Observed and simulated changes of $PM_{2.5}$ and O_3 under recent China droughts

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GCA1

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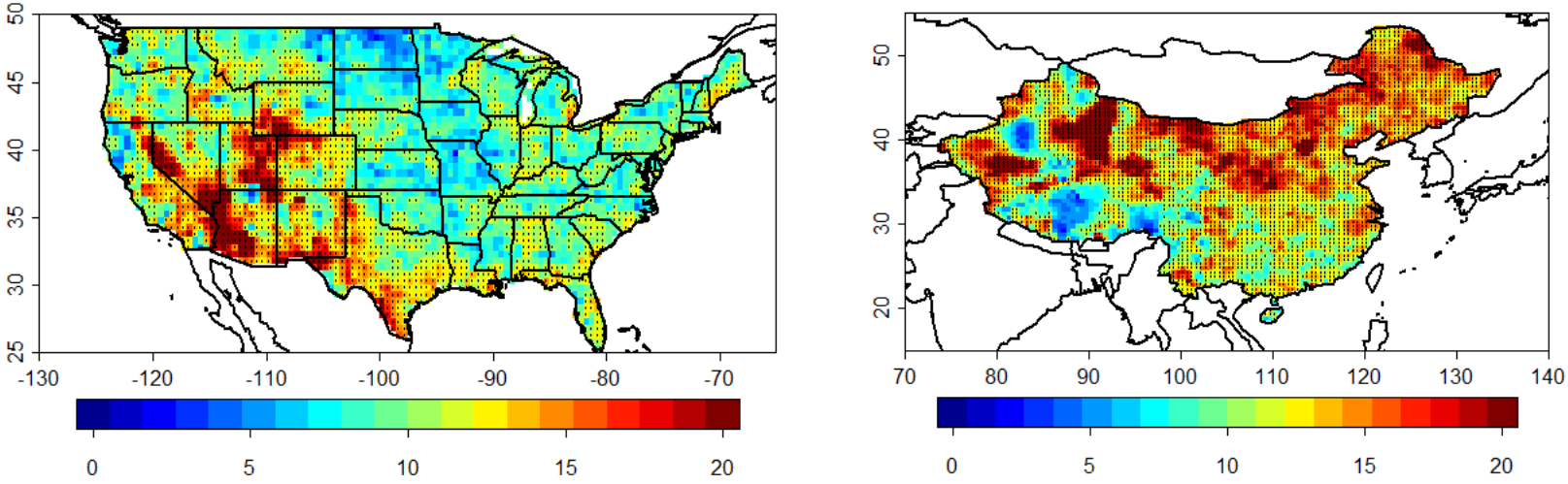
Occurrence frequency

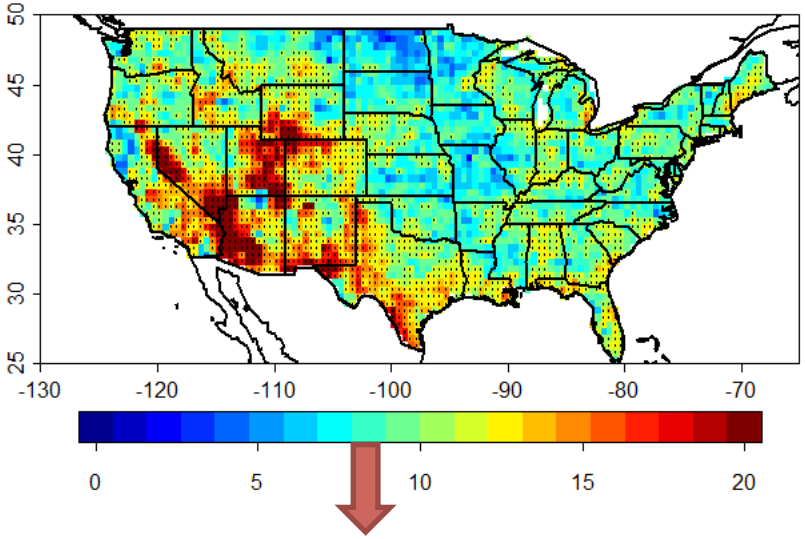
Drought occurrence frequency 1990-2014 Mar. to Oct. (%)

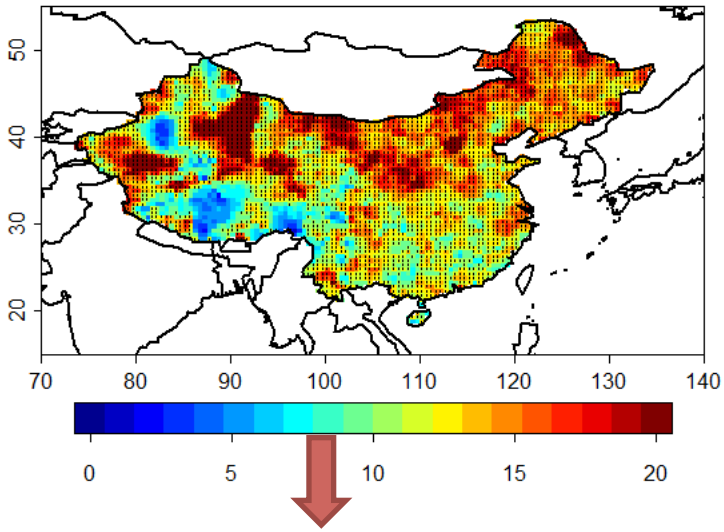


Standardized Precipitation Evapotranspiration Index (SPEI) – 1 month
Reference period (1950-2010)
Drought: SPEI < -1.3 (10^{th} percentile)
Normal: SPEI (-0.5,0.5)

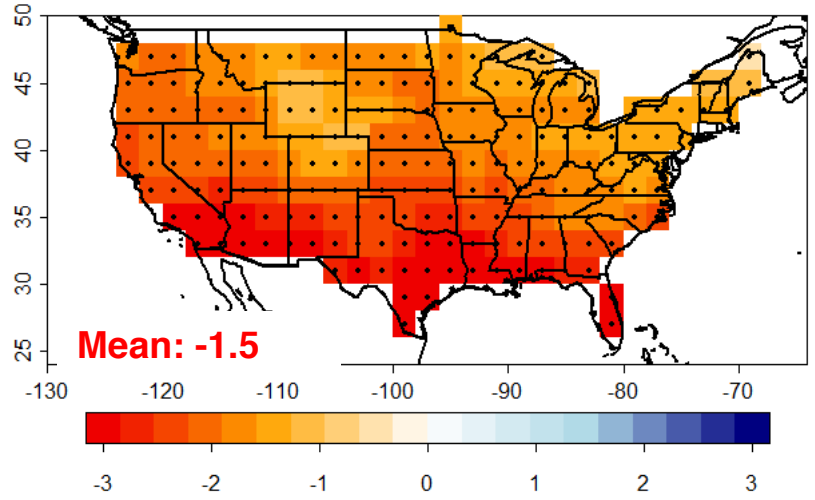
Future change

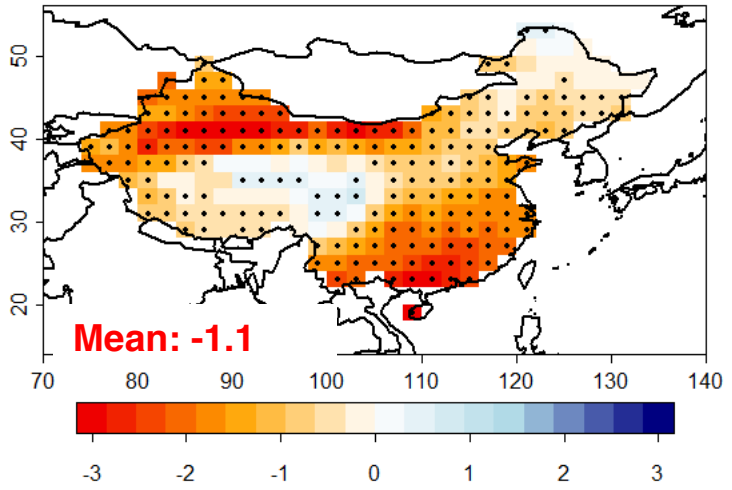
Drought occurrence frequency 1990-2014 Mar. to Oct. (%)





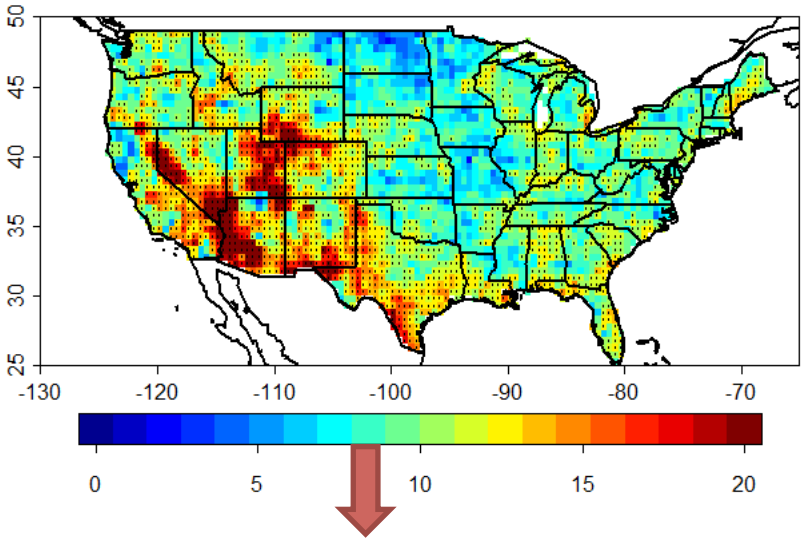
Future changes of drought (Average aridity, CMIP5–RCP8.5)

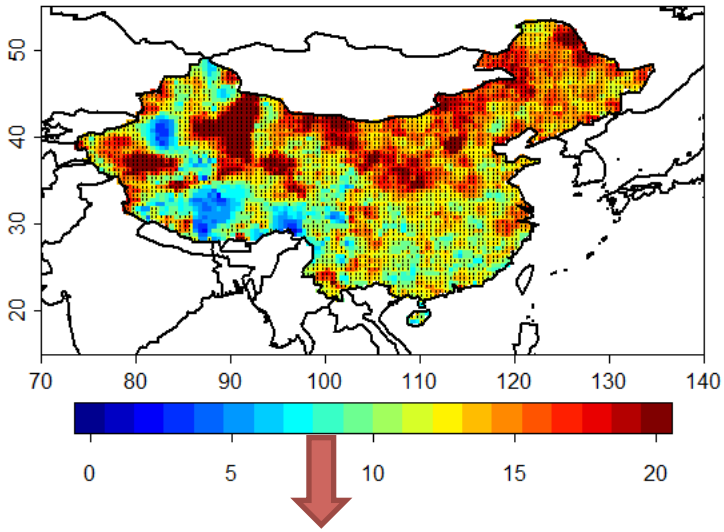




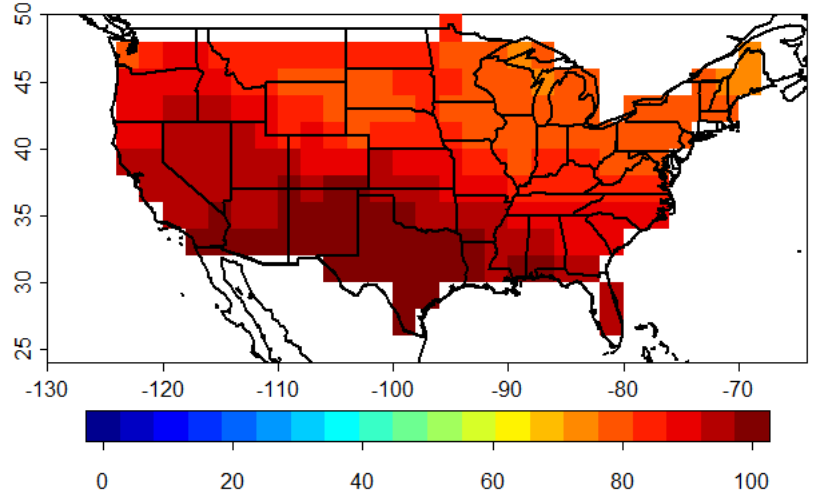
Future change

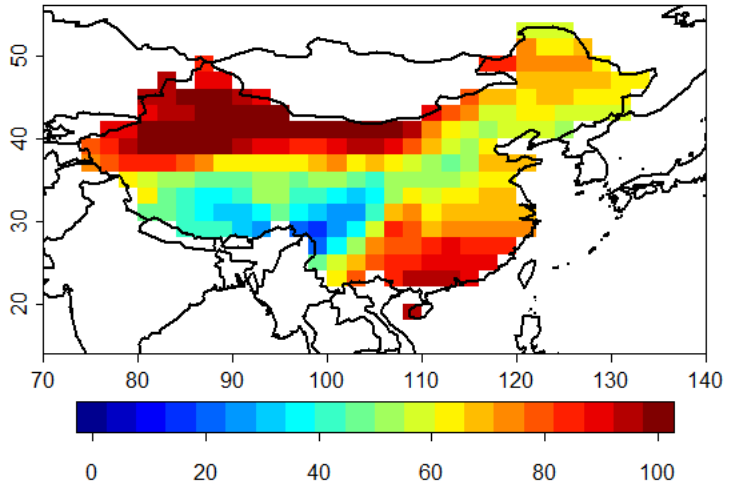
Drought occurrence frequency 1990-2014 Mar. to Oct. (%)





Future changes of drought (Frequency, CMIP5–RCP8.5)

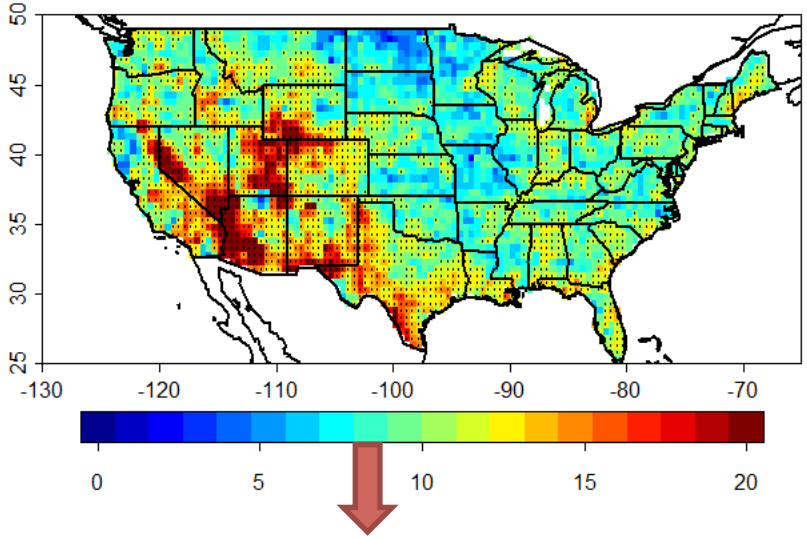


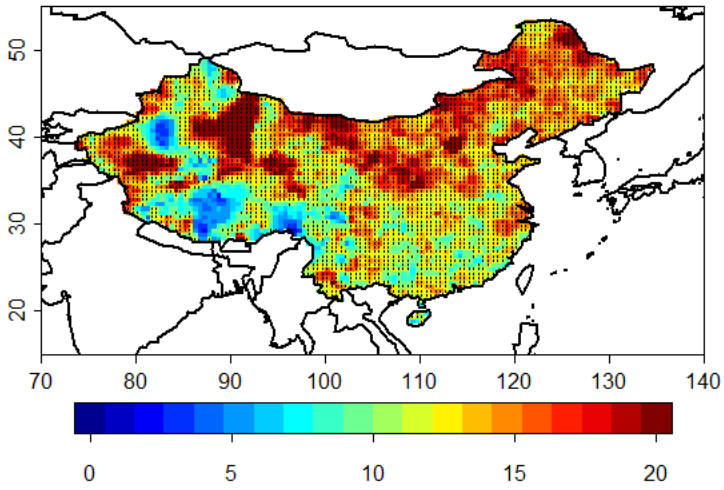


Drought

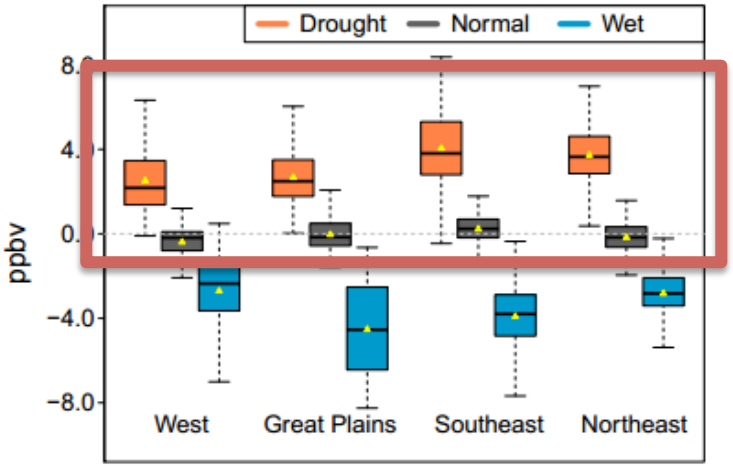
U.S. air quality – observed changes

Drought occurrence frequency 1990-2014 Mar. to Oct. (%)

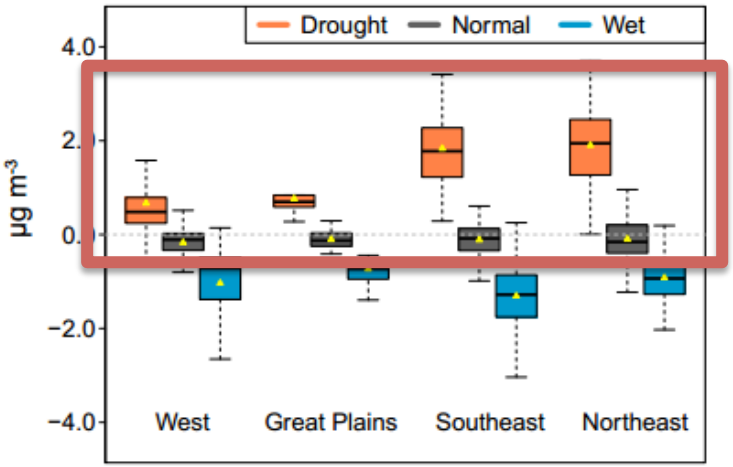




(e) Ozone anomaly



(h) $PM_{2.5}$ anomaly



Significant negative correlation
O_3 +3.5 ppbv
$PM_{2.5}$ +17%

Wang and Xie et al., 2017, ACP

U.S. air quality – causes

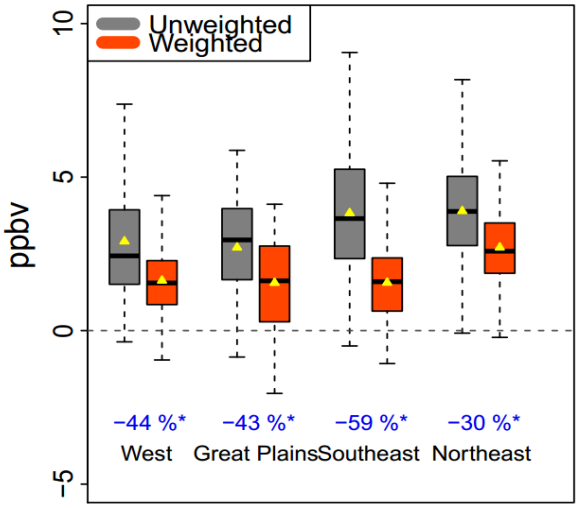
Anthropogenic emission

- 1990-2003: 4.9 ppbv
- 2004-2014: 4.2 ppbv

Meteorological condition

- Enhanced stagnation/ heat wave ~40%

O_3 change



Wang and Xie et al., 2017, ACP

Drought

U.S. air quality – causes

Anthropogenic emission

- 1990-2003: 4.9 ppbv
- 2004-2014: 4.2 ppbv

Dry deposition

- Up to 30% decrease

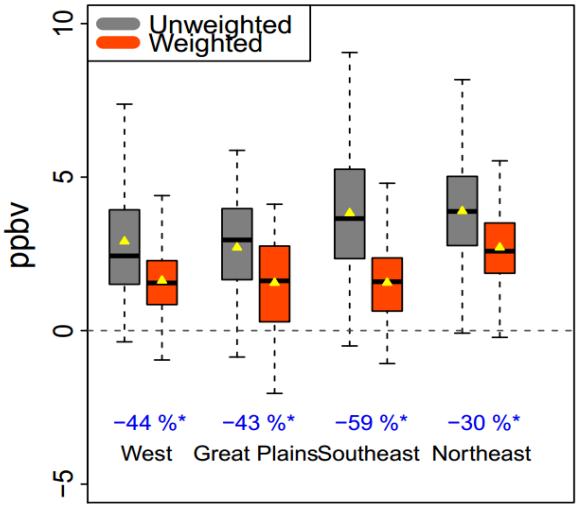
Meteorological condition

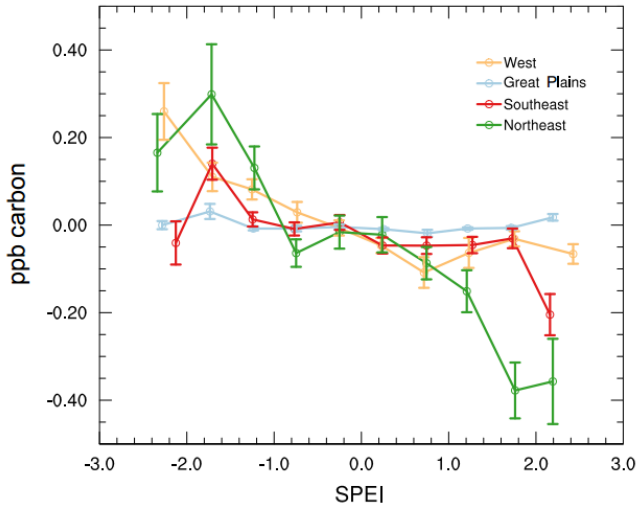
- Enhanced stagnation/ heat wave ~40%

O_3 change

BVOCs emission

- Increase by 7-20%
- Decrease at severe drought

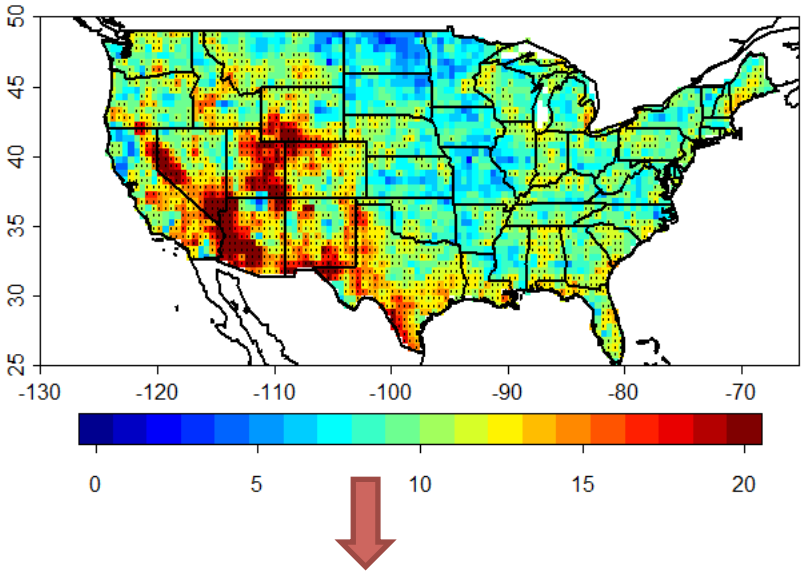


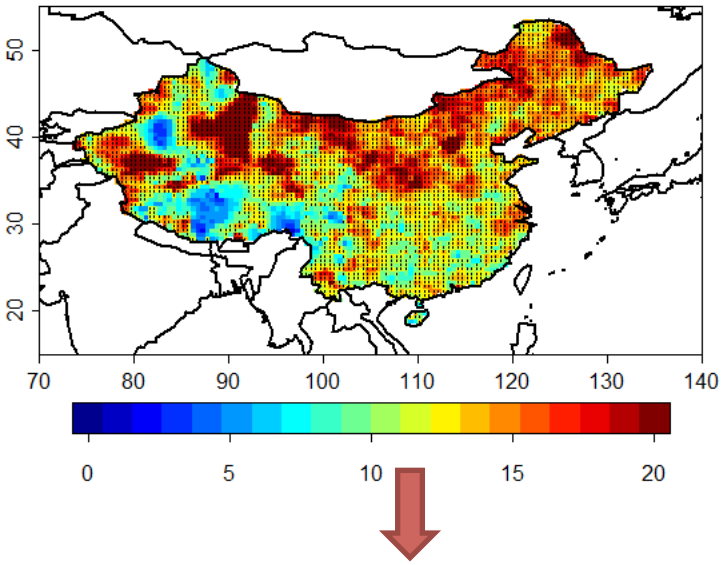


Wang and Xie et al., 2017, ACP

GEOS-Chem model performance

Drought occurrence frequency 1990-2014 Mar. – Oct. (%)



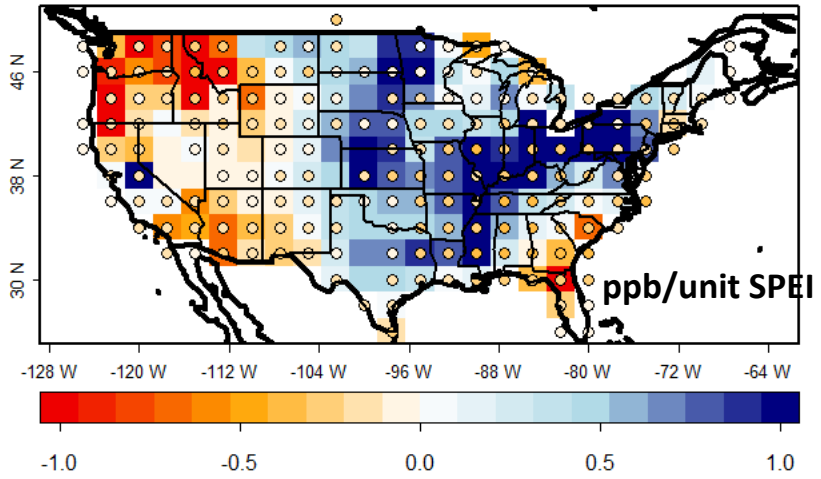


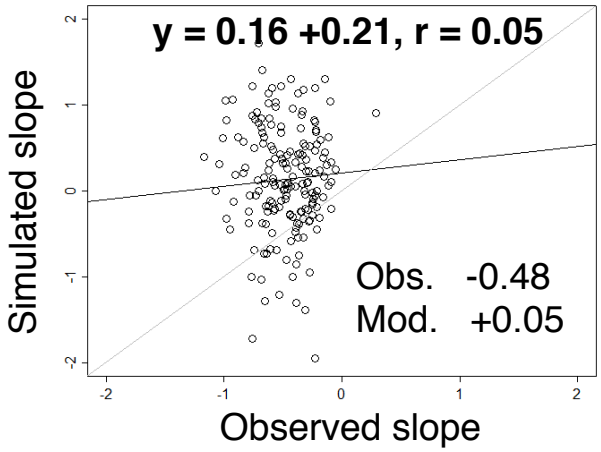
Significant negative correlation
O_3 +3.5 ppbv
$PM_{2.5}$ +17%

?

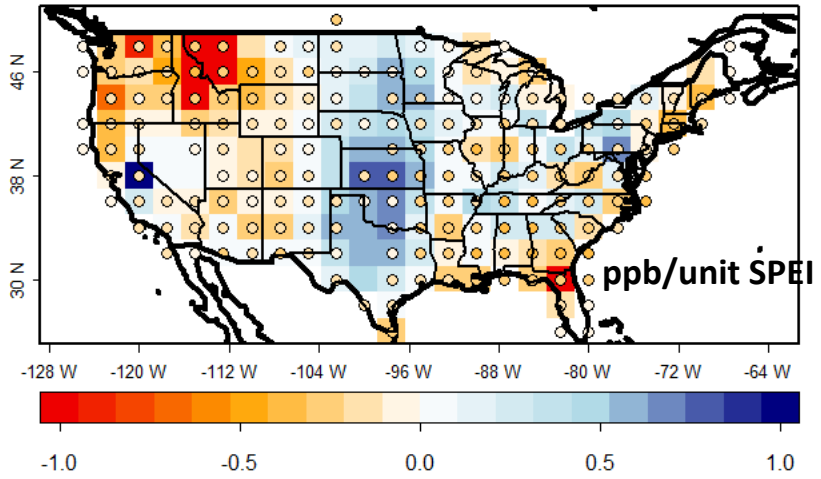
GEOS-Chem model performance

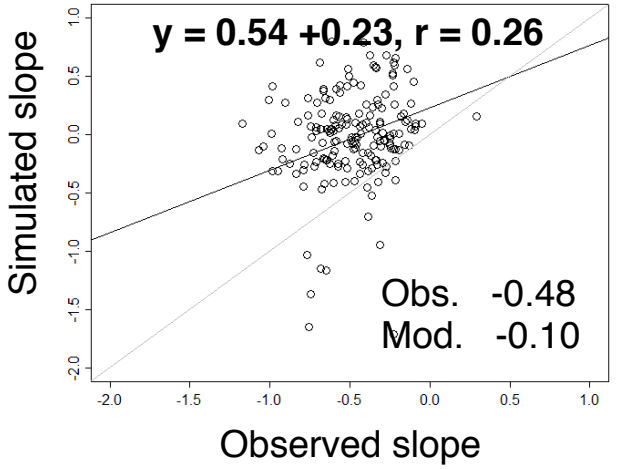
GEOS-Chem simulated $PM_{2.5}$-SPEI slope (MERRA)





GEOS-Chem simulated $PM_{2.5}$-SPEI slope (MERRA2)



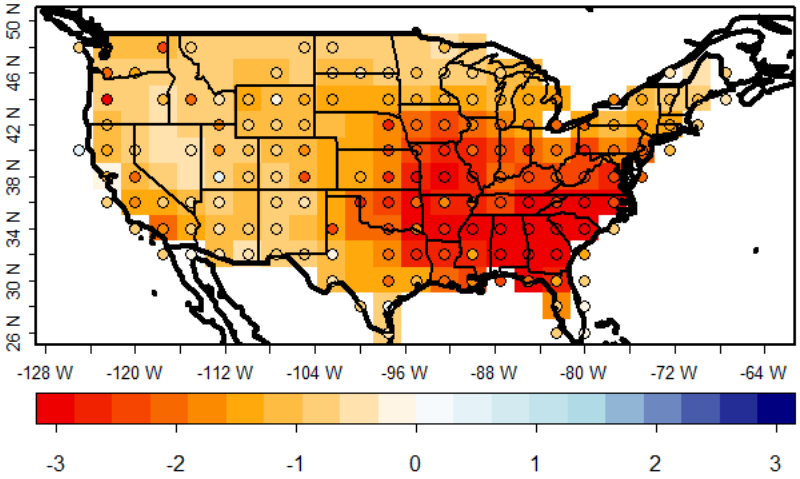


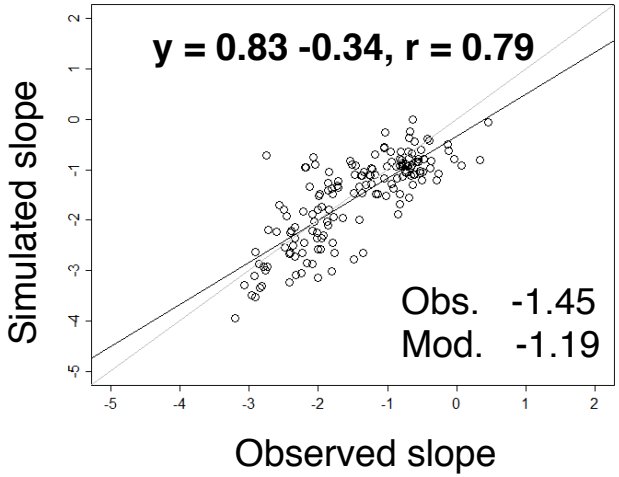
Improved $PM_{2.5}$-SPEI correlation due to improved cloud field

Xie et al., in prep

GEOS-Chem model performance

GEOS-Chem simulated O_3-SPEI slope (MERRA2, 2000-2014, Mar to Aug)

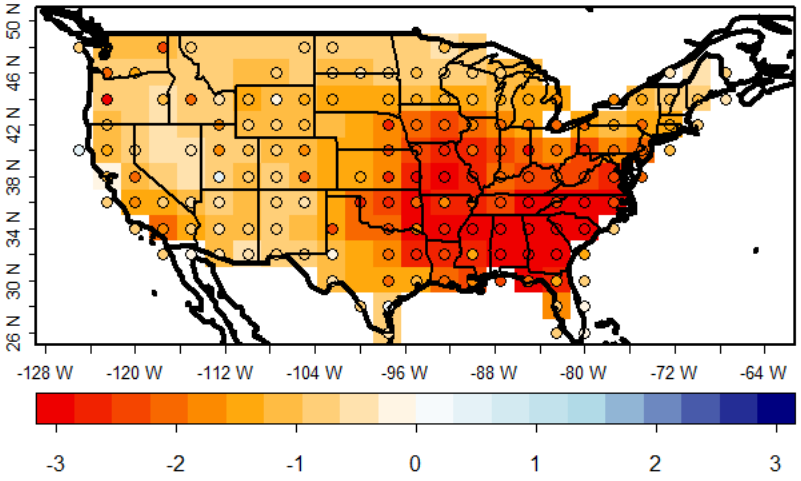


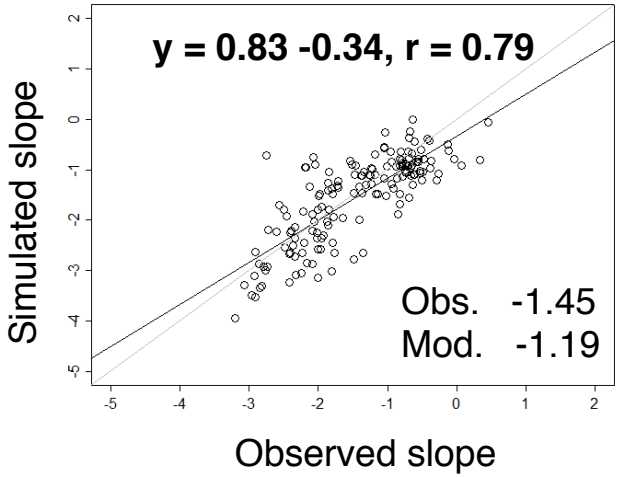


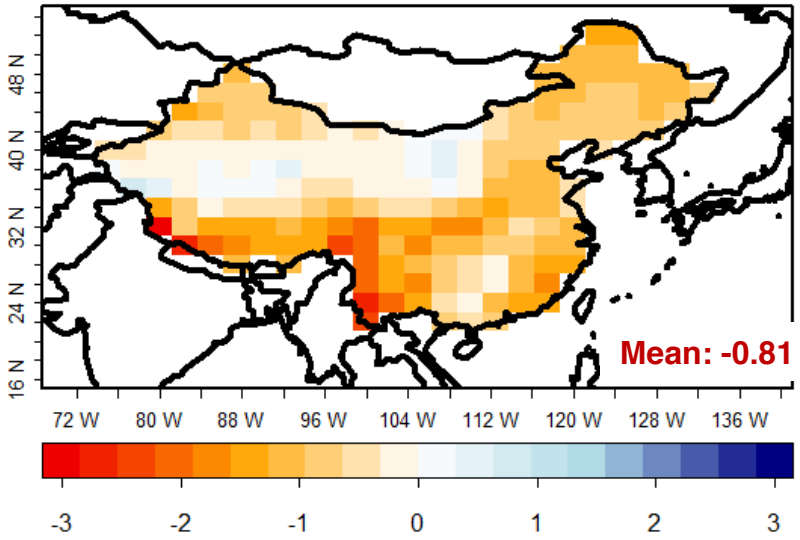
Xie et al., in prep

China O_3 change

GEOS-Chem simulated O_3-SPEI slope (MERRA2, 2000-2014, Mar to Aug)





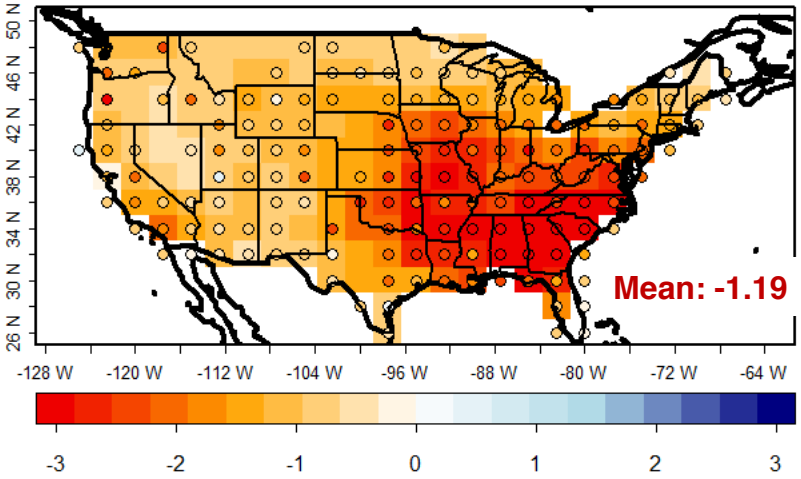


Smaller sensitivity of O_3 to drought over China

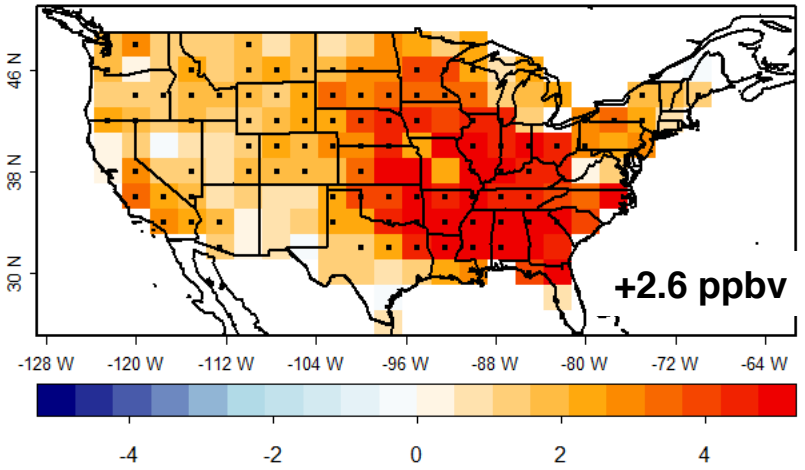
Xie et al., in prep

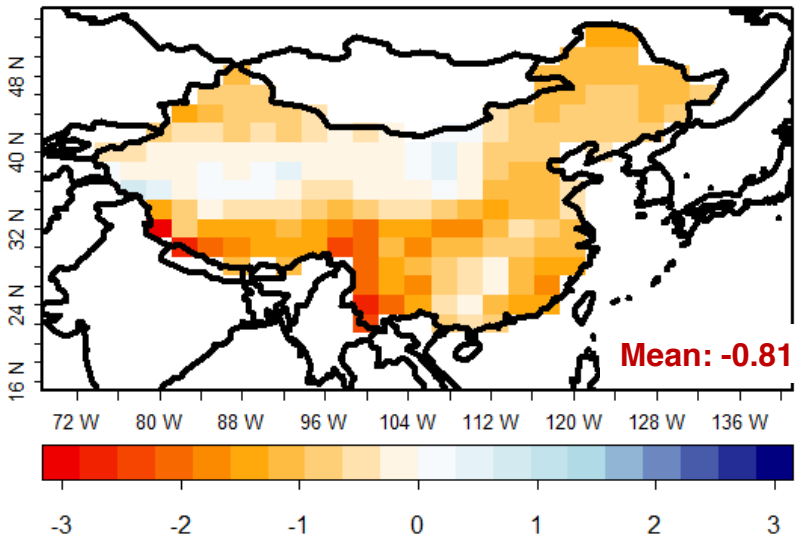
China O_3 change

GEOS-Chem simulated O_3-SPEI slope

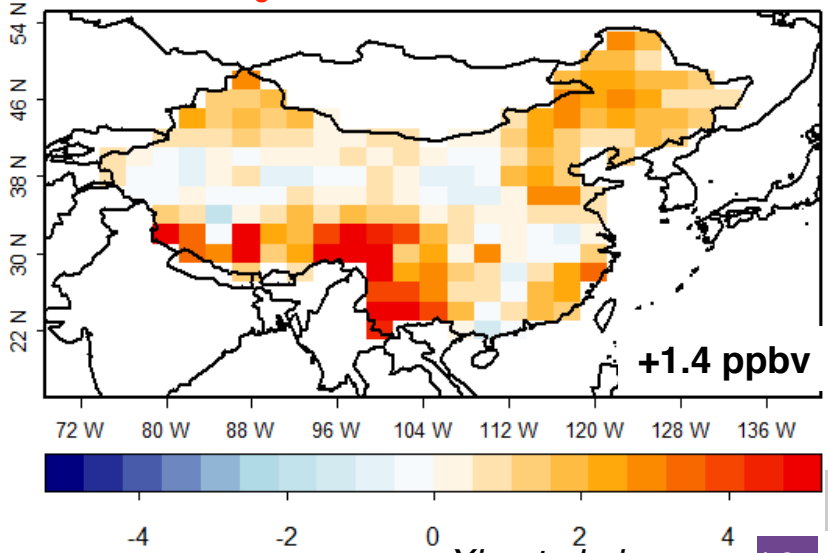


GEOS-Chem simulated O_3 change





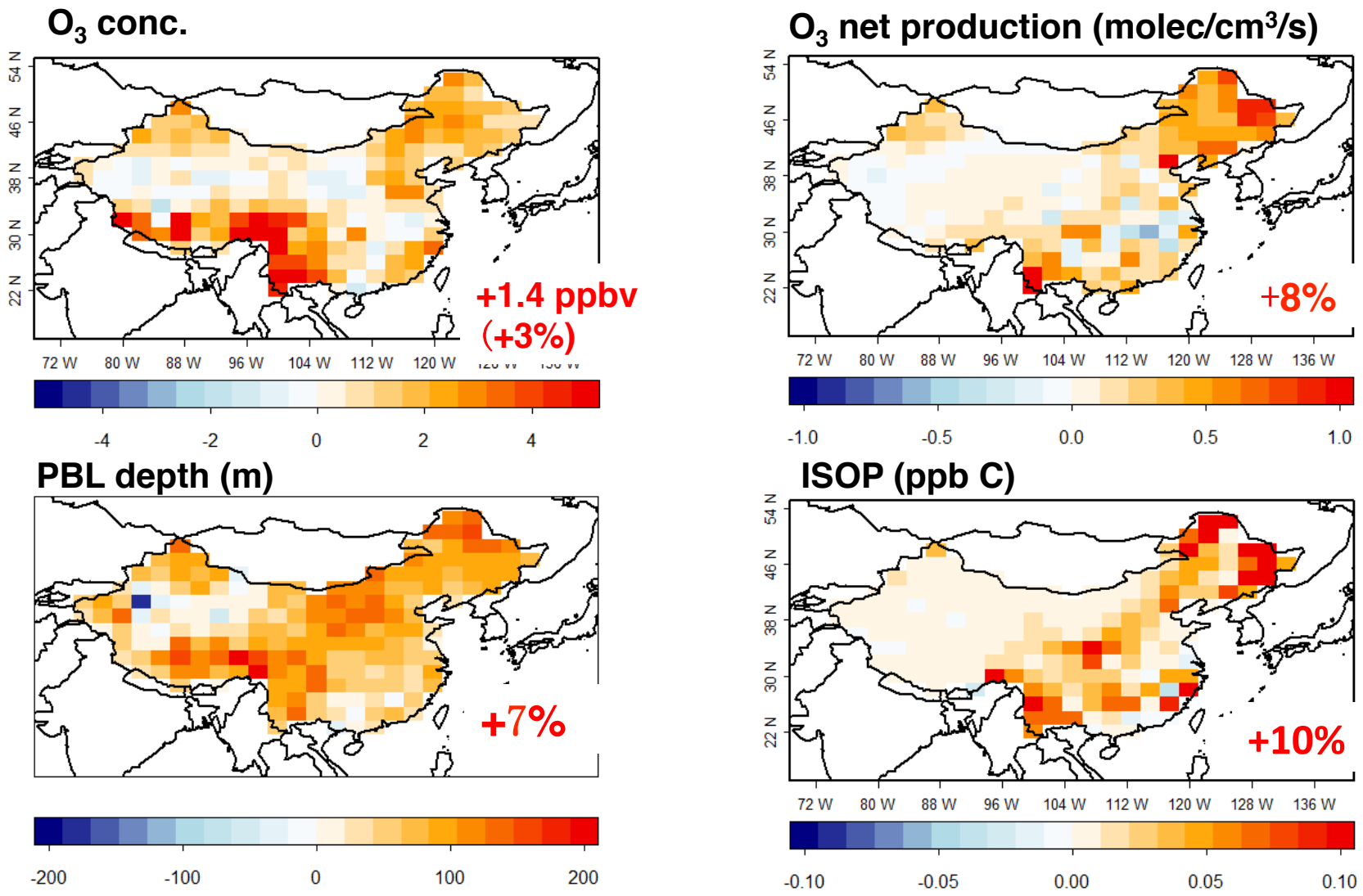
Smaller O_3 enhancement



Xie et al., in prep

Drought

China O_3 change – causes



High sensitivity: southwest (biogenic emission);Tibetan Plateau (higher PBL)

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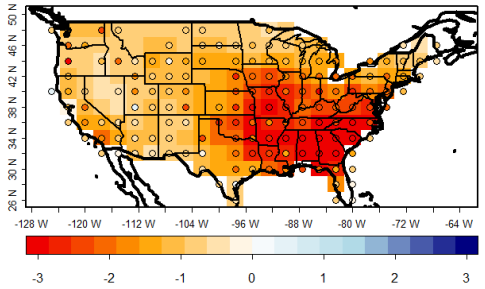
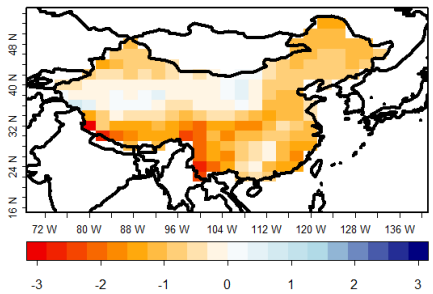
Drought

Future changes

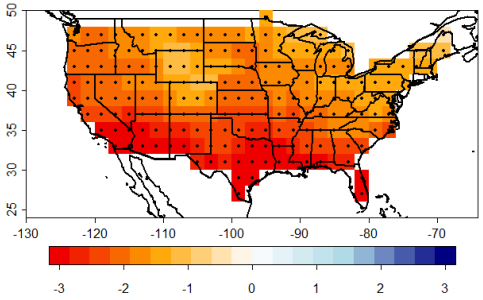
Slope

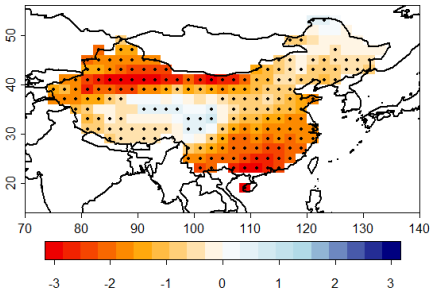




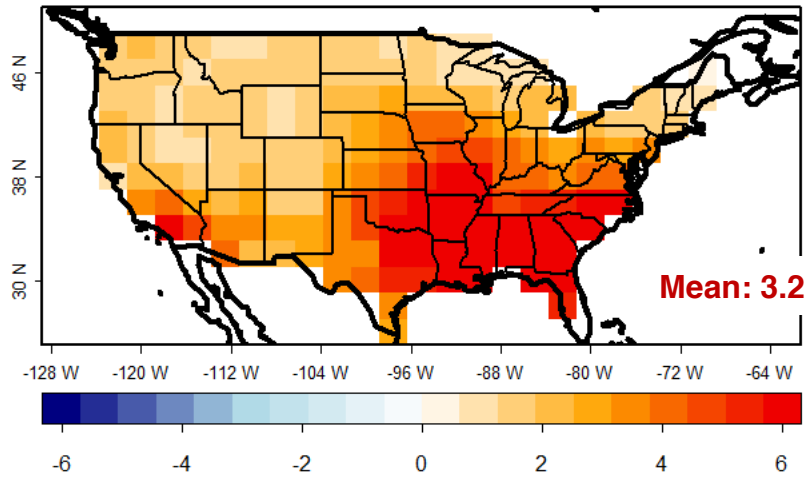
ppb/unit SPEI

Changes in SPEI

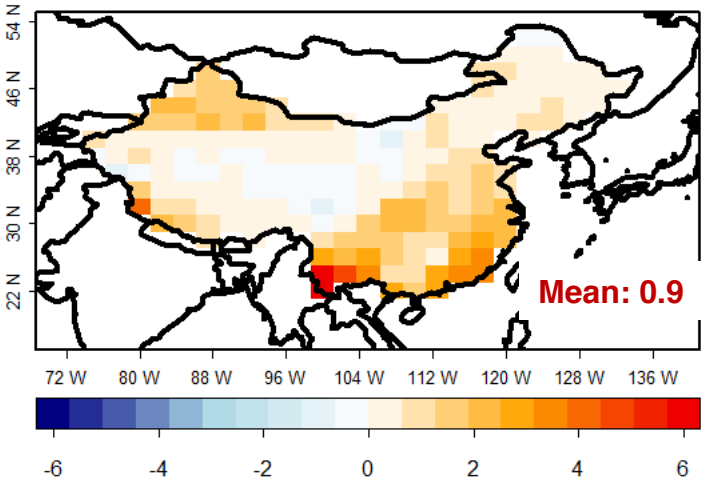




ppb

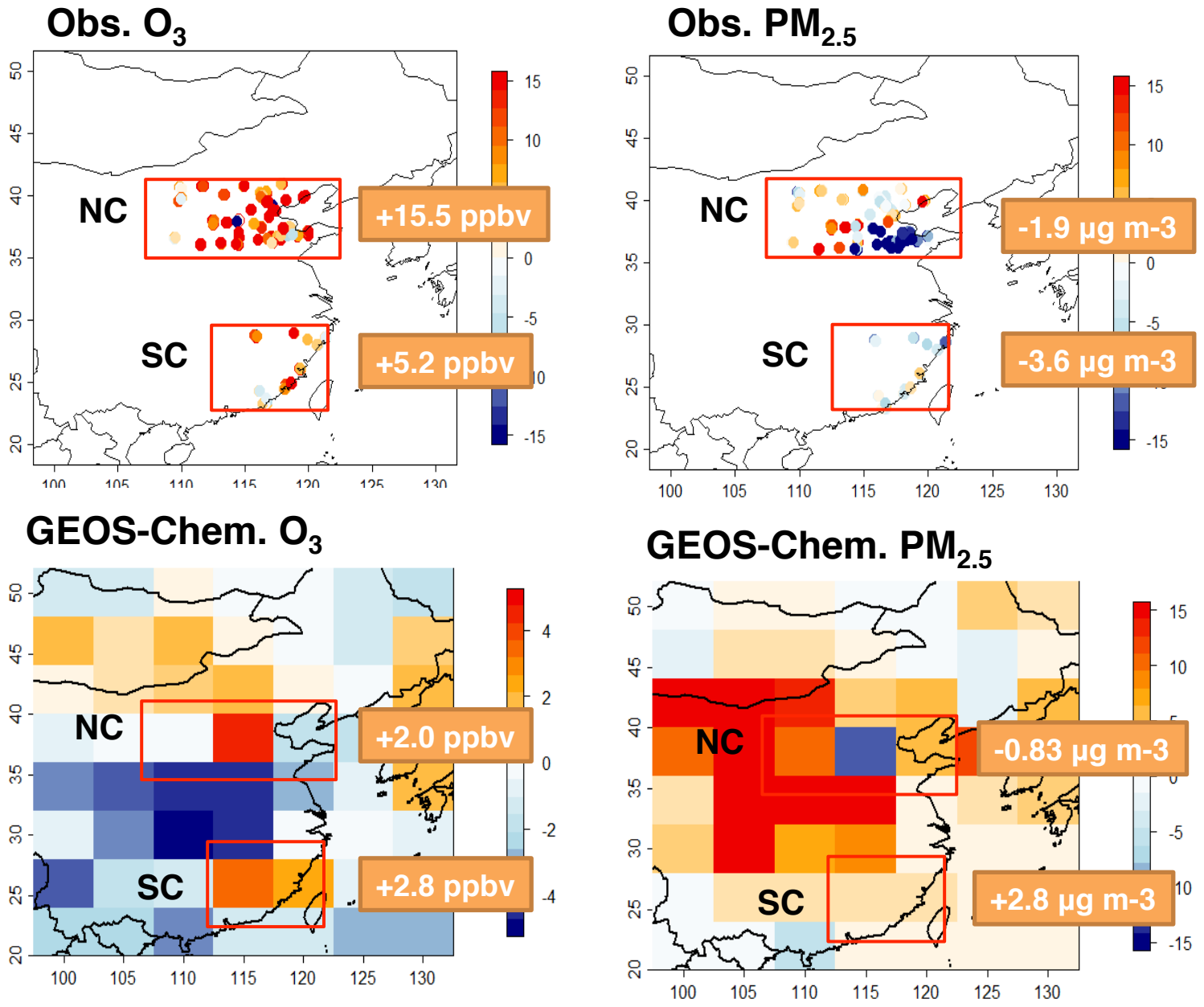


ppb



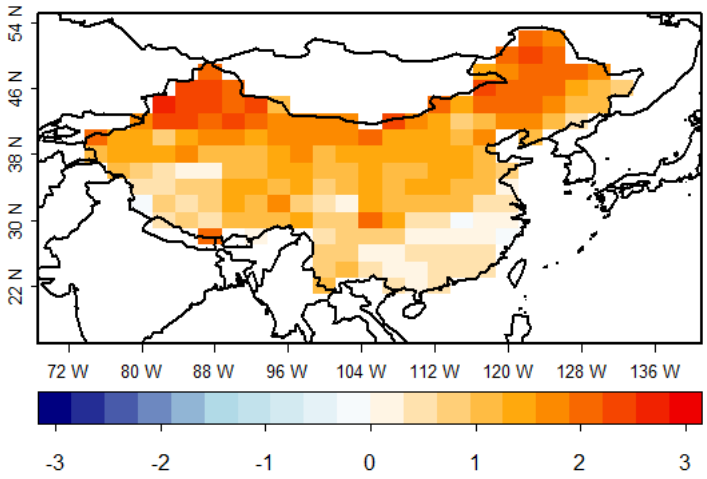
Conclusions

- Degradation of air quality under drought (Met + ecosystem-atmosphere interaction)
- GEOS-Chem can reproduce O_3-SPEI correlation but not $PM_{2.5}$-SPEI
- Less O_3 increase under drought over China compared to U.S. under current and future climate

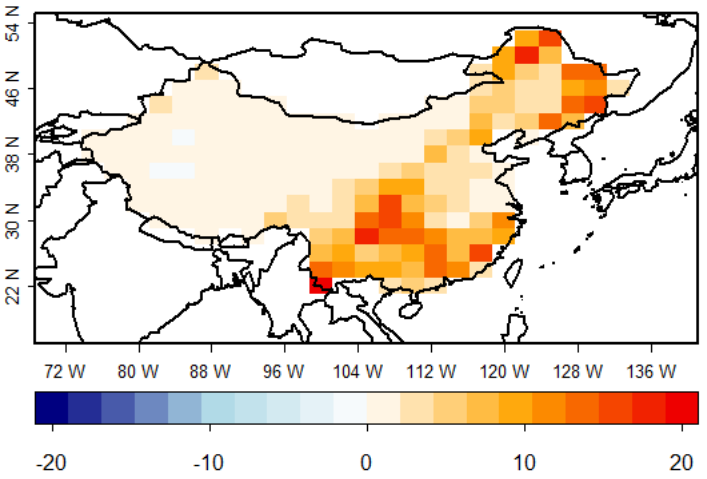


Xie et al., in prep

TS



ISOPEMI



NO2