

Making an Extreme Event: Putting the Pieces Together



R. Dole, M. Hoerling, A. Kumar, J. Eischeid, J. Perlwitz, X. Quan, G. Kiladis, R. Webb, D. Murray, M. Chen, K. Wolter, T. Zhang

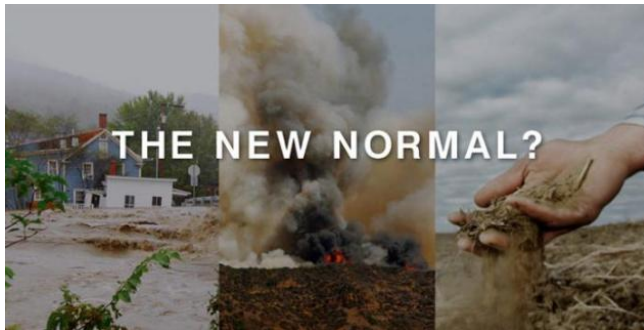
March 2012



'Astonishing' heat in March set records for the month

By Doyle Rice, USA TODAY

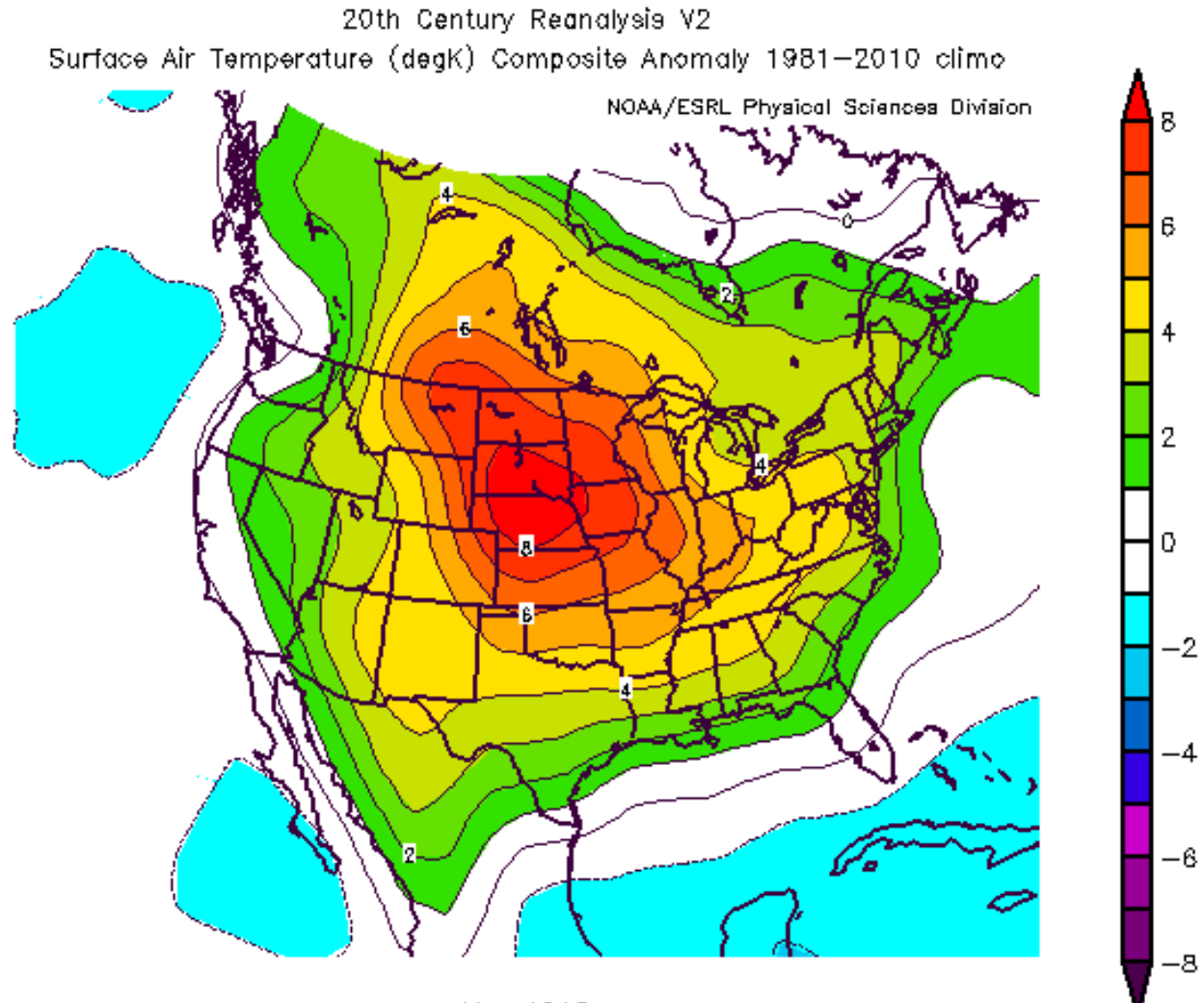
For tens of millions of Americans, last month was the warmest March in their lifetimes.



A leading climate scientist:
**"Everybody has this uneasy feeling.
This is weird. This is not good."**



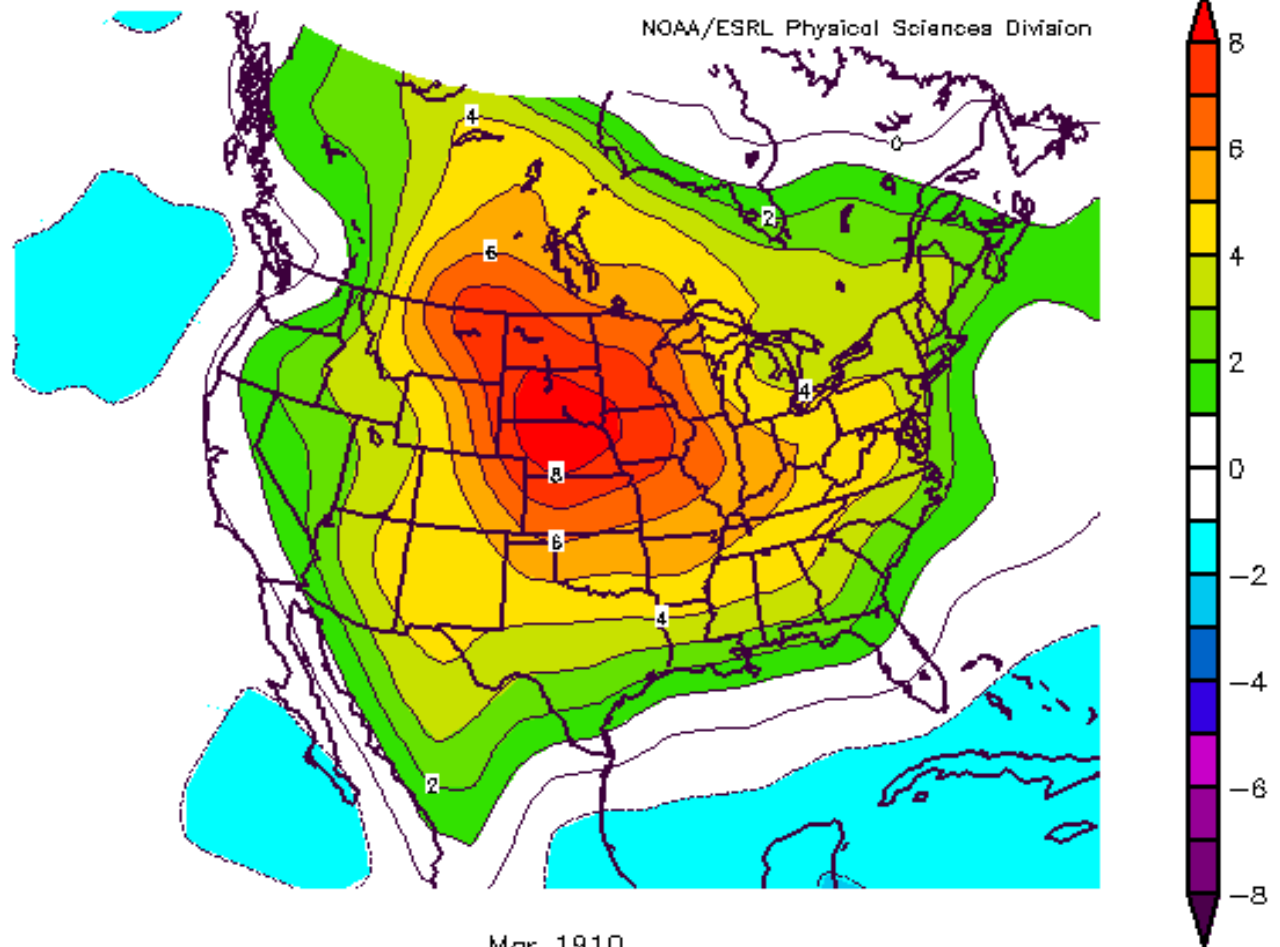
An extreme event: March Madness!



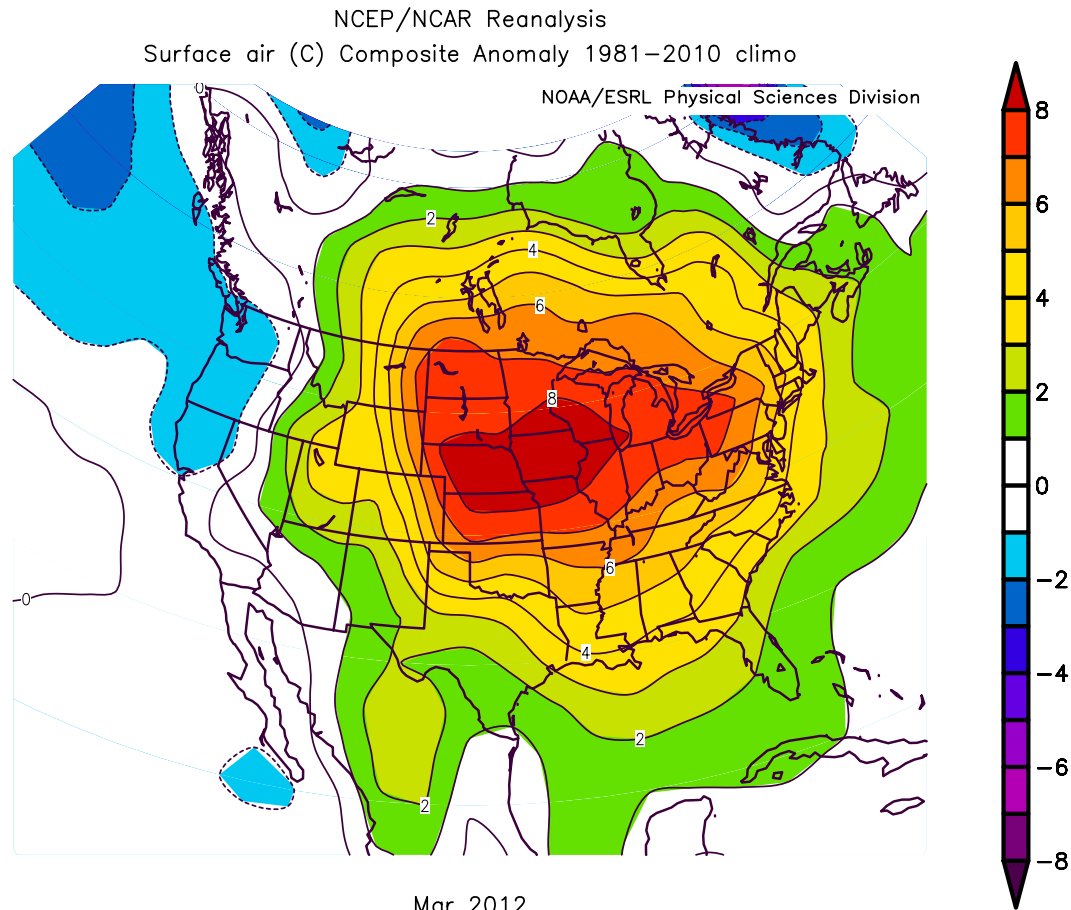
March 1910

20th Century Reanalysis V2
Surface Air Temperature (degK) Composite Anomaly 1981–2010 clima

NOAA/ESRL Physical Sciences Division



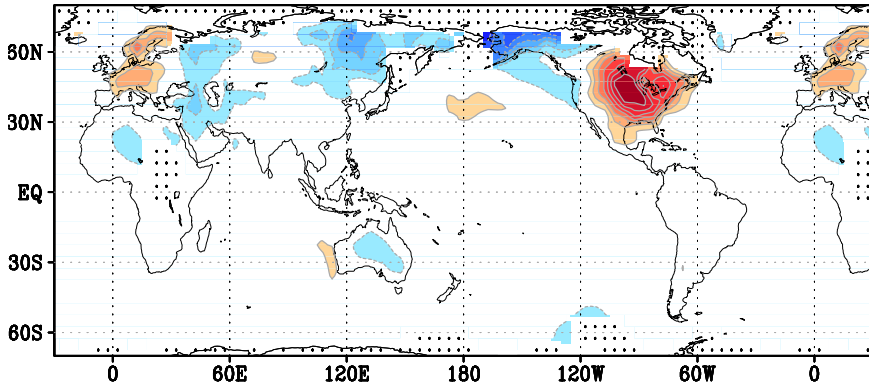
March 2012



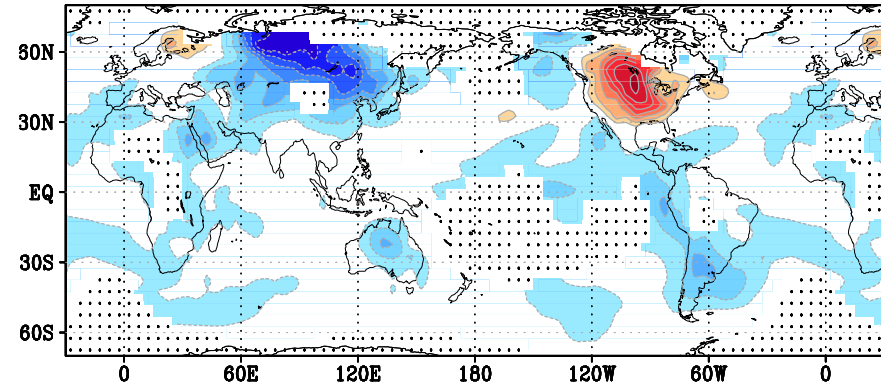
For the contiguous U.S. March 2012 was 4.8° C (8.6° F) above normal, 0.3° C (0.5° F) warmer than March 1910 (NCDC).

Global Temperature Anomalies: March 2012 and March 1910

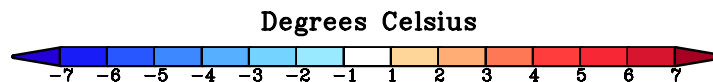
a) March 2012 Tmp Departures



b) March 1910 Tmp Departures

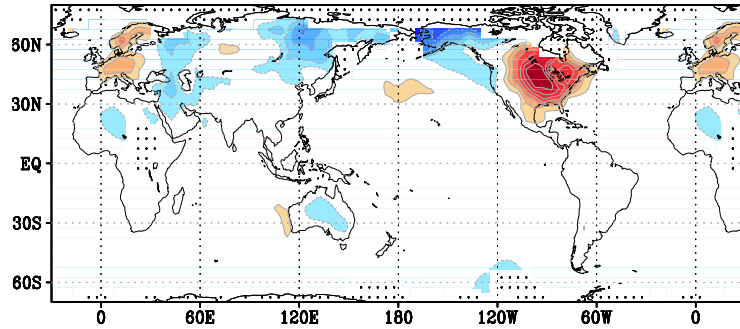


Evidence of similar features outside the U.S. Compared with March 1910, globally March 2012 is 0.9° C warmer.

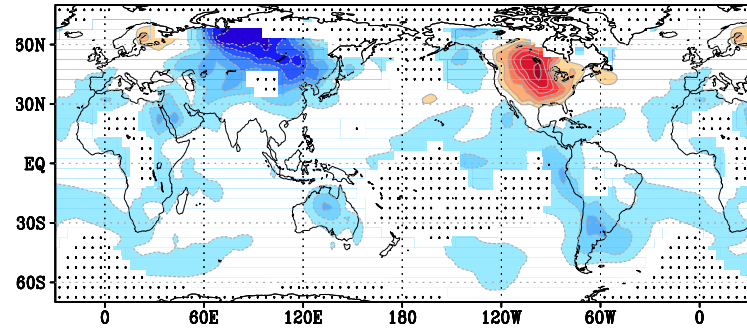


Contribution of Long-term Trend

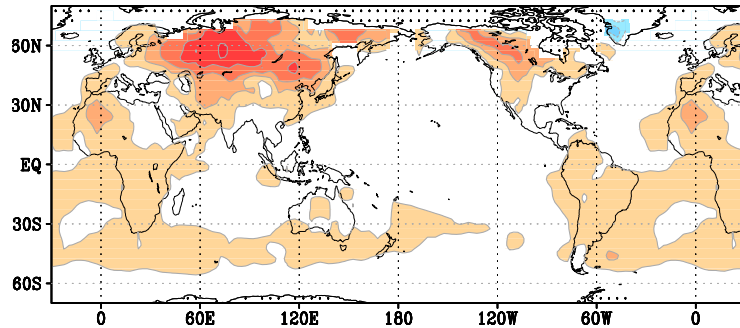
a) March 2012 Tmp Departures



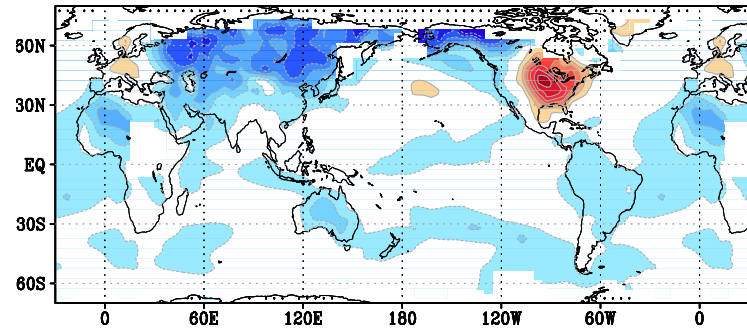
b) March 1910 Tmp Departures



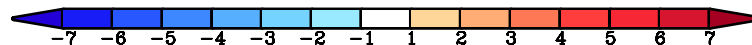
c) March Tmp Trend 1901–2011



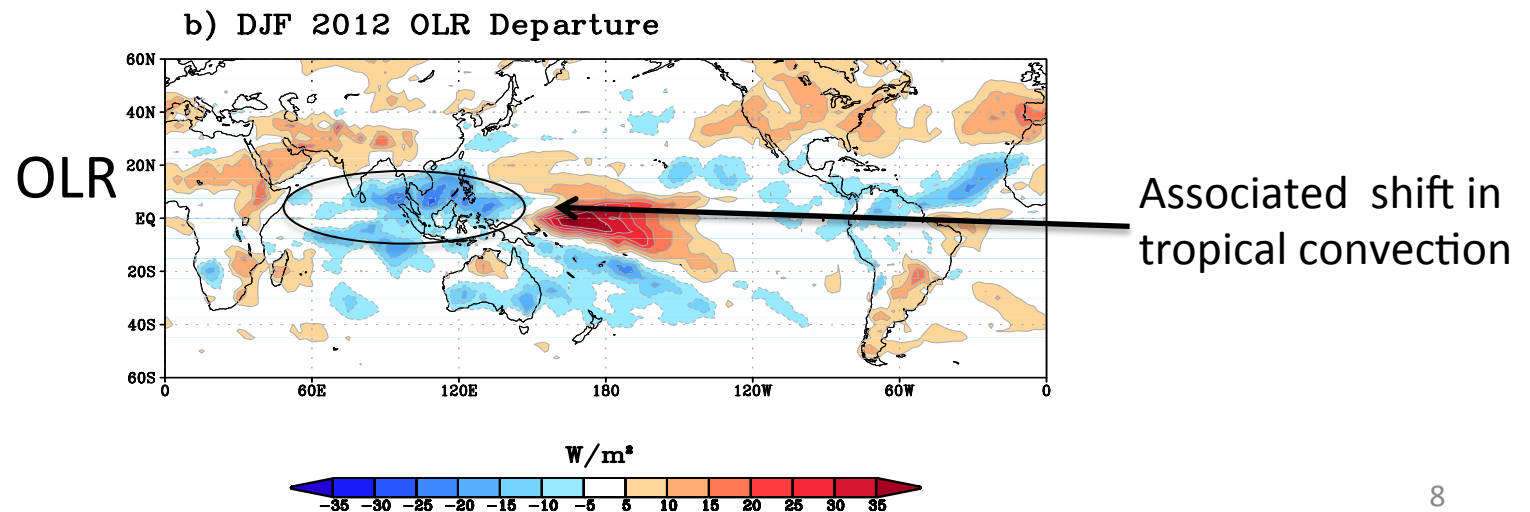
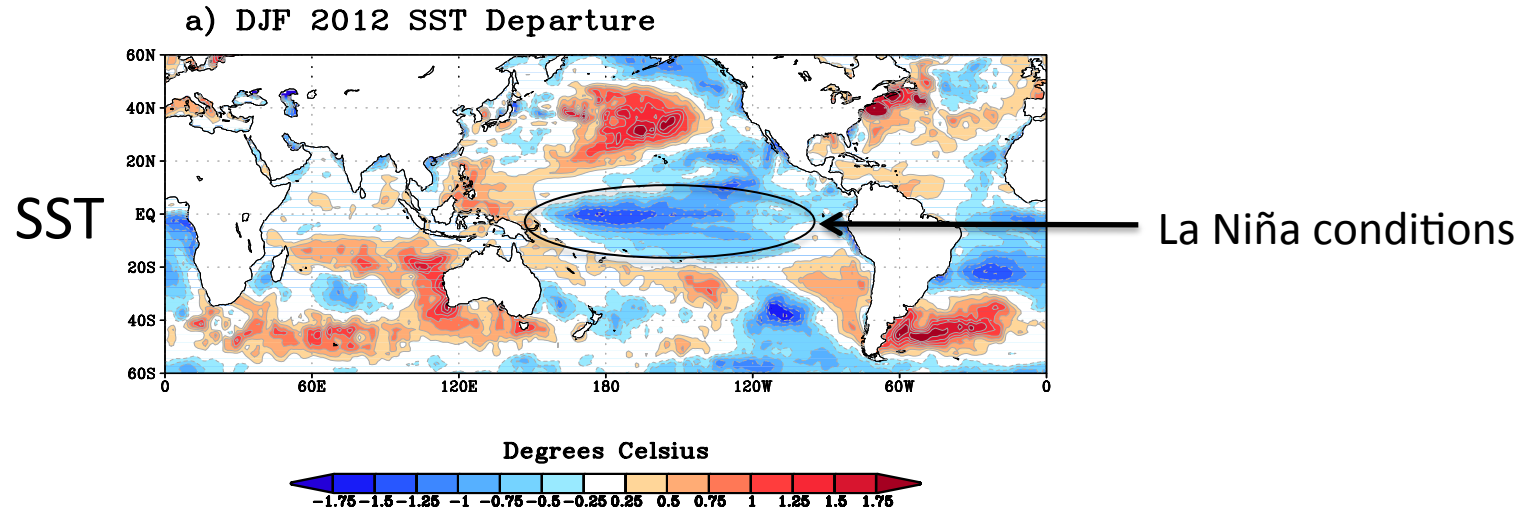
d) March 2012 Tmp (trend removed)



Degrees Celsius

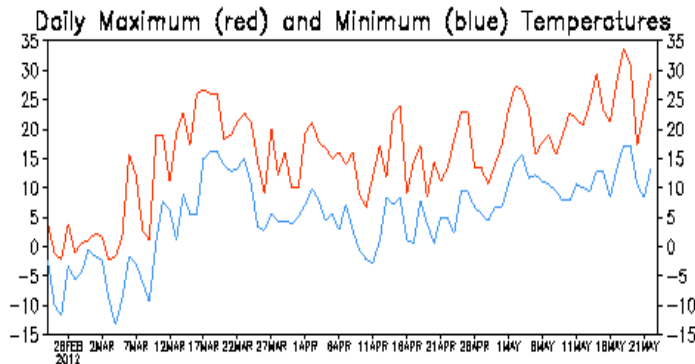
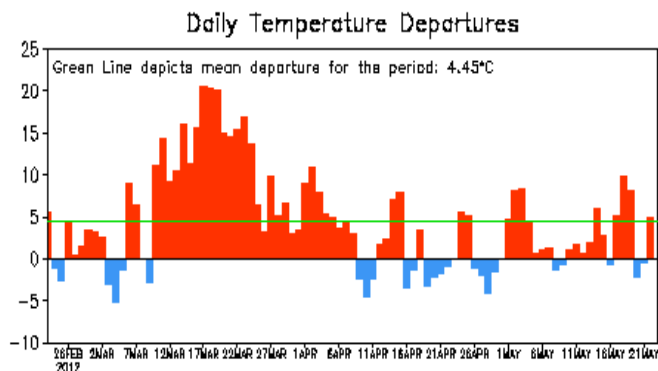
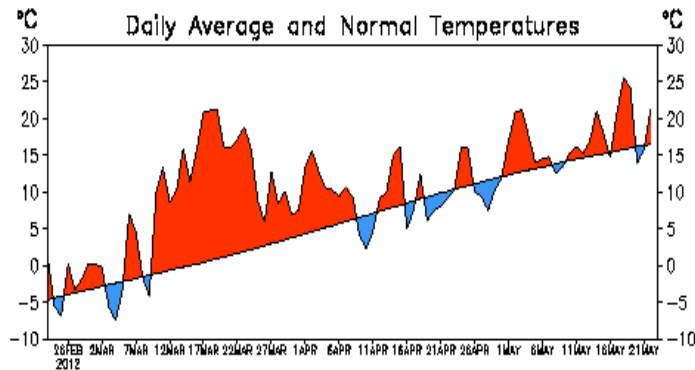


SST and OLR anomalies - DJF



Event magnitude and time scale

MINNEAPOLIS, MINNESOTA



Zero crossings
March 10 – April 6
~ 27 days

Most intense
anomalies
~ March 12-23
~ 15-20°C

Data updated through 22 MAY 2012

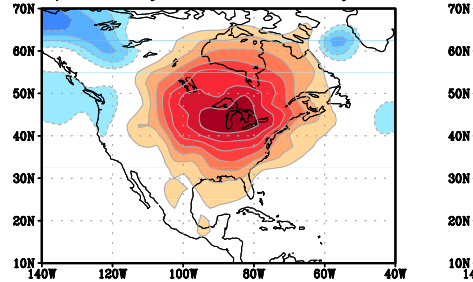
What was the proximate cause for the extreme warm temperatures?

12-23 March 2012

T'_{sfc}

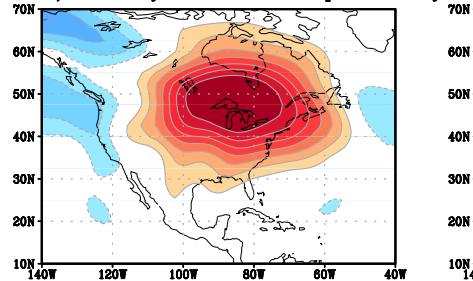
March 12–March 23 2012

a) Reanalysis Sfc Tmp Anomaly

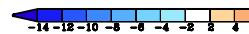


T'_{850}

b) Reanalysis 850mb Tmp Anomaly

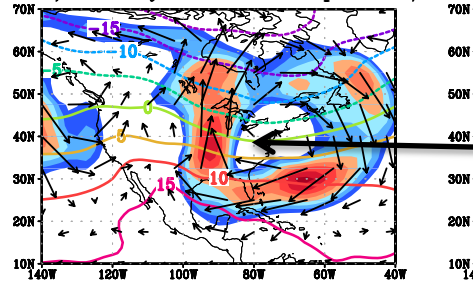


Degrees Celsius



T_{clim}, V'_{850}

c) Reanalysis 850mb Tmp Climo/850m

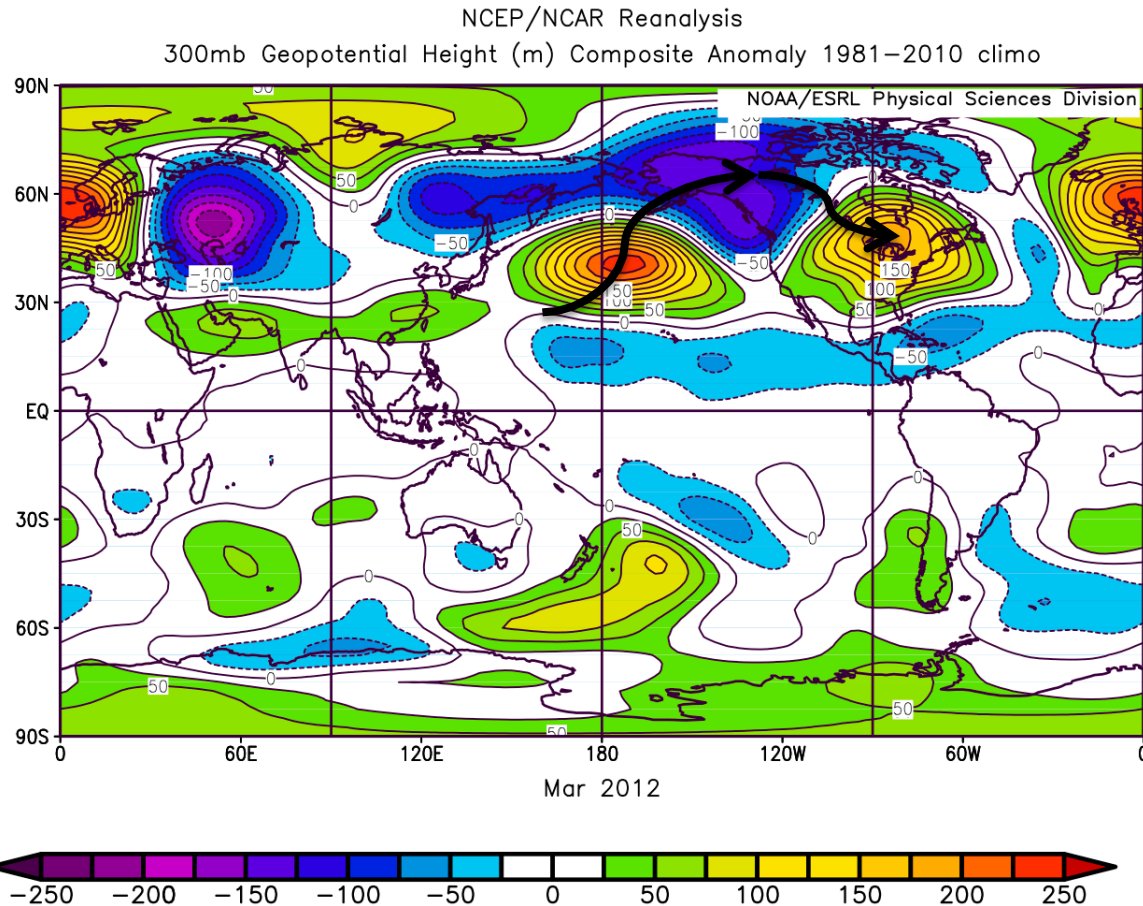


Wind Speed (m)



Intense and sustained poleward heat transports

What factors led to the anomalous winds associated with the heat wave?



Strong wavetrain emanating from the Pacific

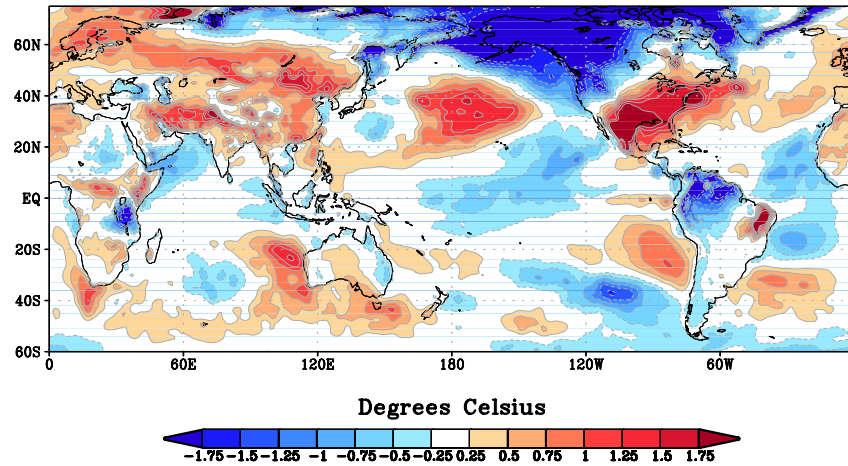
What was the Role of Anomalous SSTs?

AMIP Simulations with GFS Model, 50-member ensemble

March 2012

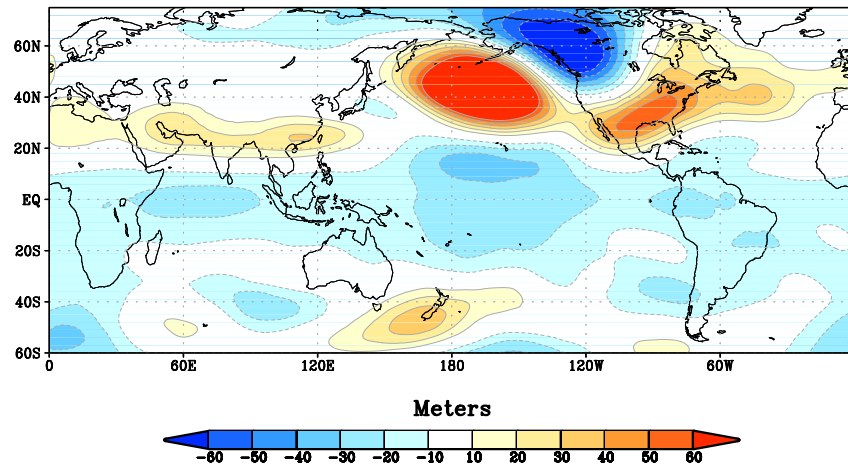
T'

a) March 2012 Temperature: GFS 50 Member Ensemble

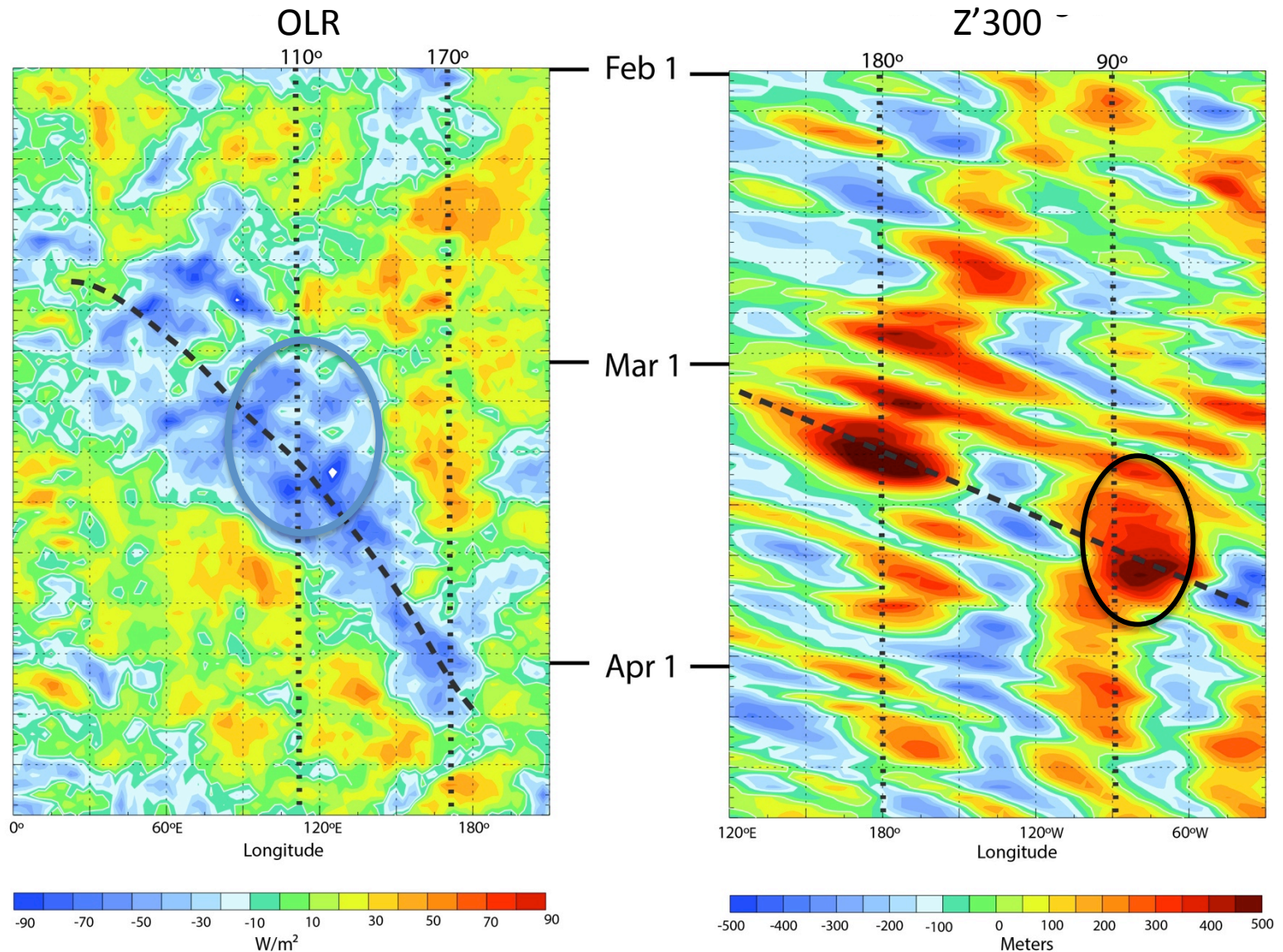


Z'
300

b) March 2012 300 hPa: GFS 50 Member Ensemble



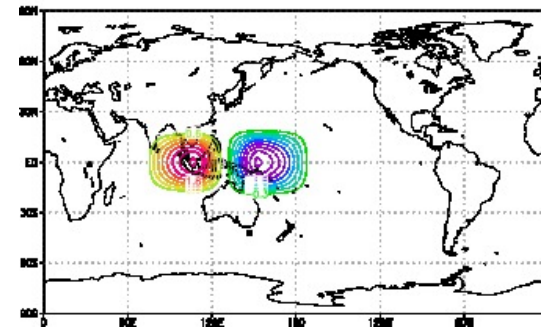
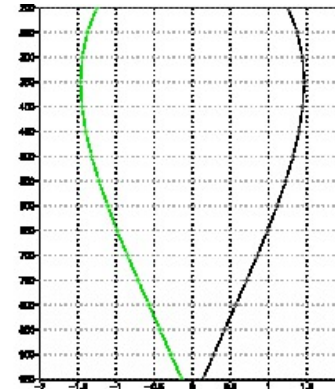
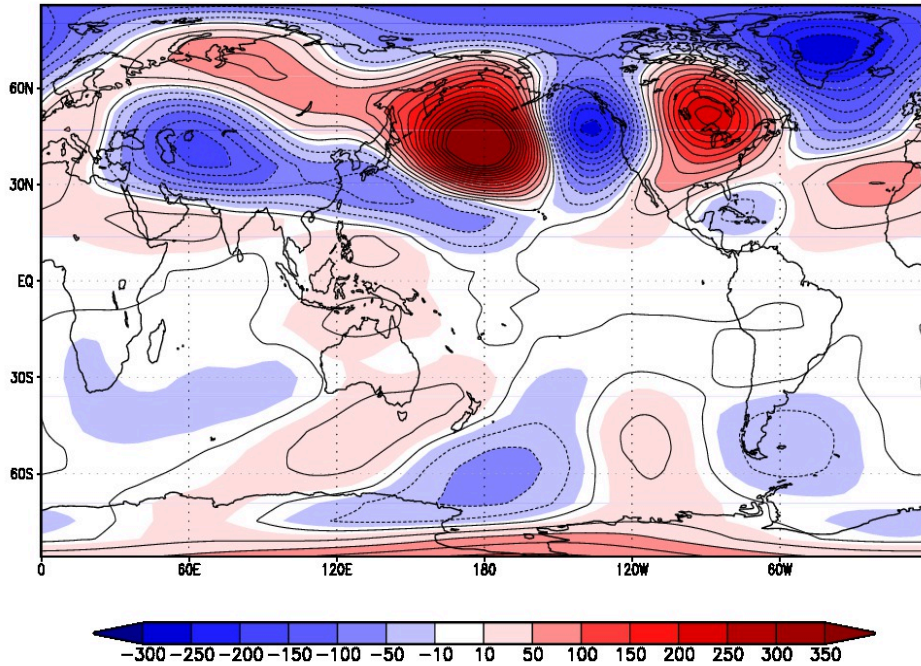
MJO and Rossby Wave Dispersion



Heat Wave

What was the source for this anomalous wavetrain?

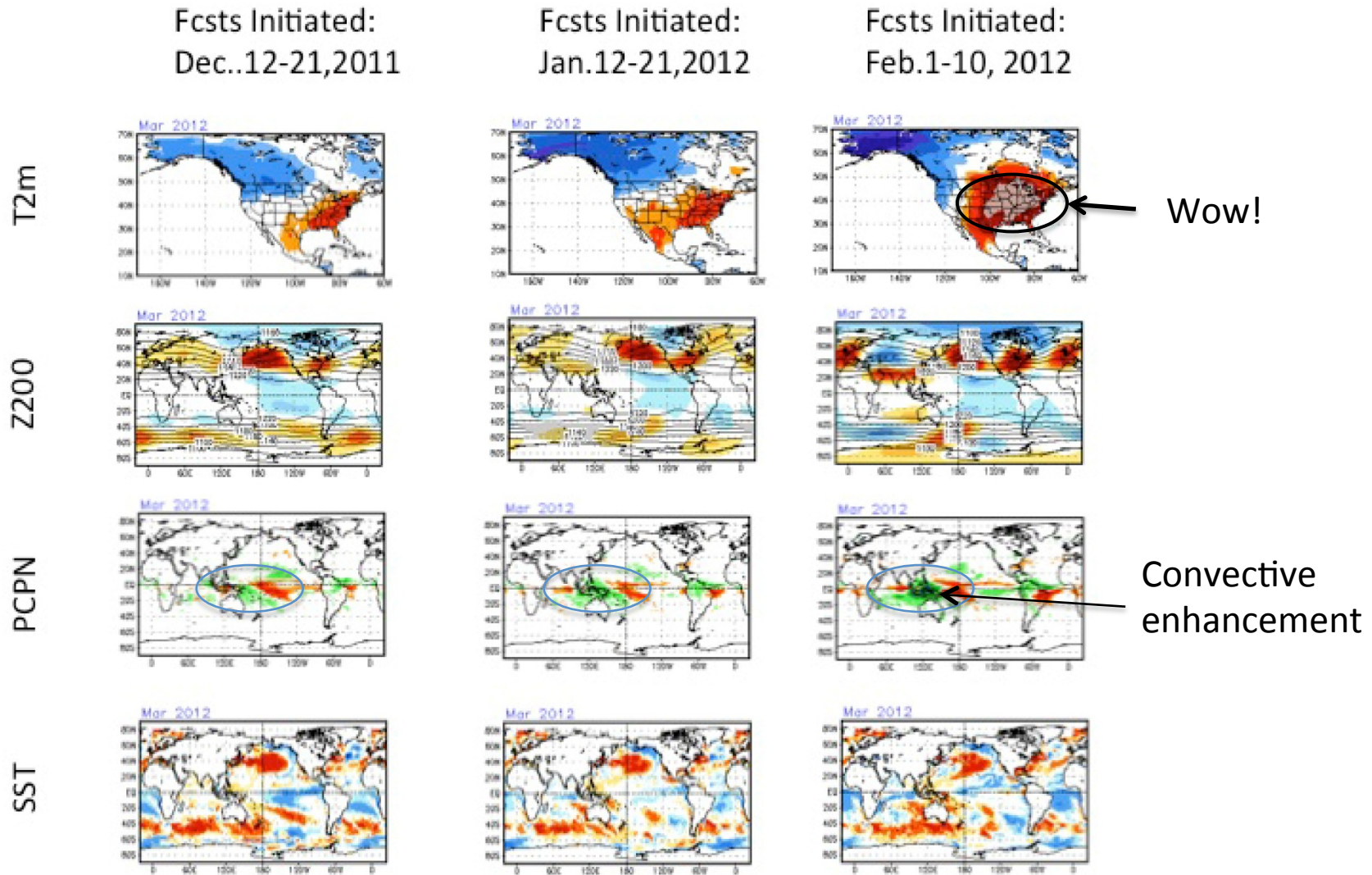
Linear Model Simulation



Peng and Whitaker (1999)

Simple linear baroclinic model experiments forced by idealized heating suggest a tropical Pacific-Indian Ocean wave source

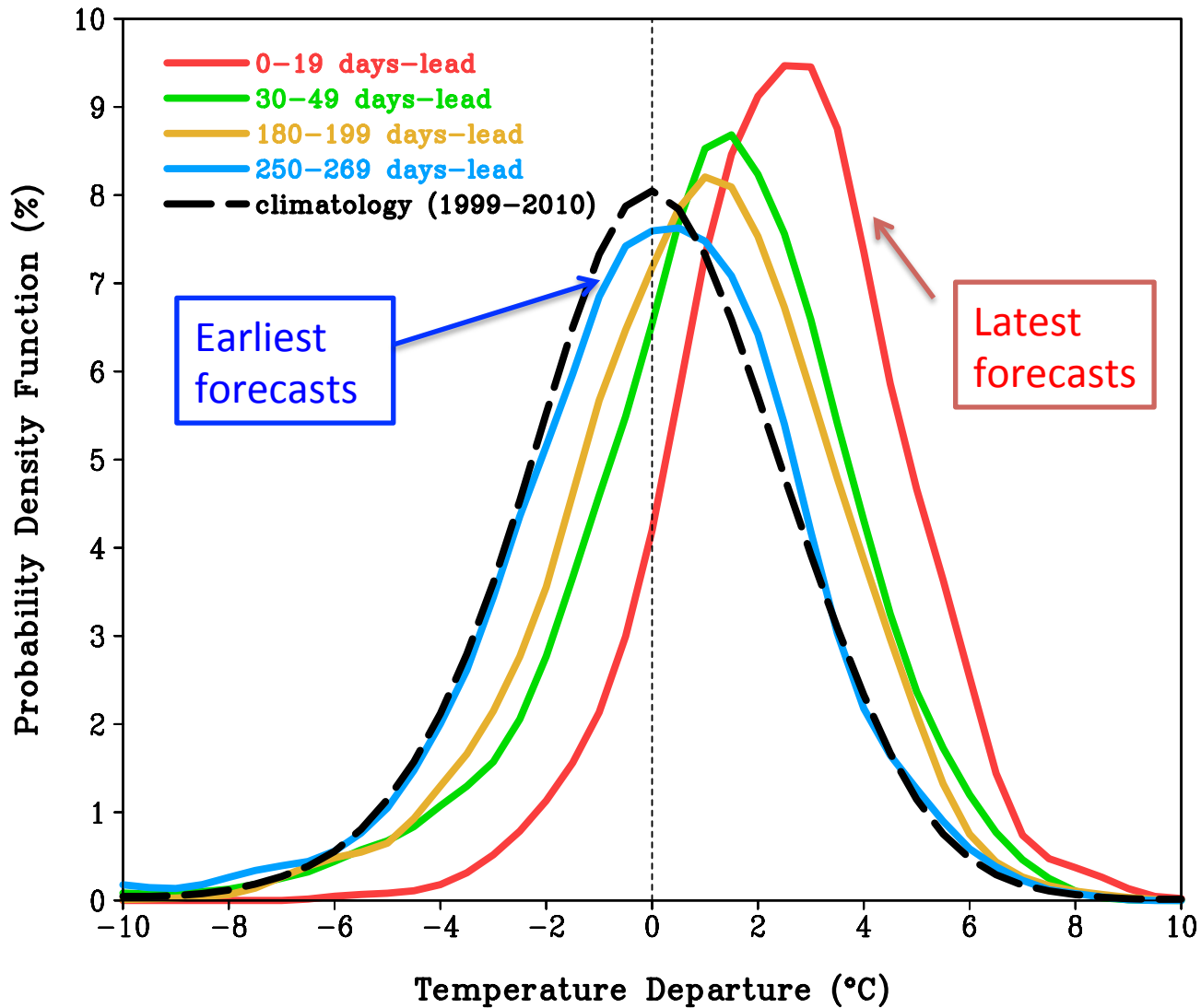
Was There Evidence of Predictability?



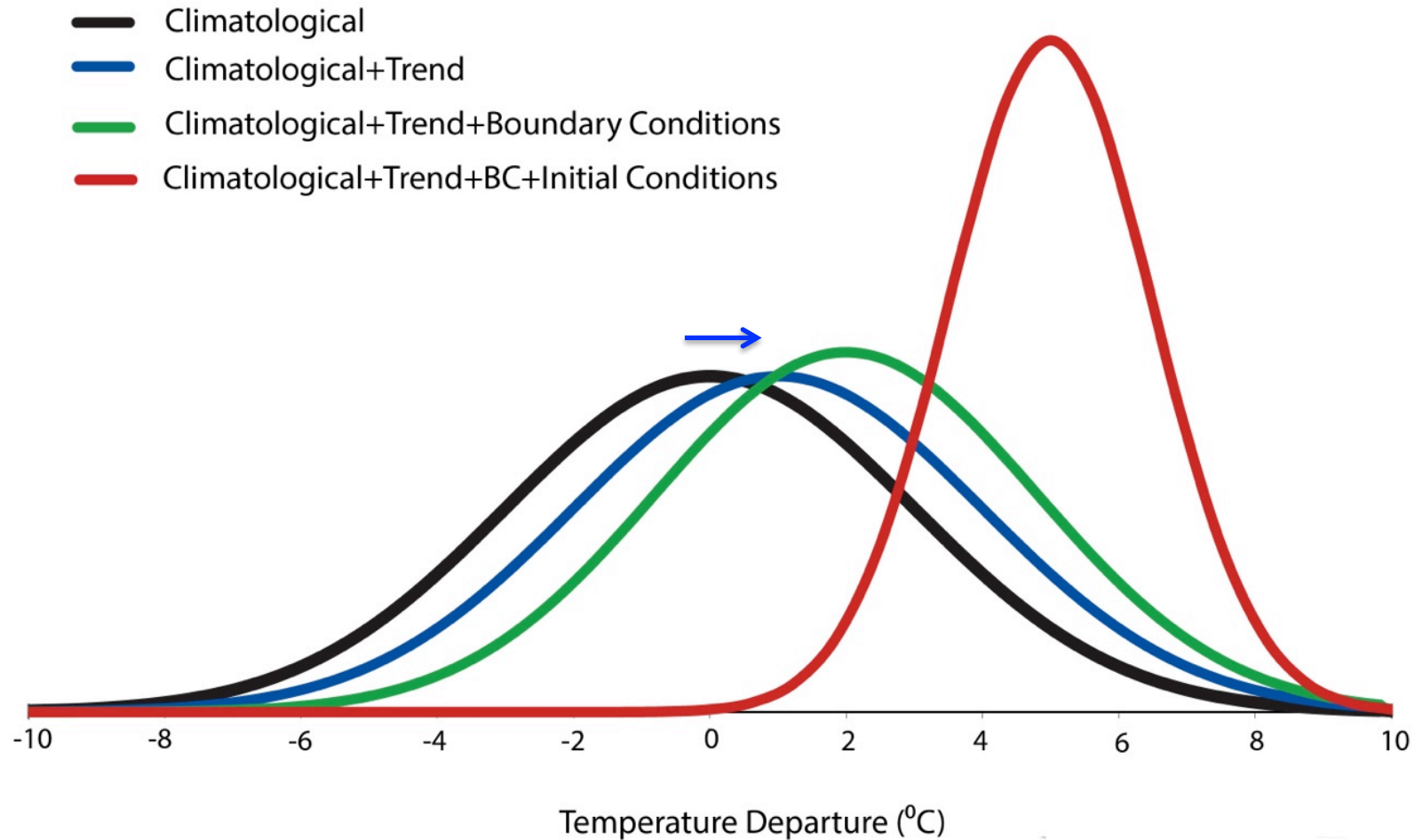
NCEP CFSv2 40-member Ensemble Forecasts for March 2012 initialized in Dec, Jan, and Feb all show a warm signal over the eastern U.S.

CFS Forecasts by Lead Time

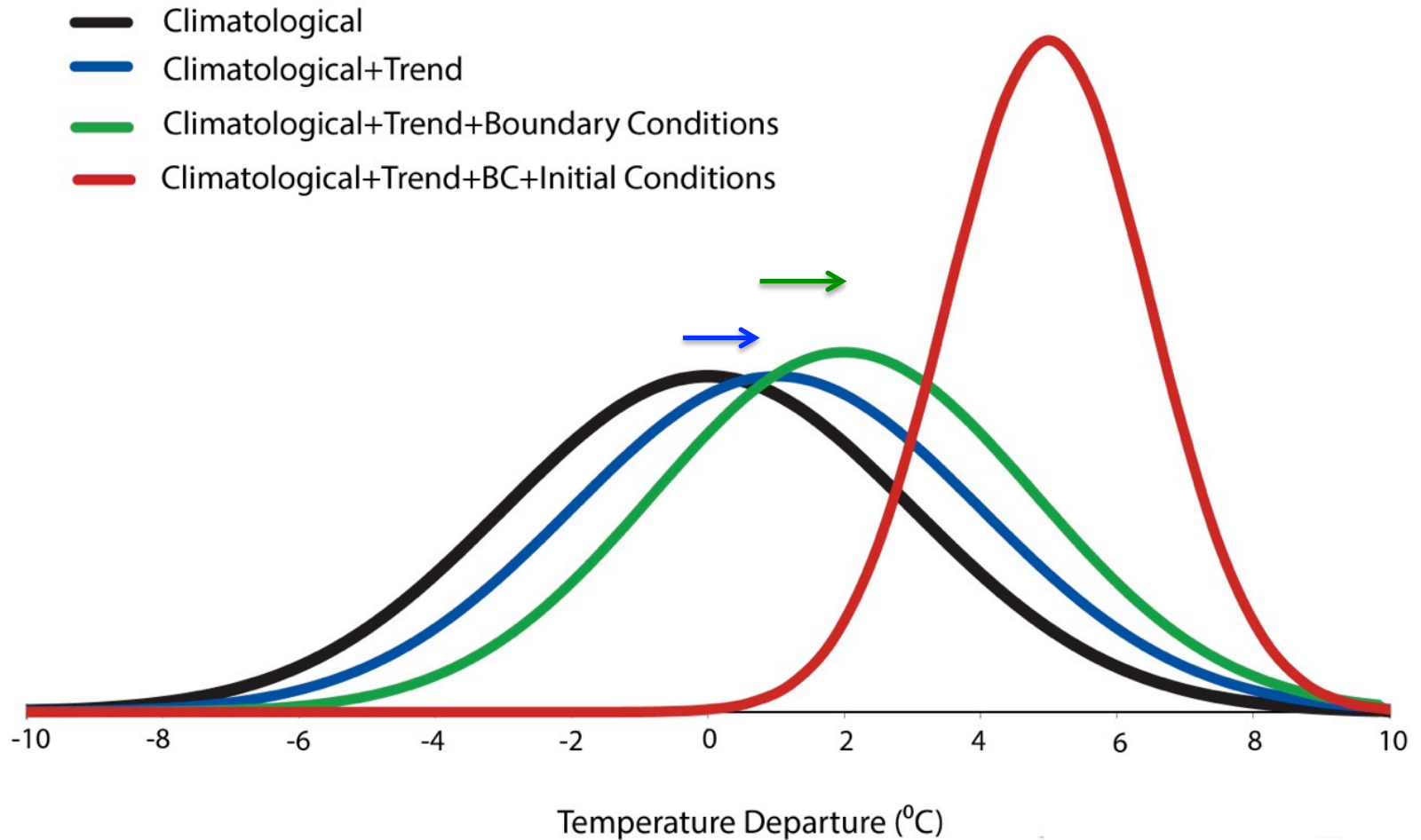
CFSv2 March 2012 T2m Monthly Departure
30°N–50°N; 110°W–80°W



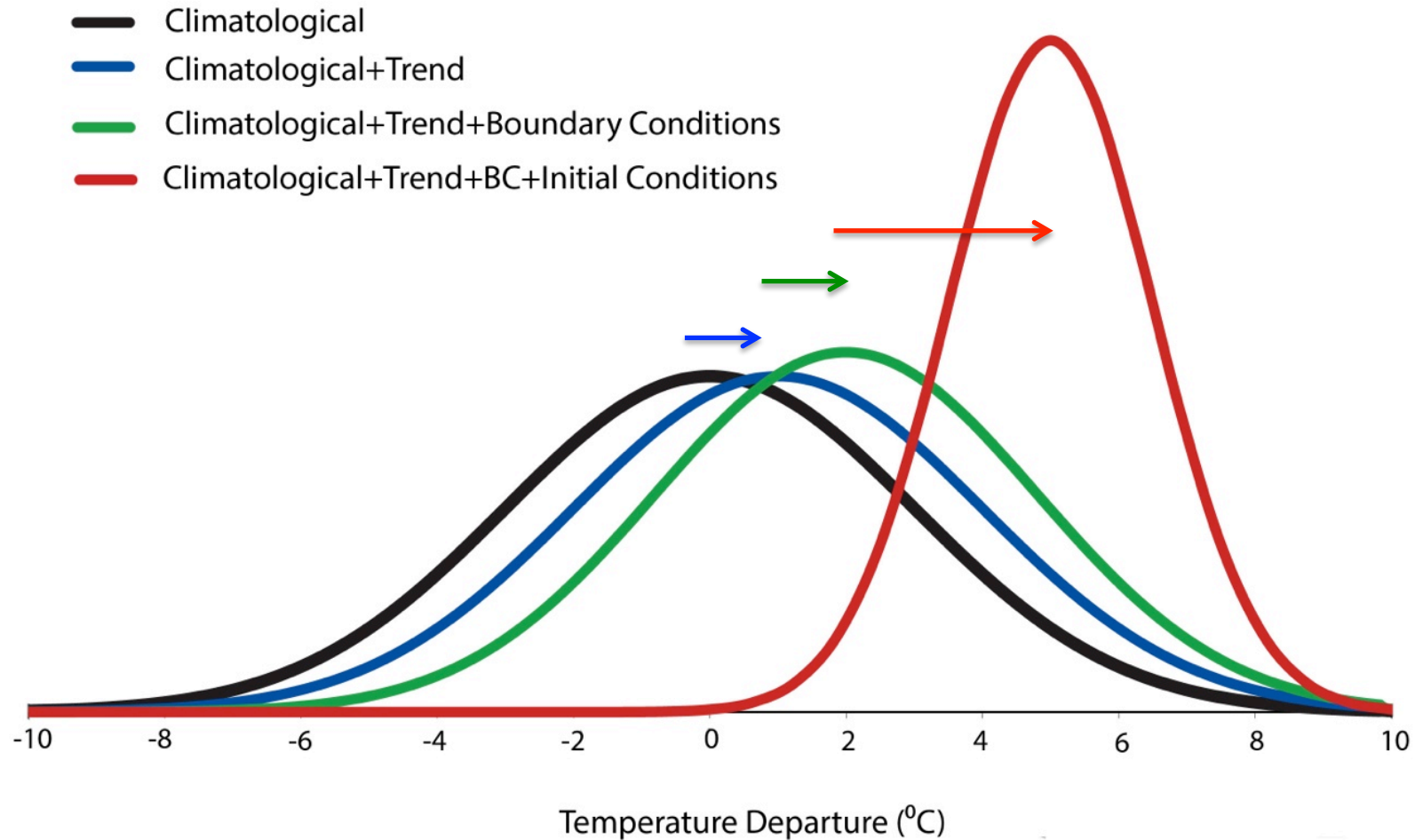
Contributions from various factors



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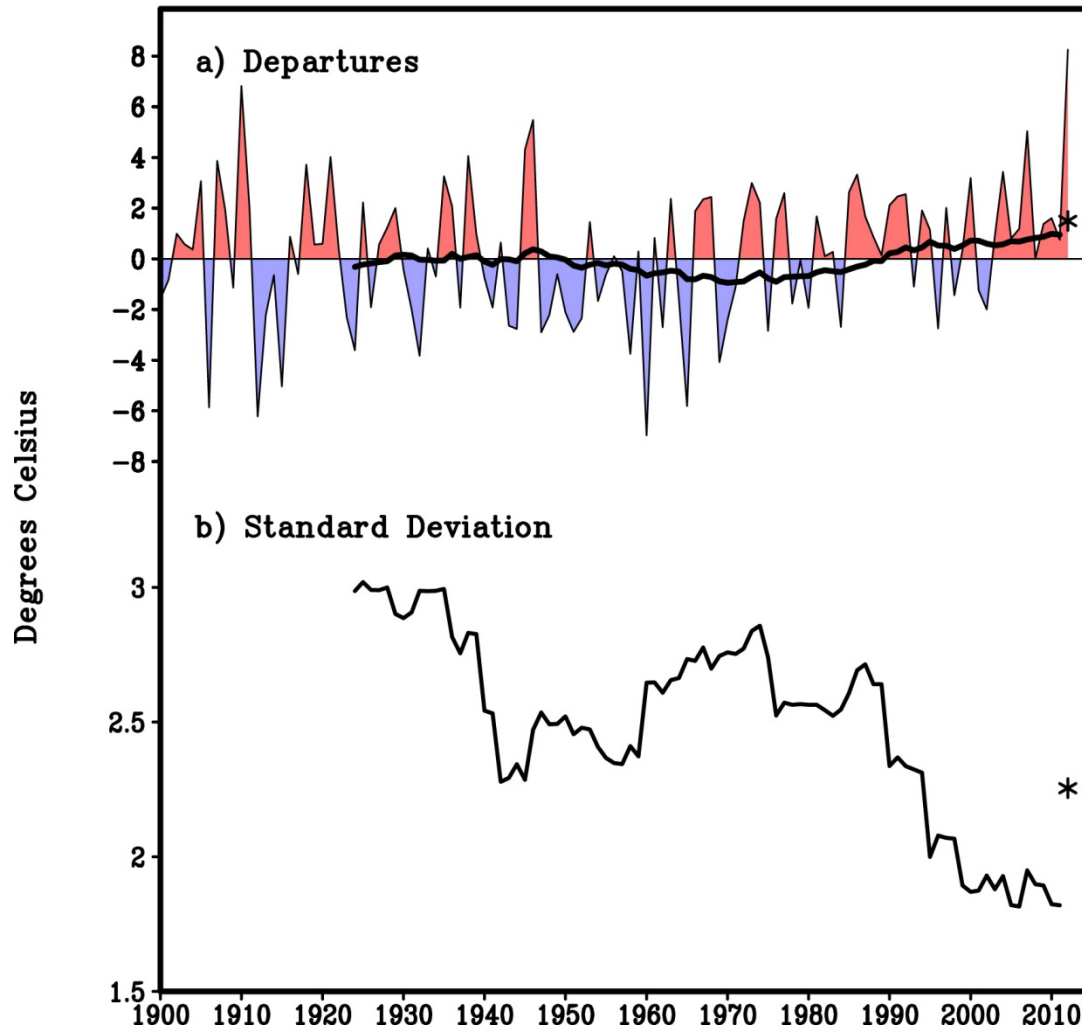
Contributions from various factors



Is the variability changing?

Is the variability changing?

Minnesota/Wisconsin March Temperature



March yearly variability and 30-year means

March variability about 30-year means

Putting the Pieces Together

- While the U.S. experienced exceptionally warm temperatures in March 2012, a March that occurred over a century earlier was nearly as warm.
- The superposition of a strong natural climate variation similar to March 1910 together with a long-term warming of the magnitude observed would be sufficient account for the record warm March 2012 U.S. temperatures.
- Coupled model forecasts and atmospheric model show that forcing from anomalous SSTs increased the probability of extreme warm temperatures in the eastern U.S. in March 2012 above that anticipated from the long-term warming trend.
- Forcing associated with a strong MJO further increased the probability for extreme U.S. warm temperatures and provided important additional predictive information on the timing and spatial pattern of the temperature anomalies.

Conclusion

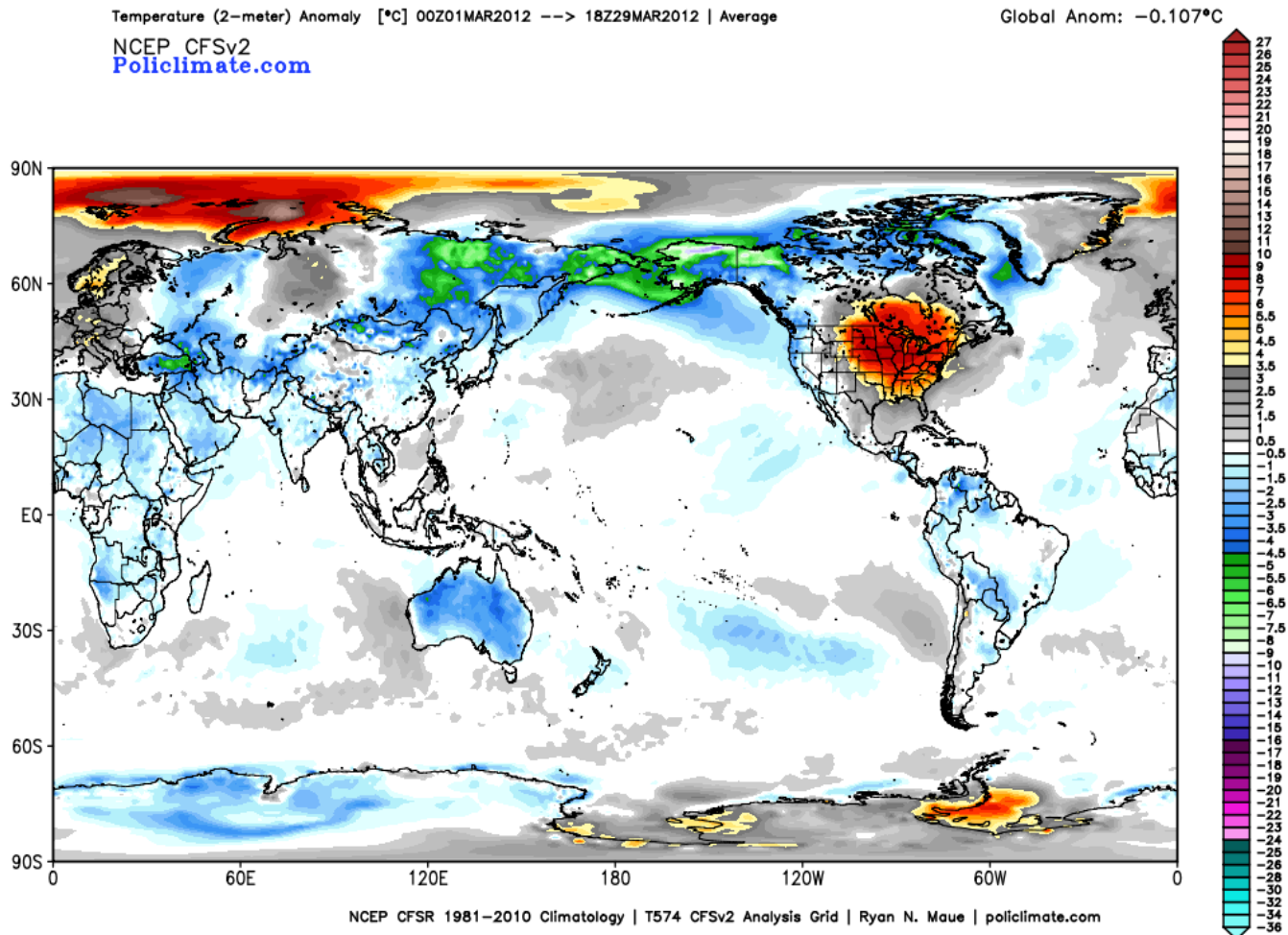
Phenomena across time scales from climate change to weather all contributed to making this event extreme, successively adding predictive information and bridging forecasts from climate to weather.

This study identifies specific aspects of variability that need to be modeled with fidelity to predict extreme events, as well as to increase confidence in model projections of future changes in extremes.

How about other factors?

- Snow cover
- Soil moisture, vegetation
- Sea ice
- Stratospheric circulation
- Mid-latitude dynamical interactions

In the global context



The March 2012 heat wave was a regional event.

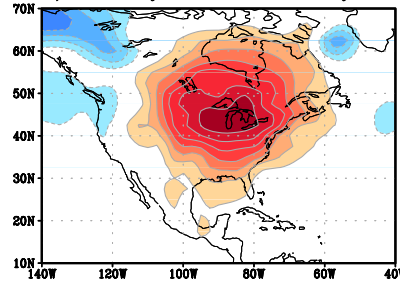
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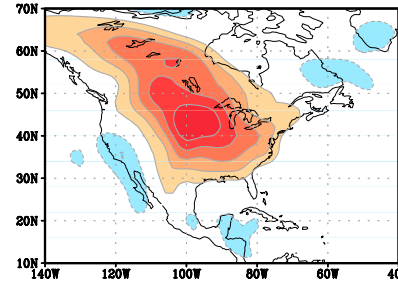
March 12–March 23 2012

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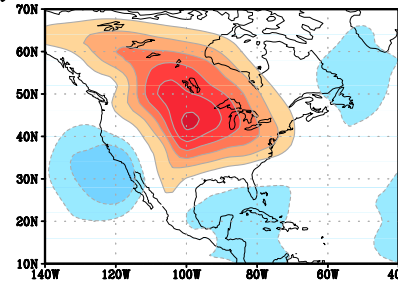
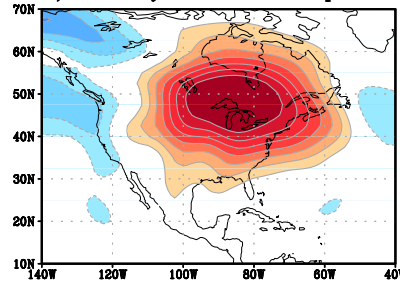
March 18–March 29 1910

18-29 March 1910

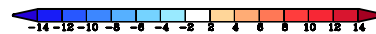


T'_{850}

b) Reanalysis 850mb Tmp Anomaly

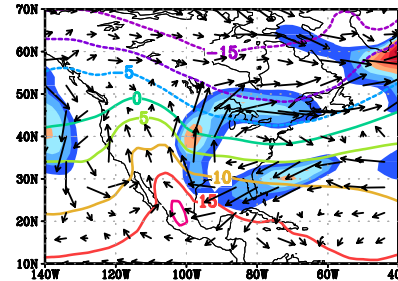
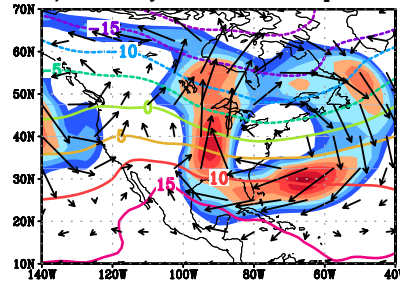


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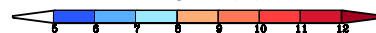


T_{clim}, V'_{850}

c) Reanalysis 850mb Tmp Climo/850mb Winds



Wind Speed (m/s)



10

Intense and sustained poleward heat transports