Atmospheric Circulation Patterns Associated with Temperature Extremes Over North America in Observations and Models

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I. Abstract

Evidence suggests that recent observed trends in temperature extremes may be the result of anthropogenic climate change. Motivated by a need to better understand the physical mechanisms associated with anticipated further changes in the future, we identify the key circulation patterns associated with extreme temperature days over North America in the current climate. In this poster we present analysis describing the characteristics of circulation anomaly patterns for 500 hPa and sea level pressure associated with extreme temperature days across the entire continent. We also present preliminary results from a comparison of these patterns with those obtained from a suite of general circulation model simulations.

II. Observational Analysis

Temperature extremes were defined as those days falling below the 5th percentile and above the 95th percentile of the daily temperature anomaly frequency distribution during the period 1961-1990. Temperature anomaly data was obtained from the HadGHCND dataset (Caesar et al. 2006). We calculated composites for each grid cell over North America (315 in total) of 500 hPa geopotential height (hgt) and sea level pressure (SLP) anomalies concurrent with extreme temperature days using NCEP/NCAR Reanalysis 1. The patterns were regridded so that in each plot the origin is the grid cell that the composite is being calculated for. Tx refers to daily maximum temperatures and Tn to minimum and a 5 refers to cold extremes and 95 to warm. (i.e. Tx5=cold max).

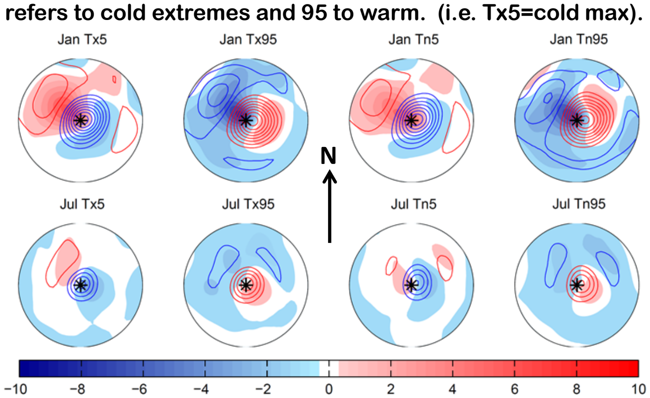

Fig 1. Continental means of the composite pattern for every grid cell in North America (n=315). Shaded colors are sea level pressure anomalies and contours are 500 hPa height anomalies (blue is neg., red is pos.) contoured every 18 meters.

The first EOF of an EOF analysis of all 315 patterns for the continent (not shown) resembles the mean patterns in figure 1. A correlation between the pattern for each grid cell and the mean pattern shows that areas within the westerlies and away from marine and topographic features contribute the greatest to the mean pattern. These areas consequently explain the majority of the continental variability. Weaker correlations are found at locations at which extremes are influenced by local circulations and/or smaller-scale processes.

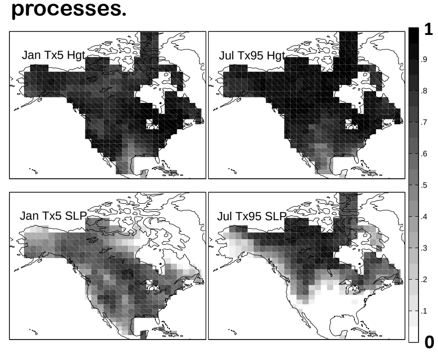

Fig 2. Coefficients from a pattern correlation between the continental mean patterns in fig. 1 and the pattern of each grid cell. The top two panels are for 500 hPa hgt and the bottom two are for SLP.

Calculations were performed to quantify pattern *symmetry* and *linearity*. A location with strong *linearity* would have patterns for days in the tails of the temperature distribution that are scaled versions (same but with anomalies of greater magnitude) of the patterns for any percentile.

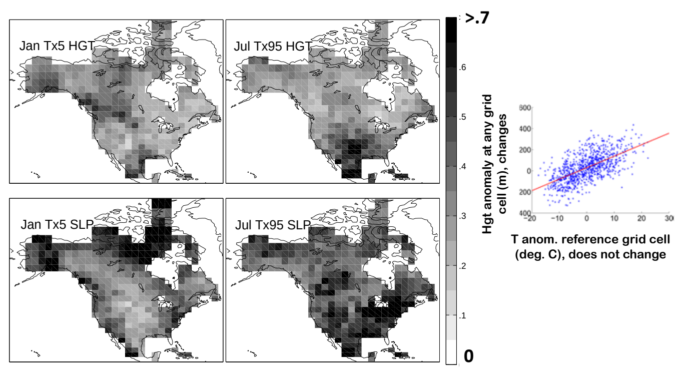

Fig 3. RMS error between patterns of linear regression coefficients (multiplied by the mean anomaly in the tail of the distribution as indicated in the figure) and the anomaly pattern. The RMS error values are normalized by the standard deviation of the anomaly pattern. The scatter plot on the right illustrates how the regression pattern was calculated at each grid cell. Lower RMS values are where patterns are more linear. Top two are hgt, bottom two are SLP patterns.

A location with strong *symmetry* would have patterns for cold and warm extremes that are the same but opposite in sign.

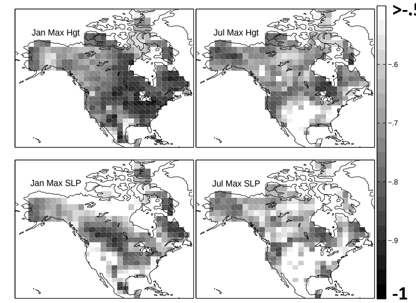

Fig 4. Correlation coefficients between composite anomaly patterns for extreme cold and warm daily maximum temps. The top two panels are for 500 hPa hgt and the bottom two are for SLP anomalies. A value of -1 would indicate perfect symmetry.

III. Model Analysis

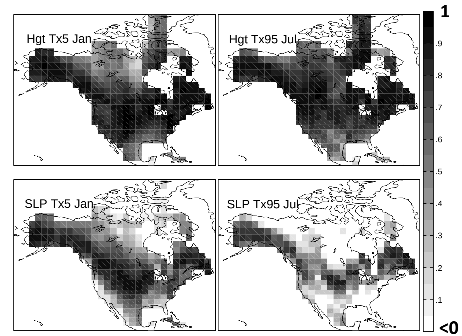

Fig. 5. The same as fig. 2, except at each grid cell the correlation is between the observed composite patterns and the simulated mean composite patterns from a suite of 17 GCMs.

IV. Conclusions/Future Direction

- Circulation patterns associated with extreme warm and cold temperature days are the most spatially coherent, linear, and symmetrical within the main belt of the westerlies and away from mountain ranges and coastlines.
- Preliminary analysis of GCMs suggest that models can realistically simulate the spatial aspects of the patterns best where the patterns are most linear and symmetrical.
- Future work includes further analysis of GCM simulations of 20th century and future climate and investigating the role of recurrent large-scale teleconnection patterns in extreme temperature days.

Caesar, J. et al., 2006: *J. Geophys. Res.*, **111**, D05101, doi:10.1029/2005JD006280.
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