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Transition Into The Anthropocene

Evaluating mechanisms of temperature extremes

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(photo: ntl geographic)

And material from: Haiyan Teng

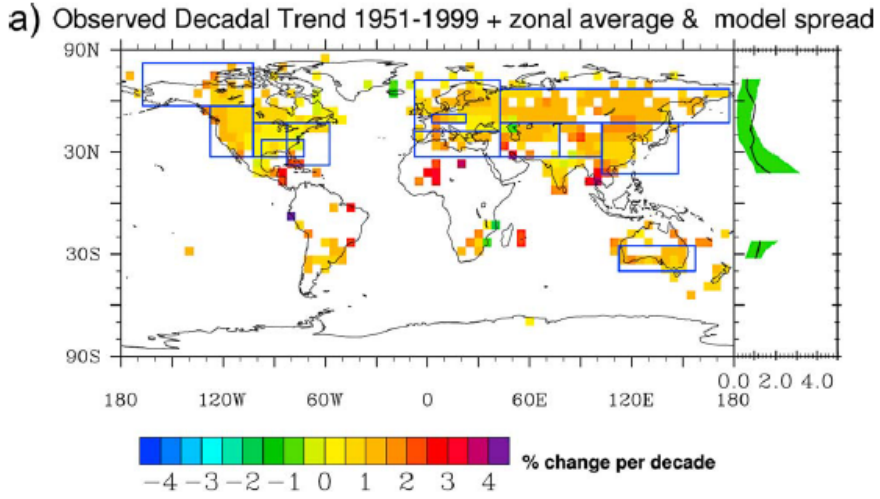
Do models simulate changes in extremes for the right reason?

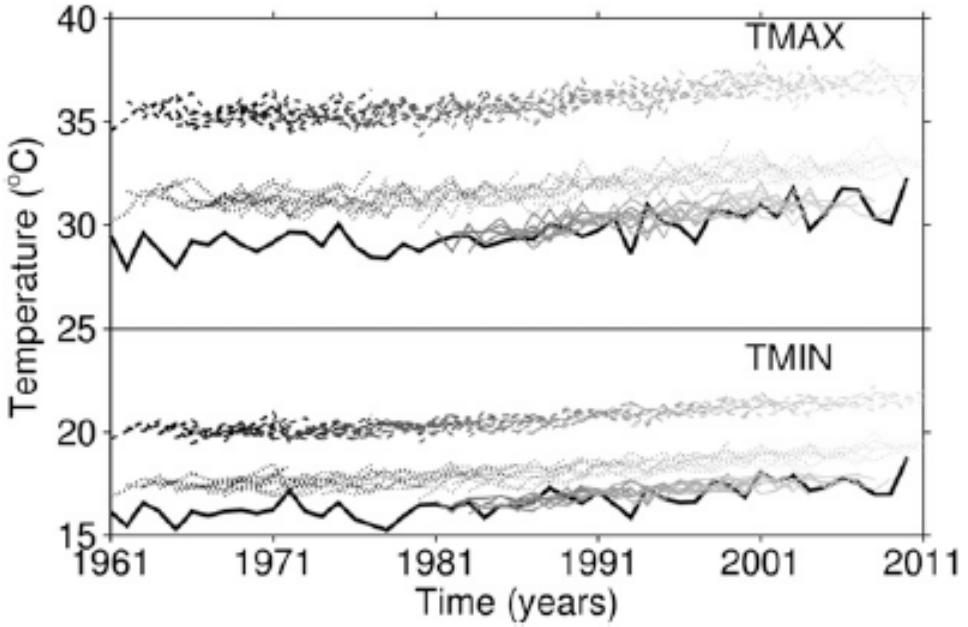
- Models capture trends in indices of moderate temperature extremes, although not in every region and variable (eg fig. 10.19)

From Morak et al. 2011, TN90

Although biases are substantial, and different for extremes from means (Hanlon et al., 2013)
Here max5day Tmax over Europe

Predictability from forcing largely





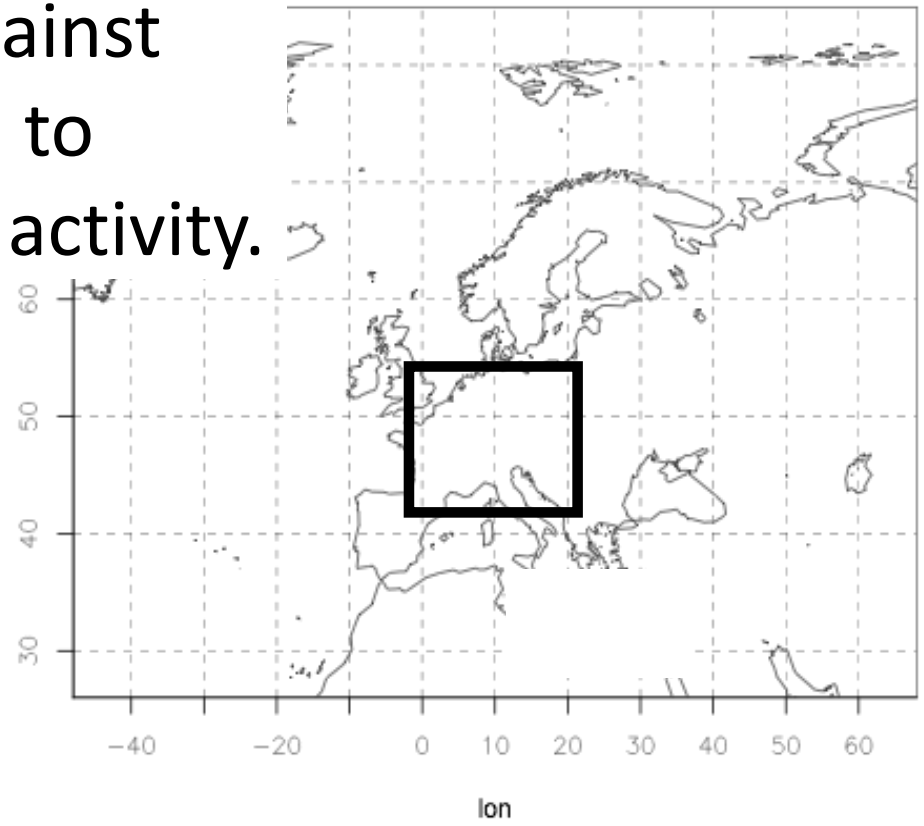
Study of Central European moderate extremes (Krueger et al., 2014, ERL)

- Area averages of the SAT anomaly over Central Europe

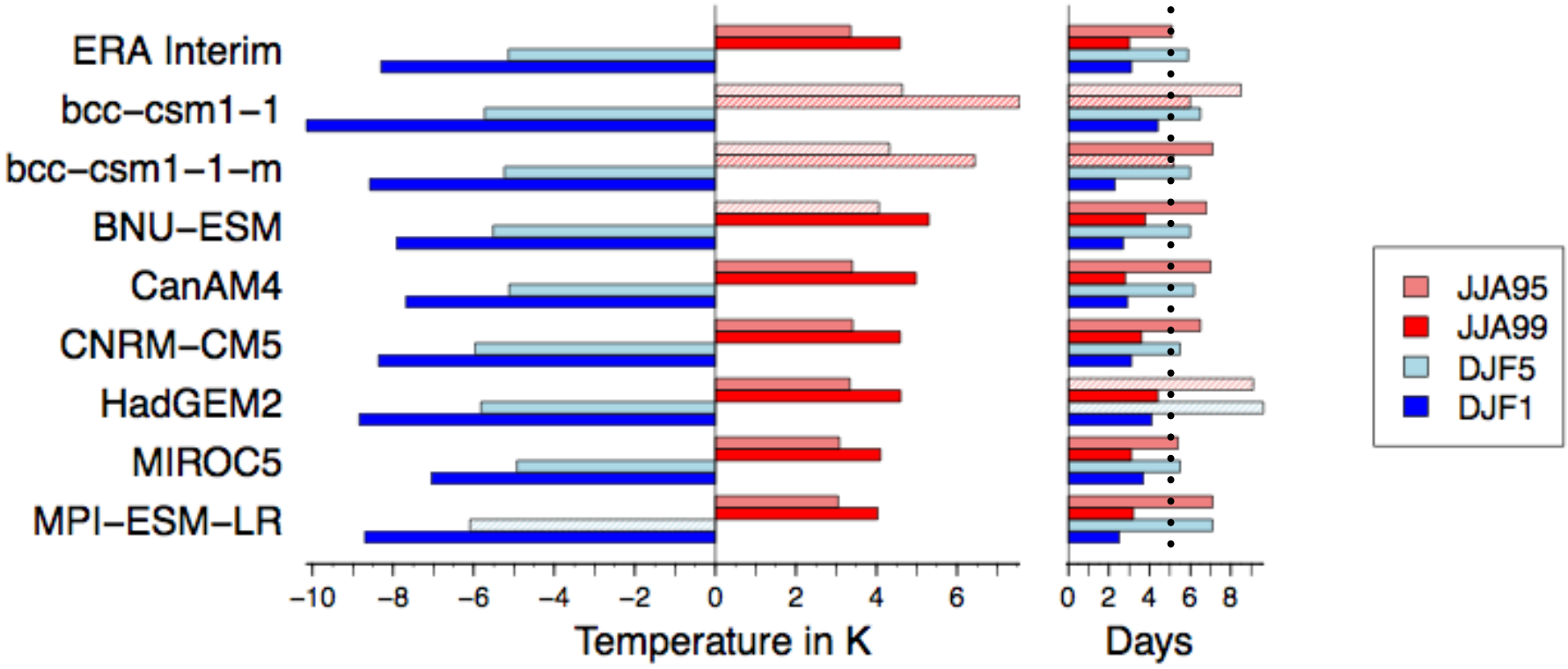
- Detrended and lowpass-filtered (10 days) anomalies (against 1981-2005 climatology) to focus on synoptic-scale activity.

- warm summer event: anomaly > 95th %

- cold winter event: anomaly <5th %



Temperature Amplitude and Length



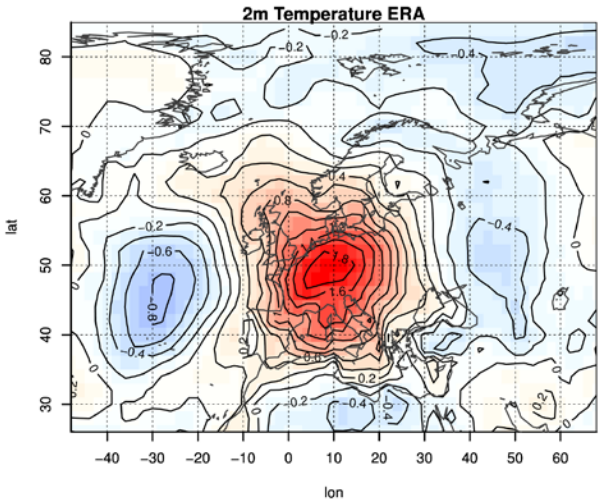
1st, 5th, 95th, 99th DJF and JJA percentiles of the area averaged temperature anomaly over Central Europe.

Average length of events in years with events.

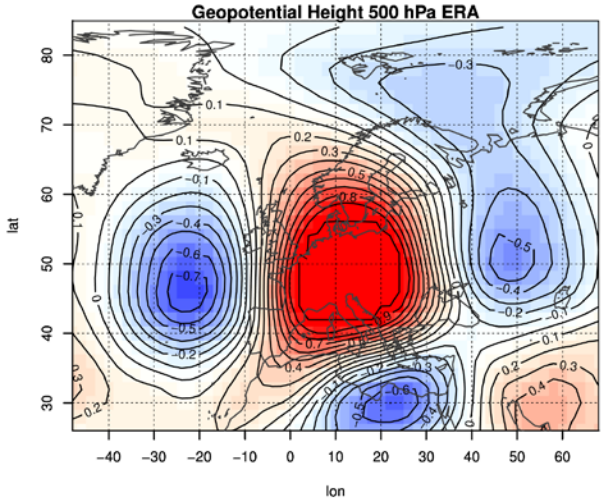
(~5 days expected total for 5th/95th pctl)

Composites of warm summer events (no ev for multi-modes)

ERA Interim

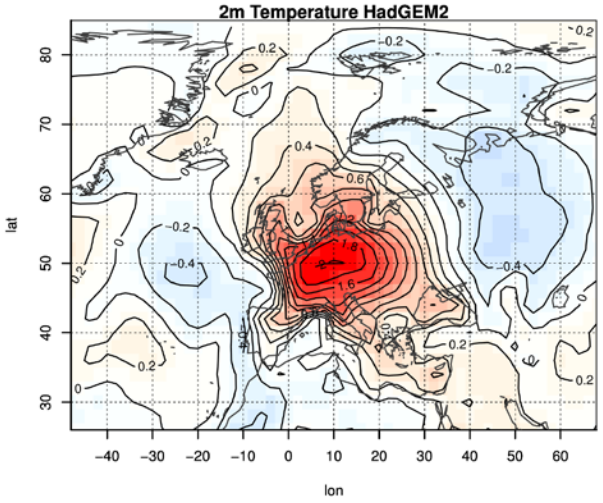


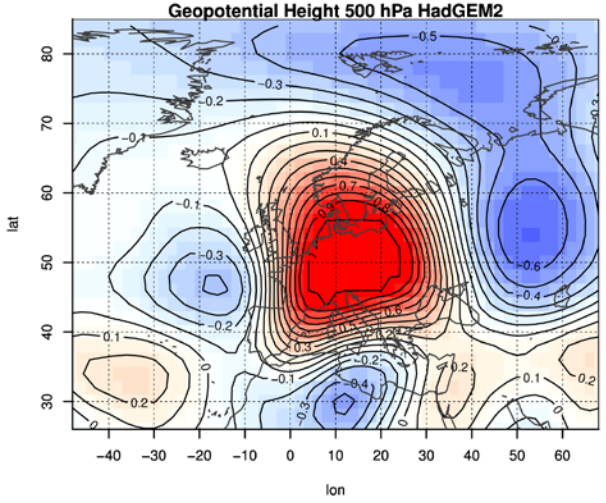
Temperature

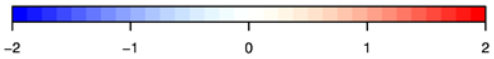


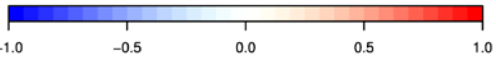
Geopotential Height

HadGEM2



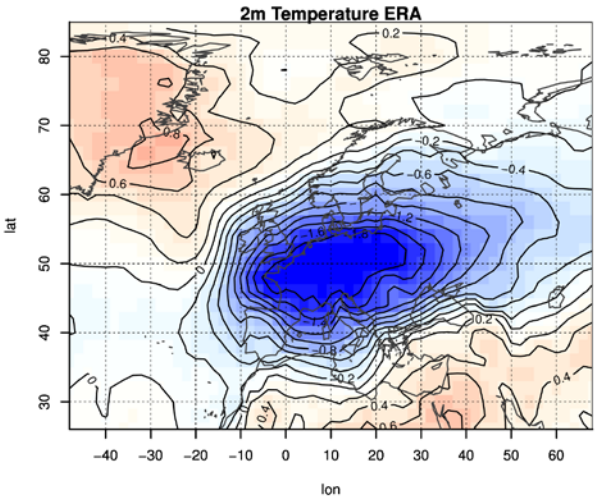


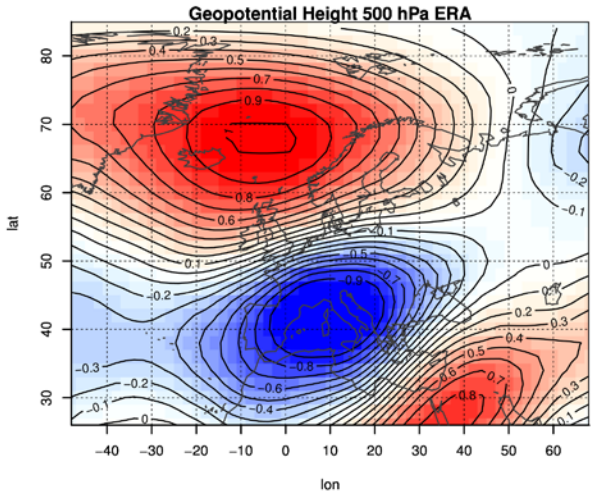




Composites of cold winter events

ERA Interim

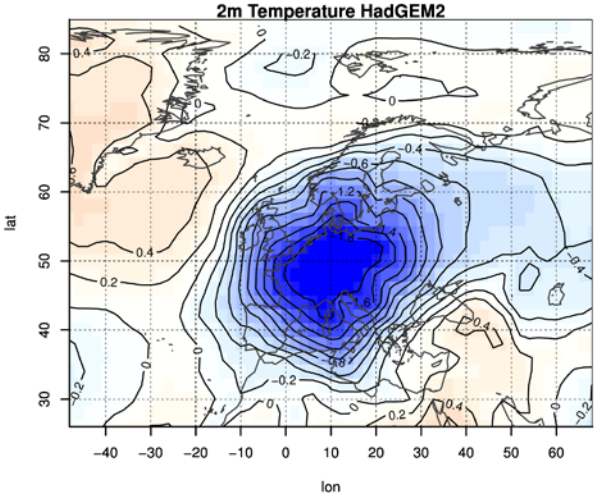


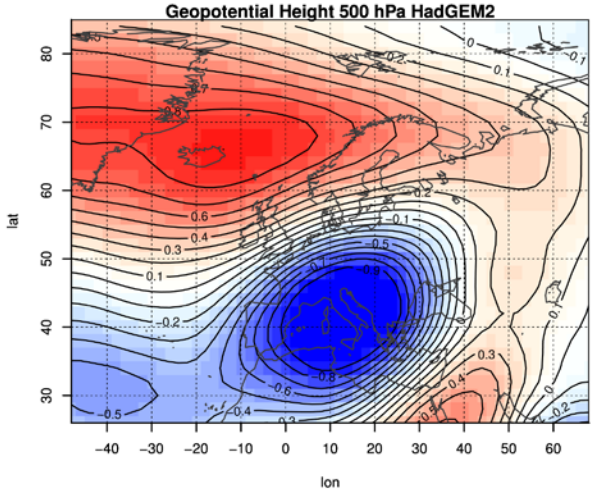


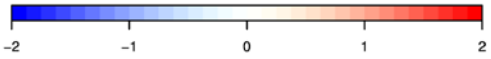
Temperature

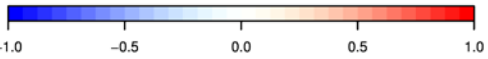
Geopotential Height

HadGEM2





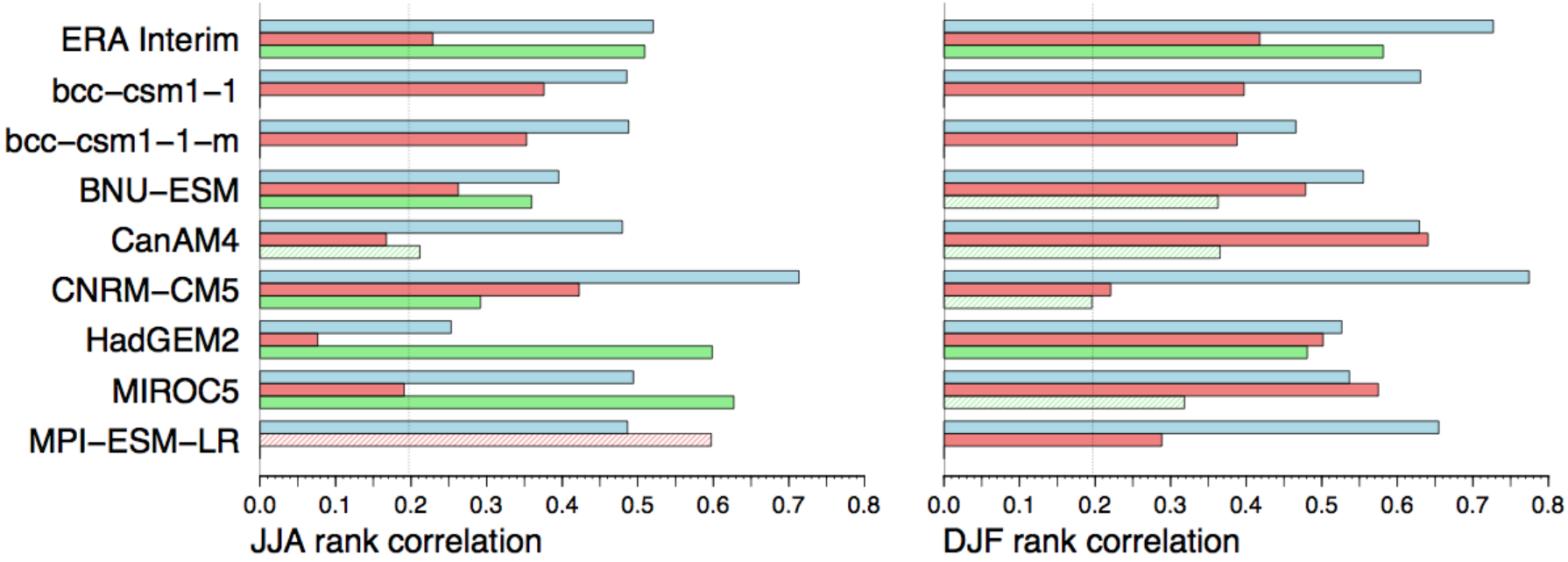




Pattern projections: Attempt to quantify contributions

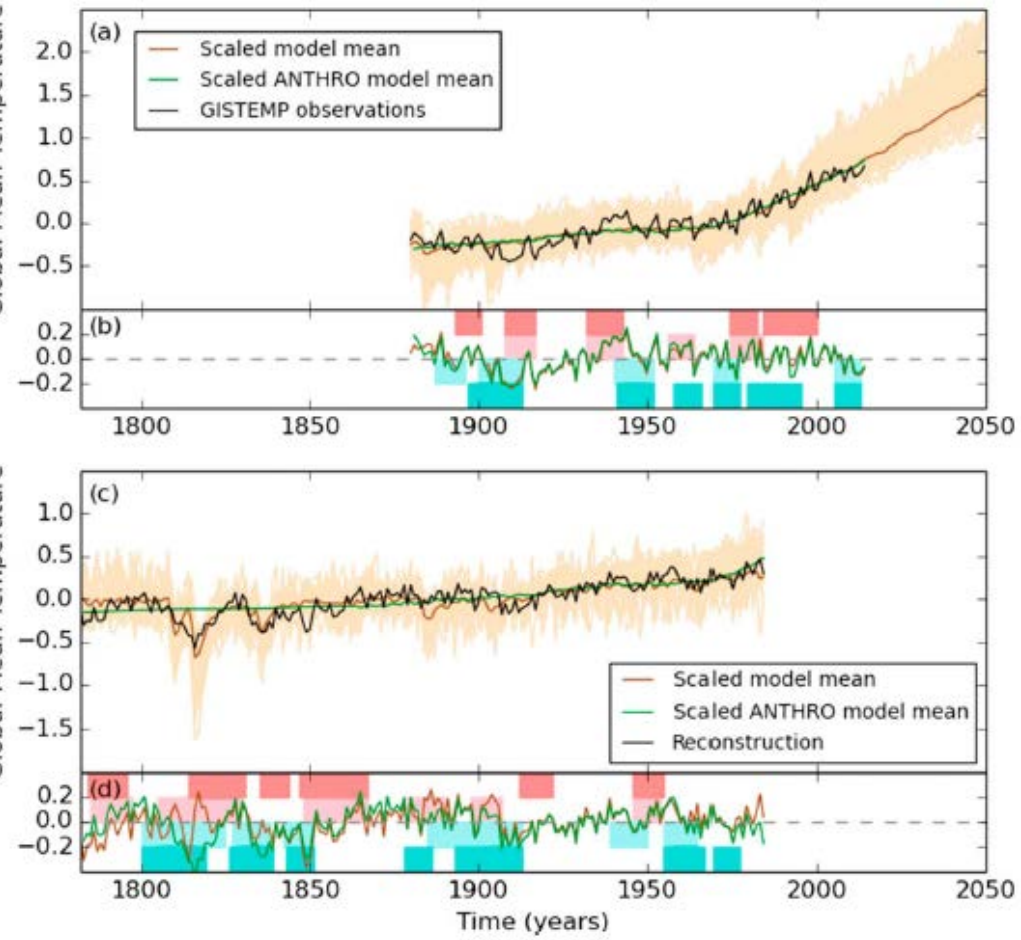
Rank correlation between patterns of temperature extremes and explanatory variables

– how best to quantify contributors to extremes? Lags/precursors?

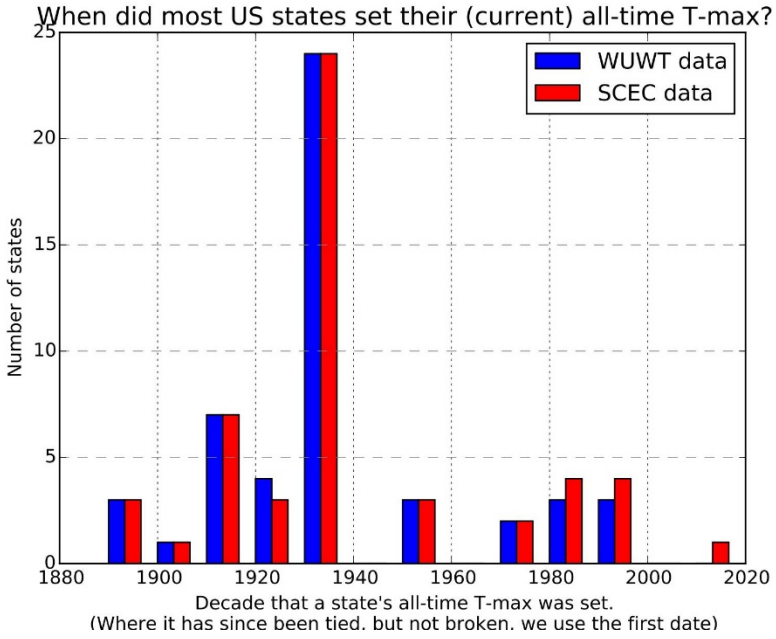


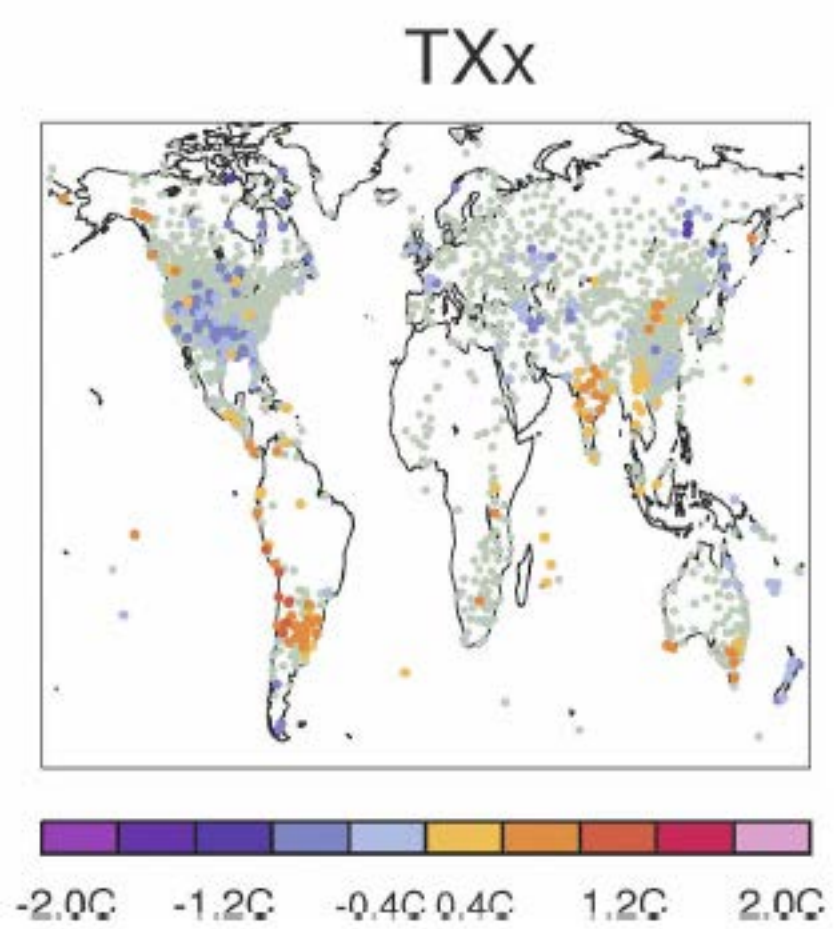
Changes in the past pronounced decadal variability

Global surface temperature (from Schurer et al. 2015)



US temperature extremes





Role of large scale drivers

- Temperature of hottest MJJASO season day/yr in El Nino yrs vs neutral
- only 11%-15% of stations have significant ENSO influence in boreal warm, different from cold)

(Kenyon and Hegerl 08)

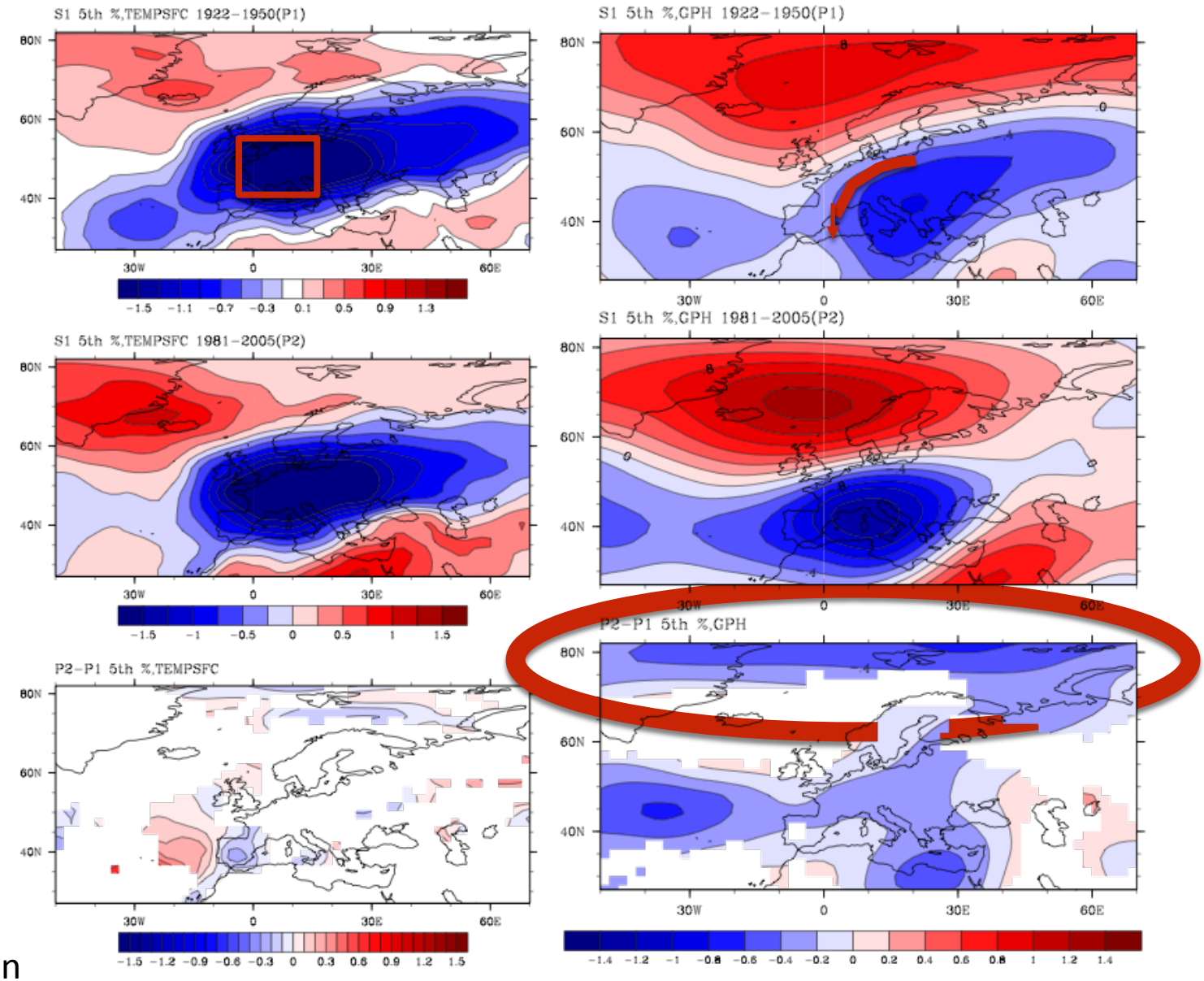
Difference for Winter extremes? Europe

1922-1950 (robust in reanalysis)

1981-2005

Differences – statistically significant?

Colfescu, in contemplation

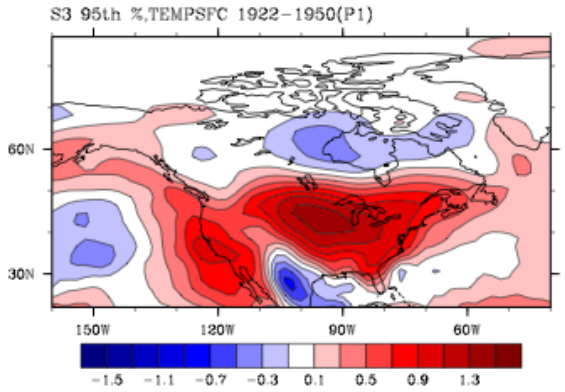


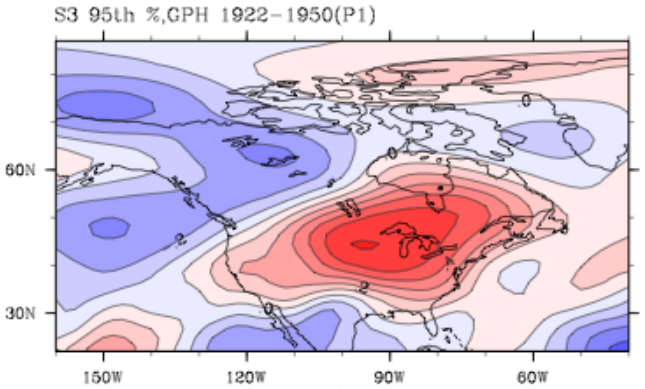
Difference summer extremes NAmerica

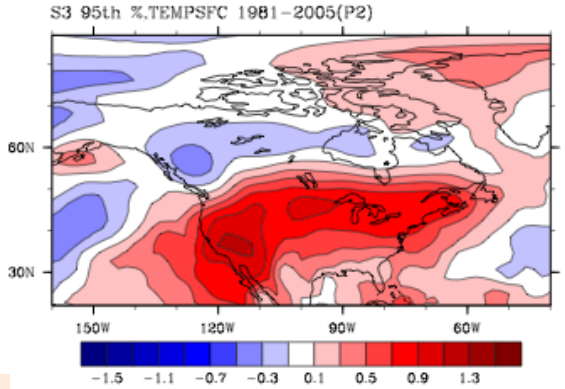
1922-1950 (robust in reanalysis)

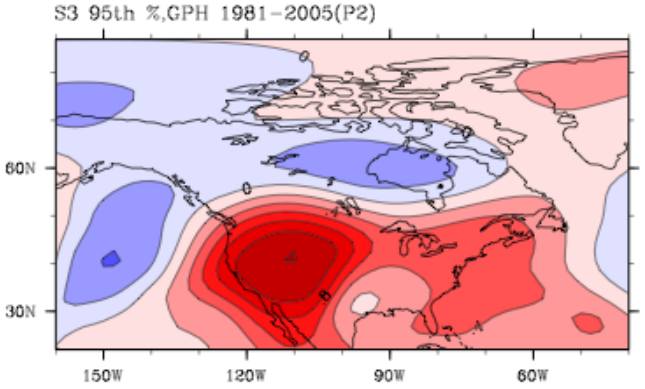
1981-2005

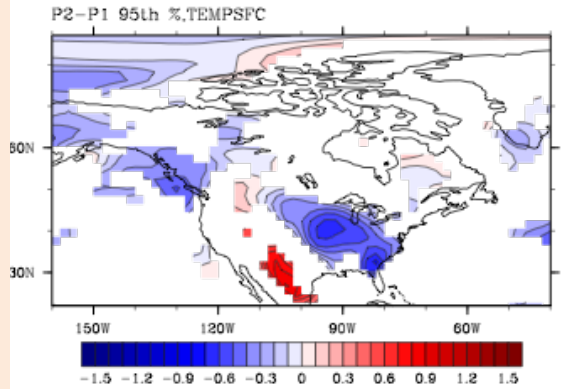
In both cases: relationship circulation to temperature anomaly much weaker early on. Data??

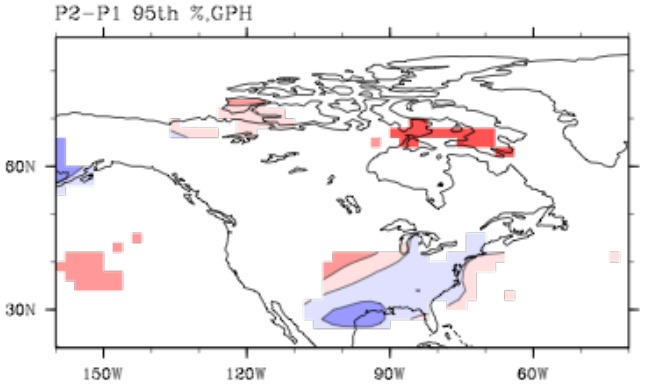












Heat wave metrics (from Tim Cowan, in prep)

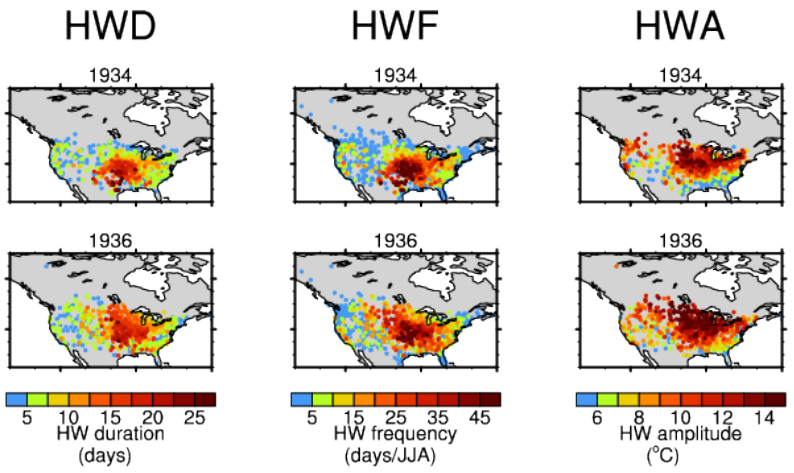
- heat wave duration (HWD) – longest heat wave per season
- Heat wave frequency (HWF) – number of heat wave days per season
- Heat wave amplitude (HWA) – hottest day (Tmax anom) of hottest heat wave

Calculated from Tmax and Tmin, where Tmax > 90th percentile for at least 3 consecutive days, and Tmin > 90th percentile for the 2nd and 3rd days (i.e. persistence of heat).

Stations

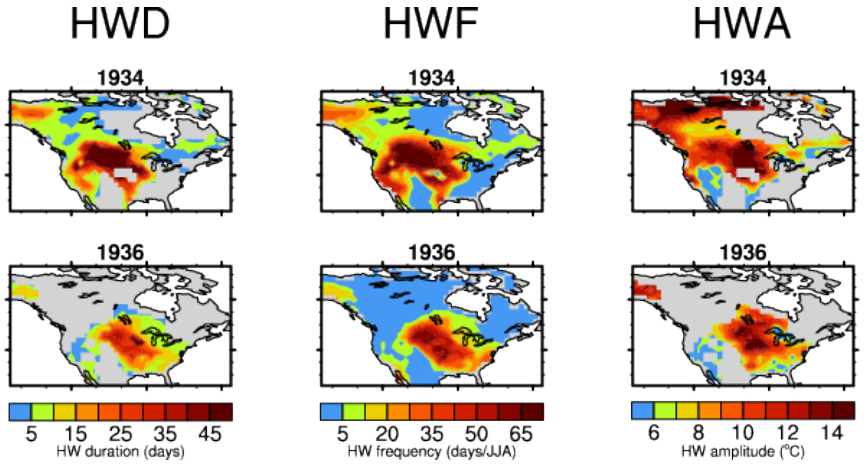
Tmax and Tmin from 887 GHCN-daily stations with high-quality 1920 – 2012:

- 829 from the United States, 58 Canada



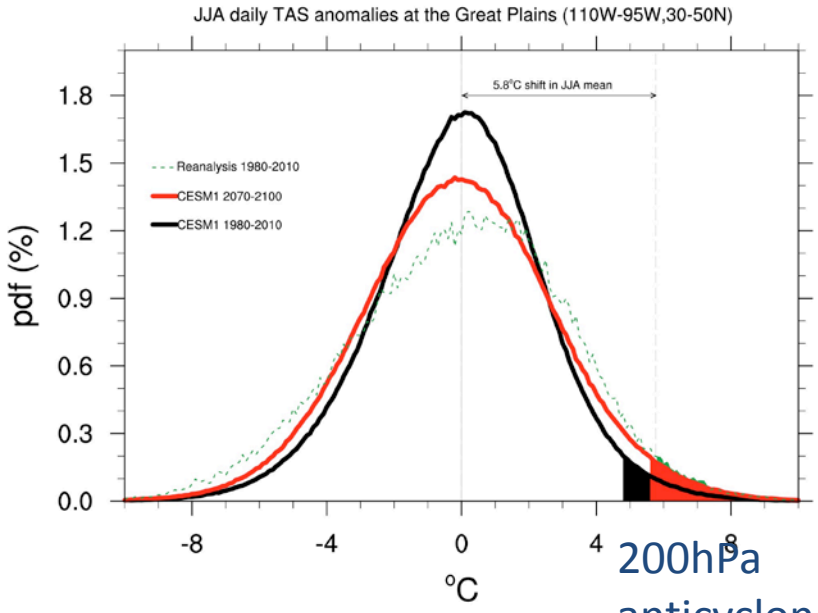
20th century reanalysis (20CR)

version 2c, good agreement (pattern-wise) against stations. 20CR overestimates heat wave metrics compared to stations (similar to temperature extremes as shown by Donat et al. 2015, Clim. Dyn)



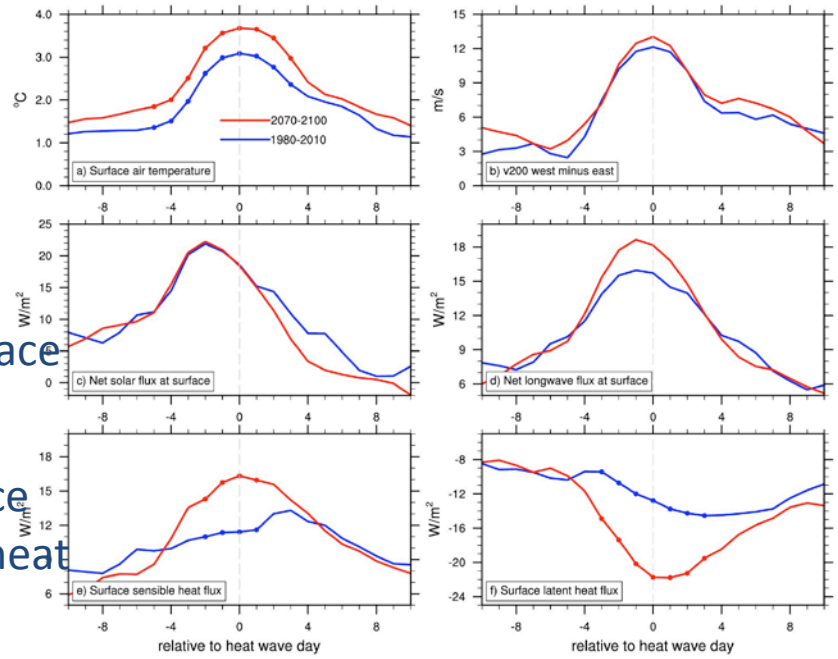
Summary

- Climate models simulate mechanisms of moderate heat waves largely ok;
  - are land surface feedbacks correct and for what magnitude of heat wave do they become important?
  - How to quantify if they are right in models? (see bias in depresys)
- What causes the decadal variability in frequency and magnitude of heat waves, eg in US?
  - large scale ocean temperatures, coupled variability, local or large scale forcers? Or all of them?
- 20th c reanalysis appears ~ok to look at this in Europe and N America
- **A 20-yr or 30 yr segment is too short to look reliably at mechanisms, frequency and intensity of extremes**



200hPa anticyclone

TAS



solar at surface

Net lw at surface

Surface sens heat

Surface latent heat

Dots: sign at 95%

Future changes

Teng, Brandstator, Meehl Washington: **Future heat waves in the US Great Plains in the CESM1 large ensemble experiment**

large ensemble diagnostic of change in heat waves in great planes

Change in variance largely linked to land surface feedbacks, not large scale dynamics.

Courtesy Haiyan Teng