Understanding Future Change in Subseasonal Temperature Variability and Heat Waves with the Large Ensemble Approach

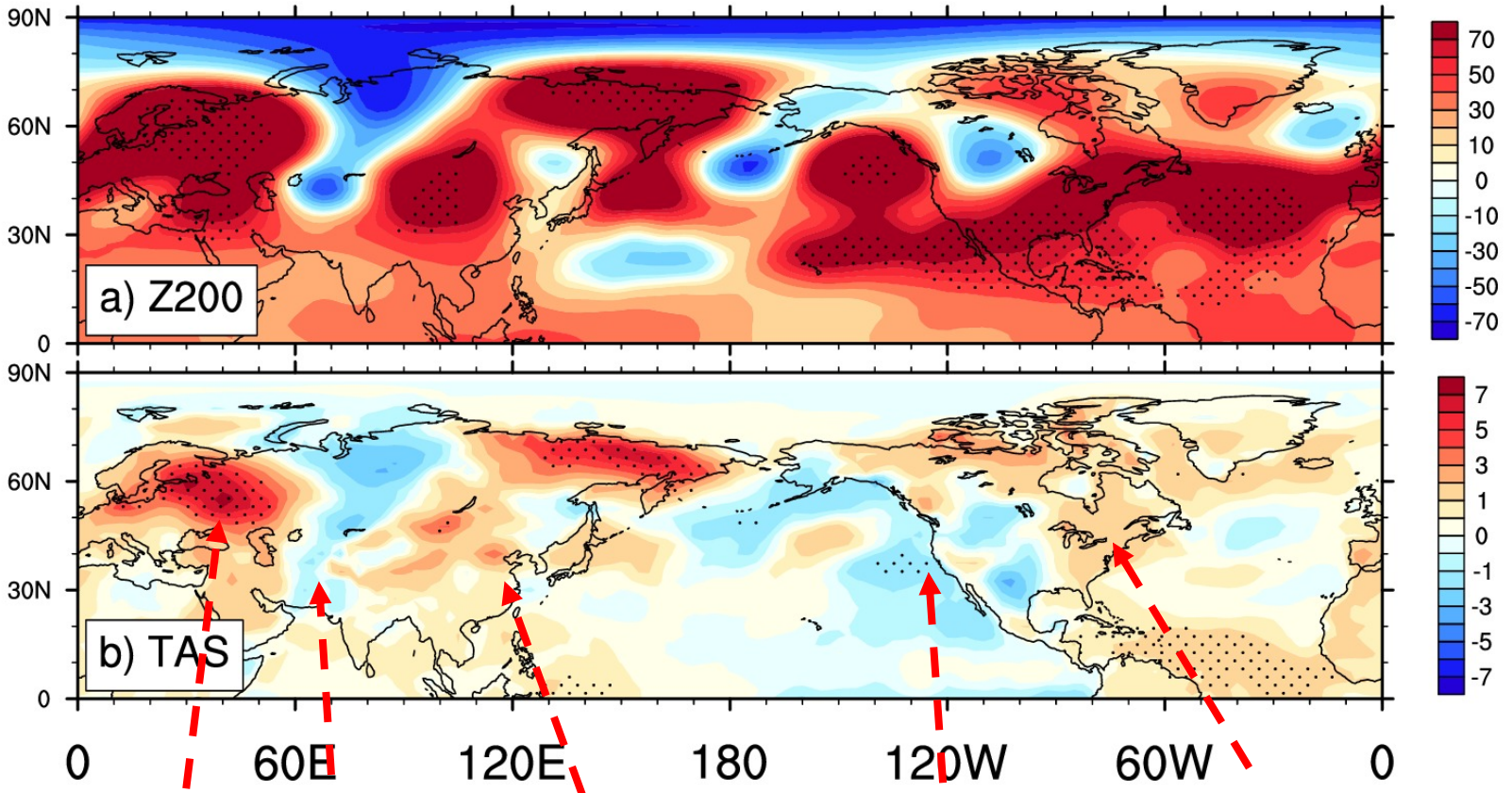
Haiyan Teng

NCAR CGD

Acknowledgement: Grant Branstator, Ahmed Tawfik, Patrick Callaghan, Andy Mai, Jerry Meehl , Warren Washington, CESM / CESM1 large ensemble / CCR production team

NCAR is sponsored by National Science Foundation

2010 July monthly mean anomalies



Russian Heat Wave

Pakistan floods

Warmest Jul since 1961 in China

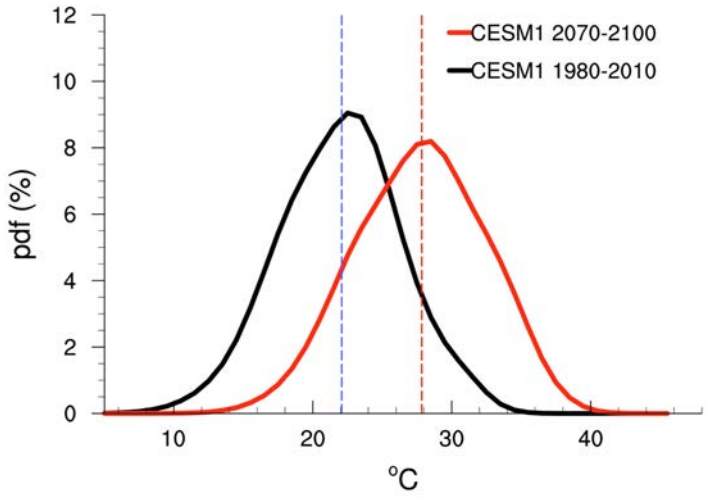
Record cool summer in Santa Barbara

New warmest record in many US cities

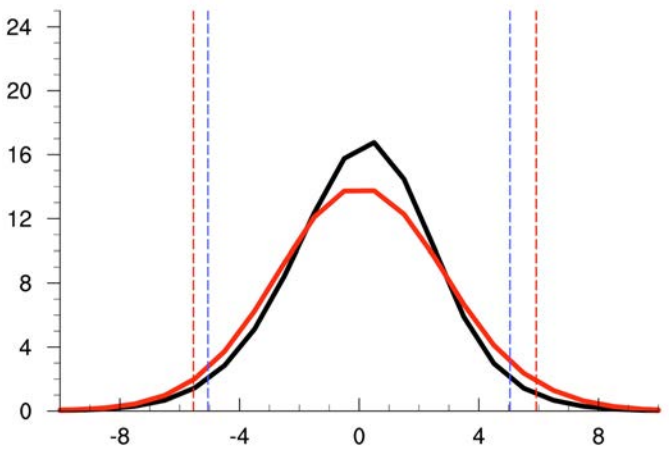
Stippling: >= 2 stddev

JJA daily surface air temperature at the Great Plains in CESM1 LE

~5°C increase in mean temperature



~1°C increase in 97.5th warm tail due to variability change



remove time-evolving climatologies

The daily climatology is defined as 30-member avgerage within a 30-day running window.

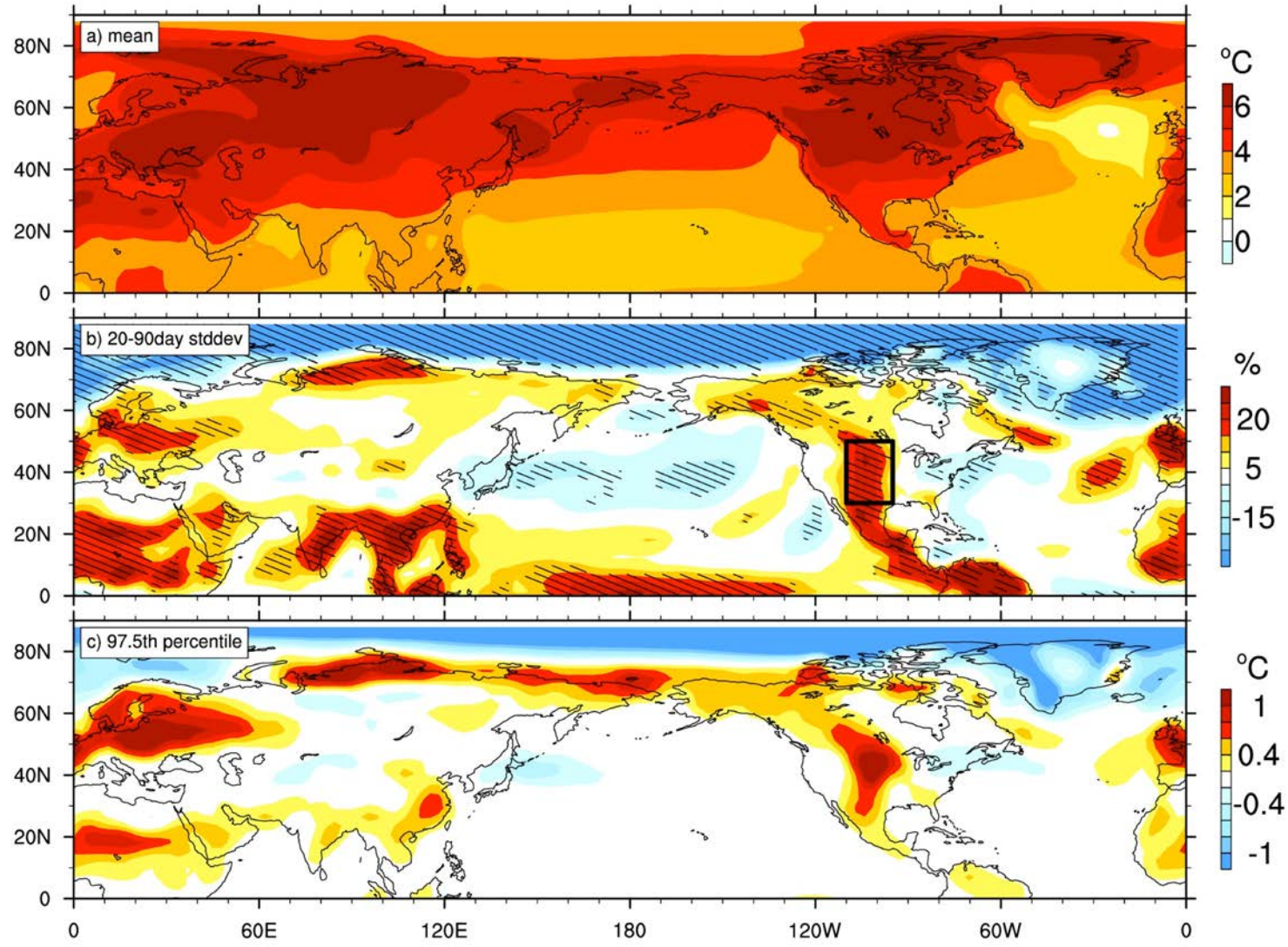
JJA surface air temperature (TAS)
change from 1980-2010 to 2070-2100 in CESM1

mean

remove time-evolving climo

20-90day Std dev

97.5th percentile

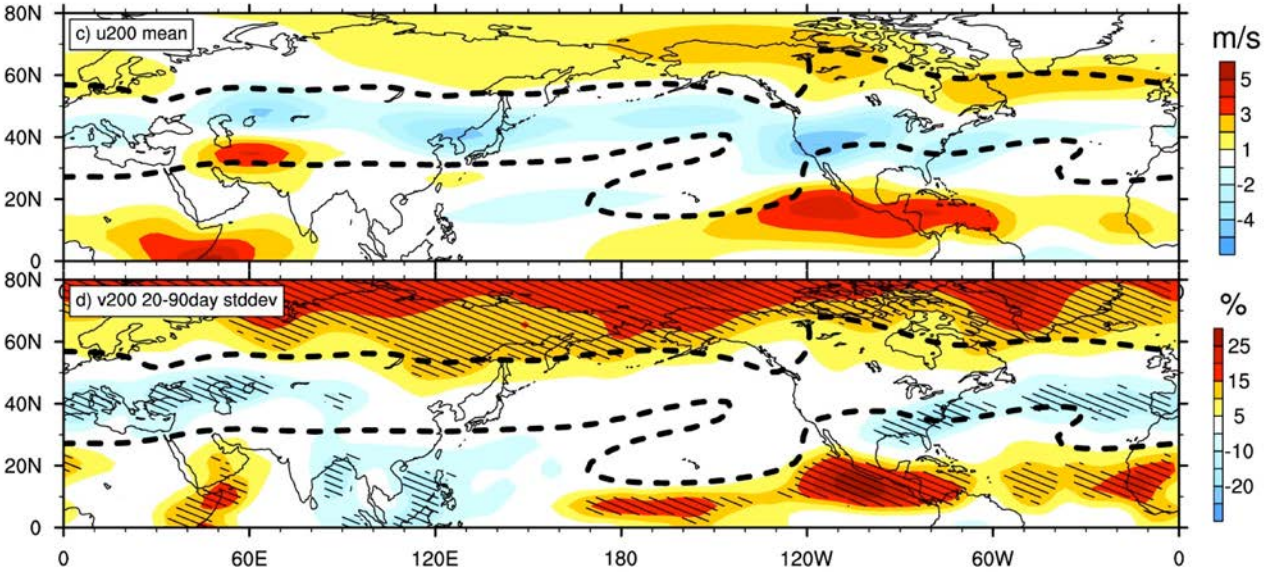


Will climate change amplify Rossby wave anomalies and cause stronger heat waves?

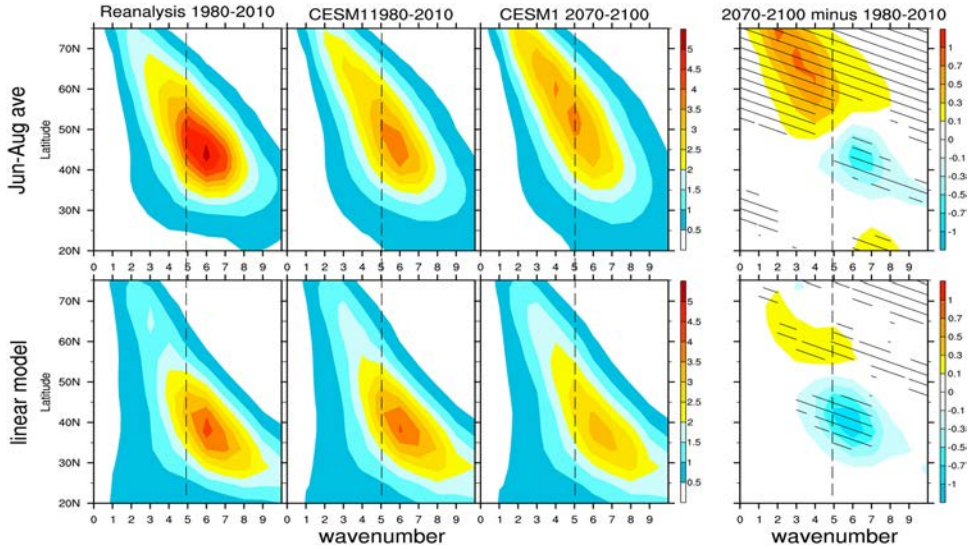
Change in the mean jet & subseasonal variability of planetary waves

U200 mean

20-90day V200 Std dev



Zonal wave variance of 20-90day V200

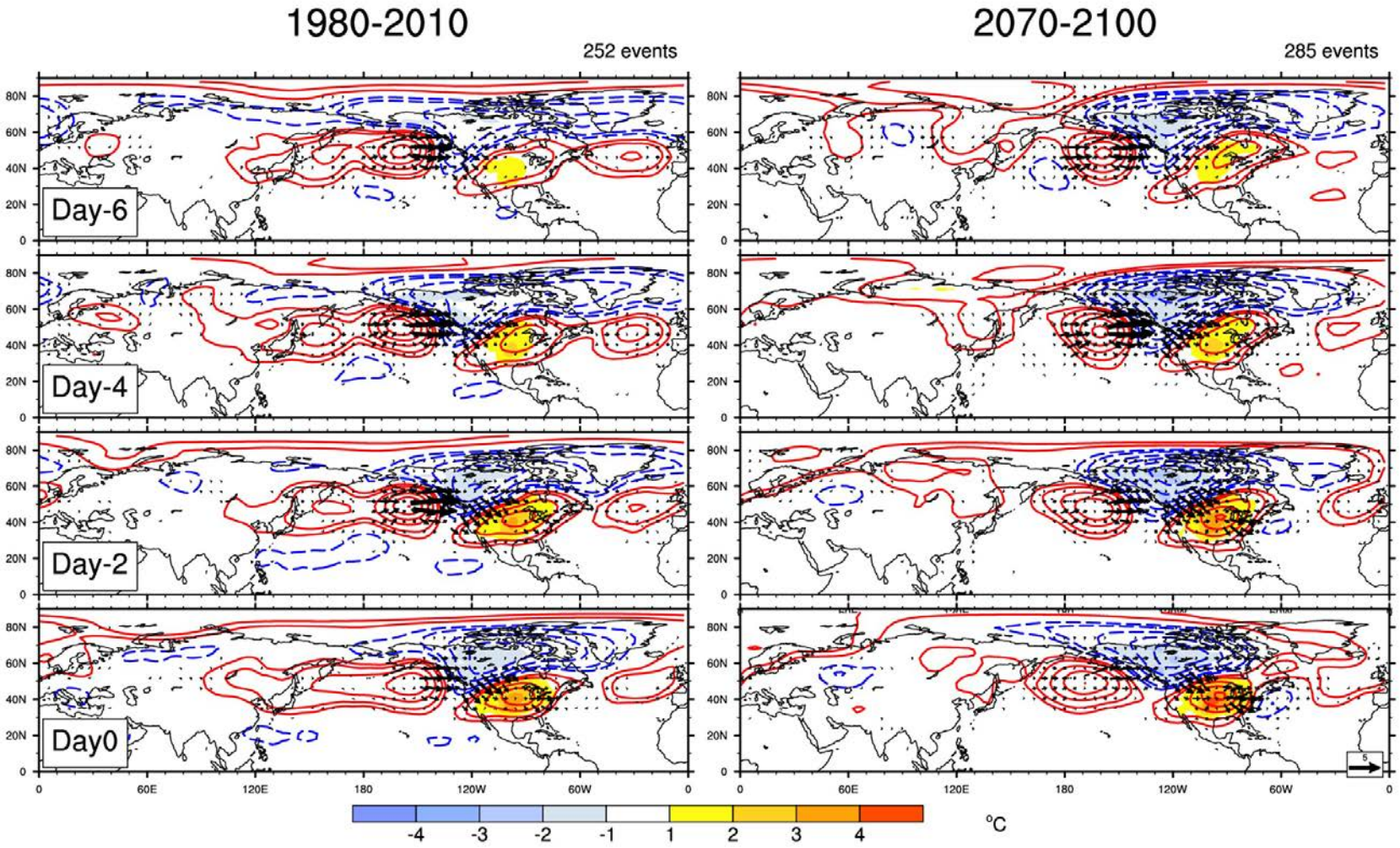


Reanalysis/CESM1

Linear planetary wave model

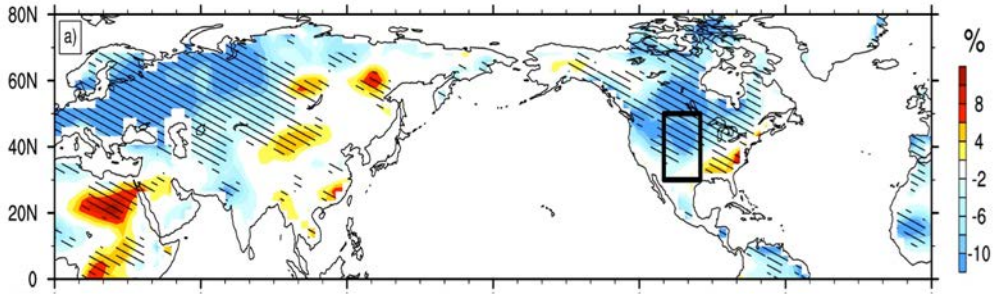
Will climate change amplify Rossby wave anomalies and cause stronger heat waves?

Great Plains heat wave composite
psi200, TAS & Plum flux



Will climate change amplify Rossby wave anomalies and cause stronger heat waves?

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

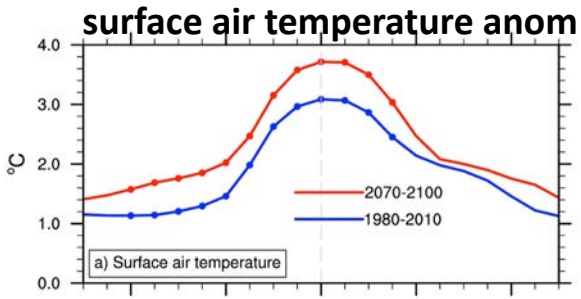


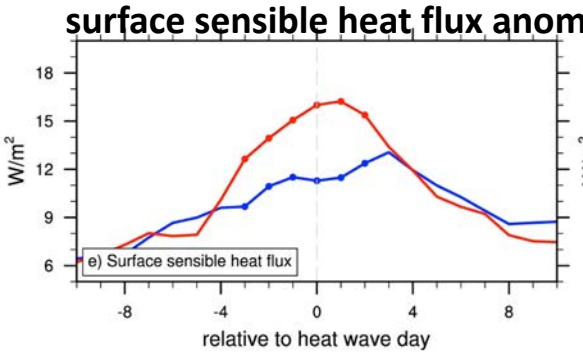
drier surface

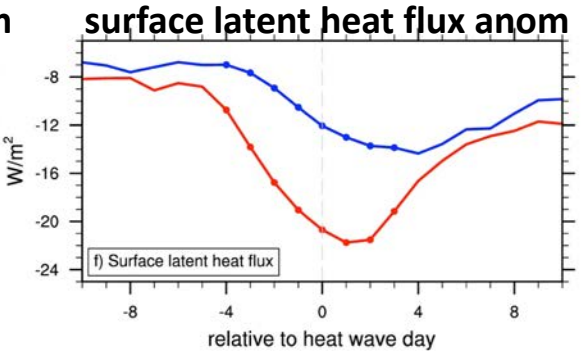
change
Bowen ratio

stronger
heat waves

Great Plains heat wave composites



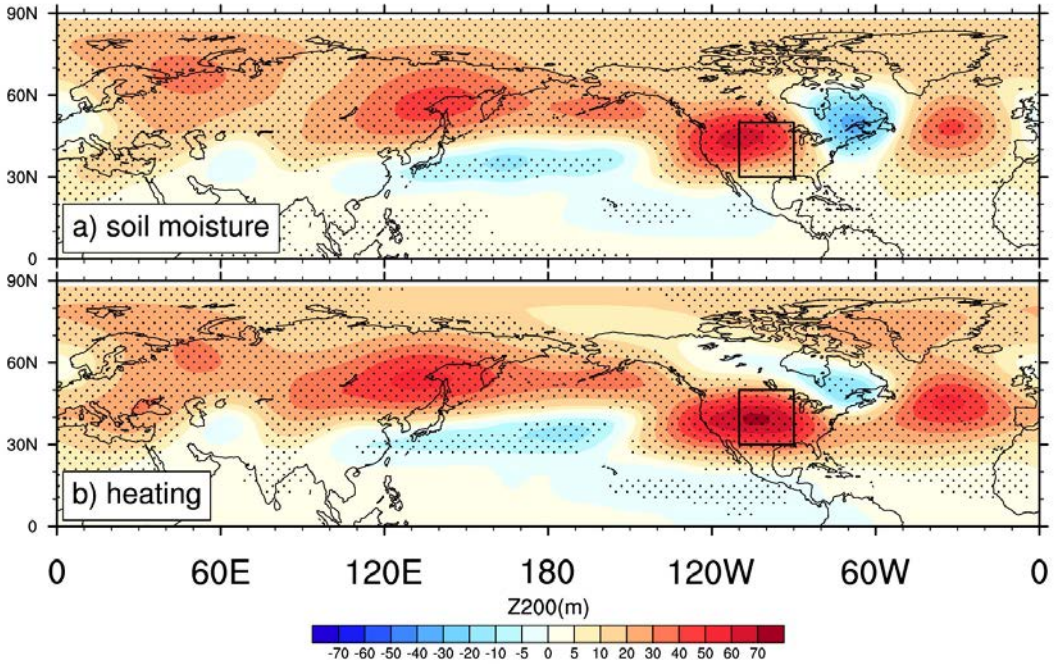




dots: 95% significant

Turning the land knob: How can regional soil moisture forcing excite circumglobal wave trains?

100-member mean MJJA Z200 response



- ✓ Take 100 different initial condtions from the 2600-year CAM5 atm/lnd stand-alone control
- ✓ Prescribe soil moisture in the Great Plains to close to zero
- ✓ Derive the near-surface diabatic heating anomalies in the soil moisture experiment
- ✓ Impose the heating in 100-member CAM5

Turning the land knob: How can regional soil moisture forcing excite circumglobal wave trains?

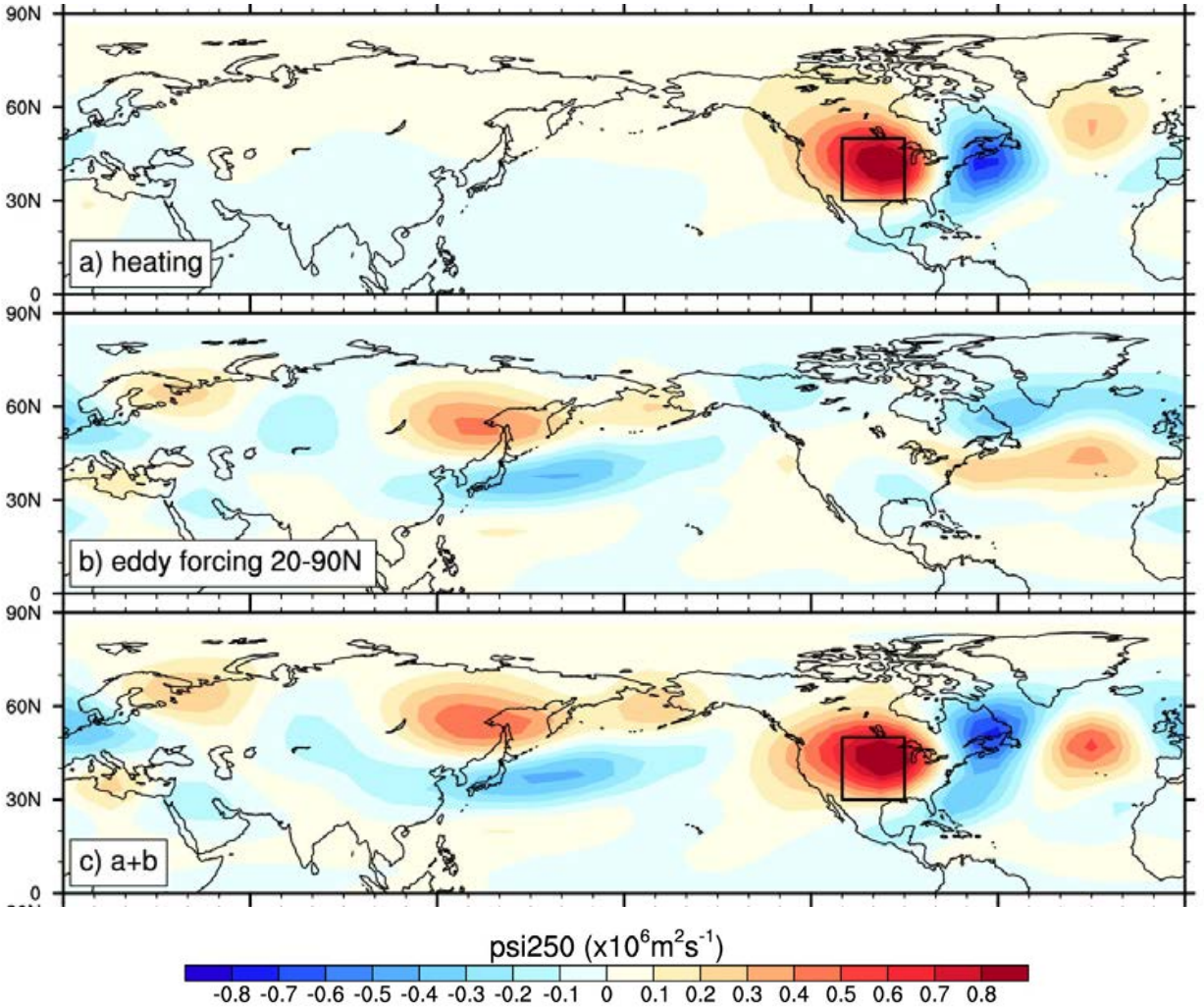
Linear planetary wave model response PSI250

heating

Eddy forcing

$-\nabla^{-2} V_{\psi}^{'} \bullet \nabla \zeta^{'}$

a+b



Will climate change amplify stationary wave variability and cause more extremes?

- Under a high emission scenario in CESM1, the **20-90day stddev of JJA TAS is increases by ~15%** over the Great Plains by the end of the 21st century.

- The increased temperature variability can be **partly** caused by **enhanced atmosphere-land interaction** under the future warmer/drier climate.

- Subseasonal variability in the planetary waves is slightly **reduced** in the midlatitude. In fact the planetary waves associated with Great Plains extremes become less, not more, circumglobal.

- CESM1 produces robust, consistent and circumglobal summertime circulation response to prescribed soil water at various US location. Synoptic eddies play a crucial role in producing the circumglobal response

Teng et al. 2016: Projected intensification of subseasonal temperature variability and heat waves in the Great Plains, Geophys. Res. Lett.

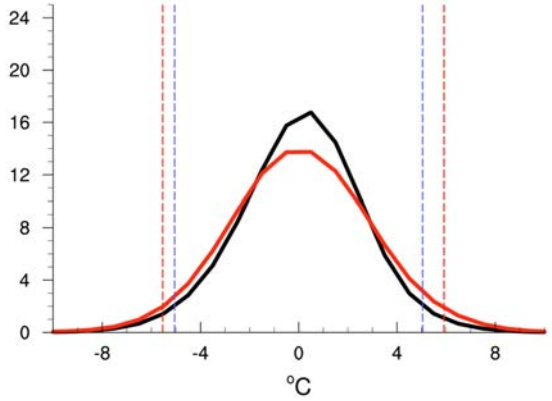
Teng et al. 2019: Circumglobal response to prescribed soil moisture over Norther America, J. Climate.

Teng et al. 2019: Amplification of waveguide teleconnection in the boreal summer, Curr Clim Change Rep, submitted.

Takeaways…

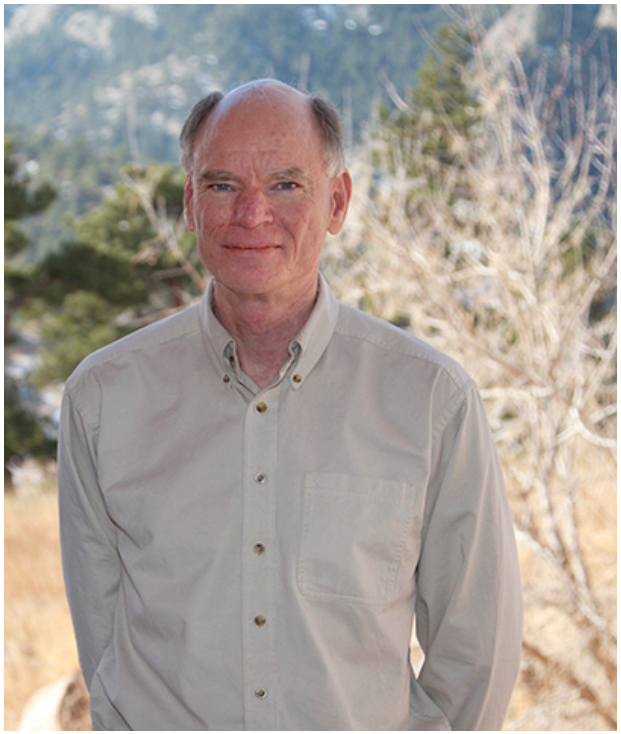
H_0

Don’t settle with stationarity: LENS is a great experiment for studying variability change!



Don’t settle with the model: turn the knob!

Acknowledgement



Grant Branstator

- Large ensemble
- Long control
- Process understanding