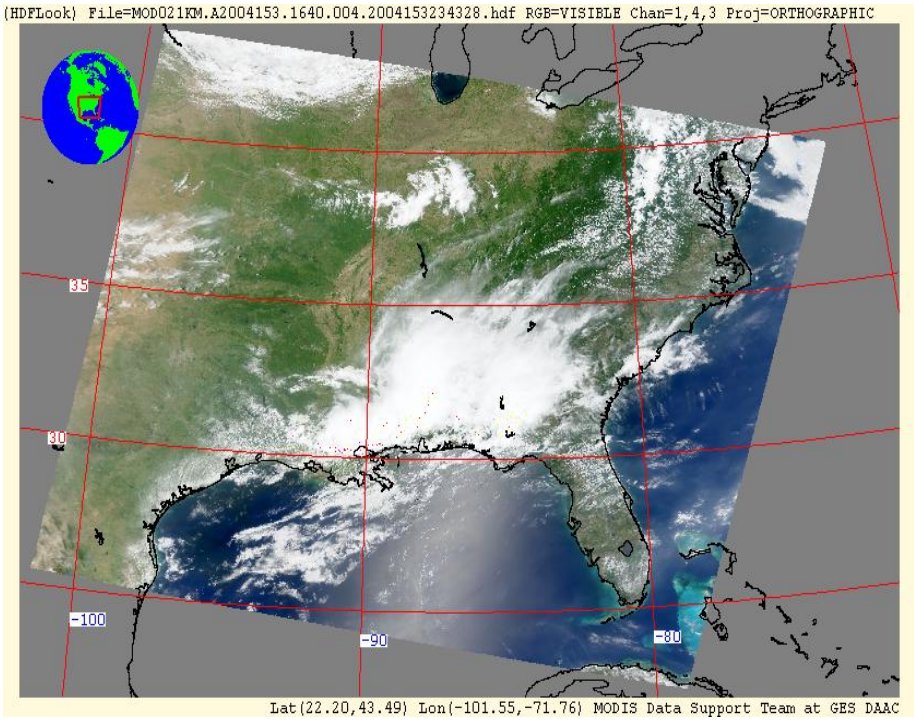
(12 Z June 1 – 18 Z June 1, 2004)



MOD05 TPW

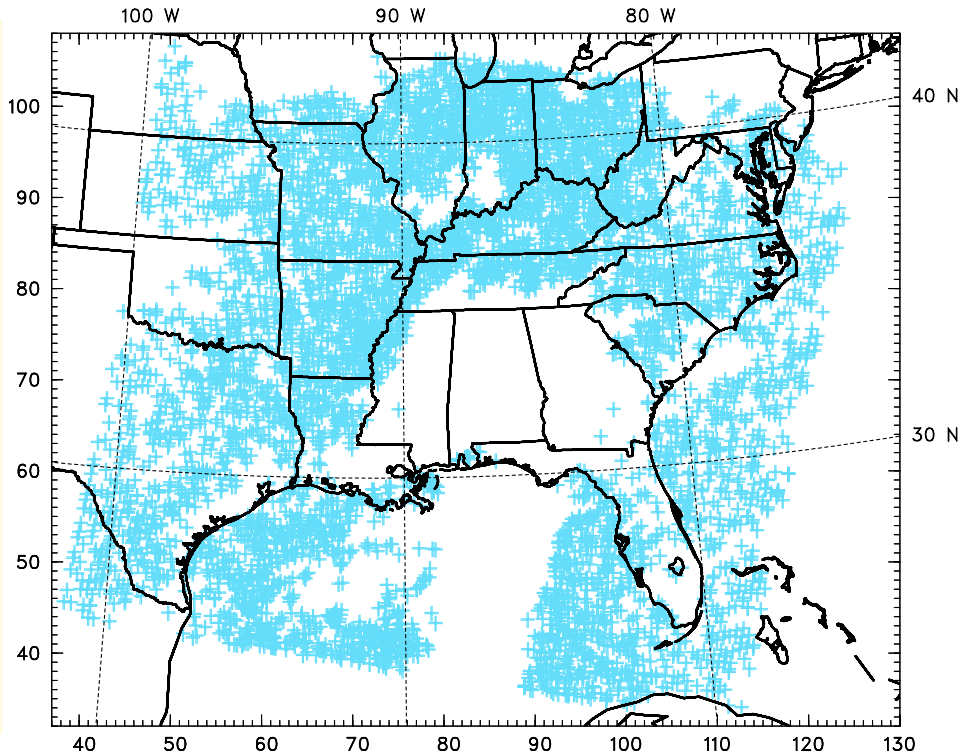
(16:40-16:45 June 1, 2004)

MODIS satellite image



Courtesy NASA

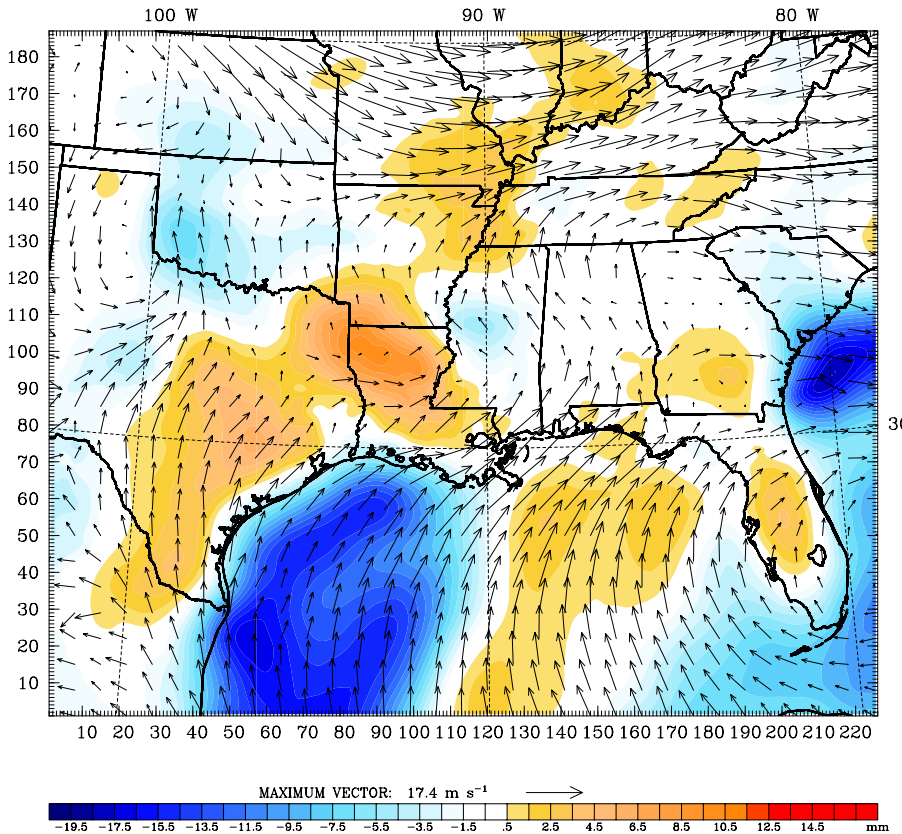
Screened Data



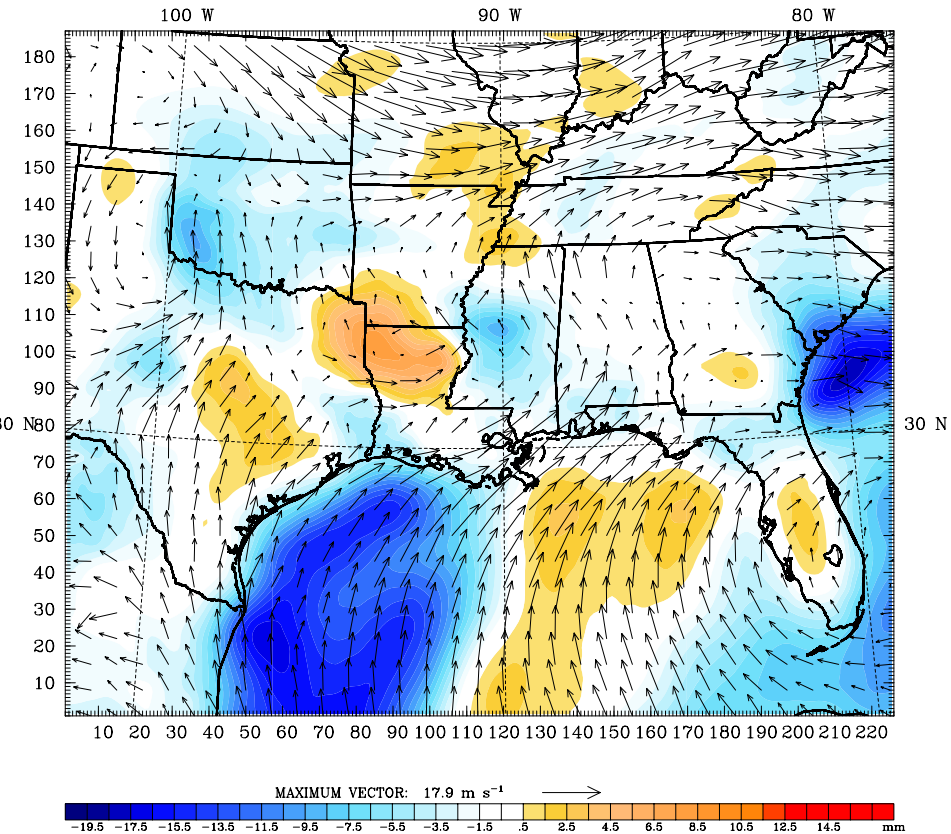
900 mb Wind and the Difference of TPW

(18 Z June 1, 2004)

MOD-CNTL

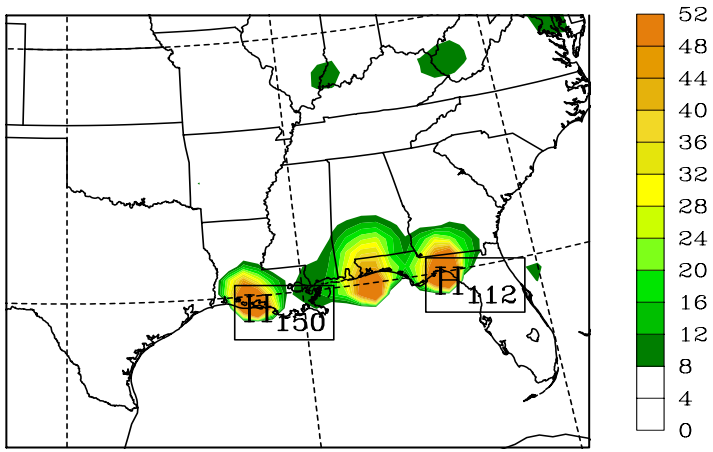


CMOD-CNTL

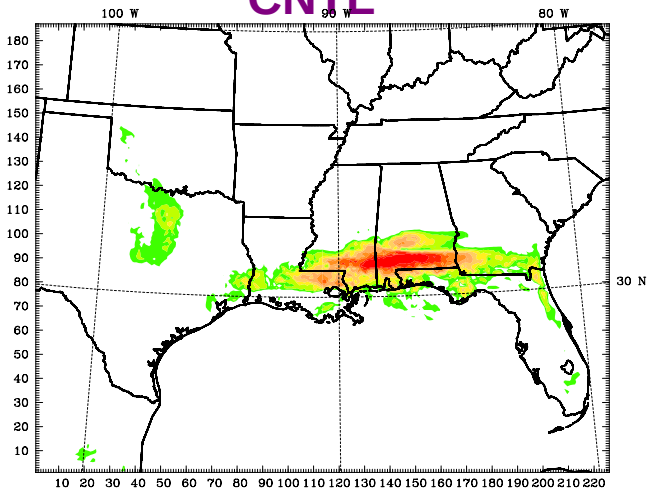


Rainfall (0 - 6h simulation)

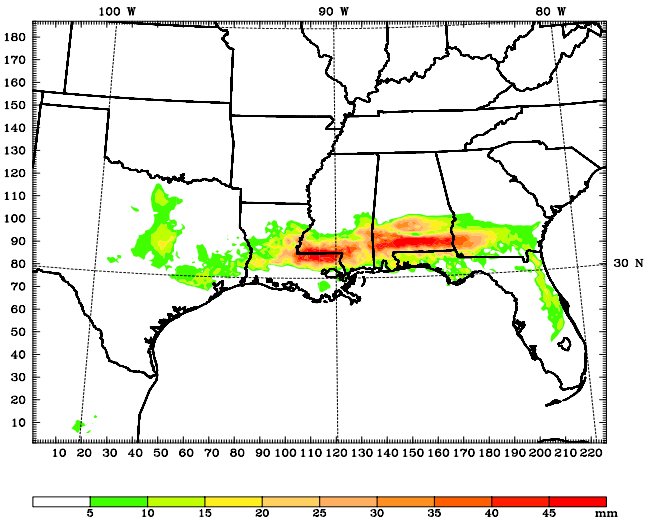
Observation



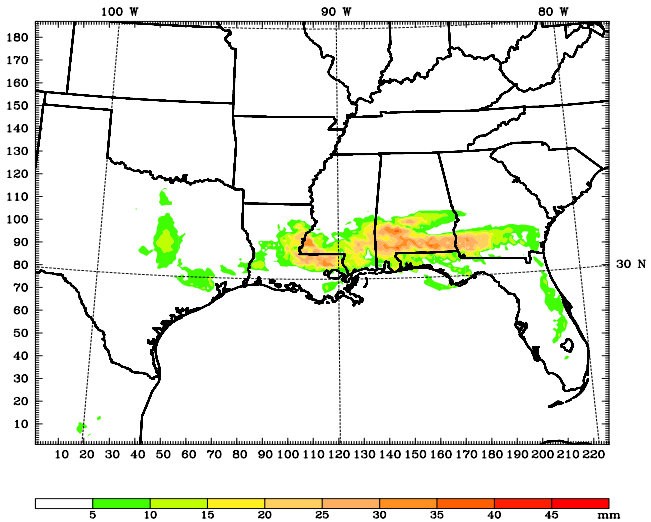
CNTL



MOD

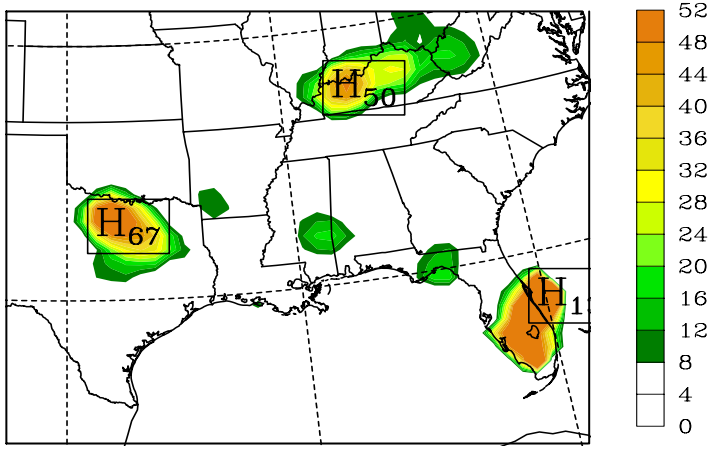


CMOD

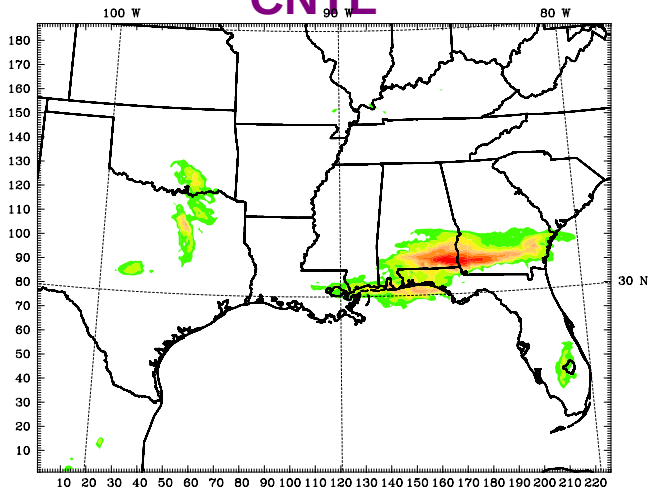


Rainfall (6 - 12h simulation)

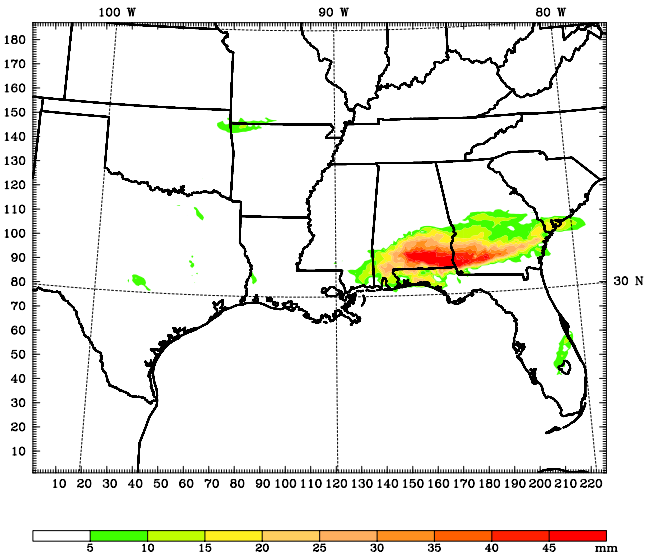
Observation



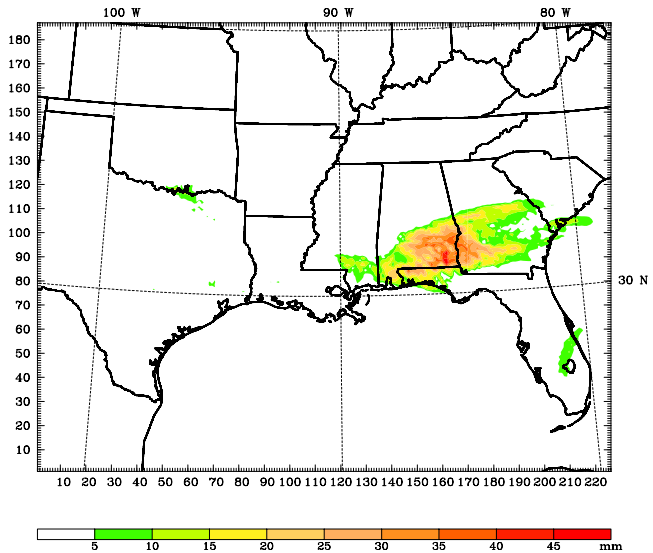
CNTL



MOD

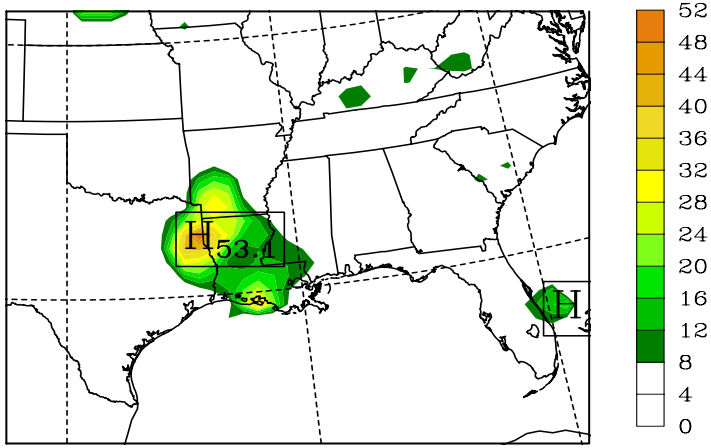


CMOD

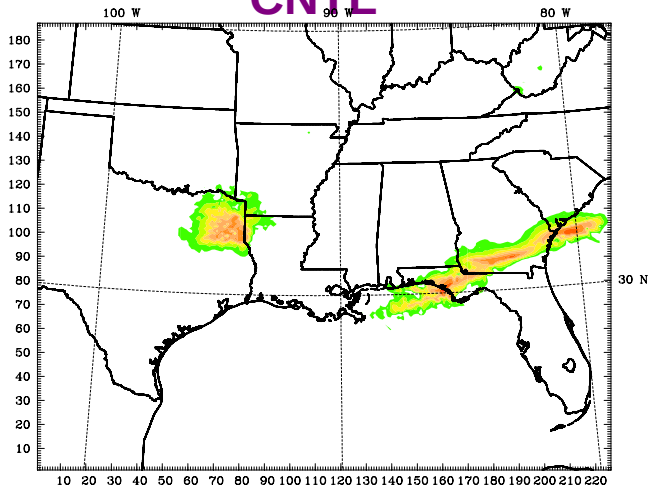


Rainfall (12 - 18h simulation)

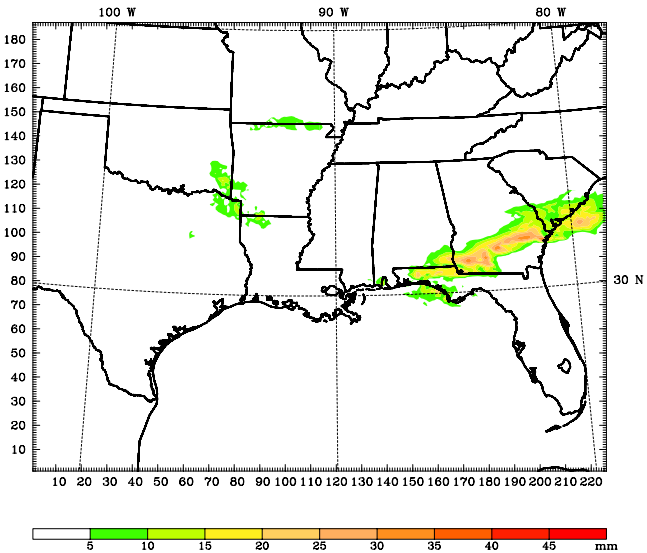
Observation



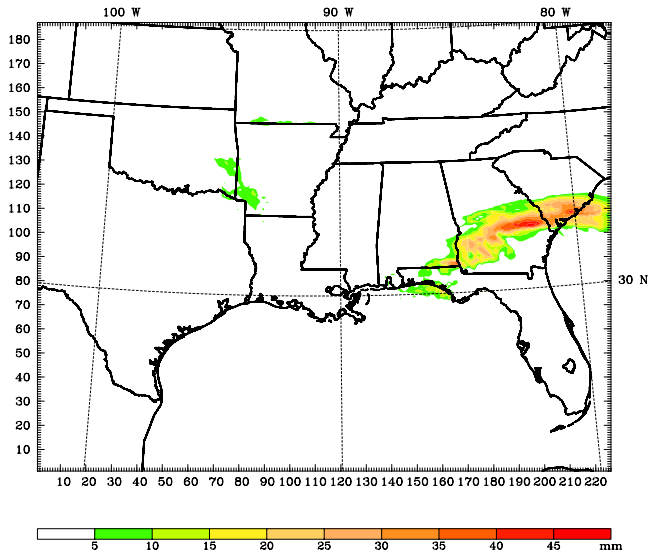
CNTL



MOD

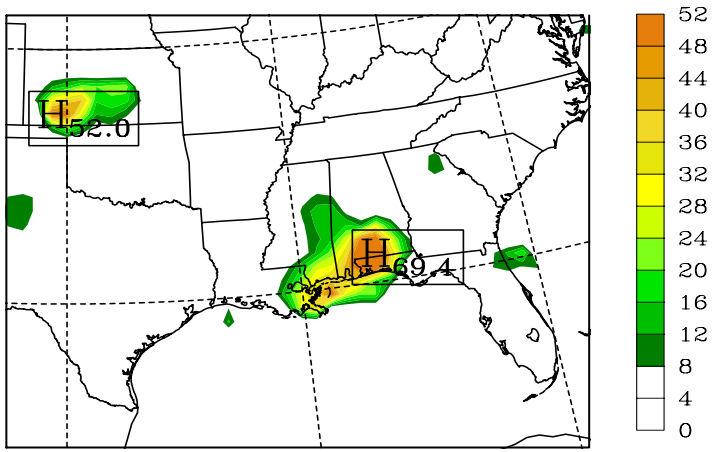


CMOD

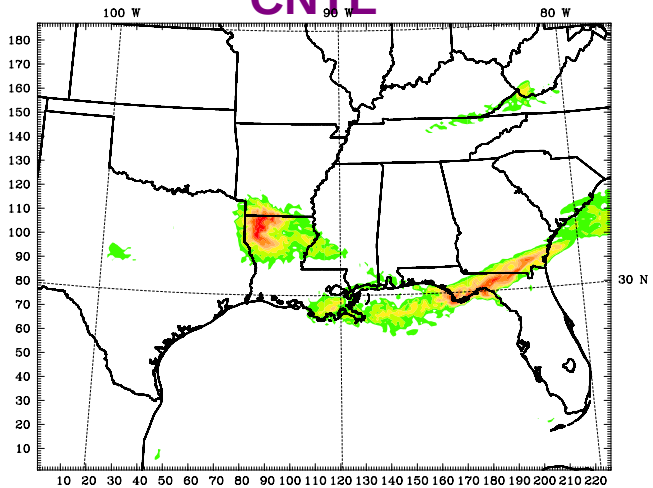


Rainfall (18 - 24h simulation)

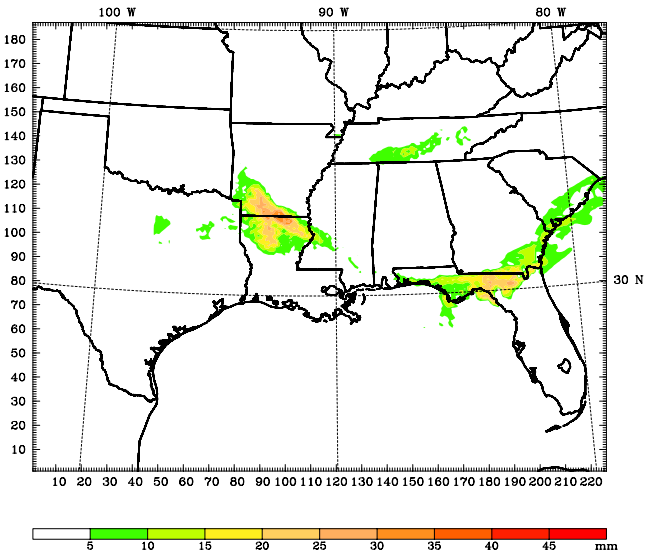
Observation



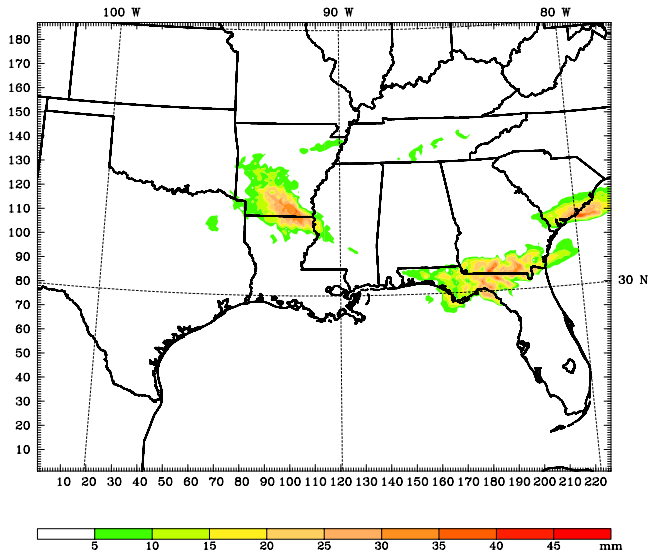
CNTL



MOD



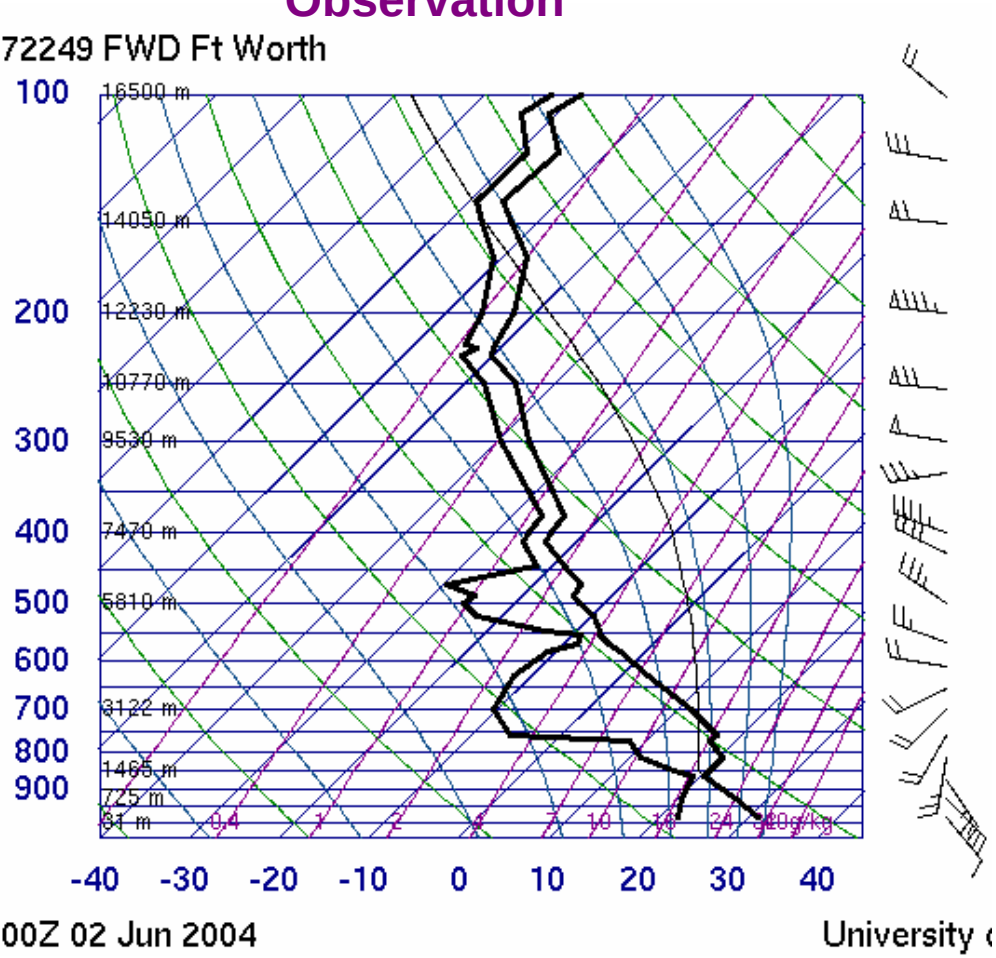
CMOD



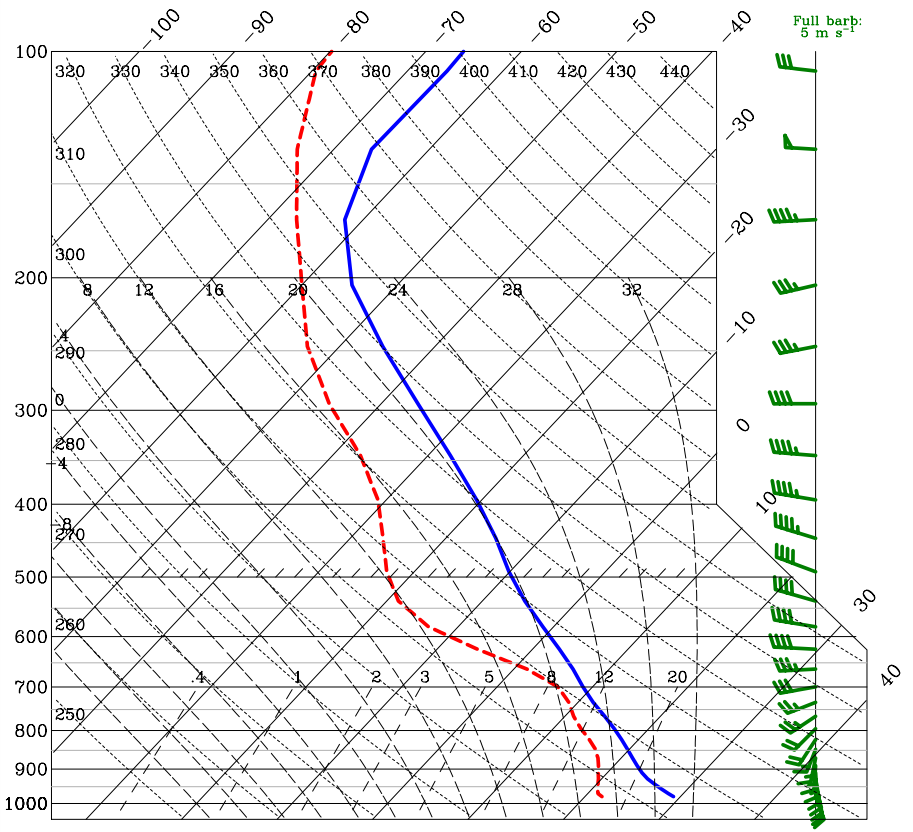
Skew-T Log-P Diagram

(00Z June 2)

Observation



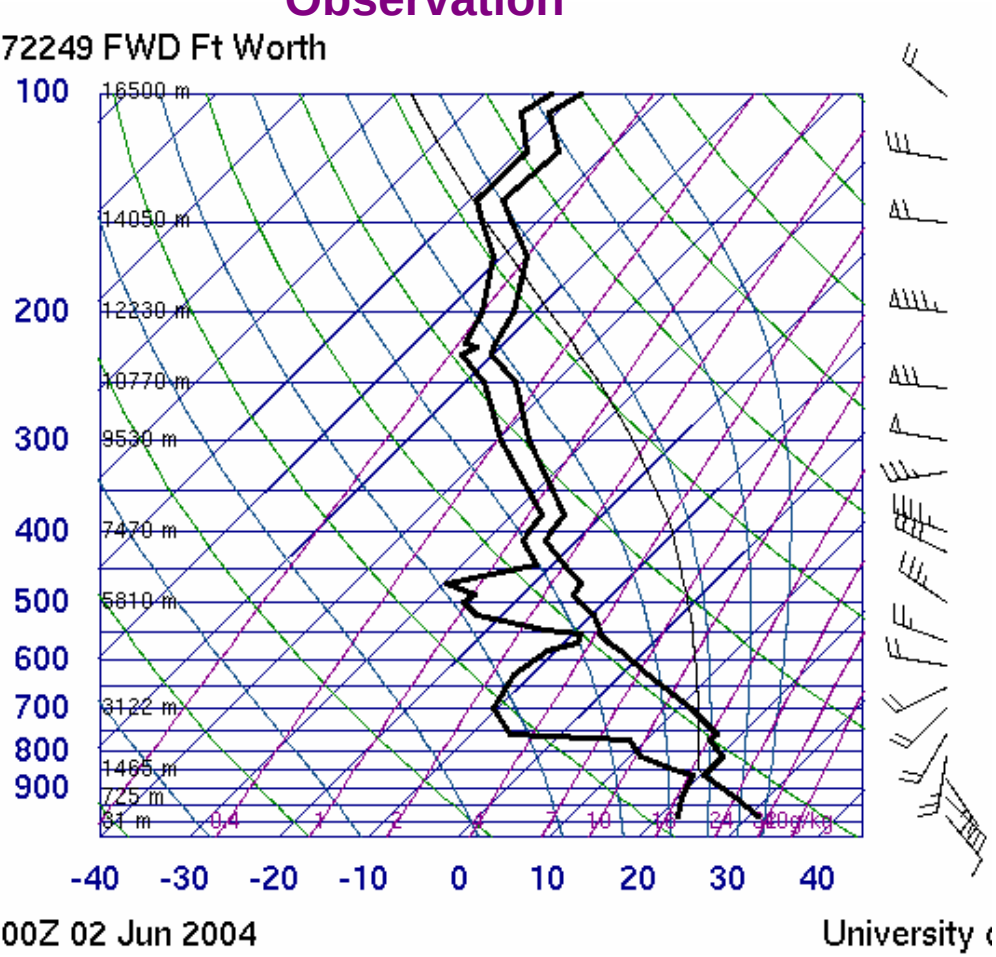
CNTL



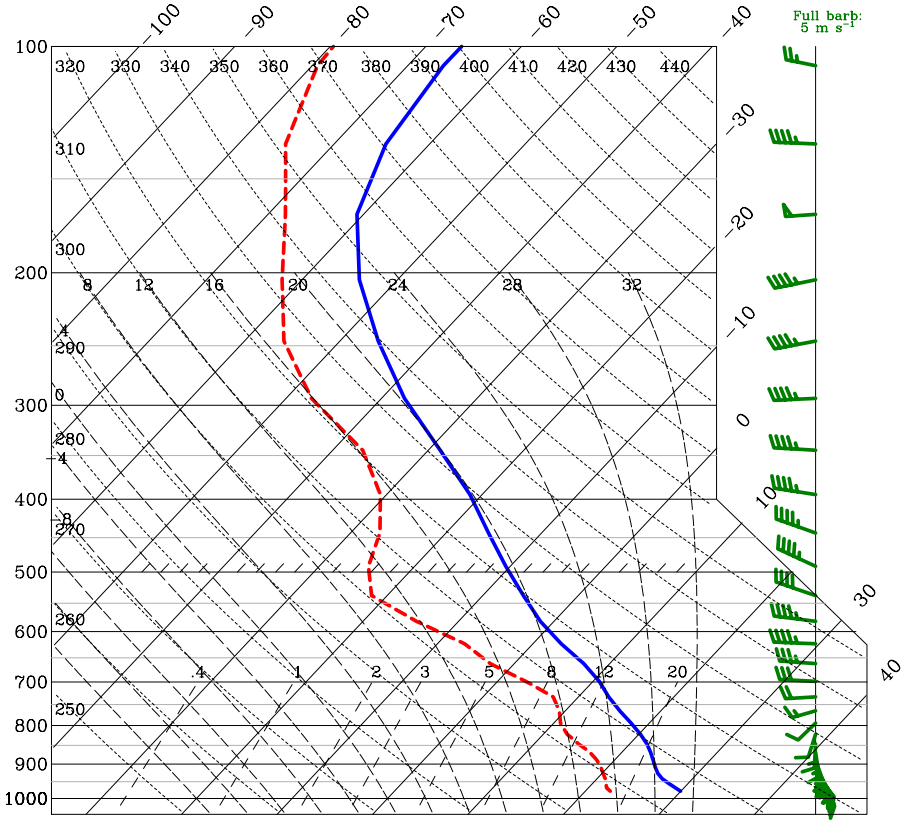
Skew-T Log-P Diagram

(00Z June 2)

Observation



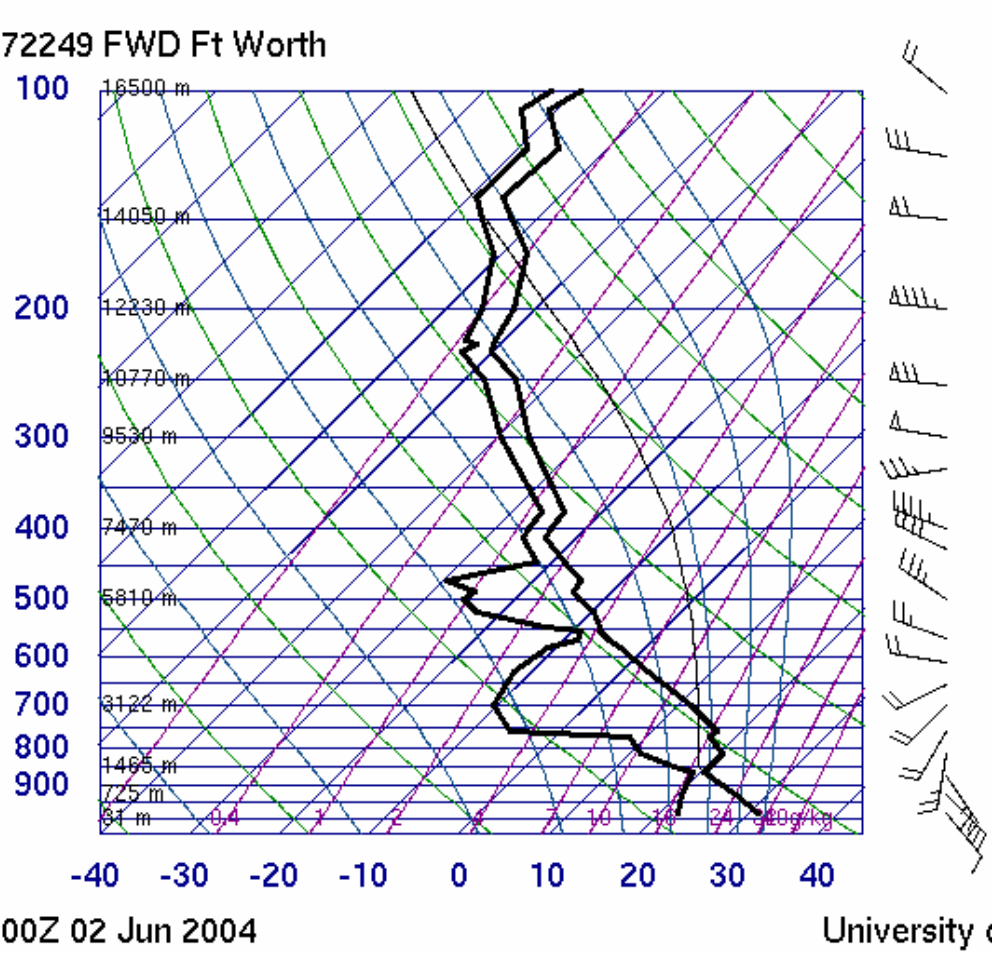
MOD



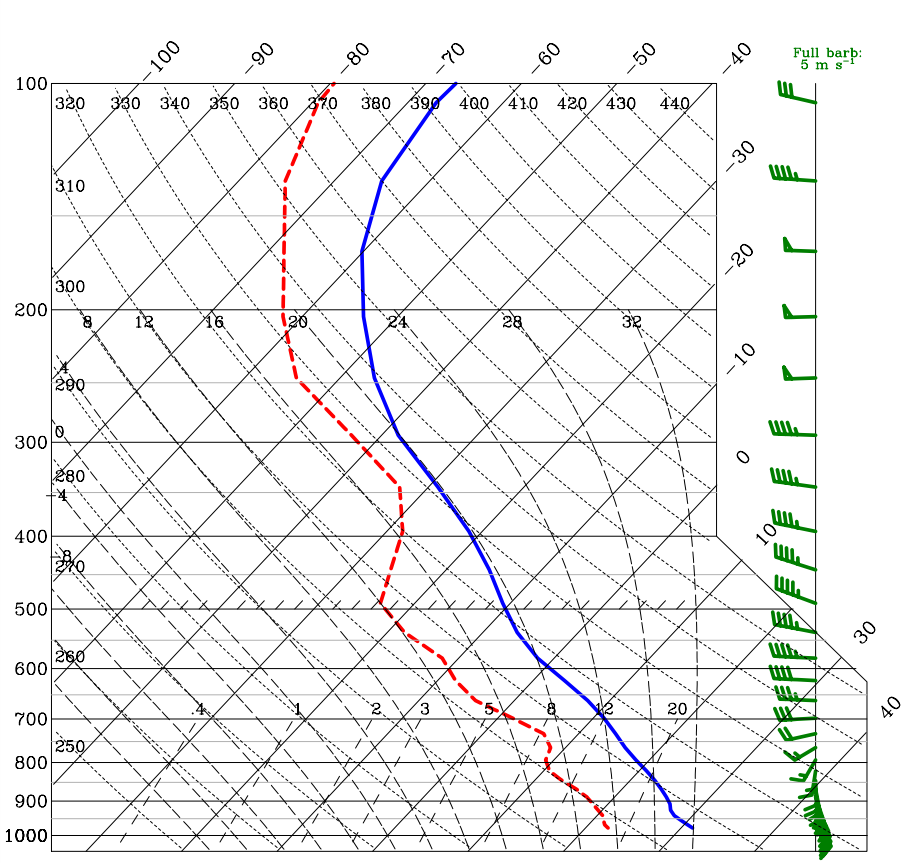
Skew-T Log-P Diagram

(00Z June 2)

Observation



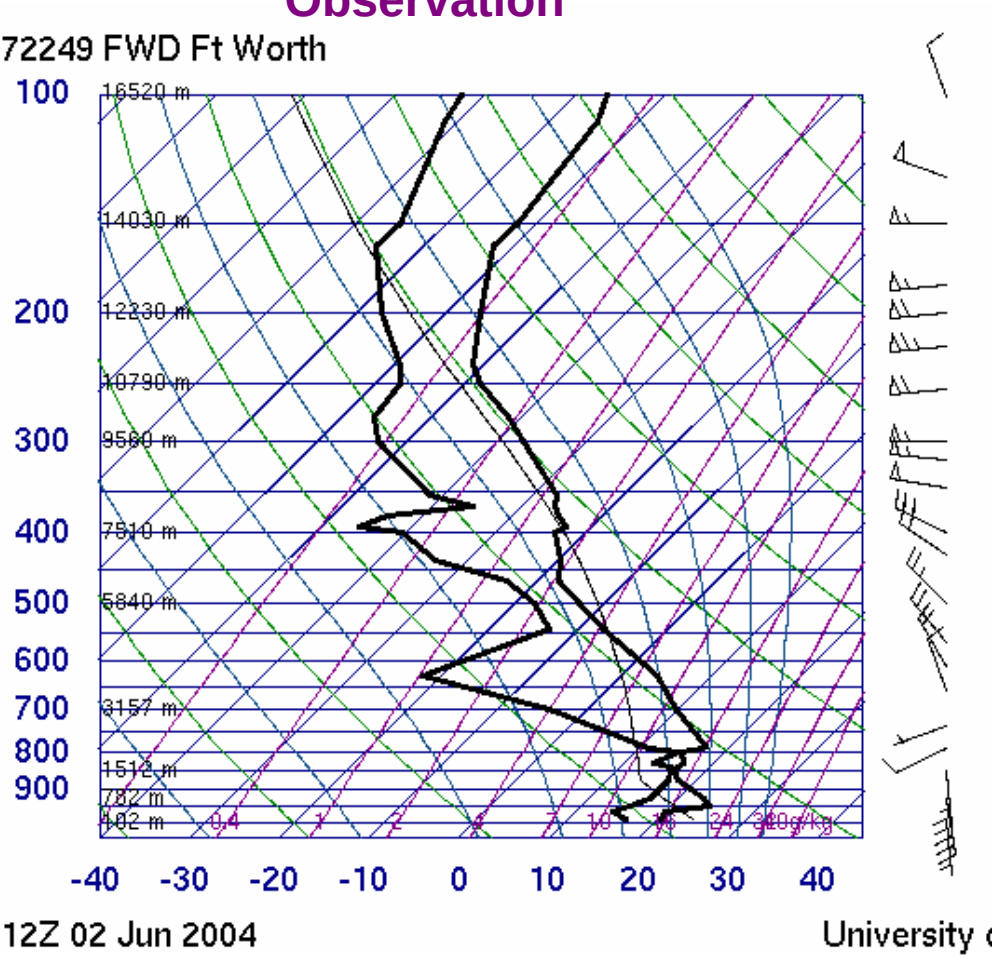
CMOD



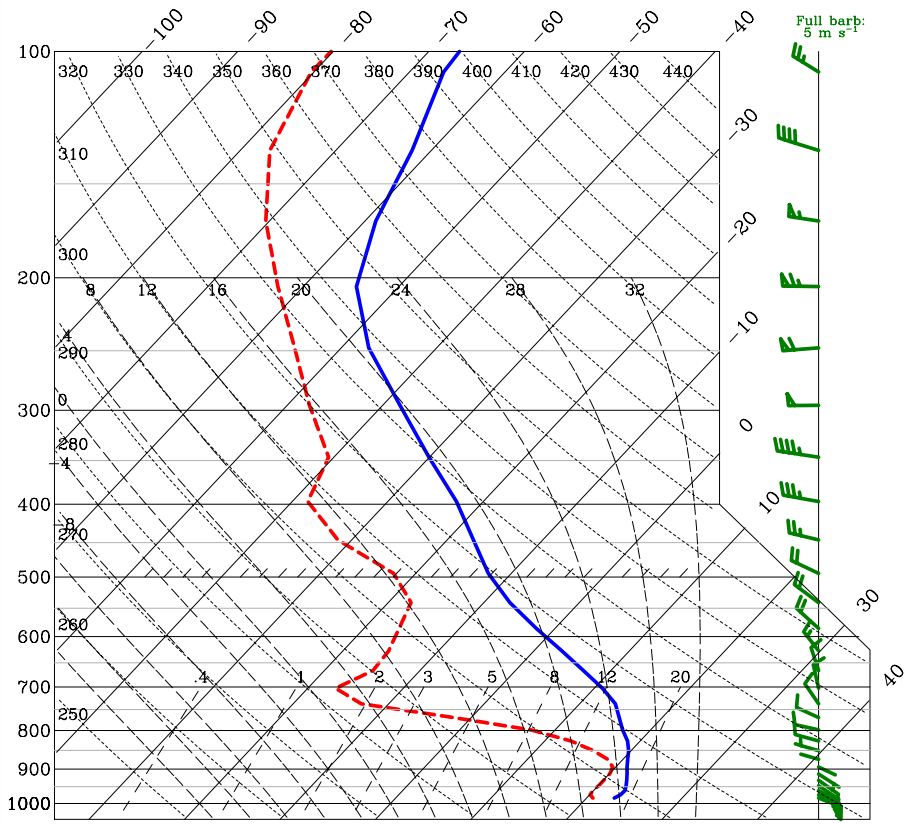
Skew-T Log-P Diagram

(12Z June 2)

Observation



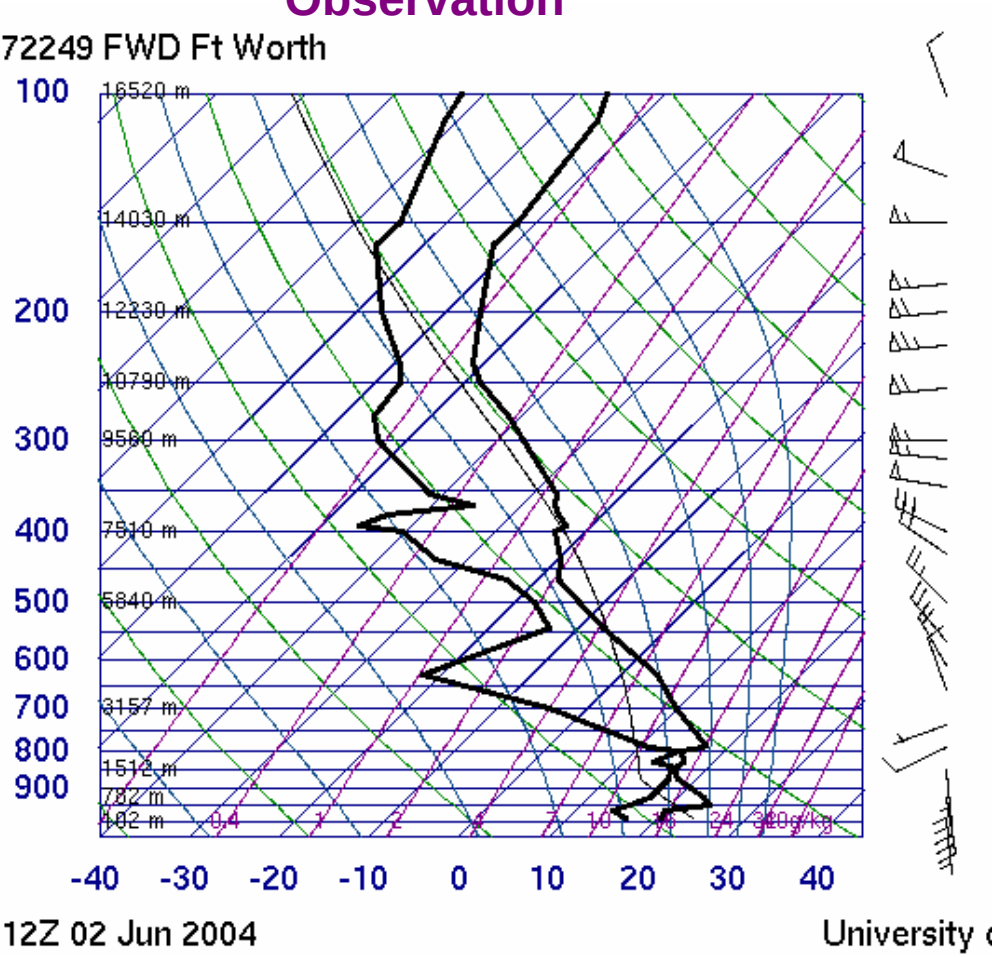
CNTL



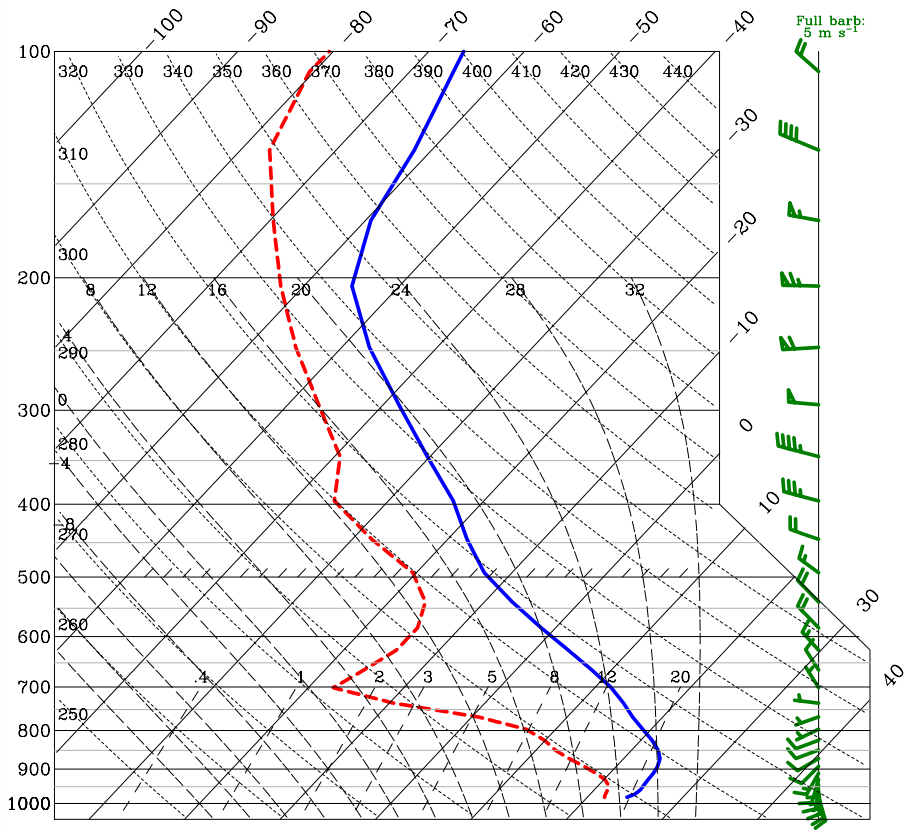
Skew-T Log-P Diagram

(12Z June 2)

Observation



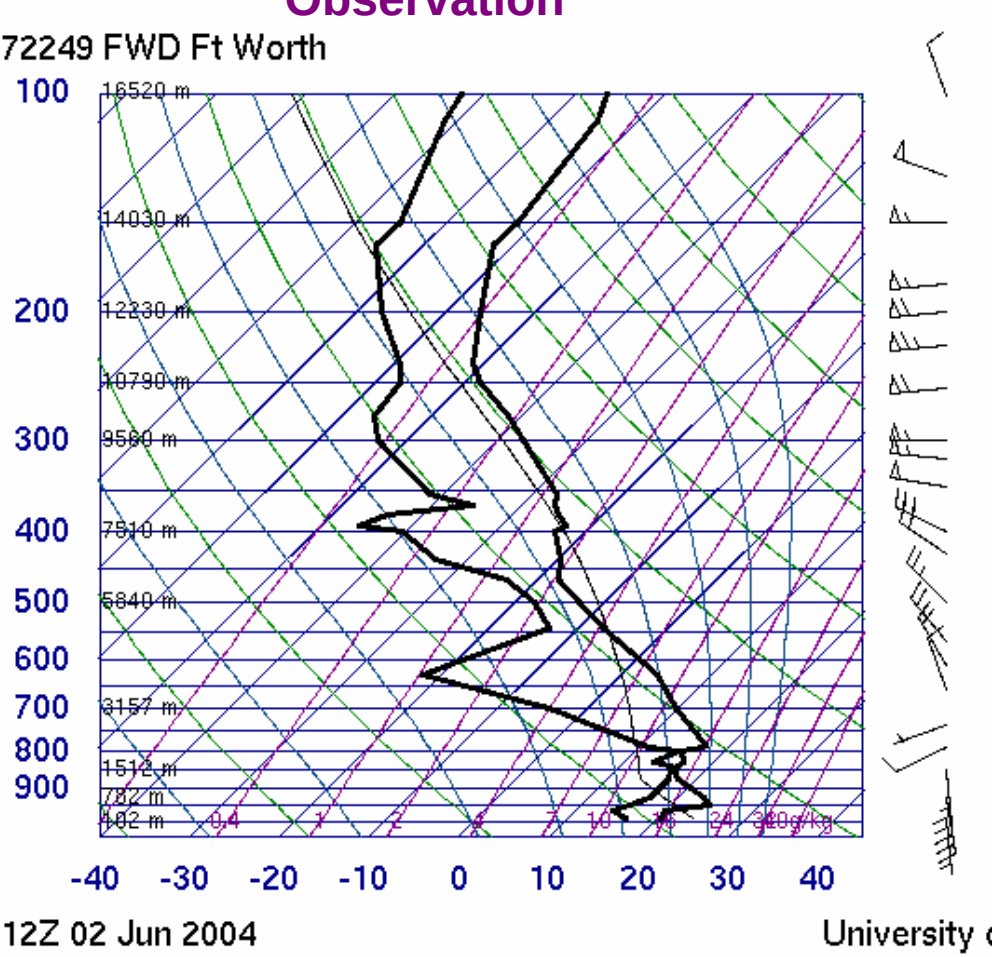
MOD



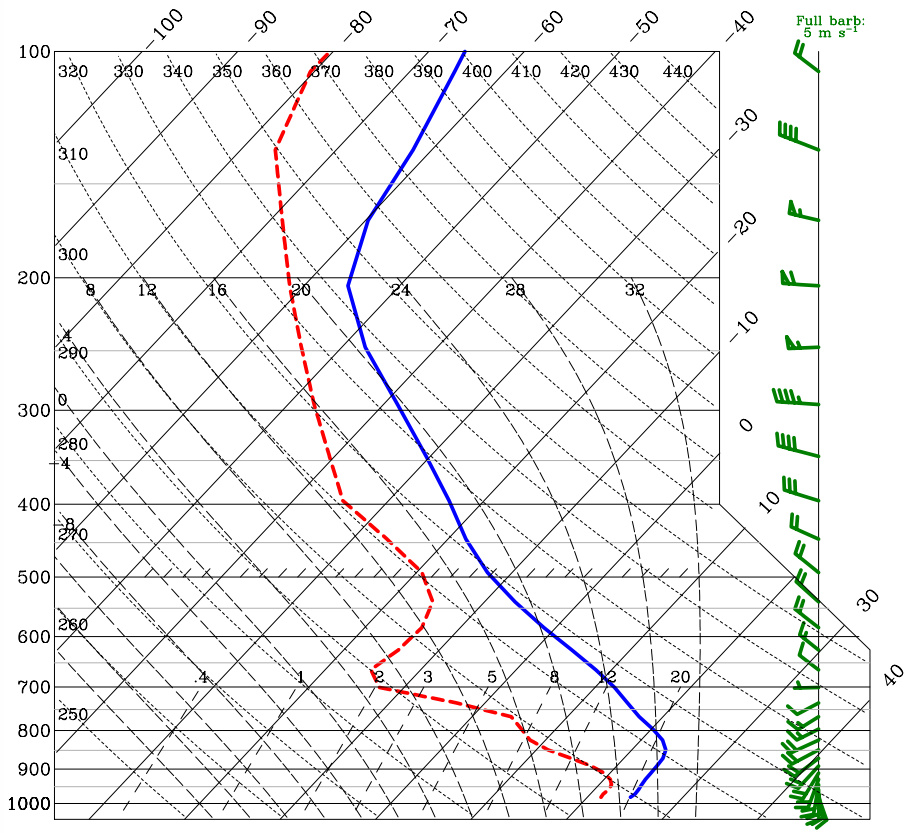
Skew-T Log-P Diagram

(12Z June 2)

Observation

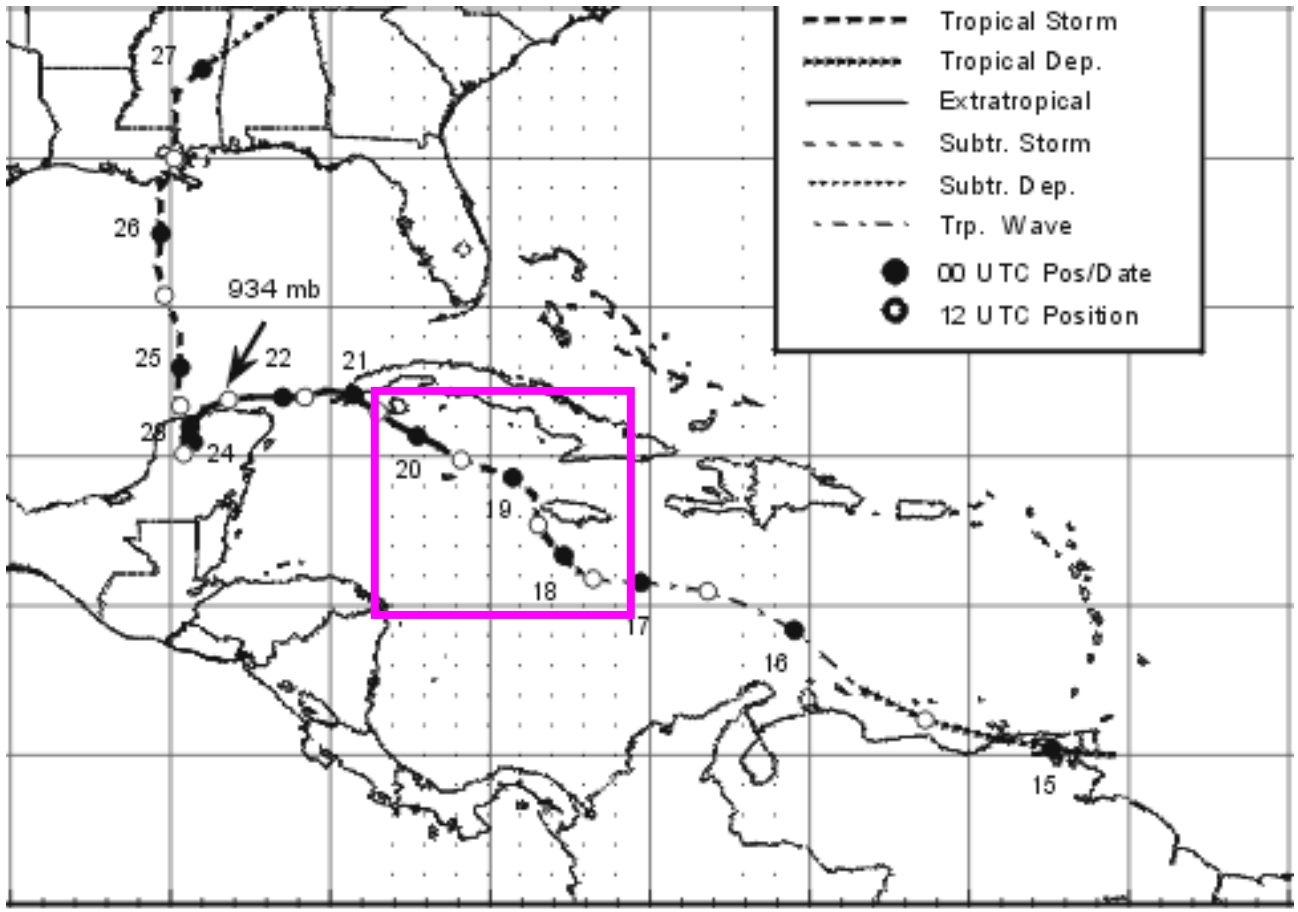


CMOD



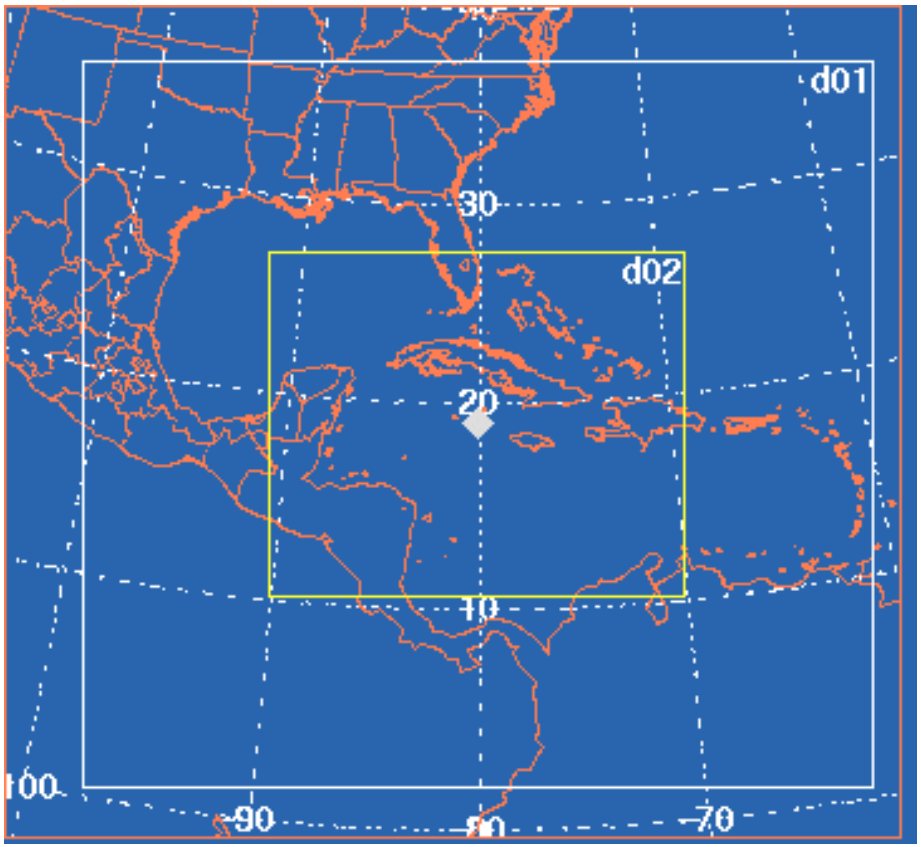
Case 2: Hurricane Isidore, 2002

18 Z 17 Sep
to
00 Z 20 Sep



Model Configuration

Weather Research and Forecast Model



Global Reanalysis: AVN 1º x 1º

Domain 1 - 30 km

2 - 10 km

Physic: Purdue microphysics

New Kain-Fritsch

RRTM long wave

Dudhia short wave

YSU PBL

Experiments

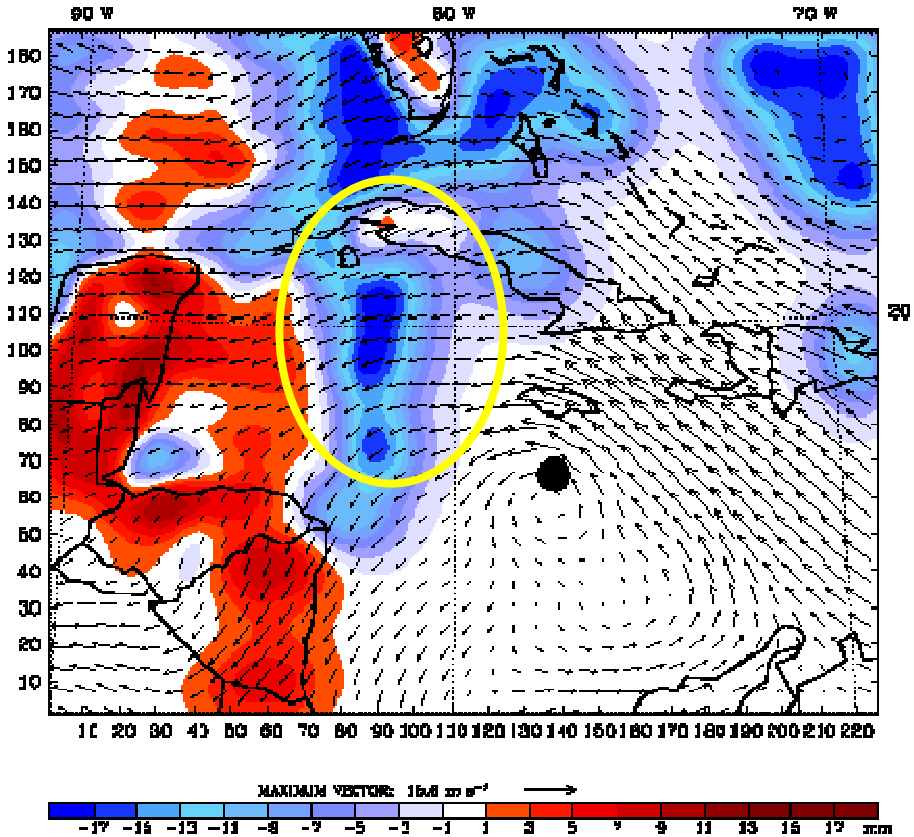
(18Z 17 – 00Z 20 Sep 2002)

	Assimilated data	*Error*
CNTL	None	
MOD	Original MODIS nIR TPW	4 mm
CMOD	Modified MODIS nIR TPW	2.5 mm

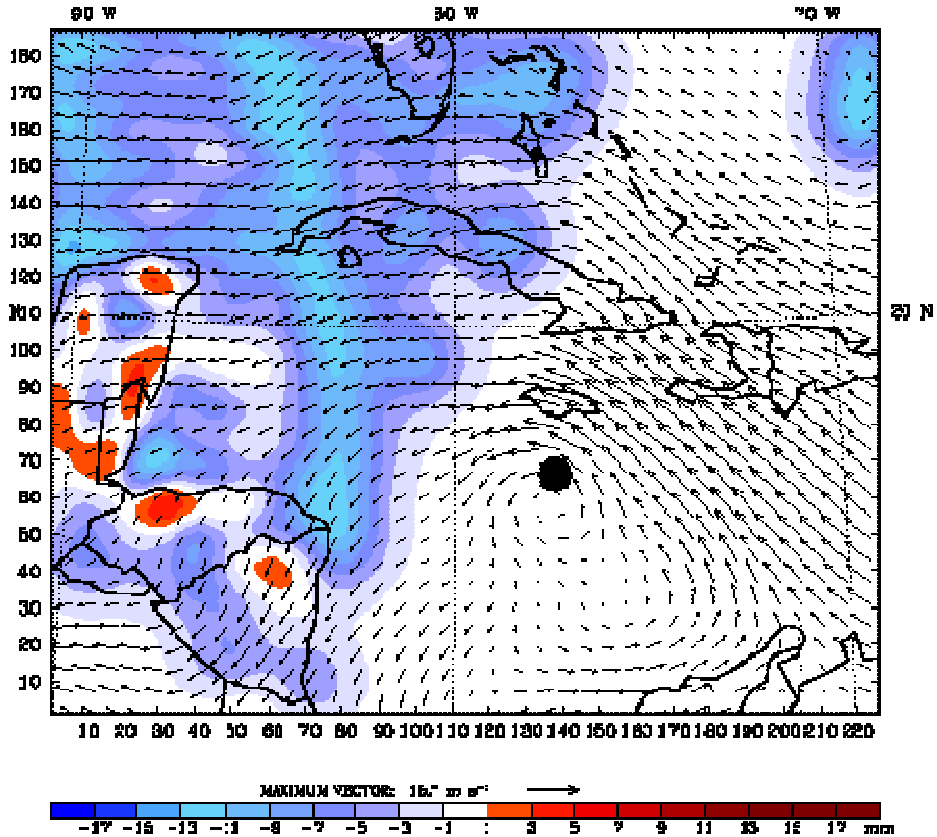
TPW Increment and 850 mb Wind

(18Z 17 Sep 2002)

MOD

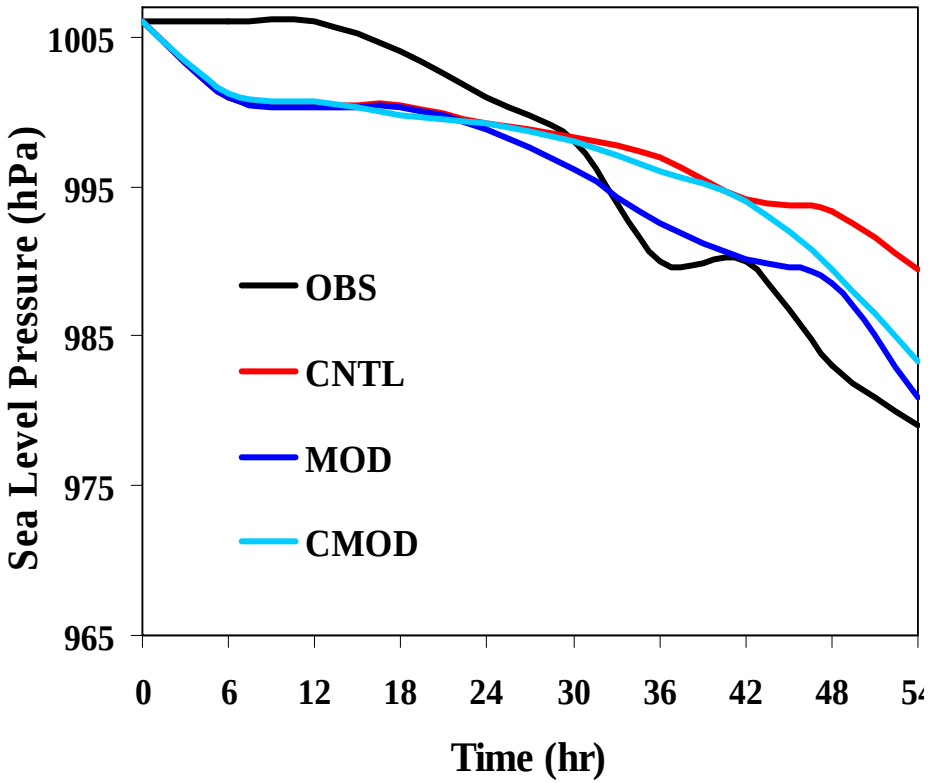


CMOD

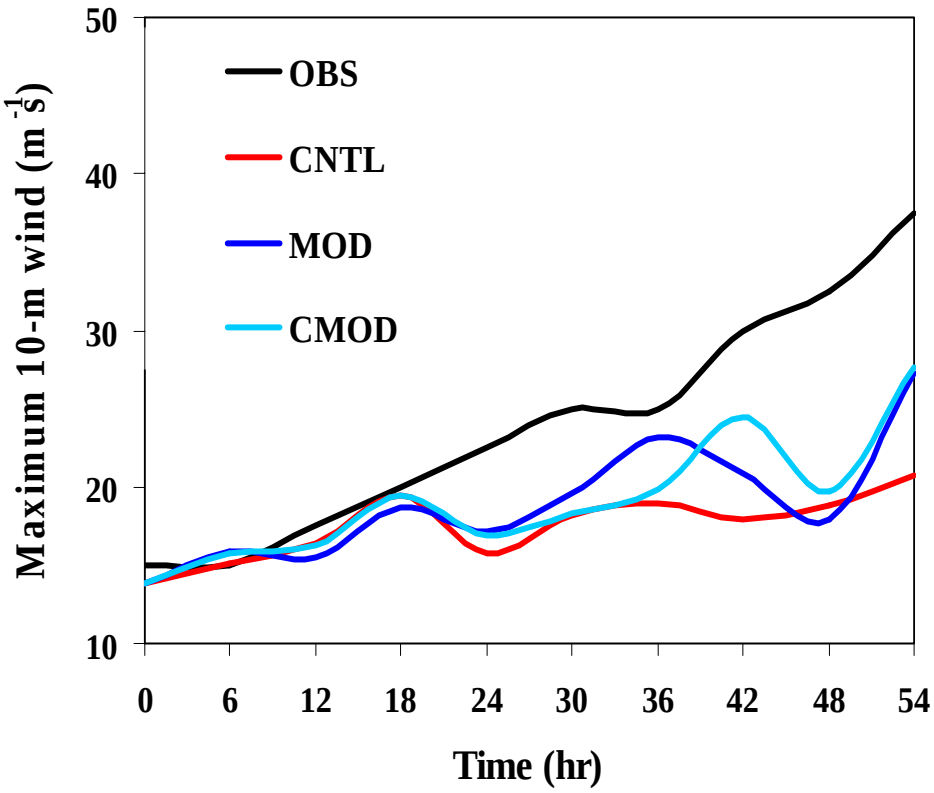


Results - Isidore

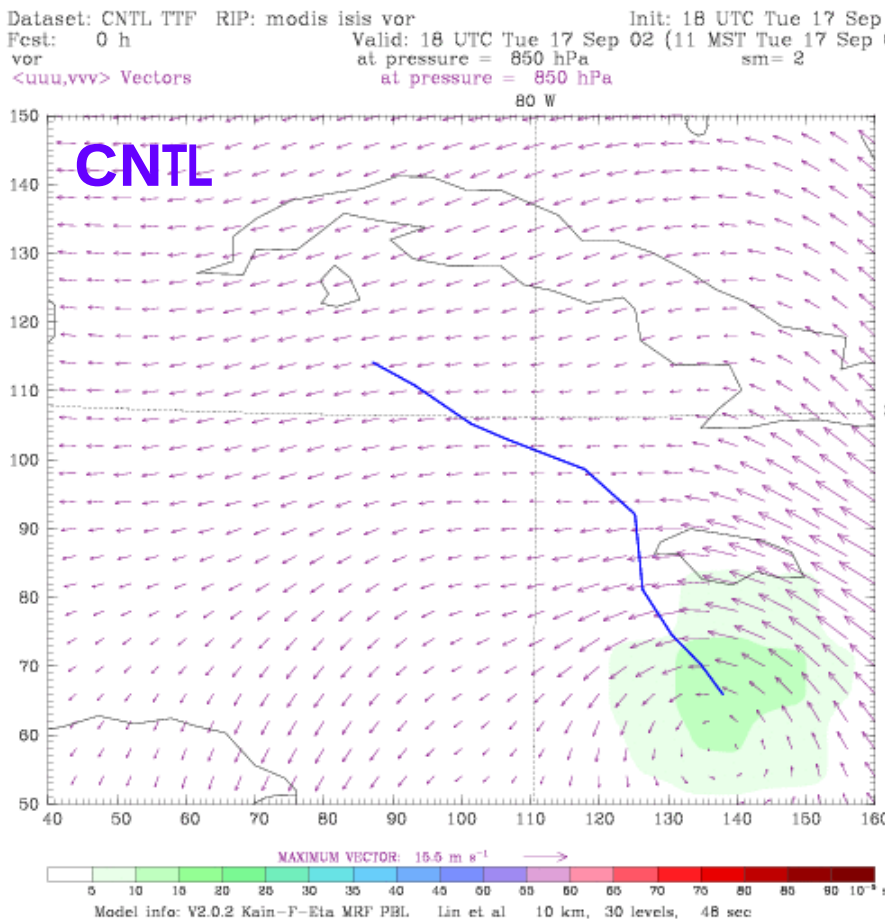
Minimum Sea Level Pressure

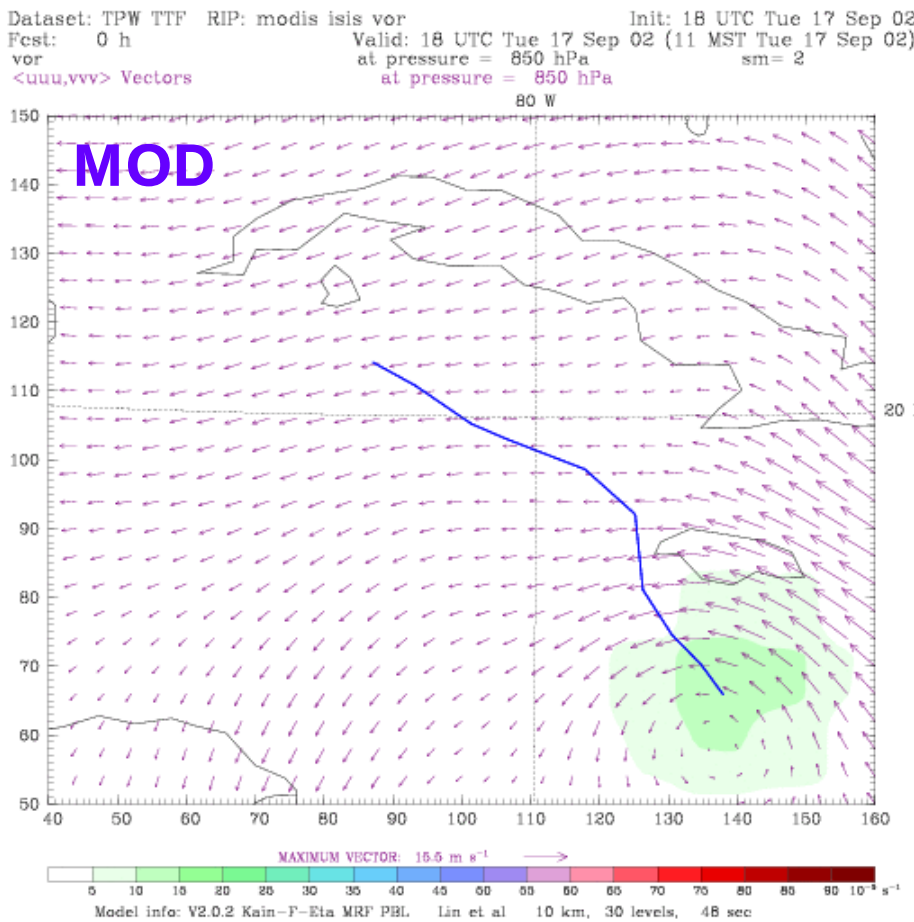


Maximum 10-m Wind Speed



850 mb Vorticity & Wind Vectors





Summary

- The MODIS nIR TPW may have a moist bias and the IR TPW may have a moist bias for a dry atmosphere and a dry bias for a moist atmosphere over land.
- The error of retrieved MODIS TPW is about 2-5 mm.
- Preliminary results show that the assimilation of MODIS nIR TPW has almost no (or slightly negative) impact on the thunderstorm stimulations over the southern US and has a positive impact on simulated Isidore intensity after one-day integration.
- One has to be very cautious when assimilating MODIS TPW!!!

Future work

- Directly assimilate MODIS brightness temperature (radiances)