NCAR UCAR | CESM
COMMUNITY EARTH SYSTEM MODEL

2016 CESM WORKSHOP

COLA | GEORGE MASON UNIVERSITY

COLA / AOES Land Group

Impacts of land use / land cover change on afternoon precipitation

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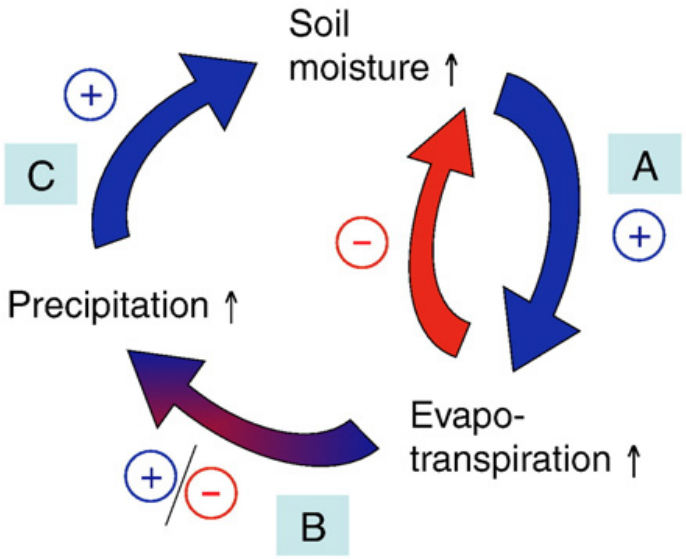
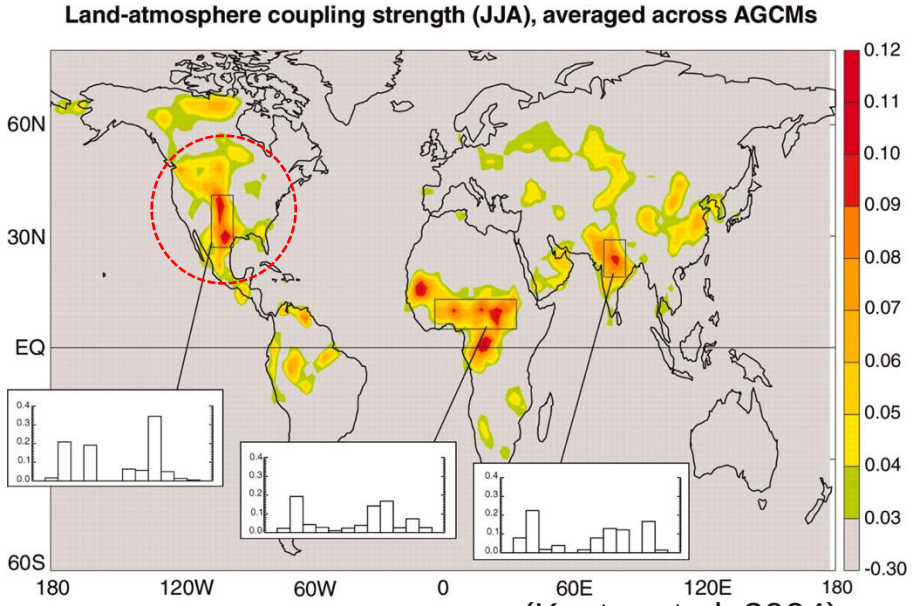
06/22/2016

Motivation

- Complexity in precipitation response to land use/land cover changes
- Soil moisture-precipitation coupling



(Seneviratne et al. 2010)



(Koster et al. 2004)

Motivation

Rain follows the plow?

source: http://www.okgenweb.org

Research Question

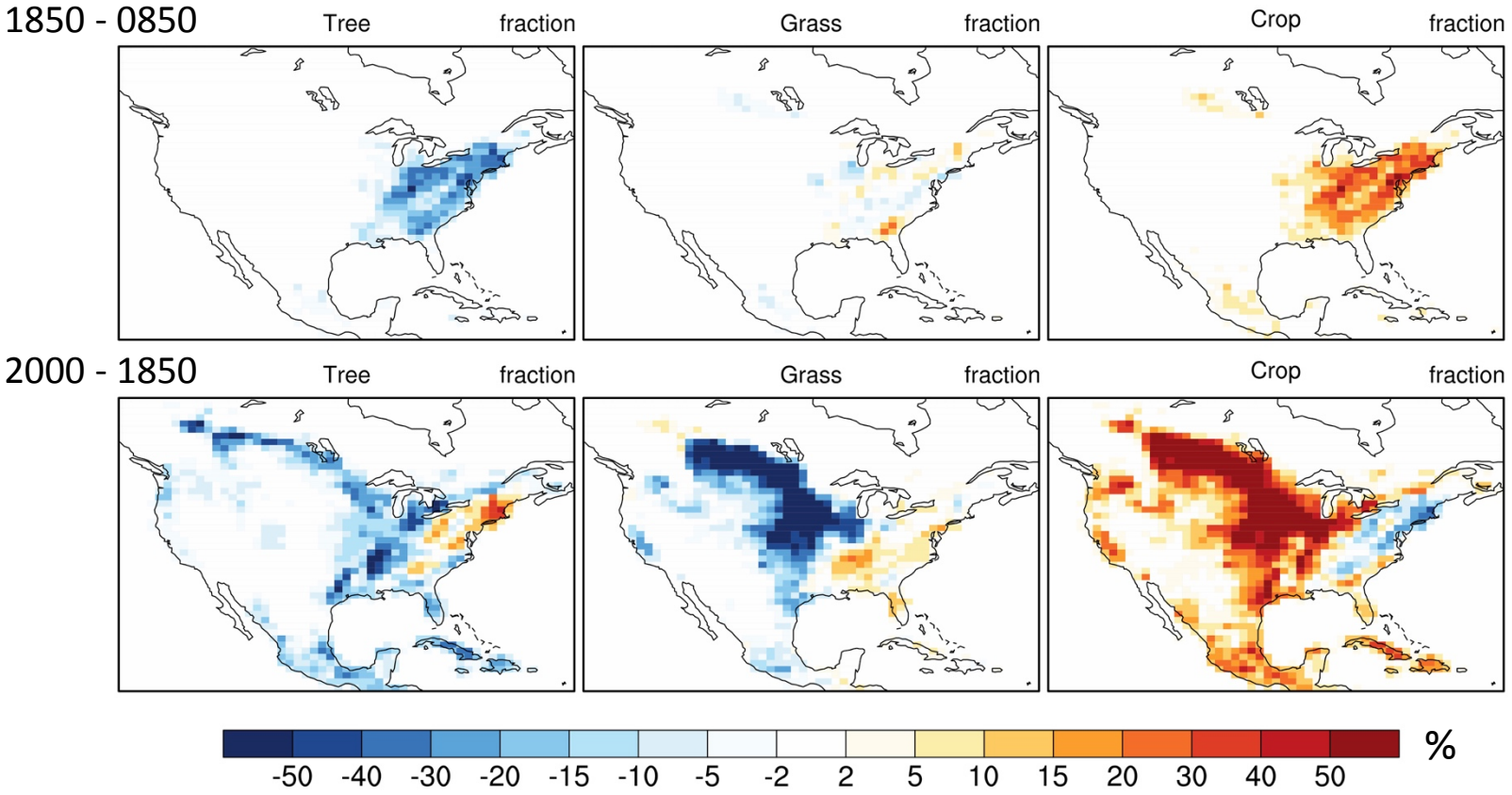
- How does land use /land cover change influence afternoon rainfall during summer?

CESM land-cover-change experiment

Name	ATM	LND	Land Cover
2000	CAM4	CLM4.5	PFTs in 2000
1850			PFTs in 1850
0850			PFTs in 0850
2000_off	CRUNCEP		PFTs in 2000
1850_off			PFTs in 1850
0850_off			PFTs in 0850

- a horizontal resolution of 0.9 ° x 1.25°
- hourly output for variables needed
- 45-year simulation

Land Cover Change



Land-Atmosphere Coupling Strength

Land segment:

$$CS_l = \sigma_{SM} \frac{\partial LH}{\partial SM}$$

Atmosphere segment:

$$CS_a = \sigma_{LH} \frac{\partial CAPE}{\partial LH}$$

- SM is morning soil moisture at 10 cm (0900-1200)
- LH is morning latent heat flux (0900-1200)
- CAPE is afternoon convectively available potential energy (1300-1800)

Sensitivity of afternoon rainfall

Criteria for locally initiated afternoon rainfall events:

- AM rainfall < 1mm
- PM rainfall > 1mm
- PM CAPE > 70 J/kg

$$S_{rain} = \sigma_{SM} \frac{\partial \Gamma(rain)}{\partial SM}$$

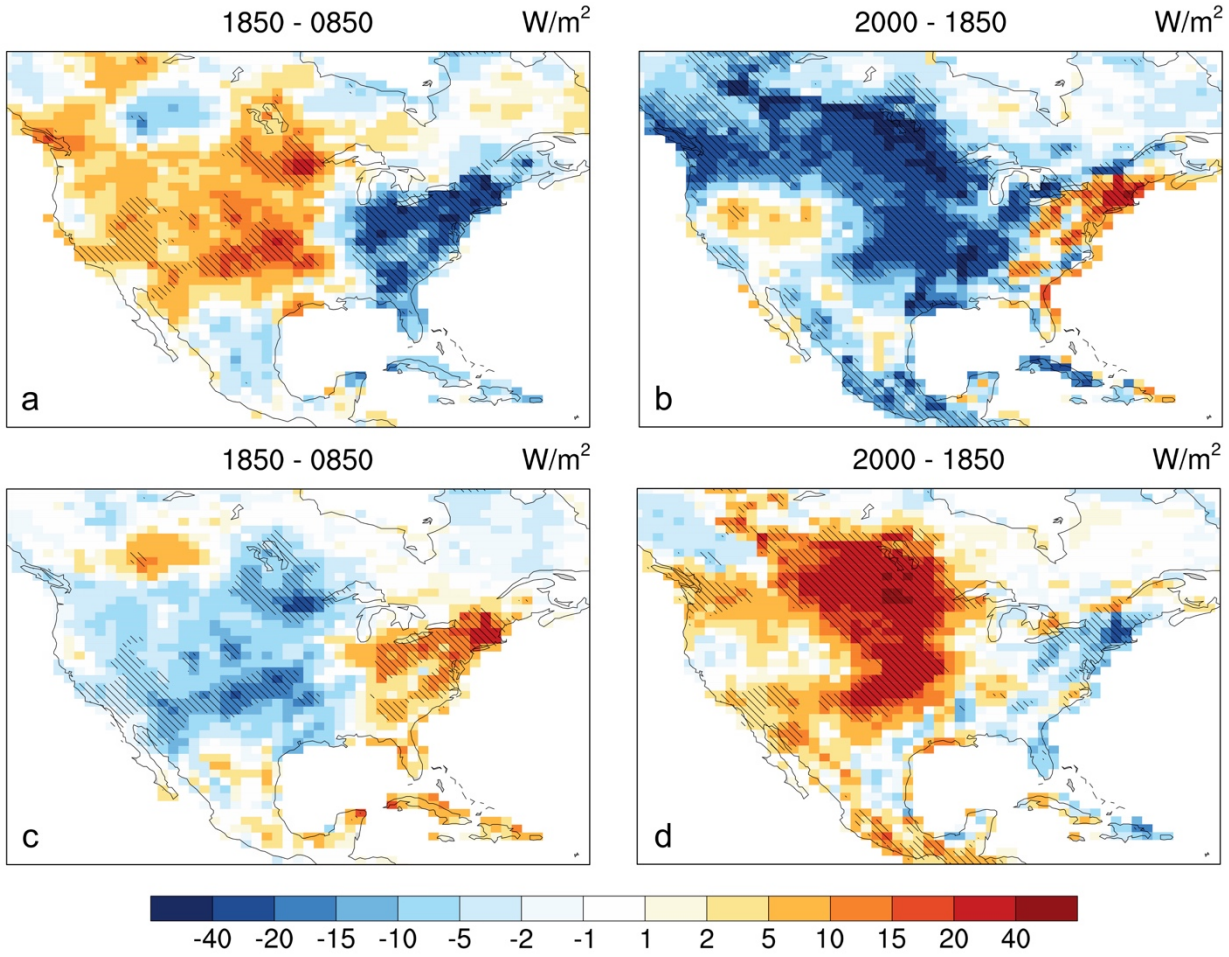
$$S_{rain} = \sigma_{SM} \frac{\partial I_{rain}}{\partial SM}$$

- SM is morning soil moisture at 10 cm (0900-1200)
- $\Gamma(rain)$ is the probability of afternoon rainfall for each SM bin
- I_{rain} is the intensity of afternoon rainfall

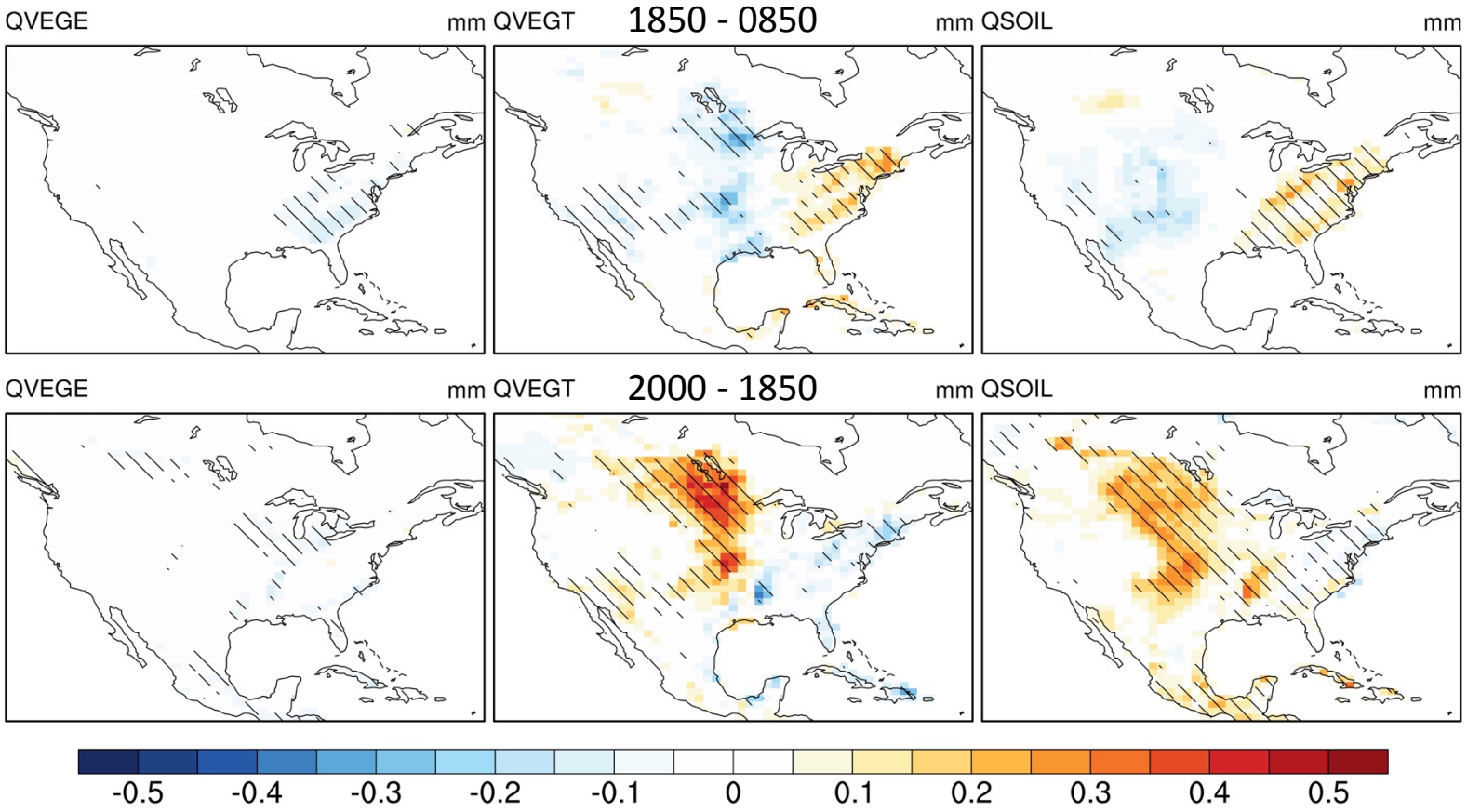
Morning Fluxes

SH

LH

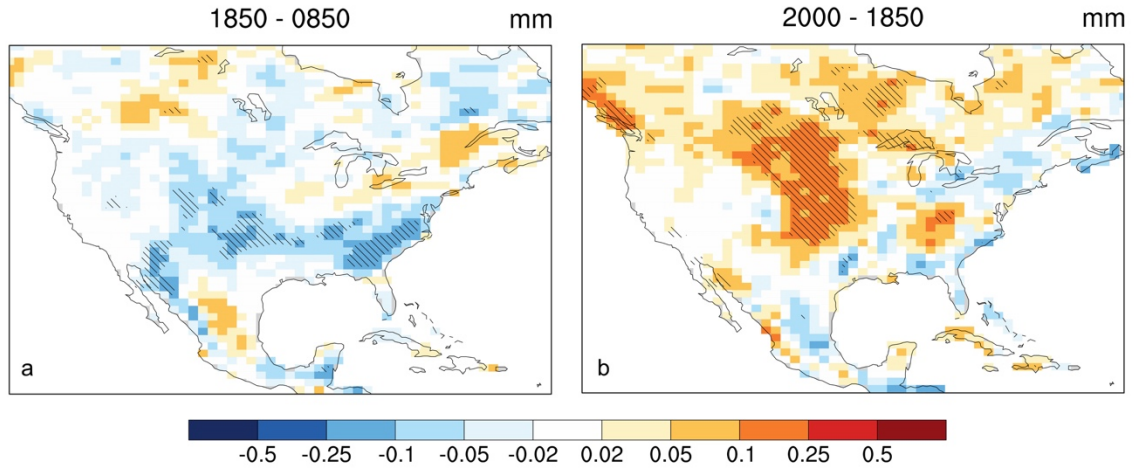


Morning ET

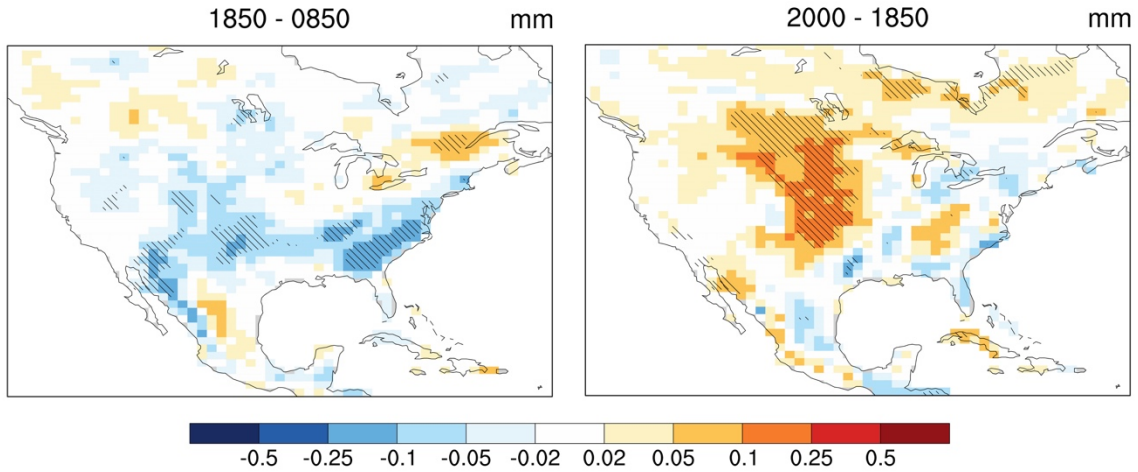

QVEGE
mm QVEGT
1850 - 0850
mm QSOIL
mm
QVEGE
mm QVEGT
2000 - 1850
mm QSOIL
mm
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
0.4
0.5

Afternoon Rainfall

total precipitation

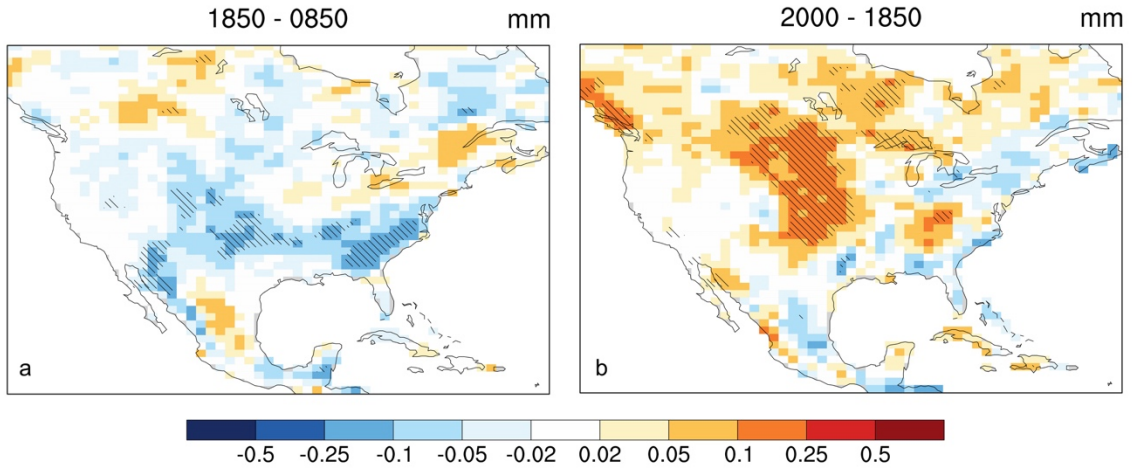


convective precipitation

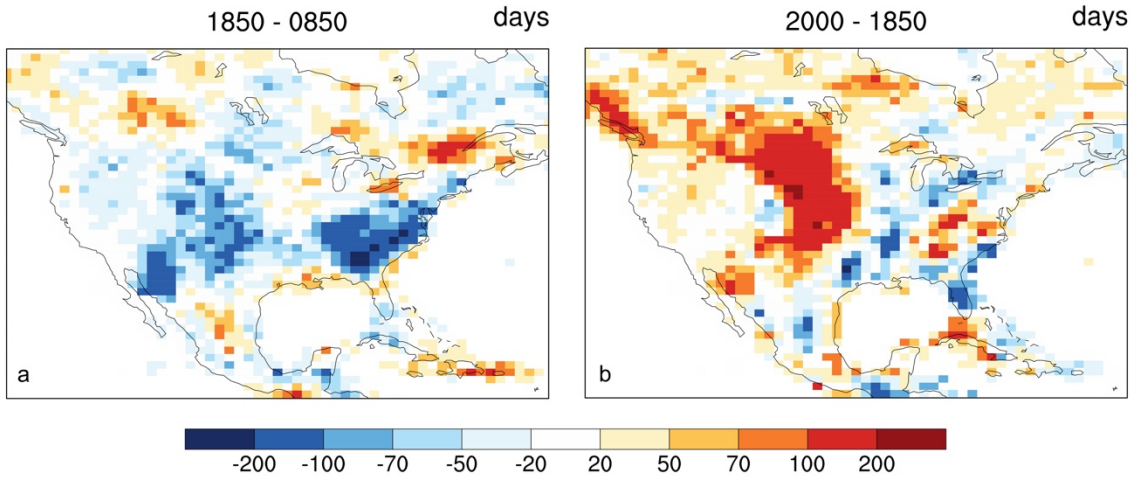


Afternoon Rainfall

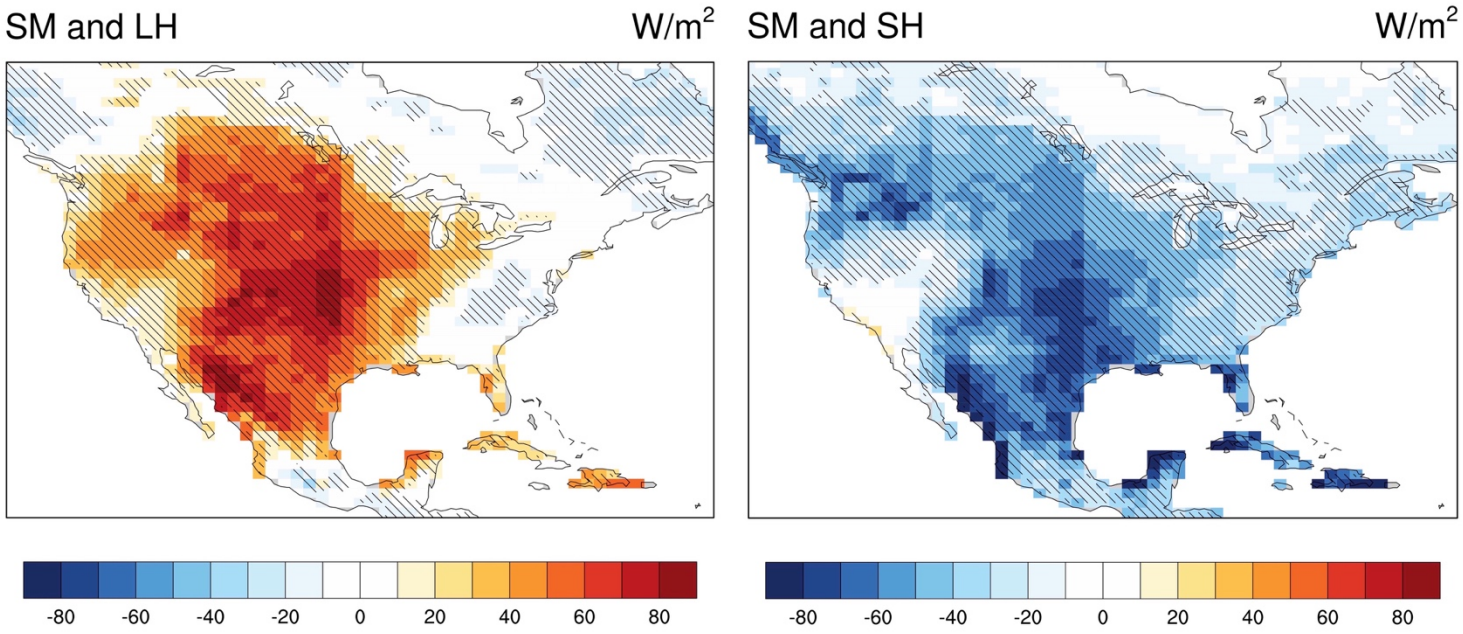
total precipitation



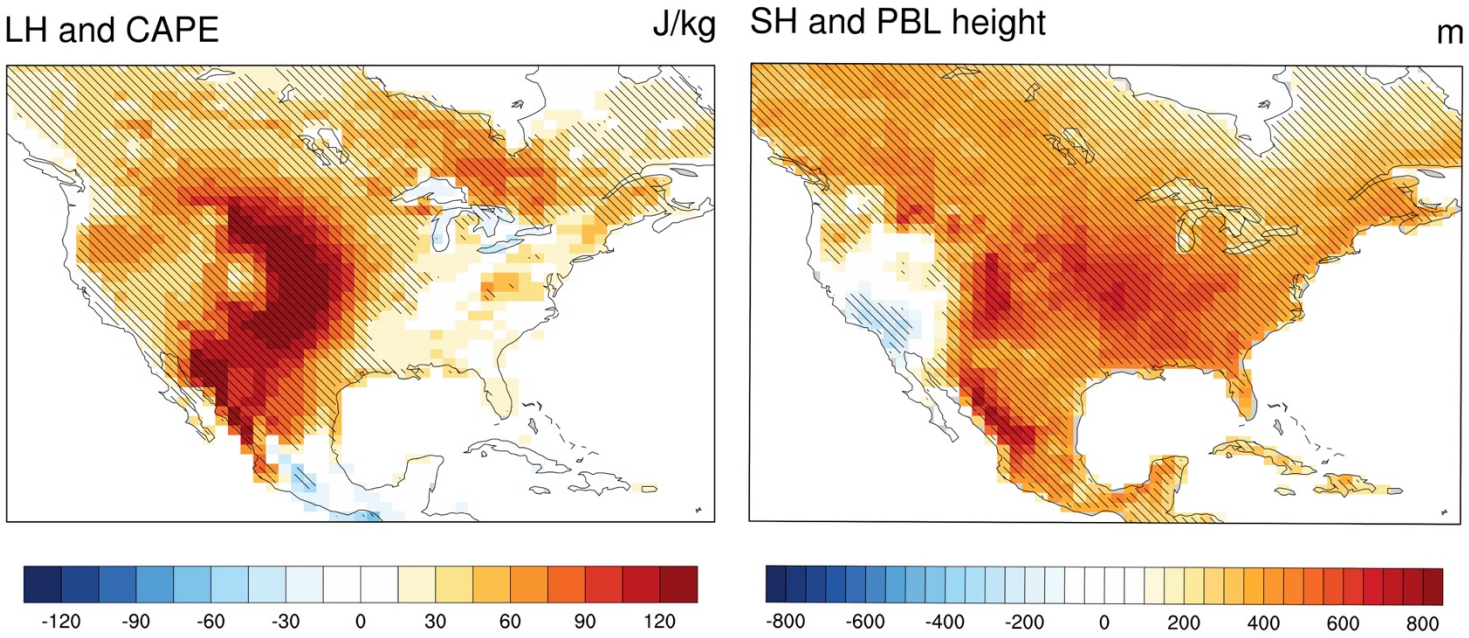
days with PRECT>1mm



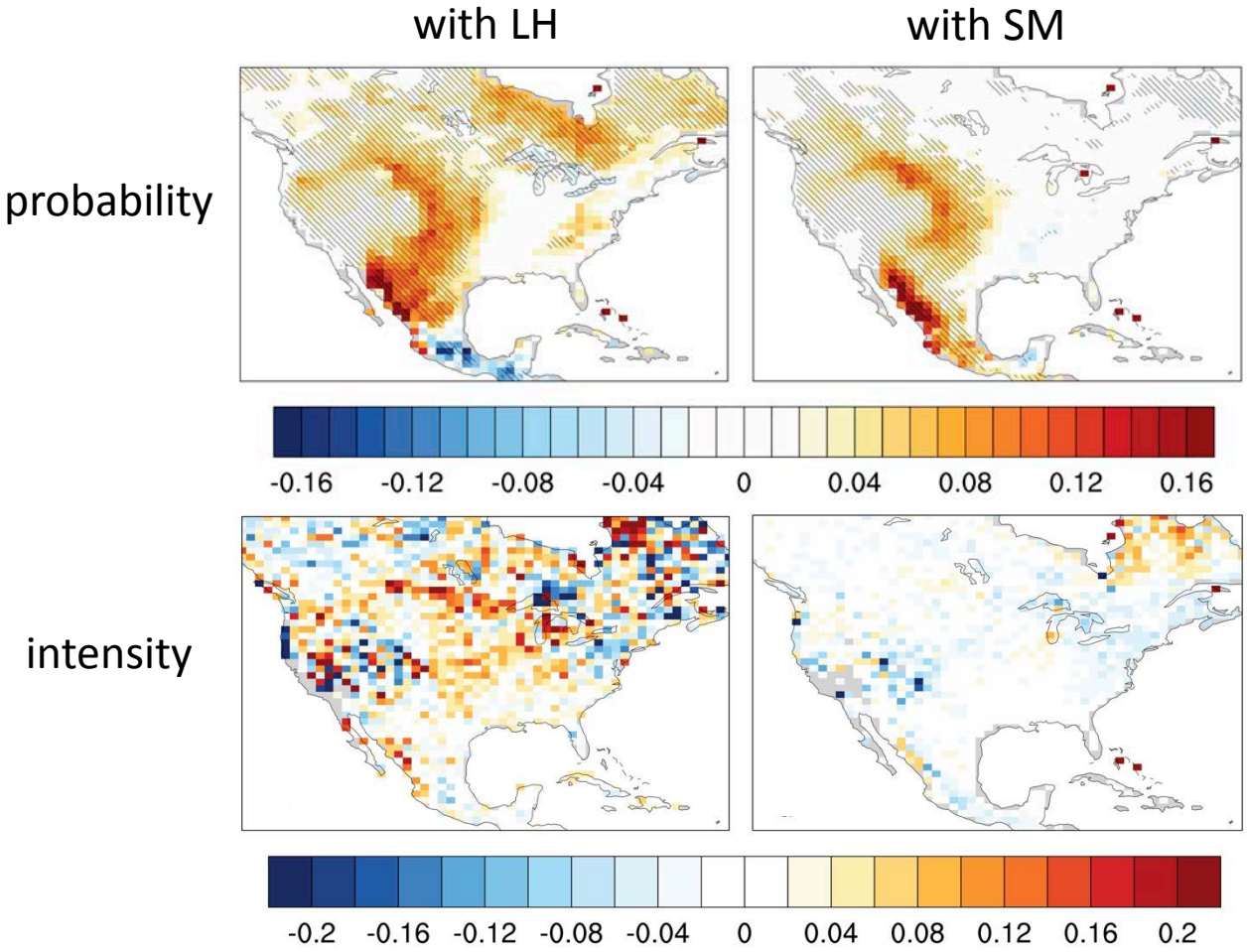
Coupling Strength (land)



Coupling Strength (atmosphere)



Sensitivity of Afternoon Precipitation



Conclusion

- Deforestation in the eastern US and agricultural activities over the Great Plains

  LH increases, SH decreases

land-atmosphere coupling "hotspot" over the Great Plains

frequency of afternoon precipitation is sensitive to the morning ET or soil moisture

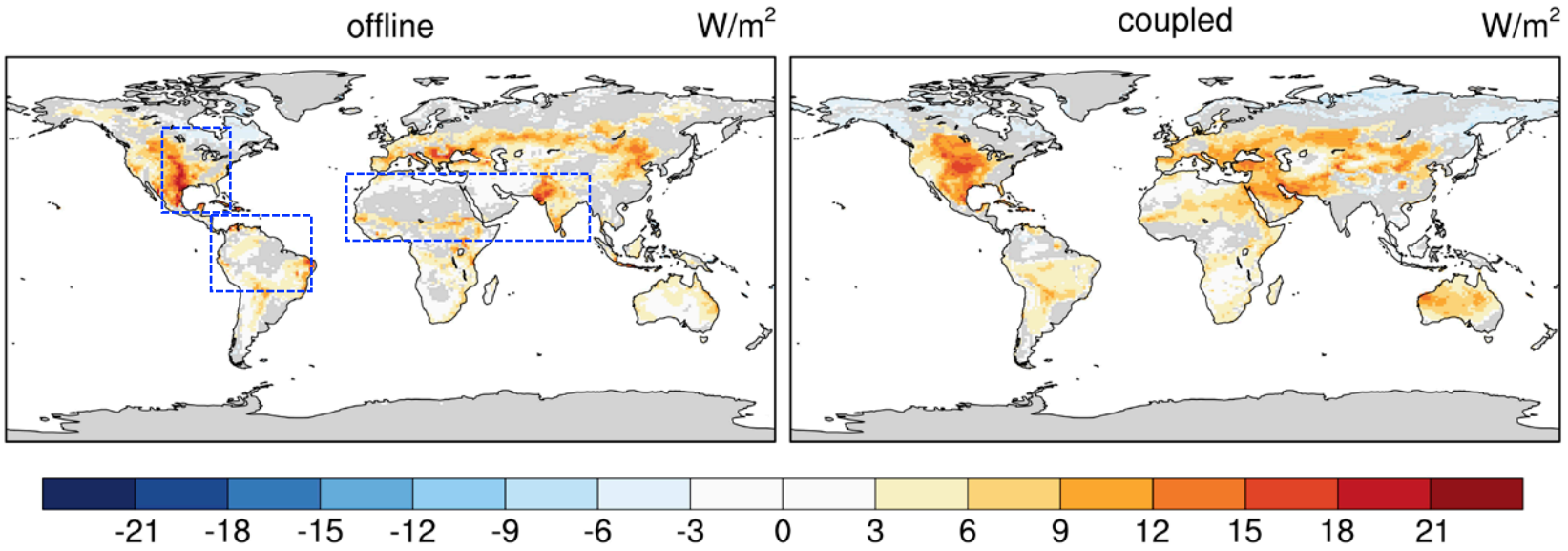
- Significantly increased afternoon precipitation over the Great Plains; local impacts undermined by the control of large-scale atmosphere conditions over the eastern US

Forward Looking

- Coupling issues between CLM and CAM
- Influence of convective triggers

Coupling Strength

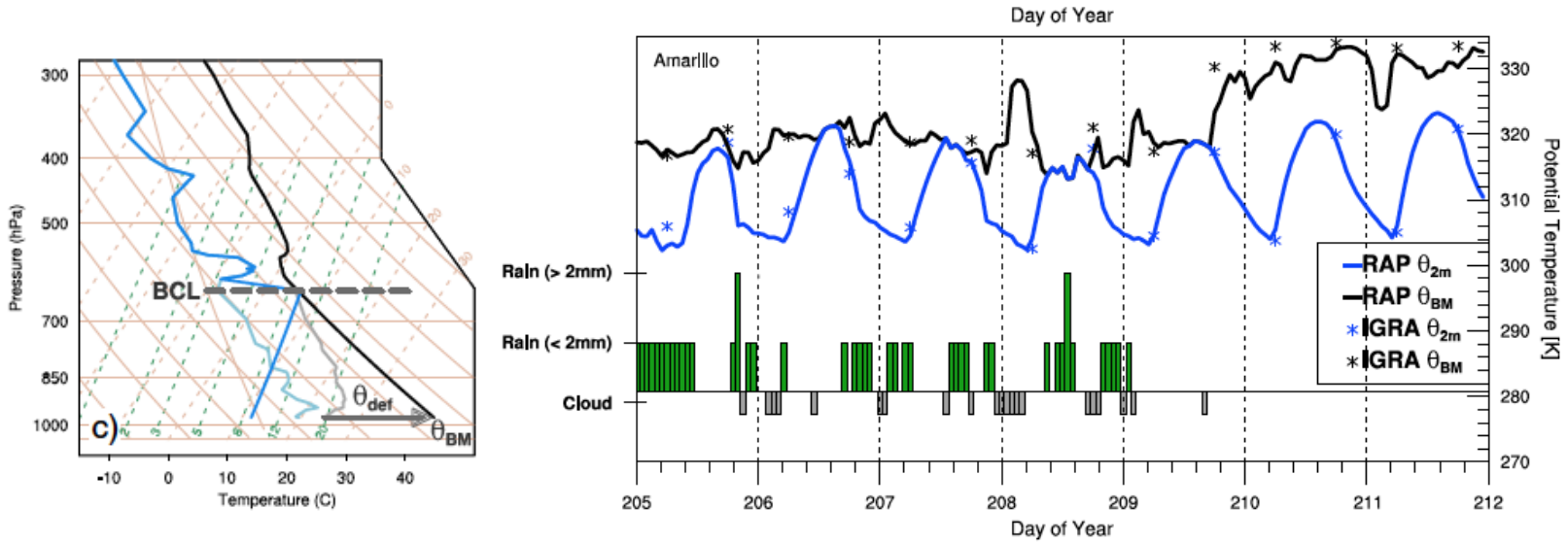
… between soil moisture and latent heat flux



Does the atmosphere model give the right behavior in the coupled simulation?

Convective Trigger

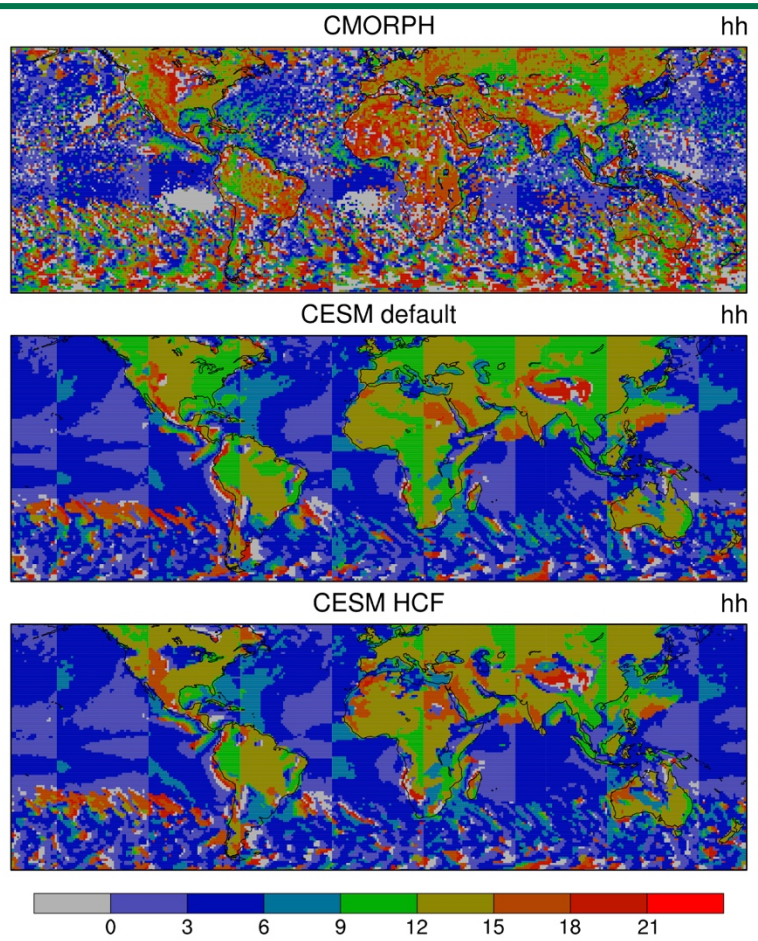
- Convective trigger in CAM
- Timing of precipitation



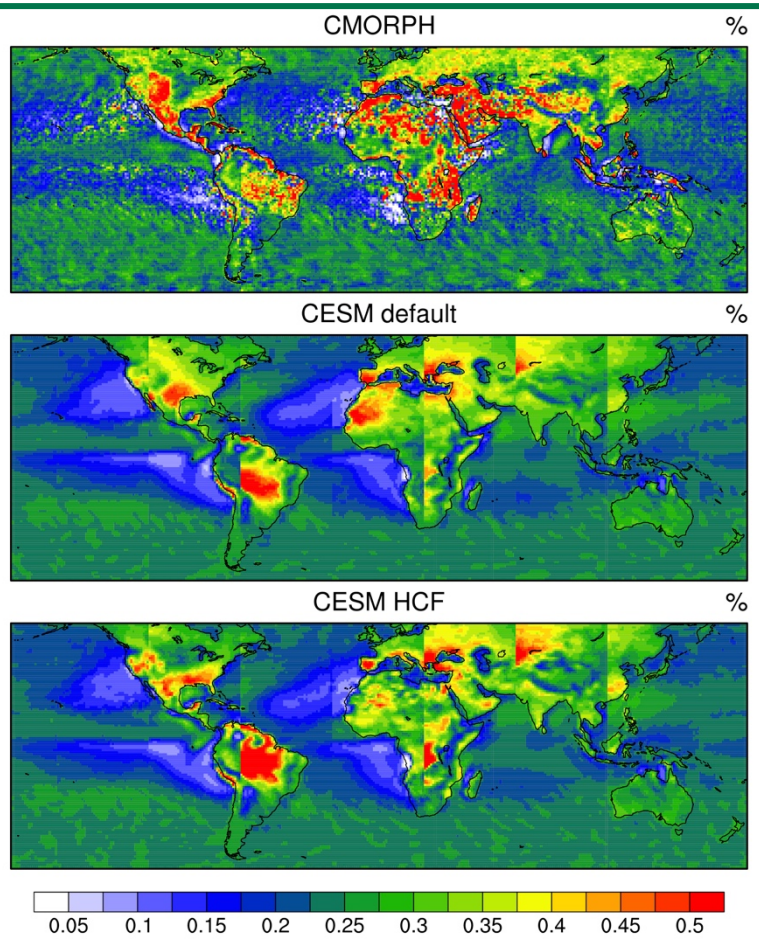
$\theta_{def} = 0$ => local convection initiation

(Tawfik and Dirmeyer 2014)

Timing of precipitation

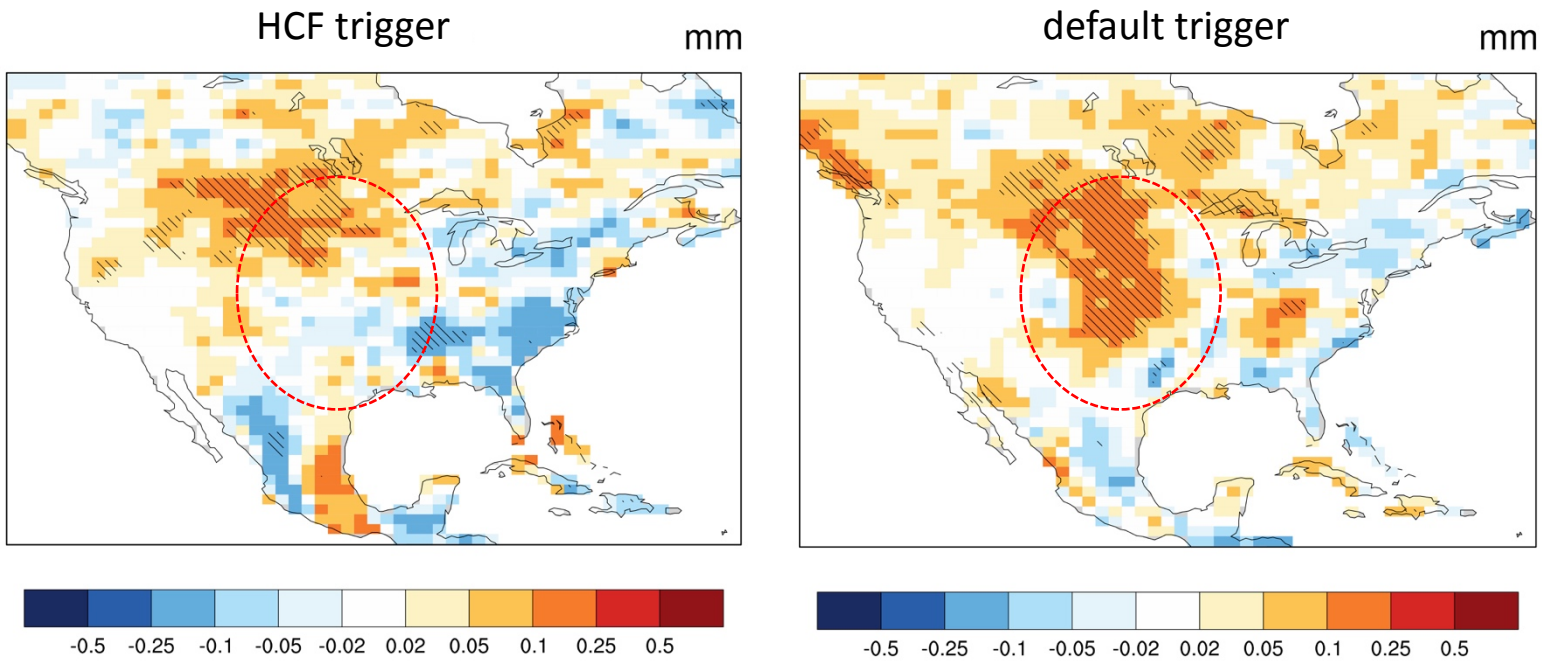


time of maximum precipitation



afternoon precipitation as percentage of daily total precipitation

Afternoon Rainfall



Thank you!

Morning ET (coupled vs. offline)