The sensitivity of an idealized West African Monsoon model to changes in parameterizations under climate forcings

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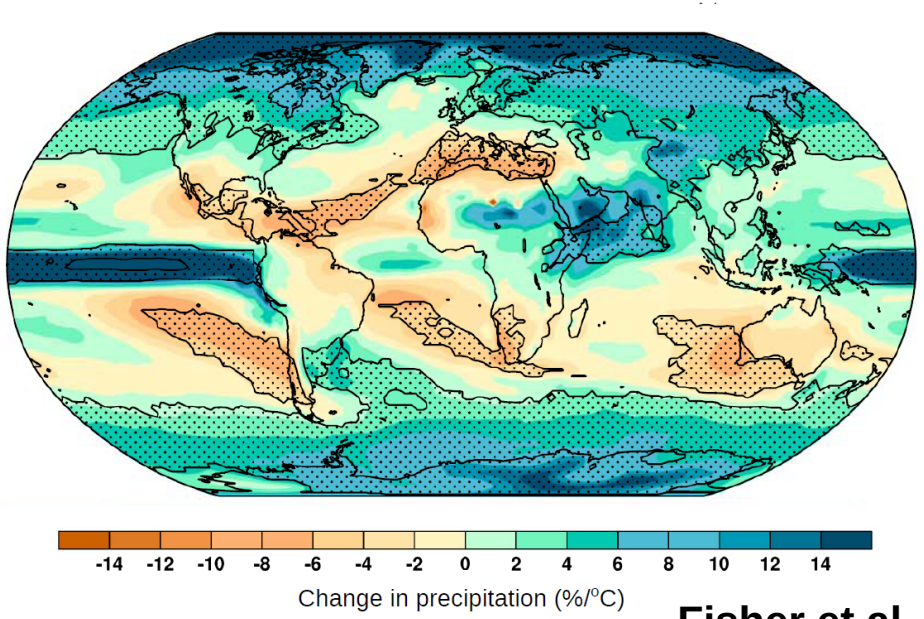
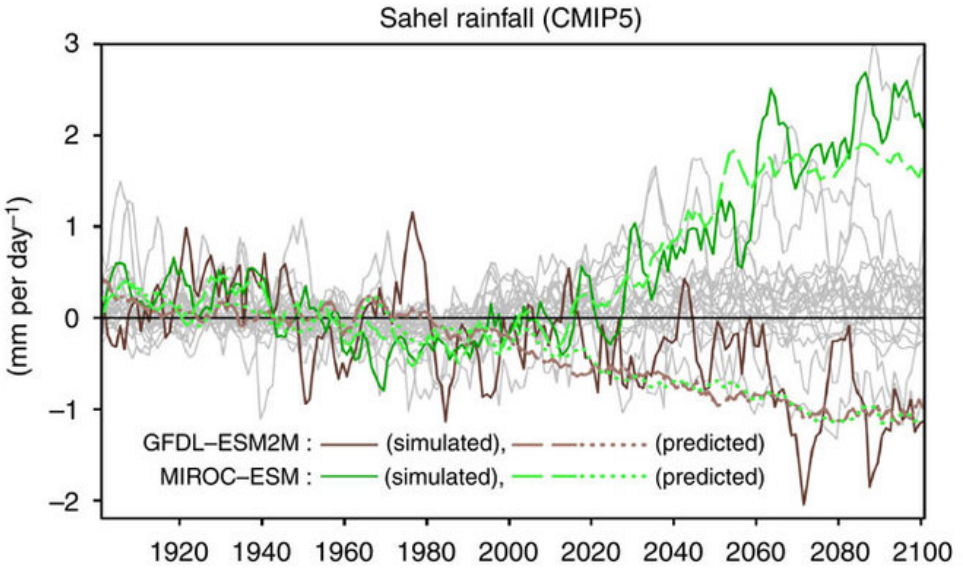
CNRM (CNRS & Météo-France) AMMA-2050

Uncertainty in model projections of West African Monsoon



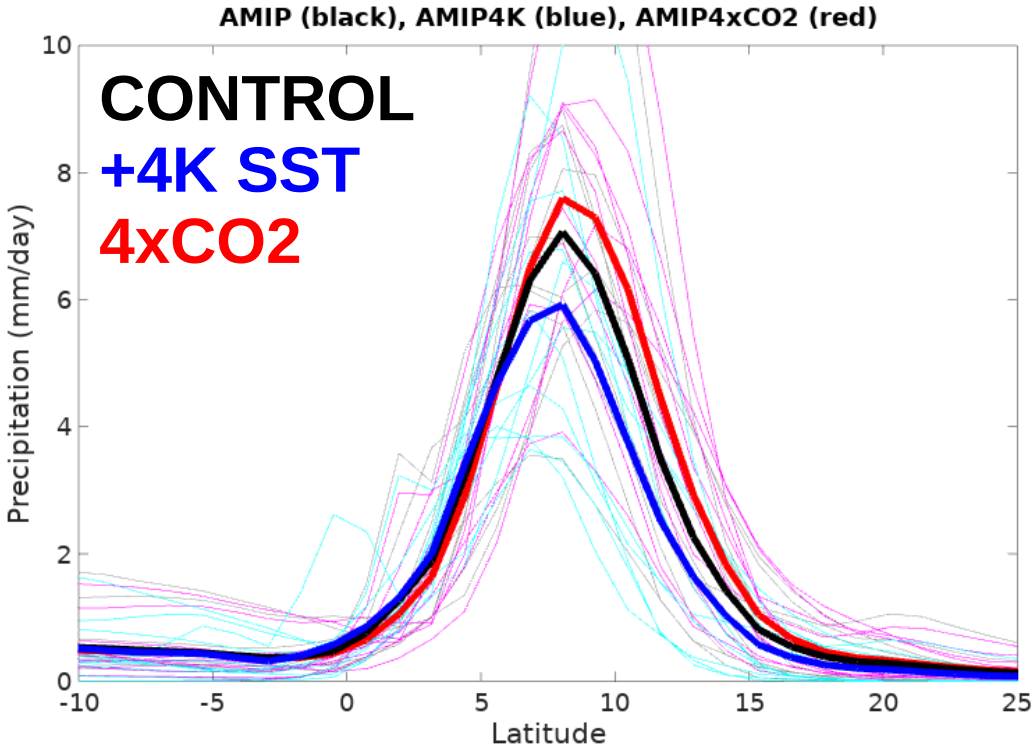
Fisher et al. 2014



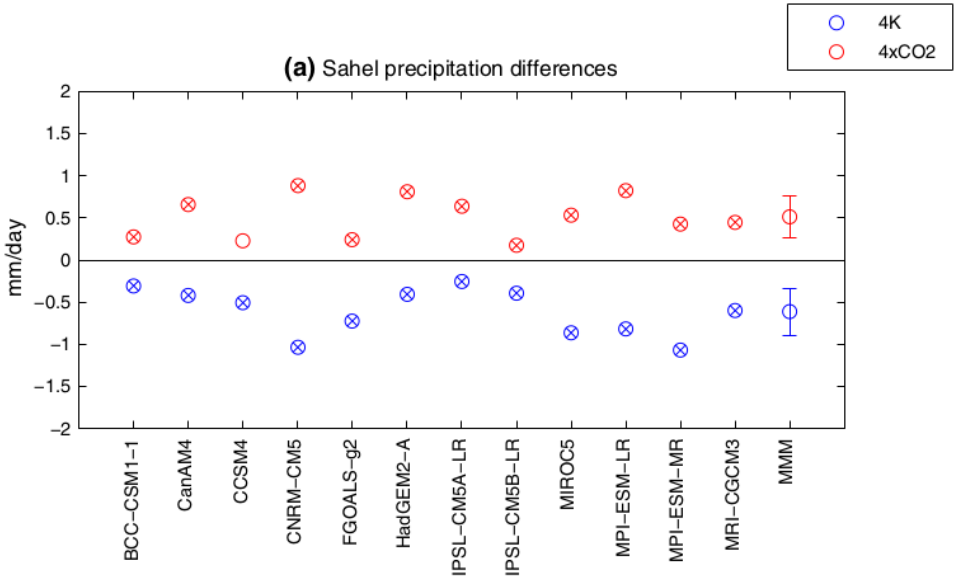
Park et al. 2015

MONSOON SENSITIVITY : LARGE SCALE CIRCULATION PATTERNS , REGIONAL CIRCULATION PATTERNS (3D and 2D) , BOUNDARY CONDITIONS (SST, land surface) , PHYSICAL PARAMETERIZATIONS

West African Monsoon response to climatic forcings in AMIP simulations



Zonally averaged precipitation (10E-10W)



Gaetani et al. (2017)

4xCO2: precipitation shifts to the north & increases over the Sahel

+4K SST: precipitation shifts to the south & decreases over the Sahel

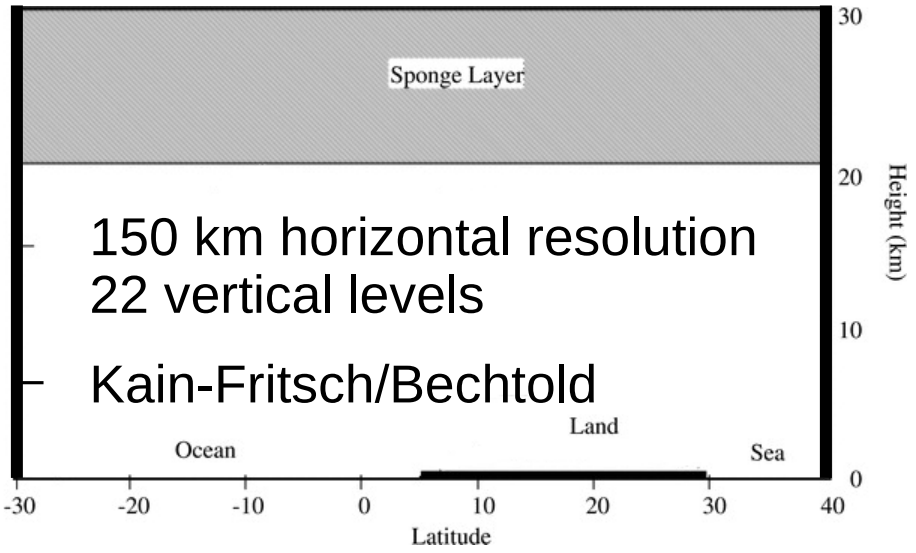
What can the 2D model tell us about the LARGE SCALE and REGIONAL response to idealized climate change forcings?

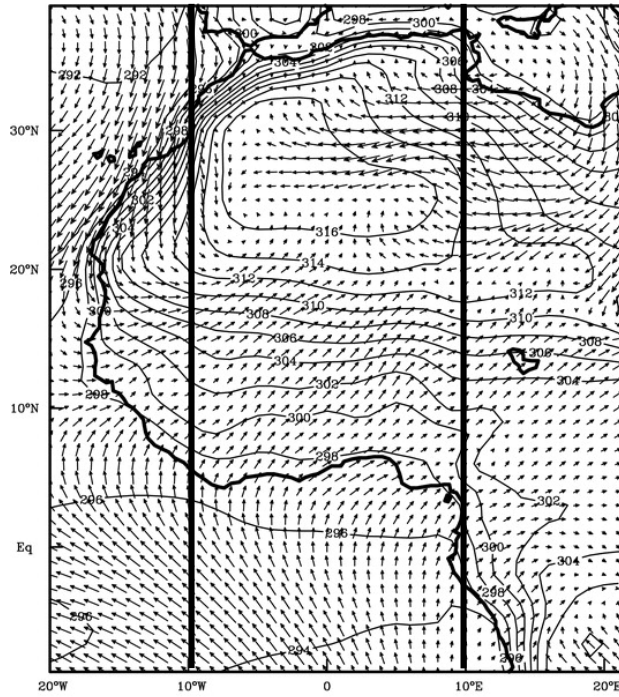
What forcings are the 2D monsoonal circulations most sensitive to?

Setup of 2D MesoNH Monsoon Simulations

Configuration

Follows Peyrillé and Lafore (2007) Peyrillé et al. (2016)

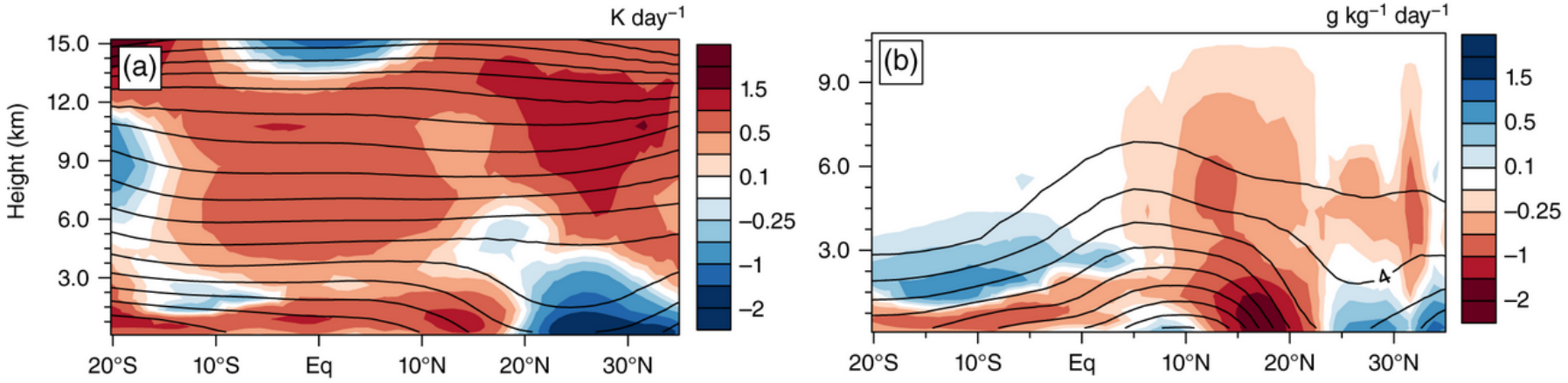




Determine large scale advective forcing:

Stage 1: 3 day relaxation to mean state –> advective forcing

Stage 2: advective forcing + 10 day relaxation **= LS FRC**

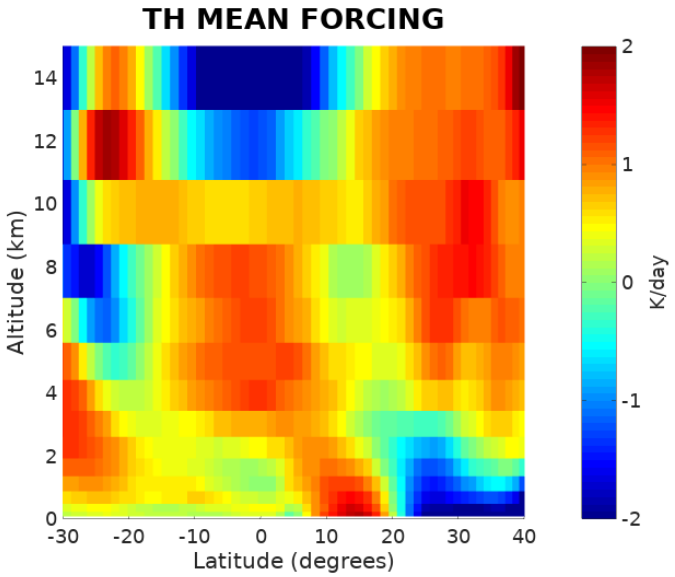


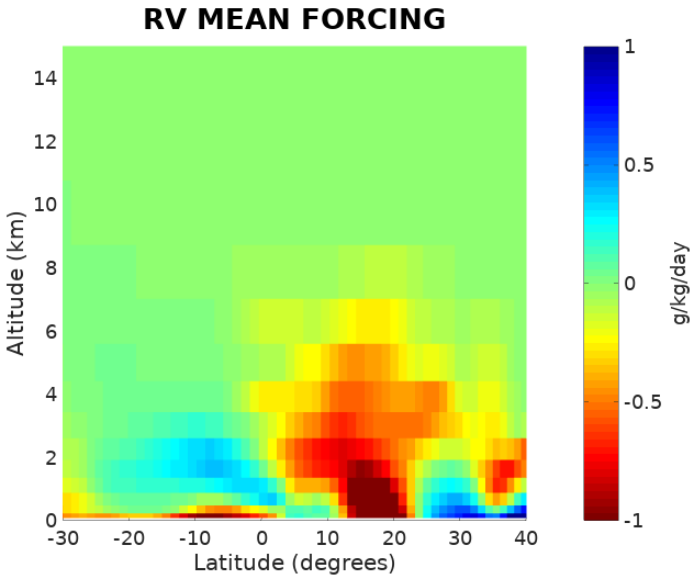
FROM REANALYSES (Peyrillé et al. 2016)

Climatic Forcing Scenarios in the 2D Model

LS FRC derived from 11 CMIP models

AMIP
AMIP +4K SST



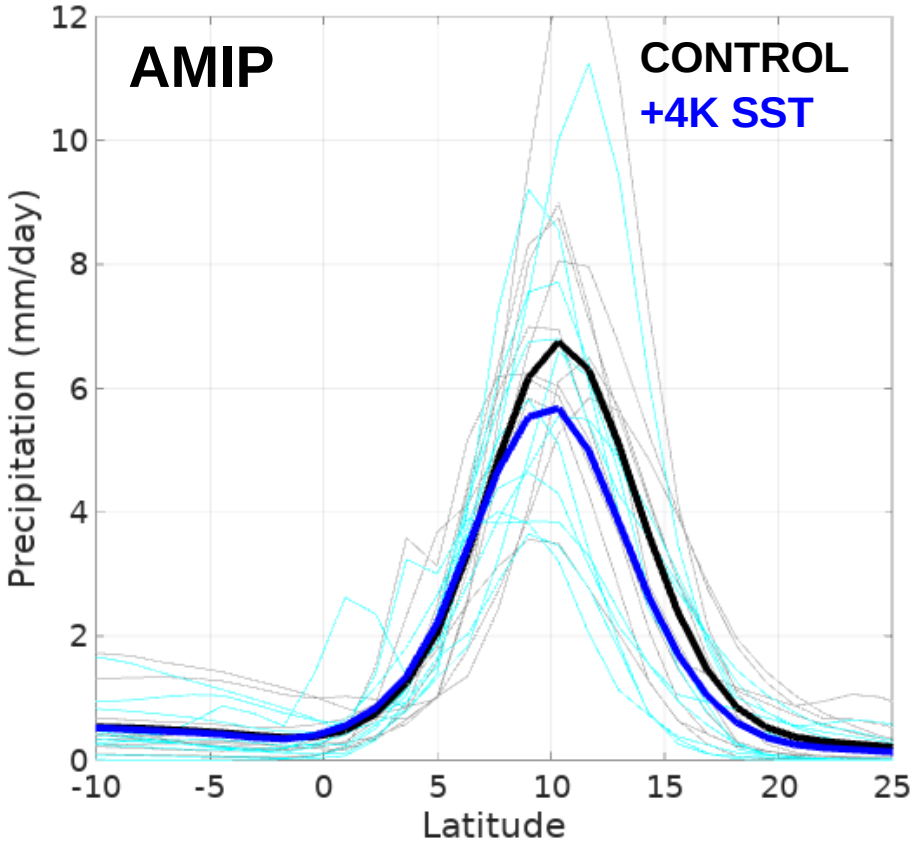


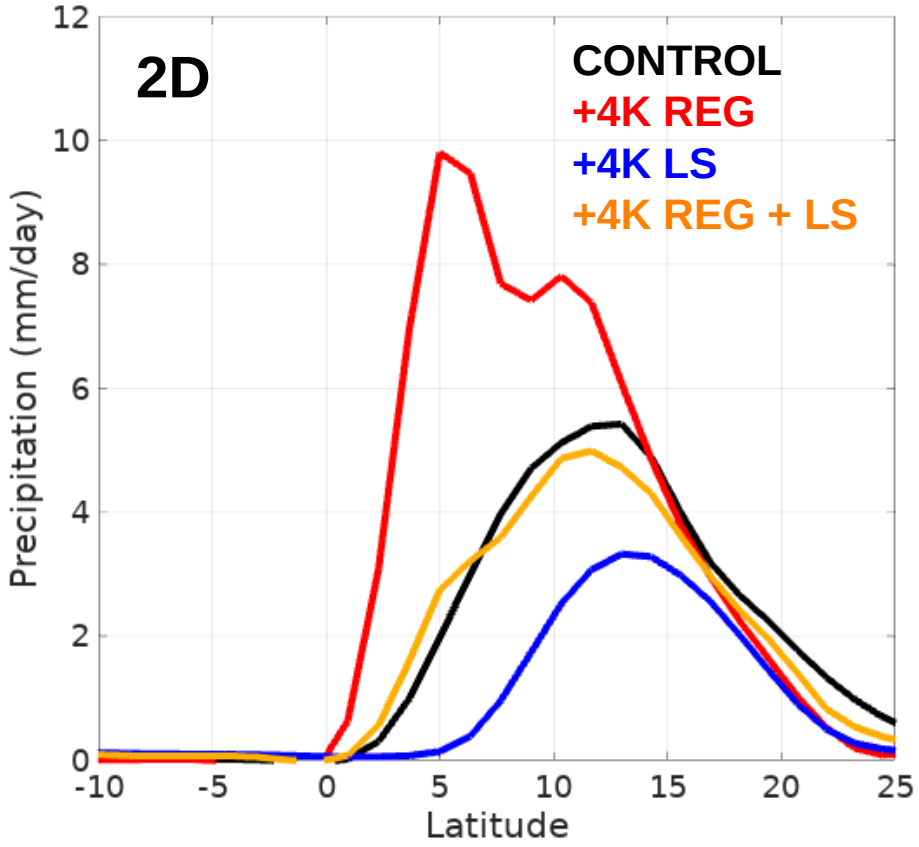
2D EXPERIMENTS

Perpetual August

CHANGE SST ONLY	**SST:** +4K SST **LS FRC:** CONTROL	**+4K REG**
CHANGE LS FRC ONLY	**SST:** CONTROL **LS FRC :** derived from +4K SST AMIP runs	**+4K LS**
CHANGE BOTH SST AND LS FRC	**SST:** +4K SST **LS FRC:** derived from +4K SST AMIP runs	**+4K REG + LS**

+4K SST Precipitation Response



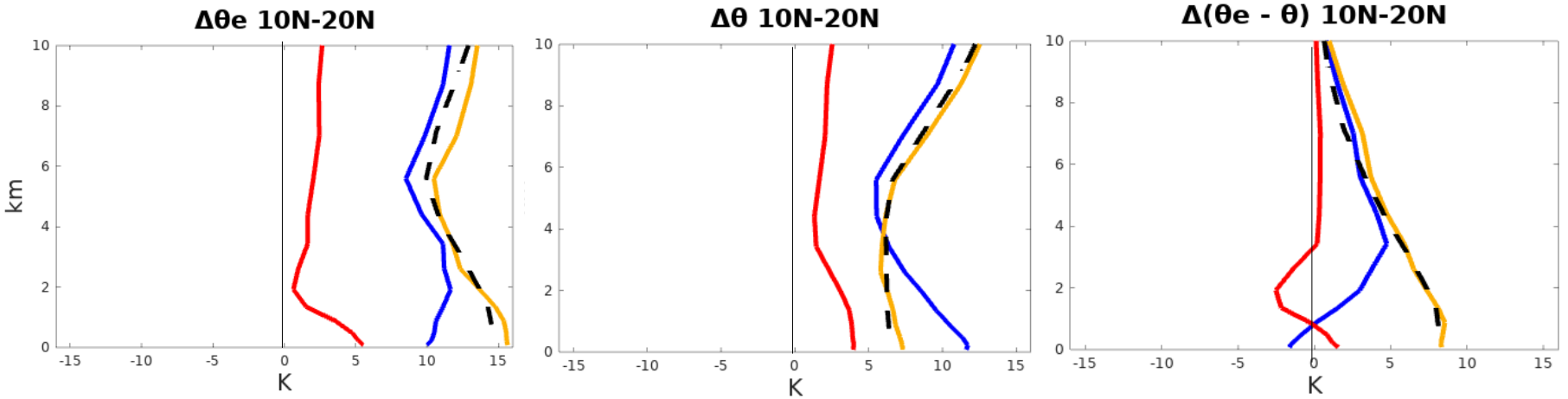


REG + LS: decrease in Sahel precipitation and southward shift

REG: southward shift in precipitation

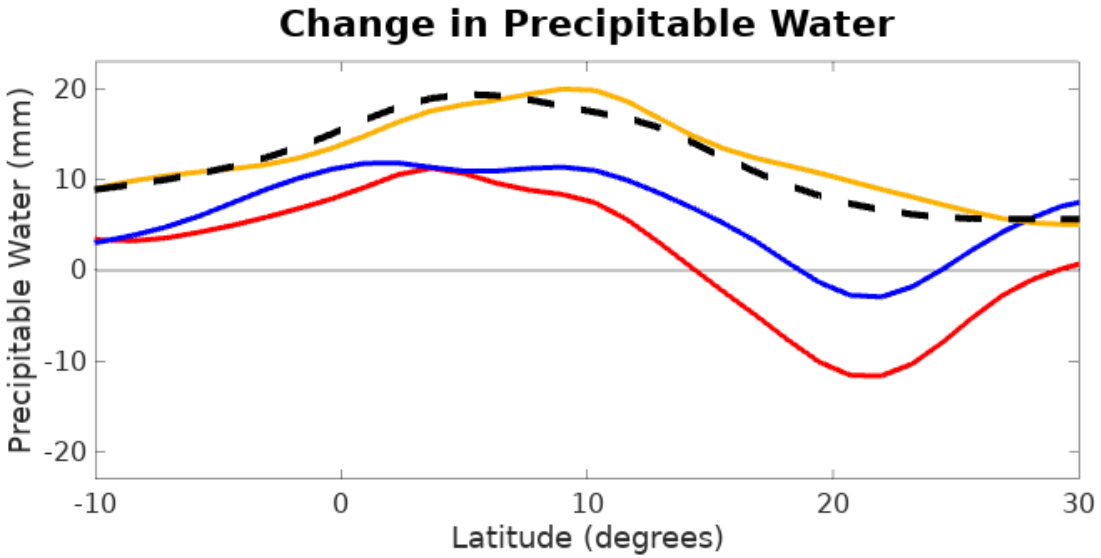
LS: decrease in Sahel precipitation

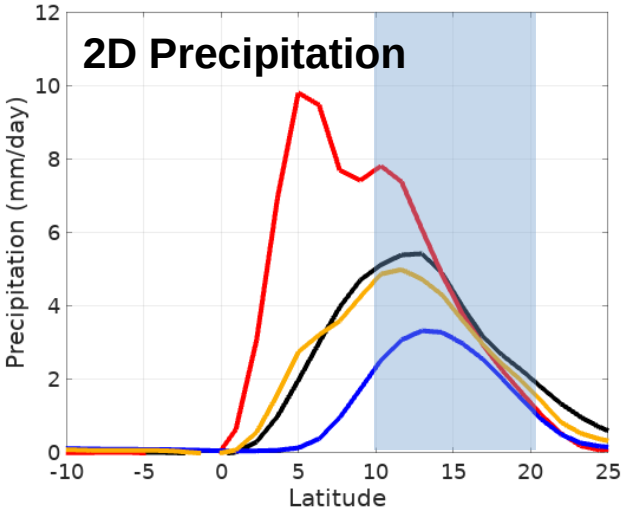
+4K SST Thermodynamic Response



AMIP **2D +4K REG**
2D +4K LS
2D +4K REG + LS

Δ: SCENARIO - CONTROL

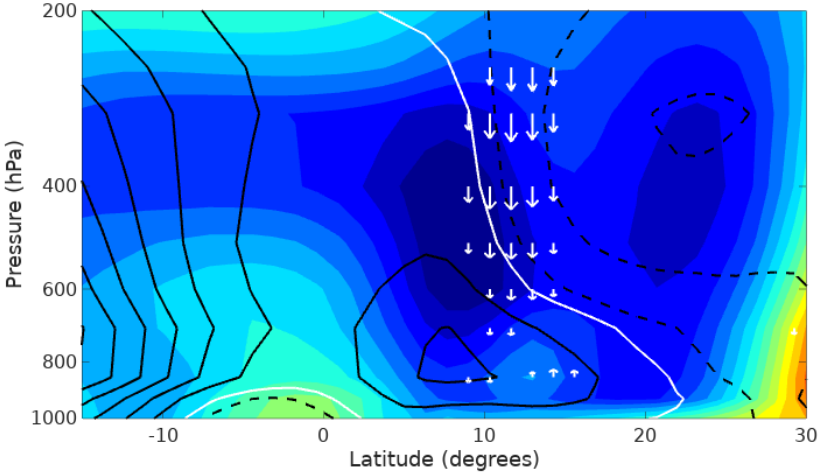




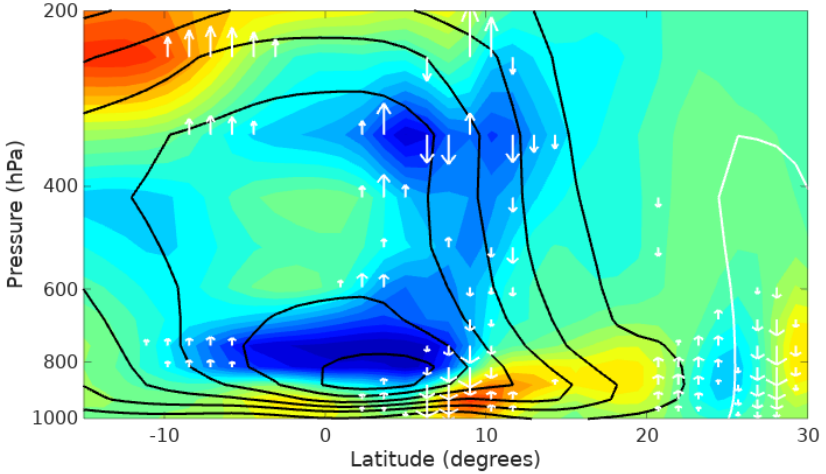
KEY POINT: Both LS and REG forcing needed to produce an increase in moisture through the entire column

+4K SST Dynamic Response

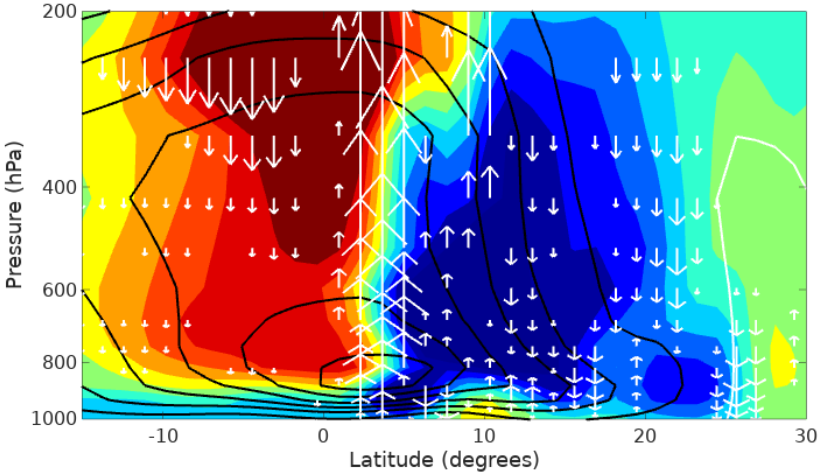
AMIP +4K SST



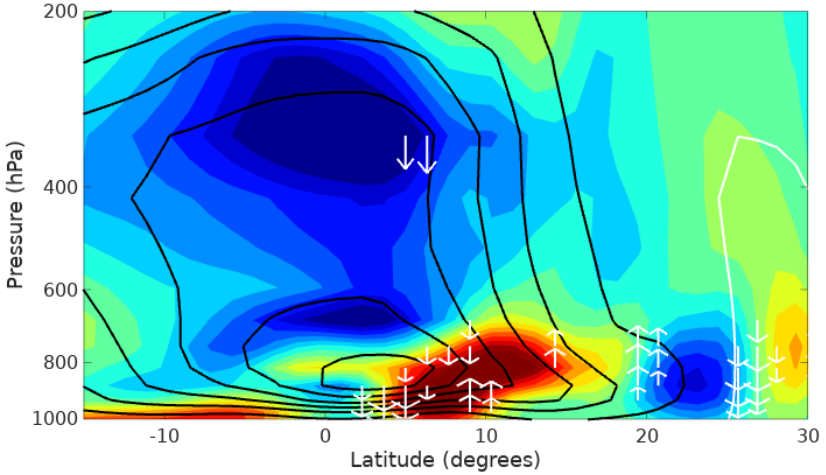
2D +4K LS



2D +4K REG

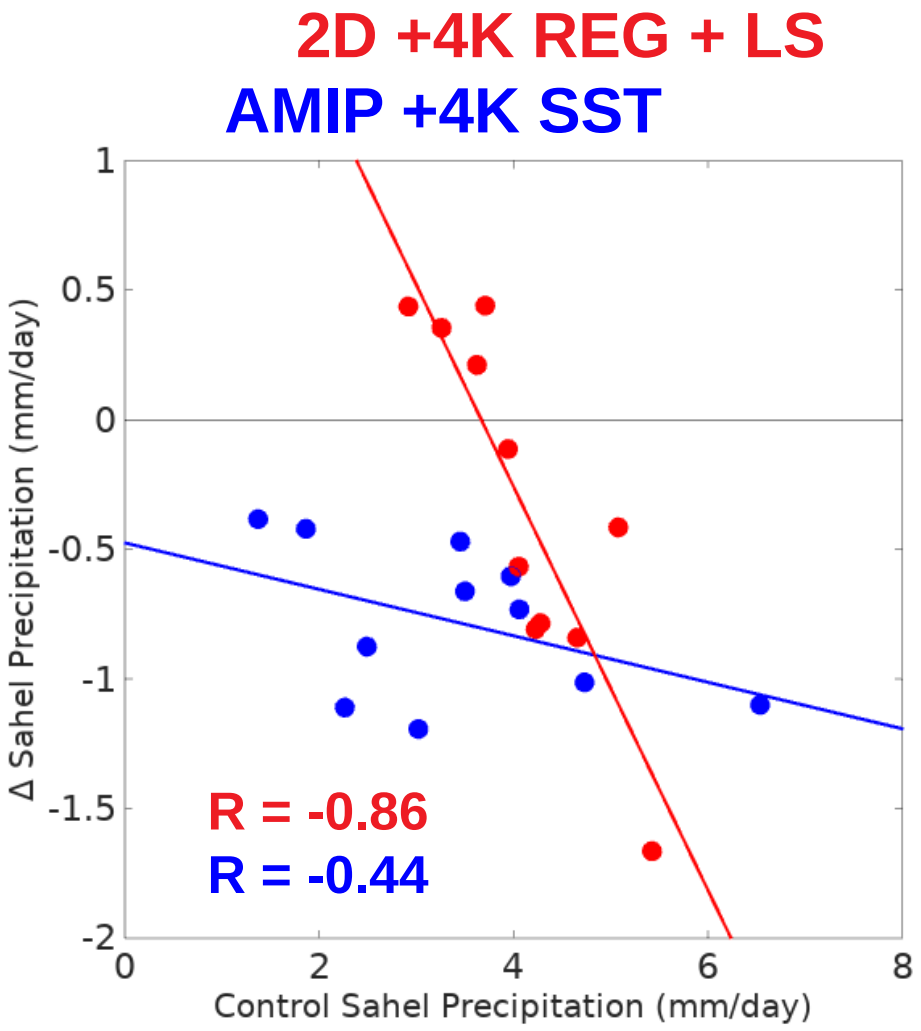


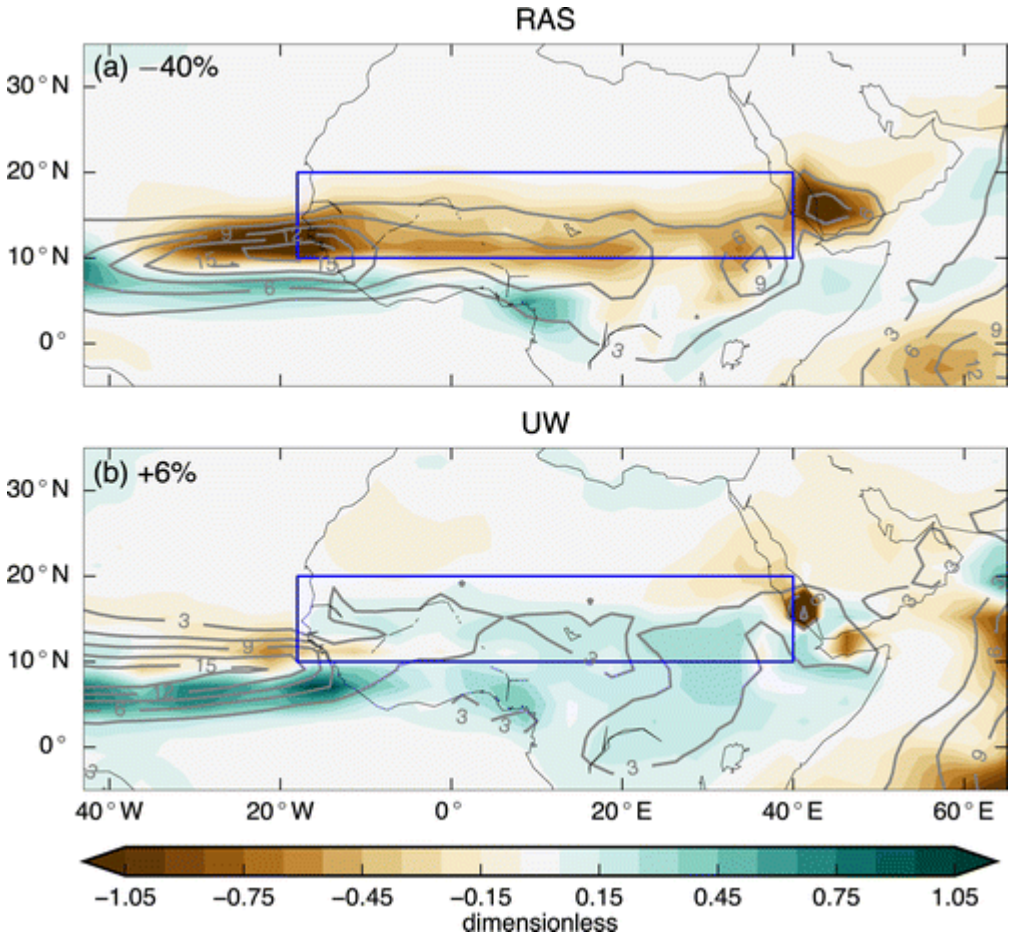
2D +4K REG + LS



KEY POINT: AMIP and 2D simulations both weaken the monsoon circulation -> connected to both REG and LS

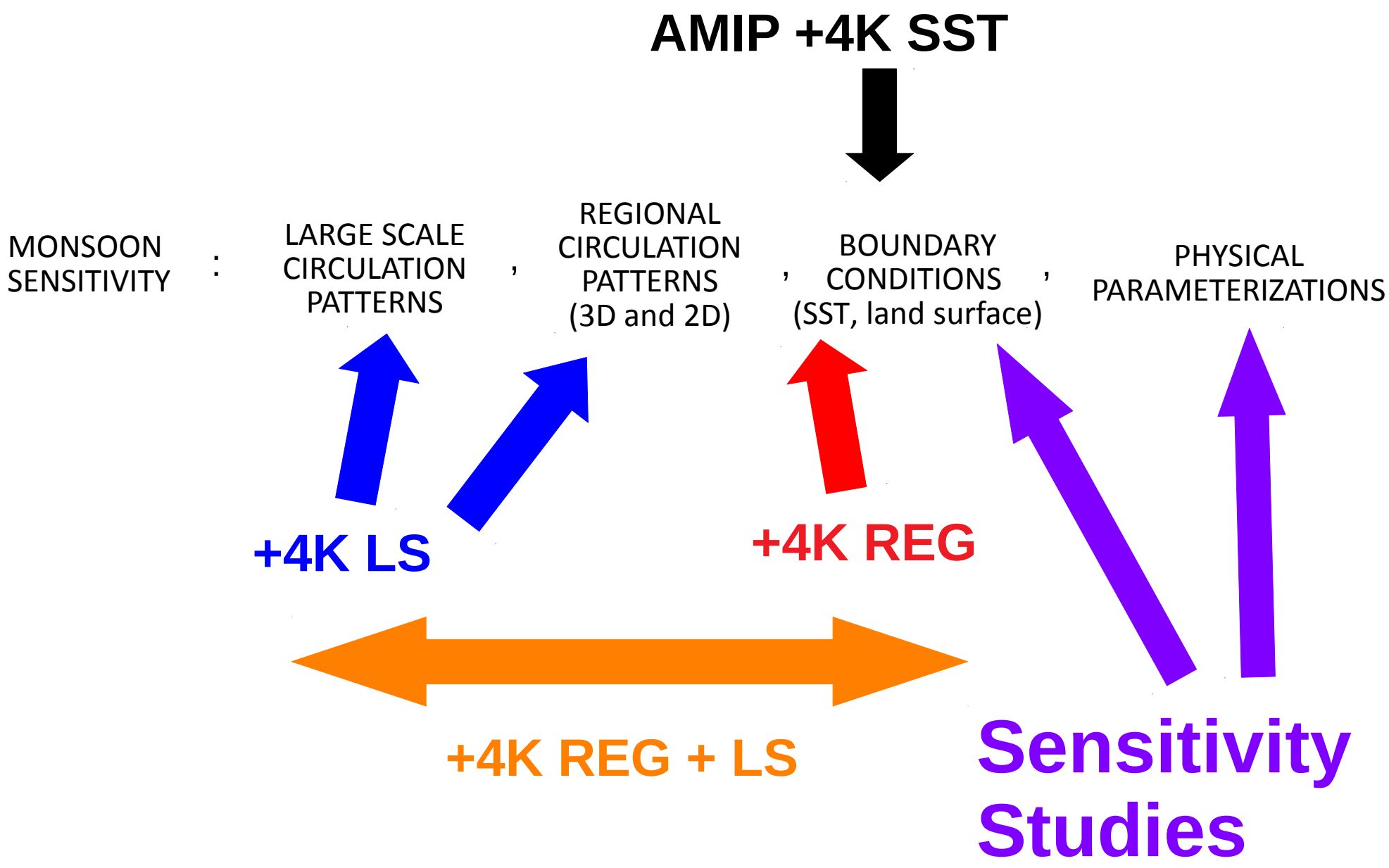
+4K SST Intermodel Variability

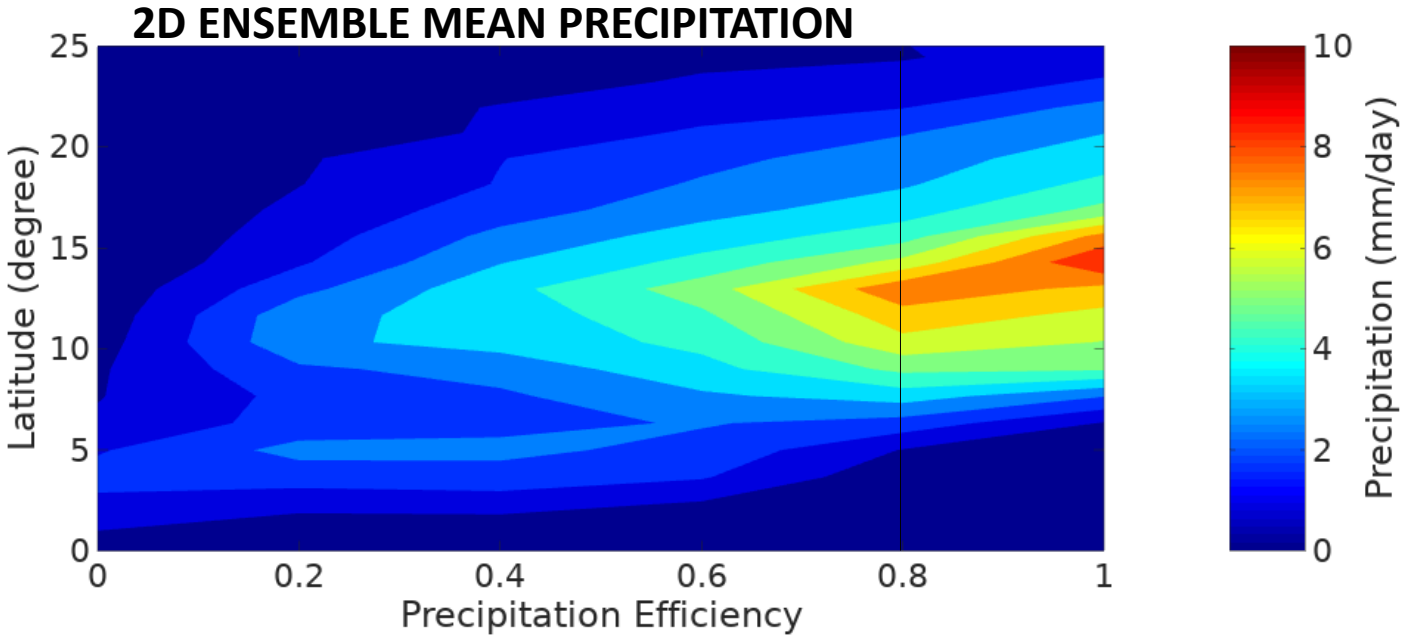




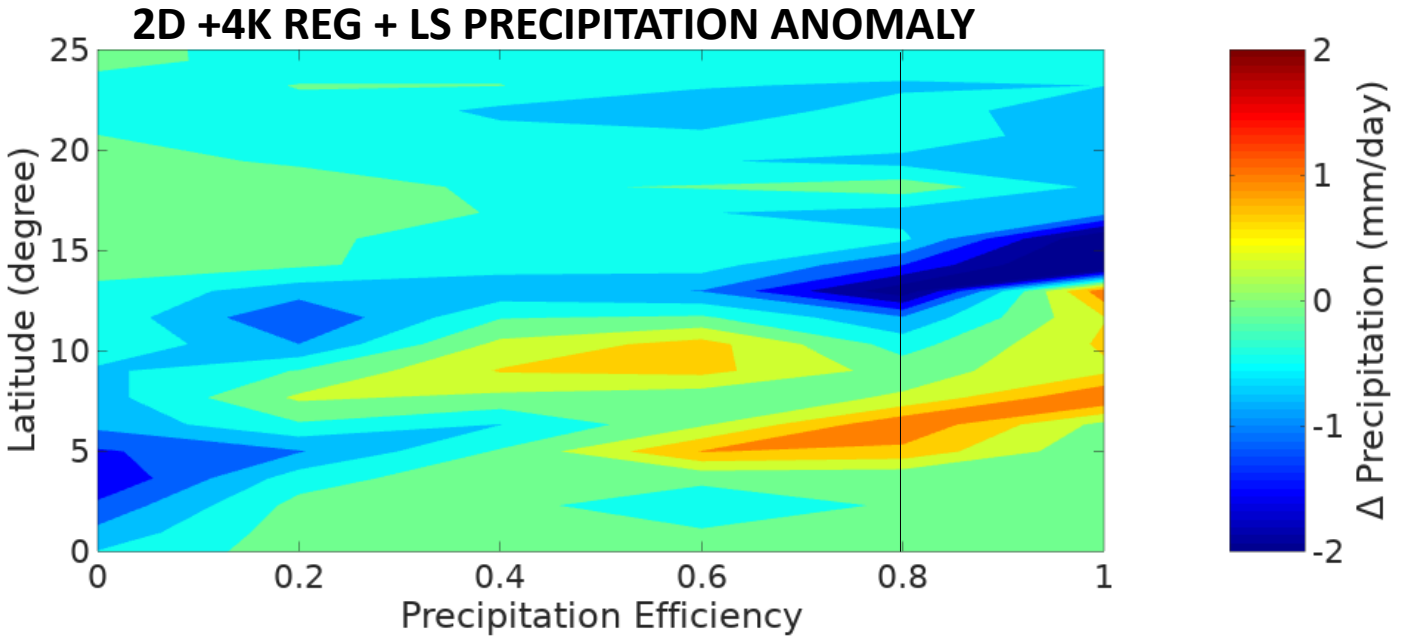
Hill et al. 2017

KEY POINT: Similar mechanisms in both AMIP and 2D simulations produce a larger decrease in precipitation in models that have stronger convective activity


AMIP +4K SST
MONSOON SENSITIVITY
:
LARGE SCALE CIRCULATION PATTERNS
,
REGIONAL CIRCULATION PATTERNS (3D and 2D)
,
BOUNDARY CONDITIONS (SST, land surface)
,
PHYSICAL PARAMETERIZATIONS
+4K LS
+4K REG
+4K REG + LS
Sensitivity Studies



Shows similar sensitivity when forced by NCEP2 Peyrillé et al. (2016)



Sensitivity of the precipitation response to precipitation efficiency

100% of convective precipitation evaporates

100% of convective precipitation reaches the surface

Sensitivity Studies

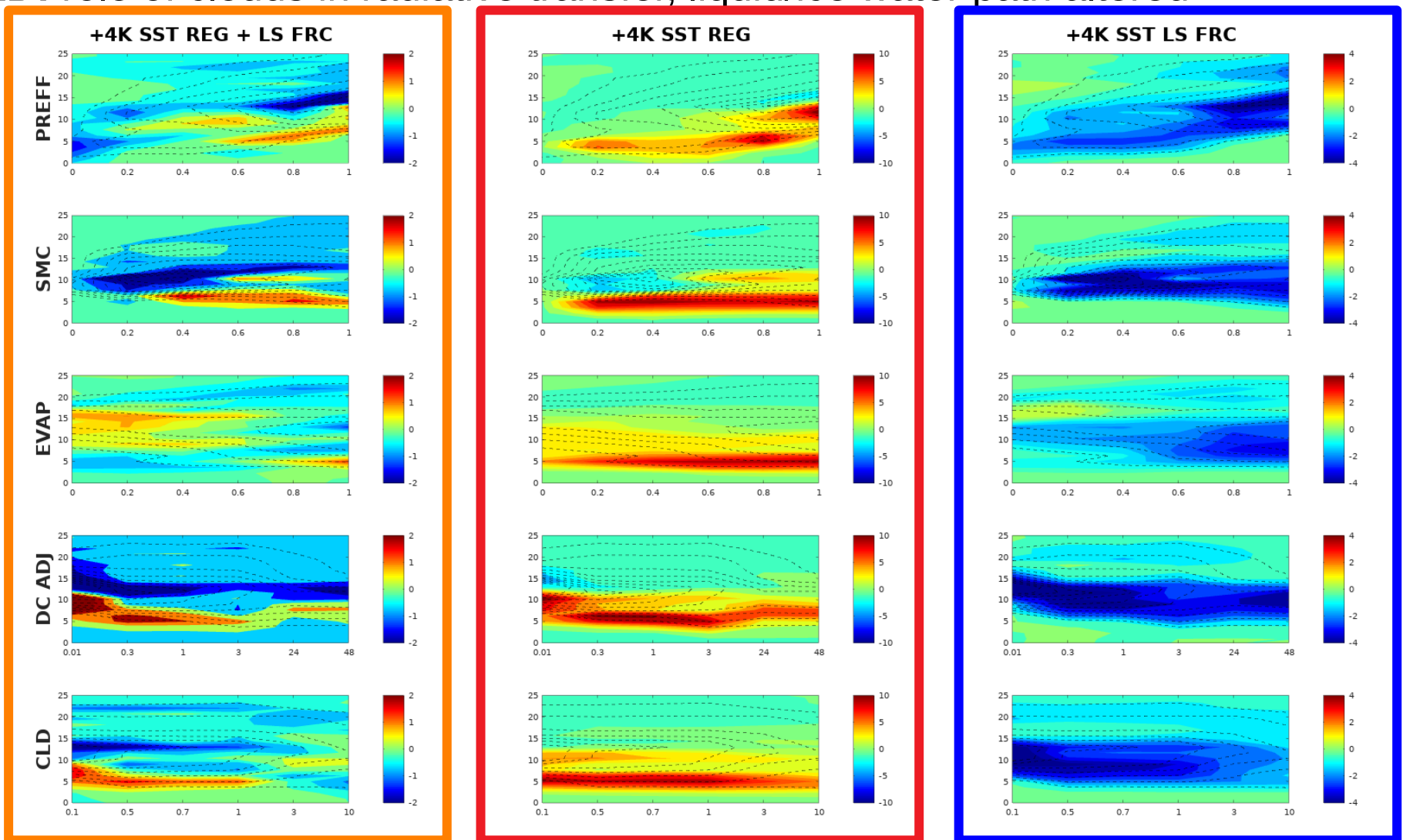
PREFF: role of downdrafts, all rainfall evaporates to all rainfall reaches the surface

SMC: moisture and temperature transport by the shallow meridional circulation

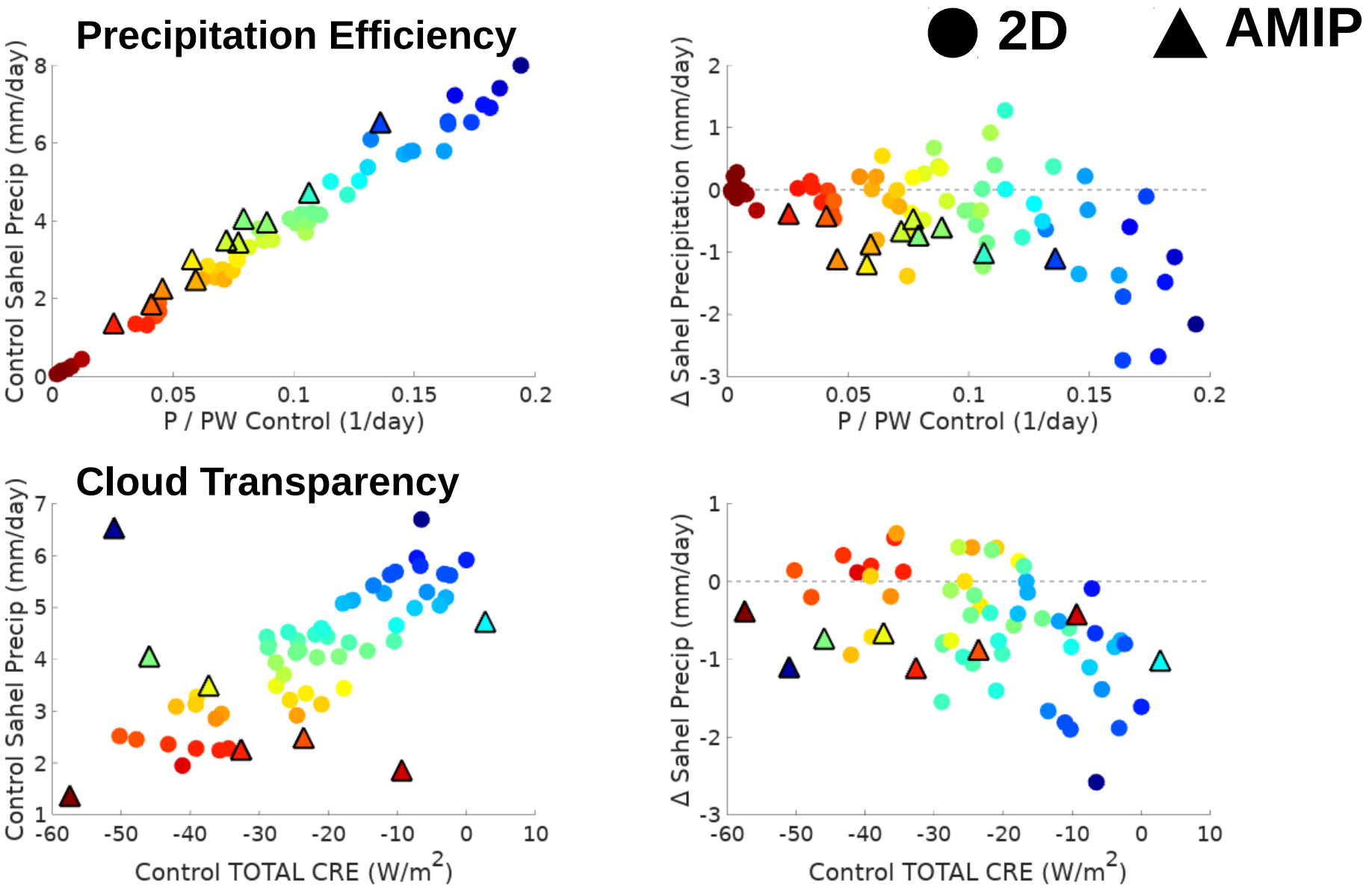
EVAP: water recycling, controls how much of the soil moisture goes into runoff

DC ADJ: deep convection adjustment time, 5 minutes to 48 hrs

CLD: role of clouds in radiative transfer, liquid/ice water path altered



Comparison with AMIP



2D model produces the decreased Sahel precipitation and southward rainband shift seen in +4K SST AMIP simulations:

large scale forcing: stabilizes and dries Sahel
regional forcing: destabilizes, shifts rainband south

Both AMIP and 2D simulations produce a larger decrease in precipitation in models that have stronger convective precipitation

2D model shows sensitivity to choices in parameterizations and surface properties, distinct behavior in REG and LS