Remote Influences of Atmospheric and Oceanic Variability on Heat Waves and Cold Spells in a Regional Climate Model

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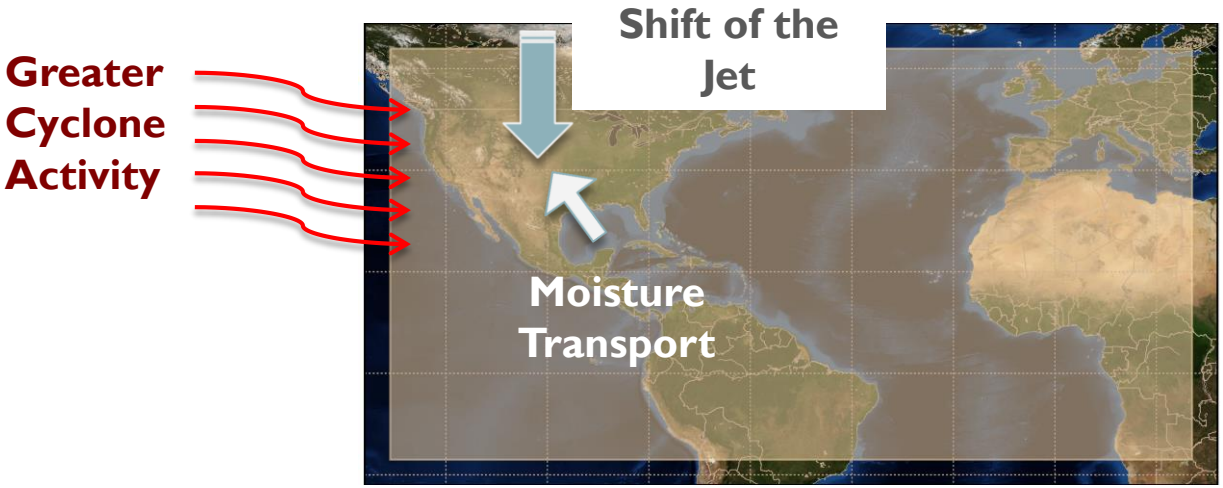
Does variability in the surface and/or lateral boundaries of a domain lead to increased likelihood of extremes within the domain?

1993 Midwest Flood : Synoptic Variability

- Bell and Janowiak (1995), Mo et al. (1995 and 1997)
  - Above normal North Pacific cyclone activity.
  - Increased moisture transport by Great Plain Low Level Jet.
  - Southward shifted North American Jet.



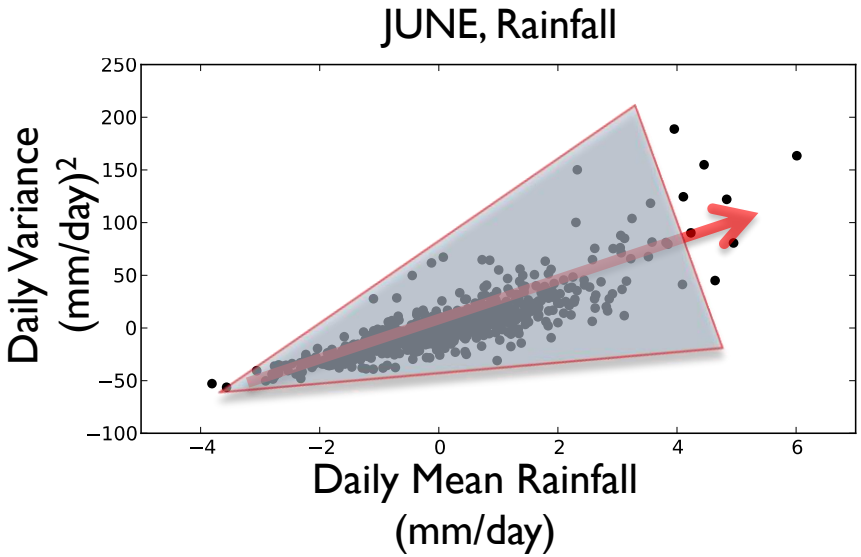
What do we know about ENSO ?

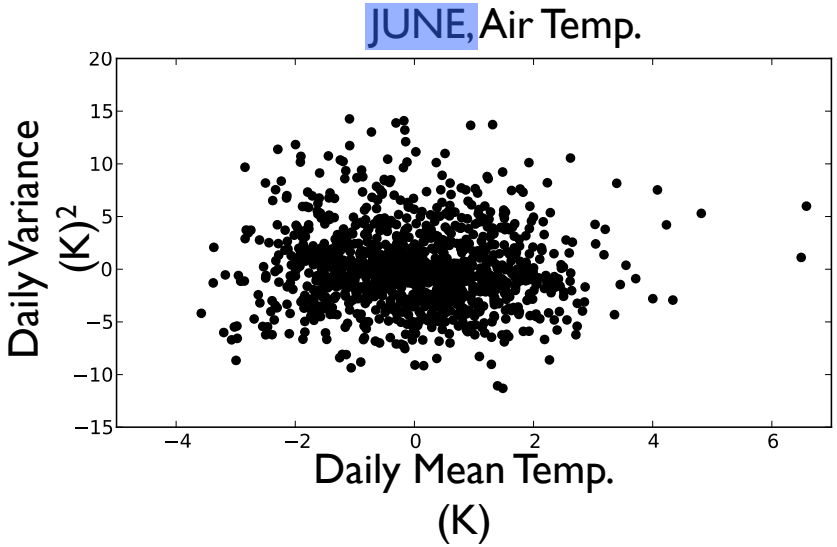
- Largest known source of inter-annual variability.
- Northwest and Southwest United States' contrasting response.
- Positive correlation with Texas and Central US rainfall.
- Future changes in teleconnections linked to the change in the mid-latitude base state circulation would affect extreme events. (Meehl et al., 2007b, GRL)
- Winter Storms and thus precipitation variability significantly impacted by ENSO. (Schubert et al., 2007, Journal of Climate)

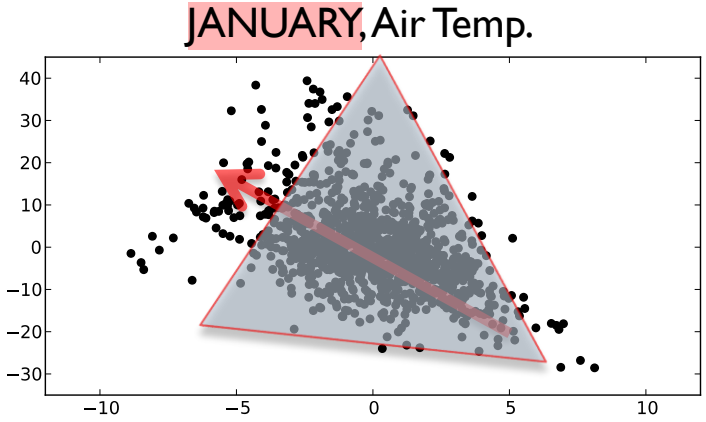
What is the response of variability to the change in mean from a regional perspective?

An Observational Analysis

Variability Vs Mean

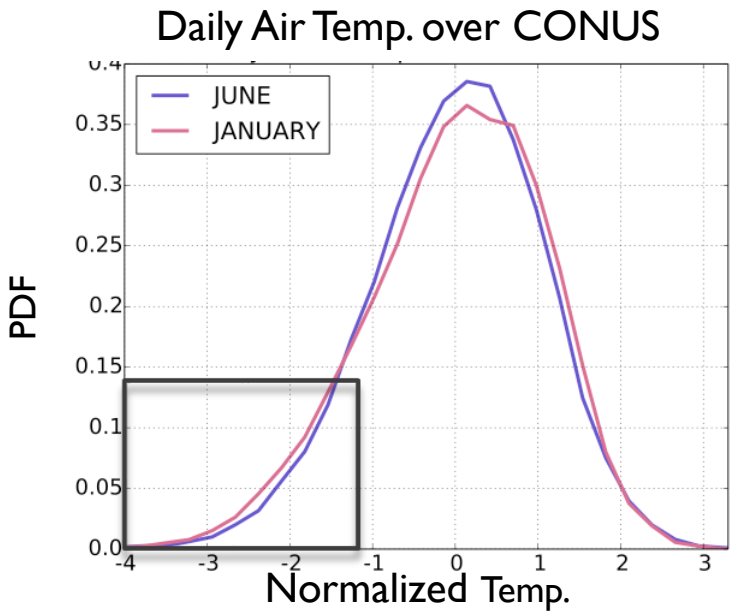


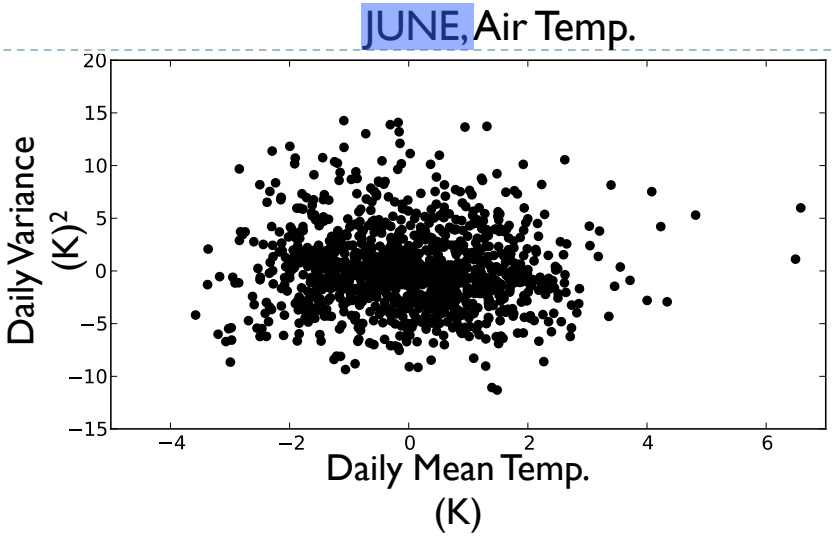


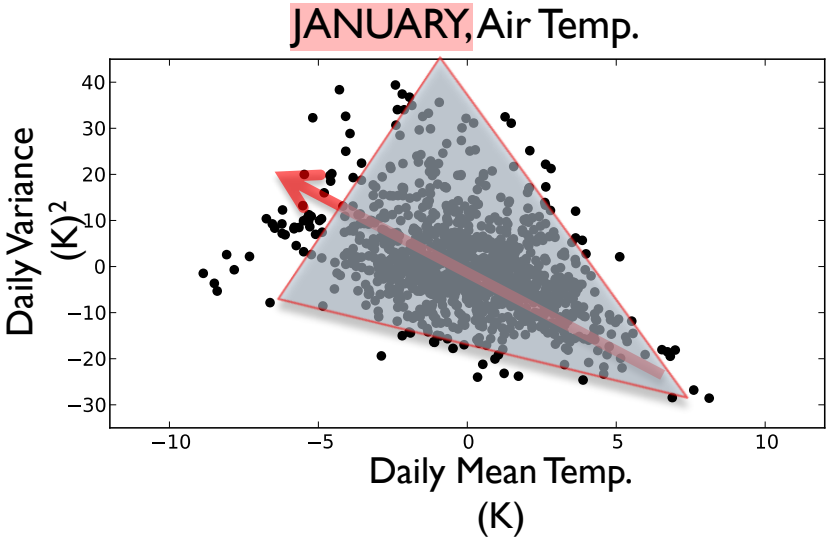


- Data Source and Region : North American Regional Reanalysis (NARR) over the Contiguous US, 1979-2013

Variability Vs Mean

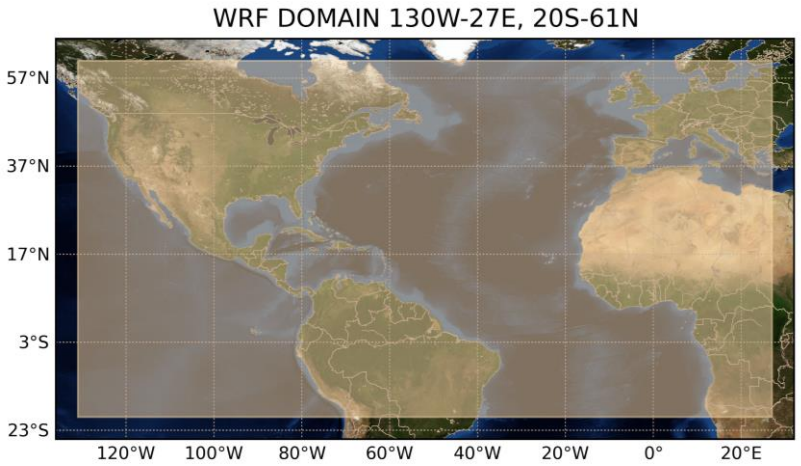






Physical Cause : Colder events determine the variability during the winter.

Model Details



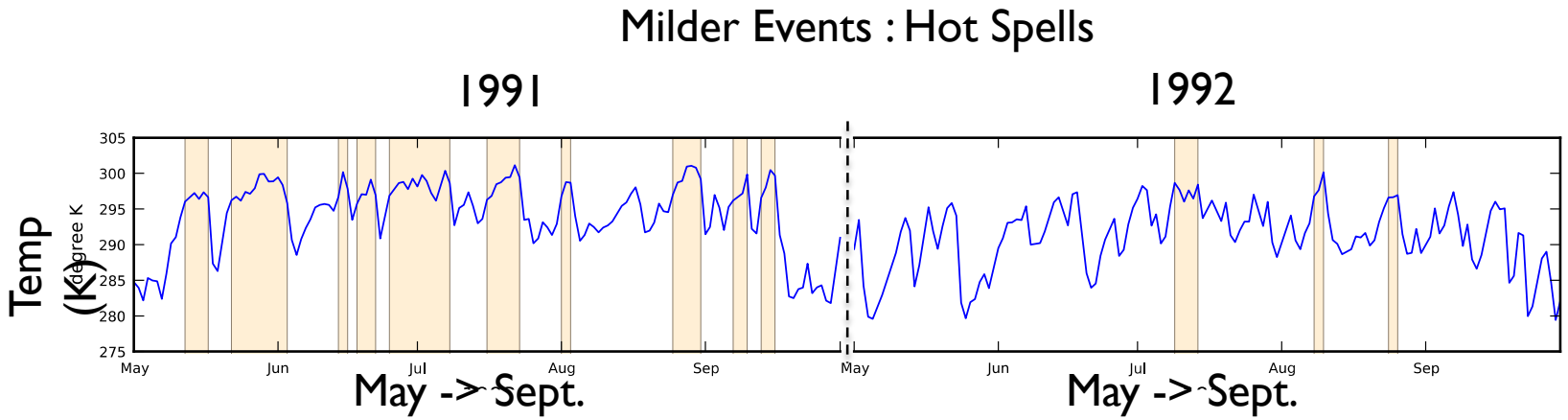
- Weather Research and Forecasting (WRF) model version 3.3
- 27 km horizontal resolution, 28 levels in the vertical.
- Physical Parameterizations - Kain-Fritsch Cumulus, Lin et al. Microphysics, RRTMG longwave and Goddard shortwave radiation, Yonsei University (YSU) planetary boundary layer schemes.

Model runs are performed by Christina Patricola.
Refer Patricola et al. (2013) for more details.

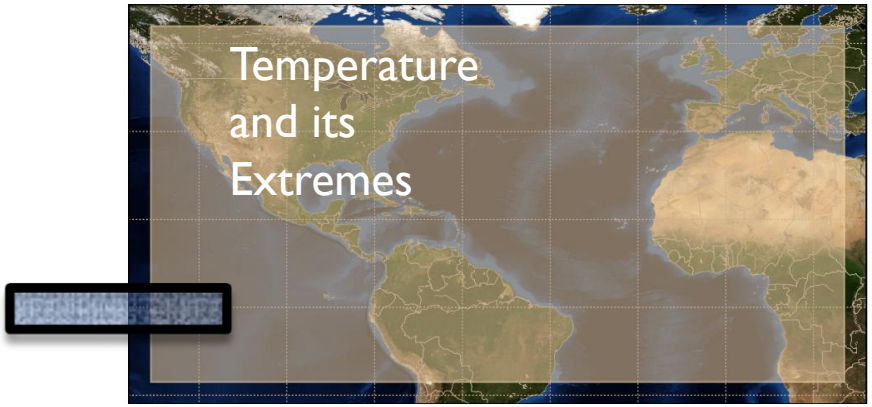
Identifying Heat Waves

- A period is considered a heat wave if :
  - ✓ temperature is above 97.5 percentile threshold for at least 3 days;
  - ✓ average temperature during the period exceeded the 97.5 percentile;
  - ✓ temperature exceeded the 81 percentile threshold for every day.

the longest such period is a single heat wave. (Kunkel et al., 2010)



Remote influences of Inter-annual Variability of SST

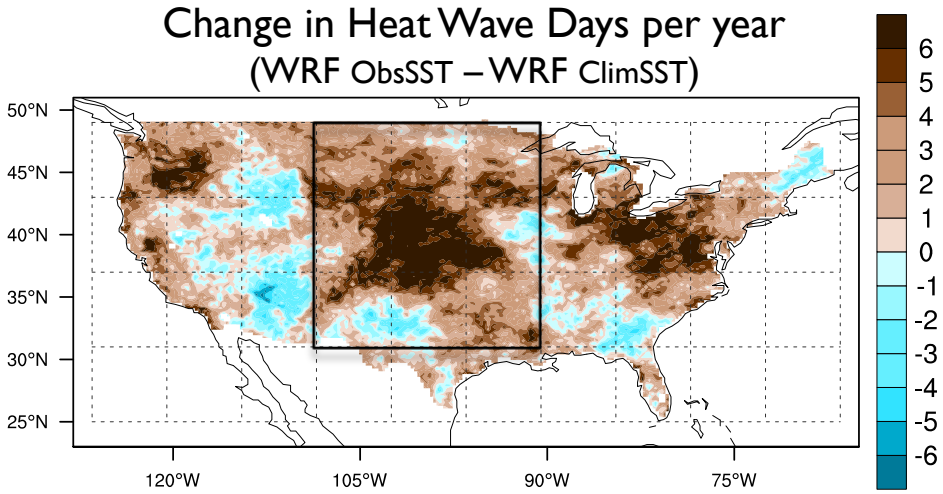


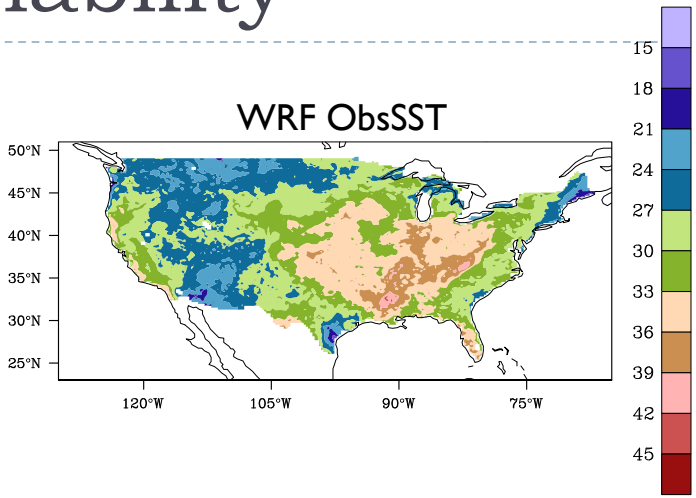
Study Methodology

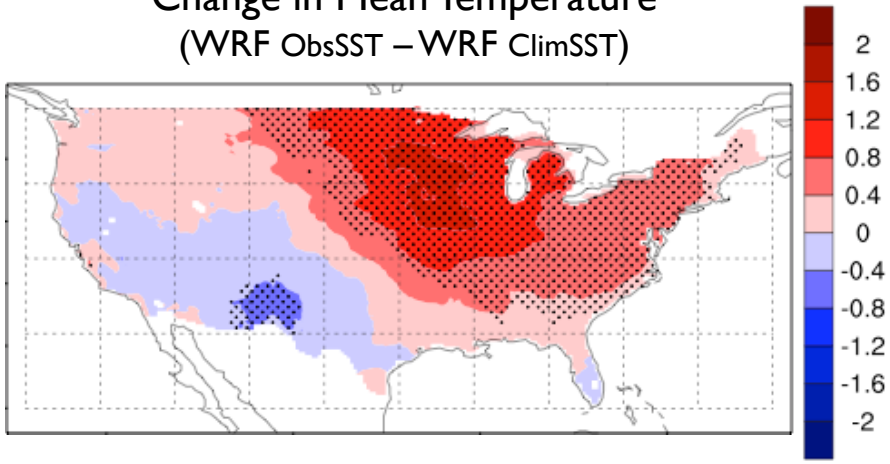
Inputs	WRF ObsSST	WRF ClimSST
SSTs	Observed (1981-2000)	Climatology (20 years)
Lat. BCs	Observed (1981-2000)	>28 days filtered out, Seasonal cycle added

*Boundary Data : HadISST and NCEP Reanalysis

Heat Waves and SST Variability

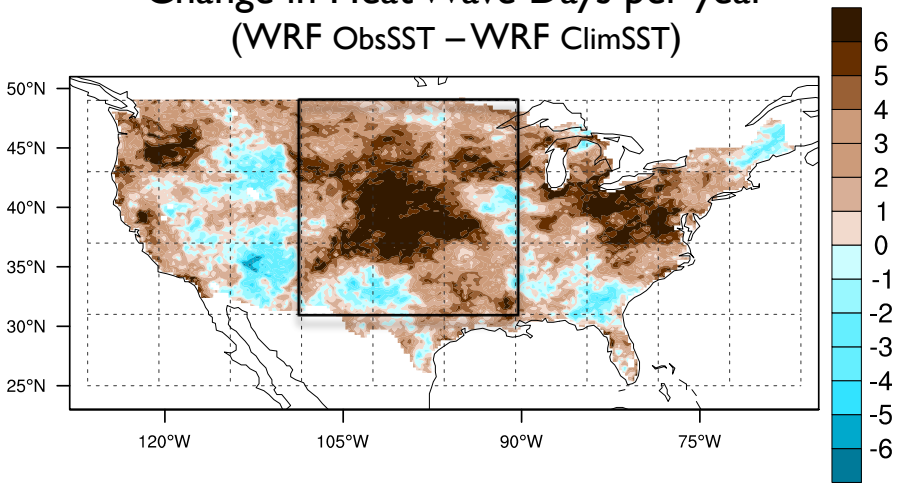




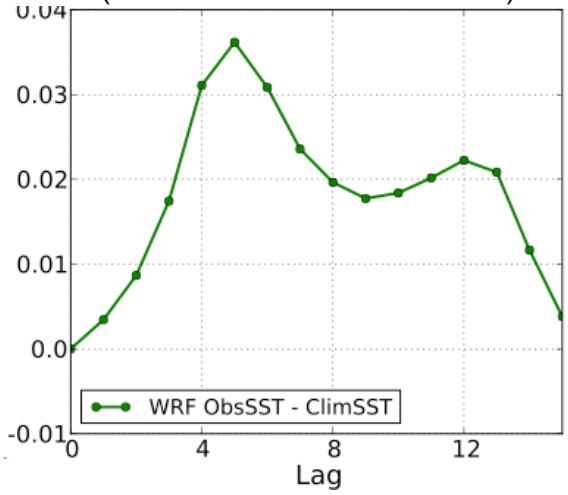


Heat Waves and SST Variability

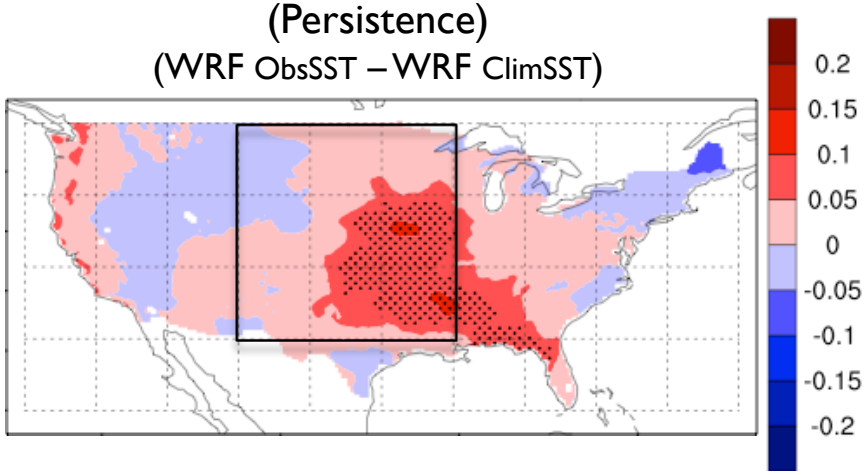
Change in Heat Wave Days per year
(WRF ObsSST – WRF ClimSST)



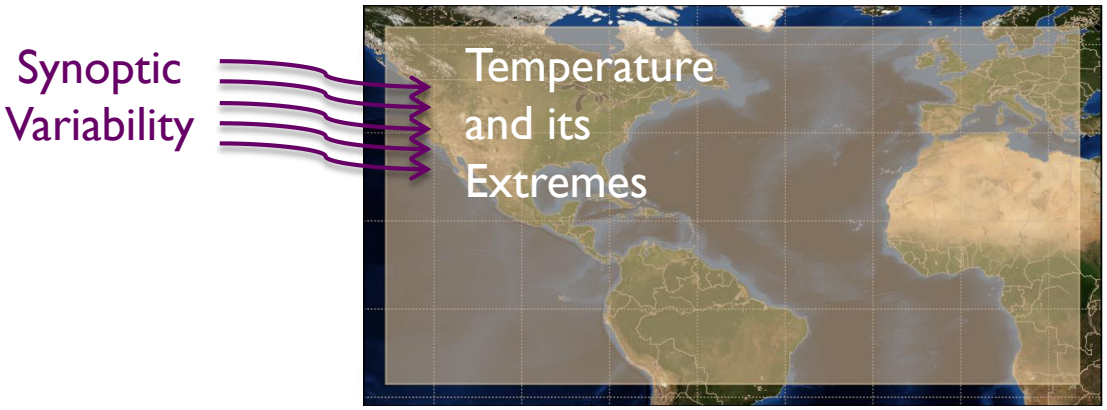
Change in Lag Autocorrelation (Persistence)
(WRF ObsSST – WRF ClimSST)



Change in Lag5 Autocorrelation
(Persistence)
(WRF ObsSST – WRF ClimSST)



Remote influences of Synoptic Atmospheric Variability



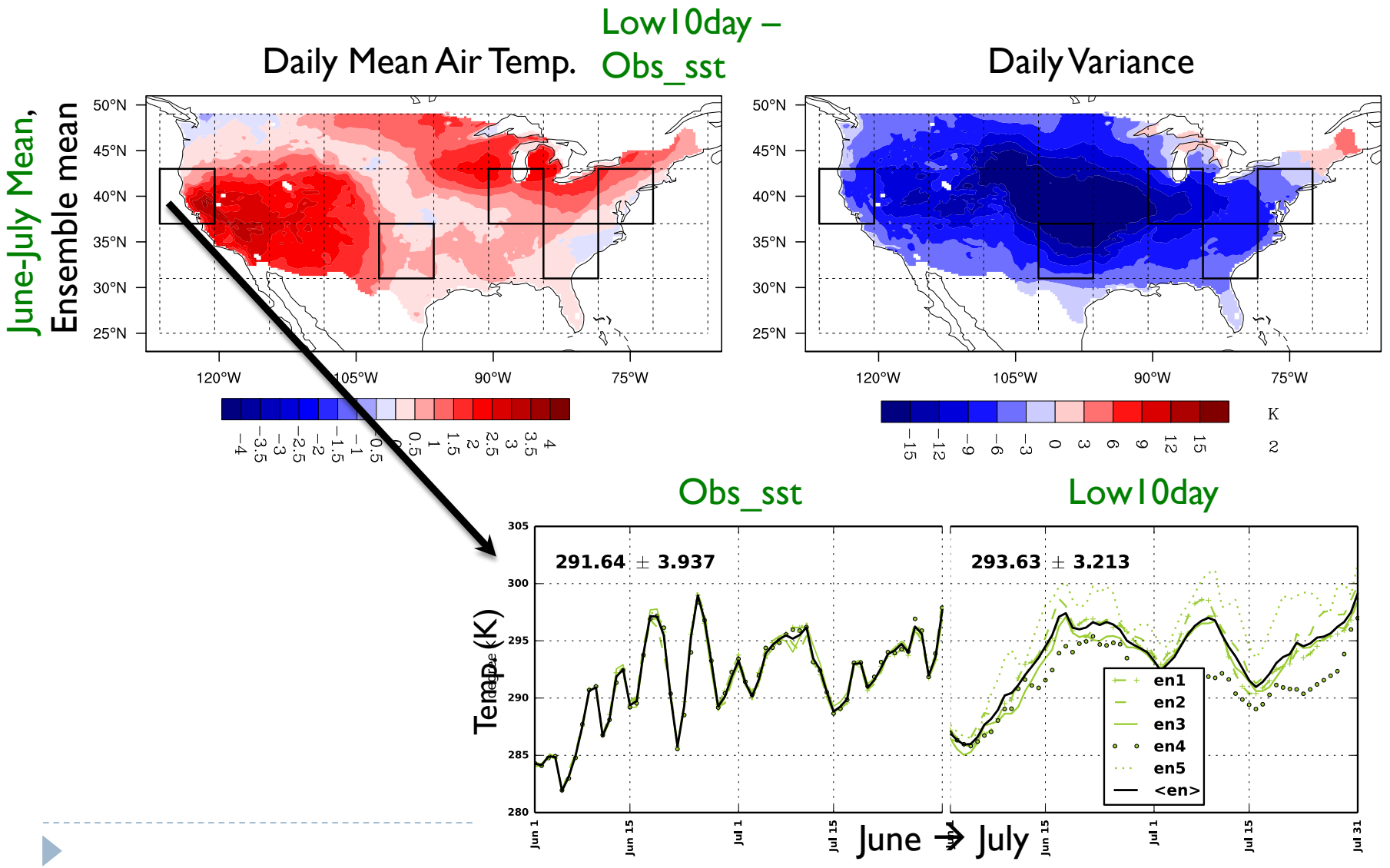
Study Methodology

5 member ensemble of seasonal runs.

Inputs	WRF ObsSST	WRF Low10day
SSTs	Observed	Observed
Lat. BCs	Observed	<10 days filtered out western boundary

*Boundary Data : HadISST and NCEP Reanalysis

Response to Synoptic Variability from the Pacific

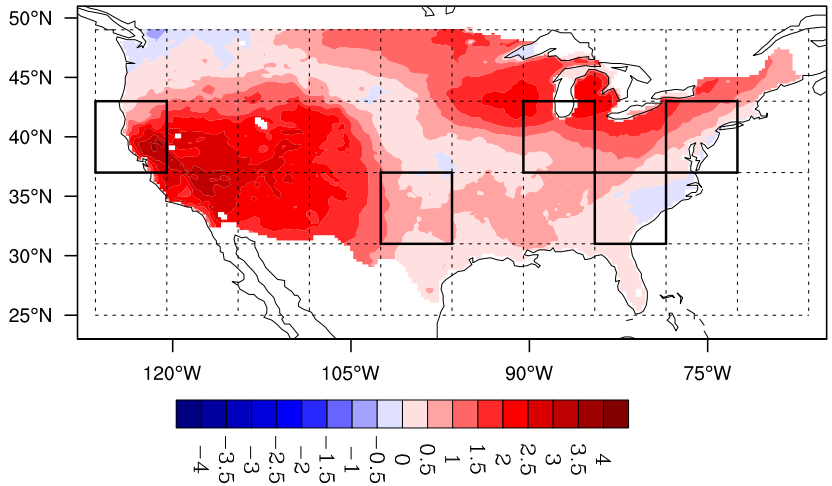


Response to Synoptic Variability from the Pacific

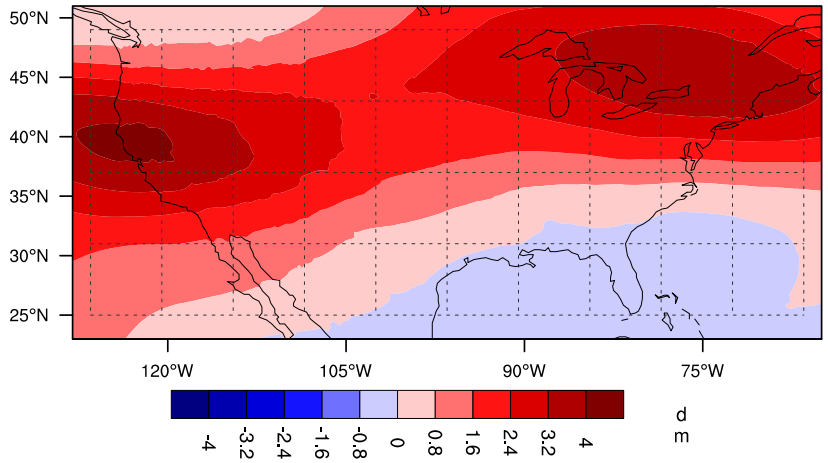
June-July Mean, Ensemble mean

Daily Air Temp.

Low10day – Obs_sst



500mb Geopotential Height



• Similar responses in surface temperature and 500mb heights indicates synoptic eddies impacts surface temperature field through changing mean upper atmosphere circulation.

Summary

- Contrasting variability-mean relationship for rainfall and (wintertime) temperature.
- Heat wave activity is sensitive to remote SST variability.
  - Increased persistence in ObsSST runs is associated with more prolonged heat waves.
- Removal of synoptic eddies from the Pacific changes mean circulation over the US.