# The role of the Mexican Plateau in shaping rainfall over Texas

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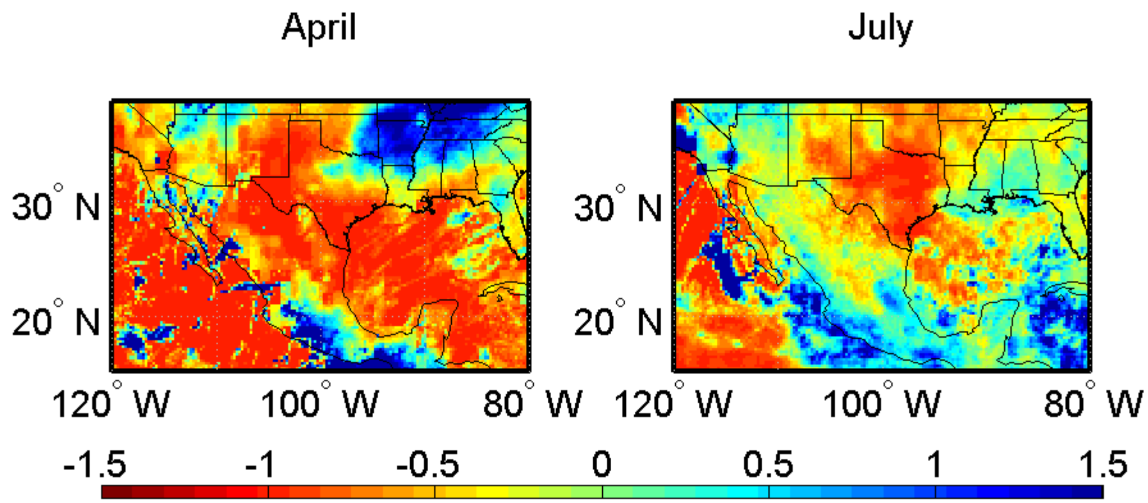
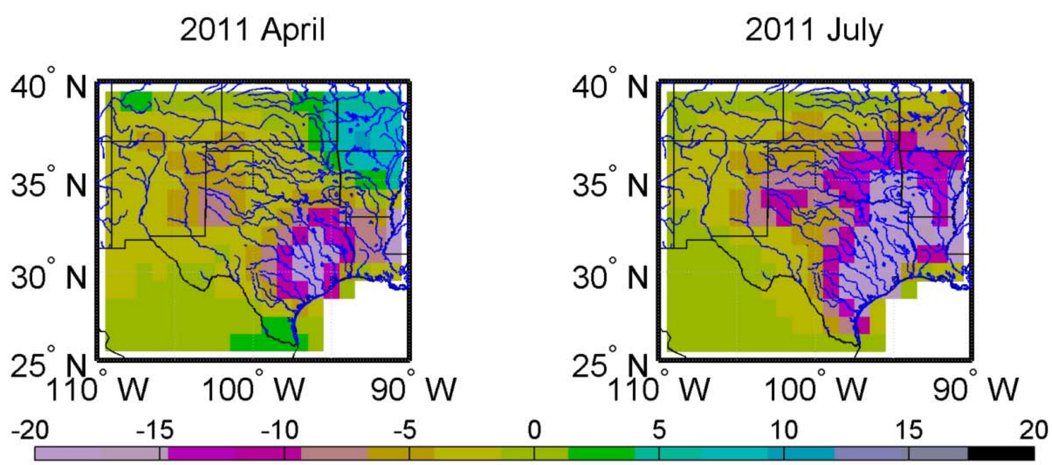
# Rainfall and soil moisture deficit




Normalized TRMM 3B43 precipitation rate anomalies

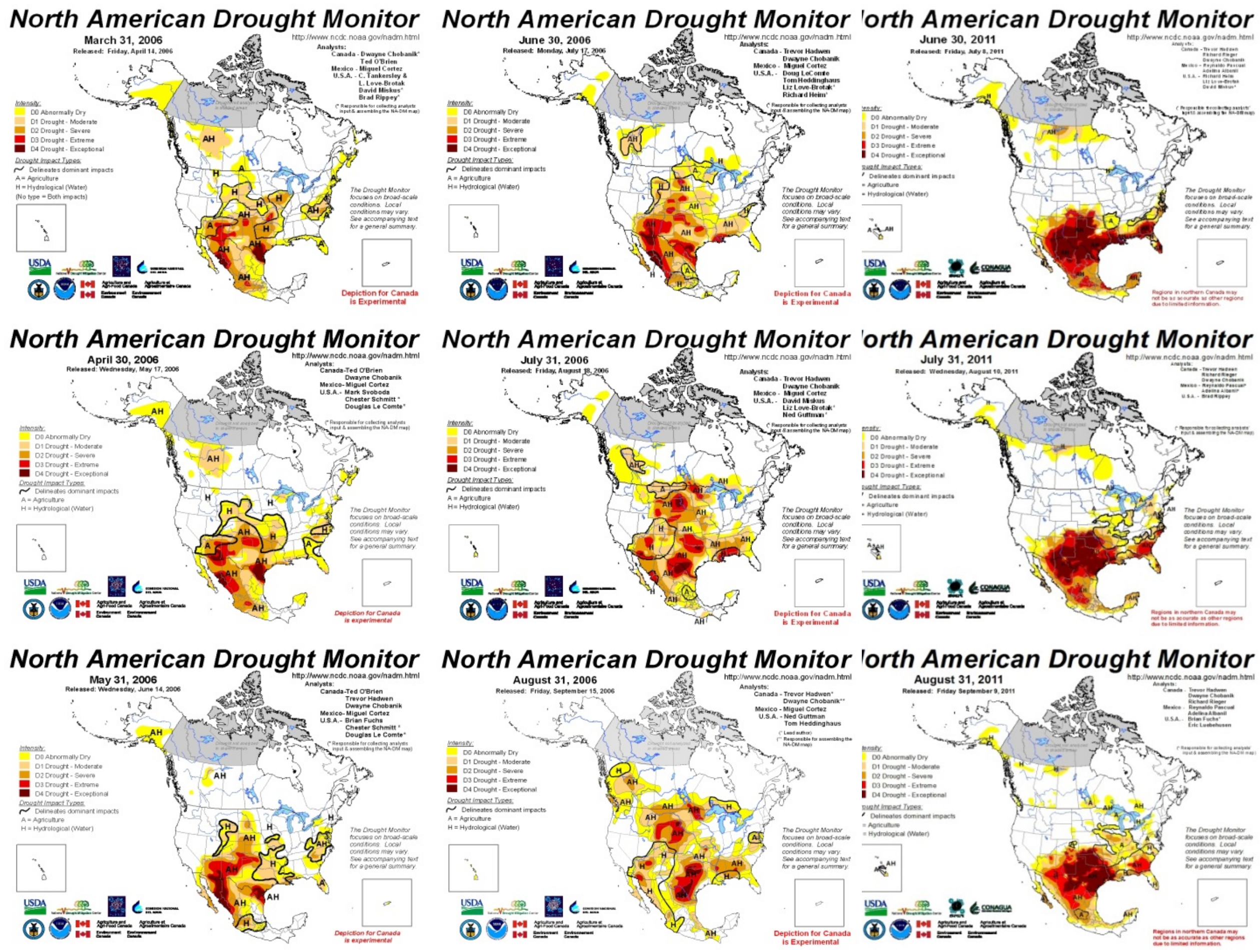



GRACE Liquid Water Equivalent Thickness Anomalies (mm)

# North American Drought Monitor

2006 spring and summer

2011 spring and summer



# Background

SST Anomalies → **Force?** → Texas drought

- A drought generally results from a synthesis of numerous factors (e.g. Hoerling et al. 2013)
- The drought continuation into the summer of 2011 was not significantly SST-forced (Seager et al. 2013)

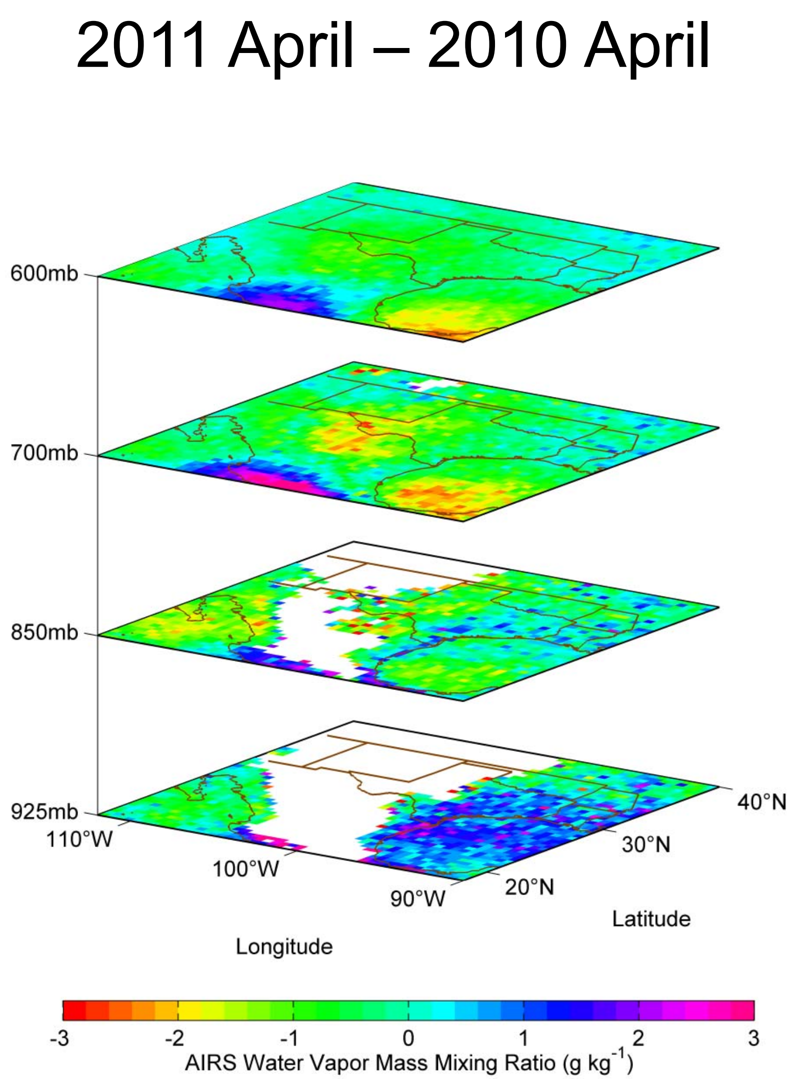
Mexican Plateau drought → **Exacerbate?** → Texas drought

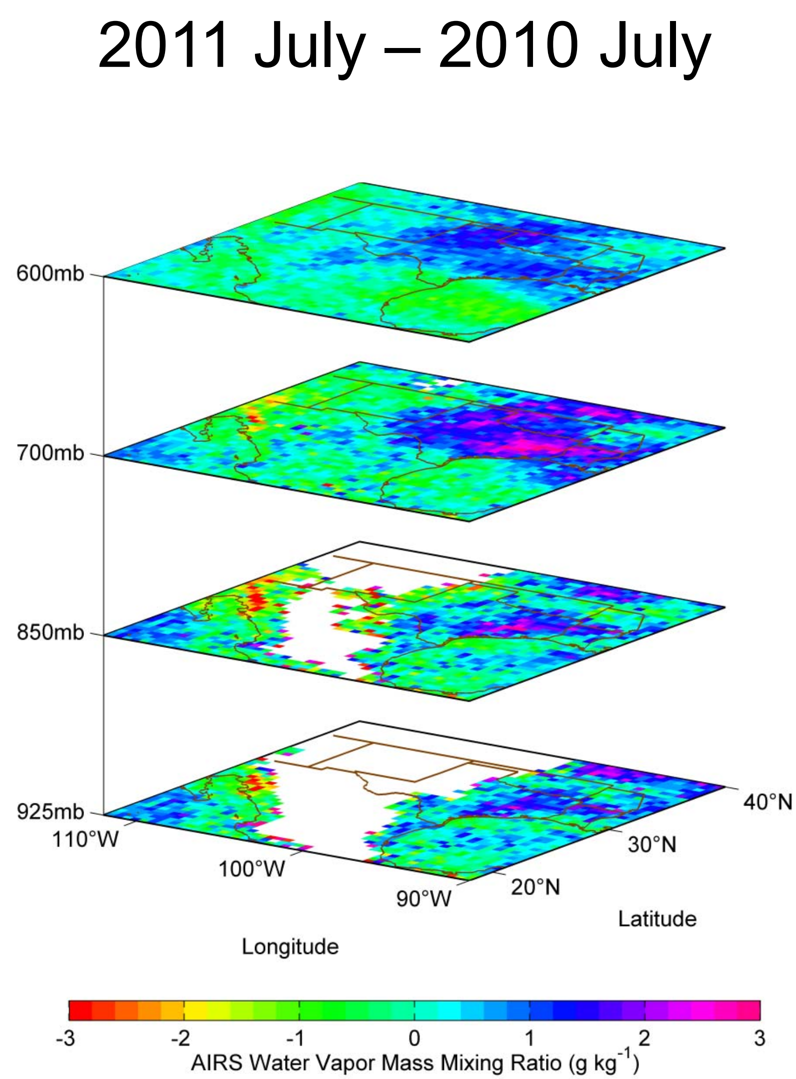
- Warm dry air advection in spring and summer (Lanicci et al. 1987, Myoung and Nielsen-Gammon 2010)
- Air descends over Texas in summer (Barlow et al. 1998)

Other factors → Texas drought

- Global warming (e.g. Hoerling et al. 2013)
- Soil moisture-precipitation feedback (e.g. Su et al. 2013)
- Aerosols?

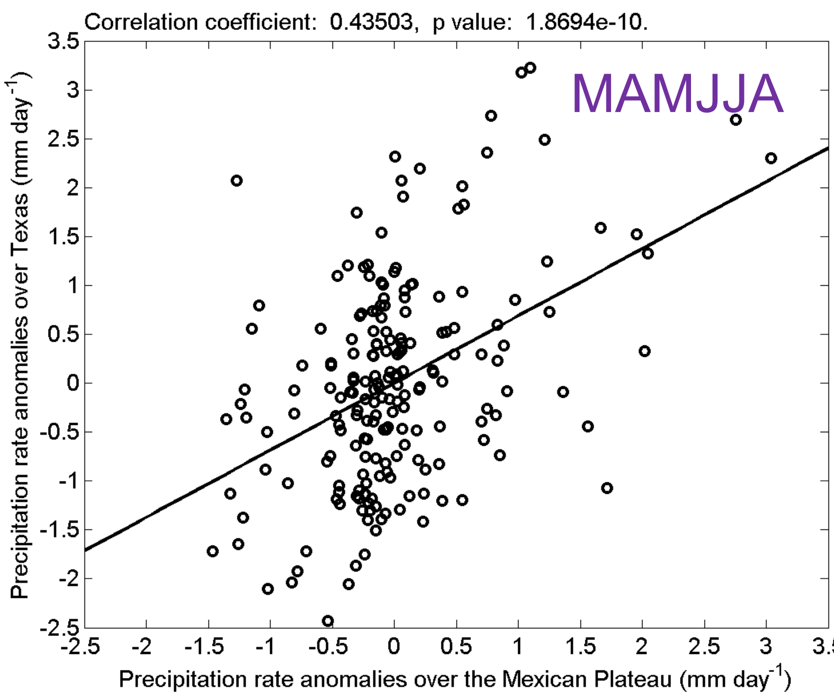
# Differences in low level water vapor content



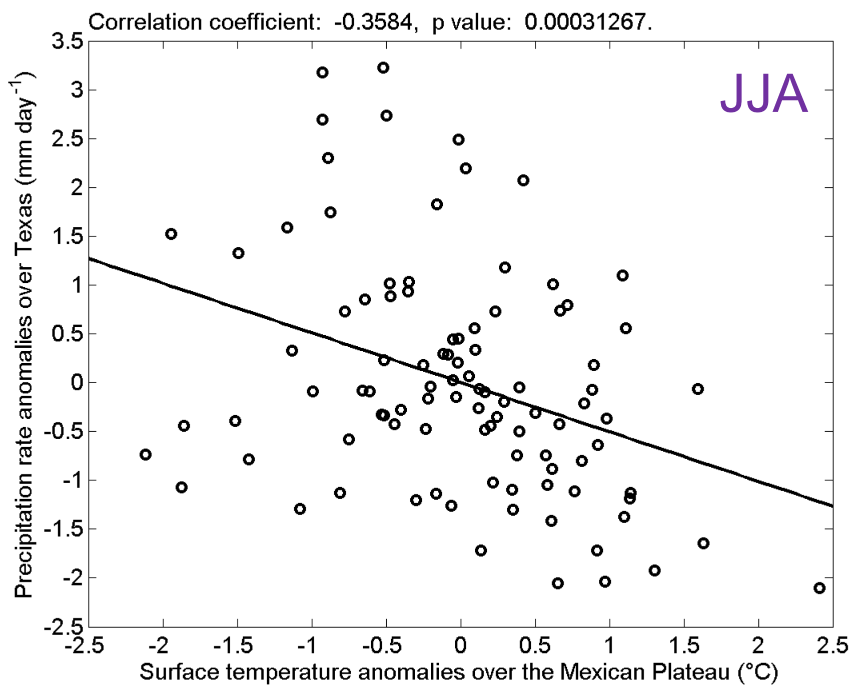
# Statistical relationships between the surface temperature/precipitation rate of the Mexican Plateau and the precipitation rate over Texas

## Precipitation .vs. Precipitation




R = 0.44

## Precipitation .vs. Temperature

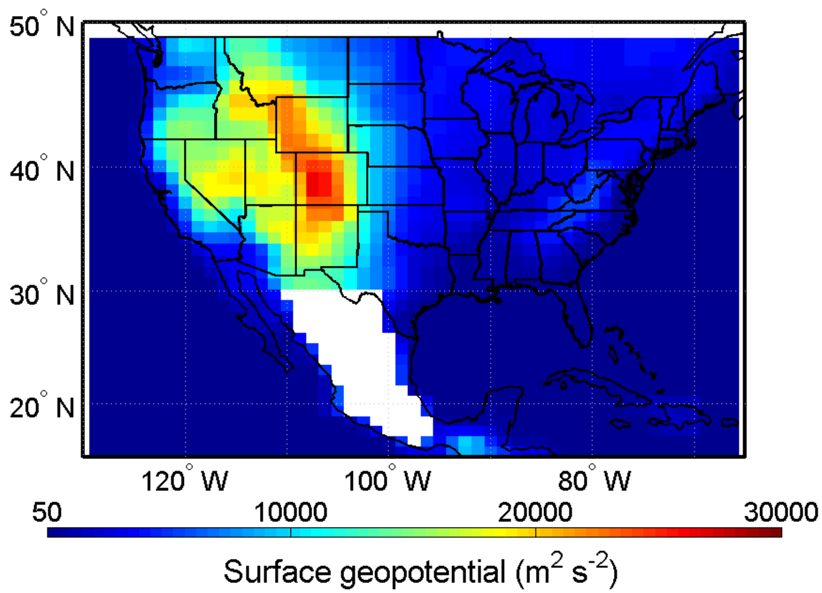



R = -0.36

# Hypothesis and experiment design

***Hypothesis:***

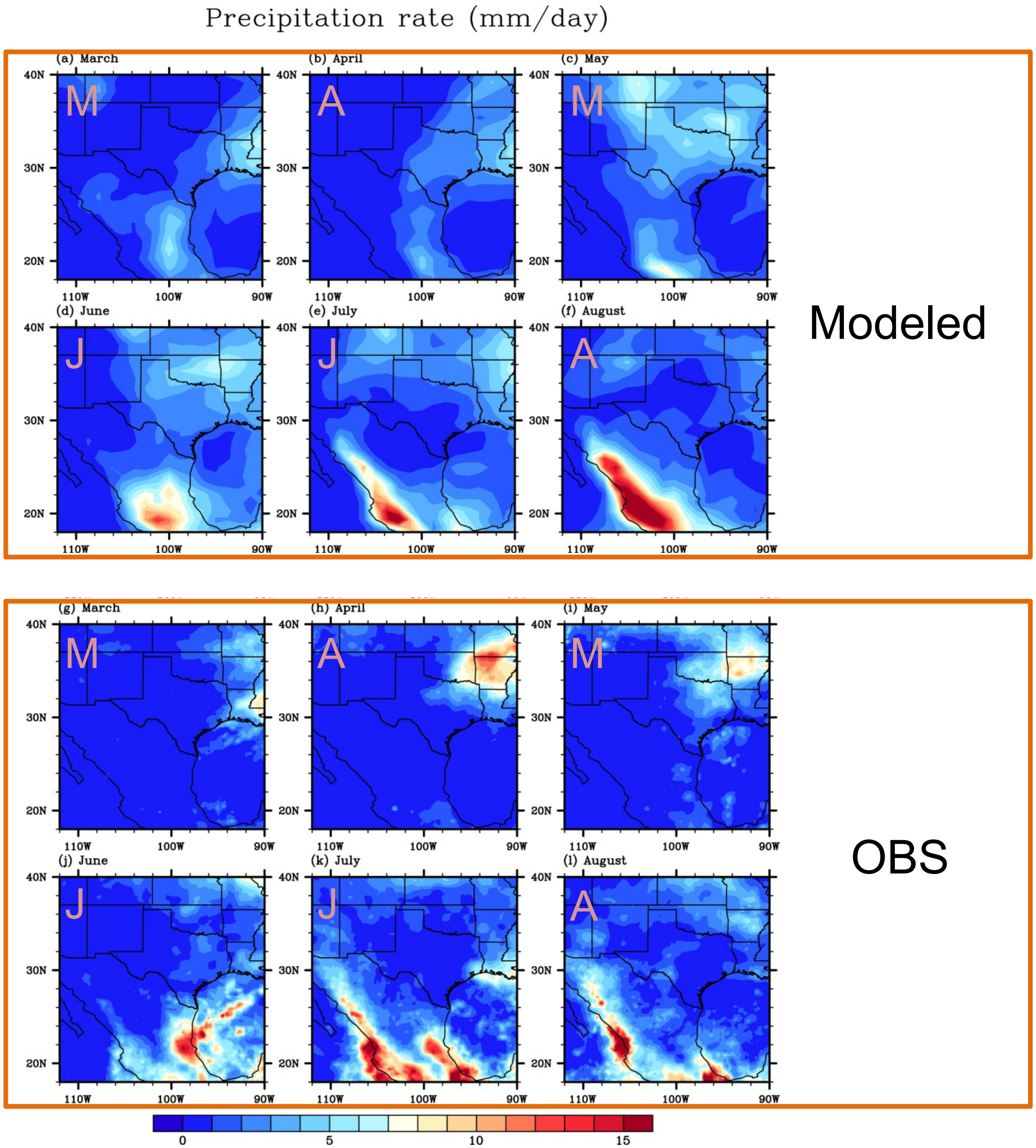
***During the summer, a warmer Mexican Plateau tends to bend the low-level jet towards the highlands and thus an anti-cyclonic flow anomaly forms over the southern US, which tend to diverge the air and reduce rainfall.***




- Prescribed climatological SST
- Integrated 12 years
- At a horizontal resolution of 1° × 1°
- Discarded 1st year for spin up

| | Topography | Albedo | Soil water |
|---|---|---|---|
| Control run (CTRL) | Default | Default | Default |
| Experiment 1 (E1 DRY) | Default | Default | 0.2 mm for each layer |
| Experiment 2 (E2 WARM) | Default | 0 | Default |
| Experiment 3 (E3 DRY & WARM) | Default | 0 | 0.2 mm for each layer |

# CESM .vs. observations I with prescribed observed SST



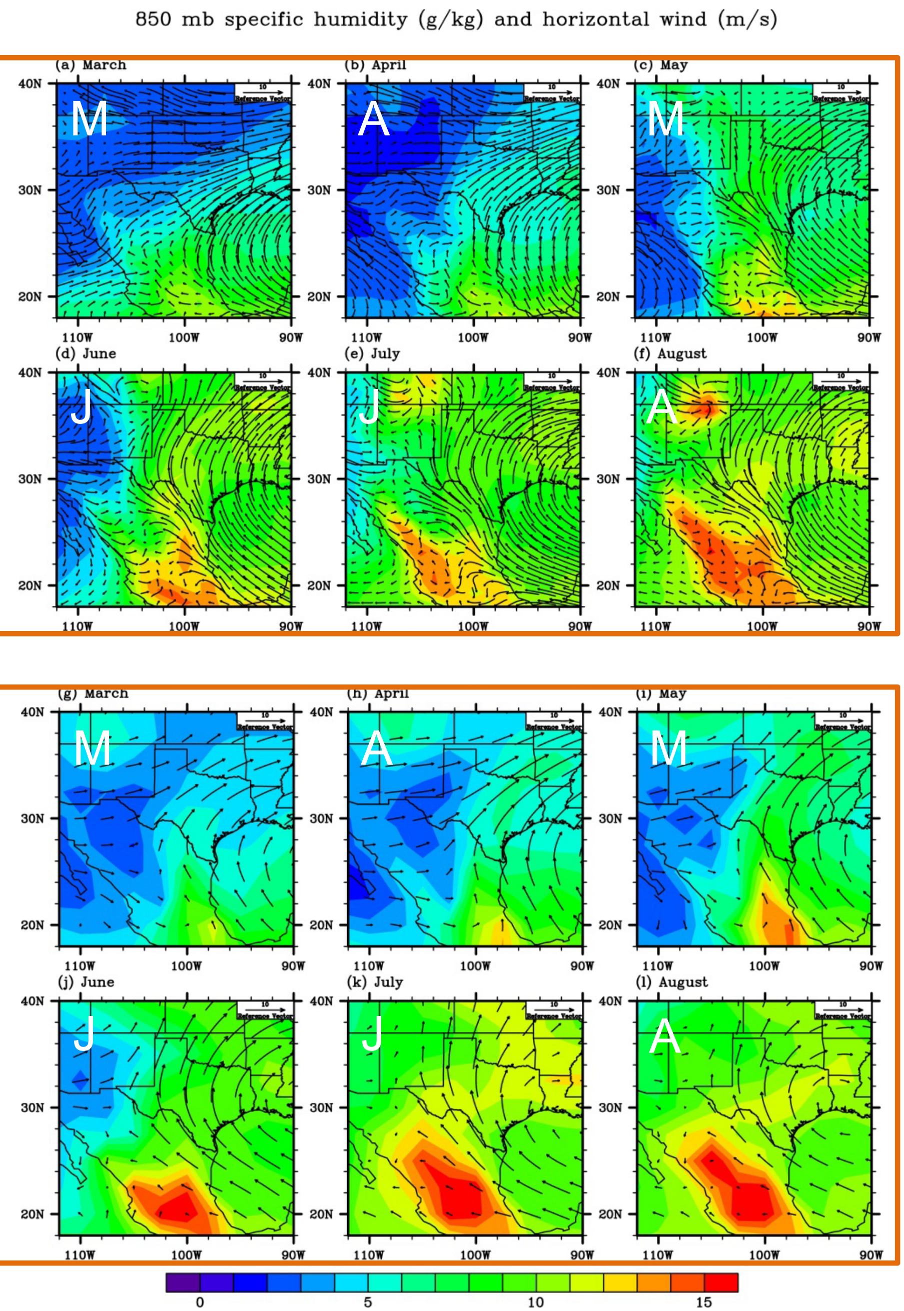

***Precipitation rate (mm/day) in 2011***

# CESM .vs. observations II with prescribed observed SST

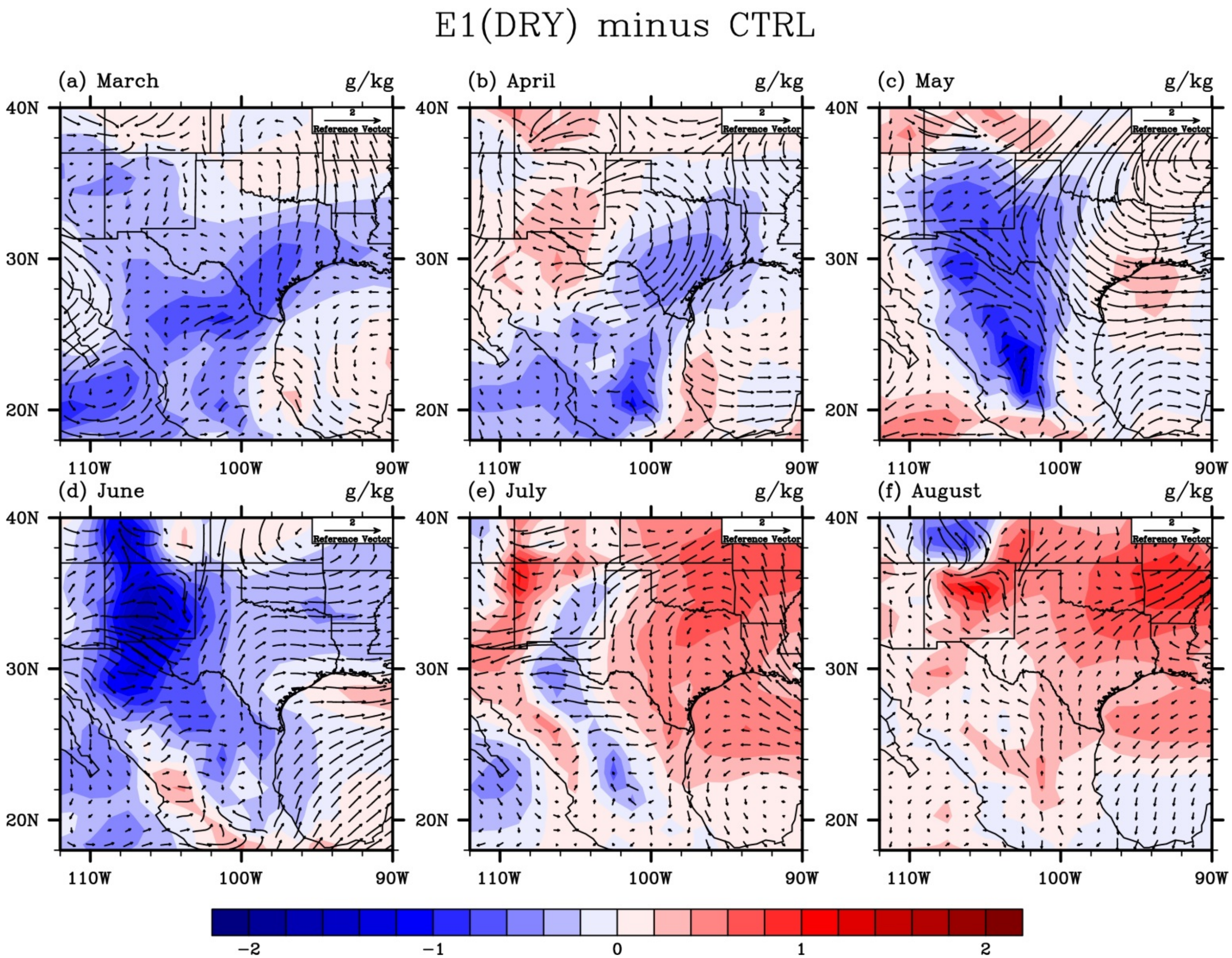
***Specific humidity (g/kg) and wind speed (m/s) at 850 hPa in 2011***

Modeled

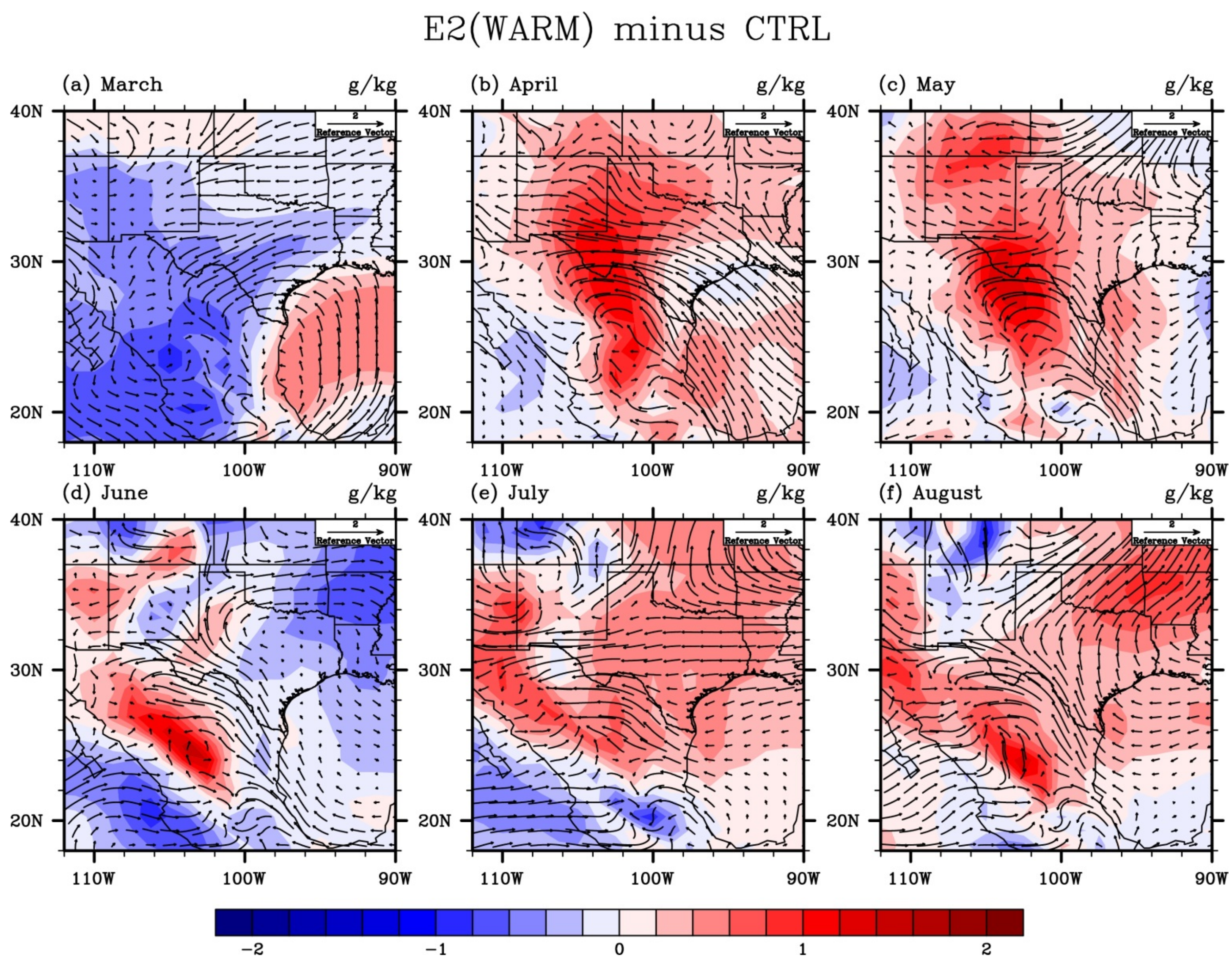
OBS



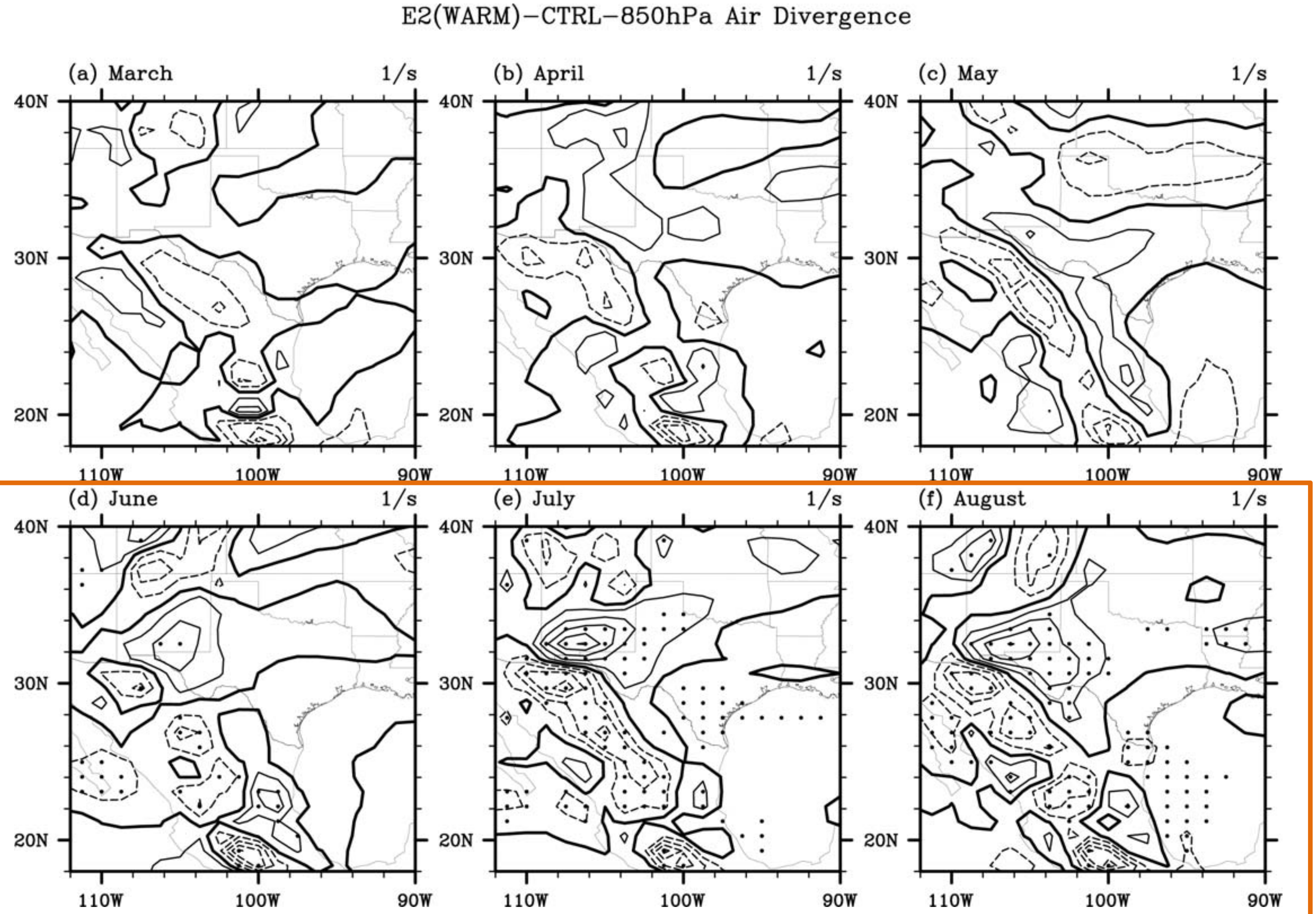
# 850 hPa specific humidity decreases over the Mexican highlands and the downstream regions



# A warm low anomaly over the Mexican Plateau and a summer anti-cyclonic flow anomaly over Texas

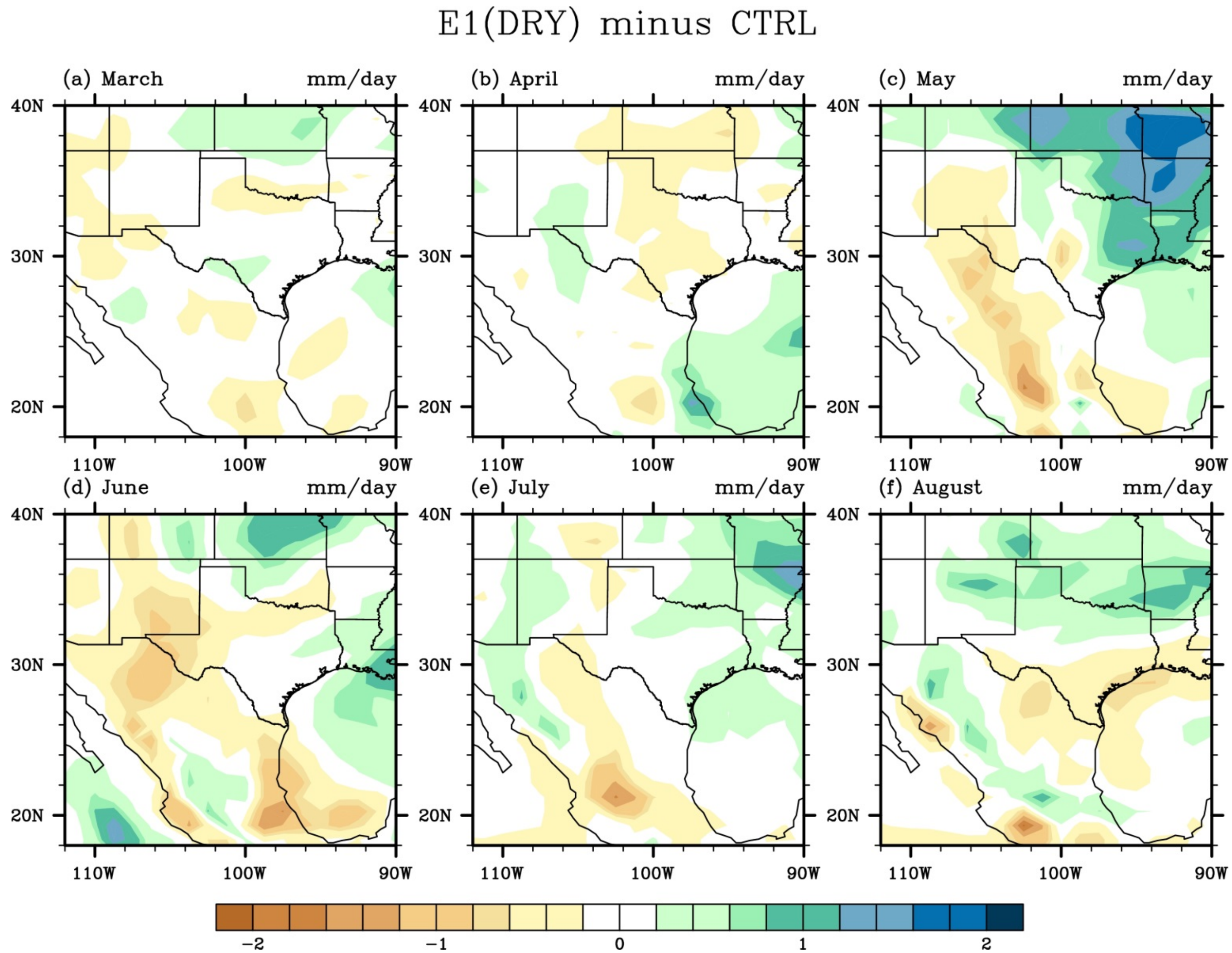


# 850 hPa air divergence

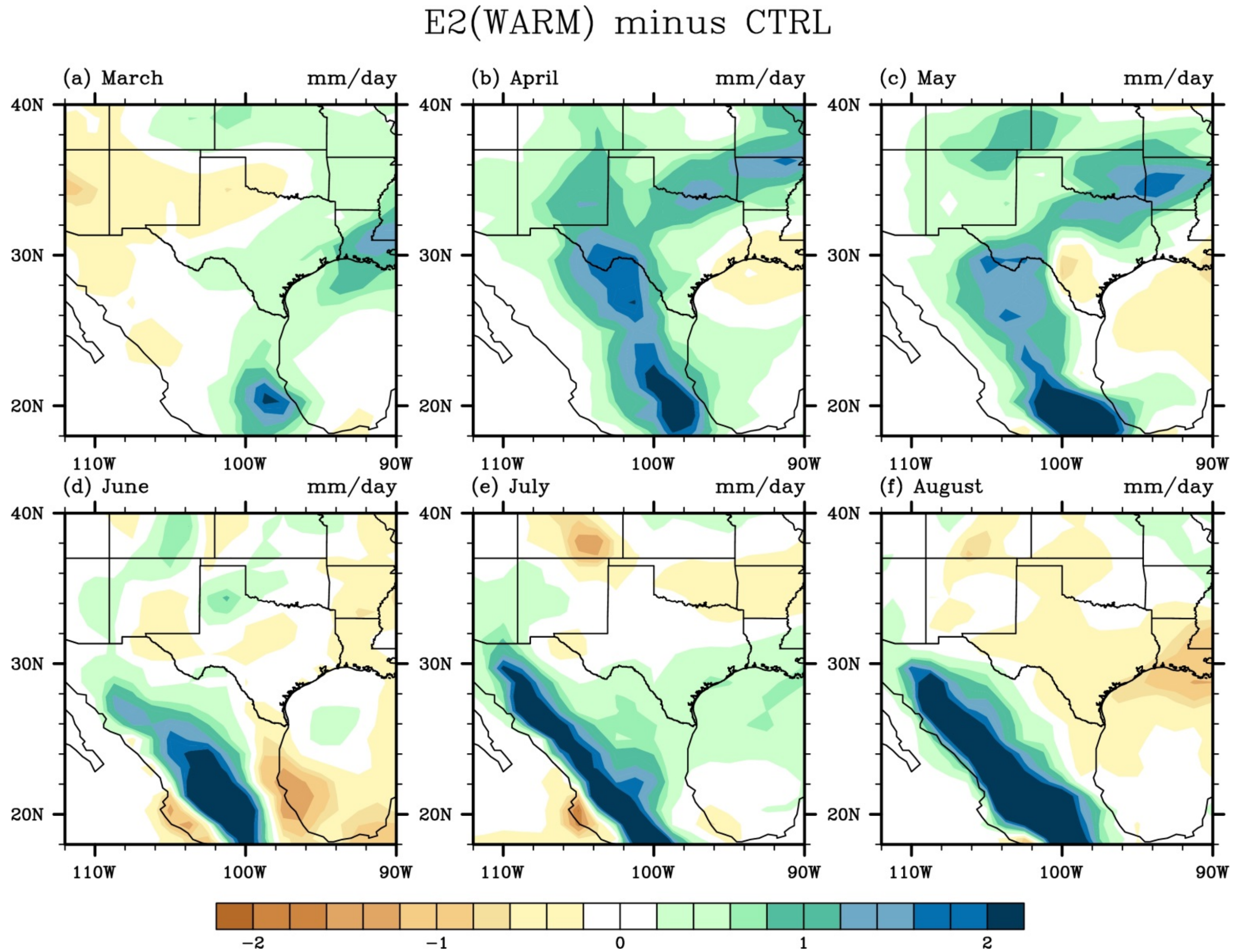



The solid contours represent the air divergence tendency whereas the dashed contours represent the air convergence tendency. The dots represent the areas that pass a student's t-test at the 95% confidence level.

# Rainfall decreases locally and downstream



# Rainfall increases over the highlands and slightly decreases over Texas during summer



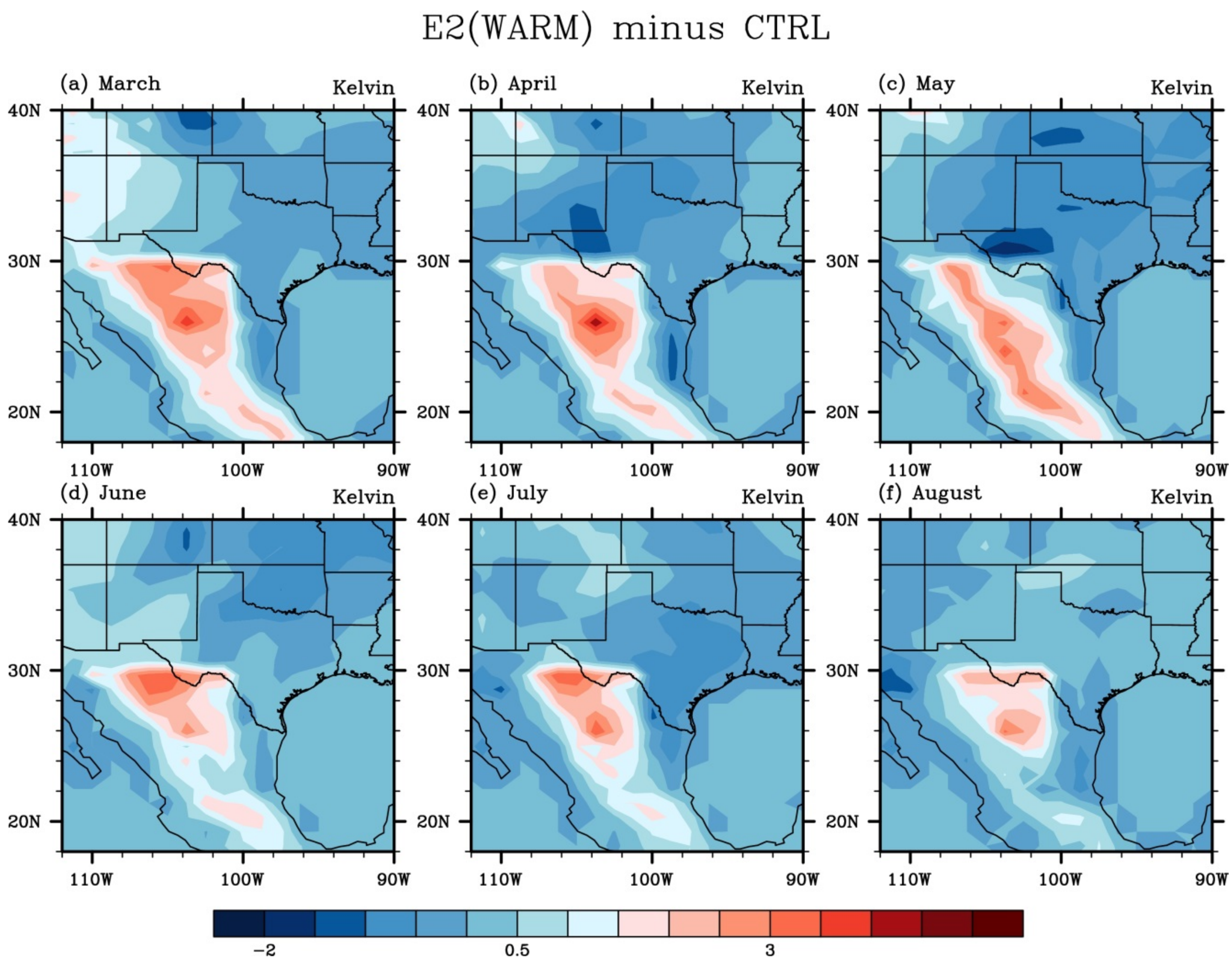
# Conclusions

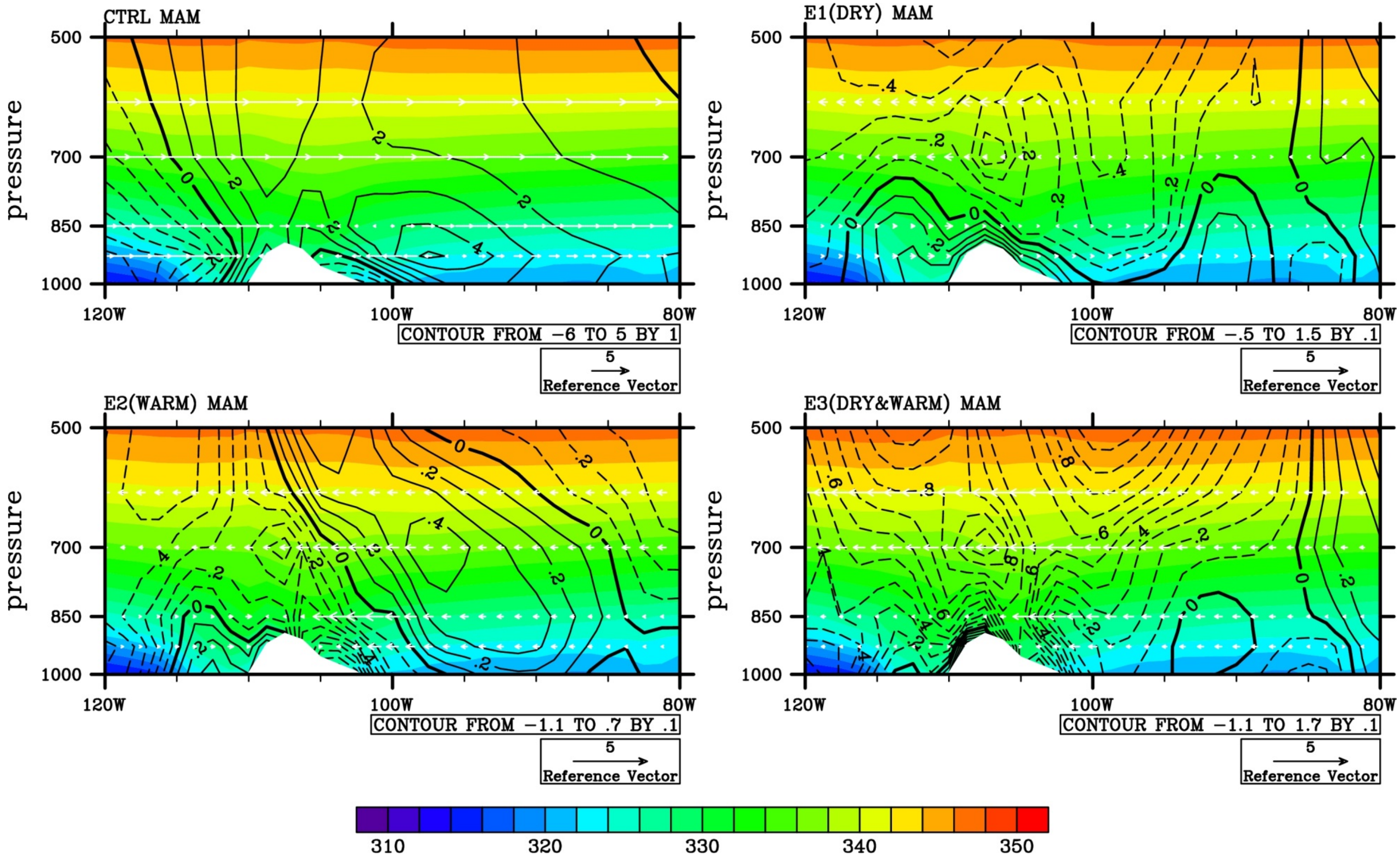
- *When the MP becomes dry, rainfall declines locally and downstream. During the spring, the dry air brought to Texas by prevailing westerly winds suppresses local convection; but dry air advection from the highlands has little influence on rainfall over Texas during the summer when Texas is no longer in the downstream areas.*

- *During the summer, a warmer MP acts like a "moisture pump" that pushes moist air over the peripheral low elevation areas to the highlands; it bends the low-level jet towards the highlands and an anti-cyclonic flow anomaly forms over the southern US, which causes air to diverge and tends to reduce rainfall over the southern US.*

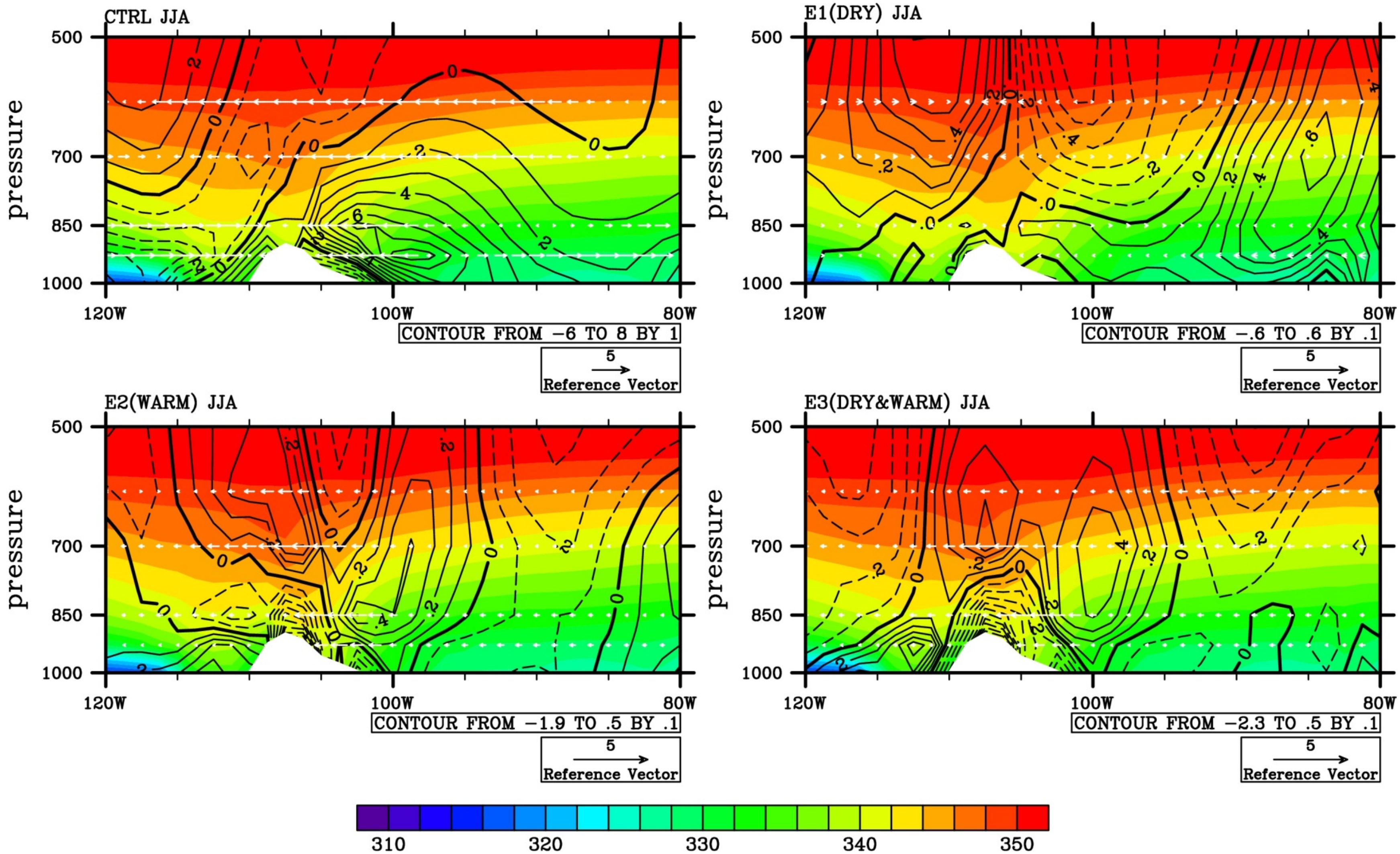

Thank you!

# Surface temperature difference between E2 and CTRL






Vertical cross sections of potential temperature (K, shadings), meridional wind (m $s^{-1}$, contours), and zonal wind (m $s^{-1}$, white arrows) along 30°N from 120°W to 80°W for spring (MAM). The contours show meridional wind speed for CTRL and differences in meridional wind speed between the experiment runs and the control run for E1, E2, and E3.




Vertical cross sections of potential temperature (K, shadings), meridional wind ($m\ s^{-1}$, contours), and zonal wind ($m\ s^{-1}$, white arrows) along 30°N from 120°W to 80°W for spring (JJA). The contours show meridional wind speed for CTRL and differences in meridional wind speed between the experiment runs and the control run for E1, E2, and E3.