

# Drought impacts on PM and Ozone in the US

---

**Yuxuan Wang<sup>1,2</sup>, Yuanyu Xie<sup>2</sup>**

<sup>1</sup> Texas A&M University

<sup>2</sup> Tsinghua University

5 May 2015

# Drought: Extreme Climate Events

Drought affects both society and the natural environment, including the atmosphere, water cycle, and land biosphere.



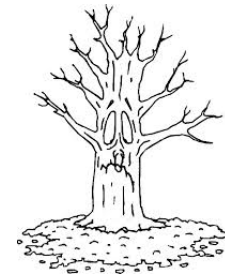
**Higher temperatures**



**Lower precipitation**



**Land surface change**



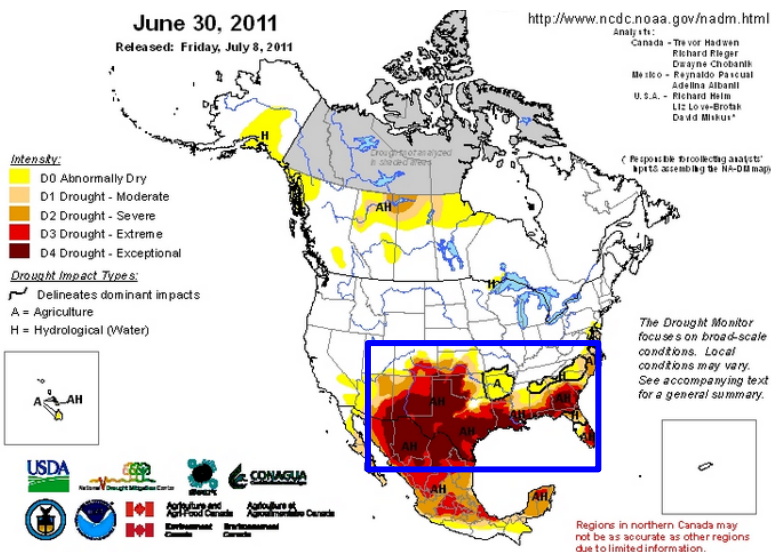
**Ecosystems: water deficit, heat stress**

**People: heat stress, water scarcity**

**Air Quality?**

# PM<sub>2.5</sub> during the 2011 Southern US drought

## NCDC drought conditions Jun 2011



## PM<sub>2.5</sub> change: June 2011 (drought) vs. June 2010 (normal month)

Observation:

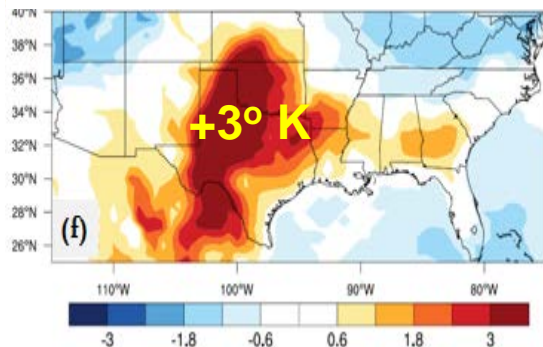
114 surface sites (IMPROVE, EPA)

Model:

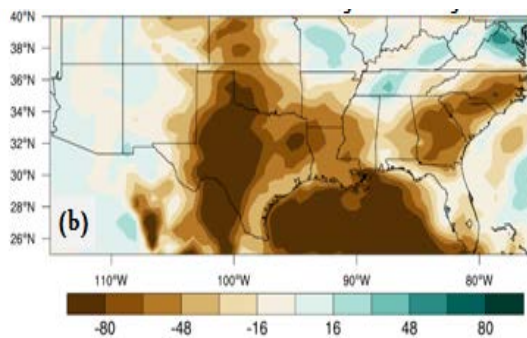
GEOS-Chem, 0.5°x0.667° nested-grid

## June 2011 – June 2010

Temperature change (K)

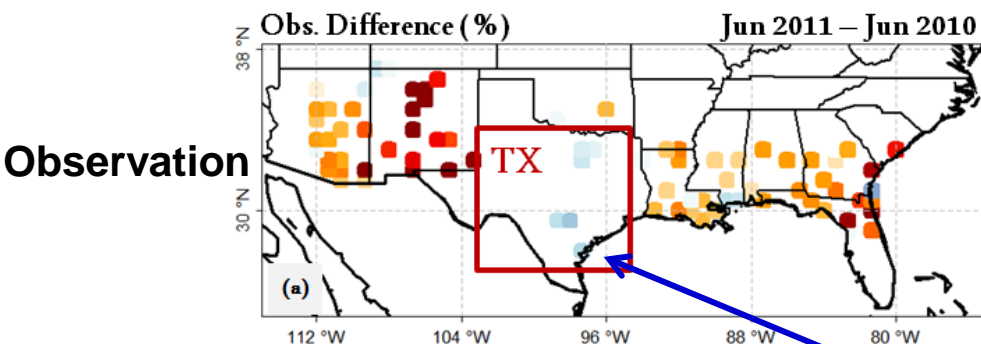


precipitation change (mm/month)

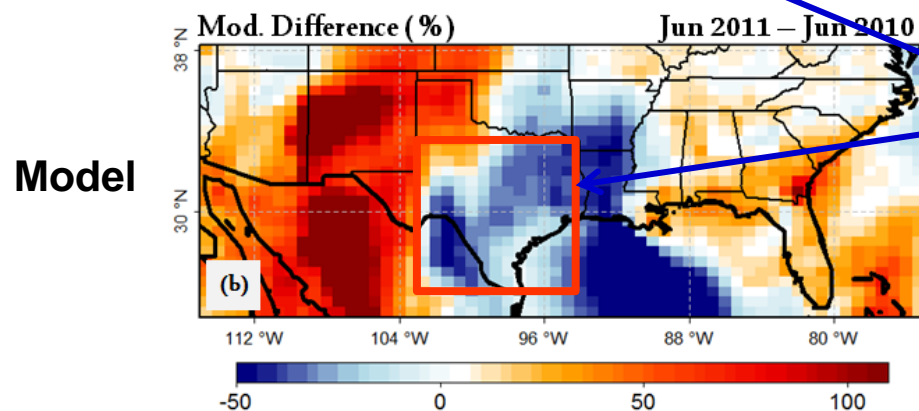


# PM<sub>2.5</sub> during the 2011 Southern US drought

PM<sub>2.5</sub> difference (%): June 2011 (drought) minus June 2010 (normal)



Southern US: +26% increase (2.3  $\mu\text{g}/\text{m}^3$ ) during drought ( $p < 10^{-4}$ )



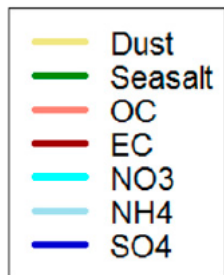
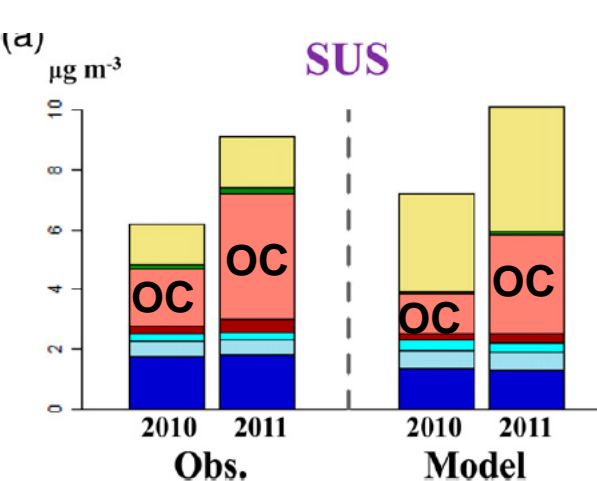
TX : 10.7% less (-1.16  $\mu\text{g}/\text{m}^3$ ) ( $p < 0.10$ )

PM<sub>2.5</sub> response to drought differs by region

Observation: 114 monitoring sites

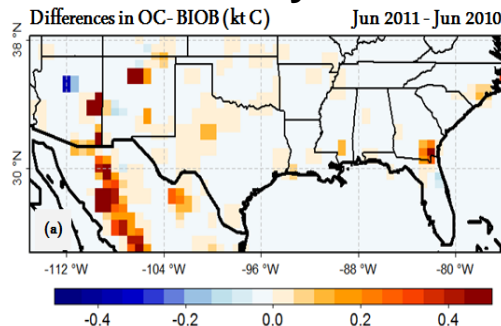
Model: GEOS-Chem, 0.5°x0.667°

# Different process involved by species and by region

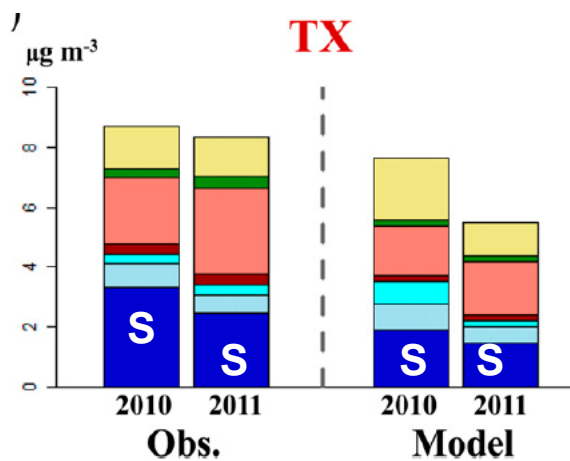
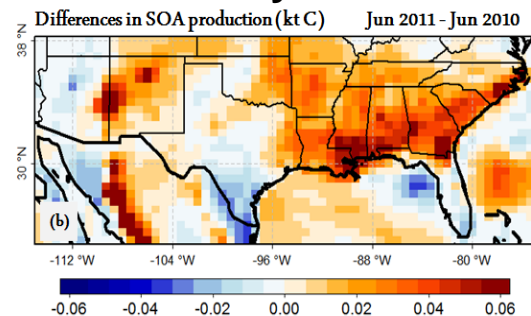


## Southern US: PM increase driven by OC

### OC diff by fires

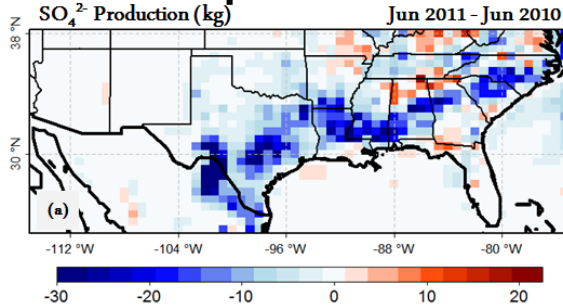


### SOA diff by BVOC

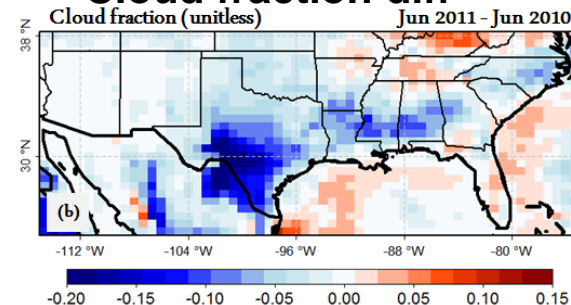


## TX: PM decrease driven by sulfate

### Sulfate production diff



### Cloud fraction diff

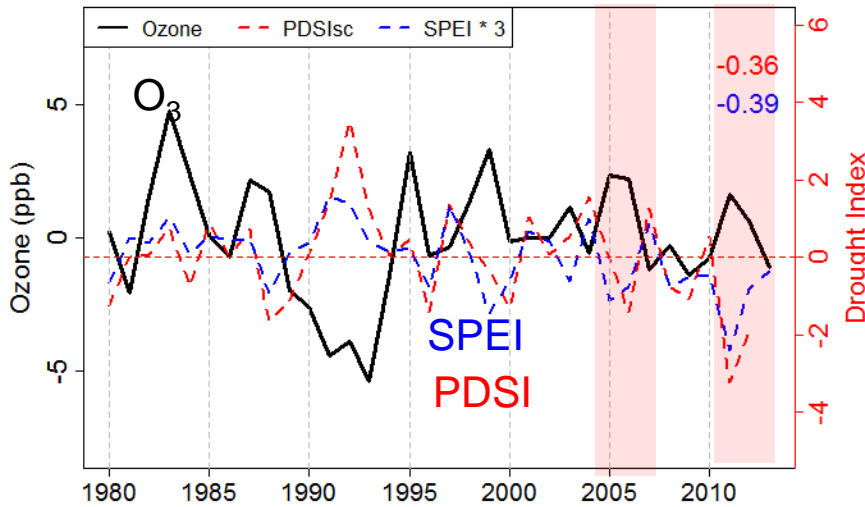


**Drought-driven change in sources and chemistry dominate over that in deposition**

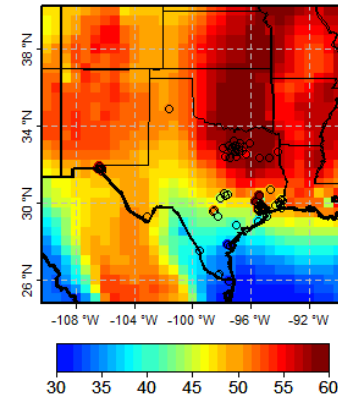
# Drought effects on O<sub>3</sub> air quality

Correlation between O<sub>3</sub> (detrended) and drought indices (PDSI, SPEI)

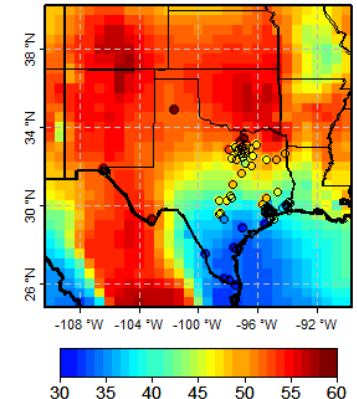
Texas ( R = -0.4)



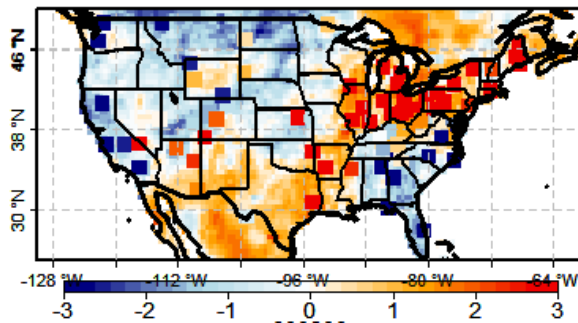
GC Ozone 200506



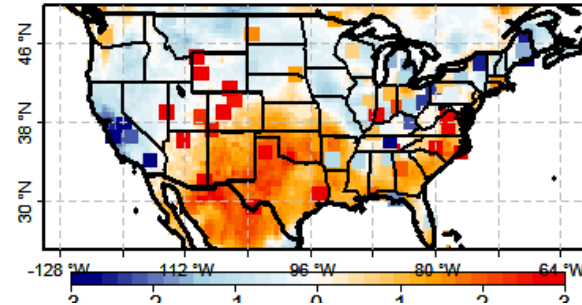
201106



SPEI 200506



SPEI 201006



# Summary

- Effects of drought on PM differ by species and region  
2011 drought: +26% of PM<sub>2.5</sub> over SUS, but -11% in Texas
- O<sub>3</sub> is higher during droughts, while the magnitude of the enhancement does not correspond to drought severity on a local scale
- Drought impacts on air quality/public health are significant and need to be considered on top of other 'direct' impacts of drought
- GEOS-Chem has some ability to reproduce the regionally and species-specific impacts of drought on O<sub>3</sub> and PM<sub>2.5</sub>

Wang Yuxuan, Xie Yuanyu, et al., Impact of the 2011 southern US drought on ground-level fine aerosol concentration in summertime, *J. Atmos. Sci.*, 72, 1075–1093, 2015