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

Haiyan Teng
NCAR CGD

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2010 July monthly mean anomalies

- Russian Heat Wave
- Pakistan floods
- Warmest Jul since 1961 in China
- New warmest record in many US cities
- Record cool summer in Santa Barbara

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 average 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
- 20-90 day Std dev
- 97.5th percentile
Will climate change amplify Rossby wave anomalies and cause stronger heat waves?
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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

dots: 95% significant

drier surface
change Bowen ratio
stronger heat waves

Great Plains heat wave composites

surface air temperature anom

surface sensible heat flux anom

surface latent heat flux anom

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 conditions from the 2600-year CAM5 atm/Ind 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 $-\nabla^2 \psi \cdot \nabla \zeta$
- $a+b$

psi250 (x10^6 m^2 s^-1)

-0.8 to 0.8
Will climate change amplify stationary wave variability and cause more extremes?

- Under a high emission scenario in CESM1, the 20-90 day 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. 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...

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

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

- Large ensemble
- Long control
- Process understanding

Grant Branstator