Results from NCEP-driven RCMs

Overview Based on Mearns et al. (BAMS, 2011)

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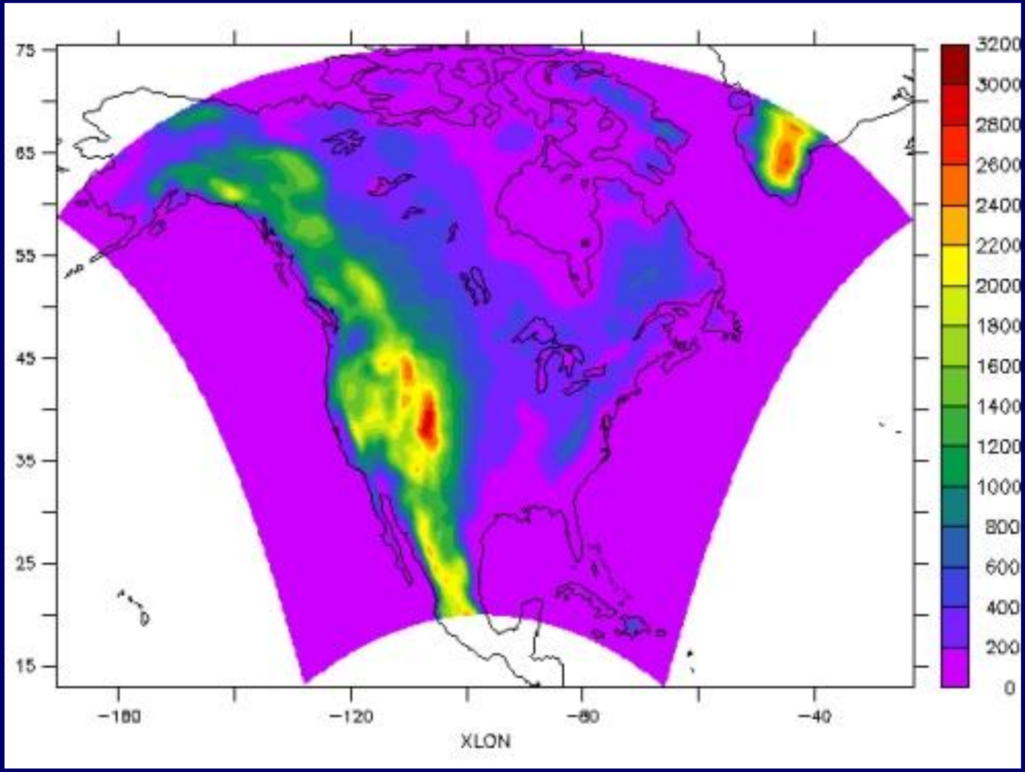
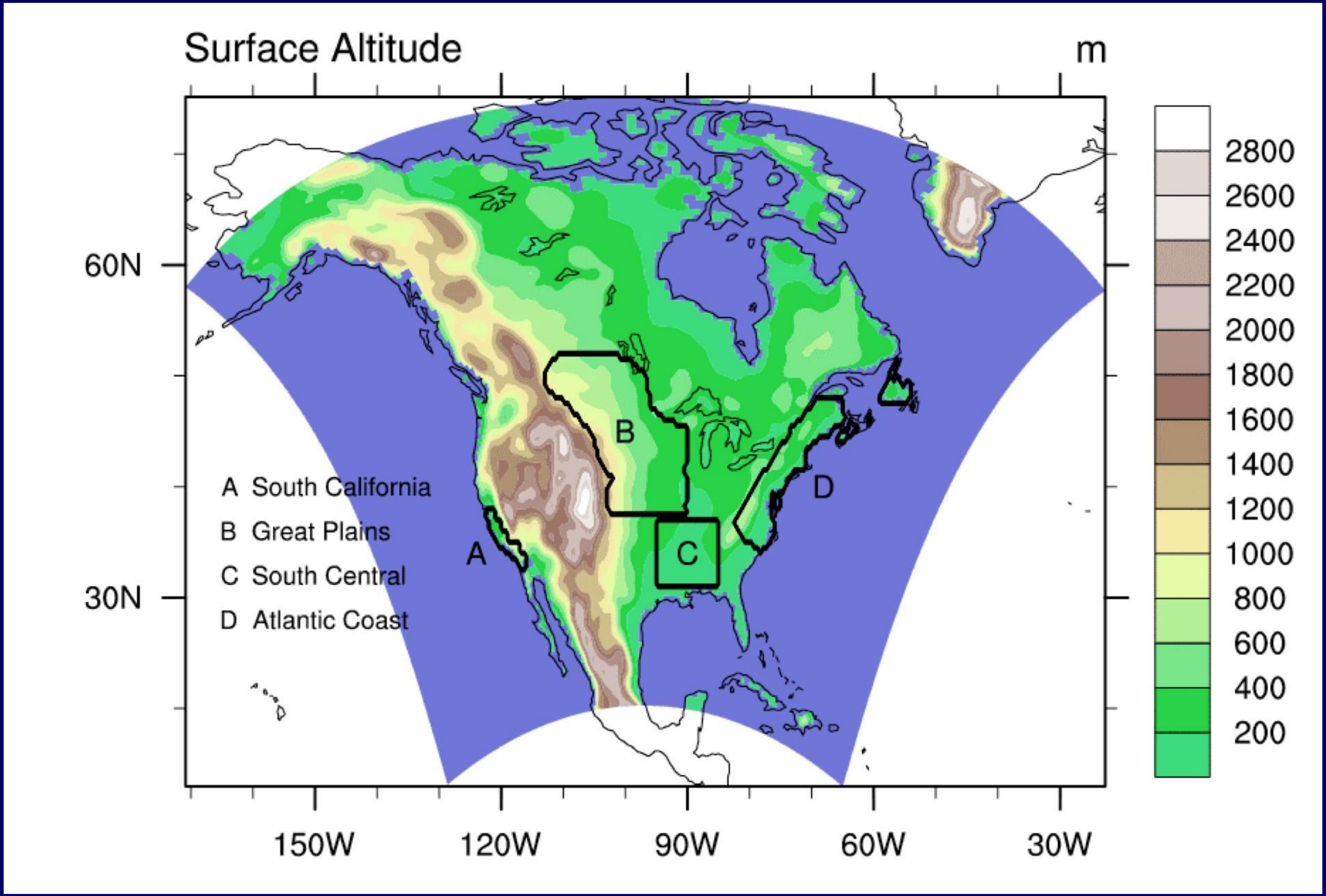
Simulations Analyzed

MM5	RegCM3	CRCM	HADRM3	RSM	WRF
Iowa State/ PNNL	UC Santa Cruz ICTP	Quebec, Ouranos	Hadley Centre	Scripps	NCAR/ PNNL

- Domain
  - Most of North America
- Period
  - 1980-2004
- Boundary Conditions
  - NCEP/DOE reanalysis
- Resolution
  - 50 km



Analysis Regions



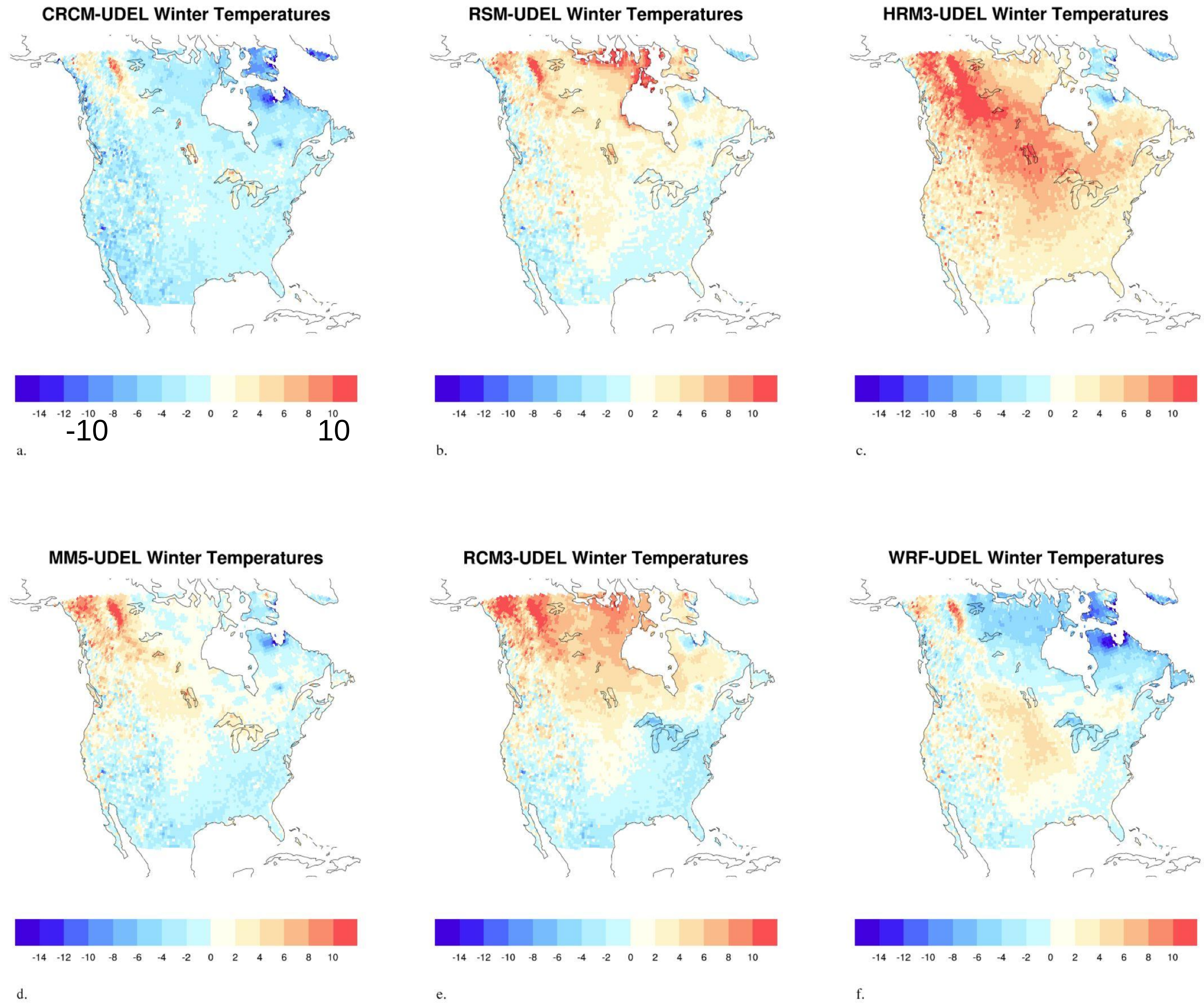
Comparison with 0.5º gridded observations from Univ Delaware

1. Means & Variability

Comparison with 0.5º gridded observations from Univ Delaware

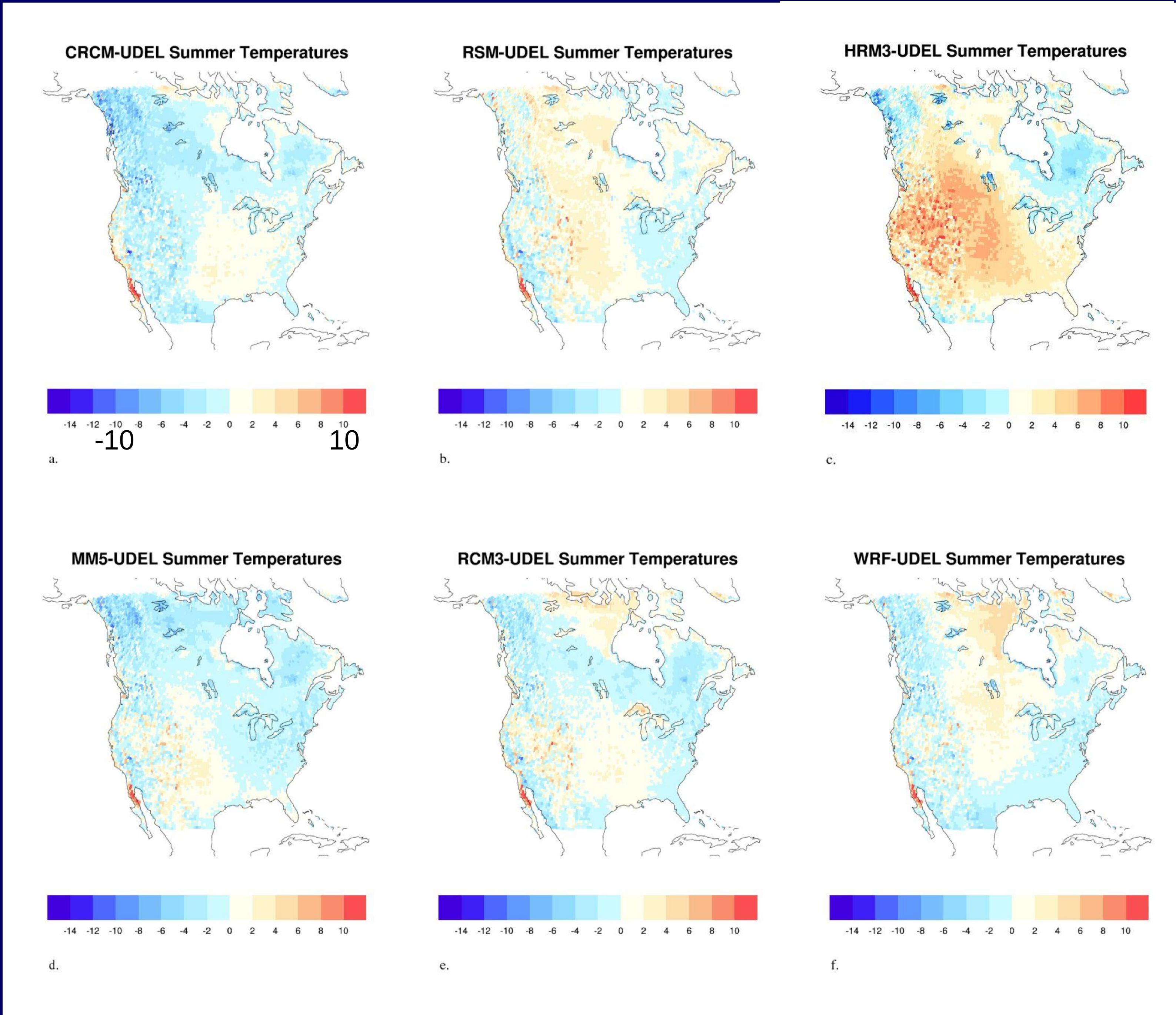
Temp. Bias

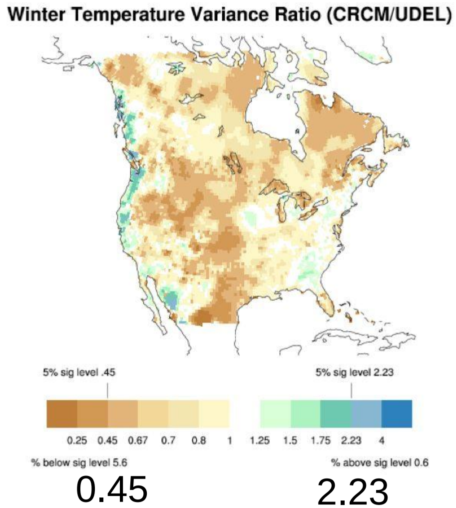
DJF



Temp. Bias

JJA





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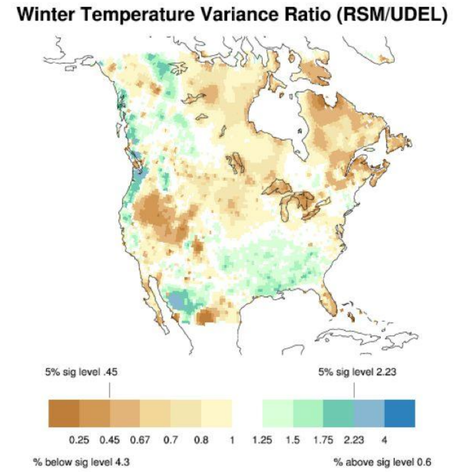
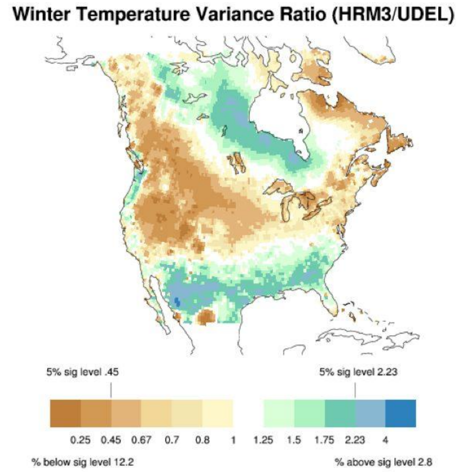
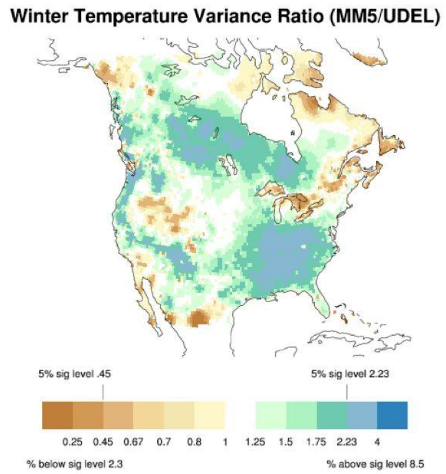


b.



c.

Interannual Variance



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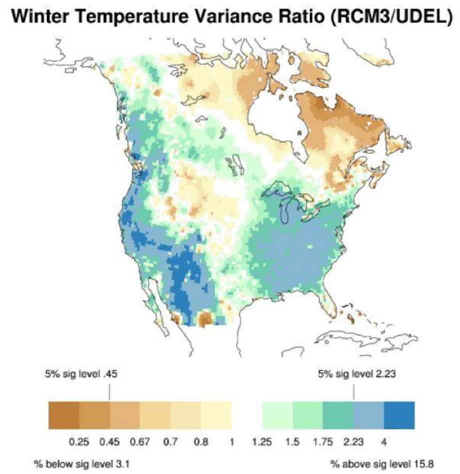
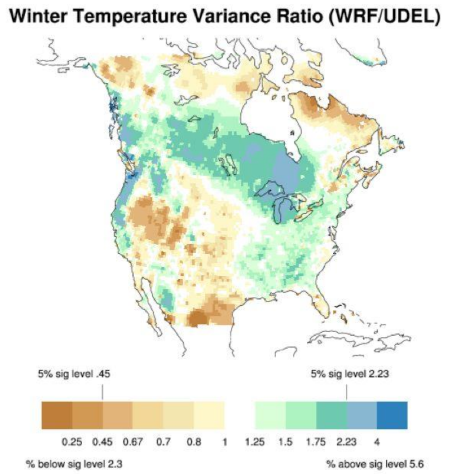
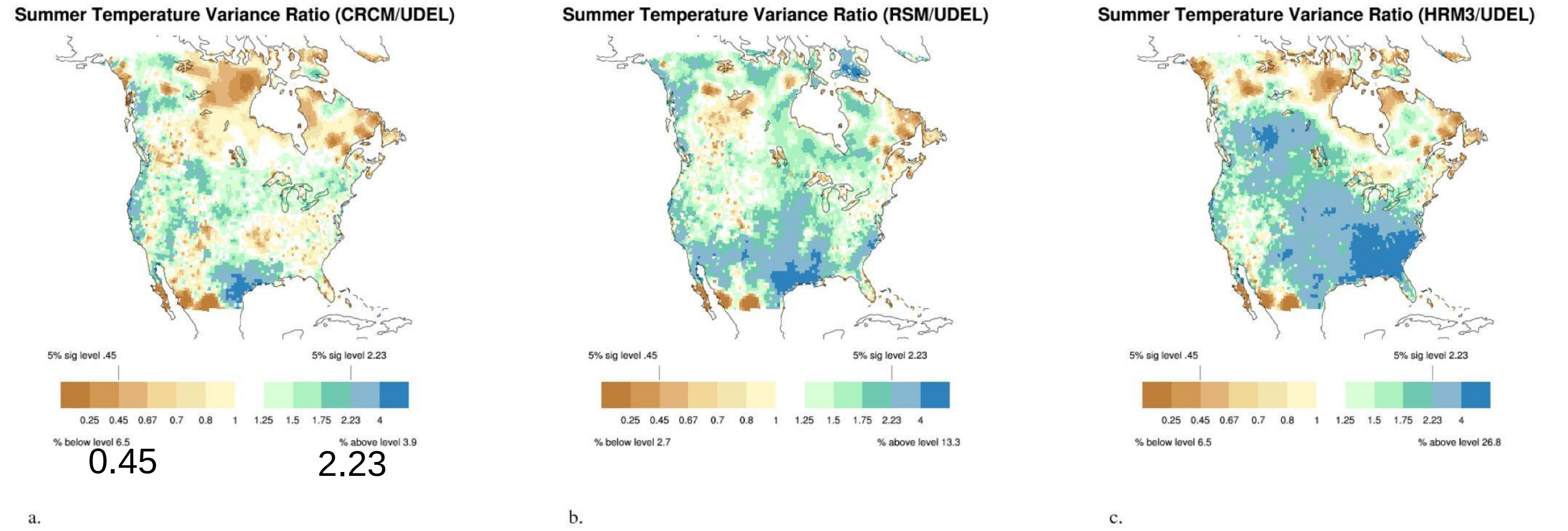


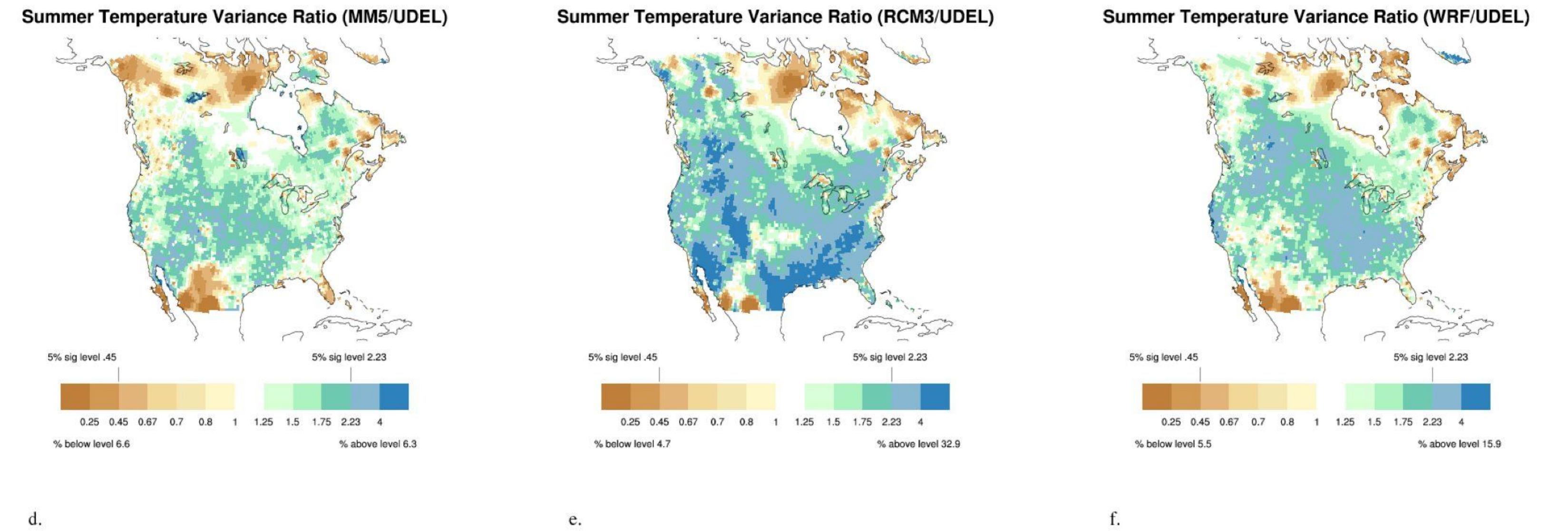
e.

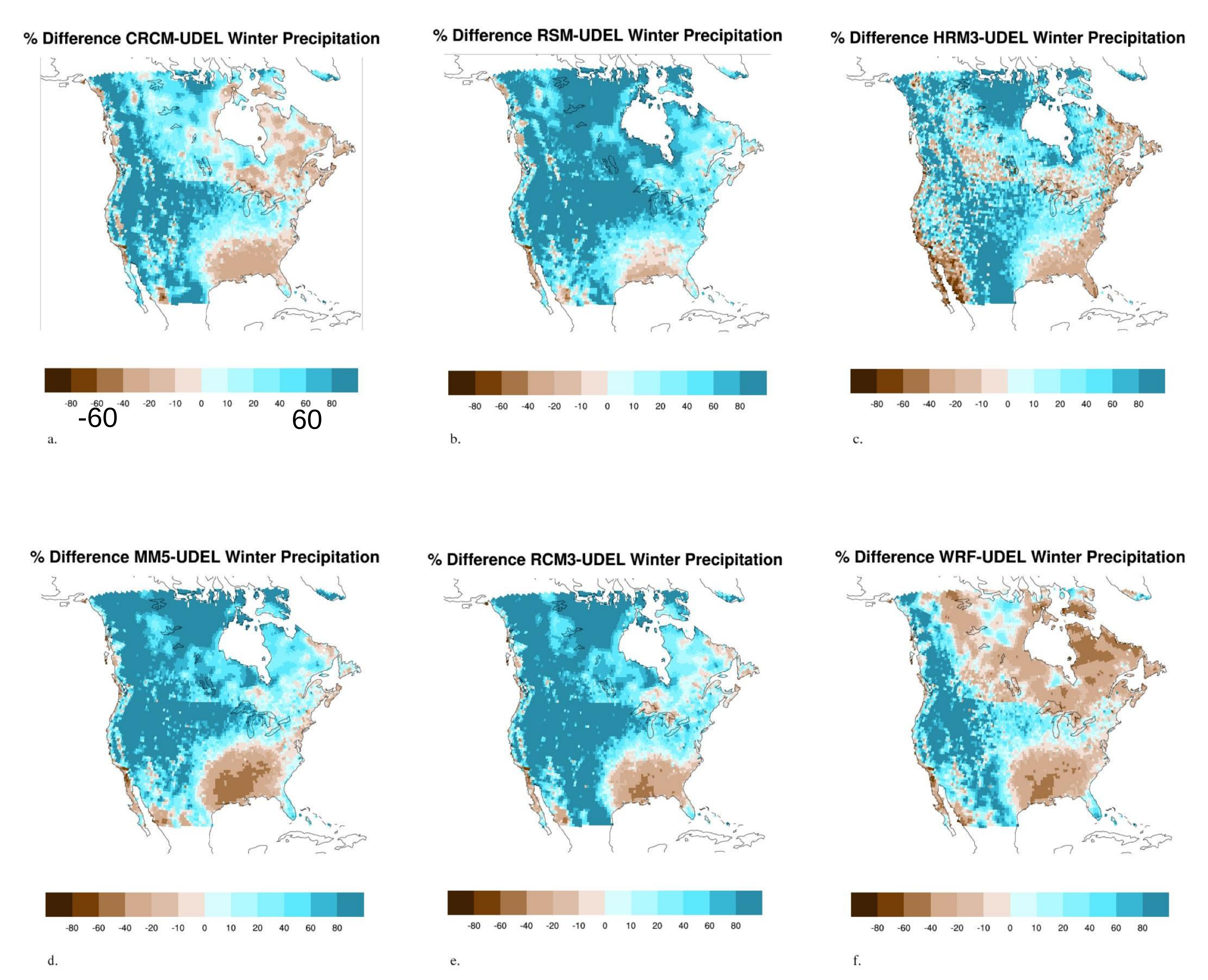


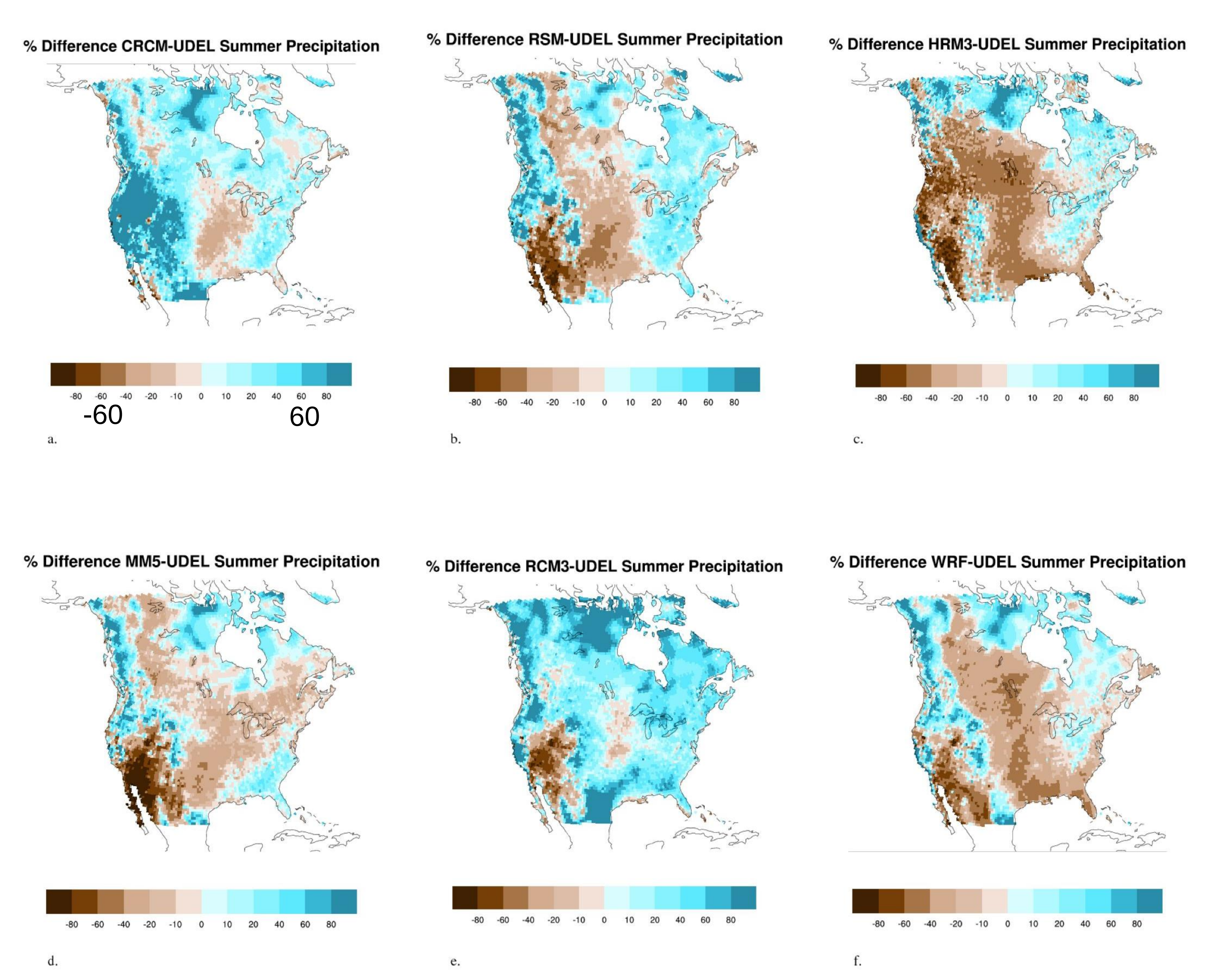
f.



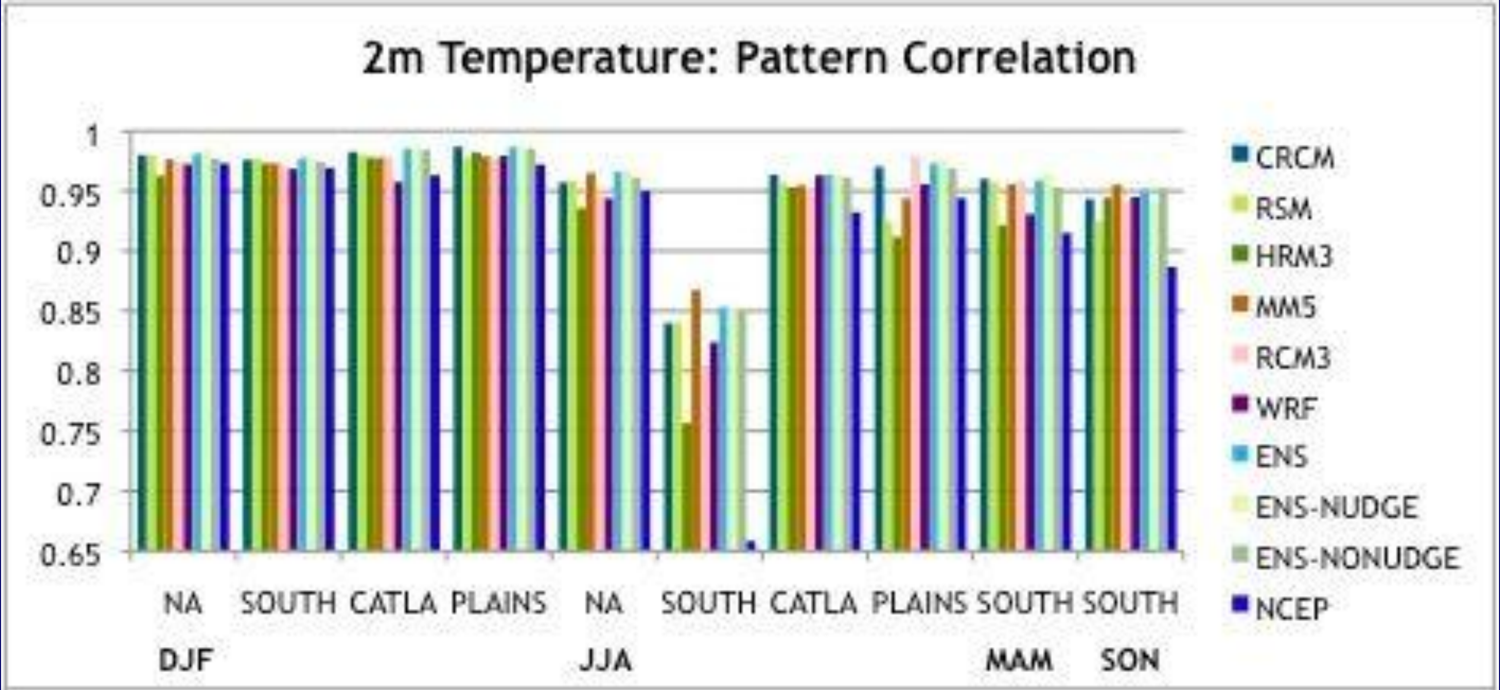
Interannual Variance

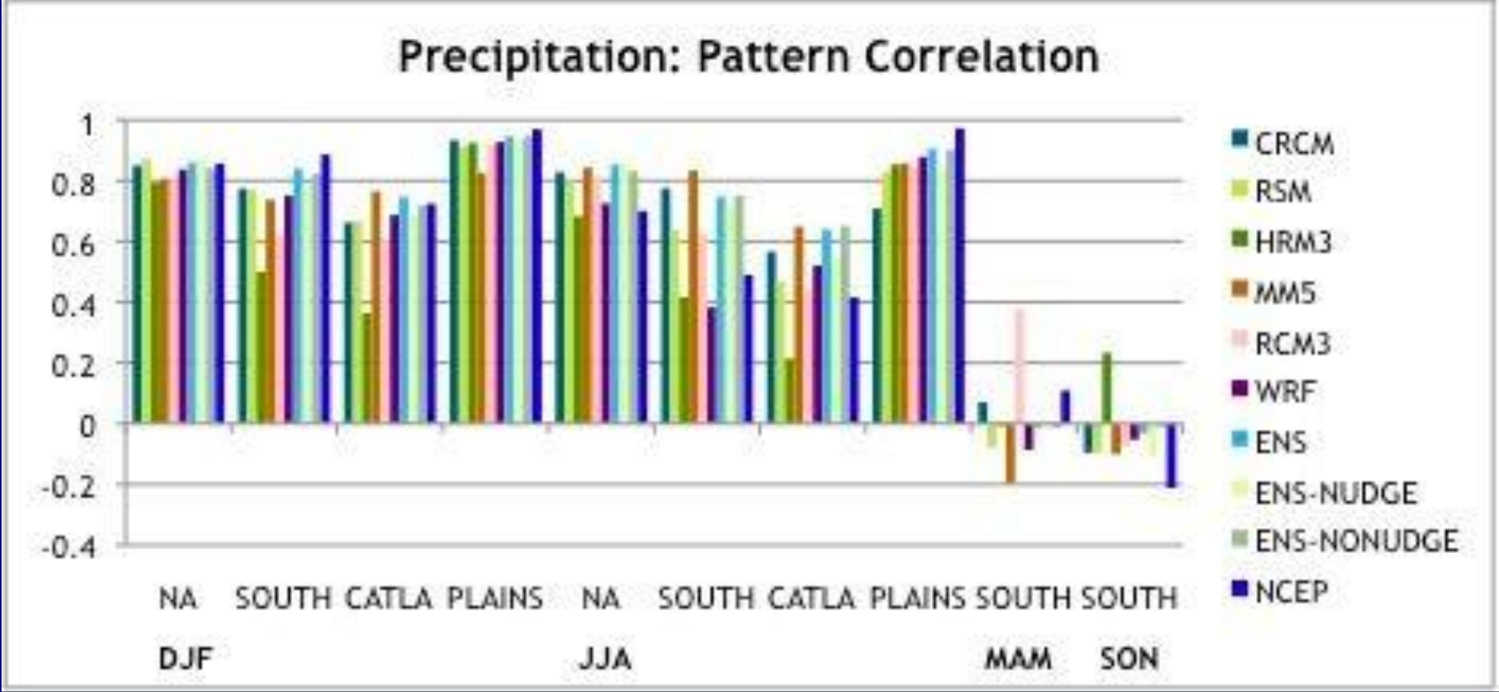



% Difference CRCM-UDEL Winter Precipitation
-80 -60 -40 -20 -10 0 10 20 40 60 80
-60
60
a.
% Difference RSM-UDEL Winter Precipitation
-80 -60 -40 -20 -10 0 10 20 40 60 80
b.
% Difference HRM3-UDEL Winter Precipitation
-80 -60 -40 -20 -10 0 10 20 40 60 80
c.
% Difference MM5-UDEL Winter Precipitation
-80 -60 -40 -20 -10 0 10 20 40 60 80
d.
% Difference RCM3-UDEL Winter Precipitation
-80 -60 -40 -20 -10 0 10 20 40 60 80
e.
% Difference WRF-UDEL Winter Precipitation
-80 -60 -40 -20 -10 0 10 20 40 60 80
f.

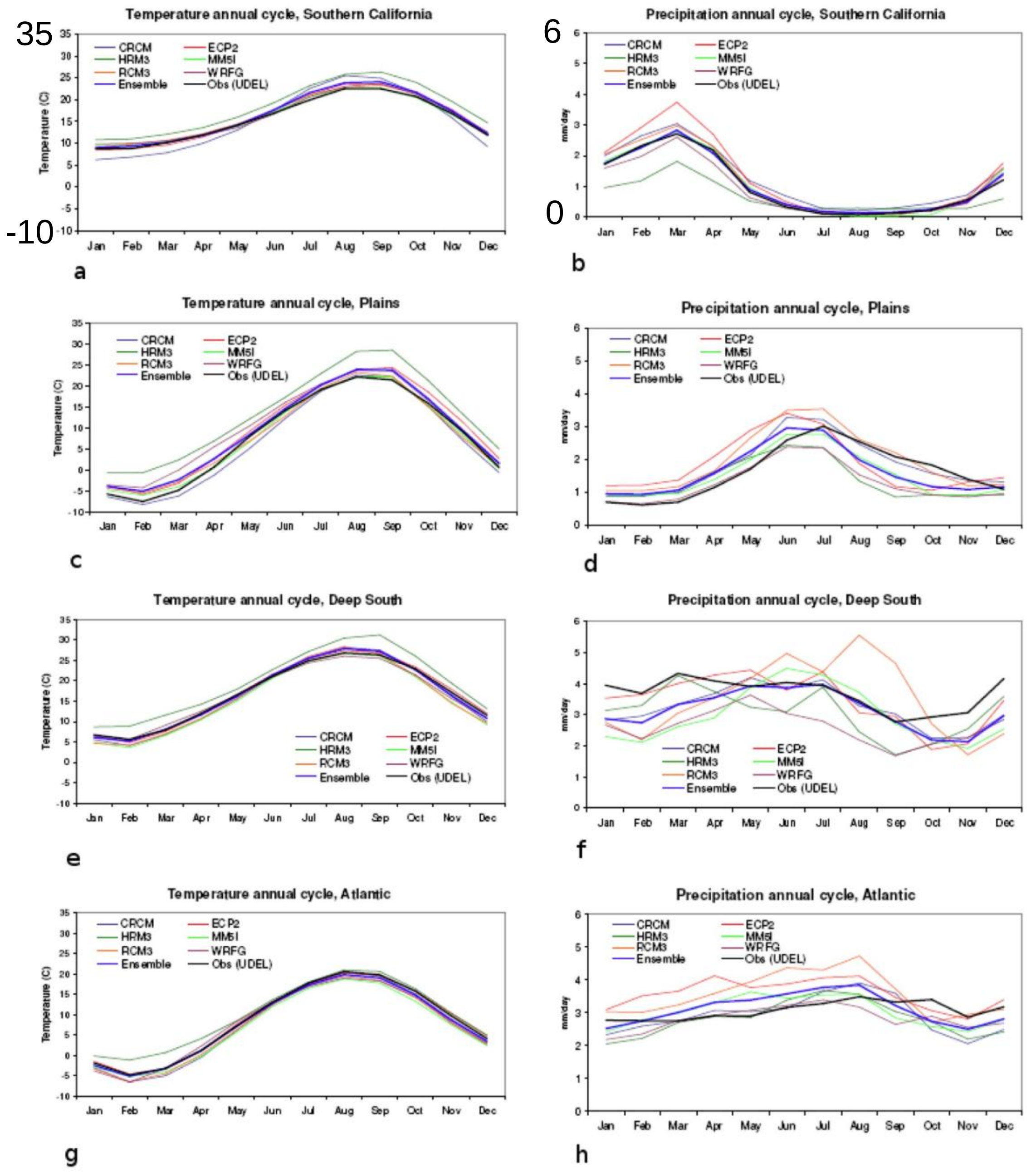


% Difference CRCM-UDEL Summer Precipitation
-80 -60 -40 -20 -10 0 10 20 40 60 80
-60
60
a.
% Difference RSM-UDEL Summer Precipitation
-80 -60 -40 -20 -10 0 10 20 40 60 80
b.
% Difference HRM3-UDEL Summer Precipitation
-80 -60 -40 -20 -10 0 10 20 40 60 80
c.
% Difference MM5-UDEL Summer Precipitation
-80 -60 -40 -20 -10 0 10 20 40 60 80
d.
% Difference RCM3-UDEL Summer Precipitation
-80 -60 -40 -20 -10 0 10 20 40 60 80
e.
% Difference WRF-UDEL Summer Precipitation
-80 -60 -40 -20 -10 0 10 20 40 60 80
f.

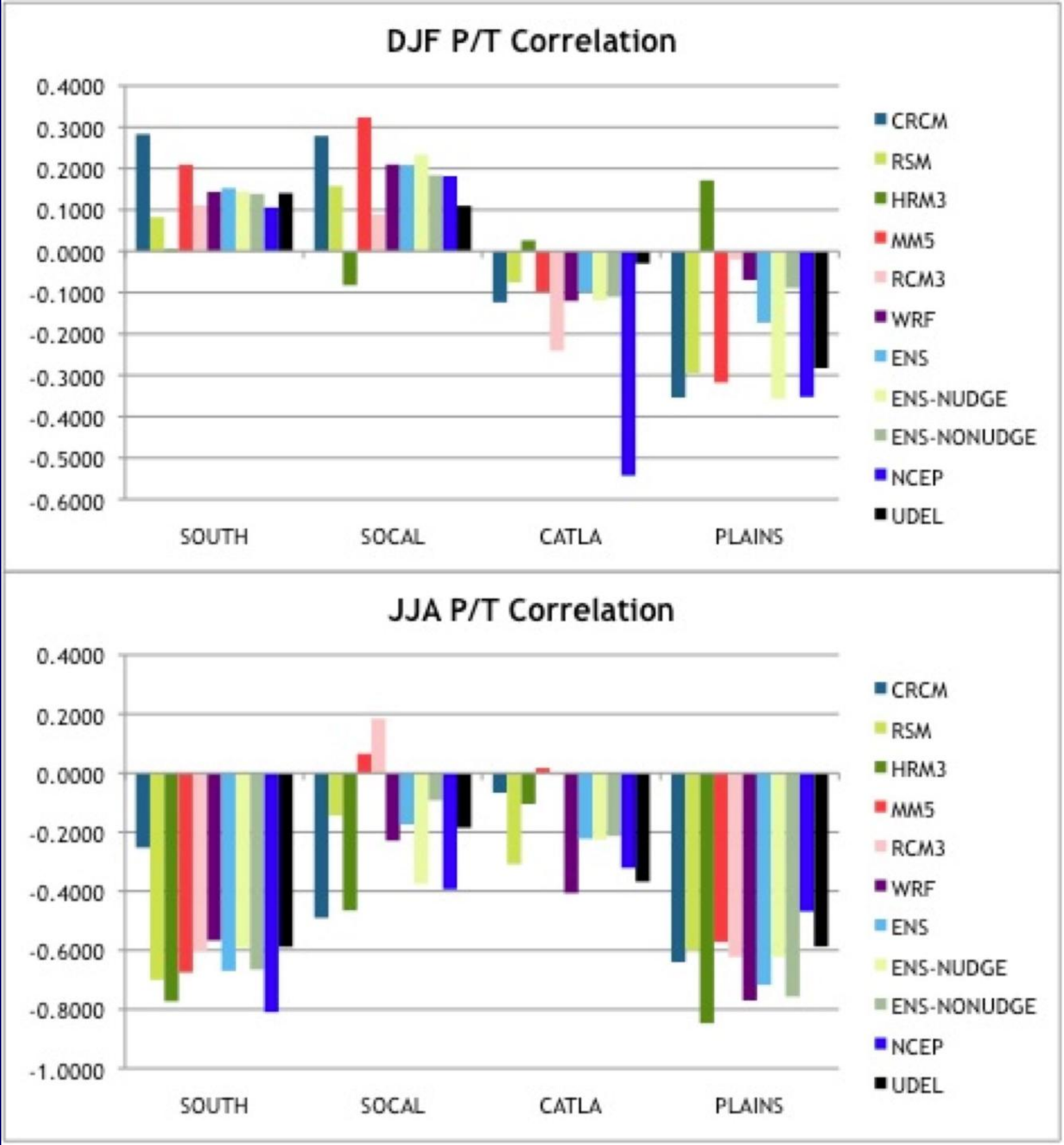

2m Temperature: Pattern Correlation
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
NA
SOUTH
CATLA
PLAINS
NA
SOUTH
CATLA
PLAINS
SOUTH
SOUTH
DJF
JJA
MAM
SON
CRCM
RSM
HRM3
MM5
RCM3
WRF
ENS
ENS-NUDGE
ENS-NONUDGE
NCEP


Precipitation: Pattern Correlation
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
NA
SOUTH
CATLA
PLAINS
NA
SOUTH
CATLA
PLAINS
SOUTH
SOUTH
DJF
JJA
MAM
SON
CRCM
RSM
HRM3
MM5
RCM3
WRF
ENS
ENS-NUDGE
ENS-NONUDGE
NCEP

Regional Annual Cycles

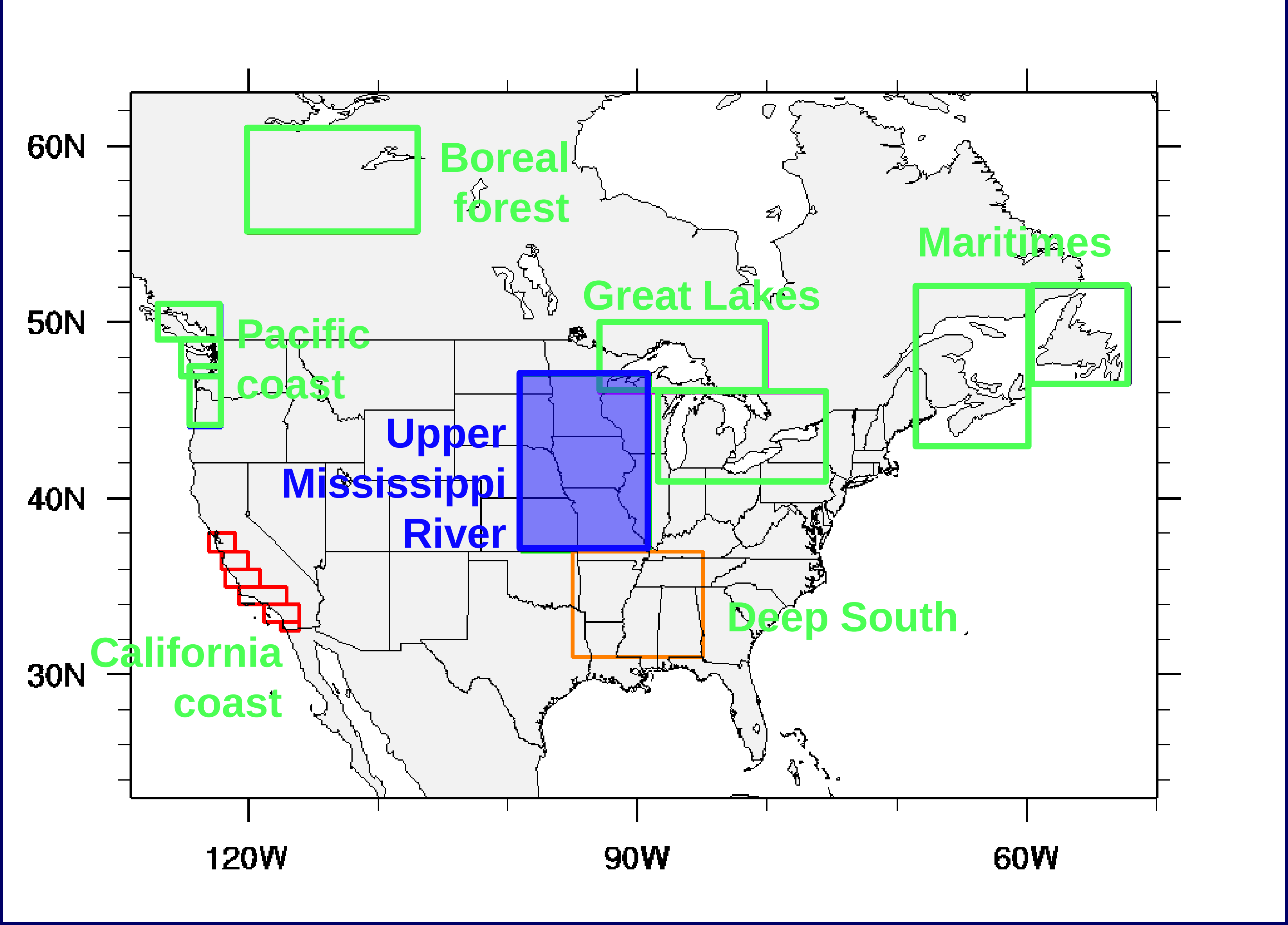


Temperature - Precipitation Correlations

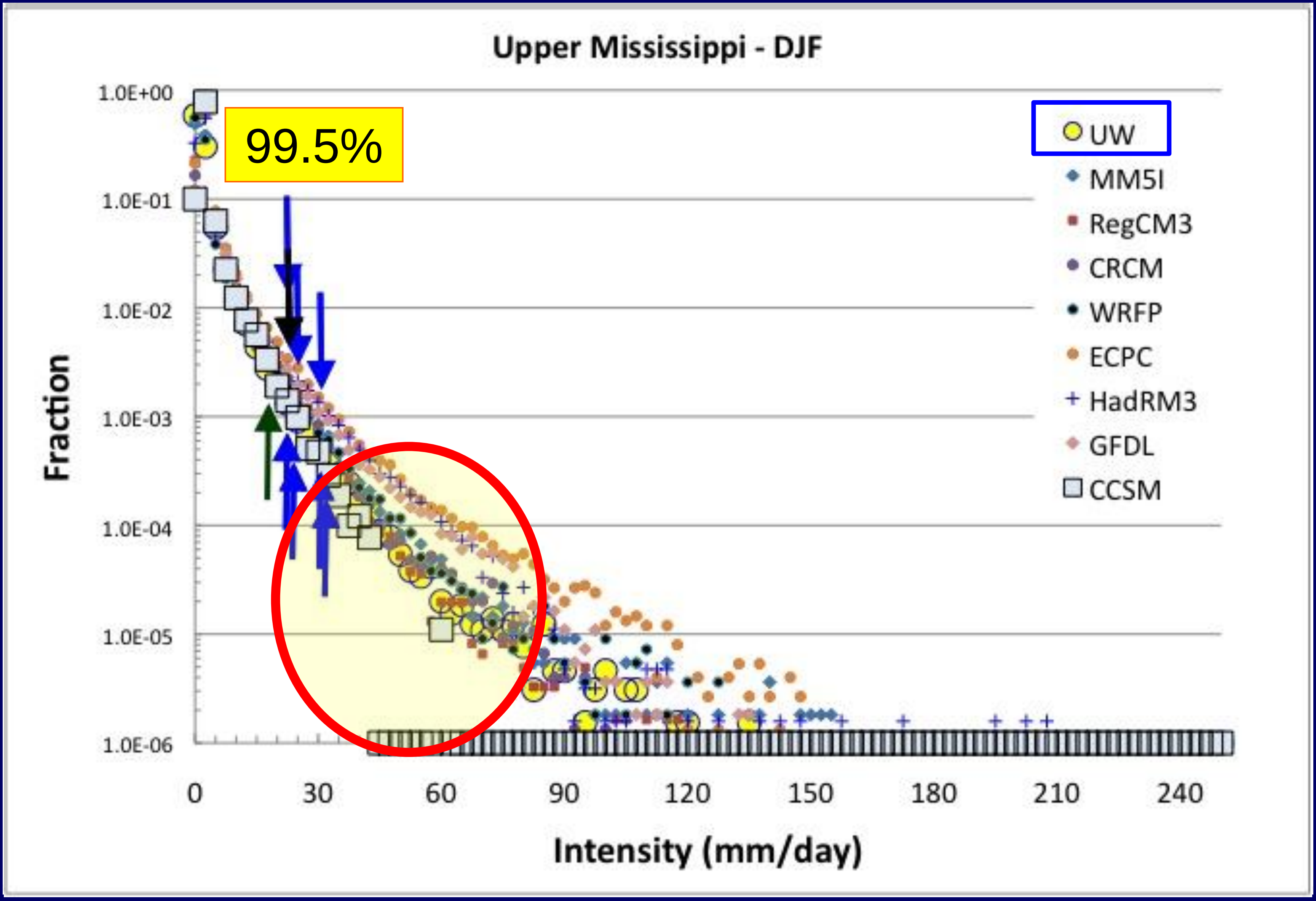


2a. Precipitation Extremes - Daily

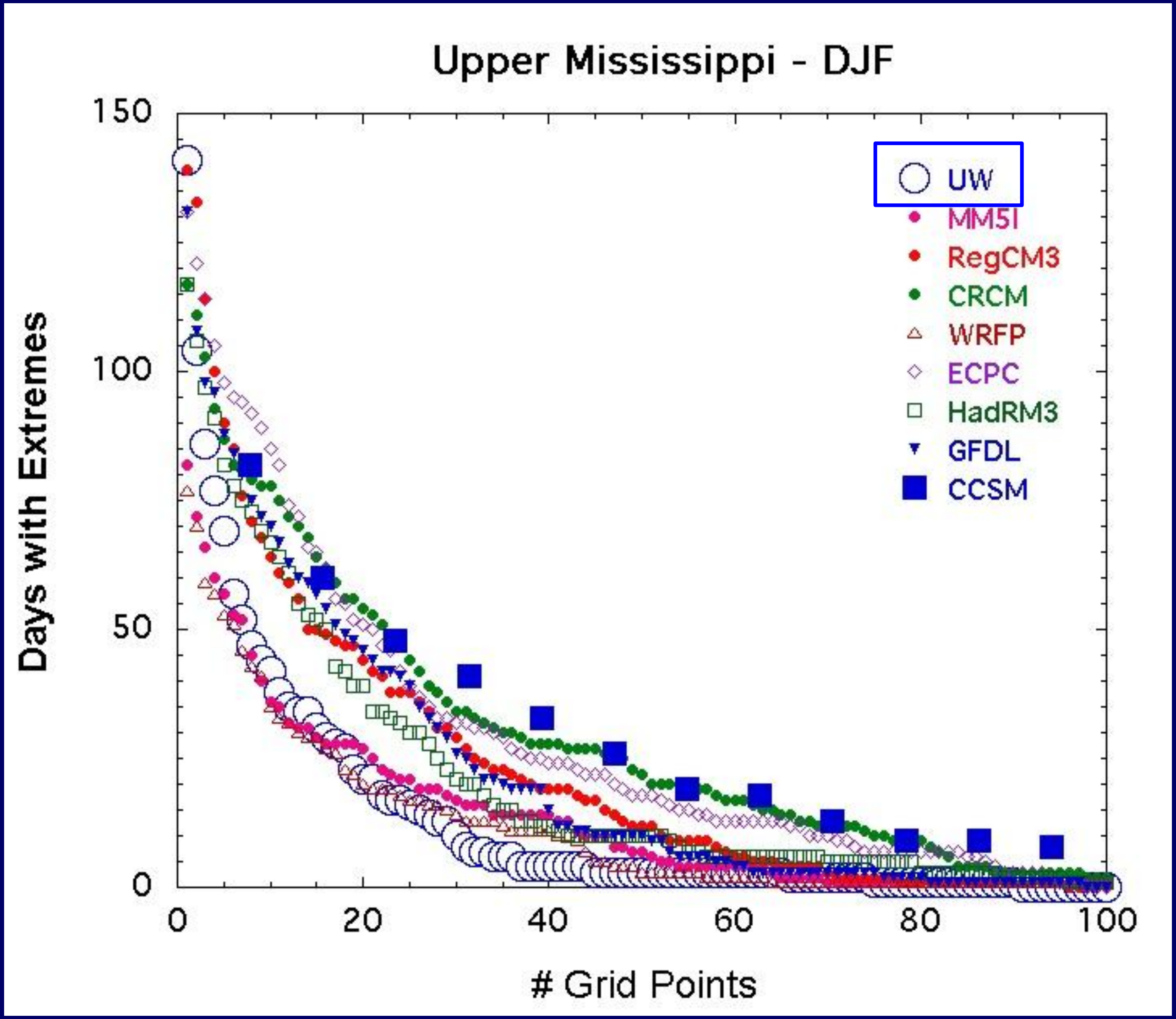
Region Analyzed



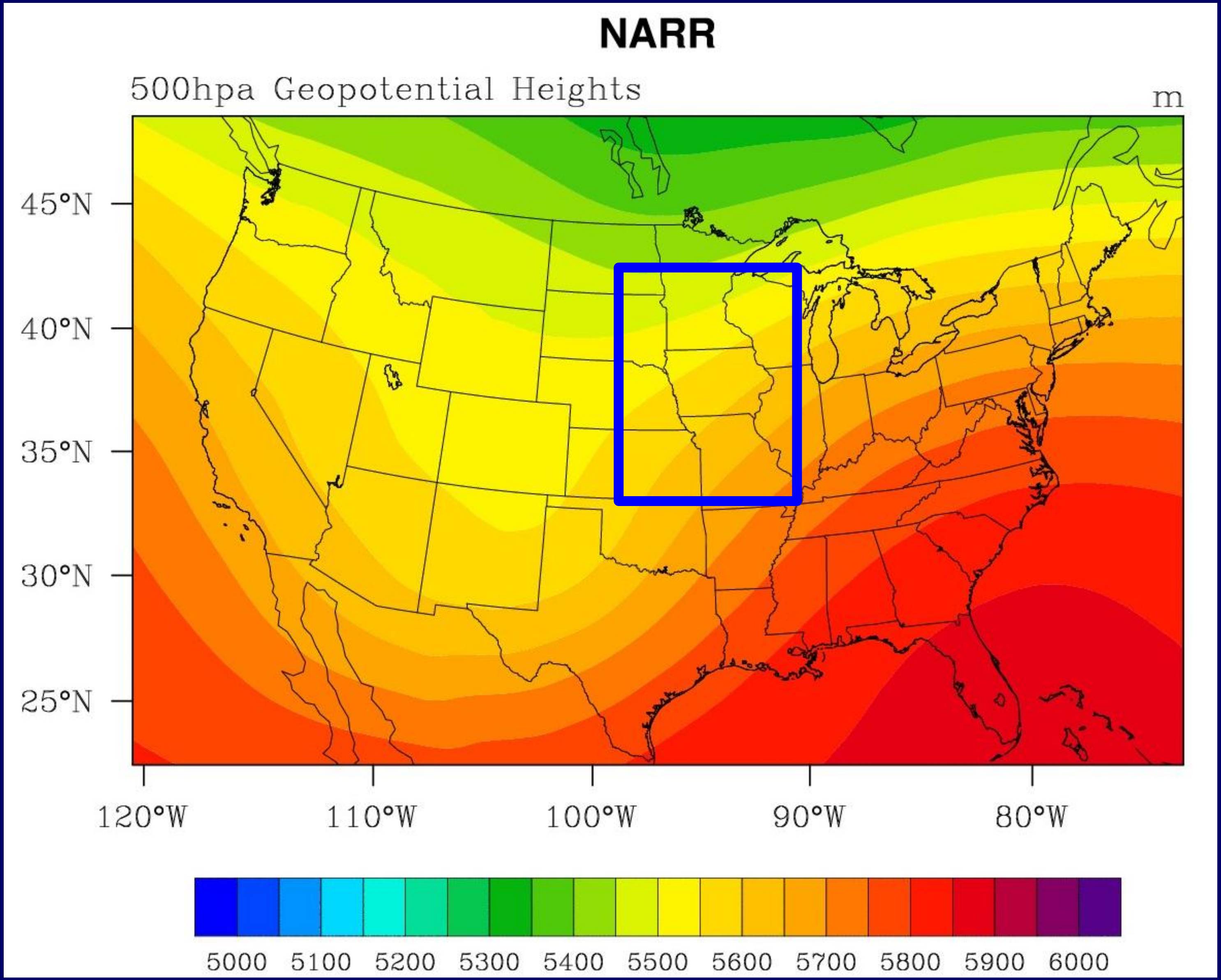
Precipitation Frequency vs. Intensity



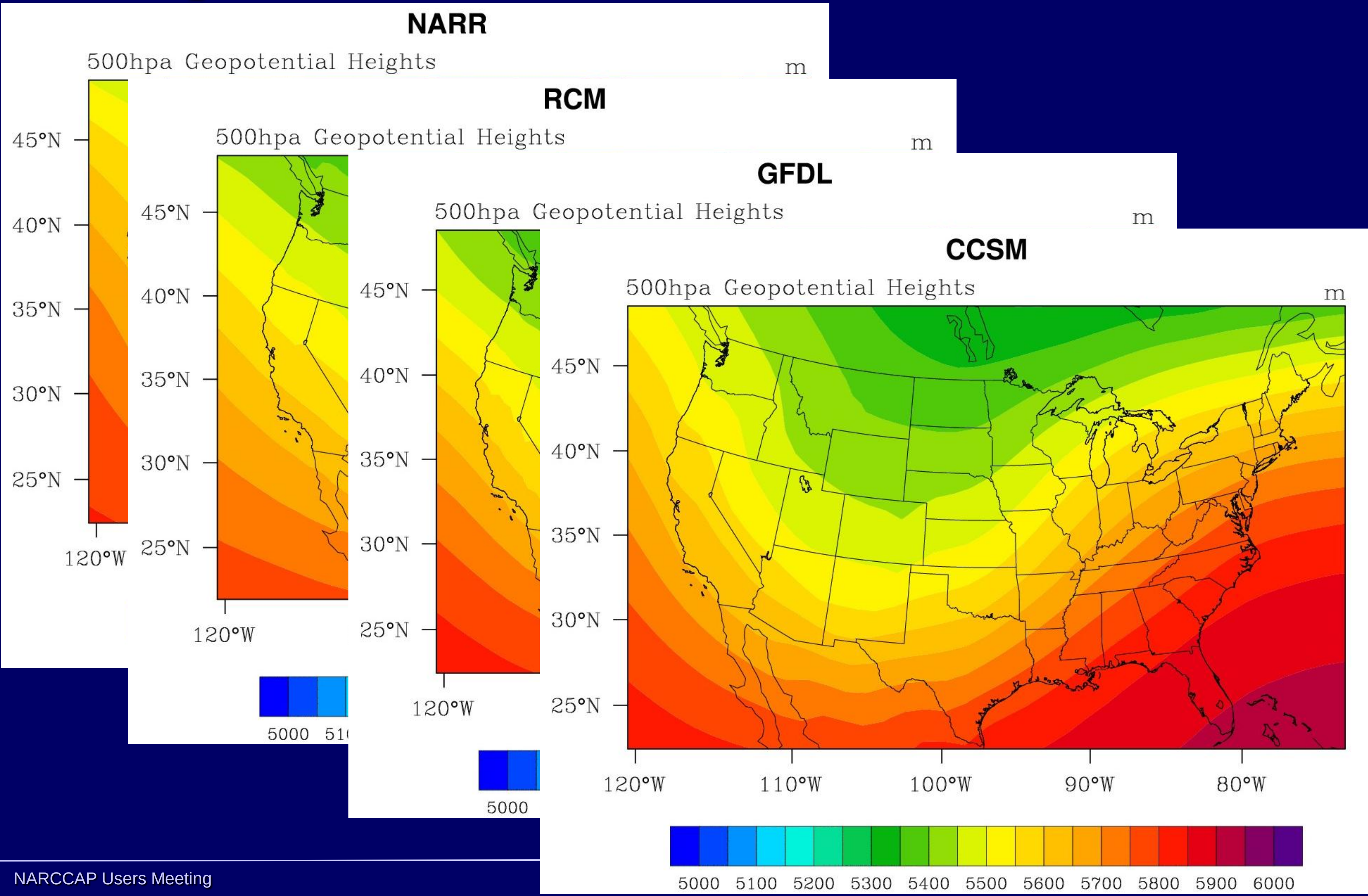
Days with Simultaneous Extremes on "N" Grid Points



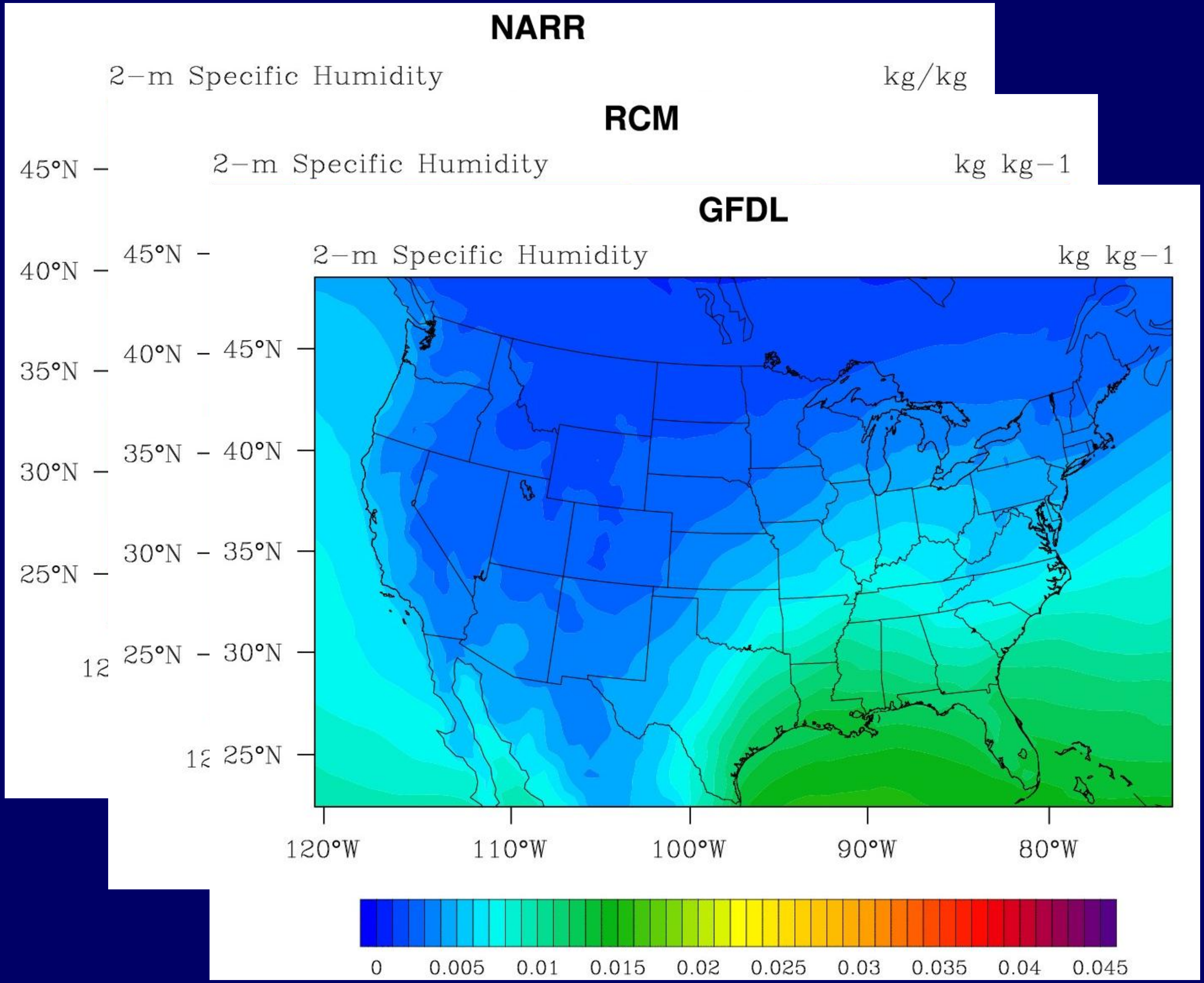
Composite Structure of Extreme Events - DJF



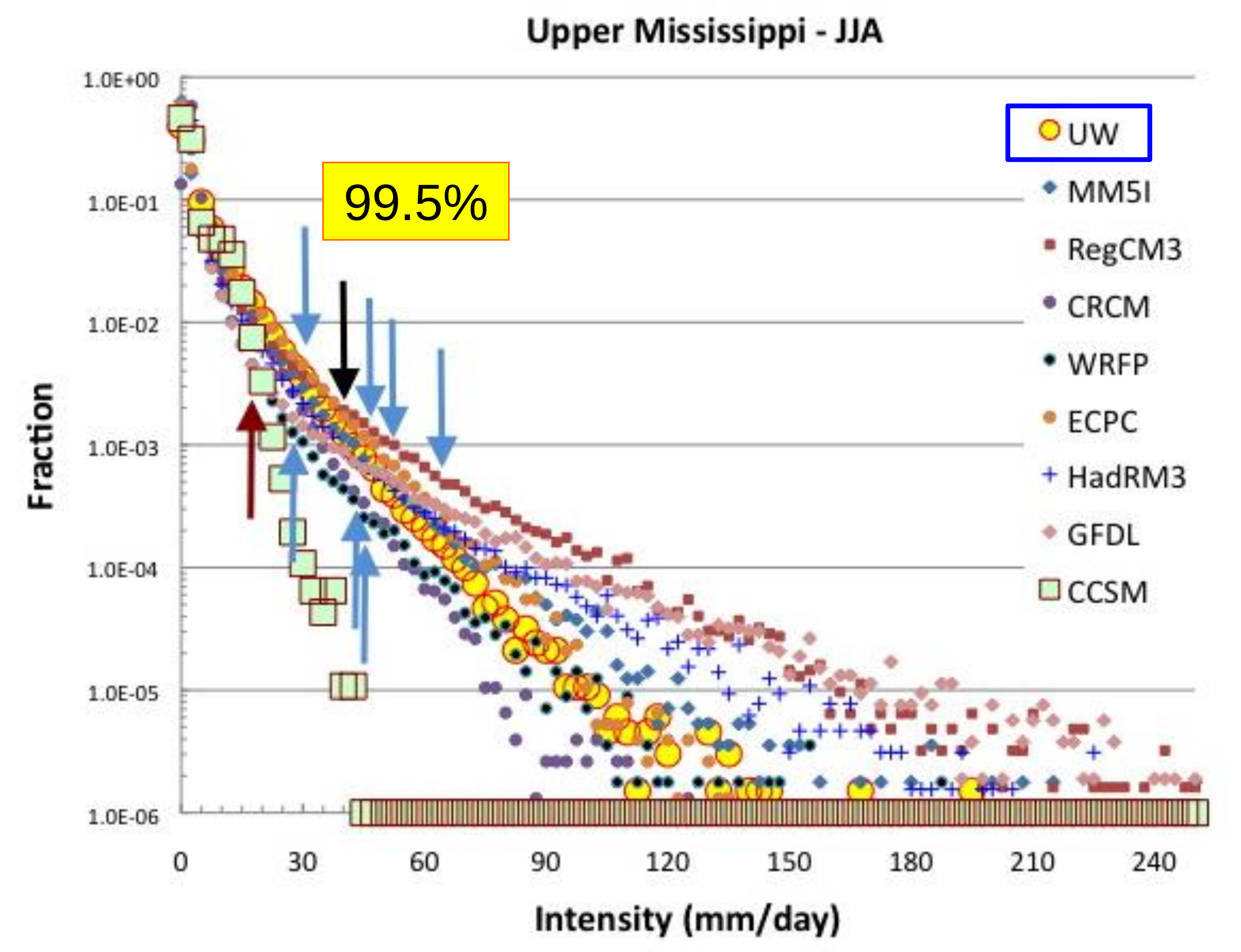
Composite Structure of Extreme Events - DJF



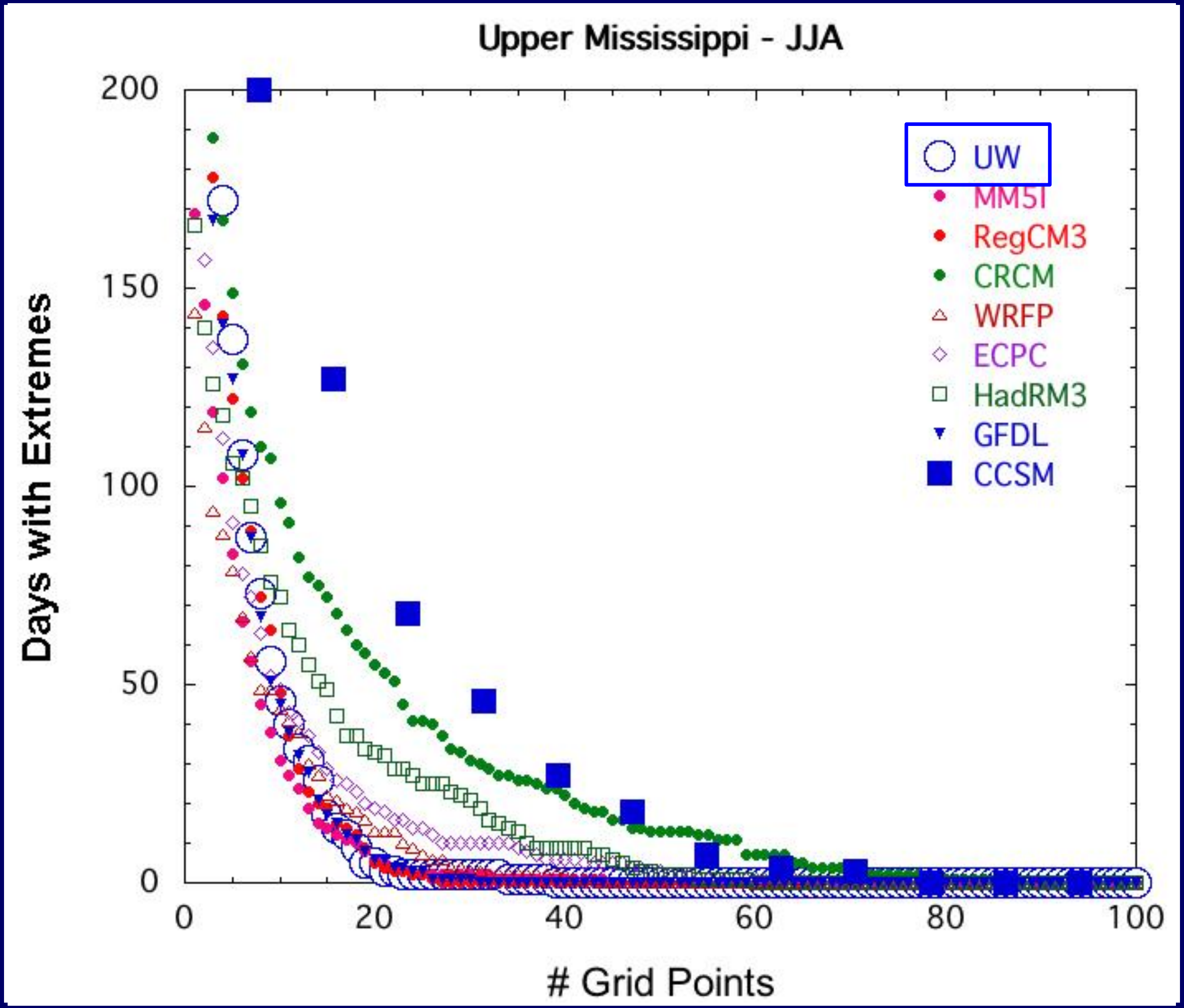
Composite Structure of Extreme Events - DJF



Precipitation Frequency vs. Intensity

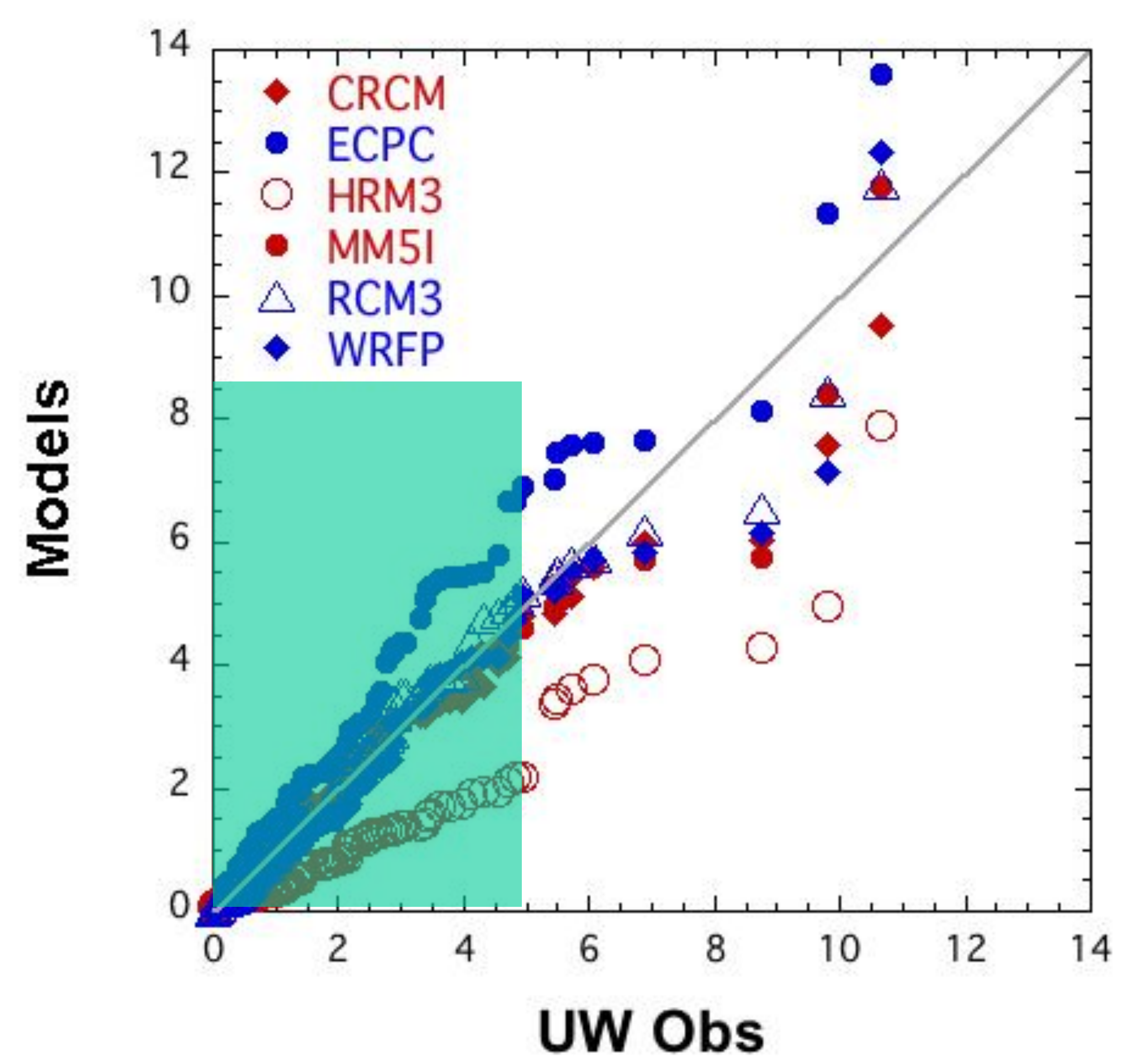


Days with Simultaneous Extremes on “N” Grid Points



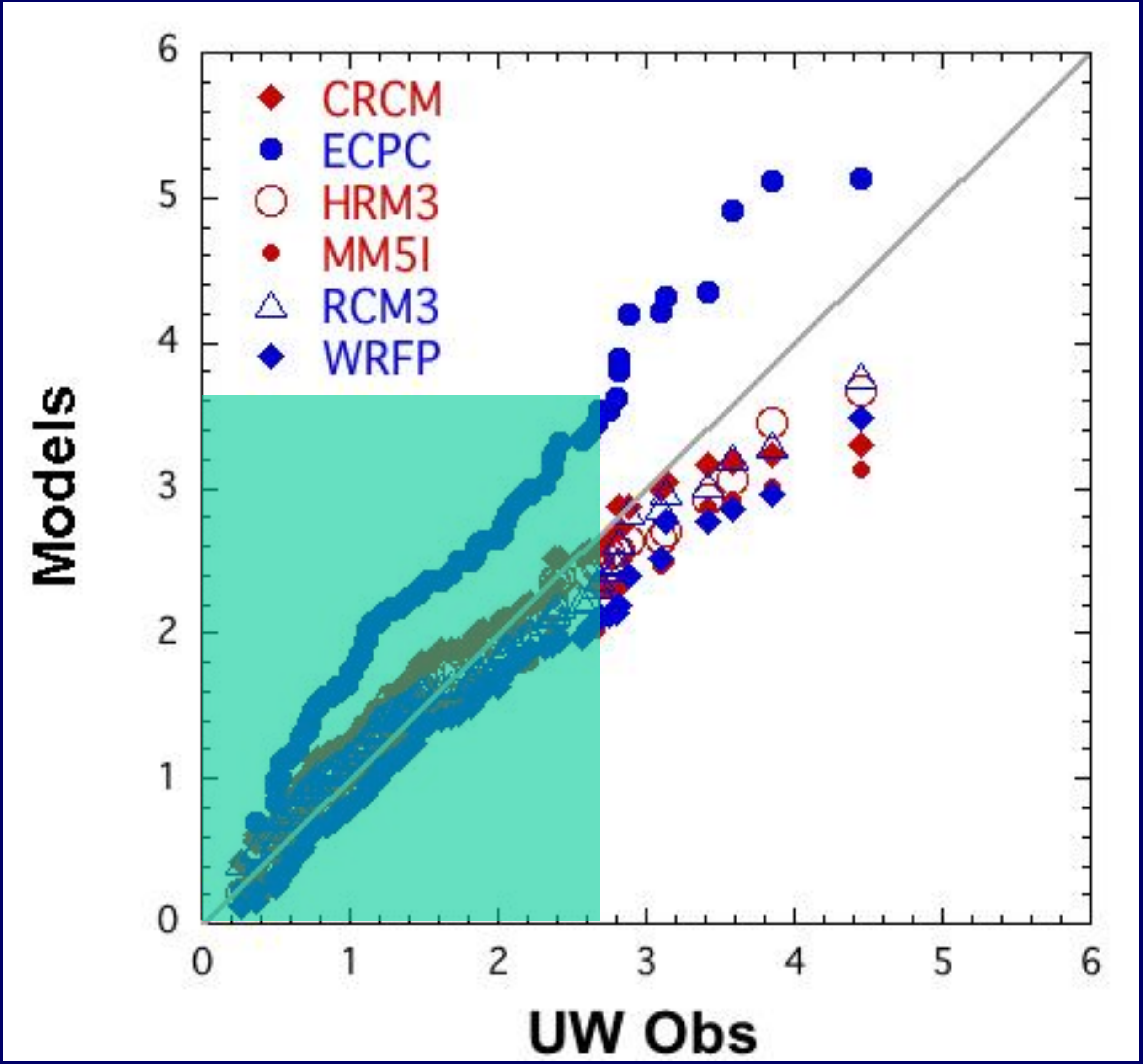
2b. Precipitation Extremes - Monthly

Ranked Precipitation – Coastal CA



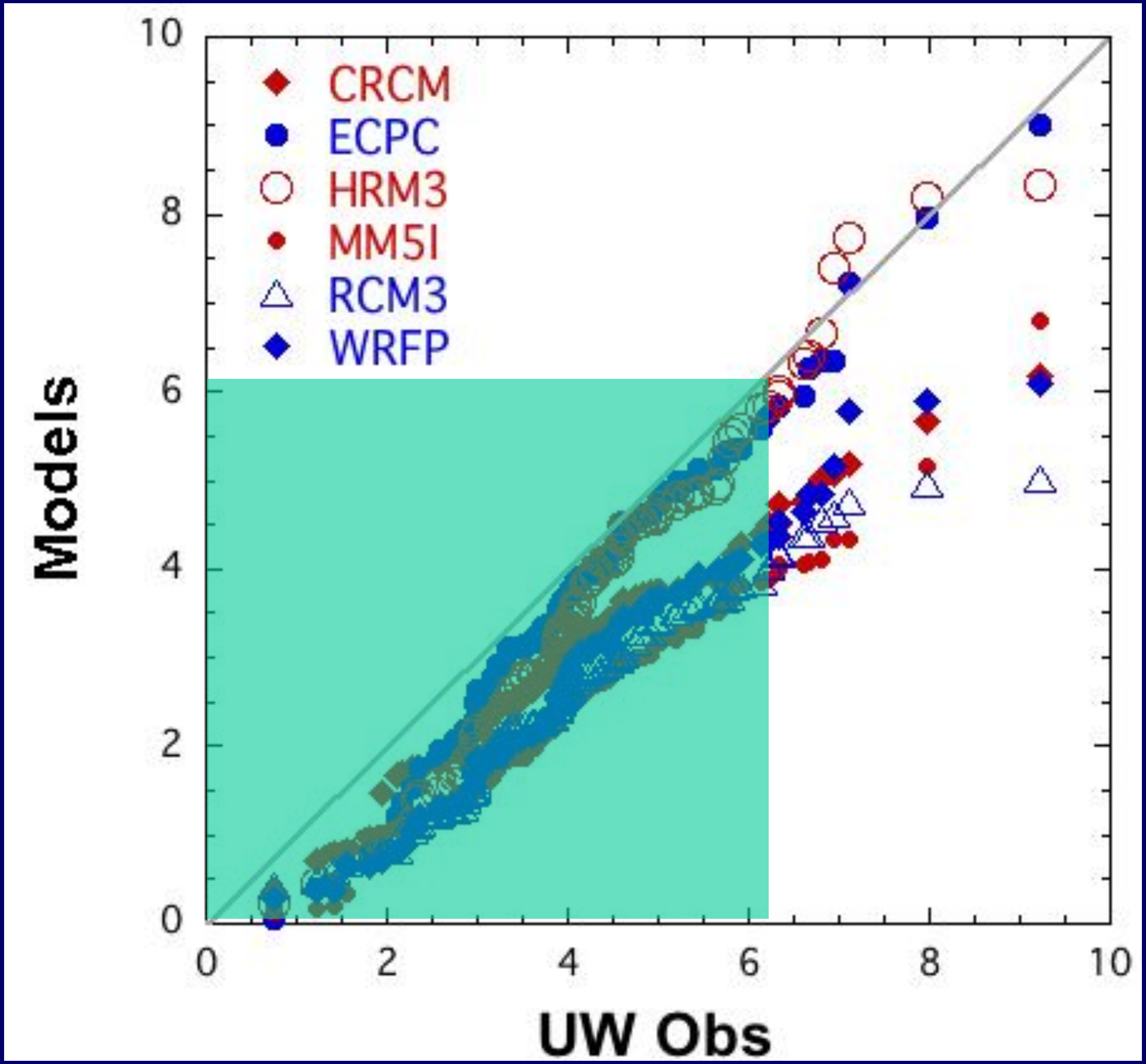
Ensemble average of top 10 = 9 % smaller than UW

Ranked Precipitation – Upper MS



Ensemble average of top 10 = 6 % smaller than UW

Ranked Precipitation – Deep South



Ensemble average of top 10 = 22 % smaller than UW

Thank You!

NARCCAP

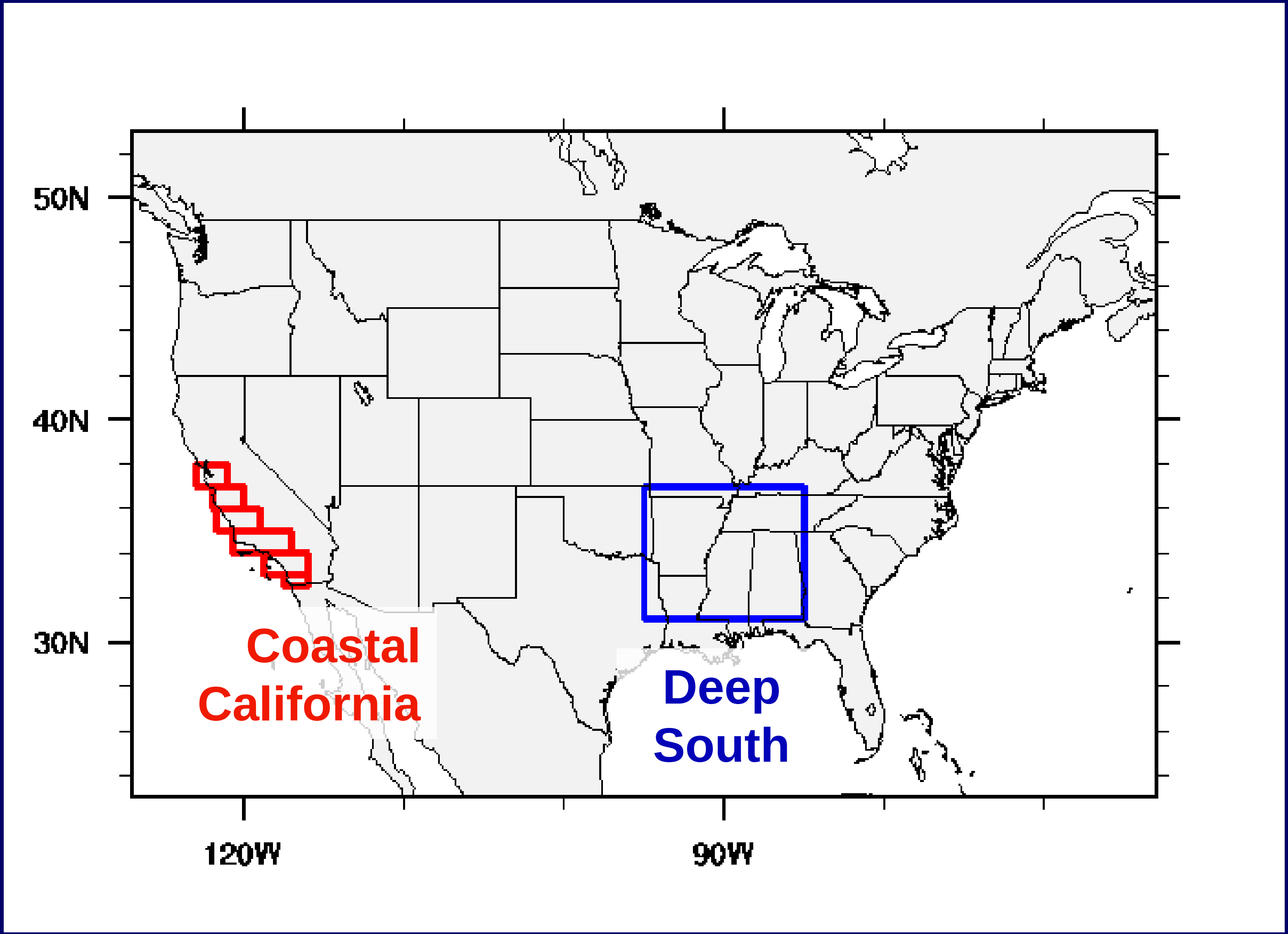
(www.narccap.ucar.edu)

- Higher resolution is necessary, but not sufficient, for simulating short-term (e.g., daily) precipitation extremes.
- Coarser models (and nudged regional models) tend to have daily extremes covering a wider area than observed extremes.
- Focusing on environments conducive to extremes yields relevant climatic behavior, even in relatively coarse models.
    - This conclusion rests on the assumption that important small-scale features are not missing (e.g., low-level jets).

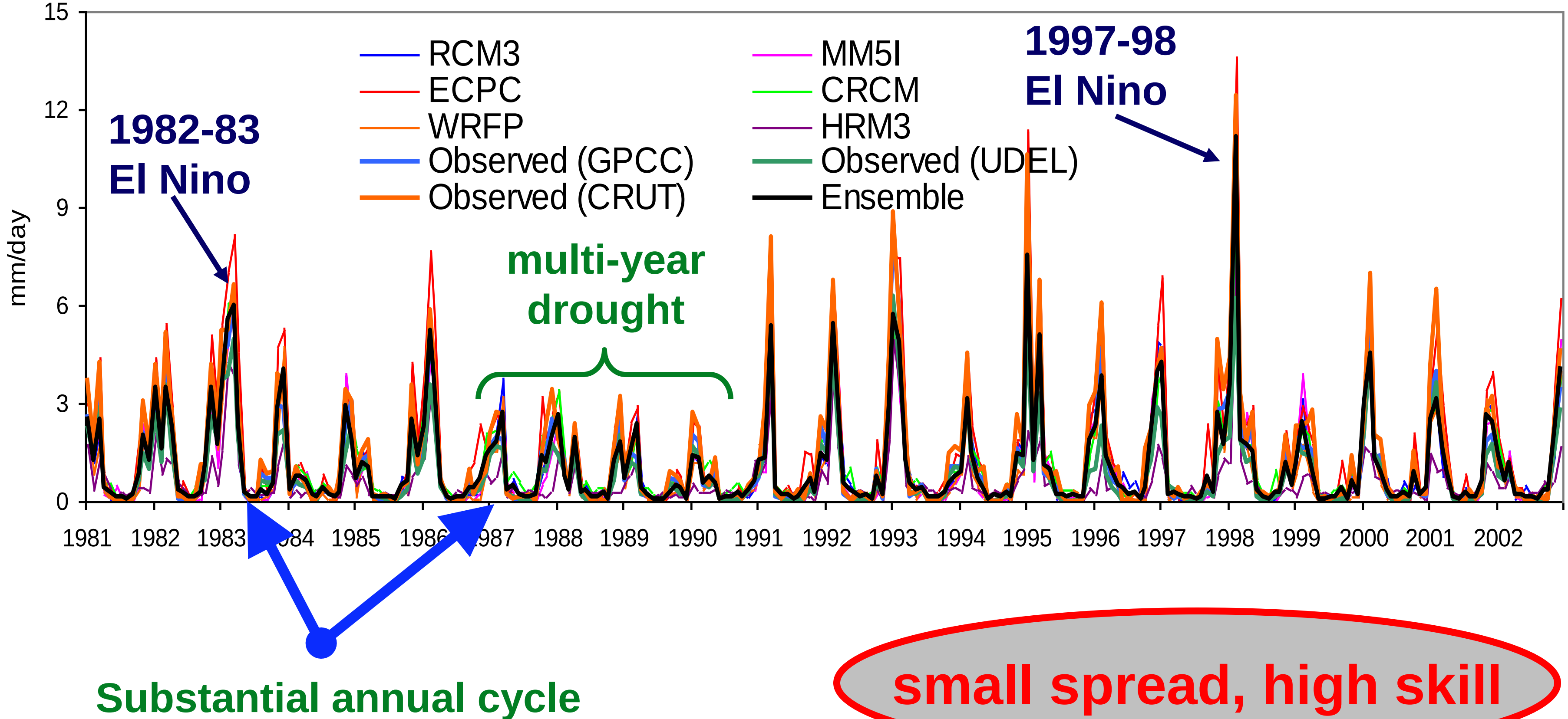
Part I: Interannual Variability

- Results shown for 1981-2002
- Comparison with 0.5º gridded precipitation analysis from the University of Delaware

Precipitation analysis for two regions



Monthly time series of precipitation in coastal California



small spread, high skill

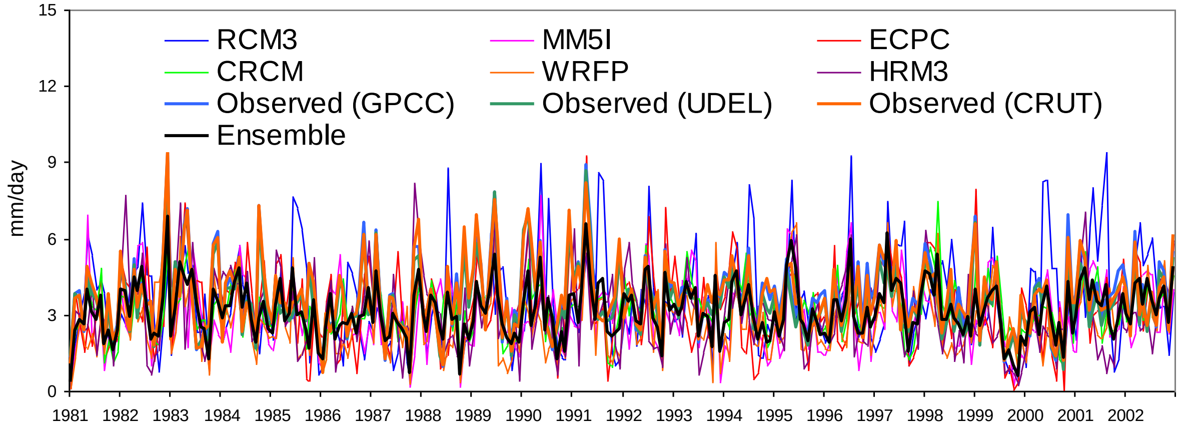
Correlation with Observed Precipitation - Coastal California

Model	Correlation
HadRM3	0.857
RegCM3	0.916
MM5	0.925
RSM	0.945
CRCM	0.946
WRF	0.918
Ensemble	**0.947**

All models have high correlations with observed **monthly time series** of precipitation.

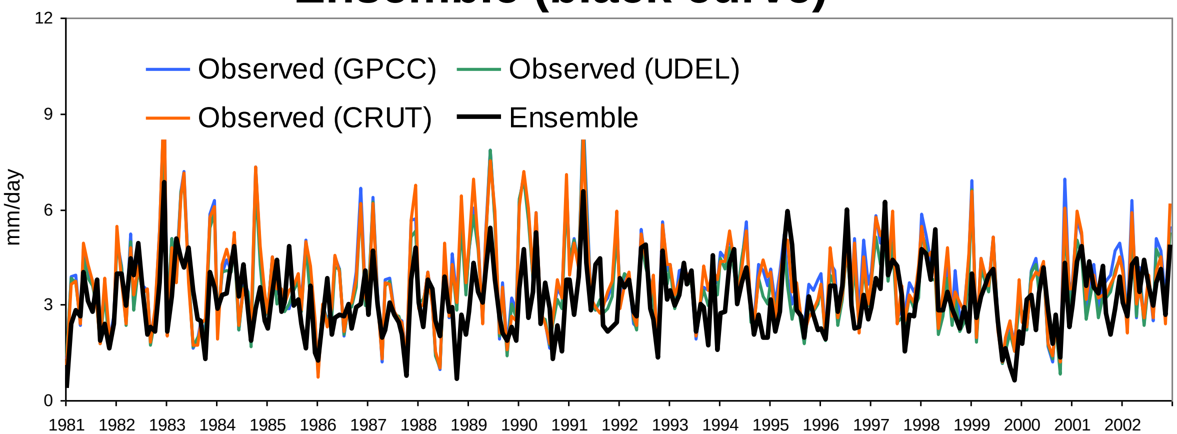
Ensemble mean has a higher correlation than any model

Monthly Time Series - Deep South



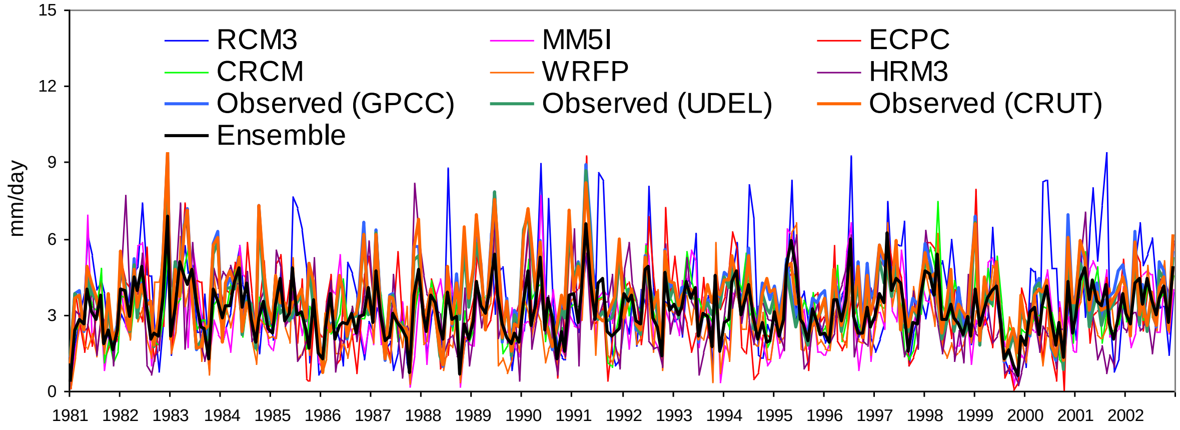
Model	Correlation
HadRM3	0.489
RegCM3	0.231
MM5	0.343
RSM	0.649
CRCM	0.649
WRF	0.513
Ensemble	**0.640**

Ensemble (black curve)

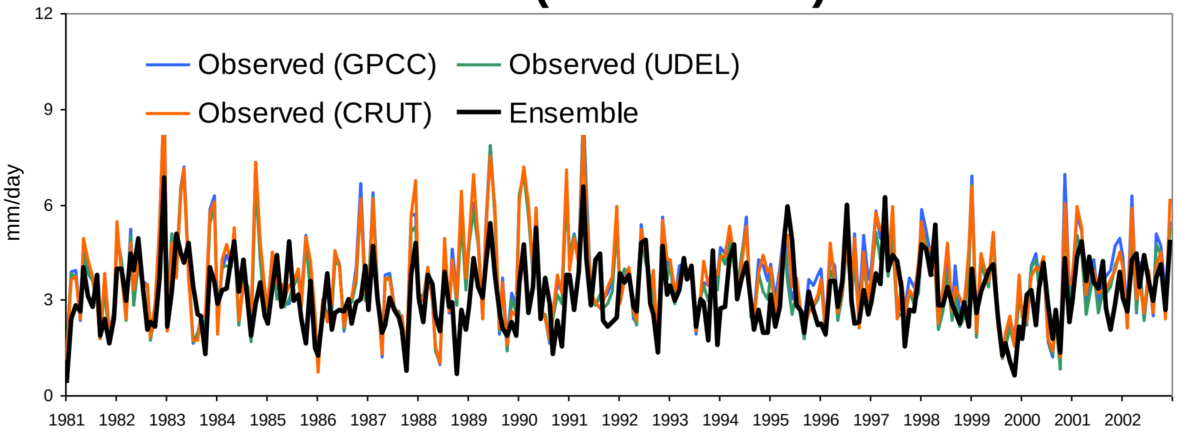


Two models (RSM and CRCM) perform much better. These models inform the domain interior about the large scale.

Monthly Time Series - Deep South



Ensemble (black curve)



Model	Correlation
HadRM3	0.489
RegCM3	0.231
MM5	0.343
RSM	0.649
CRCM	0.649
WRF	0.513
Ensemble	**0.640**
RSM+CRCM	**0.727**

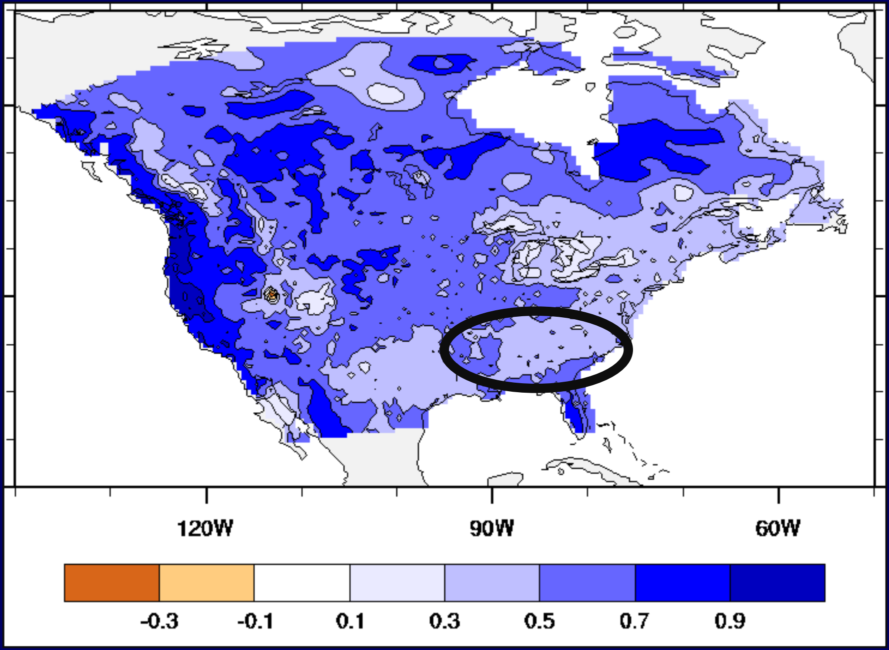
A "mini ensemble" of RSM and CRCM performs best in this region.

Correlation of Monthly Time Series

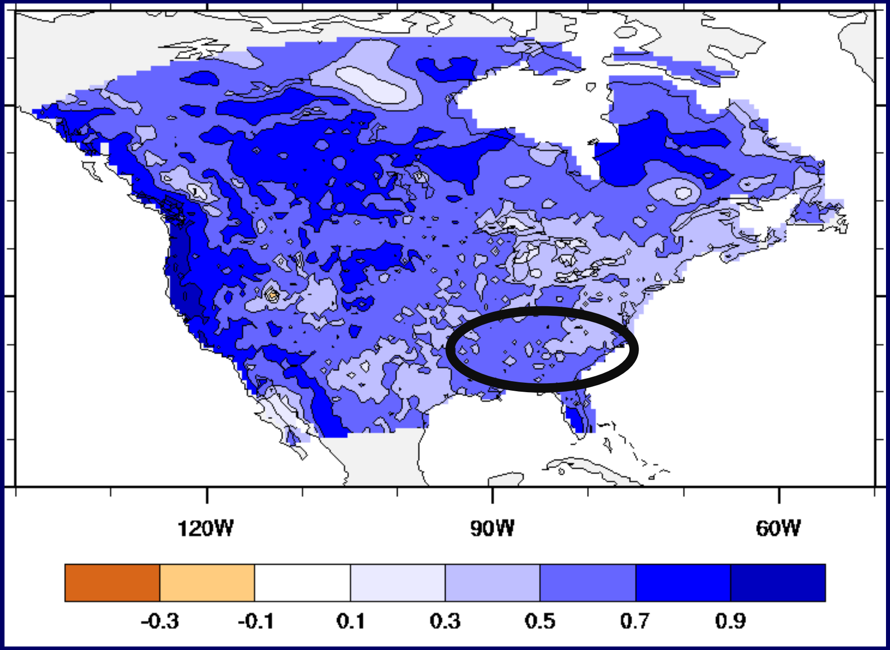
The "mini-ensemble" has better correlation than the full ensemble in the southern and eastern parts of the domain.

Other measures of forecast skill (such as bias) are not necessarily better.

Full ensemble



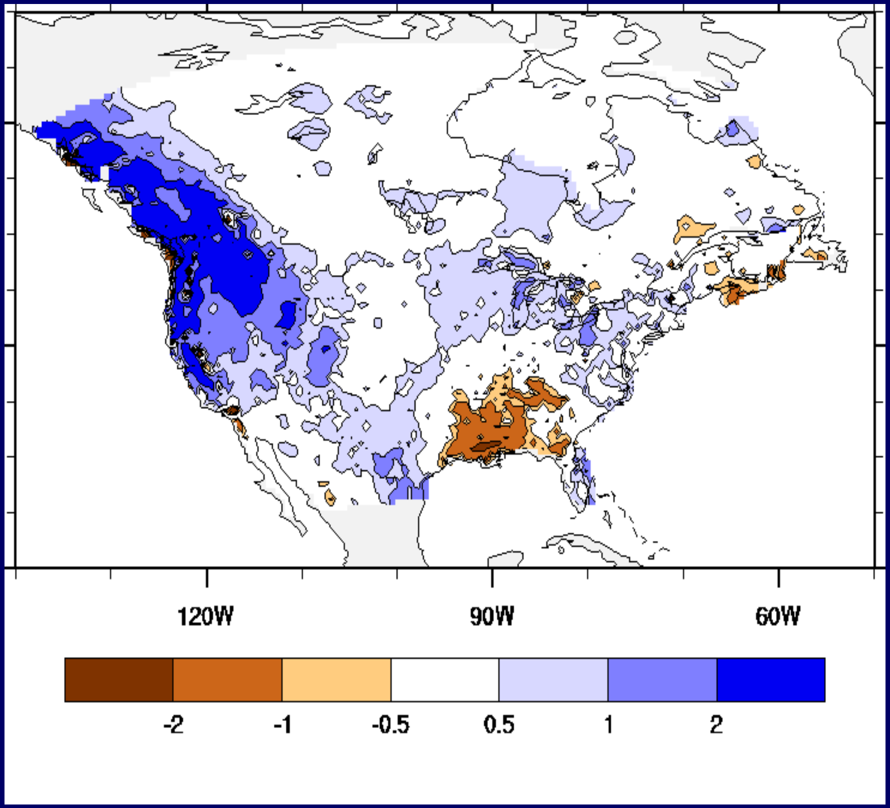
RSM + Canadian RCM



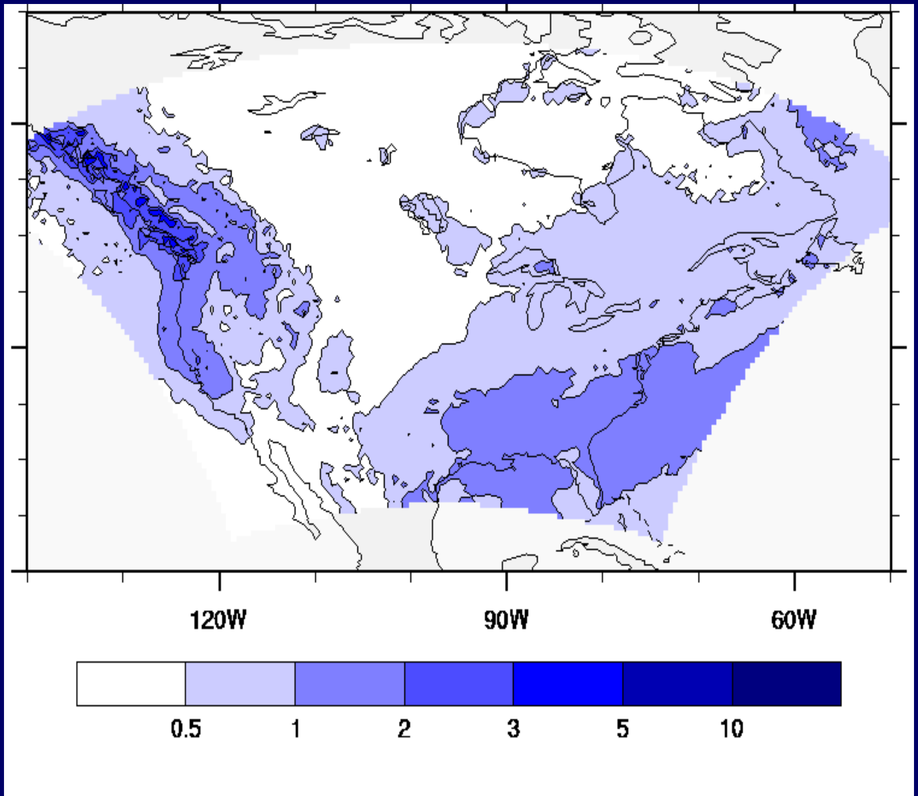
Ensemble error and spread (January)

There are hints of a spread-skill relation but it is not consistent.

Bias

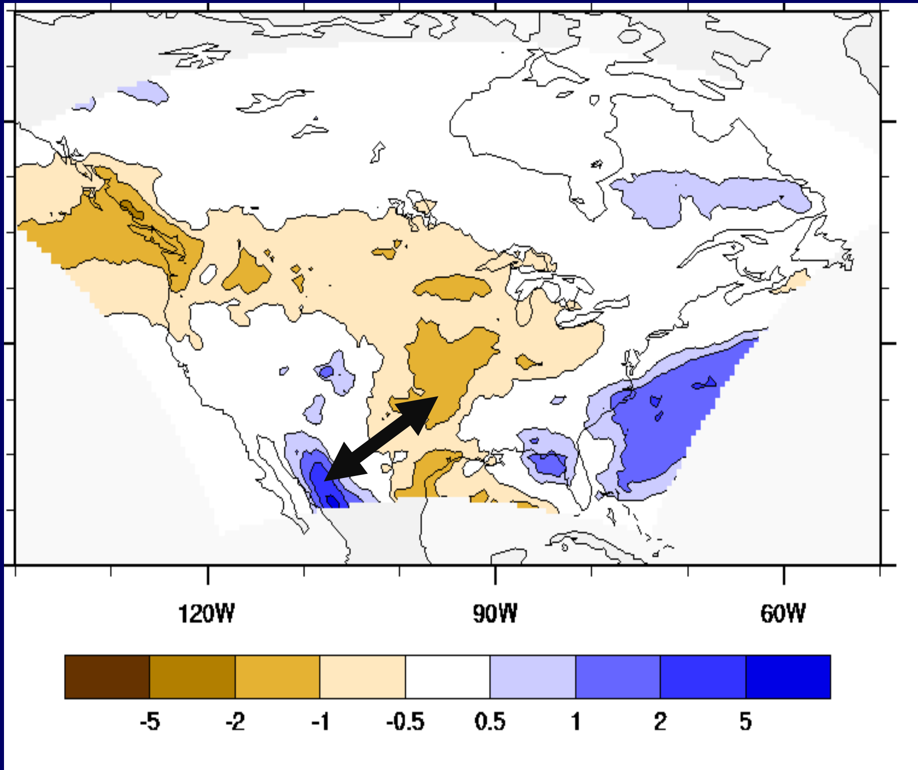


Ensemble spread

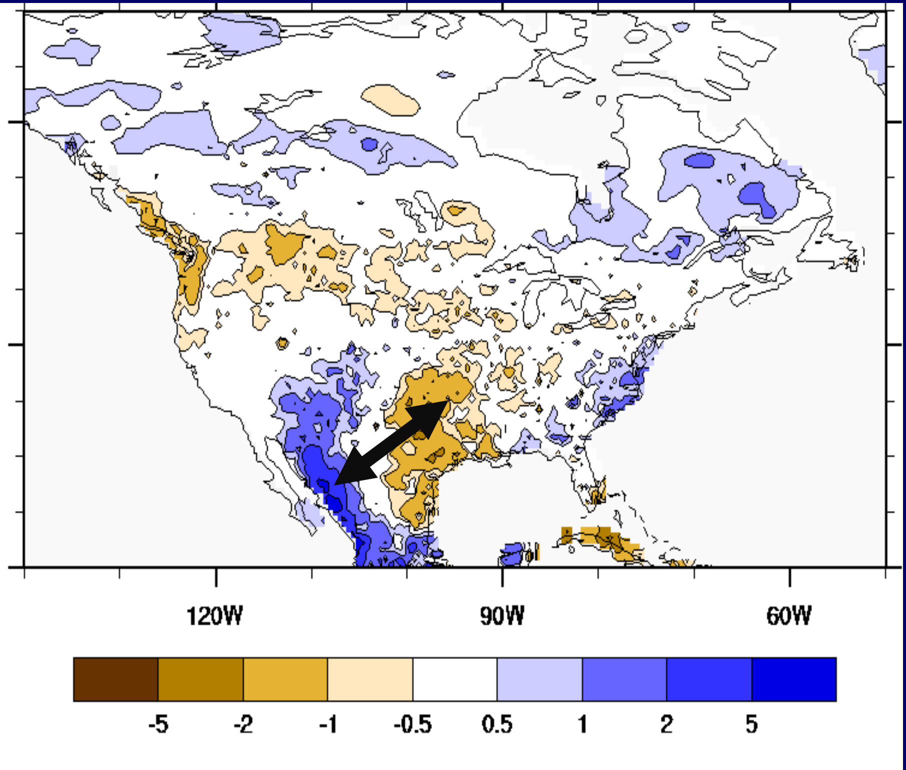


The ensemble reproduces the dipole of June-July precipitation change, but the monsoon does not extend as far north as observed.

ensemble July minus June



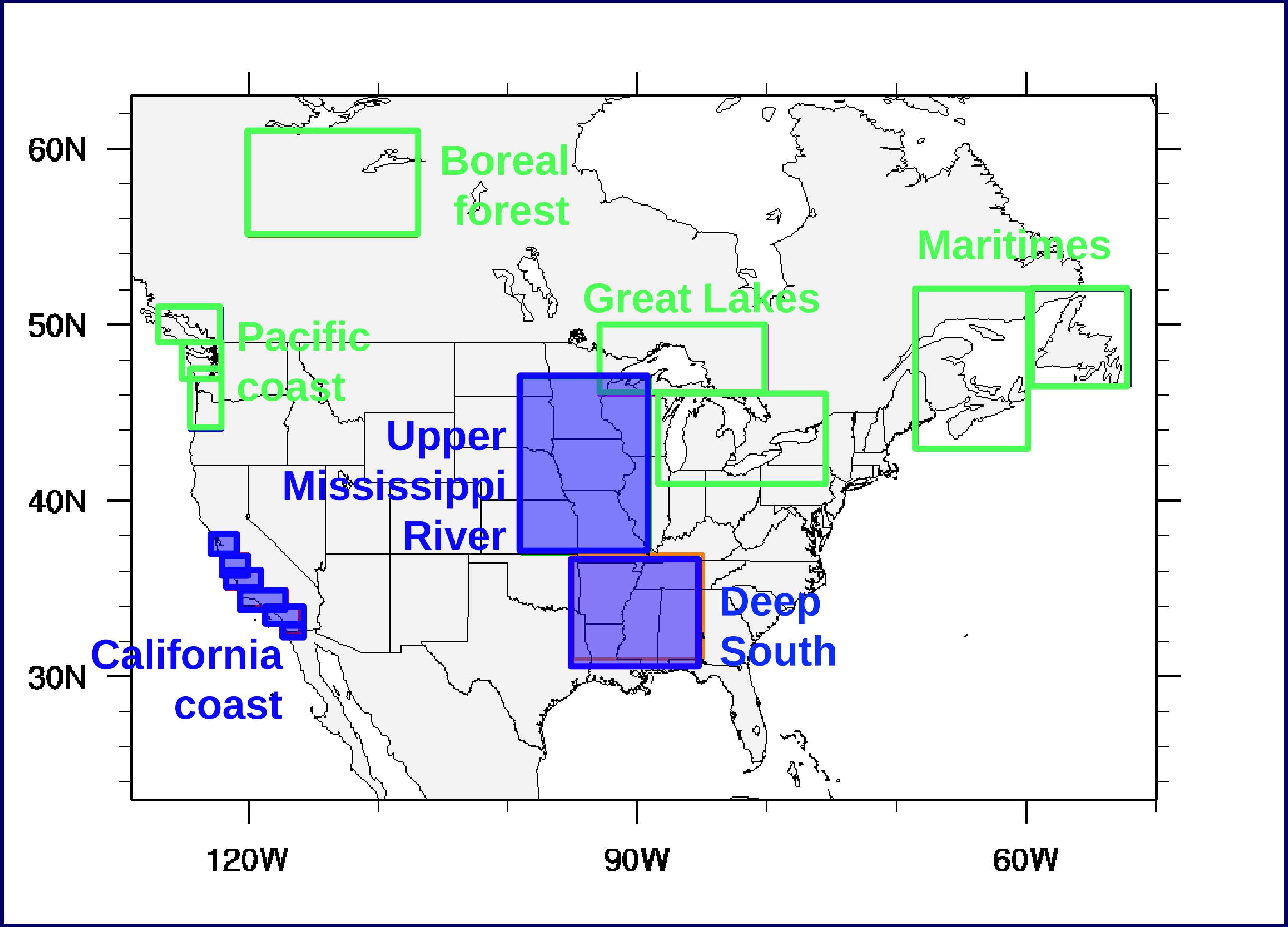
observed July minus June



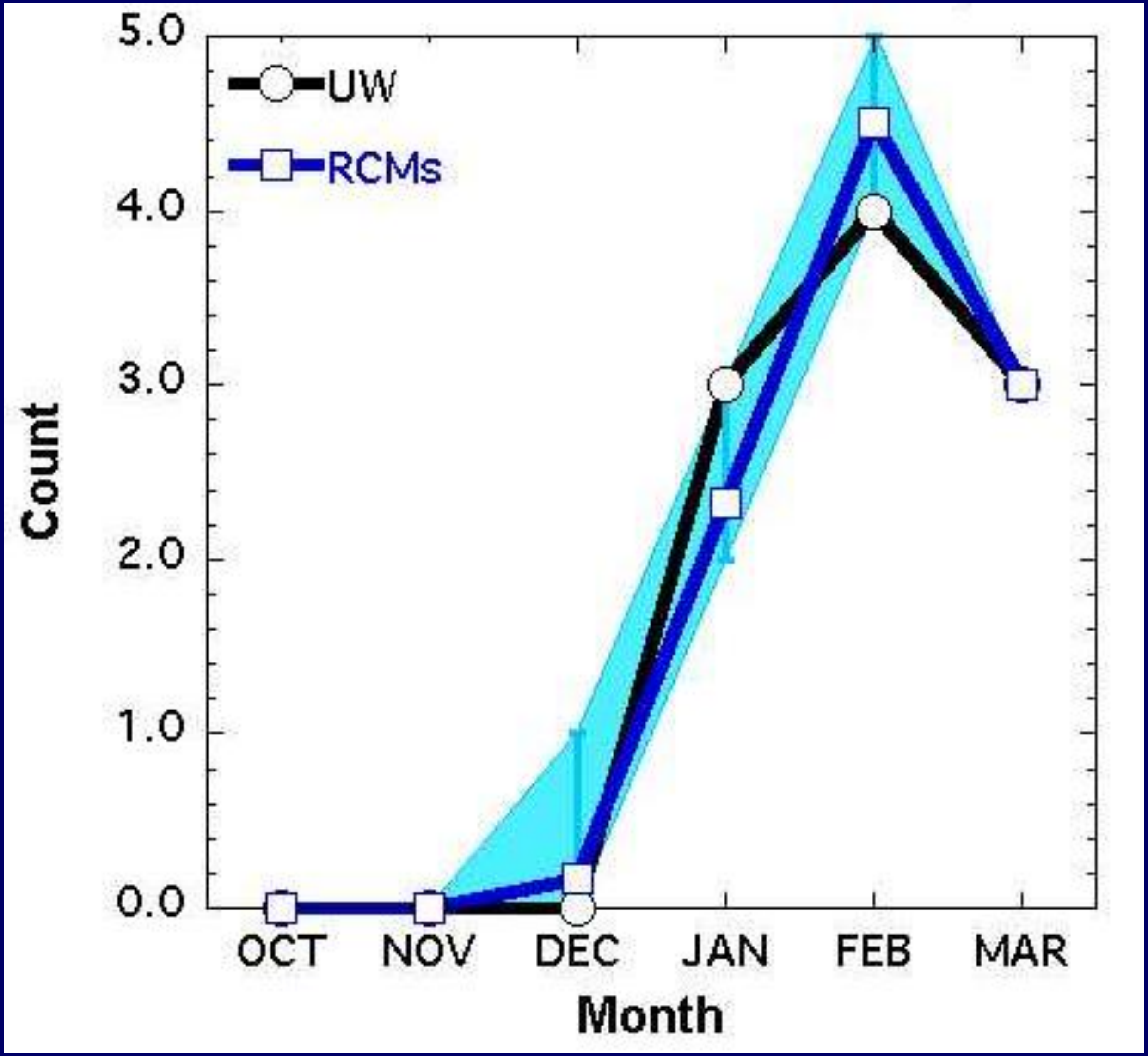
Part 2: Extreme Monthly Precipitation

- Observations
  - ✶ **Precip: University of Washington VIC retrospective analysis**
  - ✶ **500 hPa Heights: North American Regional Reanalysis**
- Comparison period: 1982 -1999
  - ✶ **1979-1981 omitted - spinup**
  - ✶ **UW data end in mid-2000**
- Analysis
  - ✶ **Cold season (Oct-Mar)**
  - ✶ **10 wettest months (top 10%)**

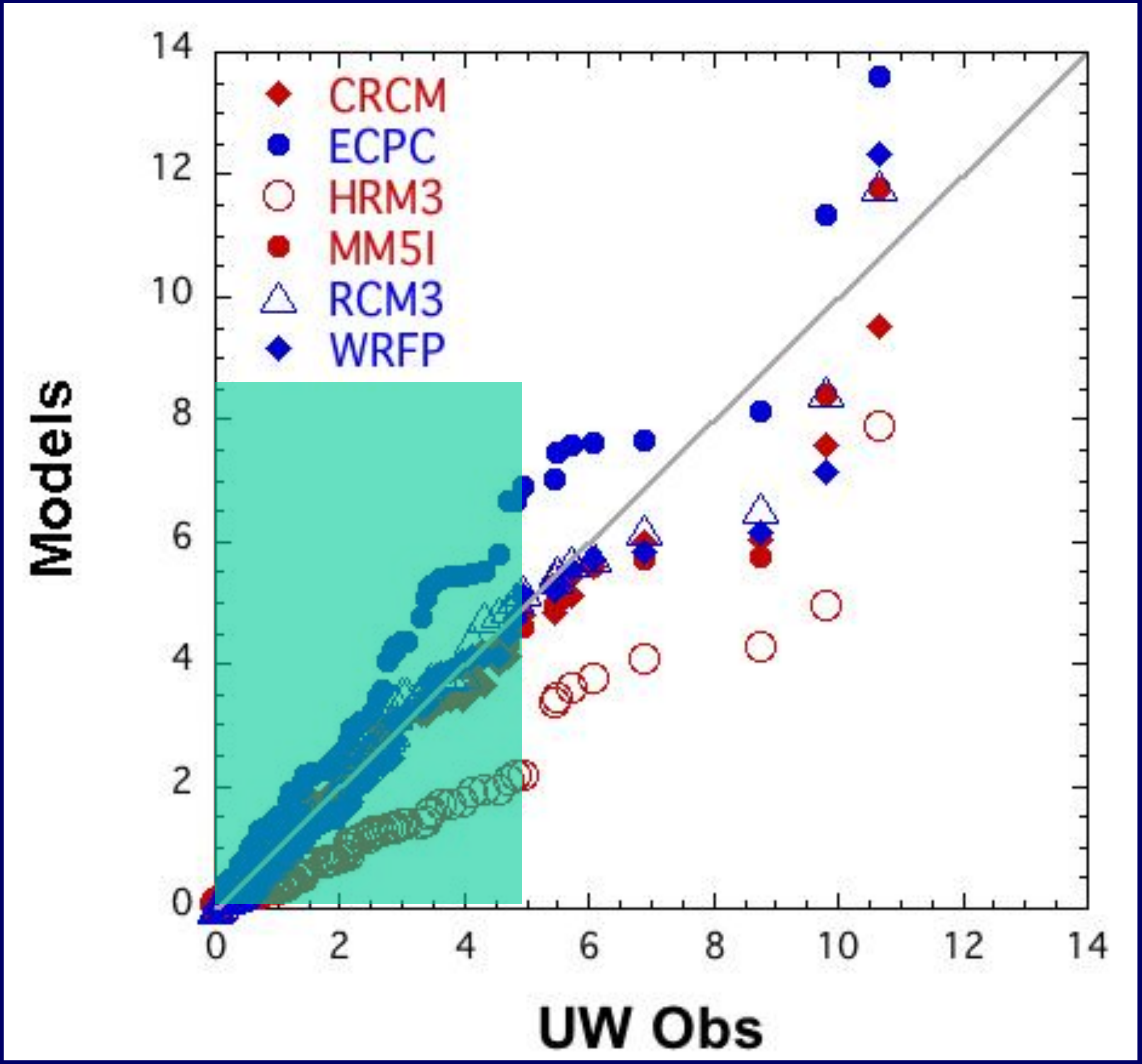
Regions Analyzed



Frequency – Coastal CA

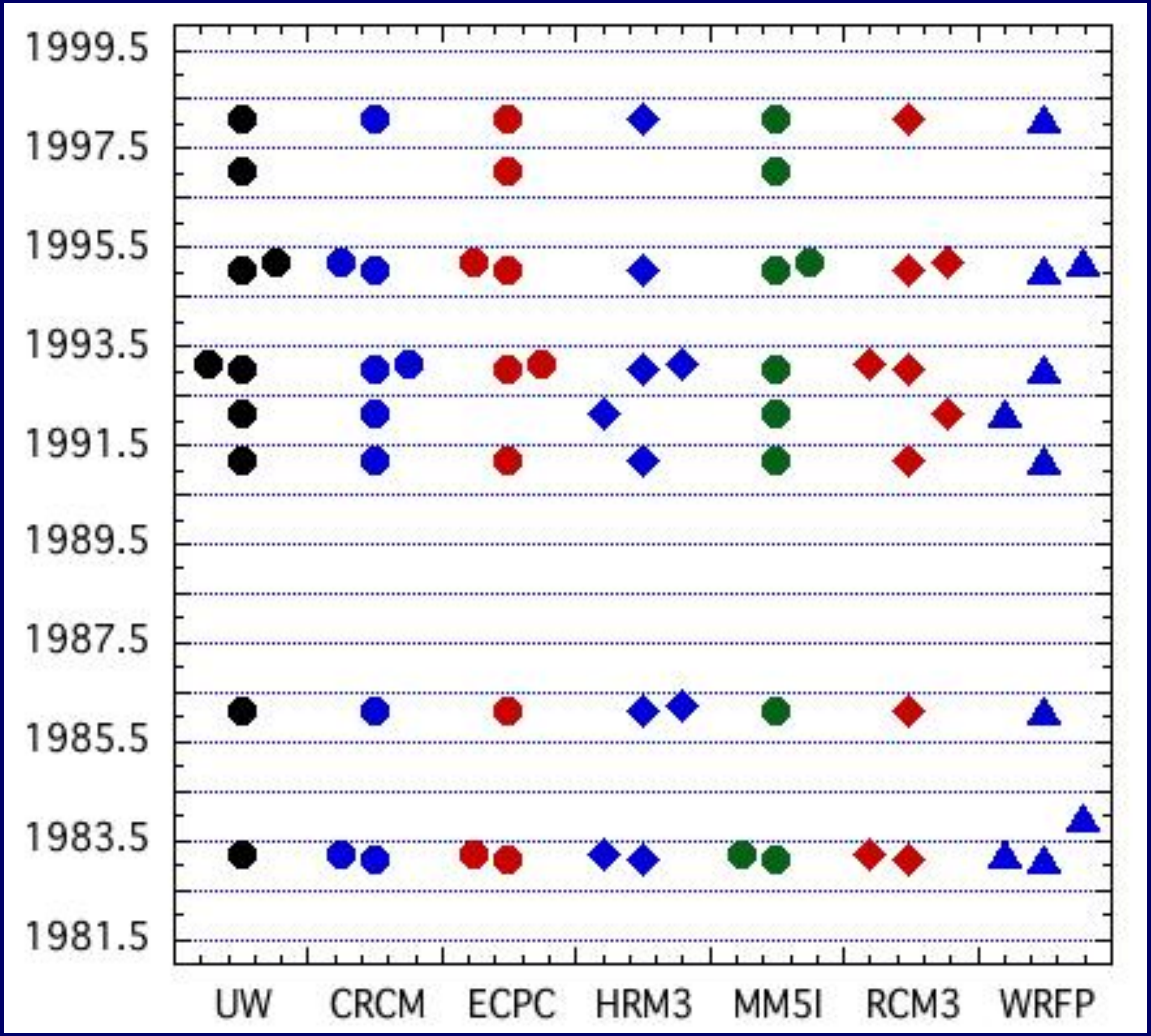


Ranked Precipitation – Coastal CA



Ensemble average of top 10 = 9 % smaller than UW

Interannual Variability – Coastal CA



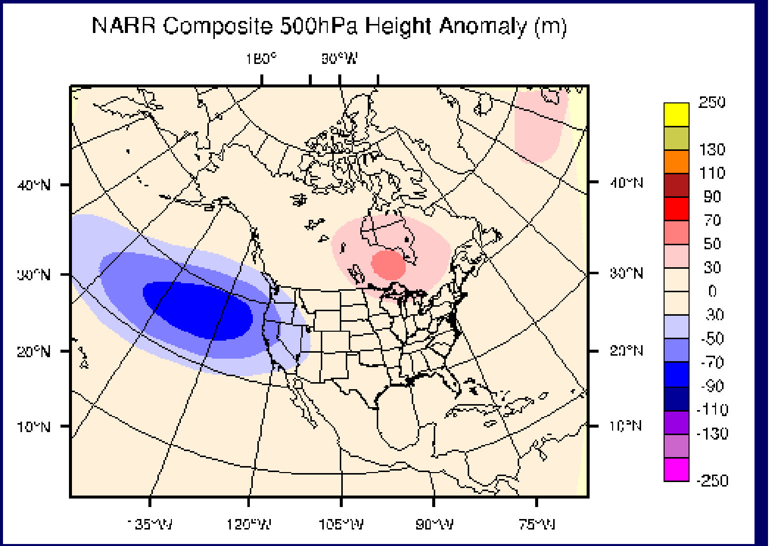
59 of 60 (98%) simulated extremes occur in cold seasons with an observed extreme.

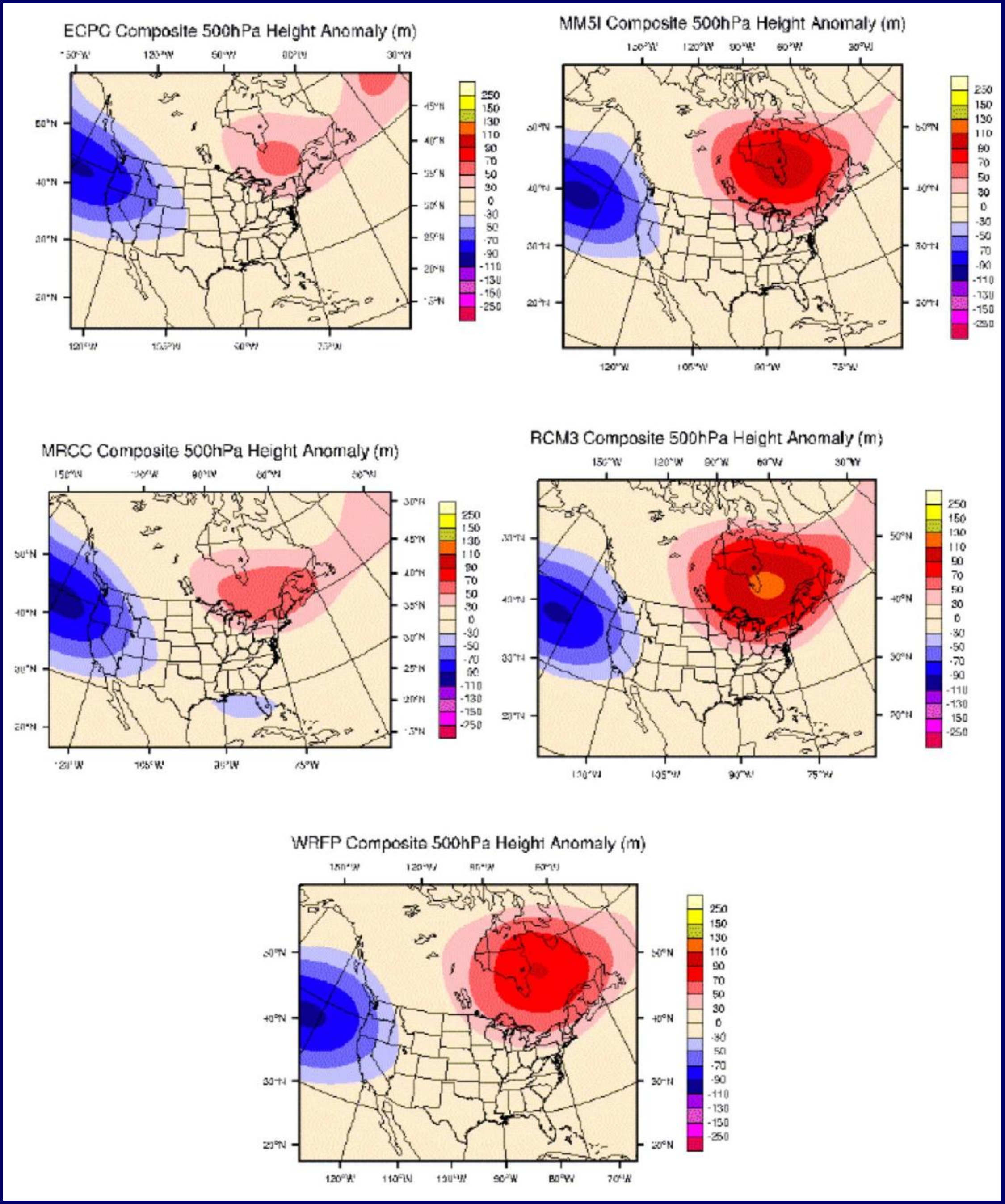
(random chance: 27)

Composite 500 hPa Height Anomalies

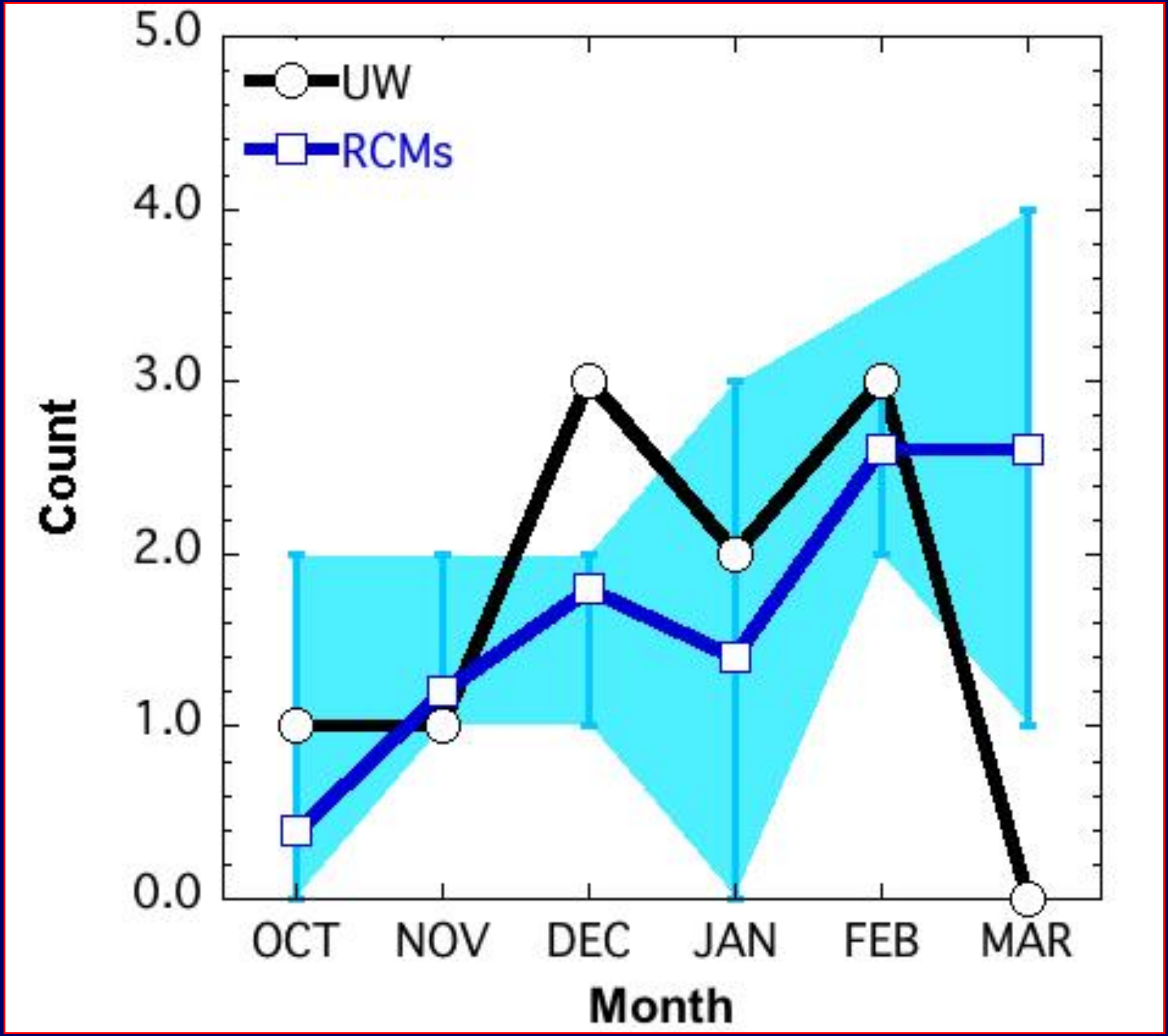
Top 10 Extremes

Coastal CA

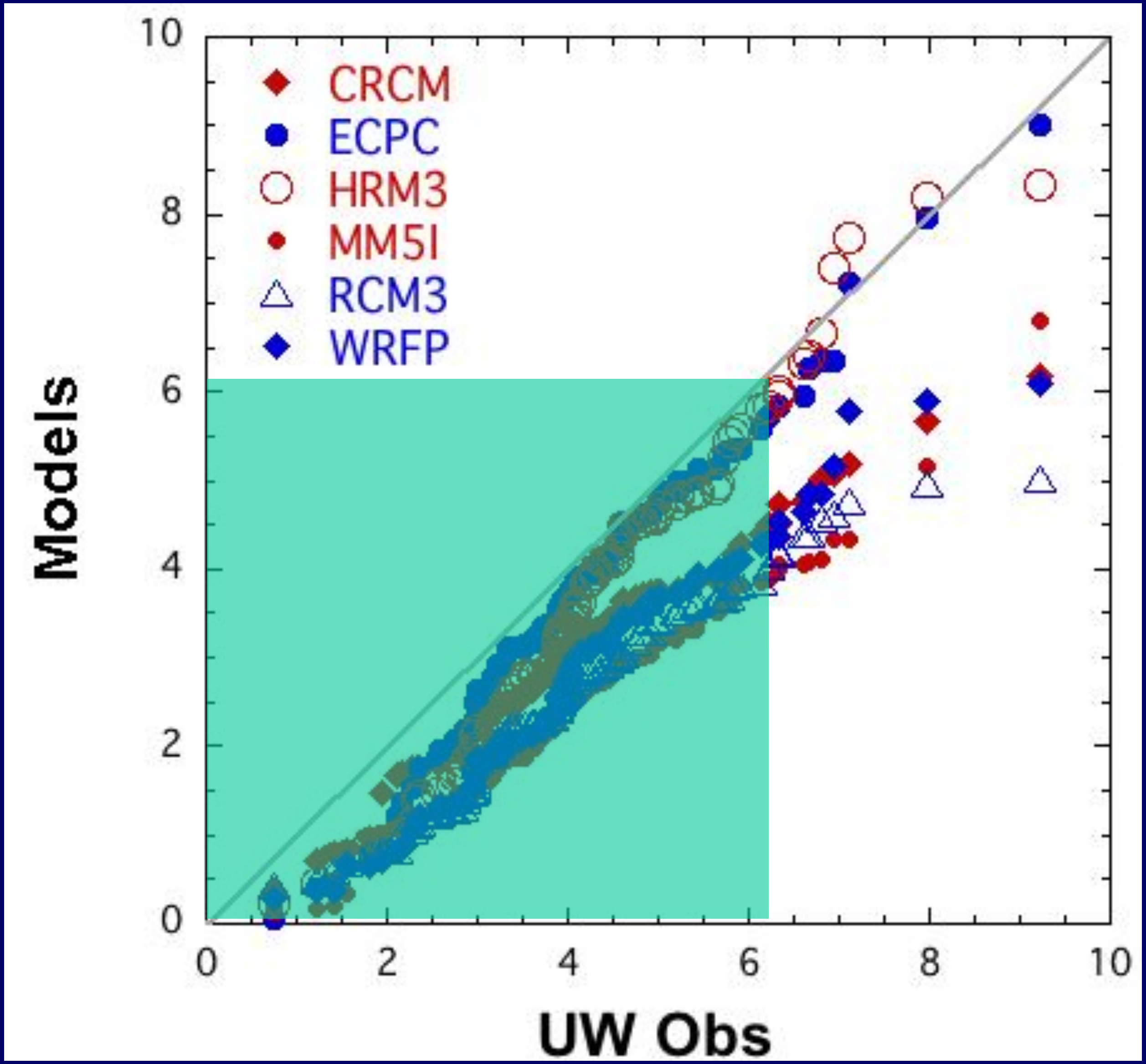




Frequency – Deep South

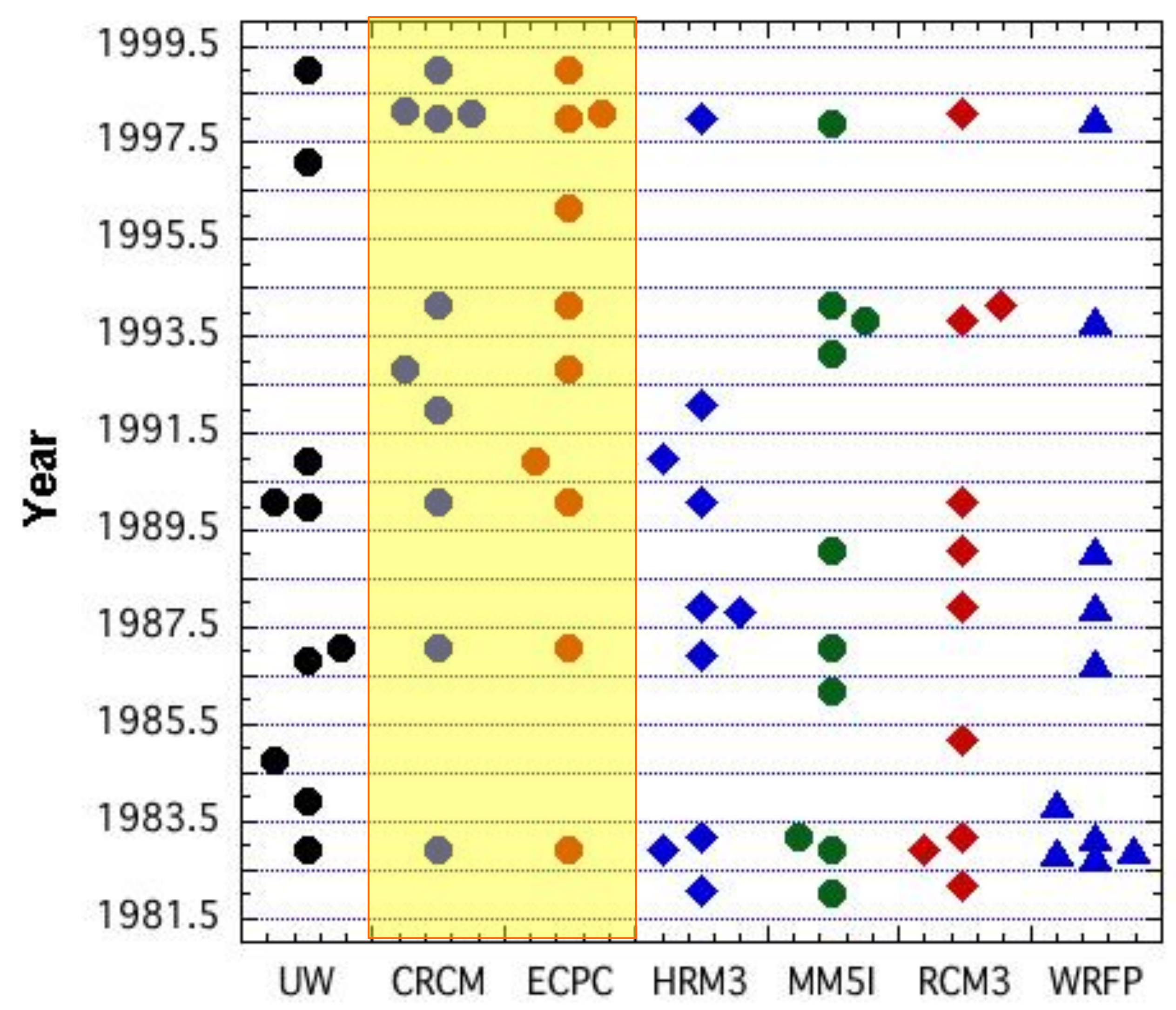


Ranked Precipitation – Deep South



Ensemble average of top 10 % smaller than UW = 22

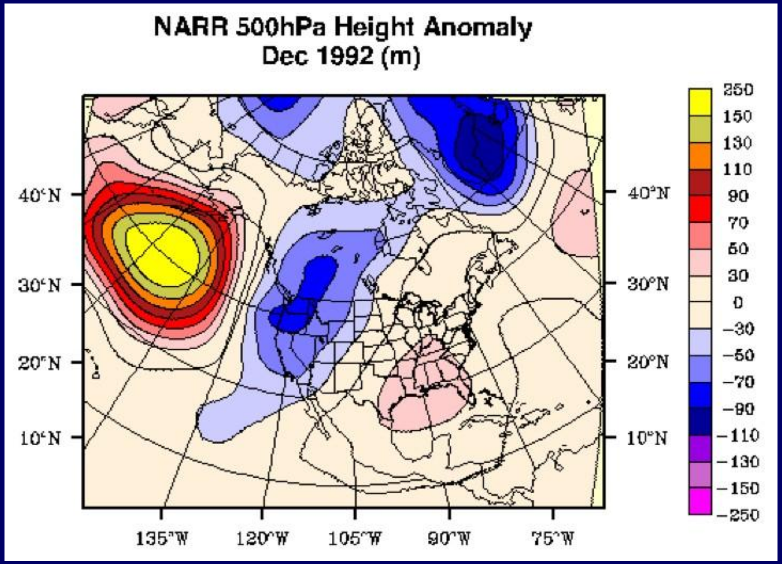
Interannual Variability – Deep South

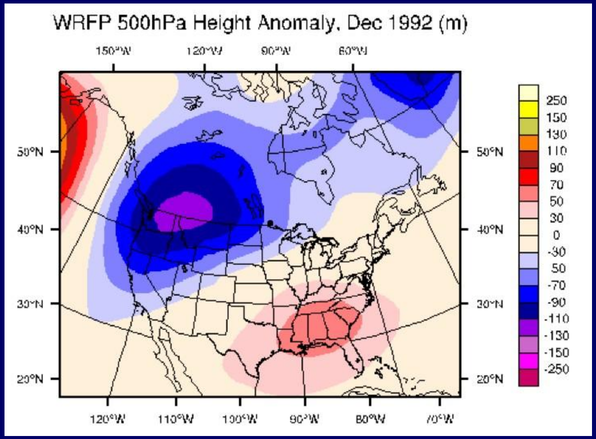


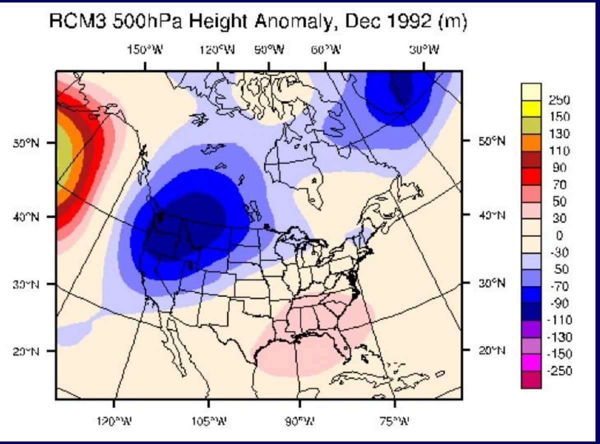
27 of 60 (45%) simulated extremes occur in cold seasons with an observed extreme.

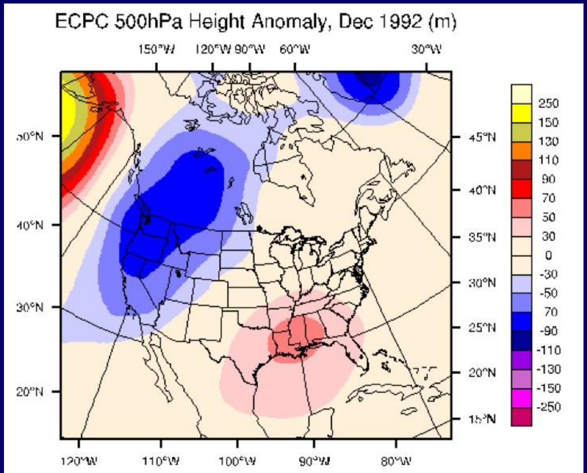
(random chance: 27)

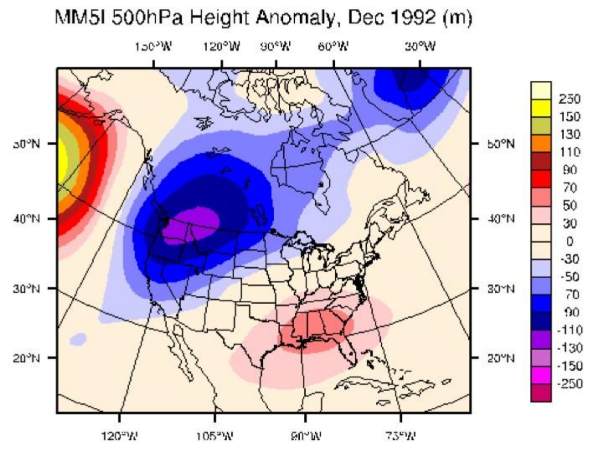
500 hPa Height Anomalies – Deep South Extreme









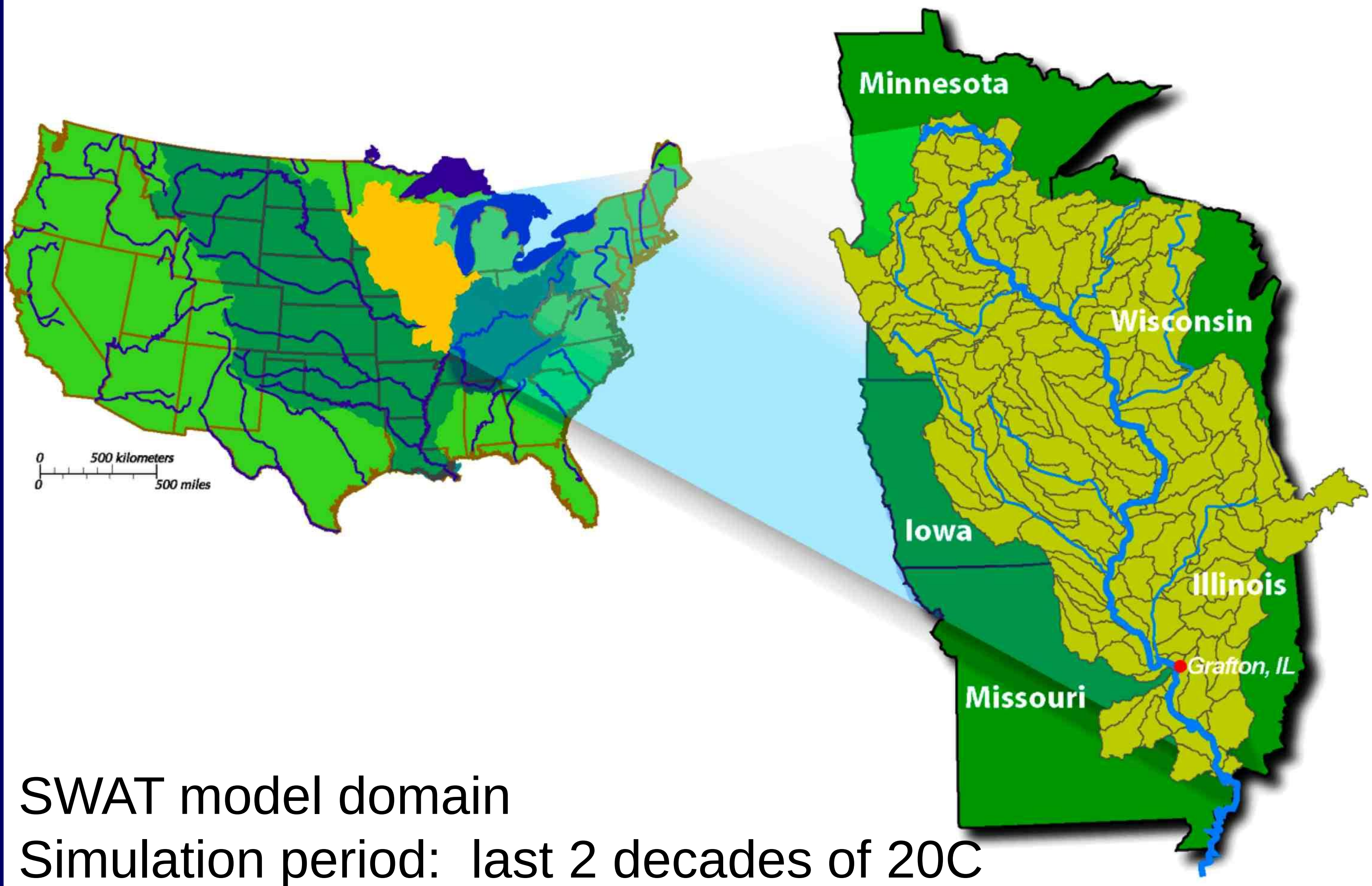


Summary
Monthly Precipitation

Where there is a substantial periodic cycle:
- Models simulate well the interannual variability
- Models simulate well monthly, regional extremes

Where there is no substantial periodic cycle:
- Models simulate poorly the interannual var. & extremes
- Interior nudging improves interannual variability
- Interior nudging does not help extremes

Hydrologic Analysis (Takle et al.)

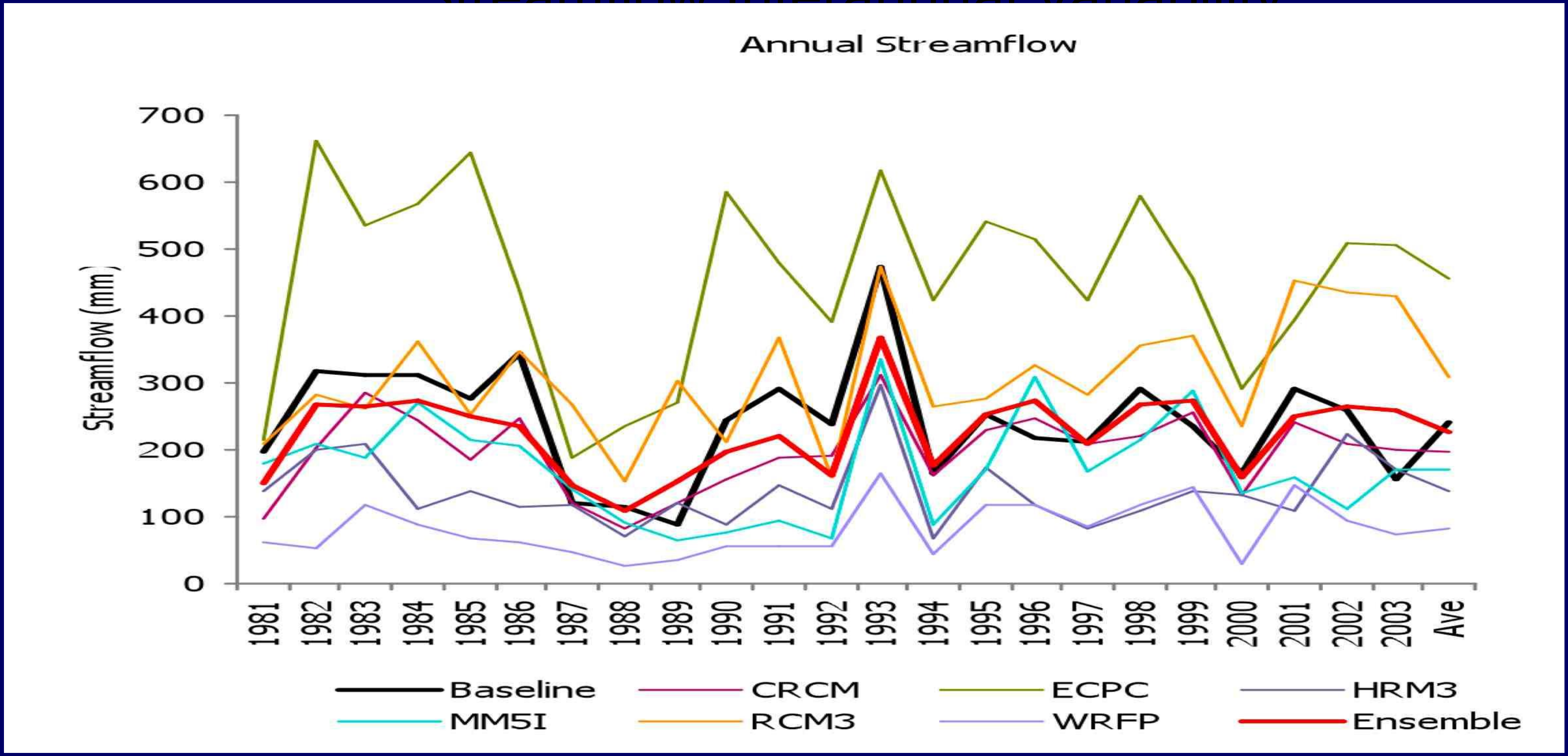


SWAT model domain

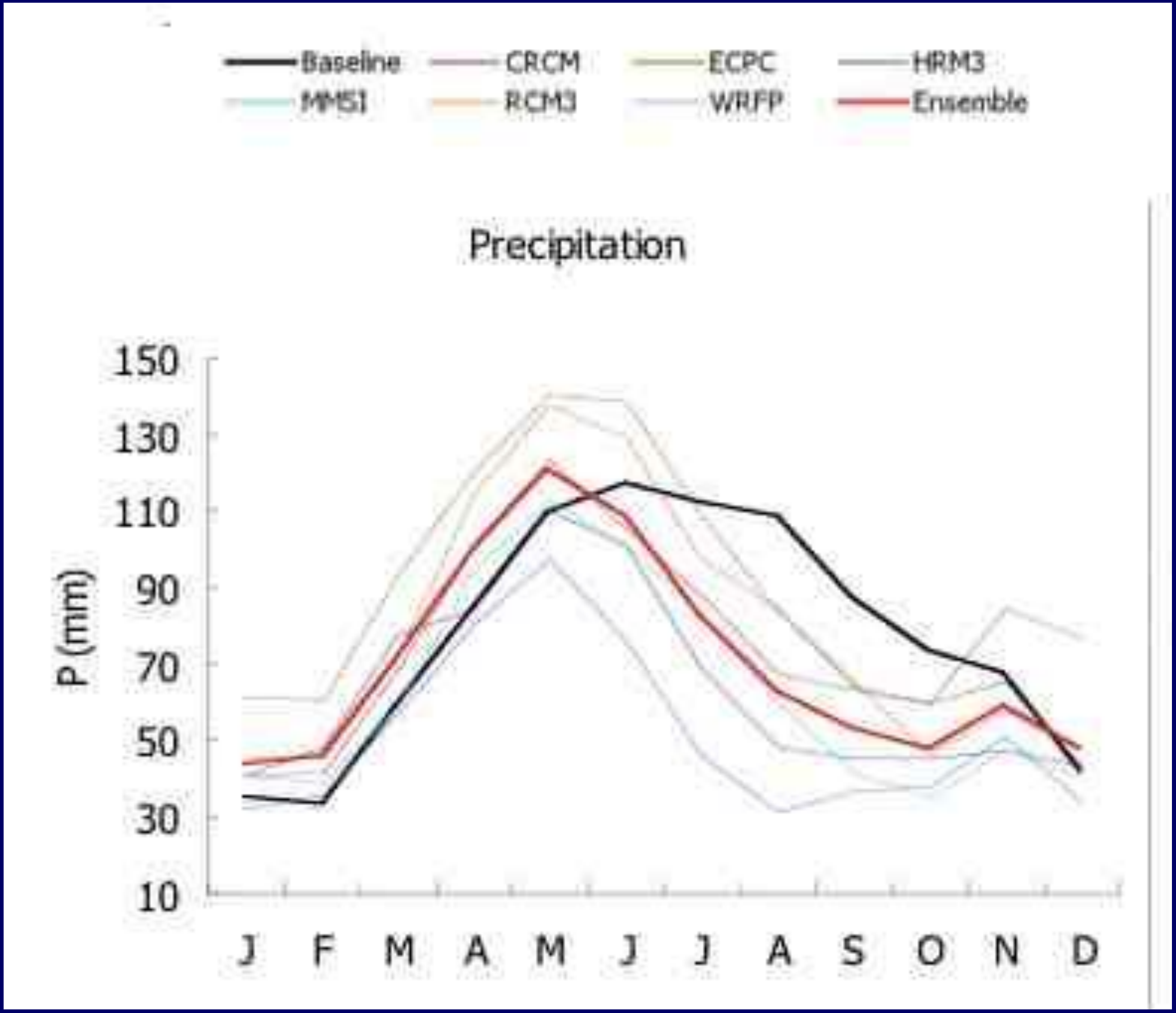
Simulation period: last 2 decades of 20C

Hydrologic Analysis (Takle et al.)

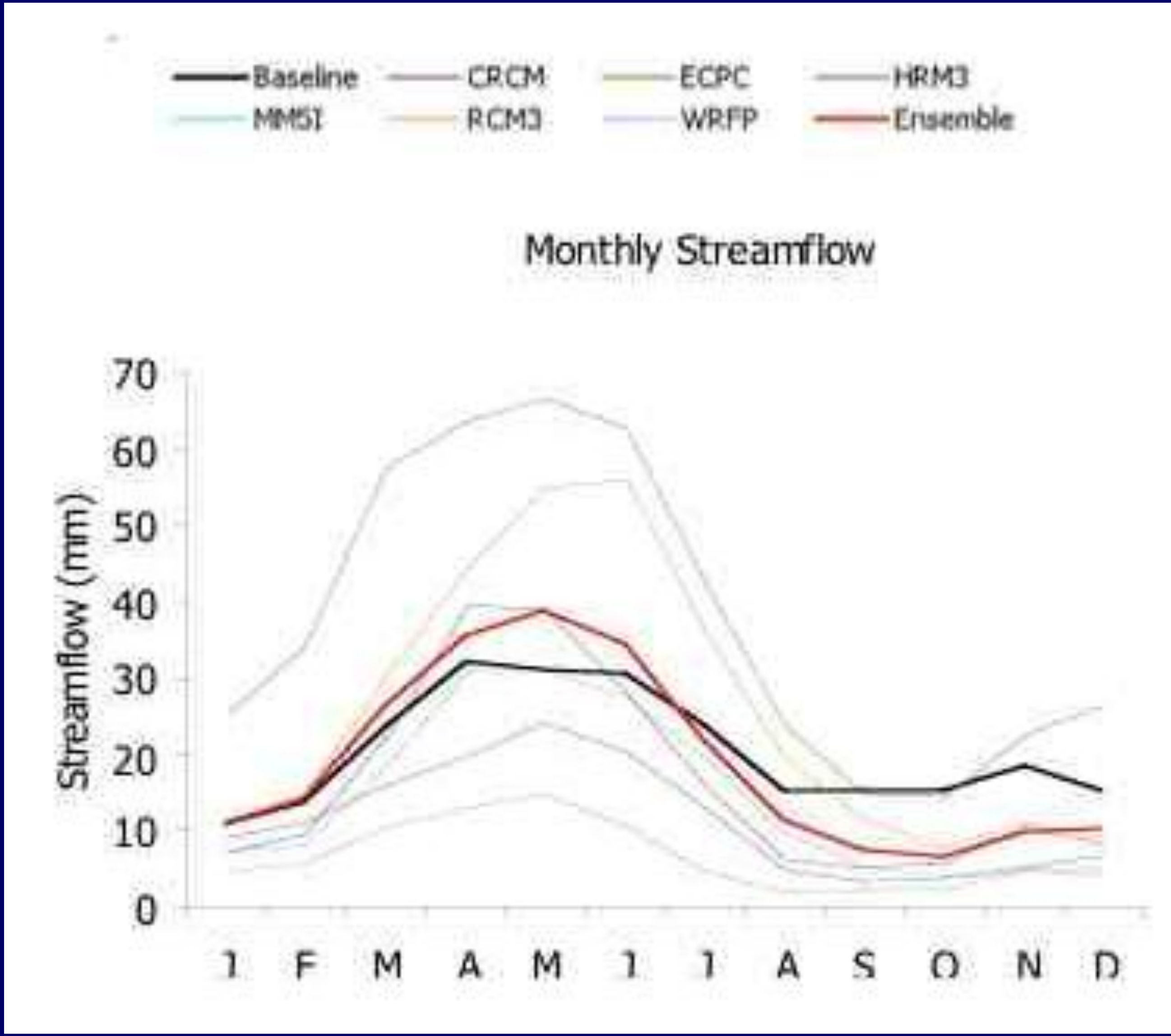
Streamflow Interannual Variability



Hydrologic Analysis (Takle et al.)



Hydrologic Analysis (Takle et al.)



Summary

MONTHLY PRECIPITATION

Where there is a substantial periodic cycle:
- Models simulate well the interannual variability
- Models simulate well monthly, regional extremes

Where there is no substantial periodic cycle:
- Models simulate poorly the interannual var. & extremes
- Interior nudging improves interannual variability
-Interior nudging does not help extremes

UPPER MISSISSIPPI STREAMFLOW

Ensemble replicates well the interannual variability
Annual cycle simulated less well