

# **Mechanisms of Regional Climate Change from Anthropogenic Forcing**

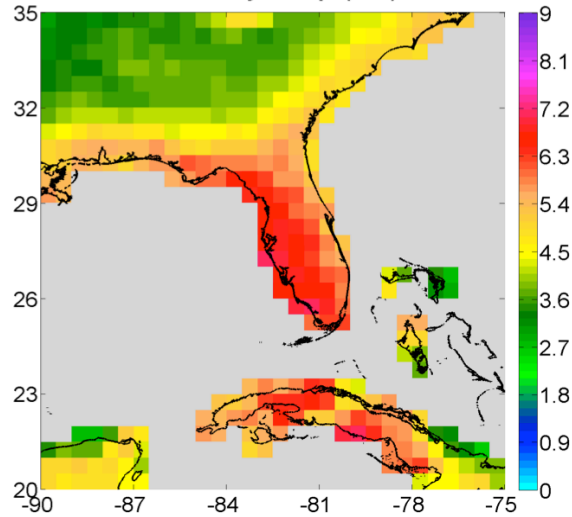
## **– The Role of Ocean**

**Jie He, Brian Soden**

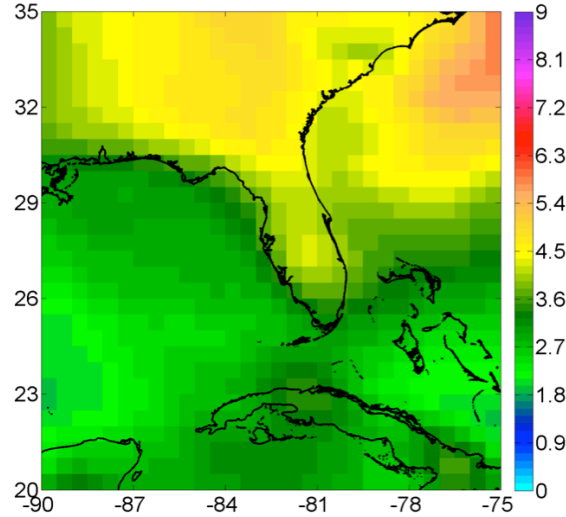
Rosenstiel School of Marine and Atmospheric Science  
University of Miami

# Challenges in regional climate change simulation

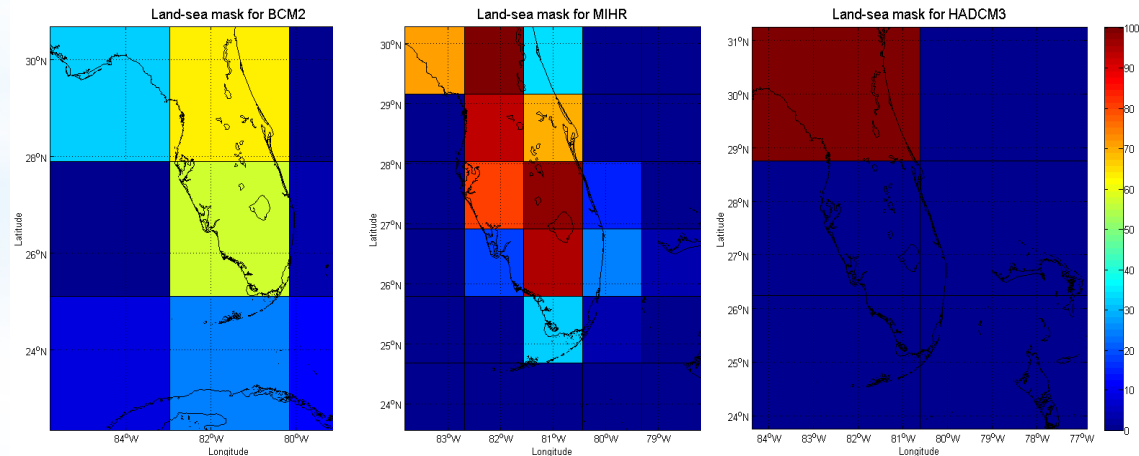
## Observed JJA Rainfall



## CMIP5 JJA Rainfall



## Low Model Resolution



Courtesy Roque V. Cespedes (RSMAS/UM)

# Can we use High Resolution “time-slice” Experiments?

High resolution atmosphere-only models forced with projected changes in SST from coupled models

1. Is **ocean coupling** important for regional climate change?
2. Is **details of SST change** important for regional climate change?

# Role of Ocean Coupling

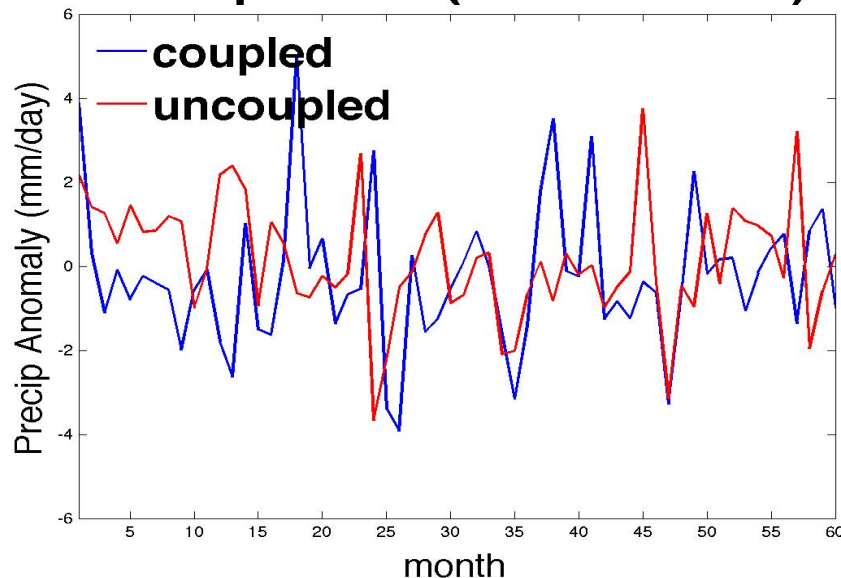
Introduction

Method

Results

Coupling is important for natural climate variability.

**Precipitation (38.8N 197.5E)**



Lack of coupling leads to inconsistency b/w atmos and ocean.

# Role of Ocean Coupling

Introduction

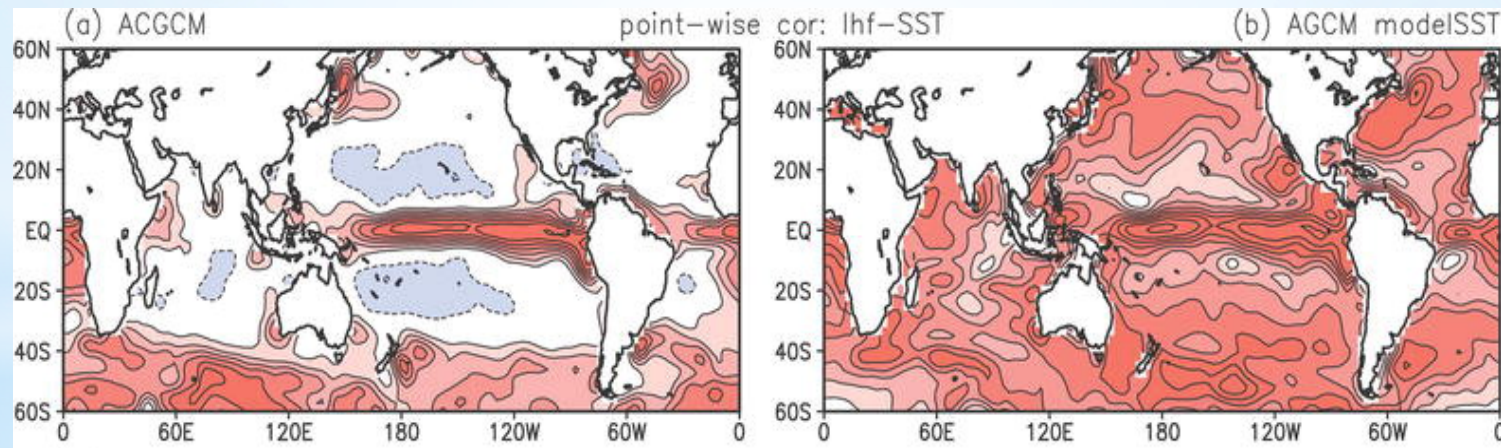
Method

Results

The importance of coupling for natural climate variability is well documented.

(e.g., Barsugli and Battisti 1998; Wang et al. 2005; Wu et al. 2006)

**coupled** VS **uncoupled**



(Wu et al. 2006)

# Role of Ocean Coupling

Introduction

Method

Results

**Compare coupled and uncoupled simulations that have the same atmospheric model and SST & sea ice.**

**Model:** CESM

**Resolution:** approximately 2° for atmosphere & land and 1° for ocean

**Simulations:**

**CPL\_1pct** (1pctCO<sub>2</sub>, coupled)

**AGCM\_1pct** (1pctCO<sub>2</sub>, uncoupled, SST and sea ice from CPL\_1pct)

**CPL\_PI** (pre-industrial, coupled)

**AGCM\_PI** (pre-industrial, uncoupled, SST and sea ice from CPL\_PI)

**Run time:** 160 years

**Climate change:** 10-year epoch difference

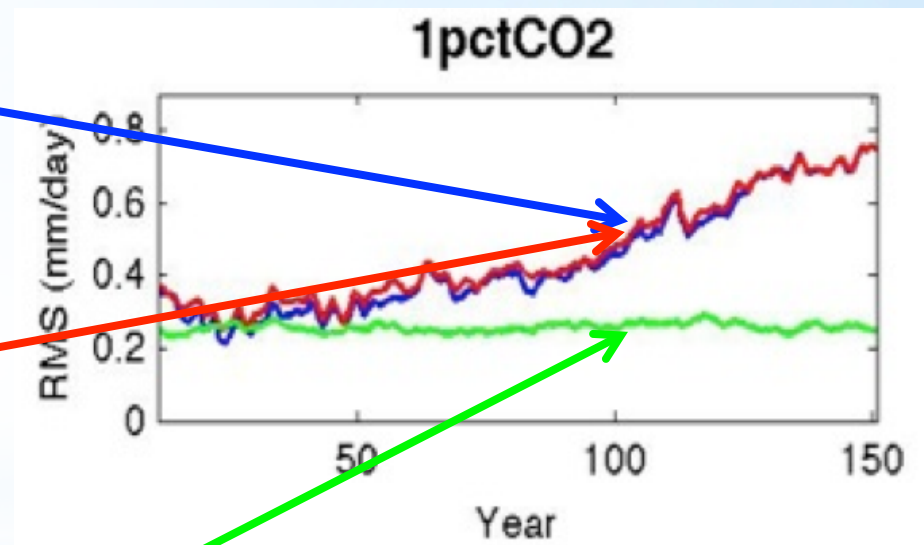
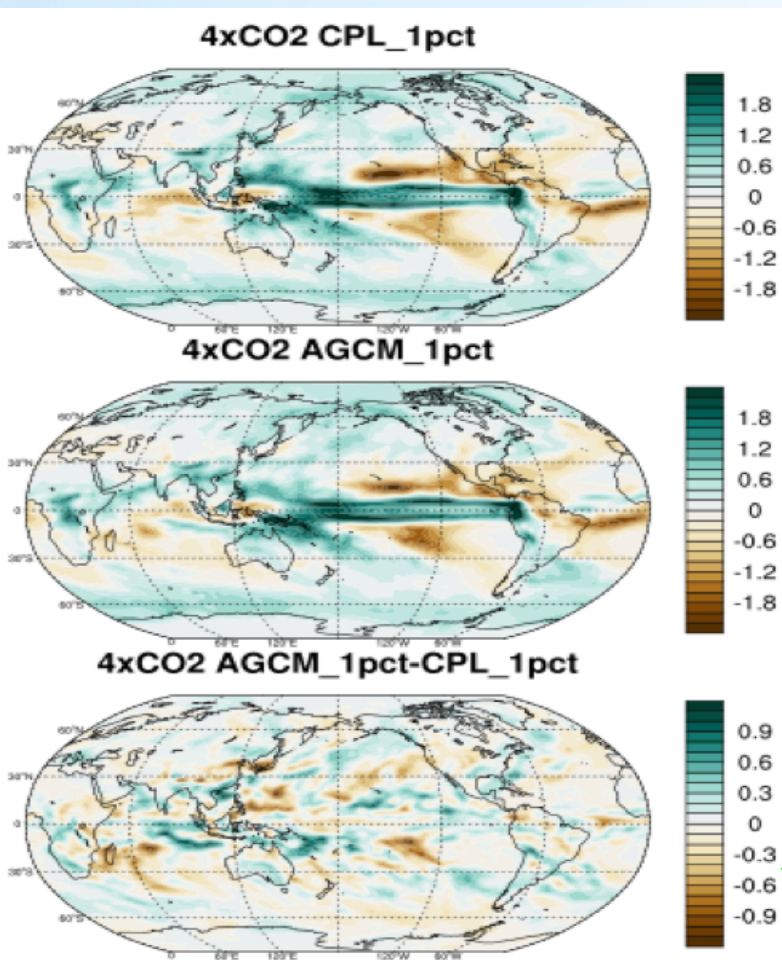
# Role of Ocean Coupling

Introduction

Method

Results

Precipitation Change (mm/day)



Error due to lack of coupling is independent of external forcing.

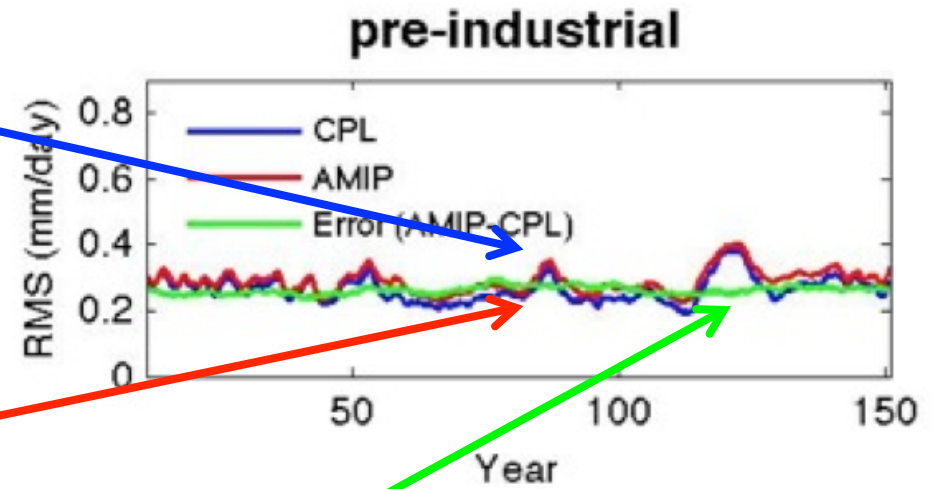
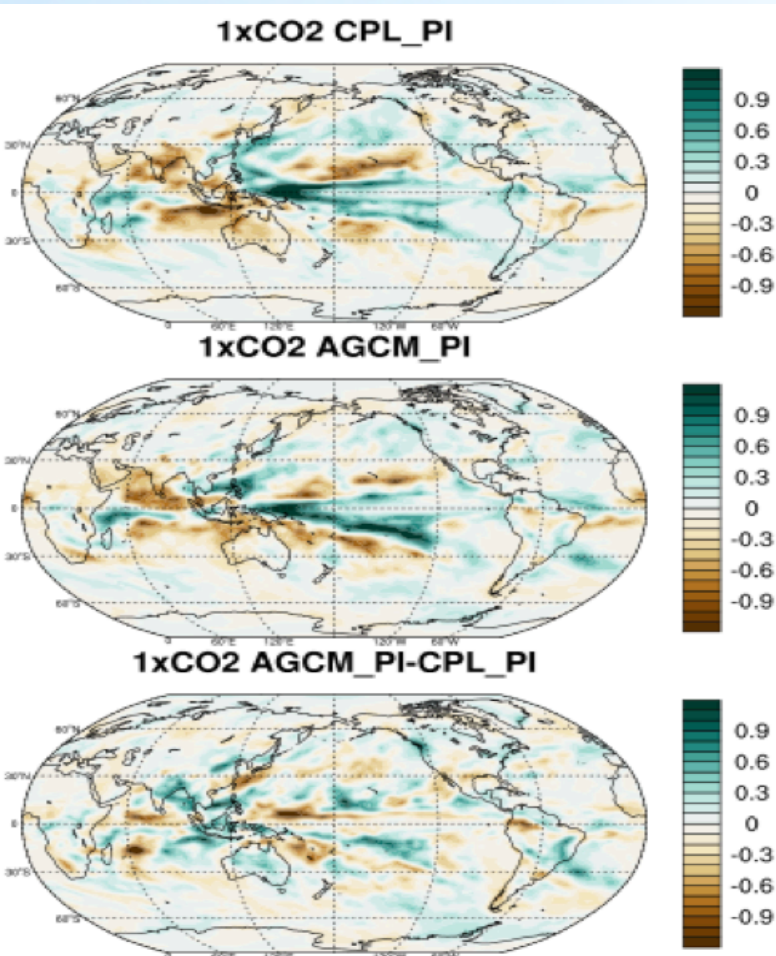
# Role of Ocean Coupling

Introduction

Method

Results

Precipitation Change (mm/day)



Error due to lack of coupling is comparable to decadal variability.



# Role of Ocean Coupling

Introduction

Method

Results

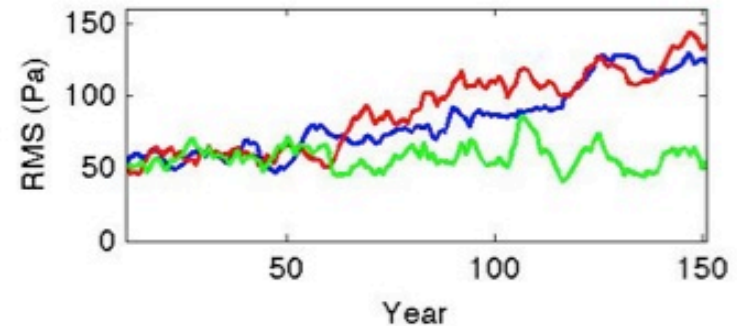
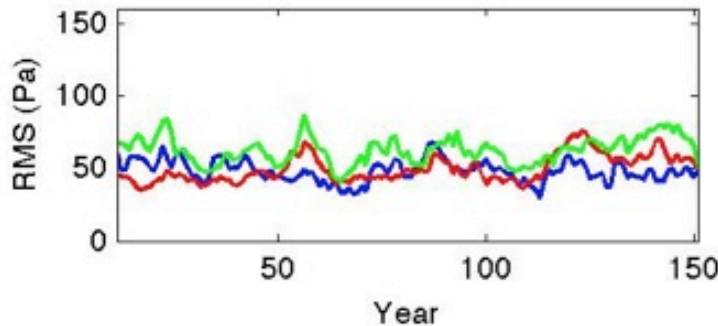
Ocean coupling is important for the simulation of **natural climate variability**.

Ocean coupling is **NOT** necessary for the simulation of **anthropogenic climate change**.

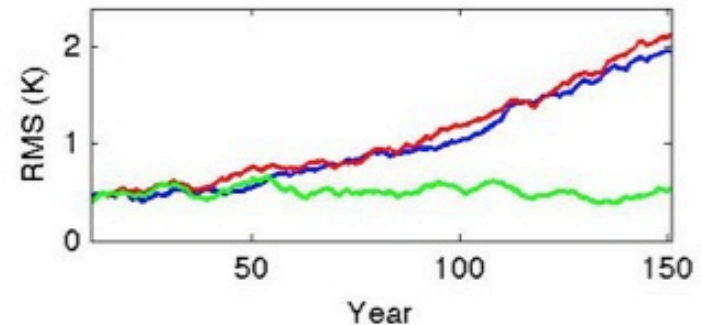
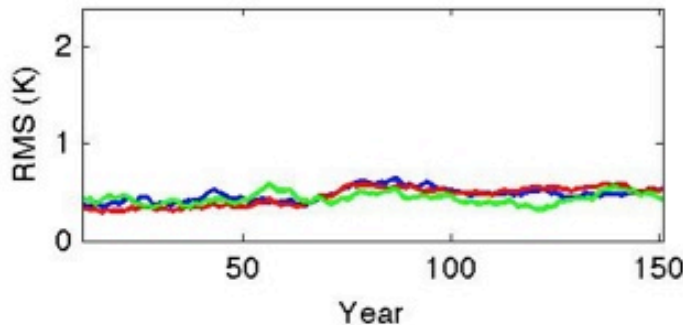
pre-industrial

1pctCO2

SLP



Land TS



1. Is **ocean coupling** important for regional climate change? **NO\***

We can use High Resolution “time-slice” Experiments.

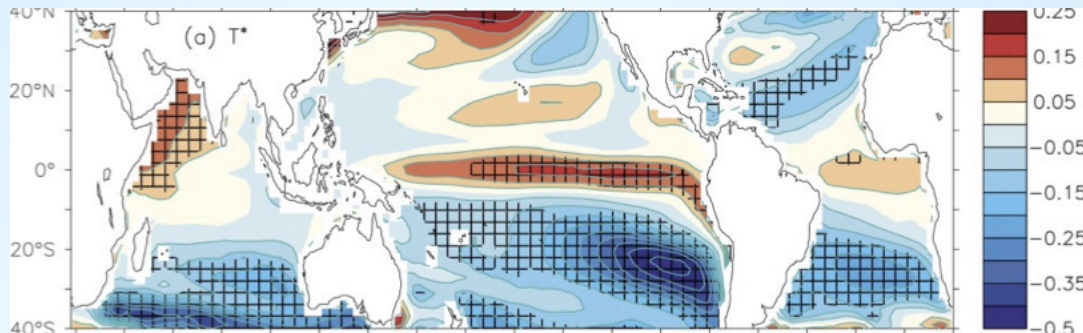
2. Is **details of SST change** important for regional climate change?

# Impact of Pattern of SST Change

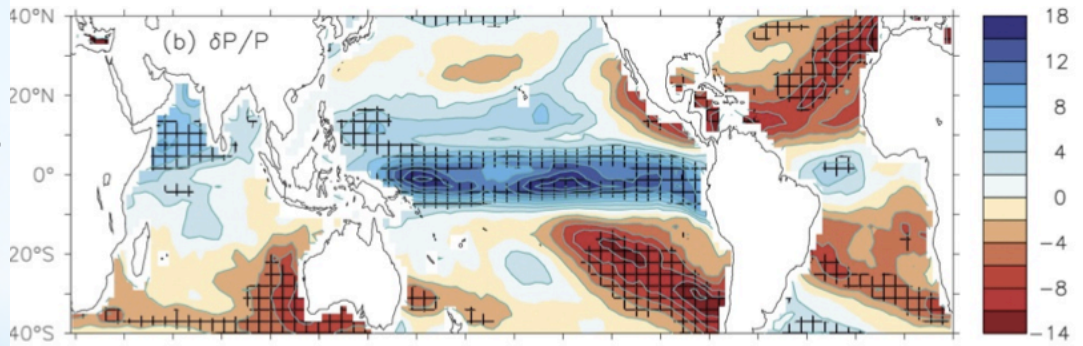
## Introduction

## Results

Relative SST  
change



precip change



**“warmer-get-wetter” over tropical oceans**  
(Ma and Xie 2013)

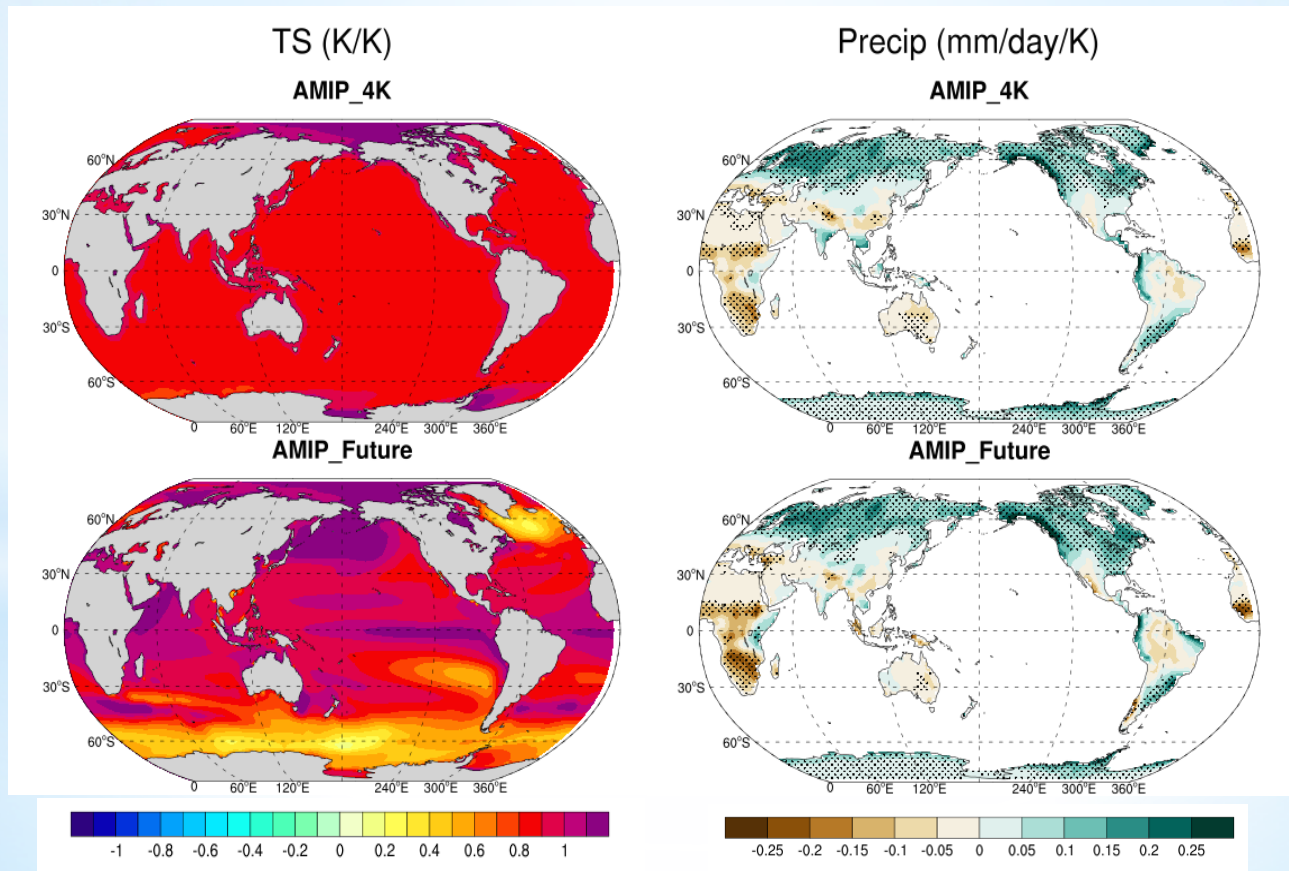
Is the pattern of SST important for climate change over land?

# Impact of Pattern of SST Change

## Introduction

## Results

Pattern of SST change is **NOT** important for climate change over **LAND** (9 models).



He et al. GRL, 2014

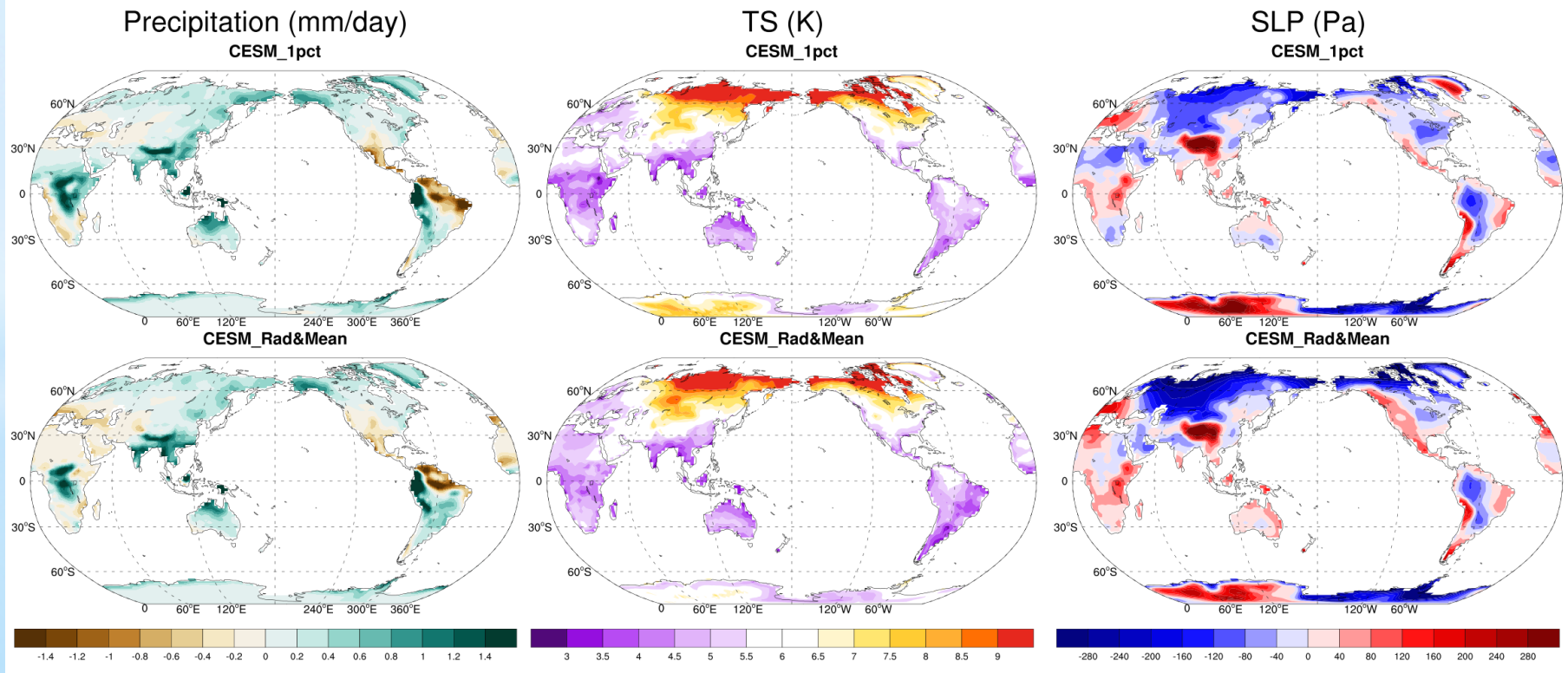
He, J., B.J. Soden, and B.P. Kirtman, 2014: The robustness of the atmospheric circulation and precipitation response to future anthropogenic surface warming, *Geophys. Res. Lett.*

# Impact of Pattern of SST Change

## Introduction

## Results

We can simulate land climate change using AGCM forced with only increased  $\text{CO}_2$  and a uniform warming.  
(results from CESM)



corr=0.86 (pr), 0.95 (TS), 0.85 (SLP)

# Conclusions

1. AGCM can perfectly reproduce anthropogenic climate change from coupled model.
2. Errors due to lack of ocean coupling are only related to internal variability.
3. Details of SST change is NOT important for land climate change. We can predict land climate change by using AGCM forced with only CO<sub>2</sub> rise and a uniform warming.

**Thank you!**