Influences of PBL Parameterizations on Warm-Season Convection-Permitting Regional Climate Simulations

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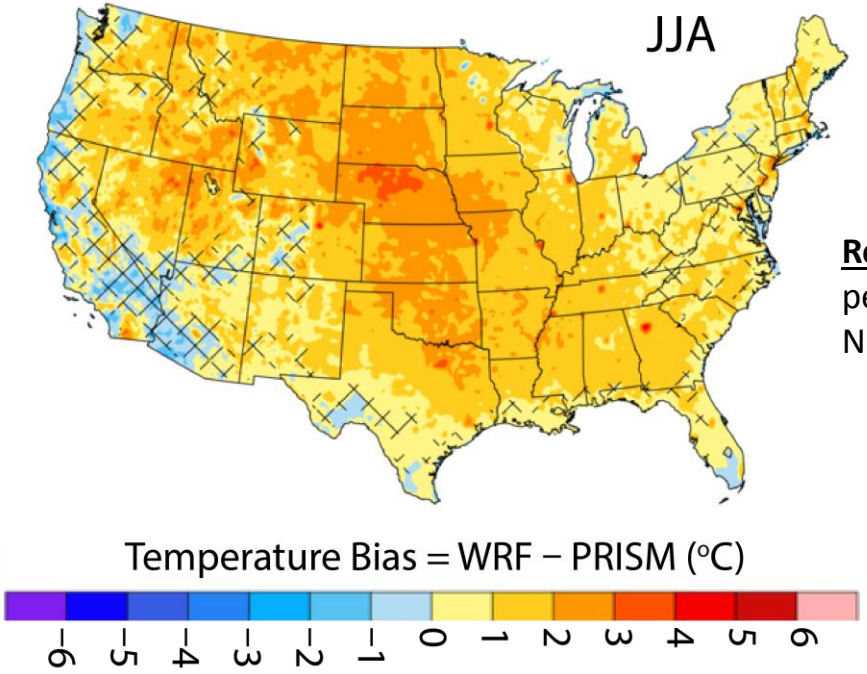
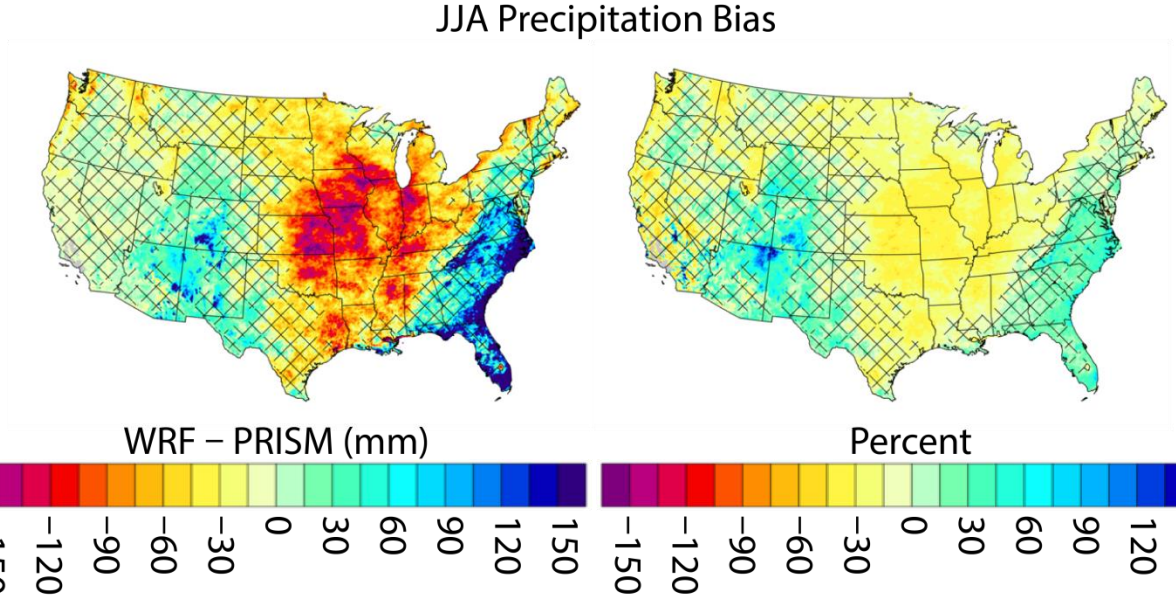
Results from 13-Yr WRF-CONUS Current Climate Simulation (Oct 2000 – Sep 2013)

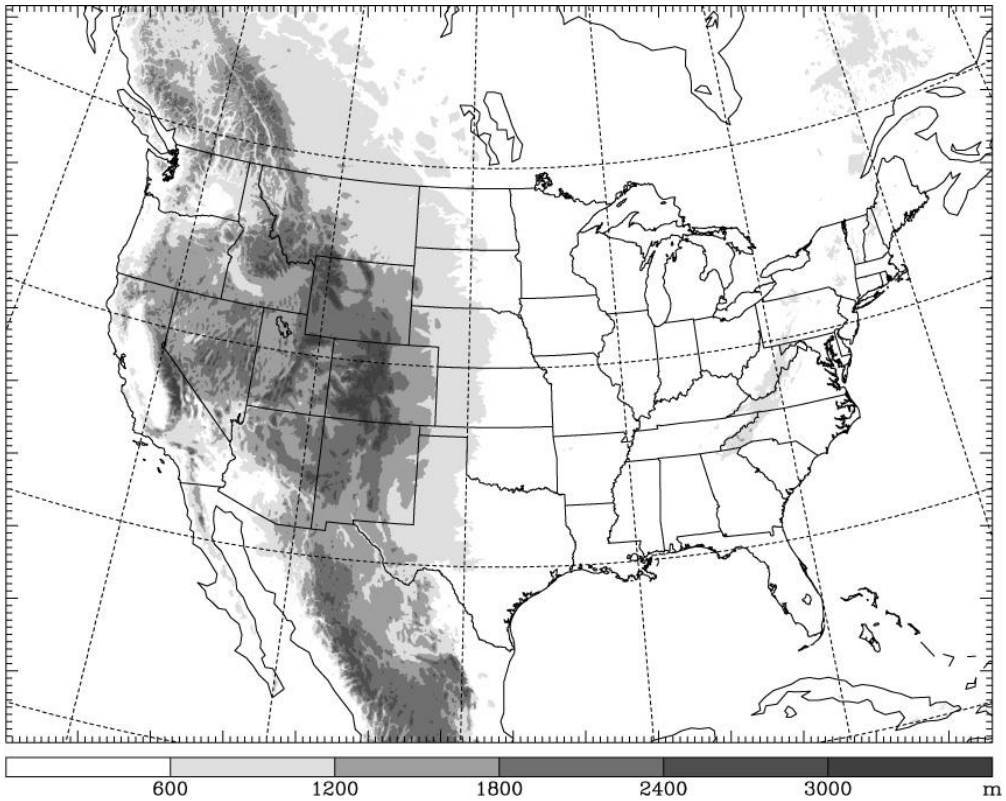


Reference: Liu, C. et al. 2016: Continental-scale convection permitting modeling of the current and future climate of North America. *Climate Dynamics*, in press.



Figures courtesy of Kyoko Ikeda (NCAR/RAL)

1 May – 1 September 2001 WRF CONUS PBL Sensitivity Simulations



- Model Setup (following Liu et al. 2016, *Clim. Dyn.*)

  - Single domain (1360 x 1016 x 51) with model top at 50 hPa

  - Δx,y = 4 km, coupled with Noah-MP LSM (Niu et al. 2011, *JGR*)

  - 4-month continuously running with LBCs from 6-hourly 0.7° ERA-Interim reanalyses

  - Spectral nudging (λ ≥ 2000 km) of ϕ, *T, u, v* above PBL

- PBL Parameterizations

  - Yonsei University (YSU)
    (Hong et al. 2006, *Mon. Wea. Rev.*)

  - Mellor-Yamada-Nakanishi-Niino (MYNN2)
    (Nakanishi and Ninno 2009, *J. Met. Soc. Japan*)

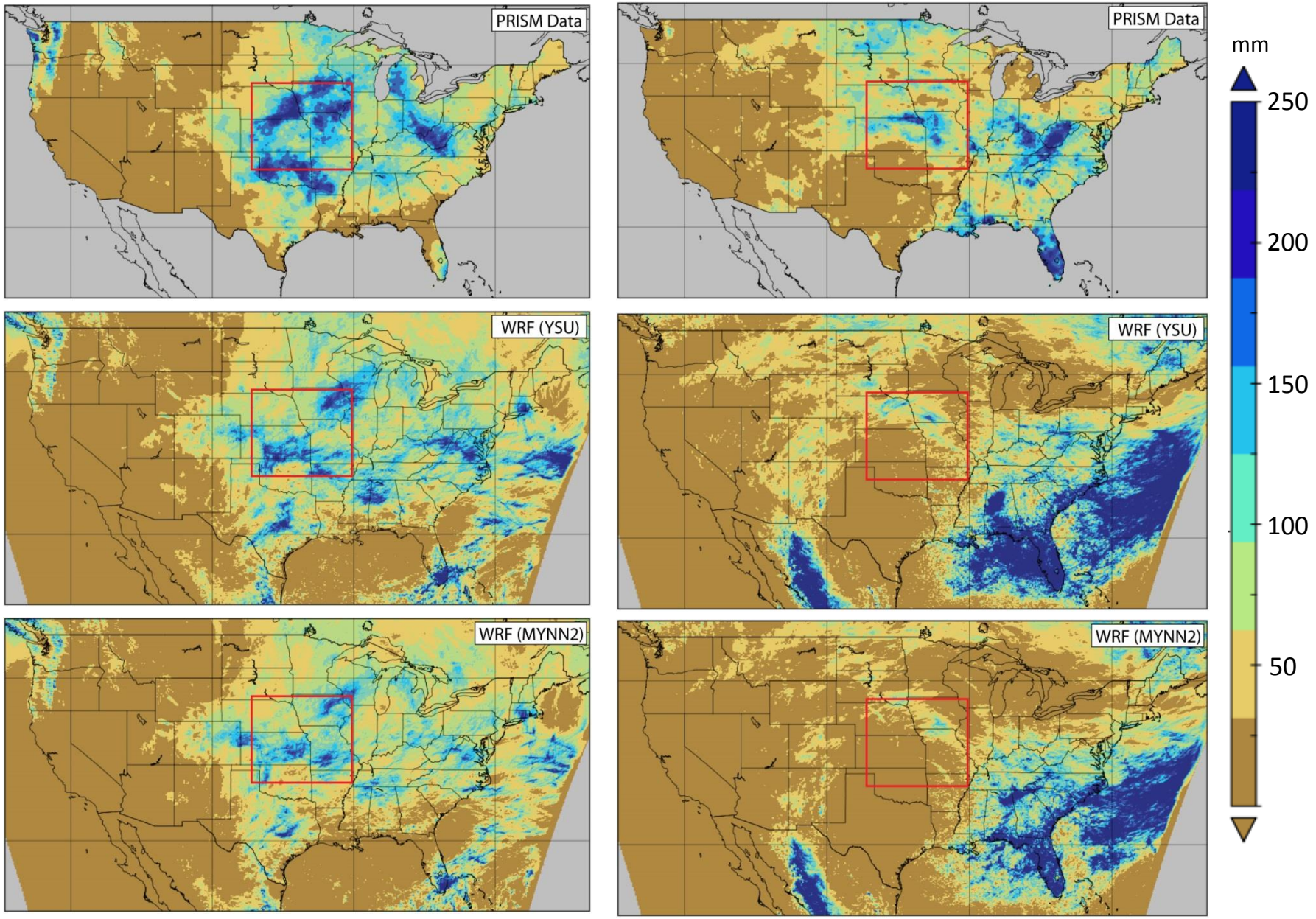
- Other Parameterizations

  - Thompson microphysics
    (Thompson et al. 2008, *Mon. Wea. Rev.*)

  - RRTMG radiative transfer
    (Iacono et al. 2008, *J. Geophys. Res.*)

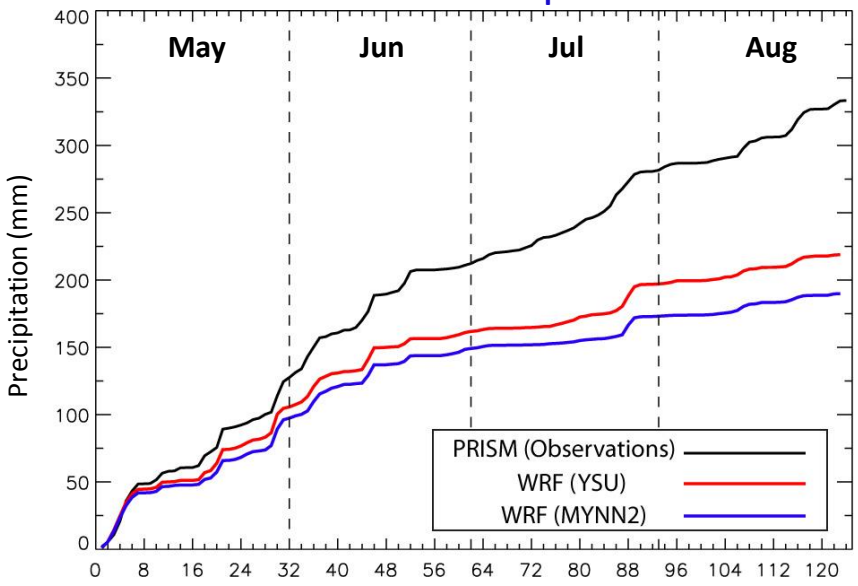
Monthly Precipitation (May 2001)

Monthly Precipitation (July 2001)

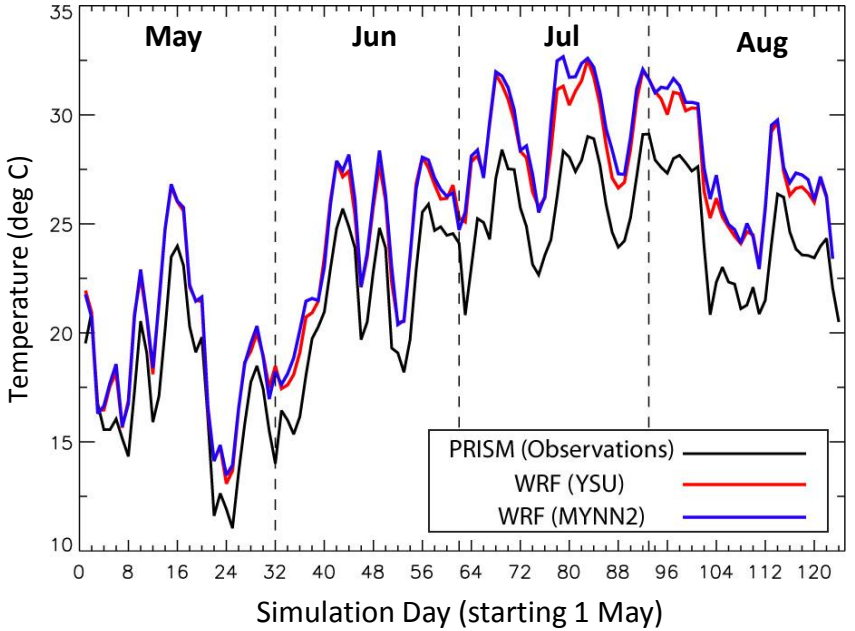


Area-Averaged (1000 x 1000 km) Time Series from 1 May – 31 Aug 2001

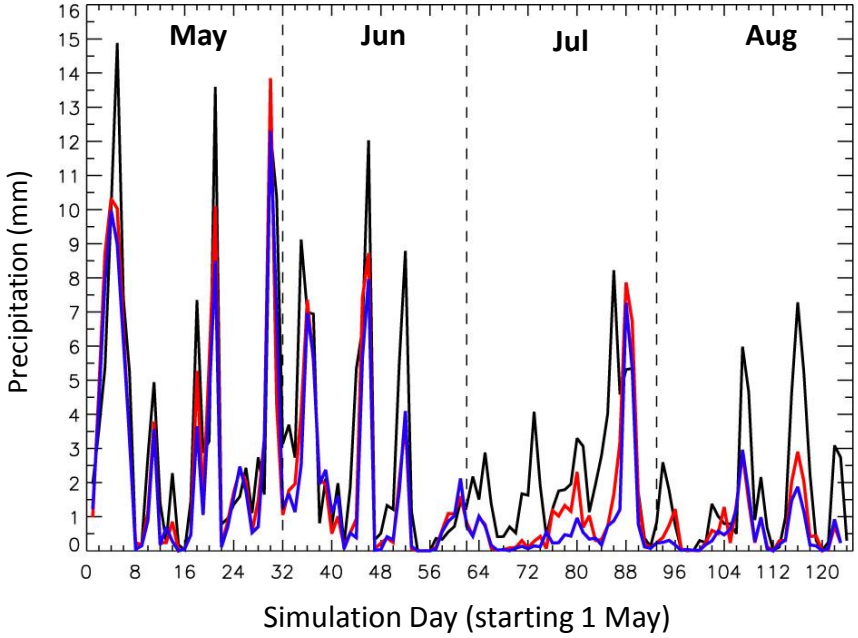
Accumulated Precipitation



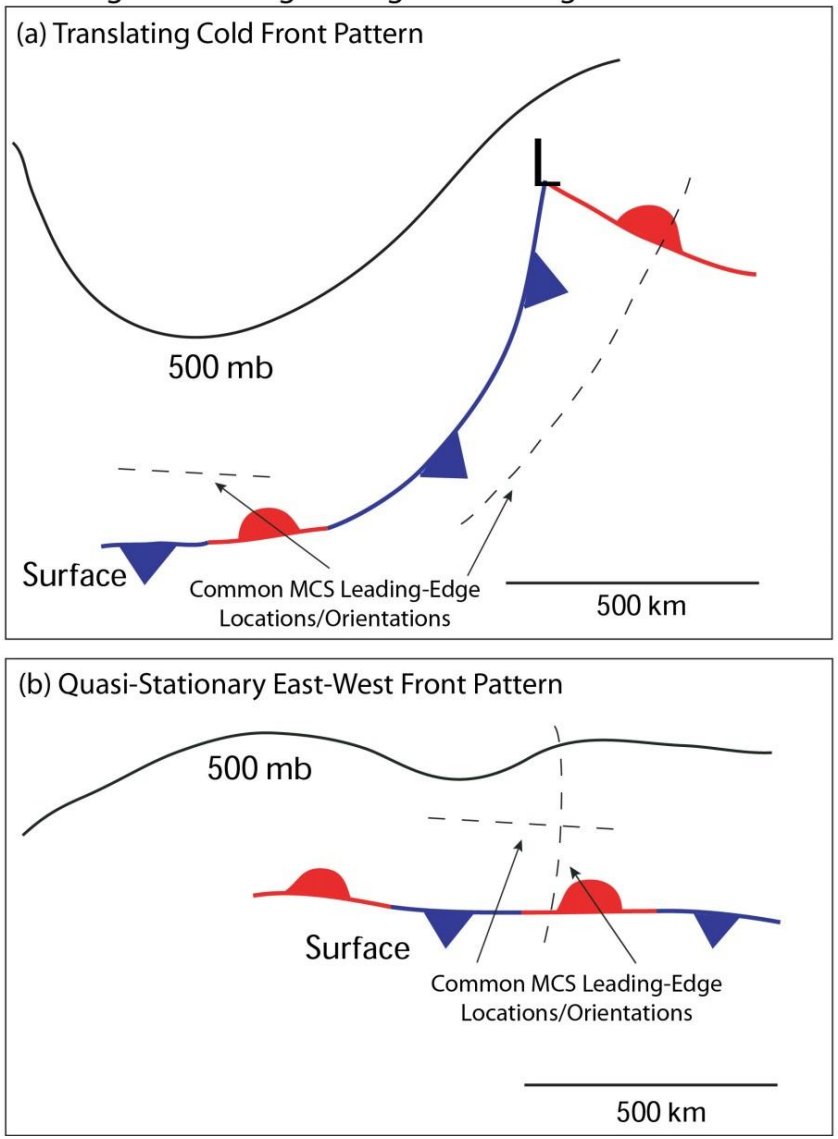
Daily Mean 2-m Temperature



Daily Precipitation



Differing Meteorological Regimes for Organized Convection

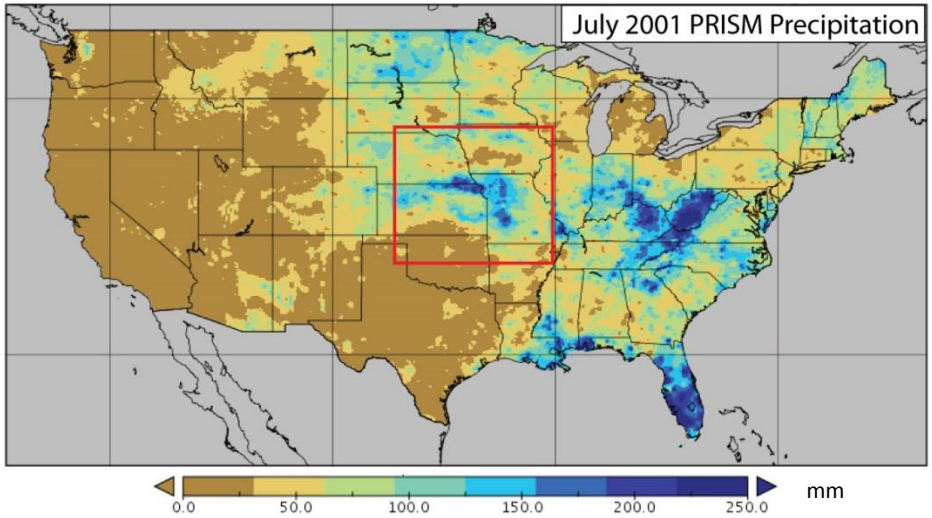


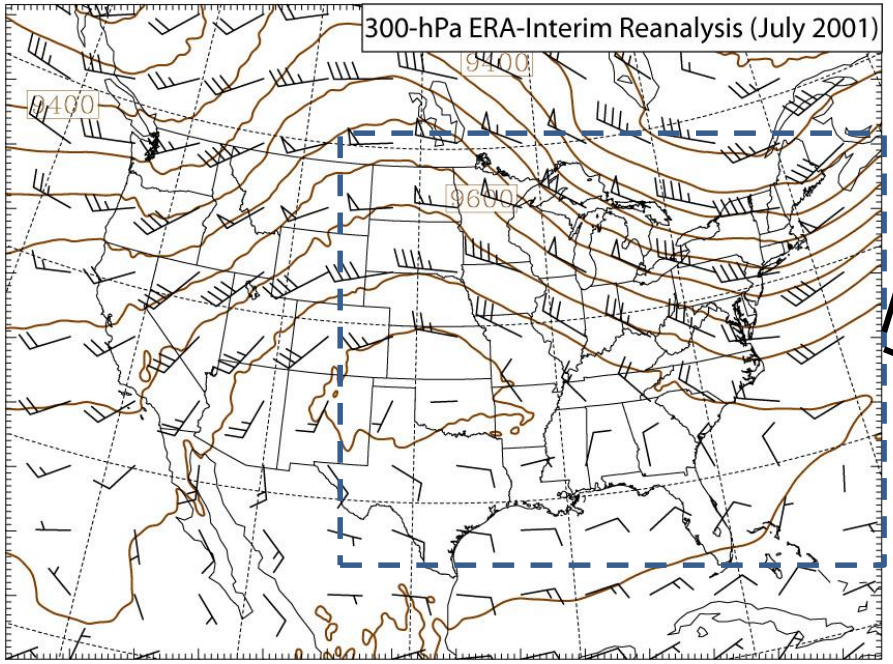
Dominant pattern prior to 15 June 2001 (precipitation widespread with lulls of several days between major events)

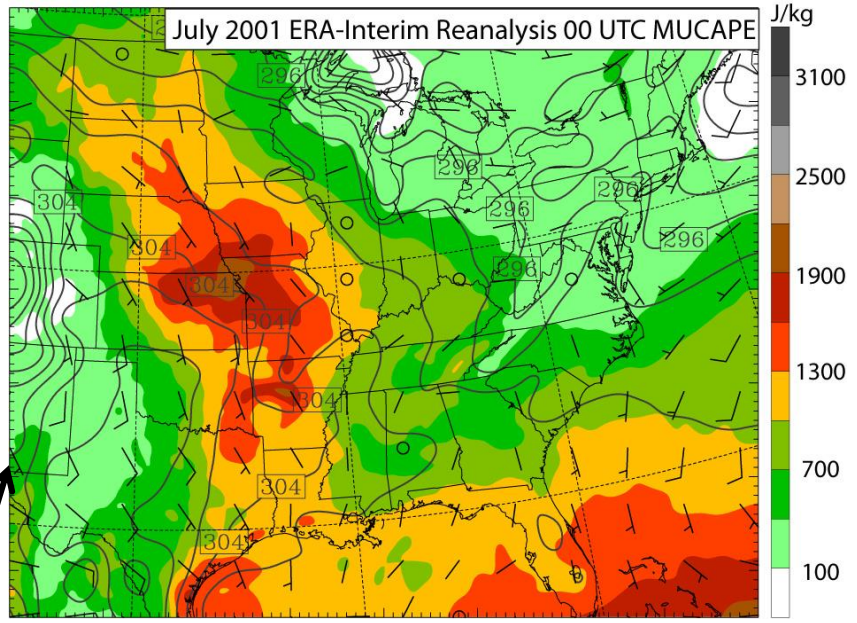
Dominant pattern after 15 June 2001 (precipitation occurs almost nightly in narrow 2-3 degree latitudinal corridors)

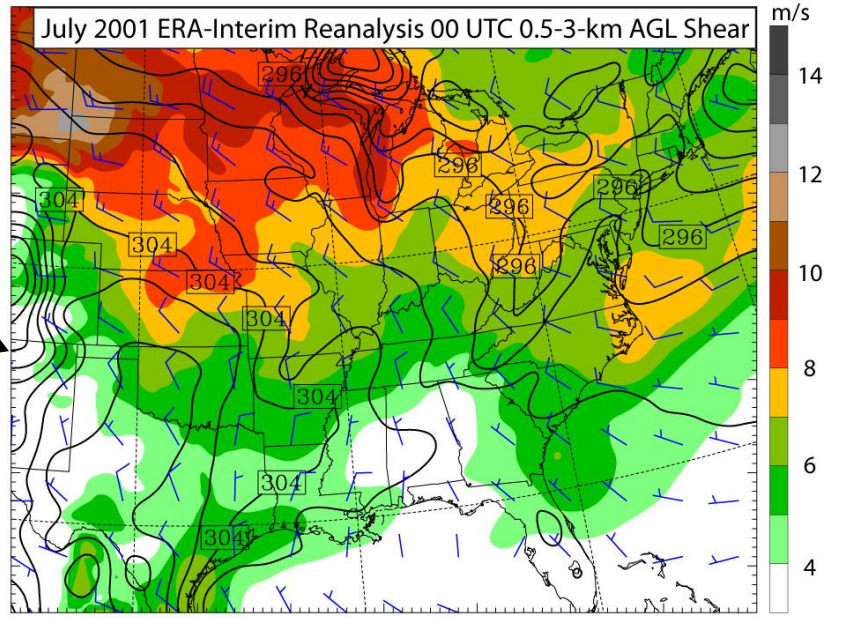
Reference: Trier, S. B., C. A. Davis, and D. A. Ahijevych and K. W. Manning 2014: Use of the parcel buoyancy minimum (B_{min}) to diagnose simulated thermodynamic destabilization. Part II: Composite analysis of mature MCS environments. *Mon. Wea. Rev.*, 142, 967-990.

July 2001 Mean Conditions

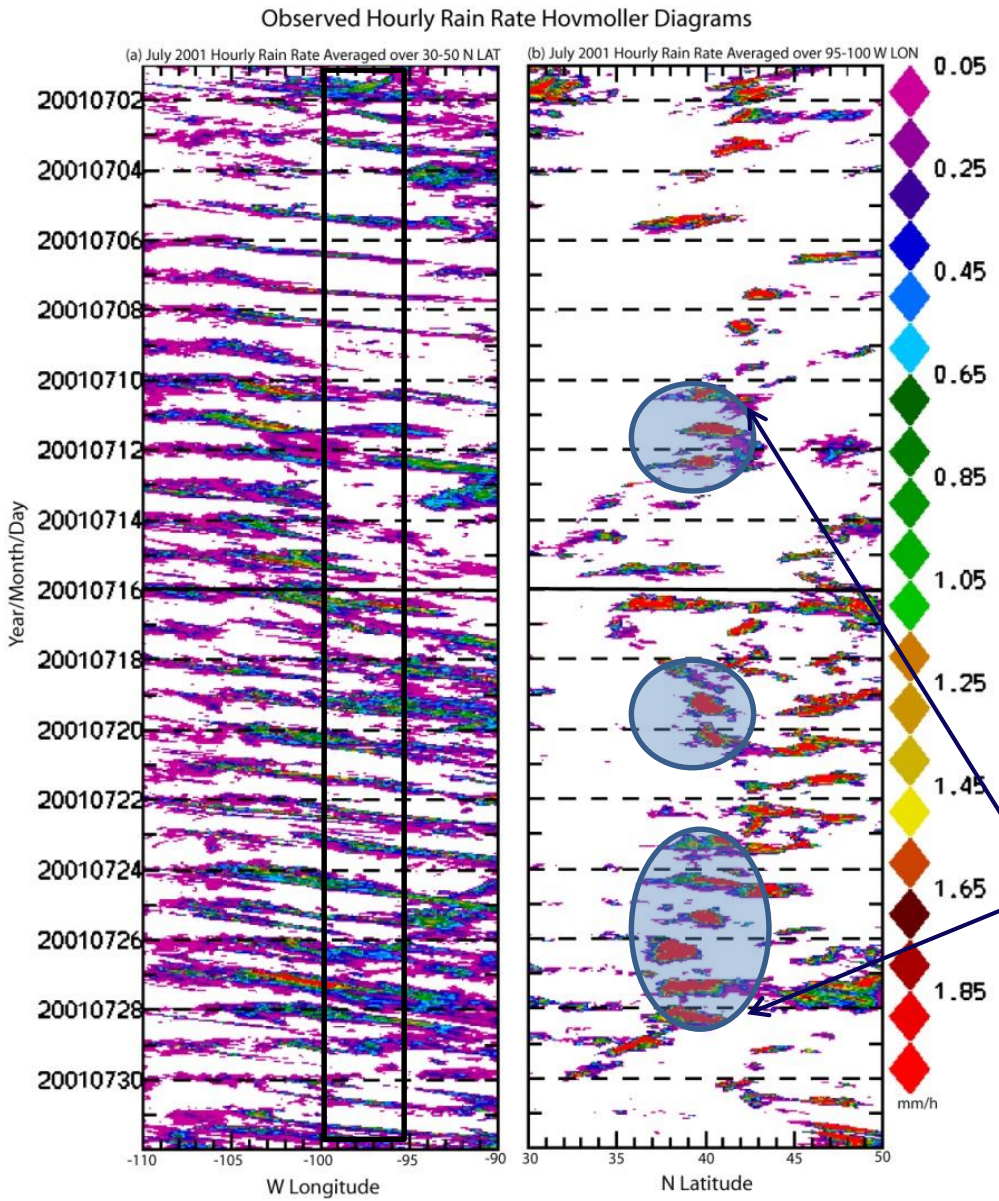


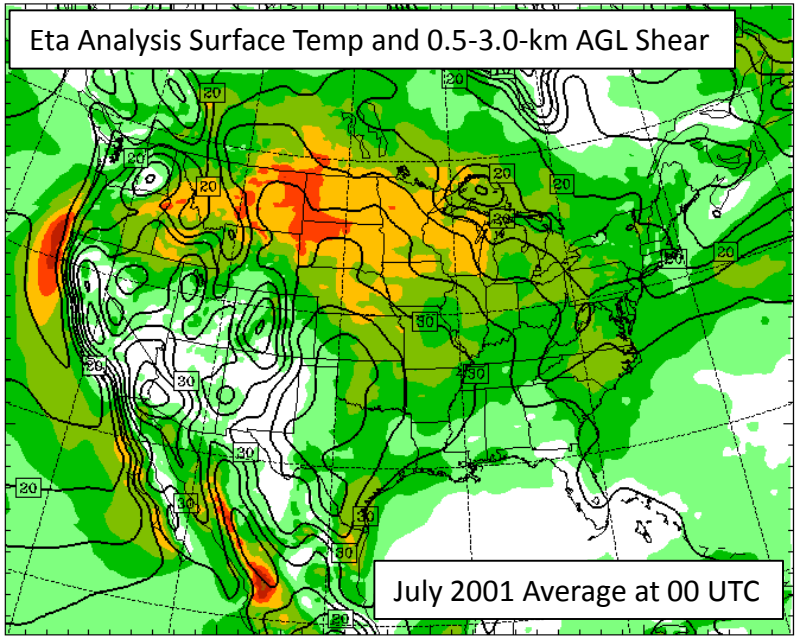


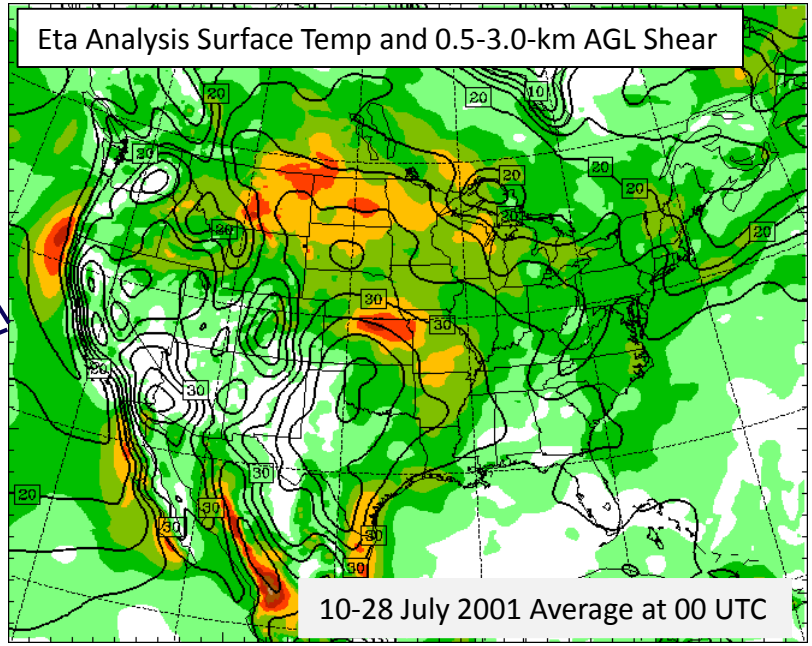




July 2001 Conditions





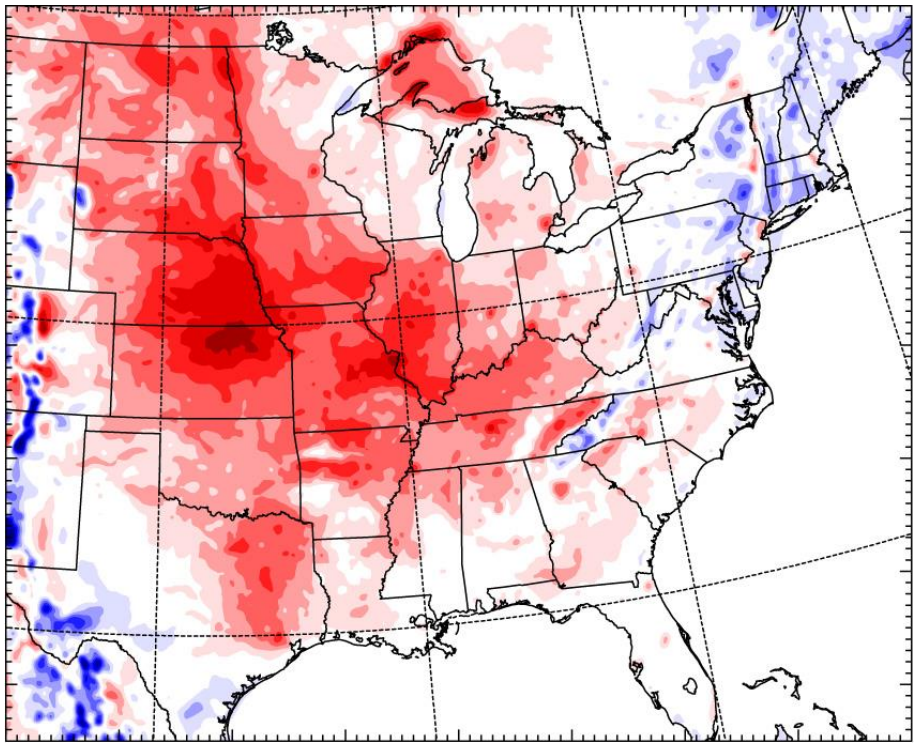


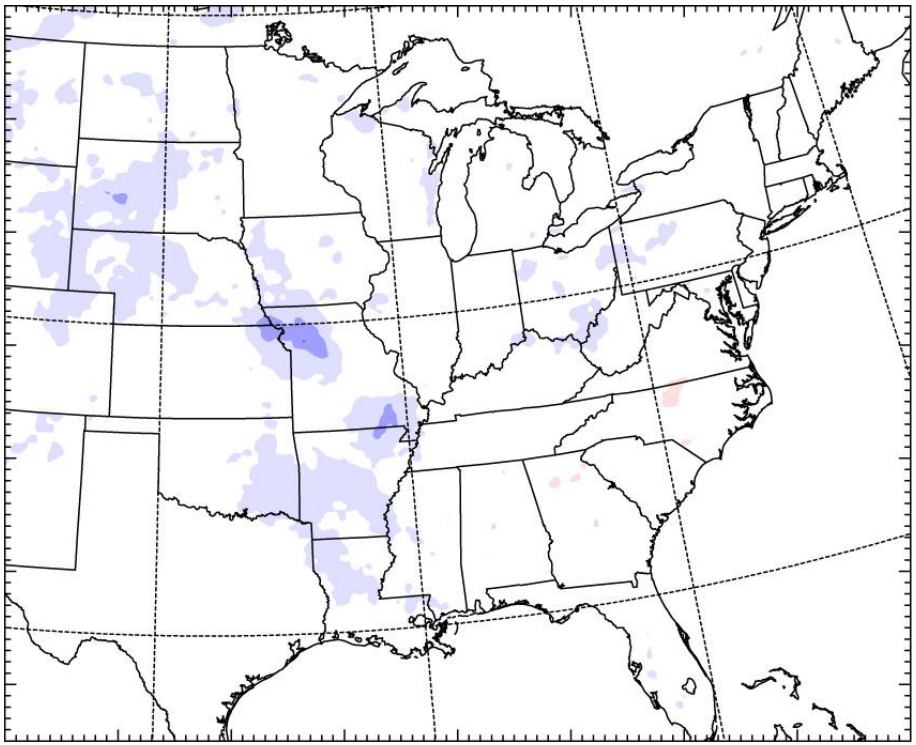
Reference: Trier, S. B., C.A. Davis, and D. A. Ahijevych 2010: Environmental controls on the simulated diurnal cycle of warm-season precipitation in the continental United States. *J. Atmos. Sci.*, 67, 1066-1090.

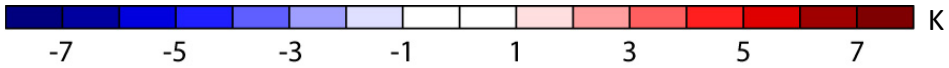
July 2001 2-m Temperature Bias at 0000 UTC

WRF (YSU) – ERA Reanalysis

WRF (YSU) – WRF (MYNN2)



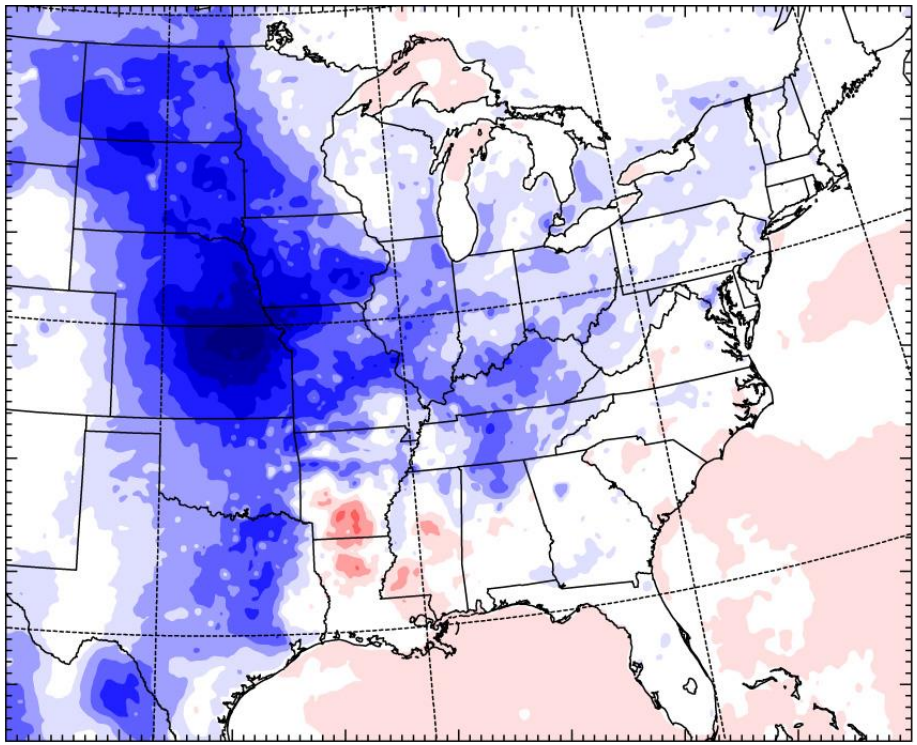


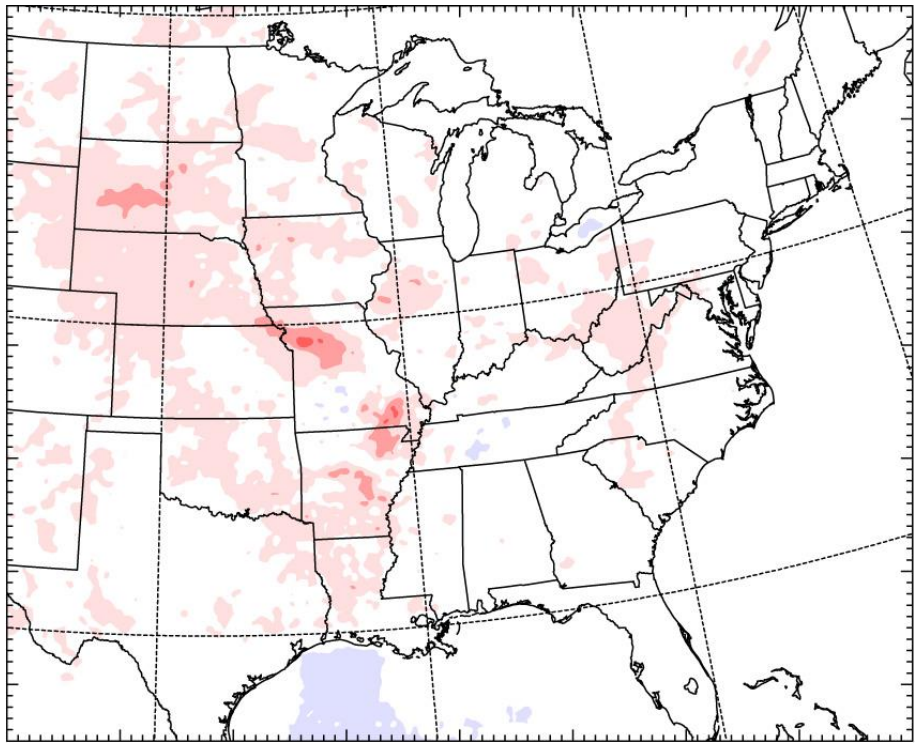


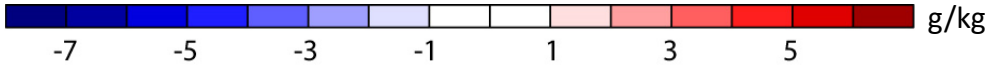
July 2001 2-m Water Vapor Mixing Ratio Bias at 0000 UTC

WRF (YSU) – ERA Reanalysis

WRF (YSU) – WRF (MYNN2)



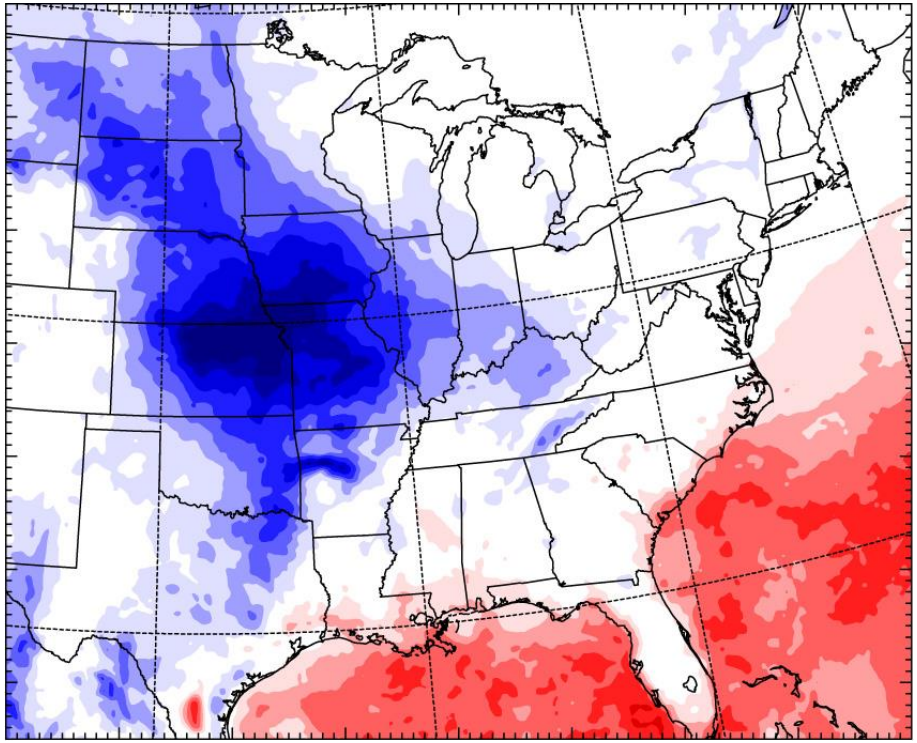


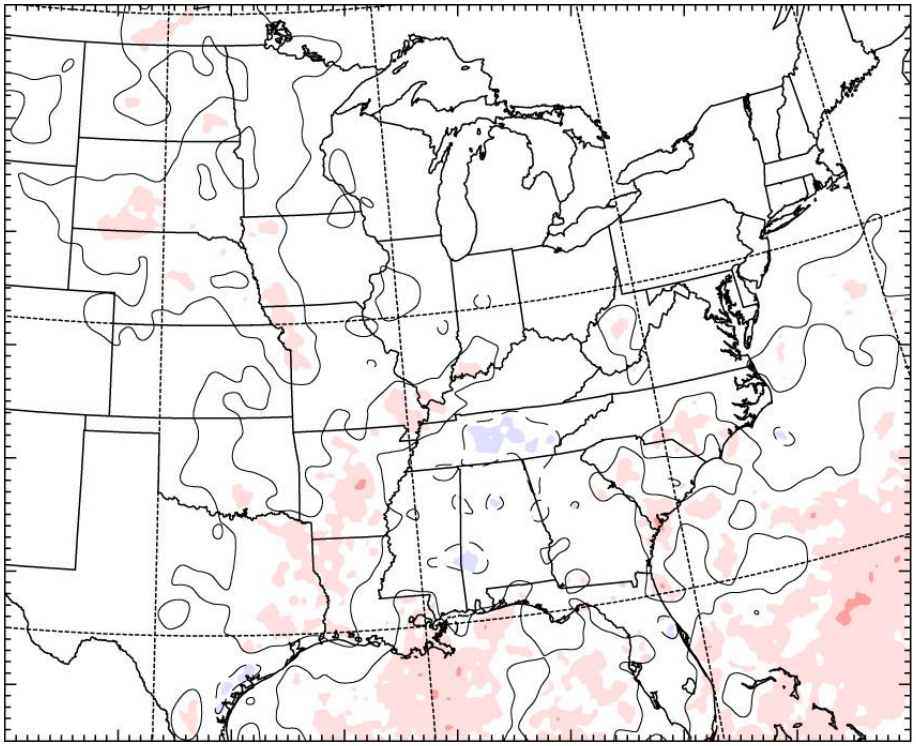


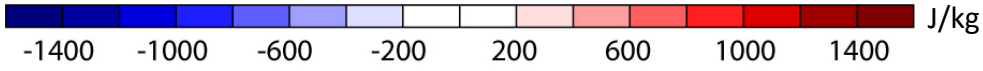
July 2001 Most Unstable CAPE (MUCAPE) Bias at 0000 UTC

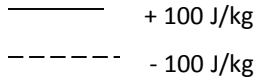
WRF (YSU) – ERA Reanalysis

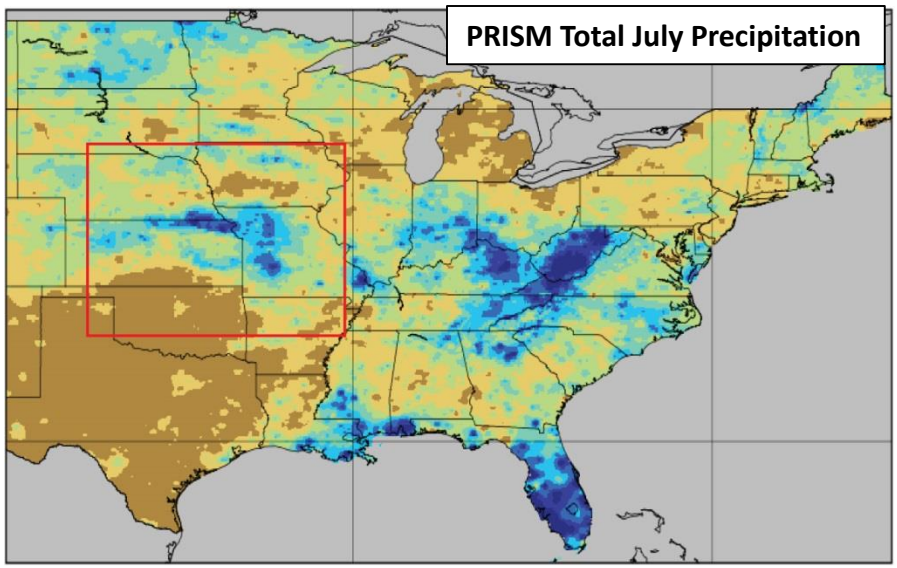
WRF (YSU) – WRF (MYNN2)

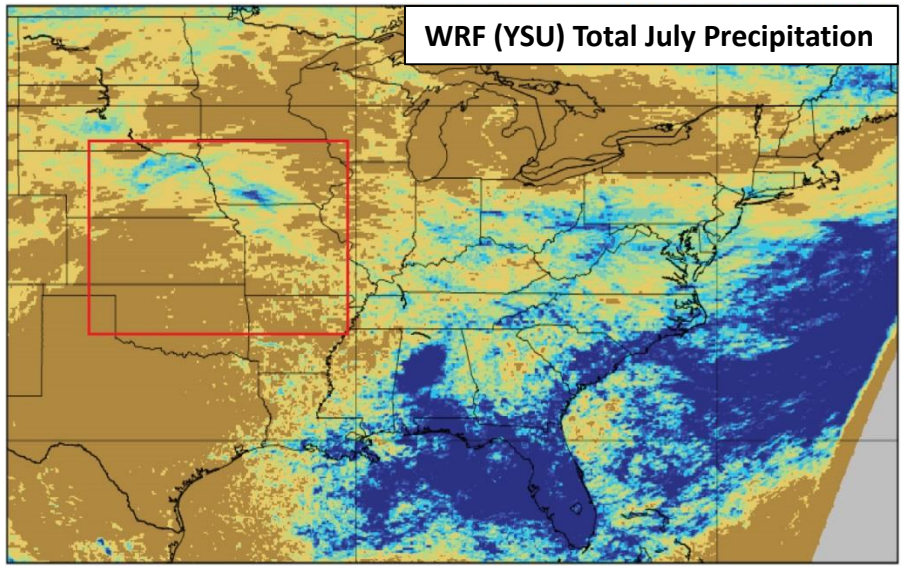


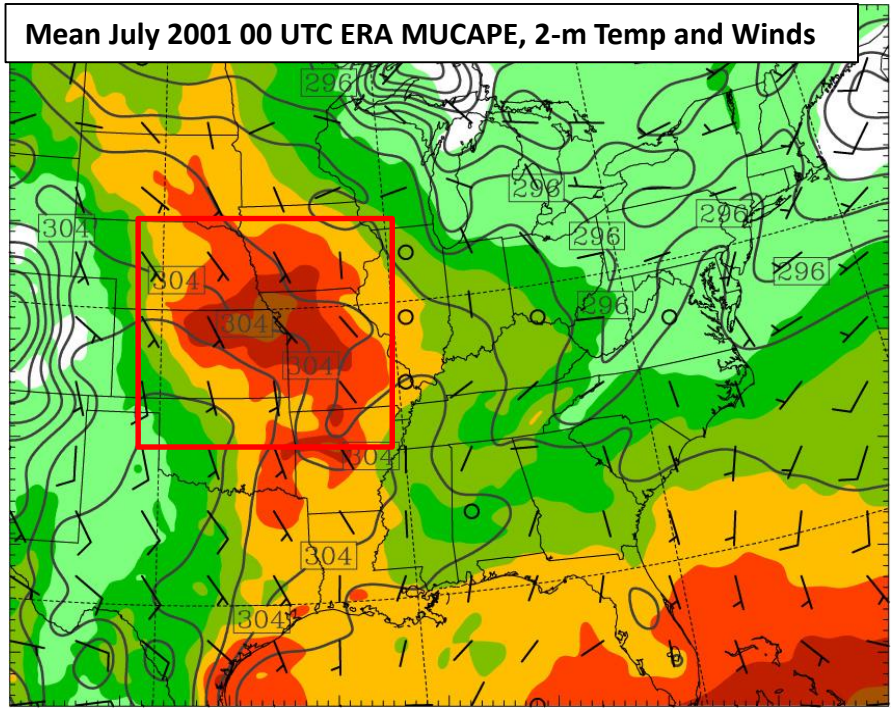


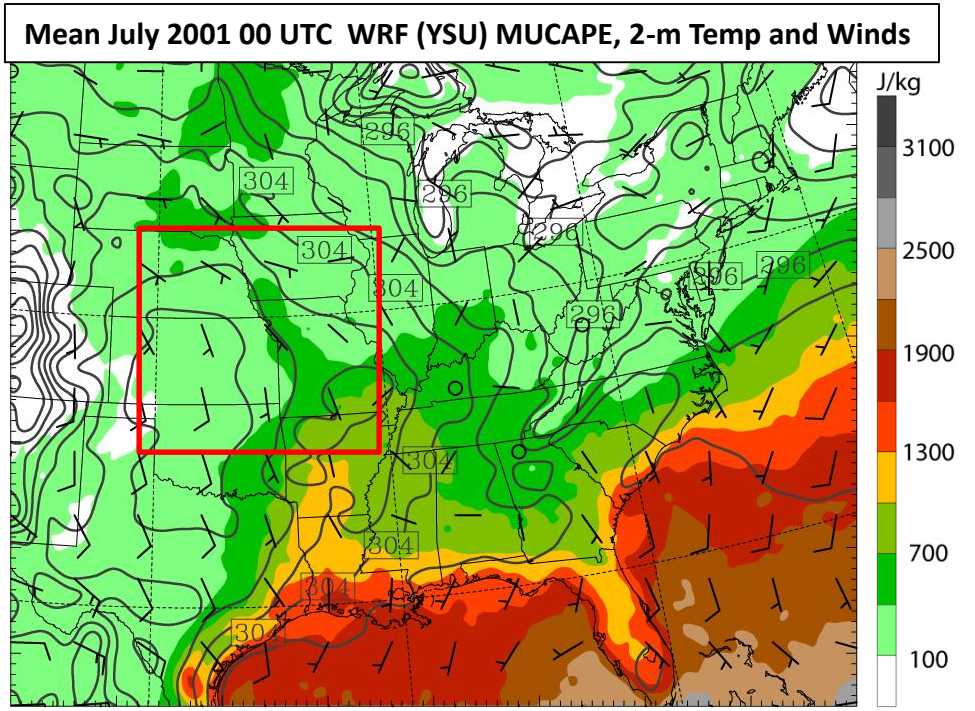


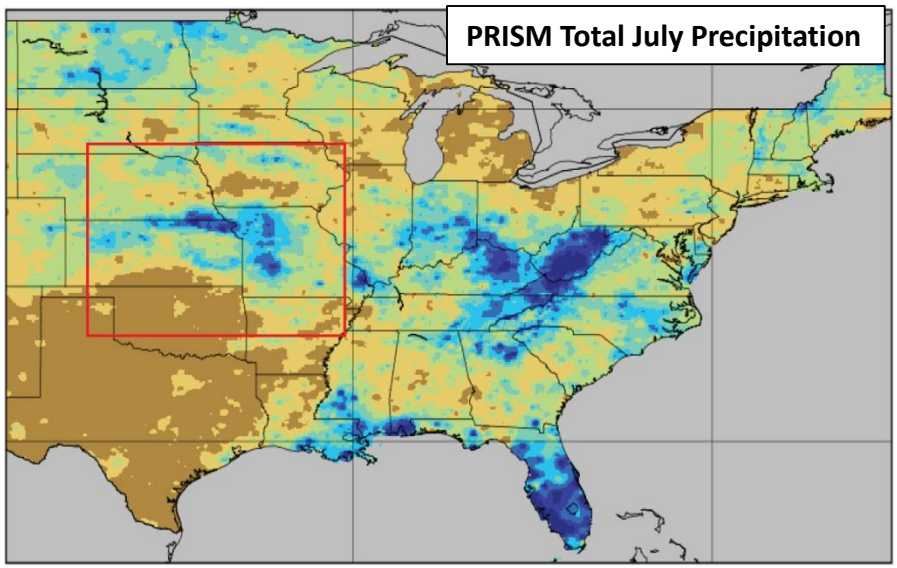


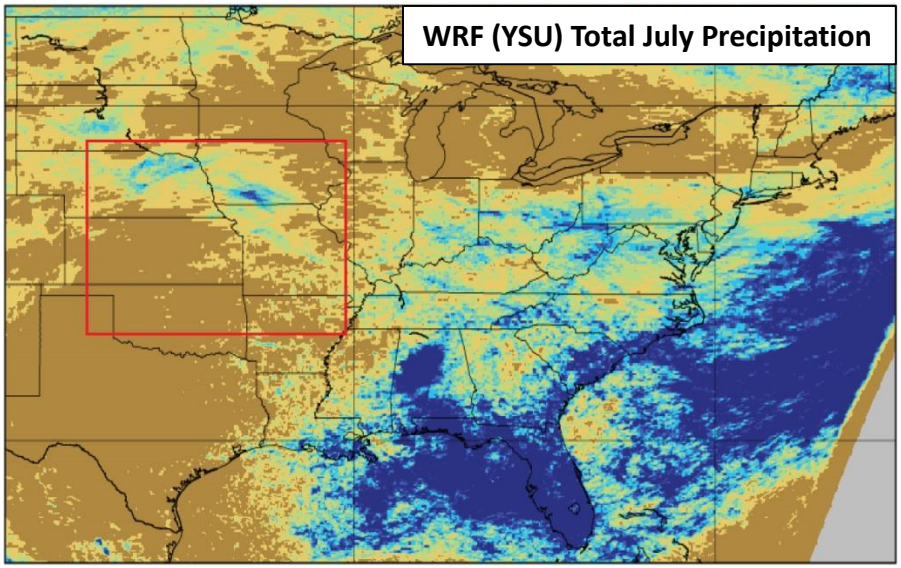

PRISM Total July Precipitation

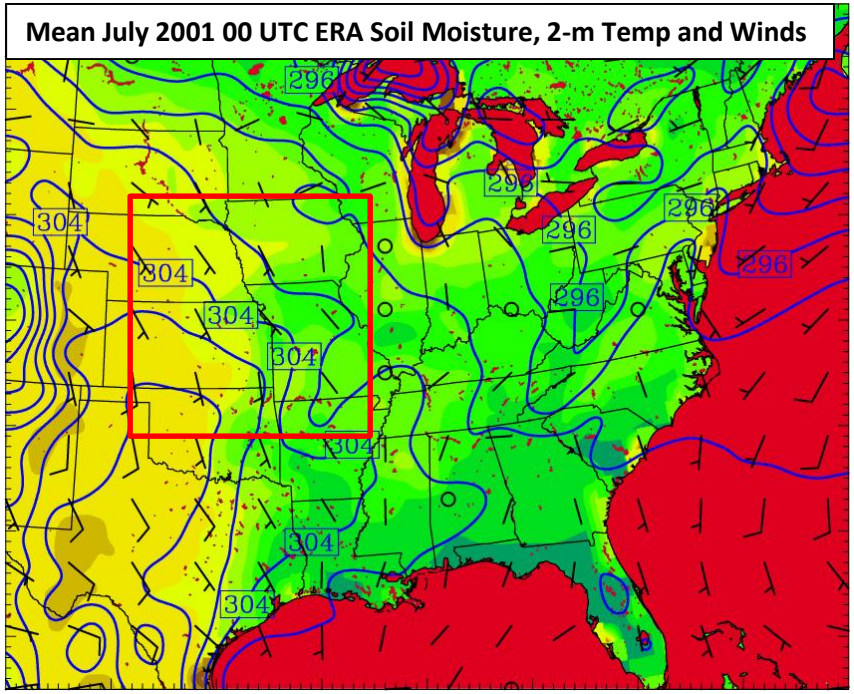

WRF (YSU) Total July Precipitation
mm
250
200
150
100
50

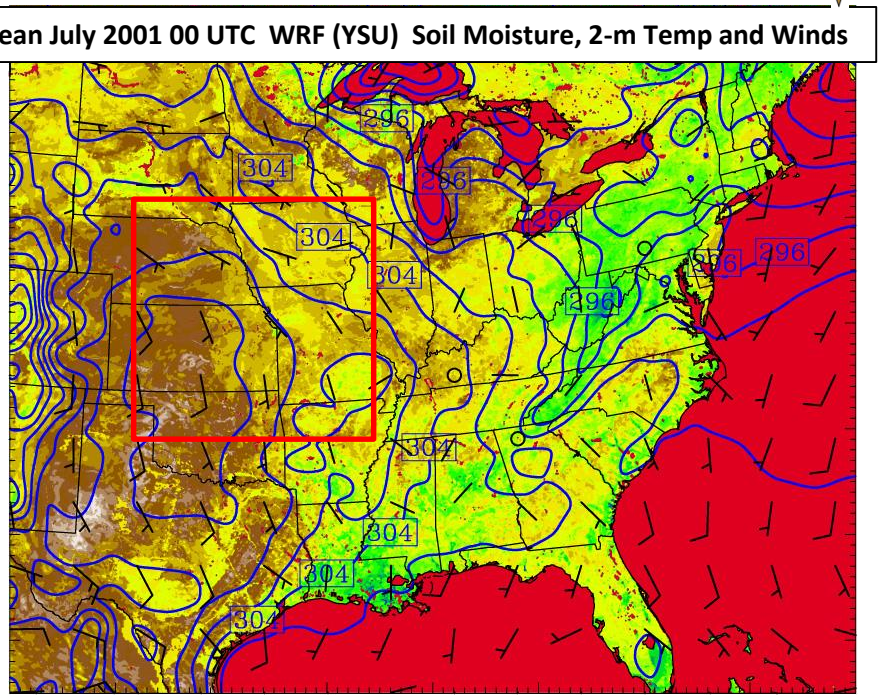

Mean July 2001 00 UTC ERA MUCAPE, 2-m Temp and Winds
296
304

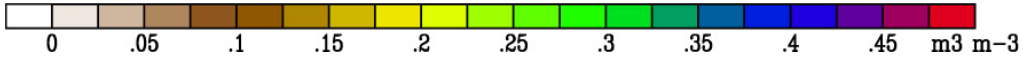

Mean July 2001 00 UTC WRF (YSU) MUCAPE, 2-m Temp and Winds
J/kg
3100
2500
1900
1300
700
100
296
304


PRISM Total July Precipitation


WRF (YSU) Total July Precipitation
mm
250
200
150
100
50


Mean July 2001 00 UTC ERA Soil Moisture, 2-m Temp and Winds
296
304


Mean July 2001 00 UTC WRF (YSU) Soil Moisture, 2-m Temp and Winds
296
304


0
.05
.1
.15
.2
.25
.3
.35
.4
.45
m3 m−3

Summary

- Four-month CONUS simulations during the 2001 warm-season (MJJA) have been completed and are currently being analyzed
- Significant near surface warm-dry model bias develops in late Spring, becoming large in mid-late summer over central U.S.
- Choice of PBL parameterization influences precipitation amounts and surface conditions but does not explain biases
- Significant position error in July heavy precipitation corridor associated with position error in simulated near-surface frontal zone. Intensity errors associated with diminished CAPE
- Anomalously low soil simulated moisture develops over central U.S. by July possibly contributing further to model warm bias