Skillful Long-lead Prediction of US Midwest Summertime Heavy Rain from Ocean Salinity

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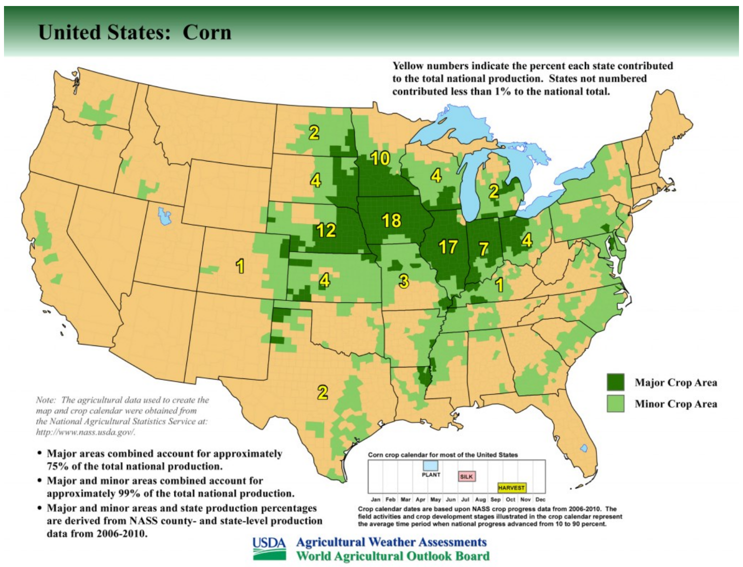
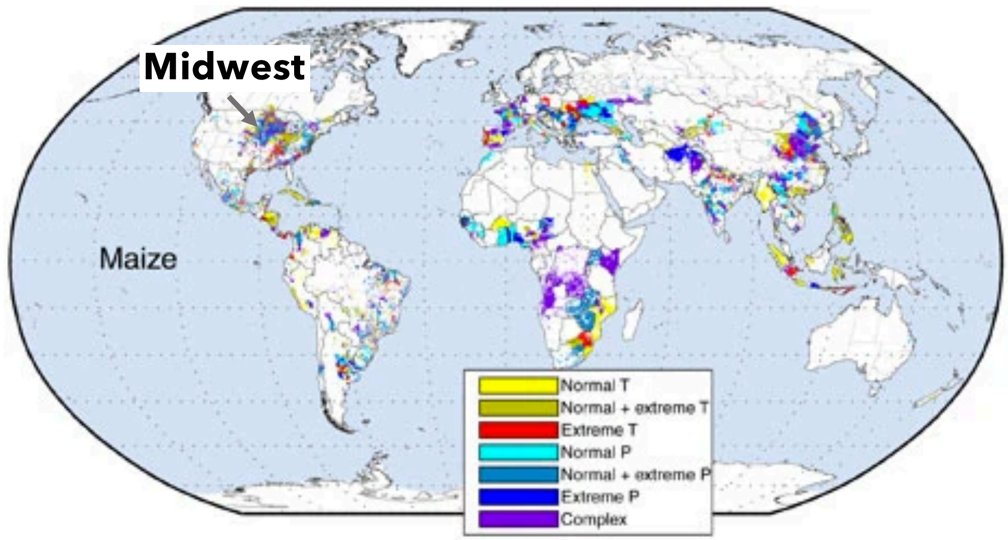
NOAA's 46th CDPW |10/26/2021

Introduction: US Midwest precipitation



Climate factors impacting corn production



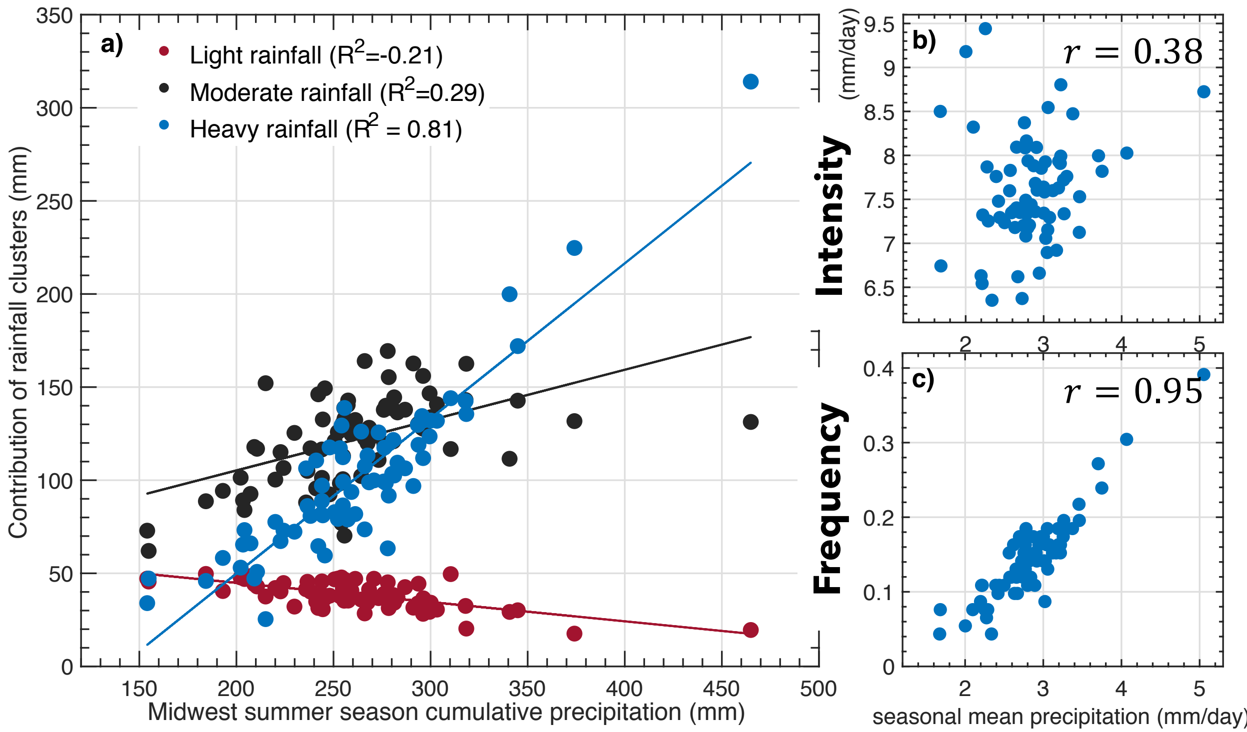
Ray *et al*. (2015) Nature Communications

- Midwest is a primary corn production area in the US

- Corn production in the US Midwest is significantly impacted by the amount of rainfall.

Heavy rainfall: important to Midwest summer rain

Statistical inference based on a 3-cluster Bayesian Gaussian mixture model (Li et al. 2013; 2016)



Statistical Model:

- Objectively categorize daily rainfall to **light**, **moderate**, and **heavy** clusters based on probability density function
- Code available at: https://zenodo.org/record/5389218#.YTEWgtNKjVo.

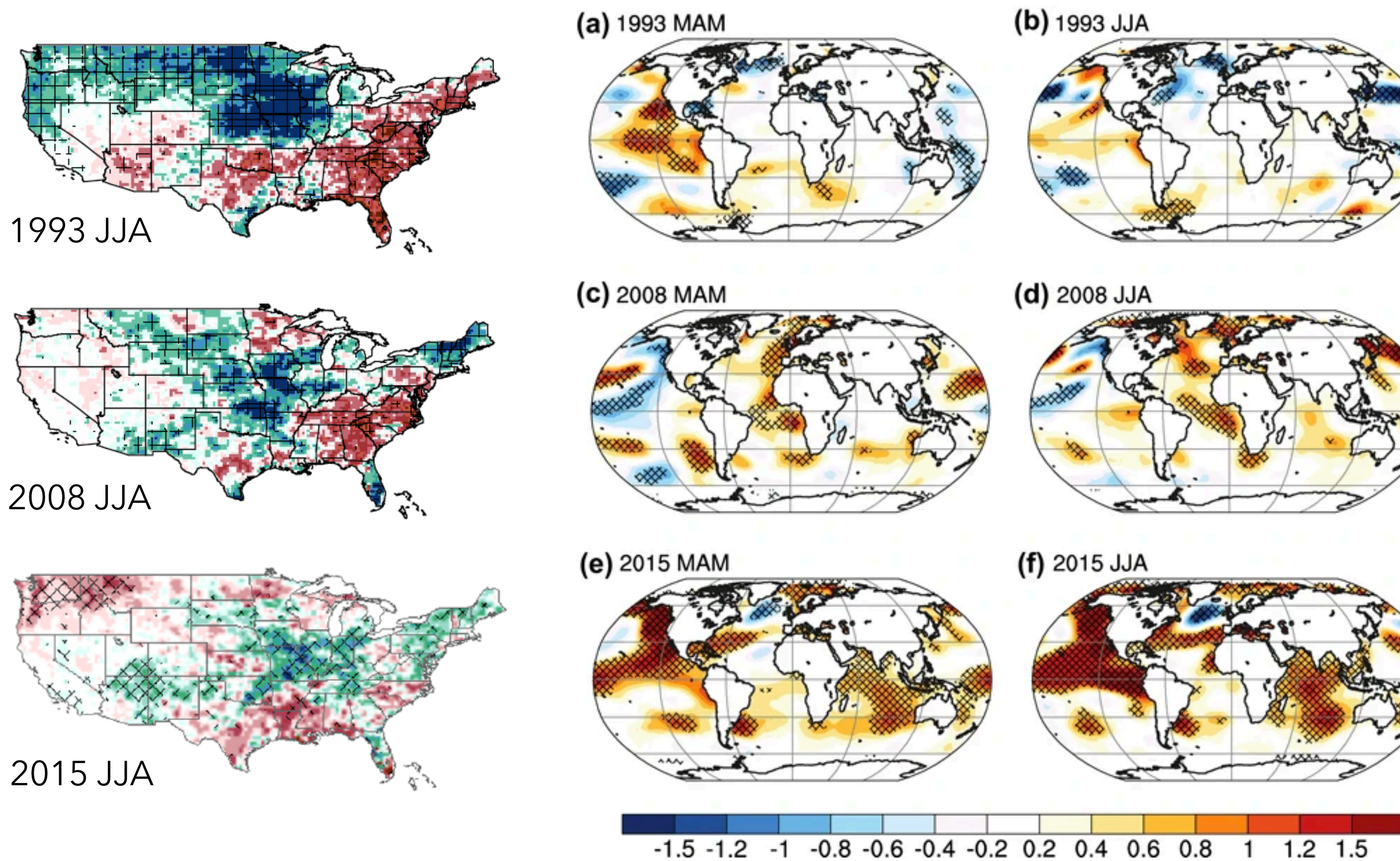
Results:

- Heavy rainfall cluster contributes the most to Midwest summer rainfall variability
- Frequency > Intensity

Li et al. (2021) GRL, Under Revision

*Midwest:
106°W-90°W; 36°N-49°N

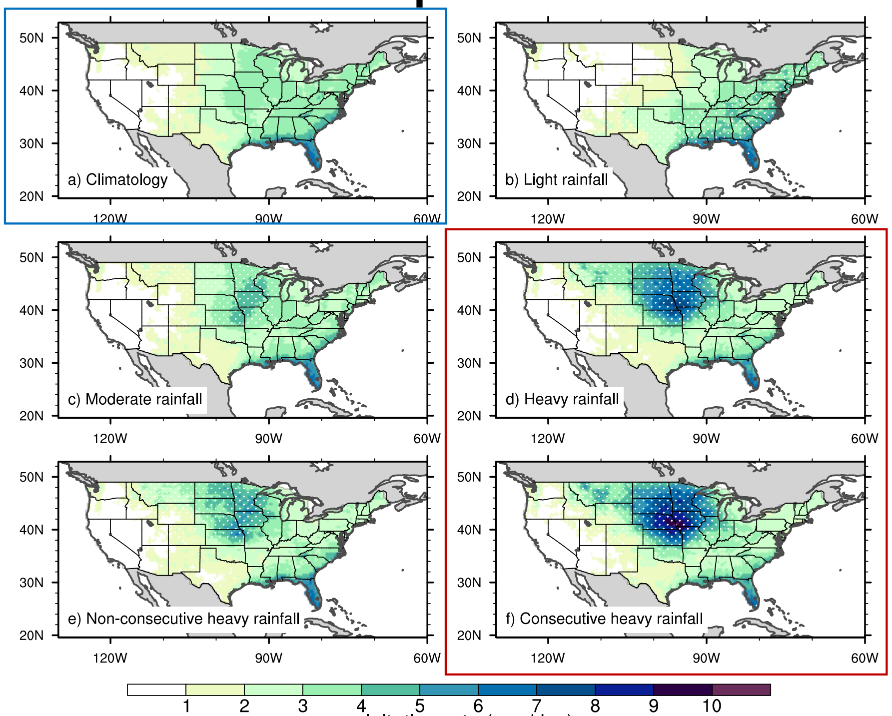
Uncertain SSTA-heavy rainfall relationship



Li et al. 2018 *Clim. Dyn.*

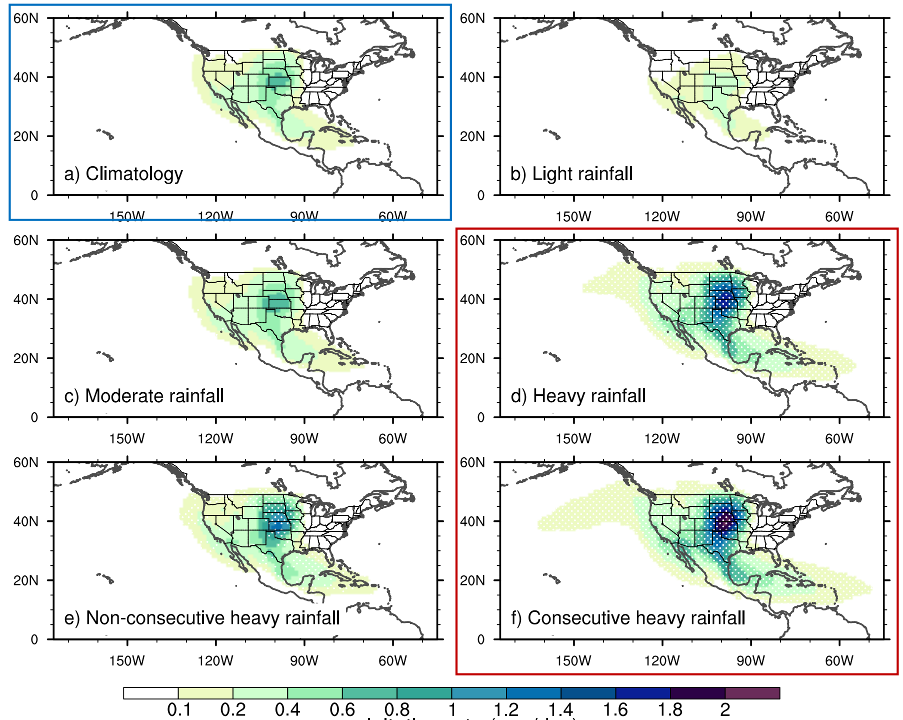
Moisture sources for US Midwest heavy rain

Precipitation



Precipitation rate (mm/day)

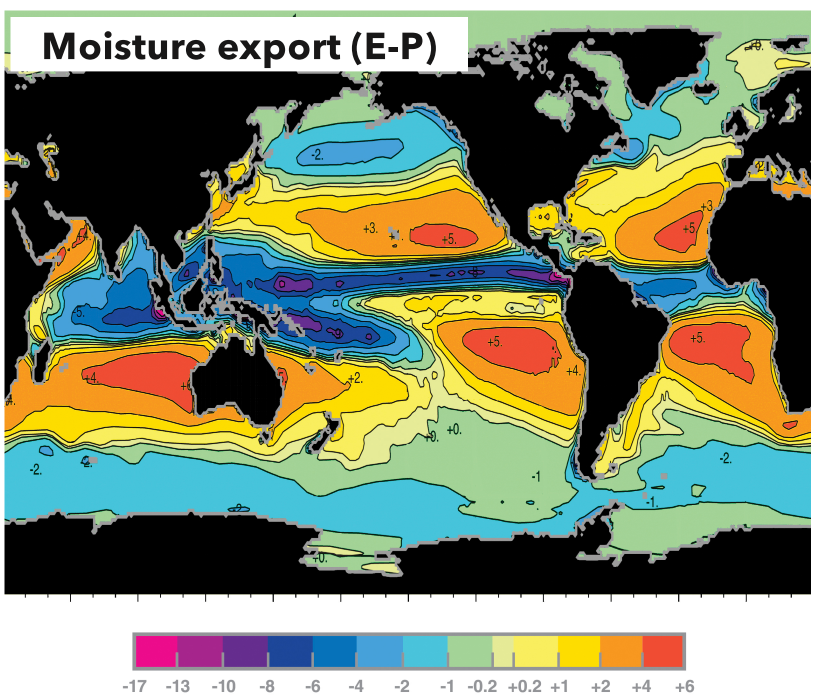
Moisture sources

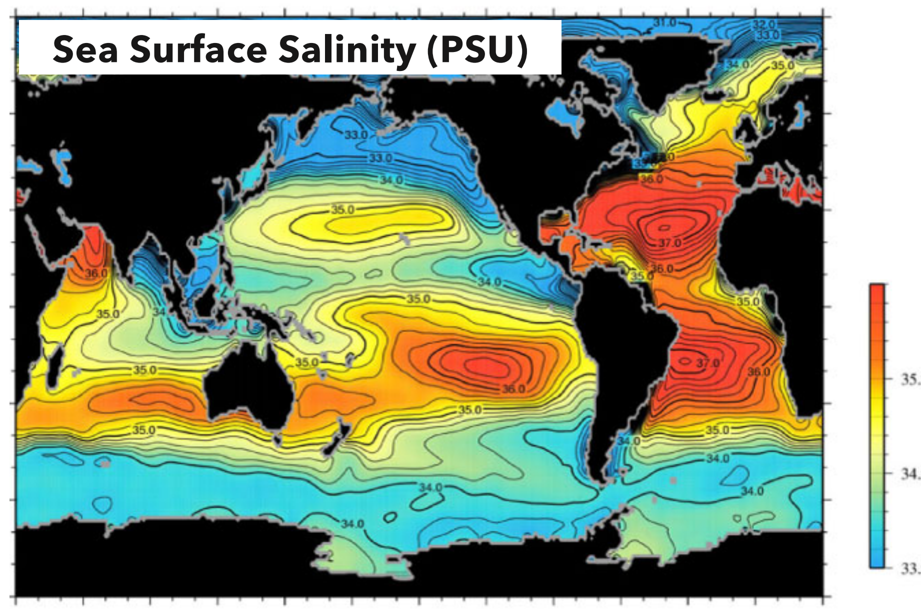


Moisture contribution (mm/day)

Oceanic moisture export leaves an imprint on salinity

Sea surface salinity as "Nature's rain gauge"





New opportunities for rainfall prediction from ocean **salinity**

RESEARCH ARTICLE

Li *et al*. Sci. Adv. 2016; 2: e1501588

OCEANOGRAPHY

North Atlantic s
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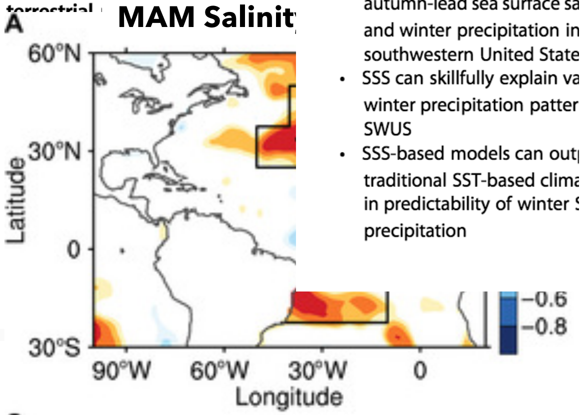
Laifang Li,[1]* Raymond W.

Water evaporating from the oce
imprint on sea surface salinity (S
terrestrial



Geophysical Research Letters

RESEARCH LET

10.1029/2018GL07929

Key Points:

- We search globally for teleconnections between autumn-lead sea surface sa and winter precipitation in southwestern United State
- SSS can skillfully explain va winter precipitation patter SWUS
- SSS-based models can out traditional SST-based clima in predictability of winter precipitation

Climate Dynamics (2019) 53:5495–5509
https://doi.org/10.1007/s00382-019-04878-y

Check for updates

Forecast of summer precipitation in the Yangtze River Valley based on South China Sea springtime sea surface salinity

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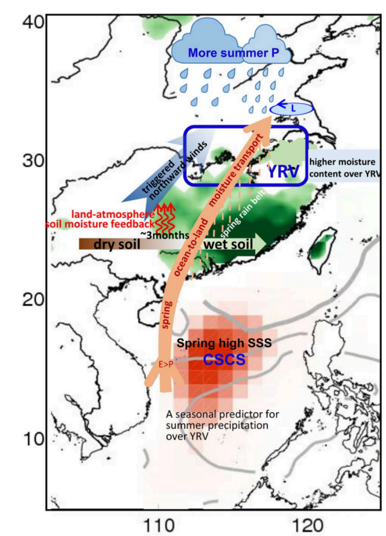
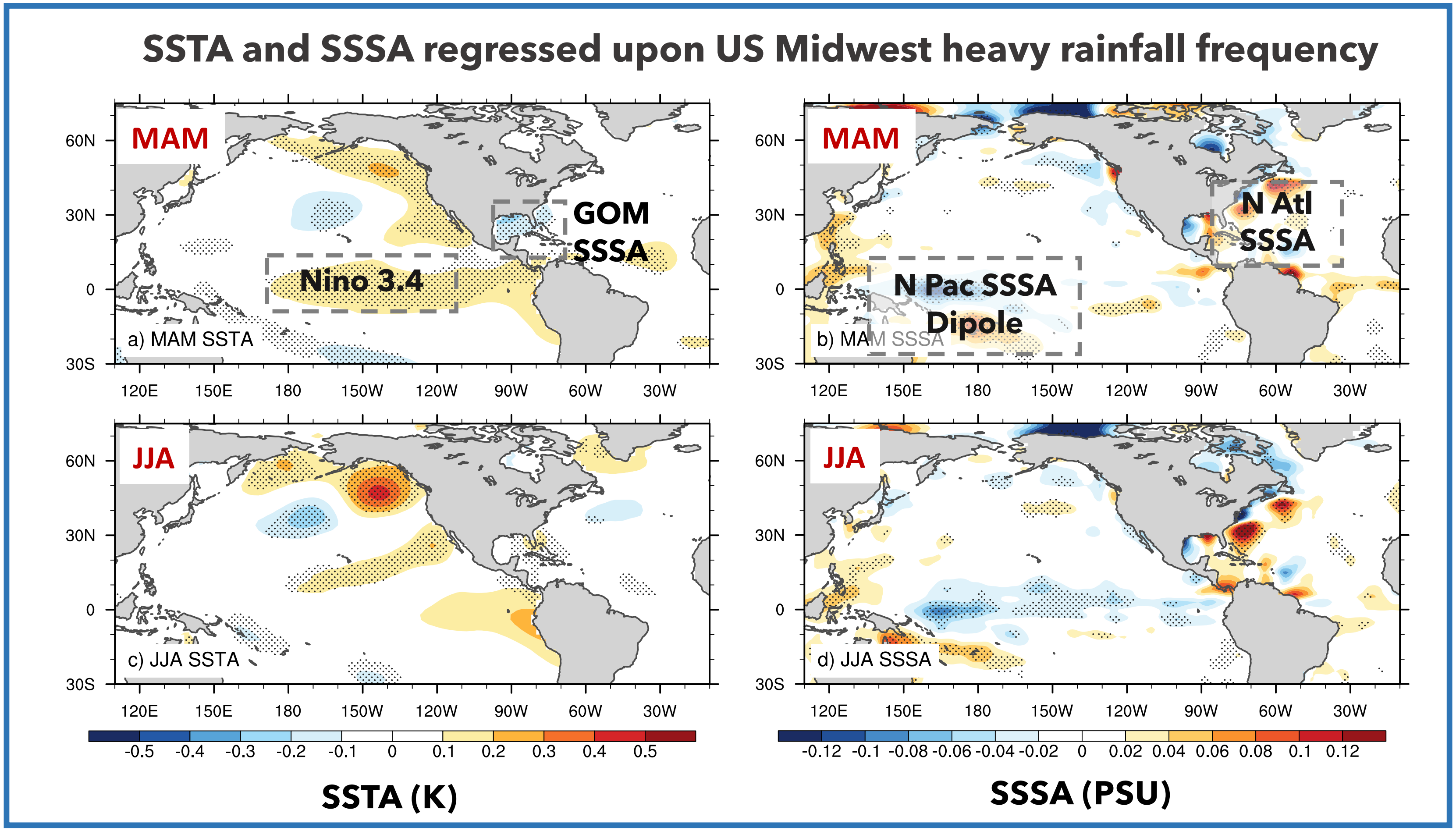
Abstract

As a major moisture source, the South China Sea (SCS) has a significant impact on the s ocean-to-land moisture transport generates sea surface salinity (SSS) anomalies that can tion on land. This study illustrates a high correlation between springtime SSS in the c over the middle and lower Yangtze River Valley (the YRV region). The linkage betwe summer YRV precipitation is established by ocean-to-land moisture transport by atmosp soil moisture feedback. In spring, oceanic moisture evaporated from the sea surface g and directly feeds the precipitation over southern China and the YRV region. The resu about 3 months triggering land–atmosphere soil moisture feedback and modulating th circulation in the subsequent summer. Evaluation of the atmospheric moisture balanc tion (stronger northward meridional winds) and a local thermodynamic contribution (h

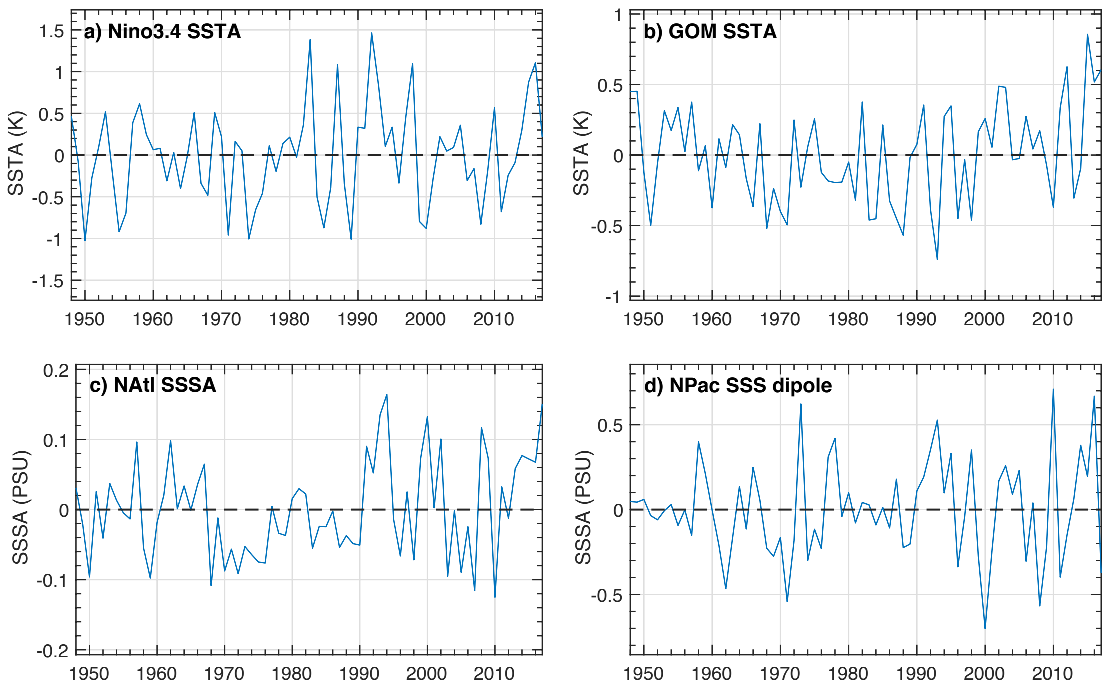


Global search for Midwest rainfall predictors



SSTA- & SSSA-based predictors

SSTA and SSSA time series



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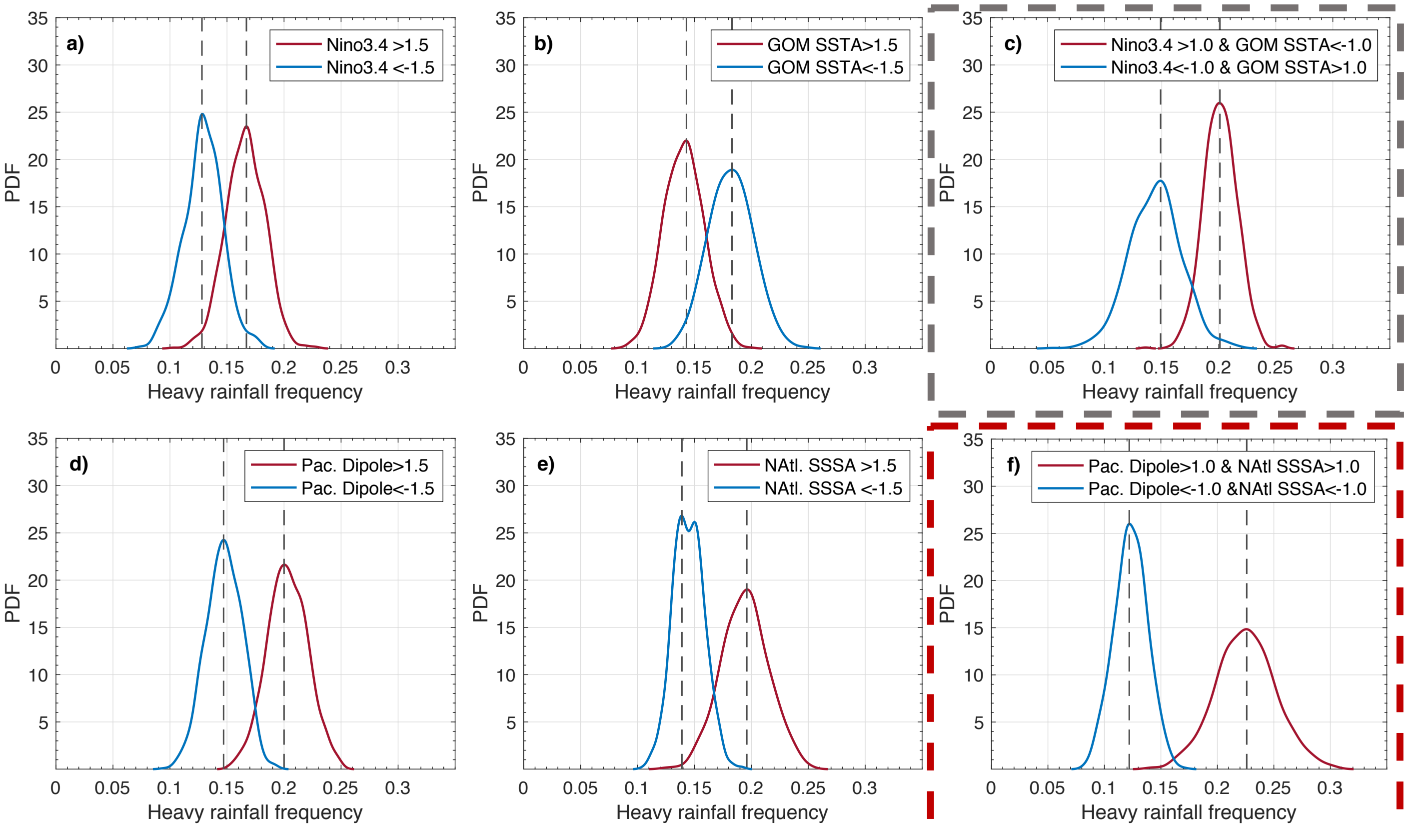
Cross correlation between SSTA and SSSA indices

	Nino 3.4	GOM SSTA	NAtl SSSA	NPac SSSA
Nino 3.4		-0.08	0.09	**0.60**
GOM SSTA	-0.08		*0.32*	-0.08
NAtl SSSA	0.09	*0.32*		-0.13
NPac SSSA	**0.60**	-0.08	-0.13	

Heavy rainfall frequency vs. predictors

Probability density function of Midwest heavy rainfall frequency



<u>Resampled</u> based on predictor indices using the Bayesian Gaussian mixture model (Li *et al*. 2013; 2016):

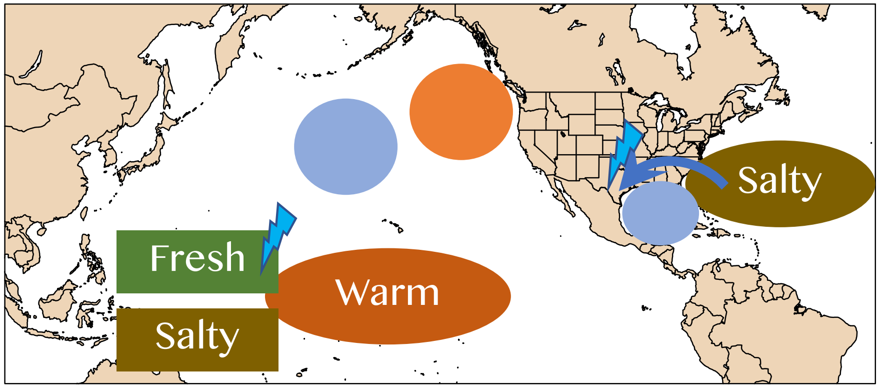
- Pre-season SSTA → moderate skill
- Pre-season SSSA → doubles the skill from SSTA-based predictors

* N. Pac SSSA dipole highly correlated with ENSO, but is more skillful than ENSO in rainfall prediction

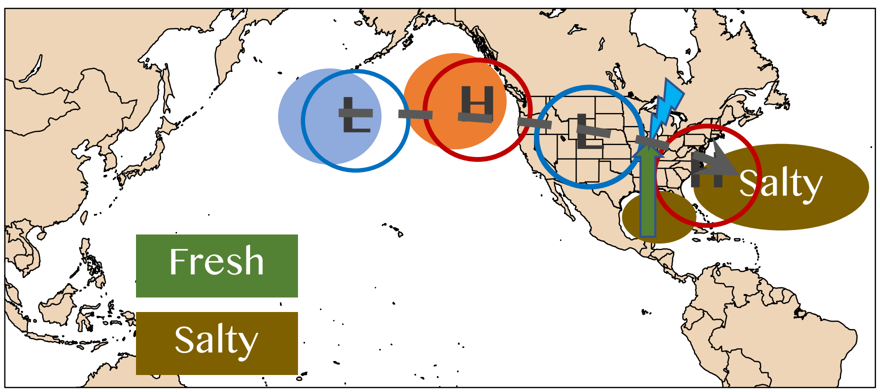
Li et al. (2021) GRL, Under Revision

Salinity-Midwest heavy rainfall relationship

MAM



JJA

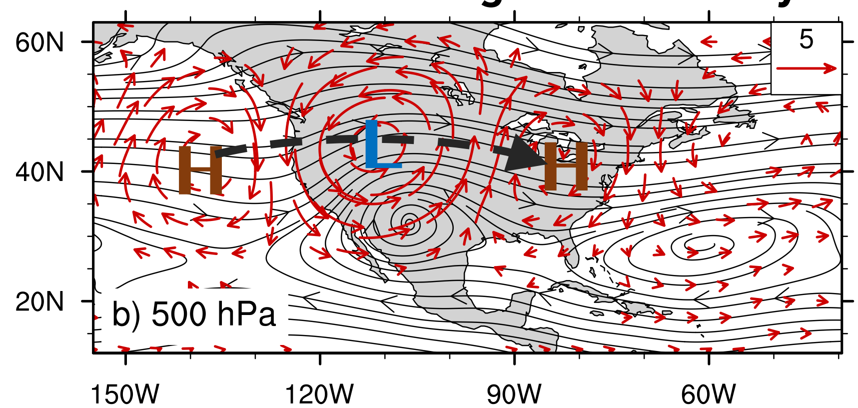


Li et al. (2021) GRL, Under Revision

<u>North Atlantic salinity</u> (Li et al. 2018):
- long memory of soil moisture
- Dynamic and thermodynamic impacts on moisture flux

<u>North Pacific salinity dipole</u> (Li et al. 2021):
- Tropical-extratropical teleconnection
- Long-persistence of extratropical SSTA
- Wave-train pattern

Atmo. circulation during Midwest heavy rain

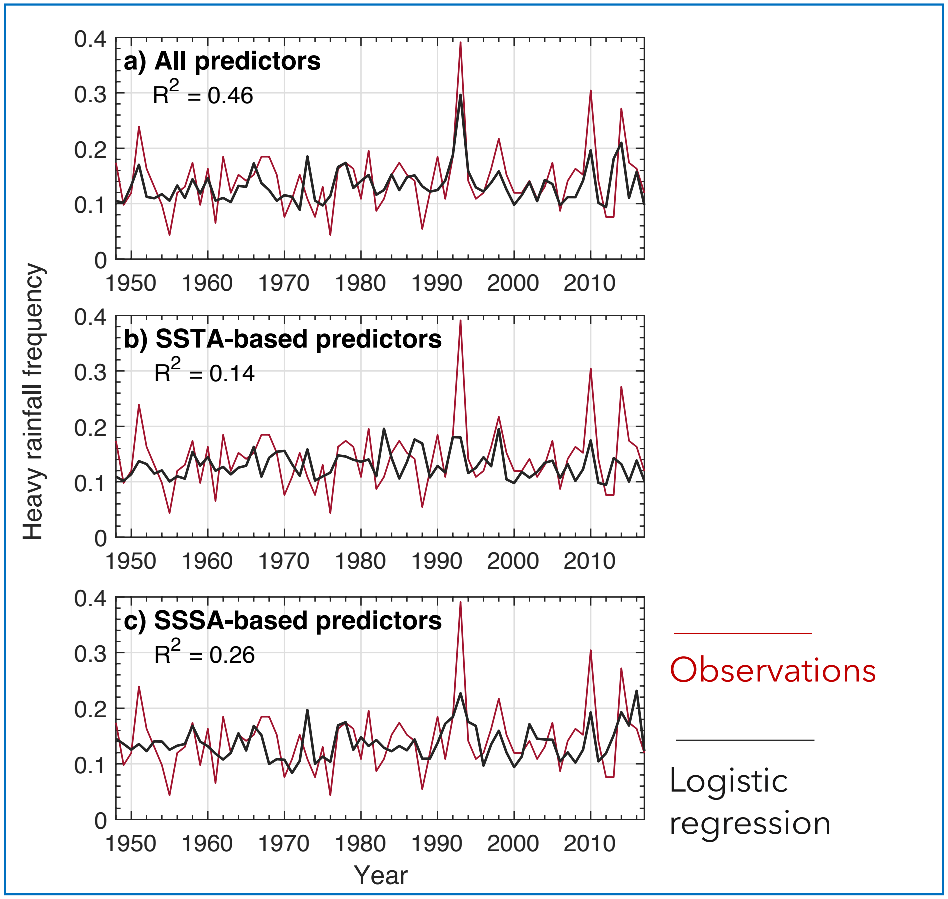


Predict US Midwest heavy rain using salinity

- Construct *logistic regression* model

$$y = \frac{1}{1 + exp(-\theta^T x)}$$

y: heavy rainfall frequency
x: predictors: Nino3.4; GOM SSTA, NAtl. SSSA, NPac. SSSA dipole
θ: regression parameters

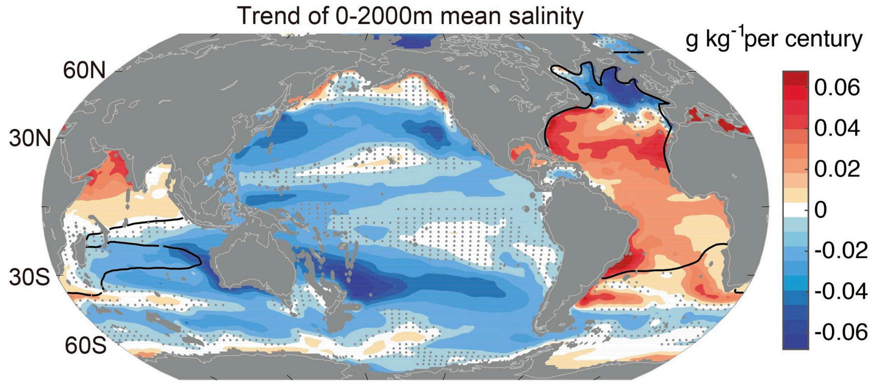


- Logistic regression with pre-season SSTA and SSSA generates skillful prediction of US Midwest heavy rainfall
- SSSA-based predictors are almost twice more skillful than SSTA-based predictors

Li et al. (2021) GRL, Under Revision

Conclusions & discussion

Pre-season salinity anomaly improves the skill (92% increase) to predict US Midwest heavy rainfall



Cheng *et al*. 2020