

# What Have I learned from the Large Ensemble Experiments

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# History

~2003

## CCSM1.4, T31

- 3.75°x3.75°
- 62 members
- 1940-2080
- “business as usual” scenario
- Selten et al. 2004, GRL

~2006-2007

## CCSM3.0, T42

- ~2.8°x2.8°
- 40 members
- 2000-2061
- A1B/Commitment scenarios
- Deser et al. 2012, Clim Dyn

~2013-2014

## CESM1.0

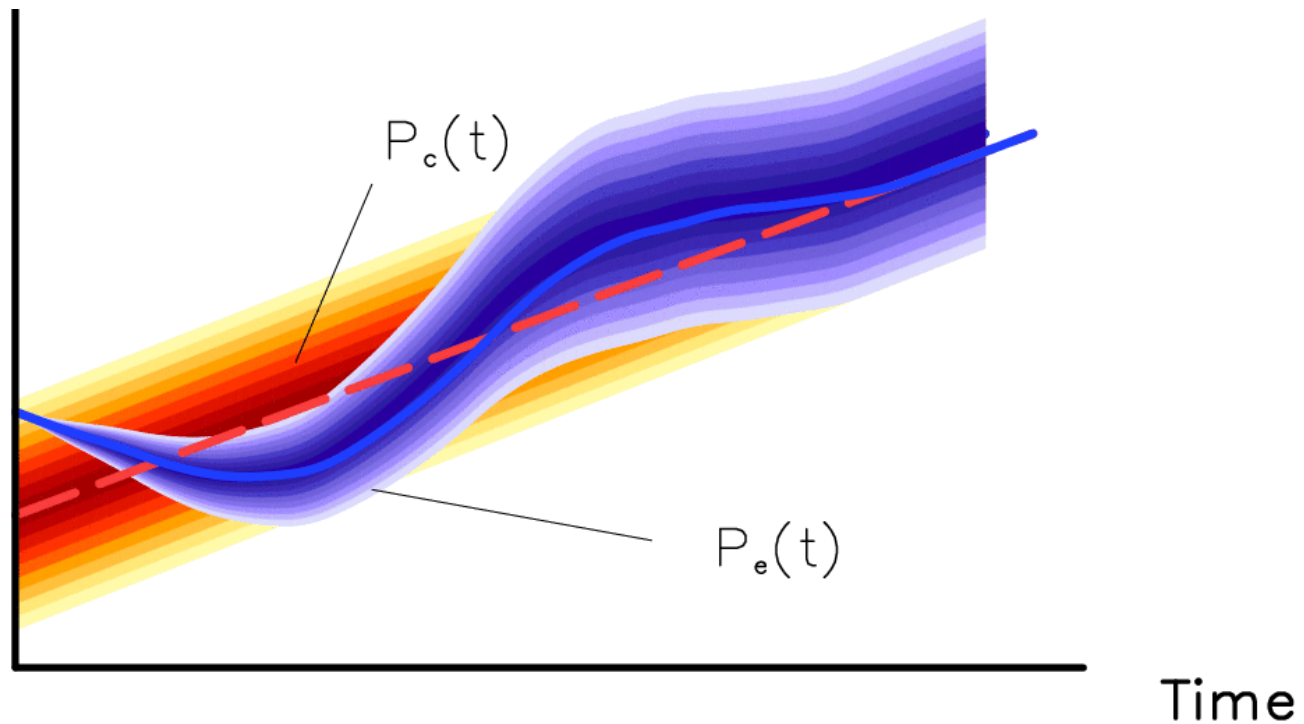
- ~1 deg
- 40+ members
- 1920-2100
- RCP4.5 scenario
- Kay et al. 2015, BAMS

The ensemble members have the same ocn/lnd/ice initial conditions, but a small random perturbation was added to the initial atm temperature field.

## Decadal Predictability

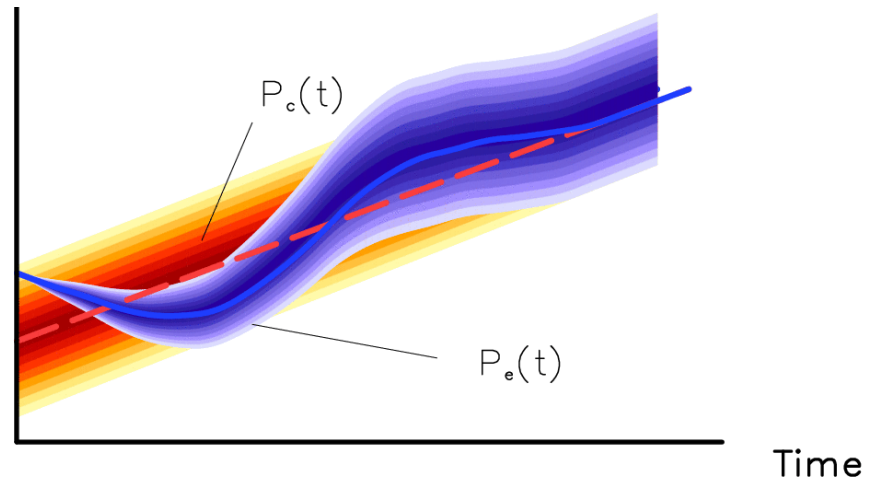
Initial-value predictability:  $P_e(t)$  vs.  $P_c(t)$

Forced predictability:  $P_c(t)$  vs.  $P_c(0)$



# Decadal Predictability Measured by Relative Entropy

**Initial-value predictability:**  $P_e(t)$  vs.  $P_c(t)$   
**Forced predictability:**  $P_c(t)$  vs.  $P_c(0)$



Kleeman (2002)

$$R = \int_s P_x(s) \log_2 \left[ \frac{P_x(s)}{P_b(s)} \right] ds$$

For normal distribution:

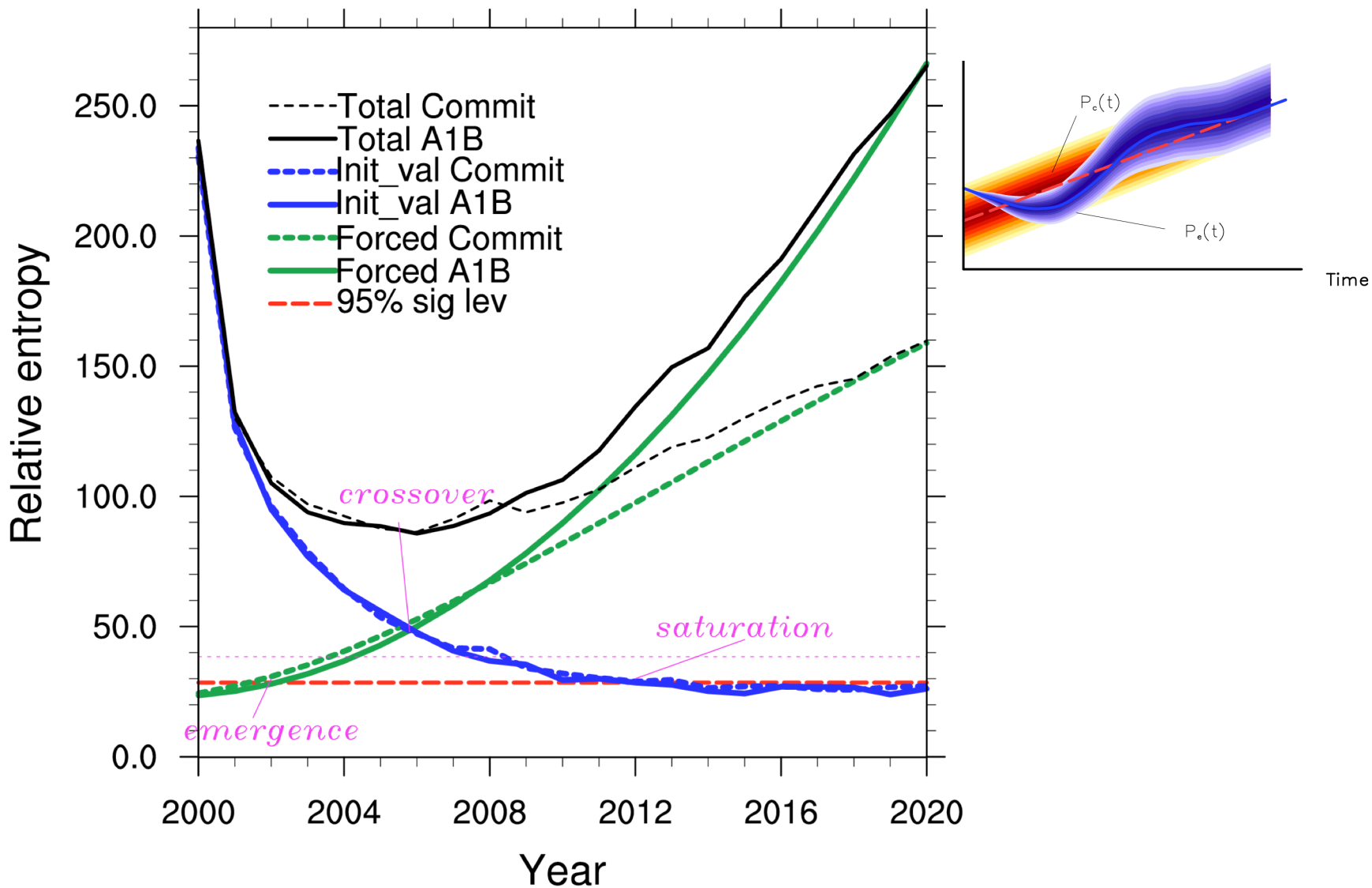
$$R = \frac{1}{2} \log_2(e) \left\{ \ln \left[ \frac{\det(\sigma_b^2)}{\det(\sigma_x^2)} \right] + \text{trace} \left( \frac{\sigma_x^2}{\sigma_b^2} \right) + \underbrace{(\mu_x - \mu_b)^T (\sigma_b^2)^{-1} (\mu_x - \mu_b)}_{\text{signal}} - n \right\}$$

dispersion

signal

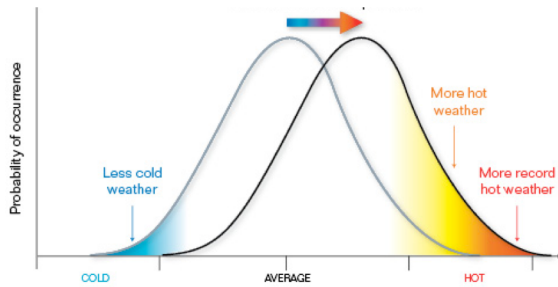


# Predictability of Global Upper 300m Annual mean Ocean Temperature

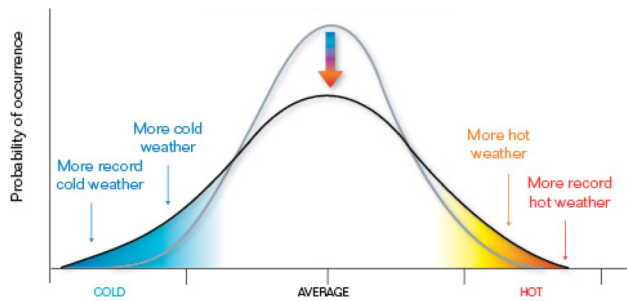


# How does Climate Change Affect Temperature Variability

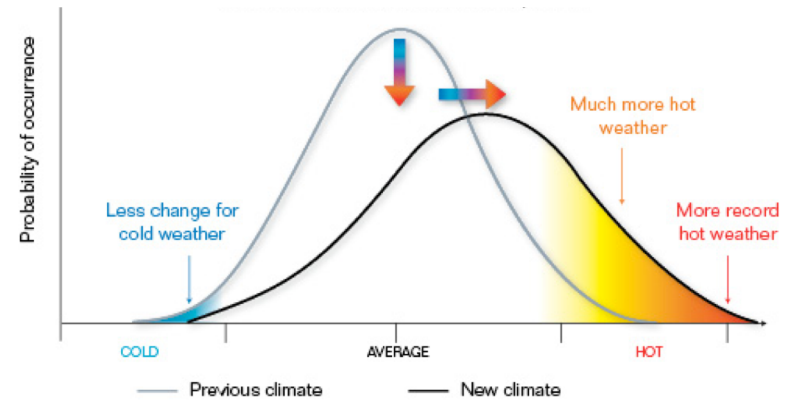
increase in mean



increase in variance

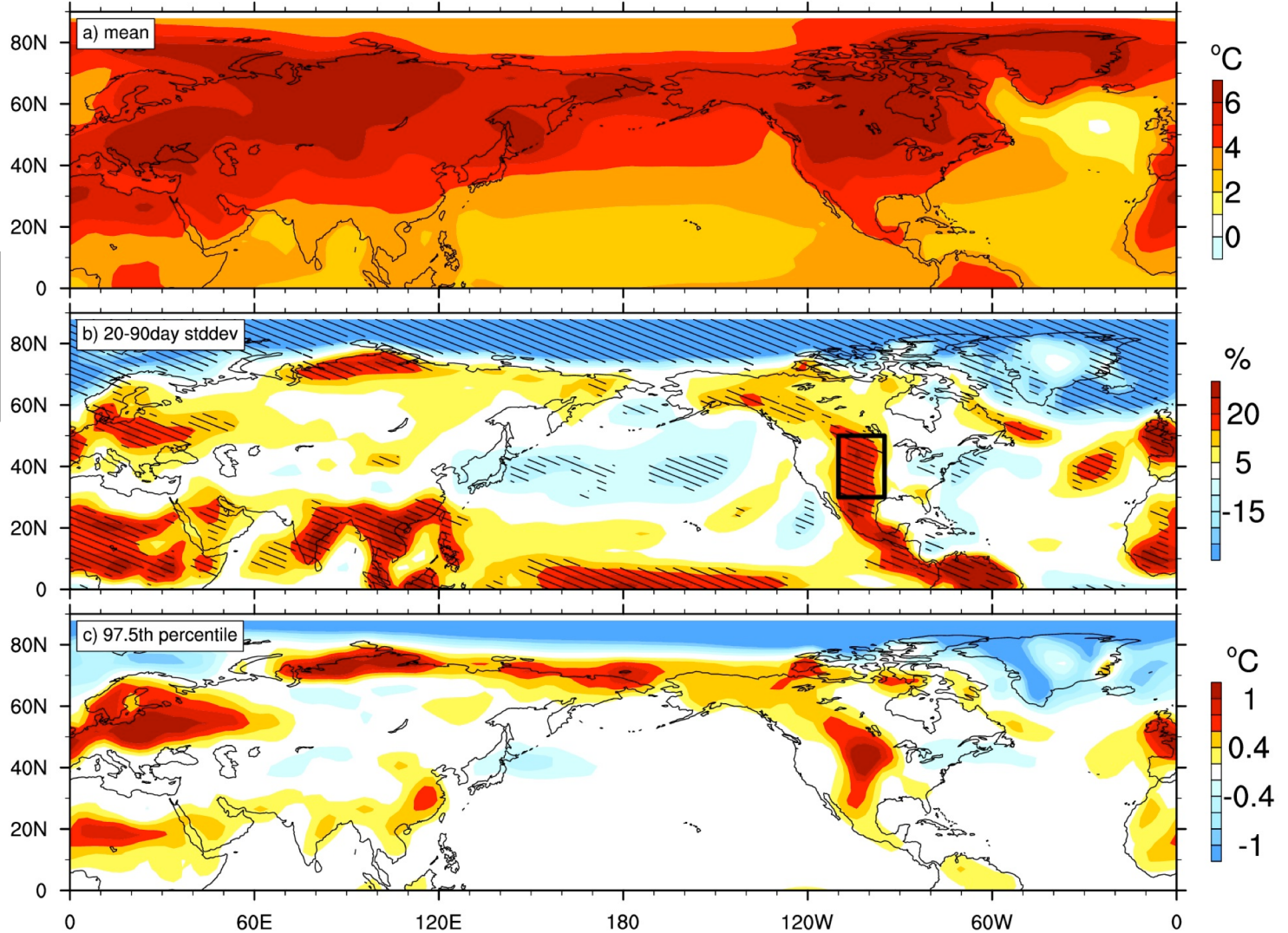


increase in both mean and variance



# JJA Surface Air Temperature Change from 1980-2010 to 2070-2100 in CESM1

mean



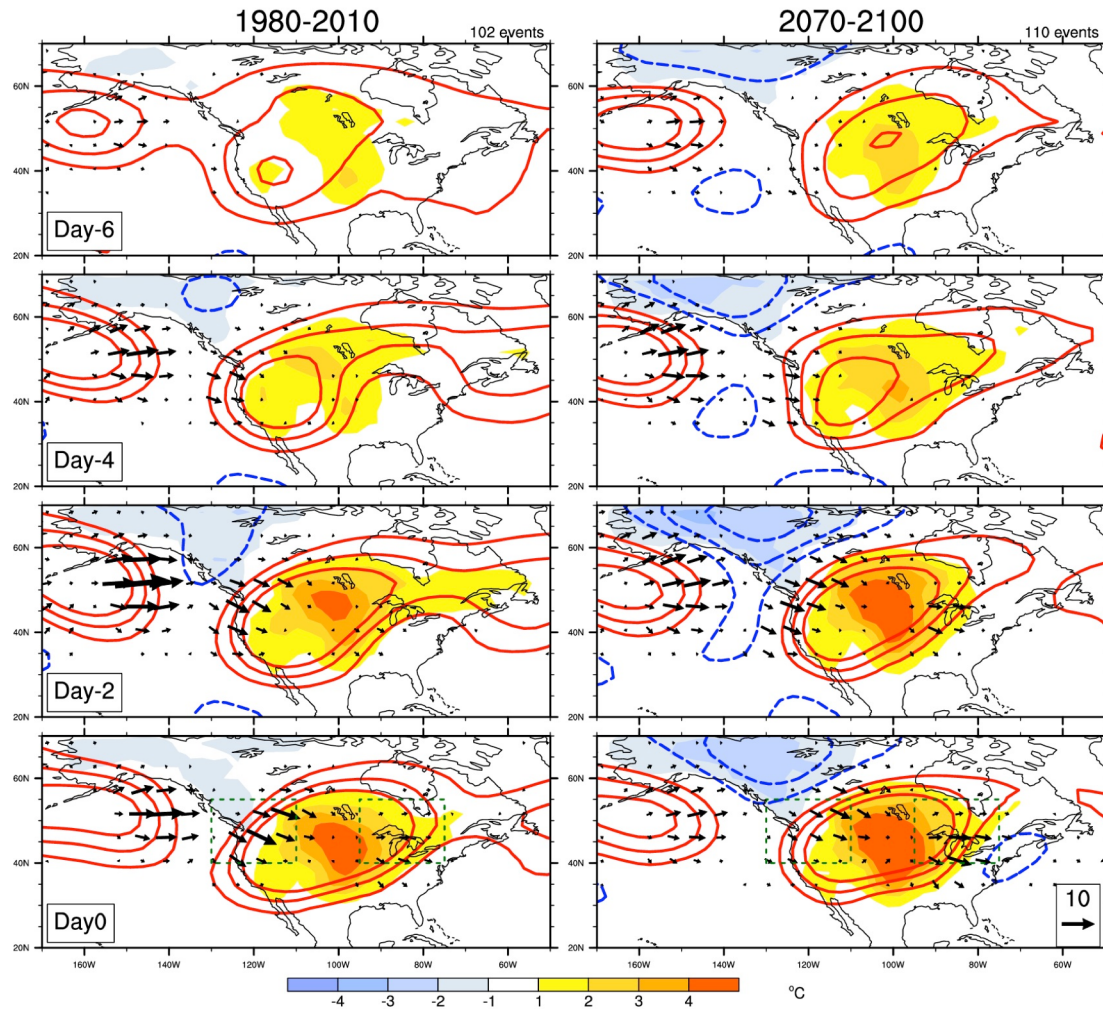
remove  
time-evolving  
climo

20-90day  
Std dev

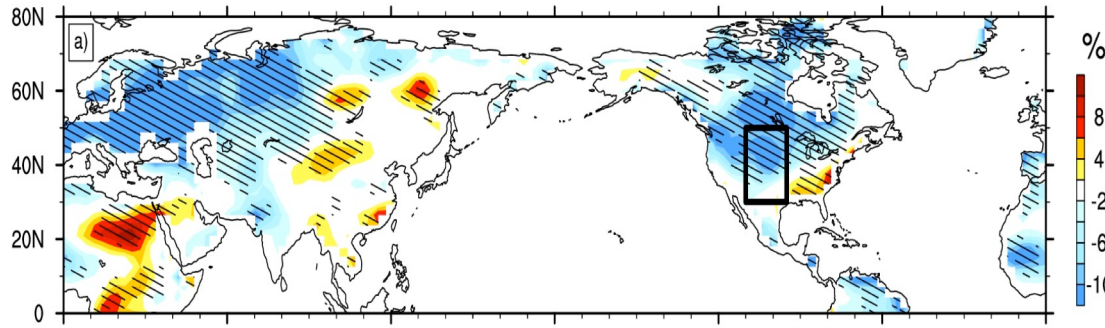
97.5th  
percentile

# Great Plains Heat Wave Composite

psi200, TAS & Plum flux

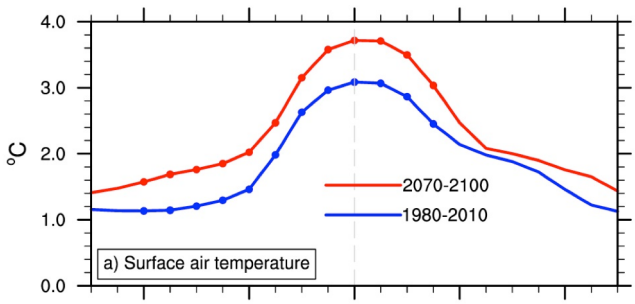


**Percentage change in JJA mean soil moisture  
from 1980-2010 to 2070-2100 in CESM1**

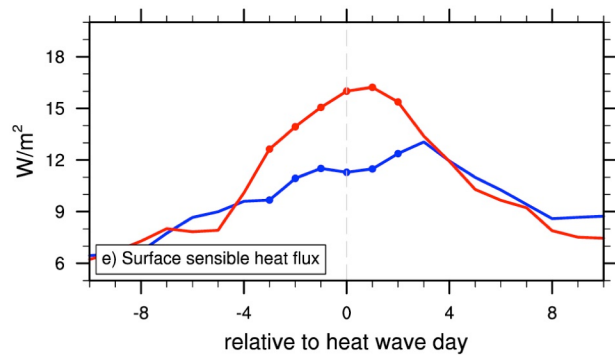


**Great Plains heat wave composites**

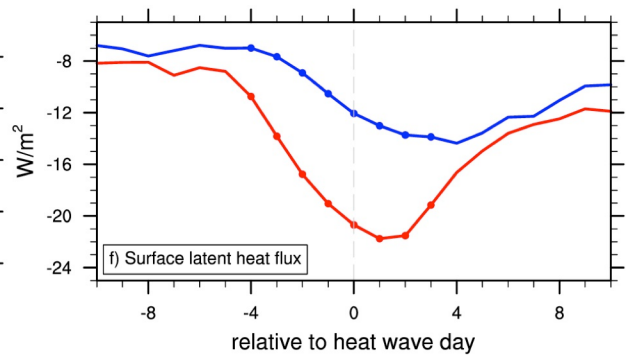
**surface air temperature anom**



**surface sensible heat flux anom**



**surface latent heat flux anom**



*dots: 95% significant*



## Looking forward...

~2003

**CCSM1.4, T31**

~2006-2007

**CCSM3.0, T42**

- **Decadal predictability**

~2013-2014

**CESM1.0**

- **Extremes due to variability change**

*As “large ensemble” has become a standard research approach, think about:*

- **How to store and analyze large datasets?**
- **What are the scientific problems that you want to investigate with this approach?**