Understanding the Statistics of Monthly Climate Extremes: Is there a case for "global weirding"?

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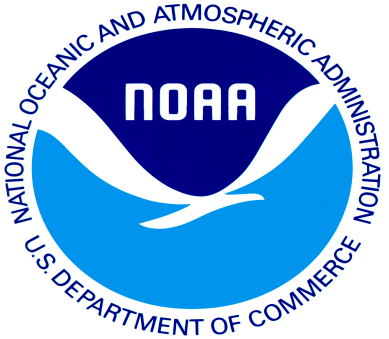

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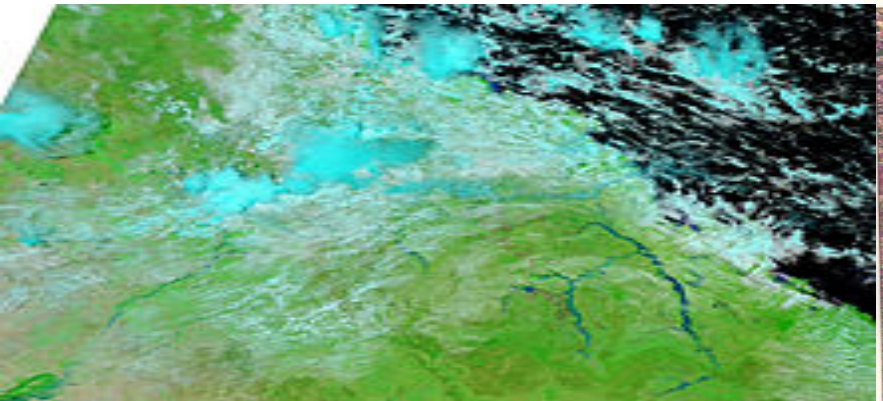
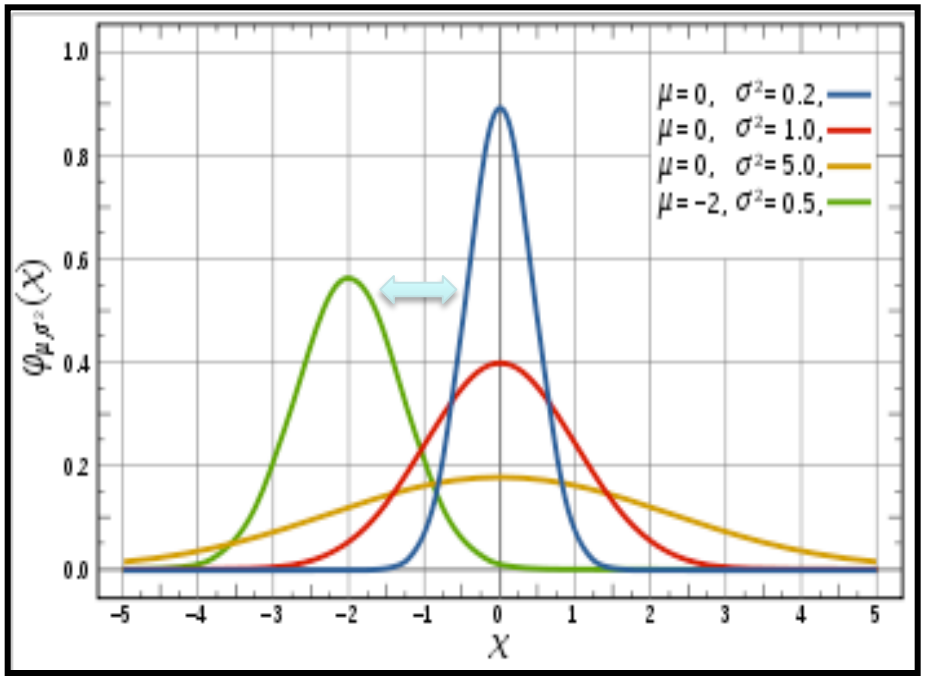
1. **Have extremes become more extreme in the second half of the 20th century compared to the first half?**
2. **What are the projections for how extremes might change in the 21st century?**



Changes in the PDF moments = changes in the probability of extremes

Mean & Variance



Skewness

Observational Datasets

Name	Resolution (lonxlat)	Years
GPCC Precipitation	1x1	1901-2009 (109)
GISS Surface Temperature Anomalies	2x2	1880-2010 (131)

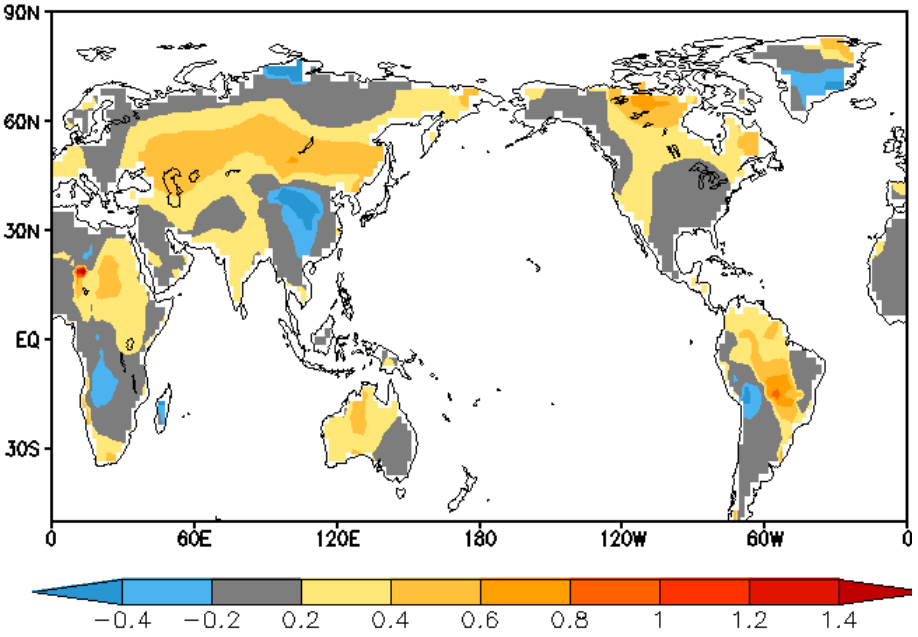
NCAR/CCSM4 Simulations

Experiment	Years	# Ensemble Members
Pre-industrial	1300	1
20th Century	1850-2005	5
21st Century RCP2_6	2005-2100	5
21st Century RCP4_5	2005-2100	5
21st Century RCP8_5	2005-2100	5

Observed 20th Century Changes in Surface Temperature Moments

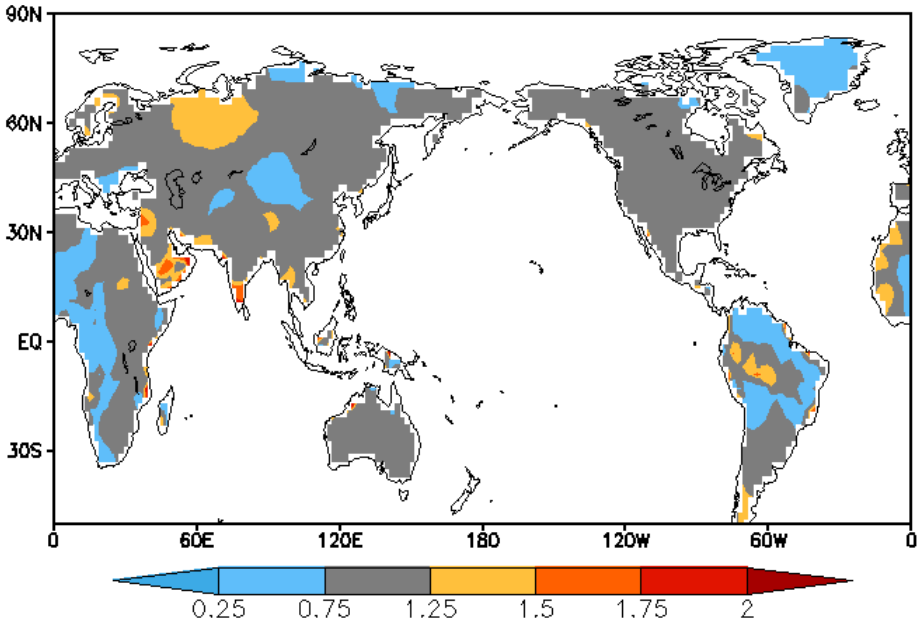
Mean (°C)

1950-1999 minus 1900-1949



Variance Ratio

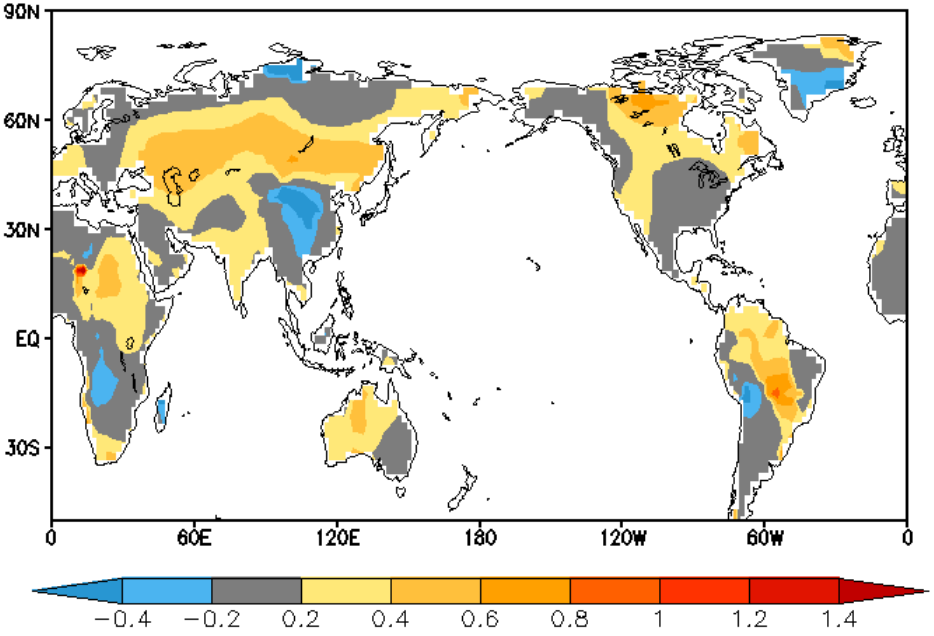
1950-1999 / 1900-1949



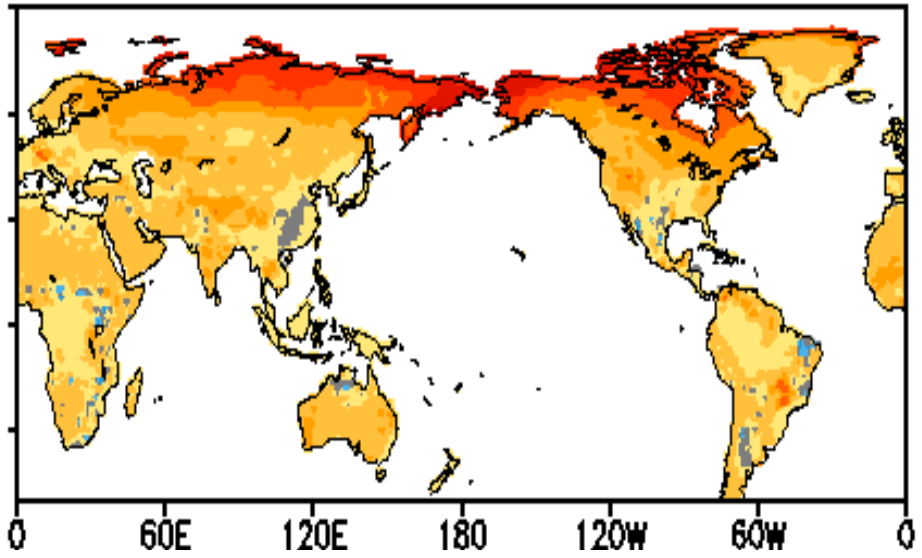
20th Century Changes in Surface Temperature Means (°C)

1950-1999 minus 1900-1949

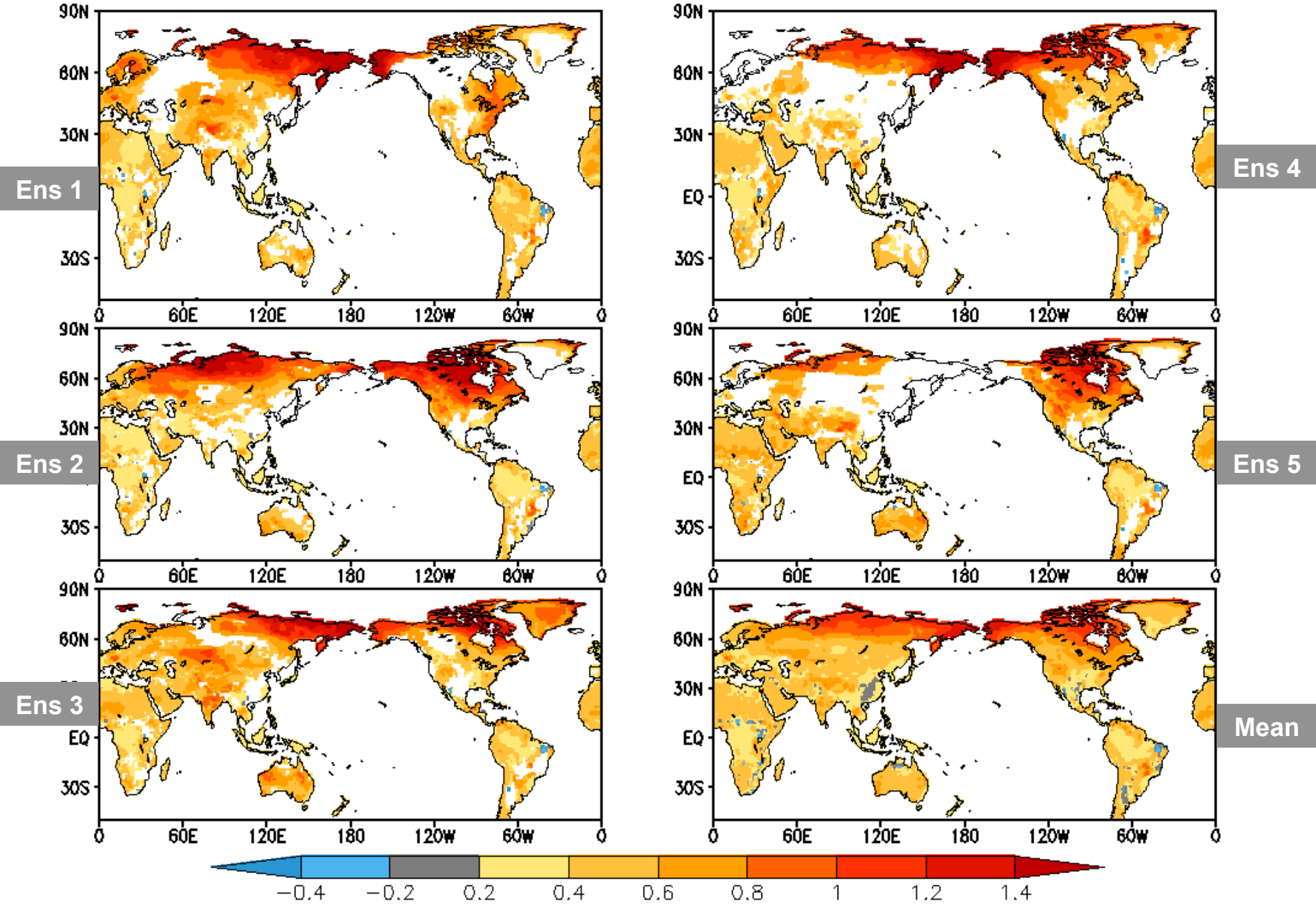
Observations



CCSM4 Ensemble Mean



CCSM4 20th Century Surface Temperature Mean Changes



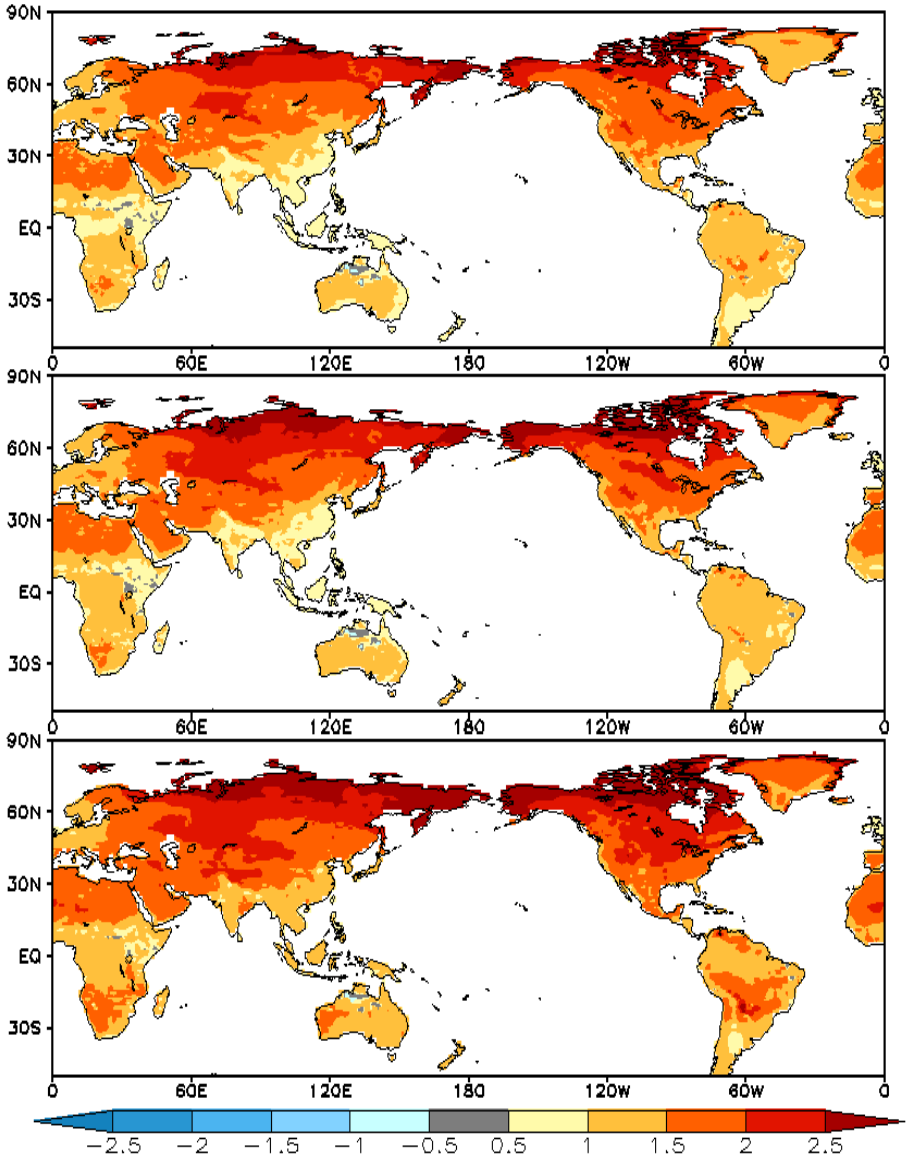
Projected Changes in Temperature Mean

2000-2049 minus 1950-1999

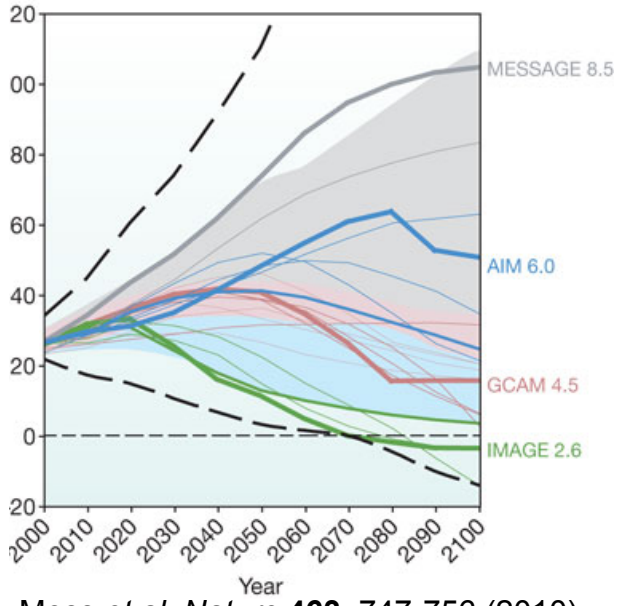
RCP2_6

RCP4_5

RCP8_5



Representative concentration pathways



Moss *et al. Nature* **463**, 747-756 (2010)

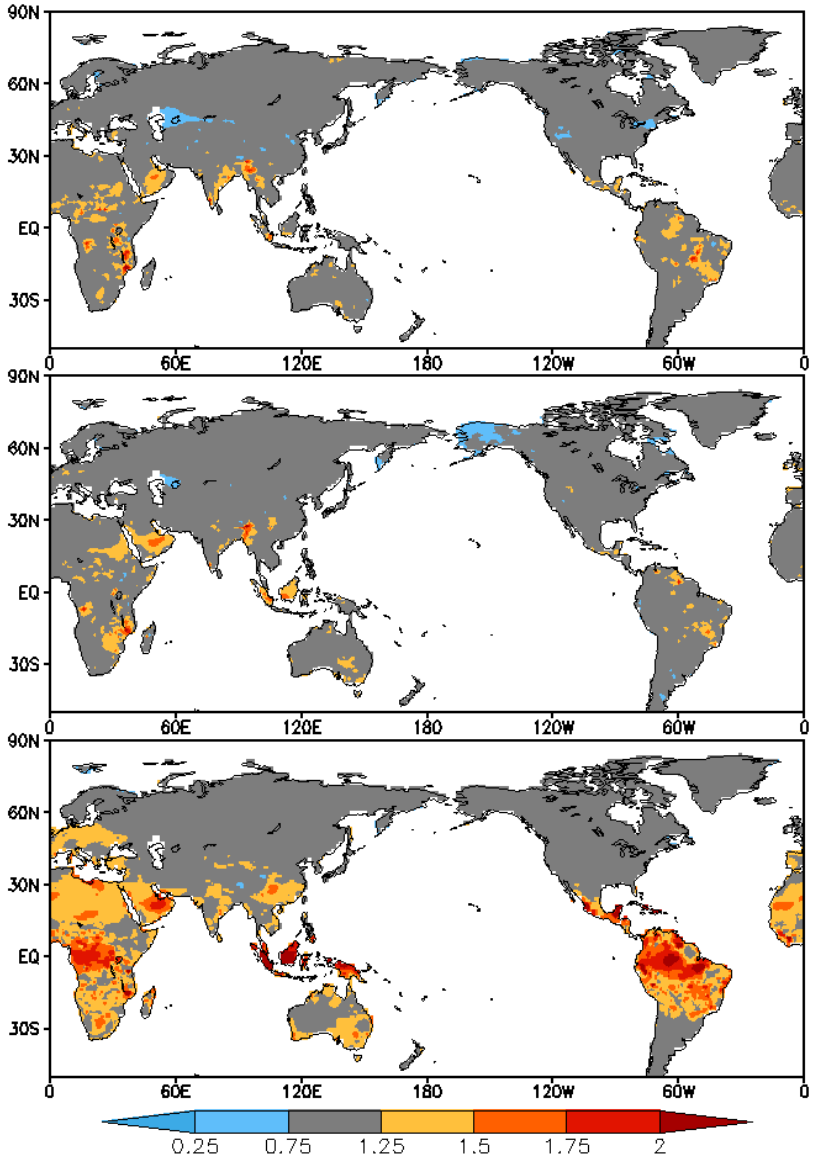
Projected Changes in Temperature Variance

2000-2049 / 1950-1999

RCP2_6

RCP4_5

RCP8_5

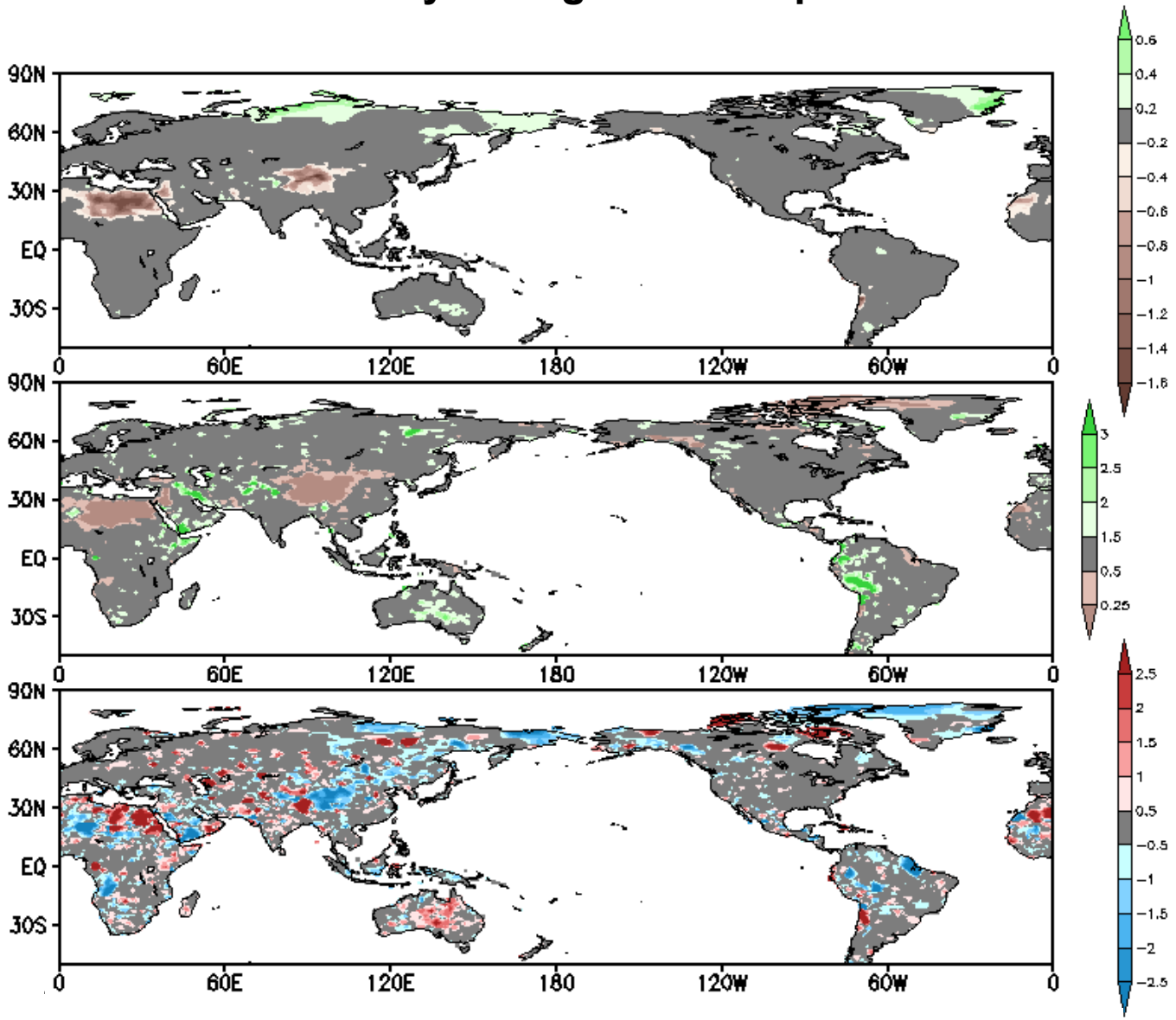


Observed 20th Century Changes in Precipitation Moments

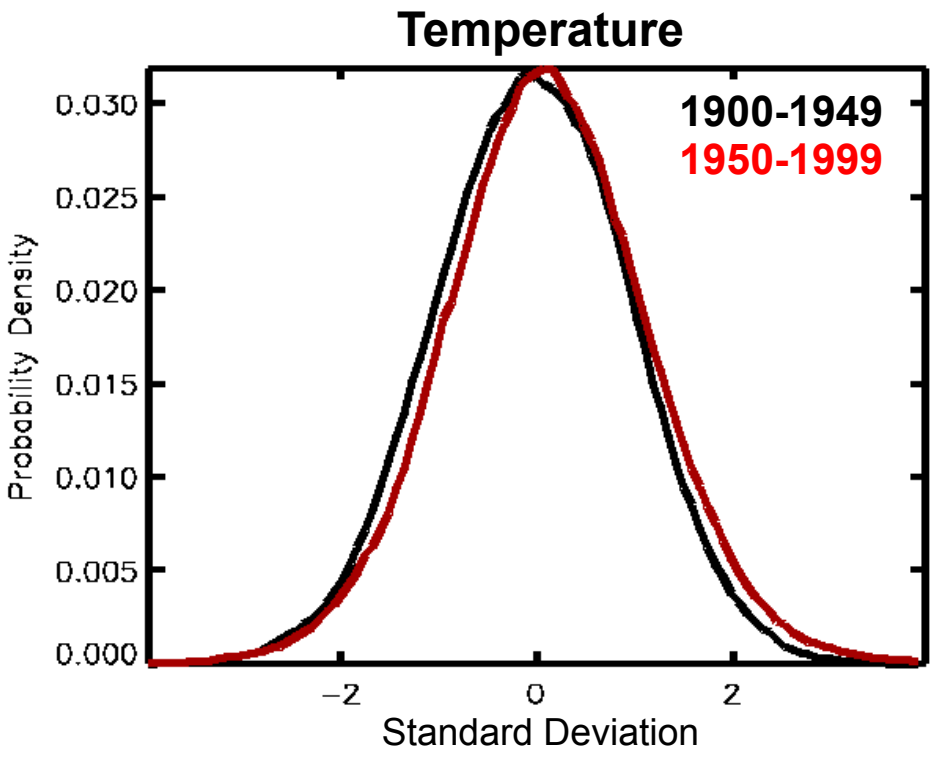
Mean

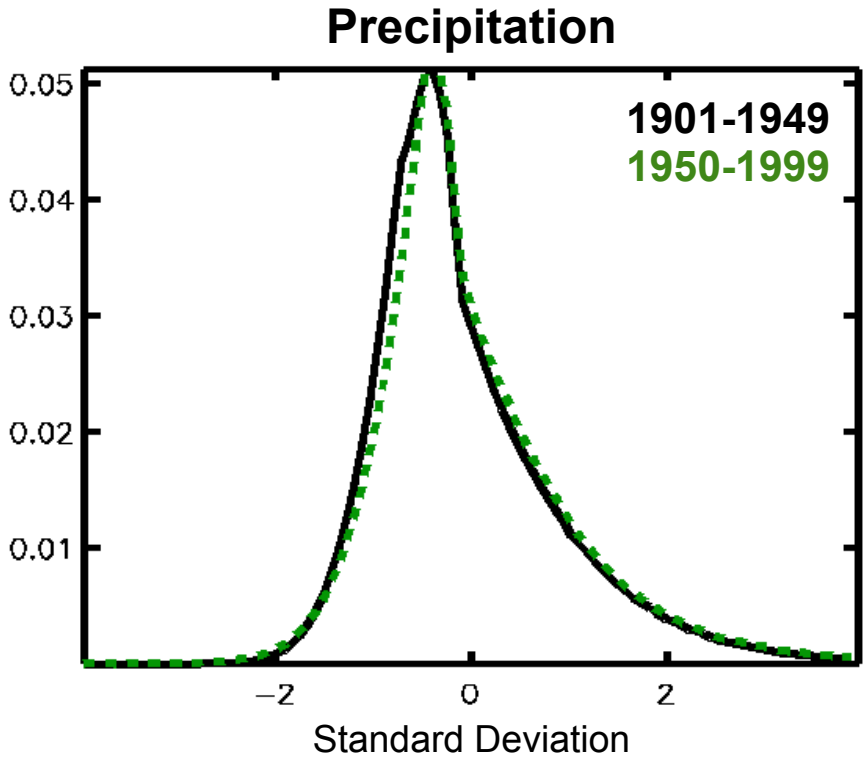
Variance

Skewness

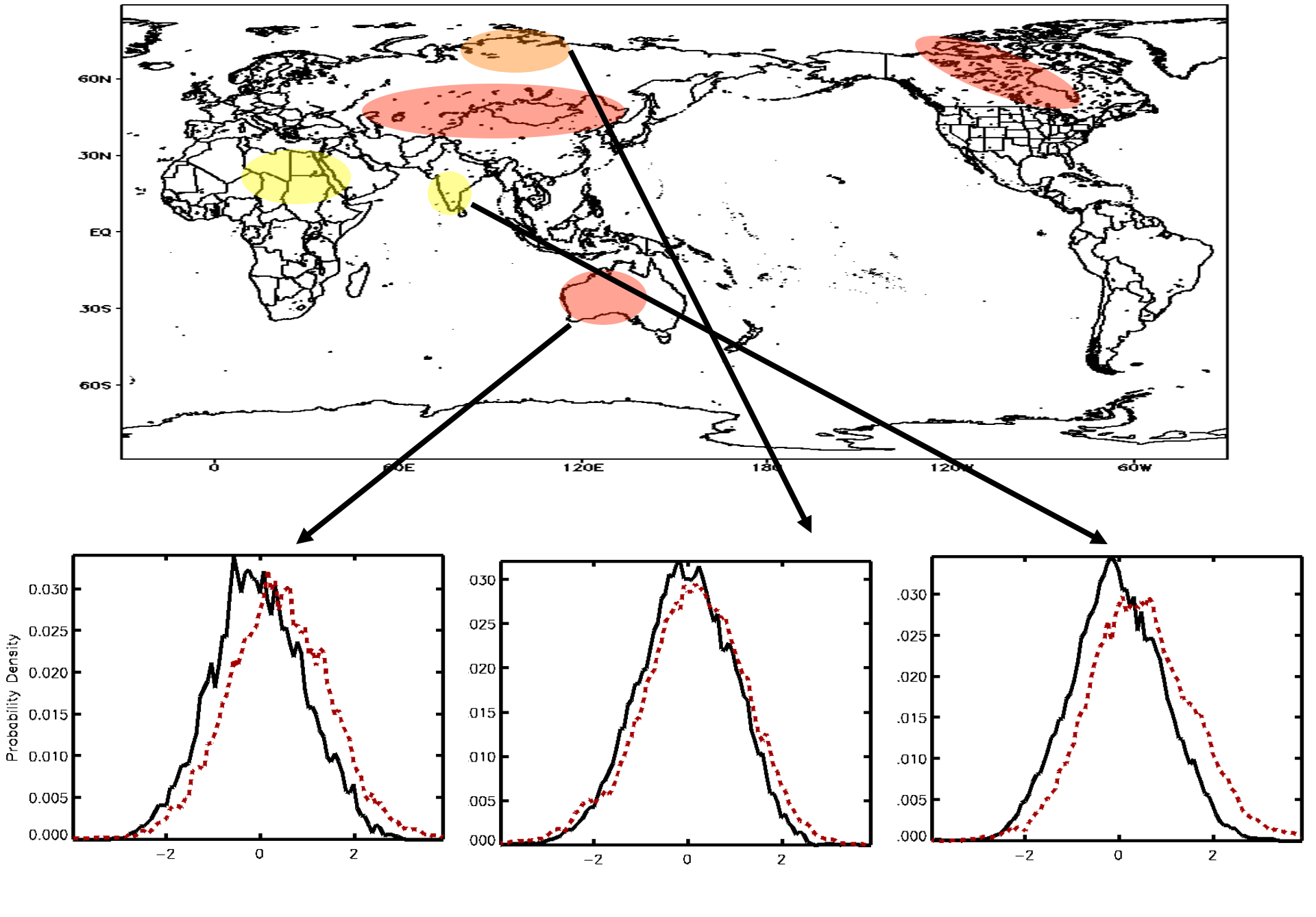


Global PDFs

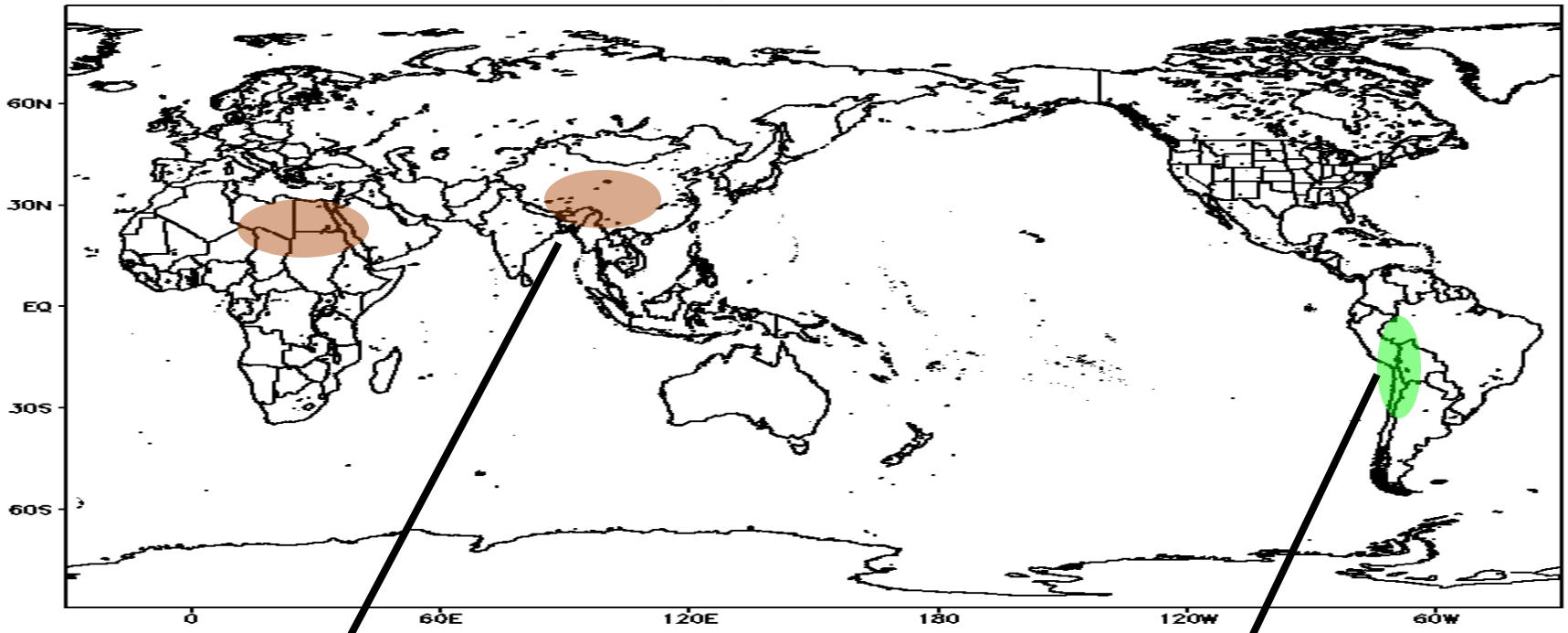

Temperature
1900-1949
1950-1999
Probability Density
0.030
0.025
0.020
0.015
0.010
0.005
0.000
−2
0
2
Standard Deviation

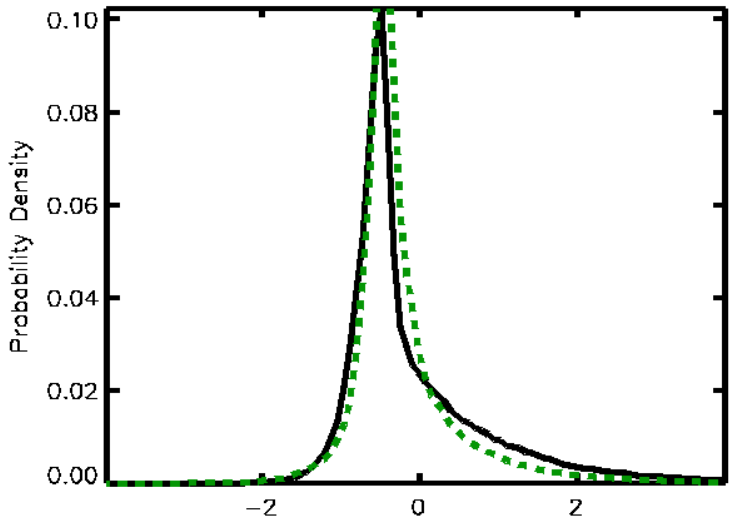

Precipitation
1901-1949
1950-1999
0.05
0.04
0.03
0.02
0.01
−2
0
2
Standard Deviation

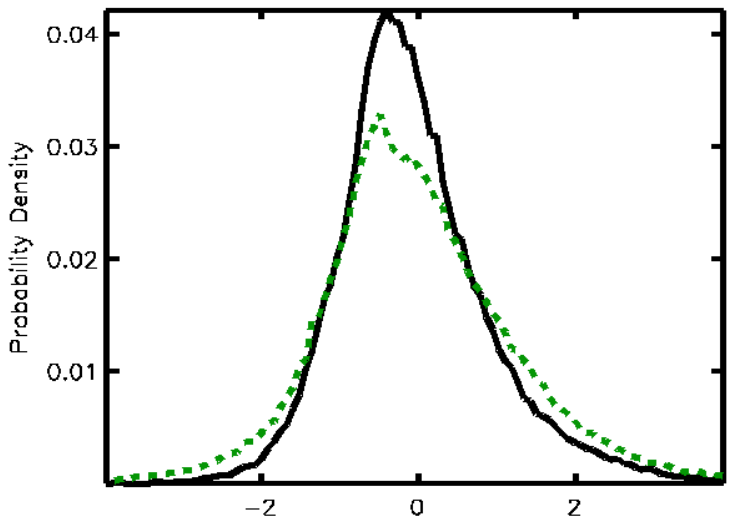
Summary: Temperature



Summary: Precipitation







Conclusions

1. “Global weirding” is highly regionally (and seasonally) dependent.

2. A 5-member ensemble from one AR5 class model is unable to represent 20th century changes in PDF moments of temperature and precipitation.

3. Future projections indicate that the mid-latitudes will warm and the tropical temperature will become more variable; precipitation is not projected to change.

4. It is unknown whether these projections are reliable.