Towards Establishing NARCCAP Regional Model Credibility for the North American Monsoon

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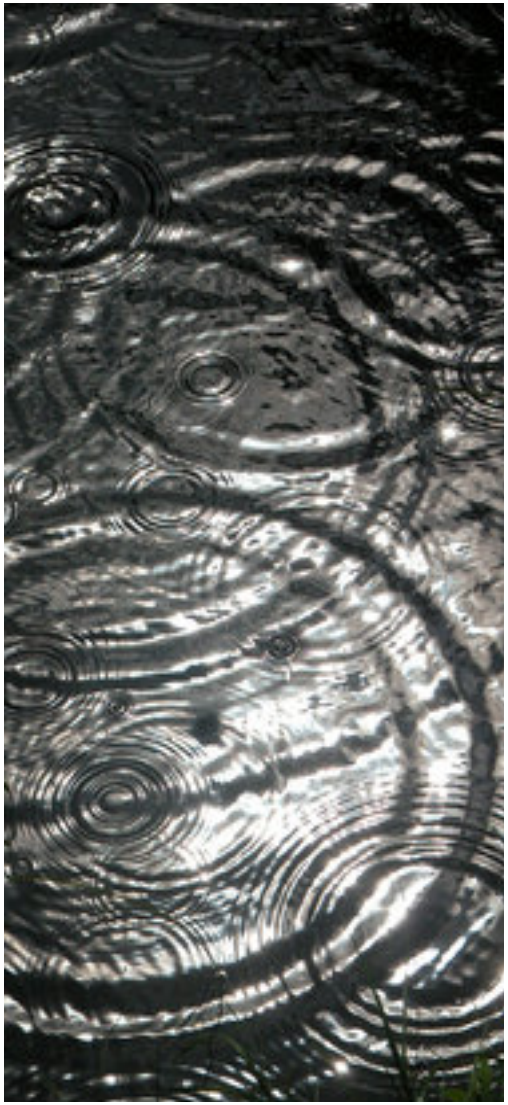
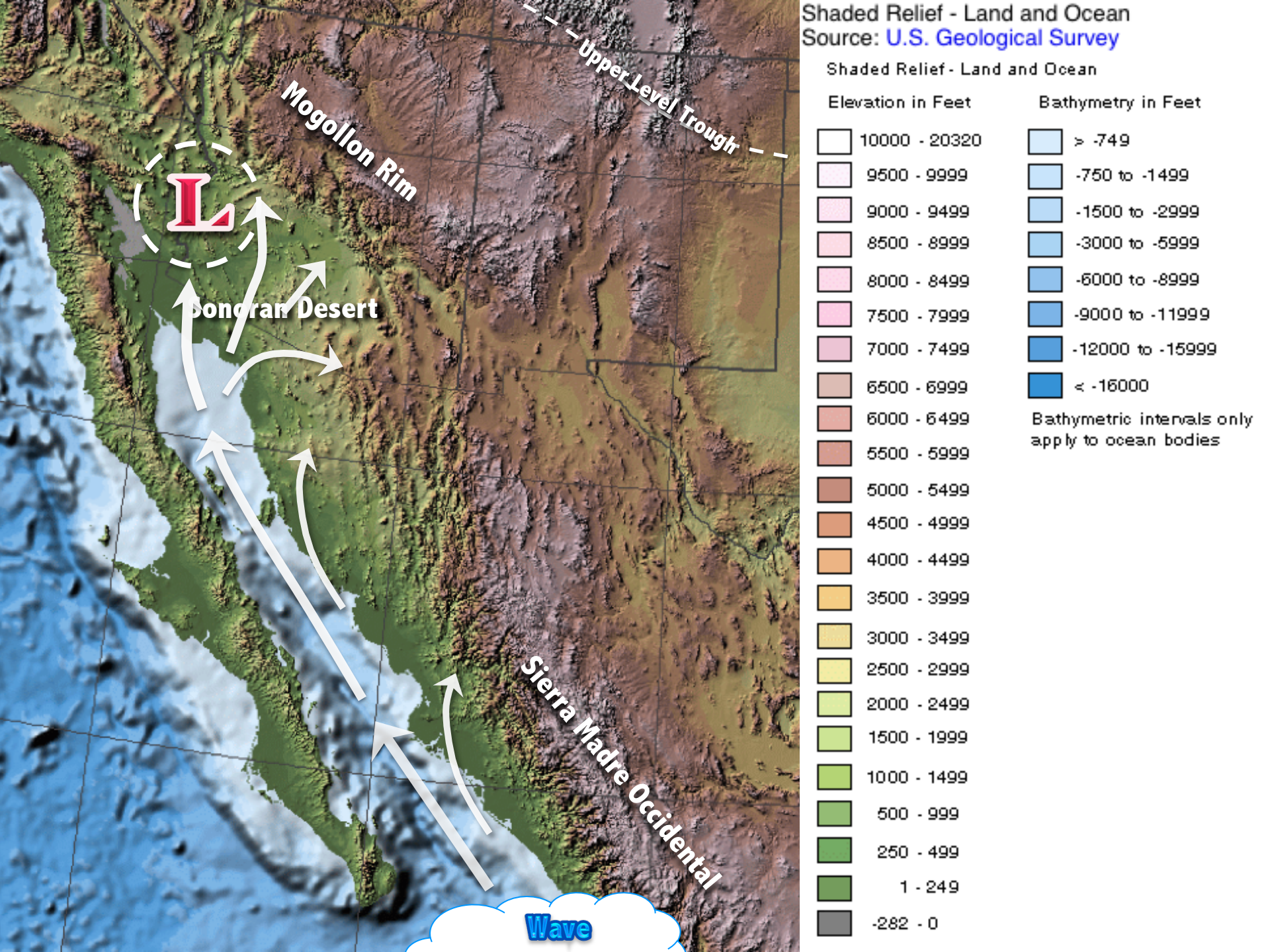
Introduction



- Metrics are great, but…
  - A metric gives you ONE number that is supposed to be a measure of model performance.
  - One could use many metrics, even "processed-based" metrics, but being summarized measures, it can still be very unclear what a model is actually doing.
- Establish whether or not the atmospheric *processes* (ingredients) that define the monsoon system are credibly simulated.
- Identify bias in related processes and establish the potential impact of that bias on projections.
- In this case, we are going to focus on certain aspects of precipitation to start, because biases in it can tell us a lot about the system as a whole.


Shaded Relief - Land and Ocean
Source: U.S. Geological Survey
Shaded Relief - Land and Ocean
Elevation in Feet
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9500 - 9999
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8500 - 8999
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4000 - 4499
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2500 - 2999
2000 - 2499
1500 - 1999
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500 - 999
250 - 499
1 - 249
-282 - 0
Bathymetry in Feet
> -749
-750 to -1499
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-3000 to -5999
-6000 to -8999
-9000 to -11999
-12000 to -15999
< -16000
Bathymetric intervals only apply to ocean bodies
Upper Level Trough
Mogollon Rim
L
Sonoran Desert
Sierra Madre Occidental
Wave

NARCCAP

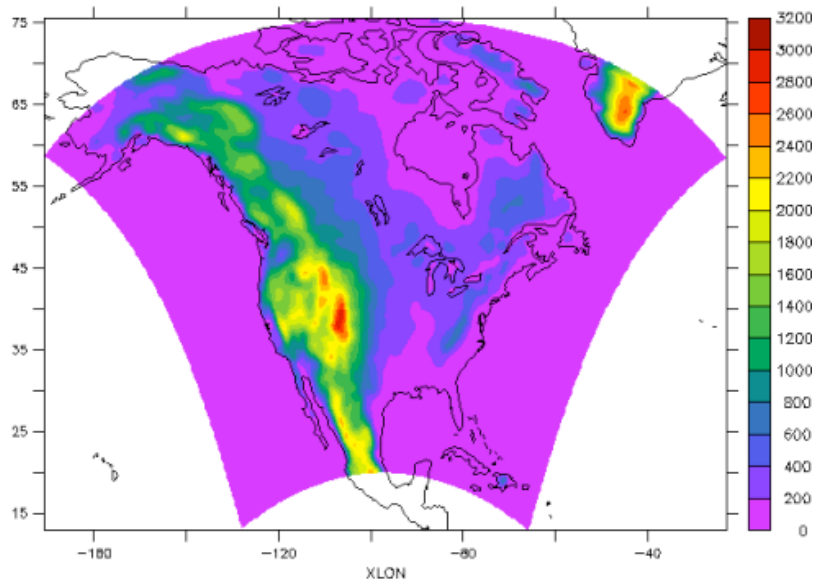
North American Regional Climate Change Assessment Program

- 6 RCMs downscaling 4 GCMs (12 combinations planned – 11 available)
  - Current: 1971-2000 (1999)
  - Future: 2041-2070 (2069)

- RCMs are also being used to dynamically downscale the NCEP/DOE Reanalysis 2
  - 1980-2004

- 50-km horizontal resolution over most of North America

- Plus, 2 global 50-km timeslices (GFDL and CAM).



www.narccap.ucar.edu

Other Datasets

- For comparison:
  - **NARR** (North American Regional Reanalysis), **32-km** horizontal resolution.
  - **UDEL** (University of Delaware), **½ degree** resolution, gridded observations, for land only.
  - **NAME** (North American Monsoon Experiment), **1 degree** resolution, gridded observations from a special observing period during July 2004
  - **TRMM** (Tropical Rainfall Measuring Mission) satellite derived precipitation. **¼ degree** resolution, available Dec. 1997 – present.

  - Plus a number of others not listed here and not shown in this presentation.

Metrics (Arizona)

JJA	CRCM	ECP2	HRM3	MM5I	RCM3	WRFG
f1	0.703	0.128	0.004	0.050	0.063	0.052
f2	0.085	0.108	0.341	0.156	0.121	0.189
f3	0.167	0.167	0.167	0.167	0.167	0.167
f4	0.097	0.259	0.067	0.142	0.172	0.264
f5	0.200	0.127	0.200	0.154	0.156	0.162
f6	0.185	0.165	0.147	0.160	0.166	0.177
W	0.075	0.145	0.164	0.134	0.133	0.350

- f1: large-scale circulation
- f2: spatial distribution of mesoscale added-information
- f3: pdf of daily precip an tmin/ tmax
- f4: extremes in daily precip and tmin/tmax
- f5: temperature trend
- f6: annual cycle of precip and temperature

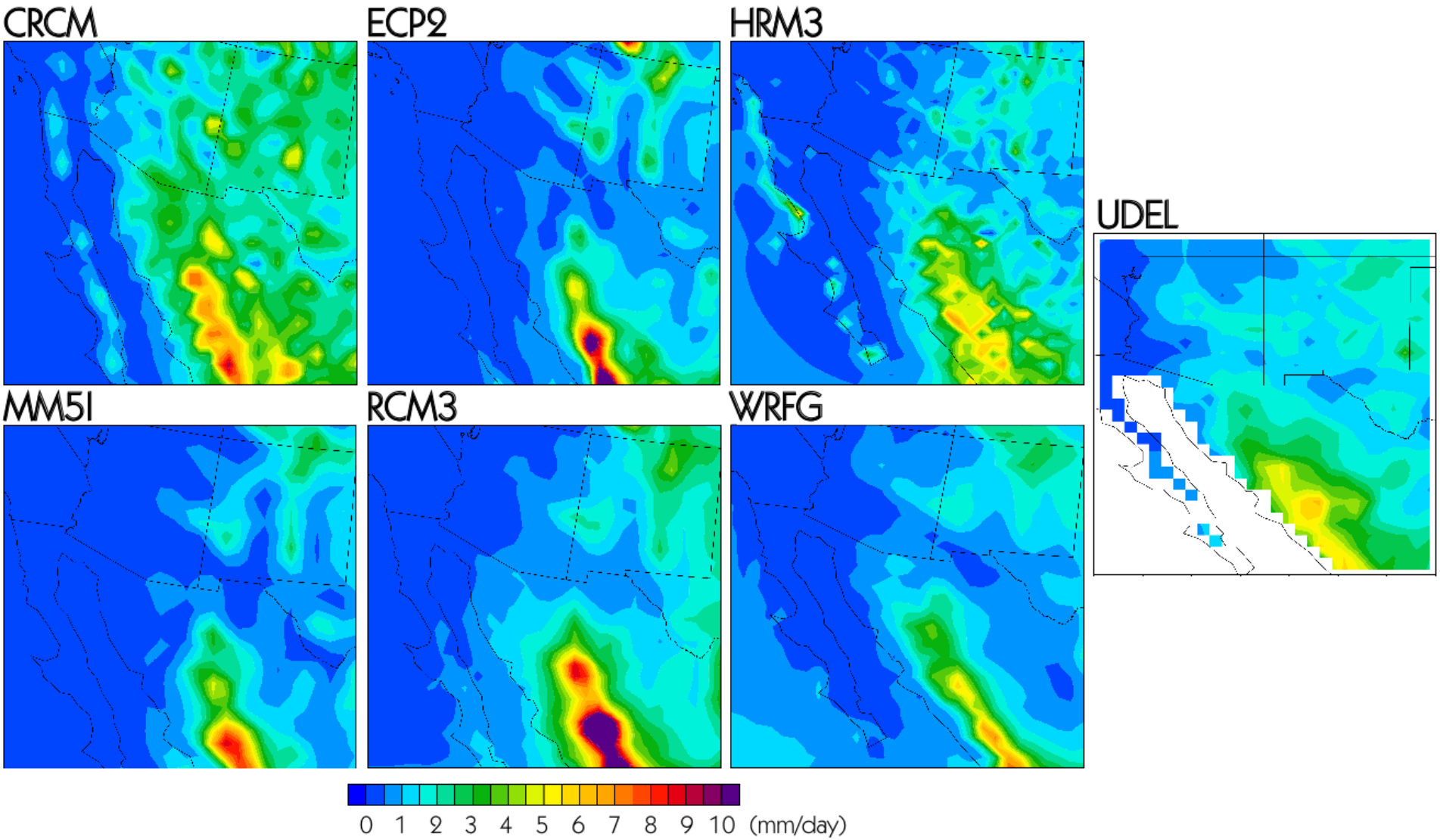
Metrics

What do these weights do to ensemble mean precipitation over the core monsoon region?

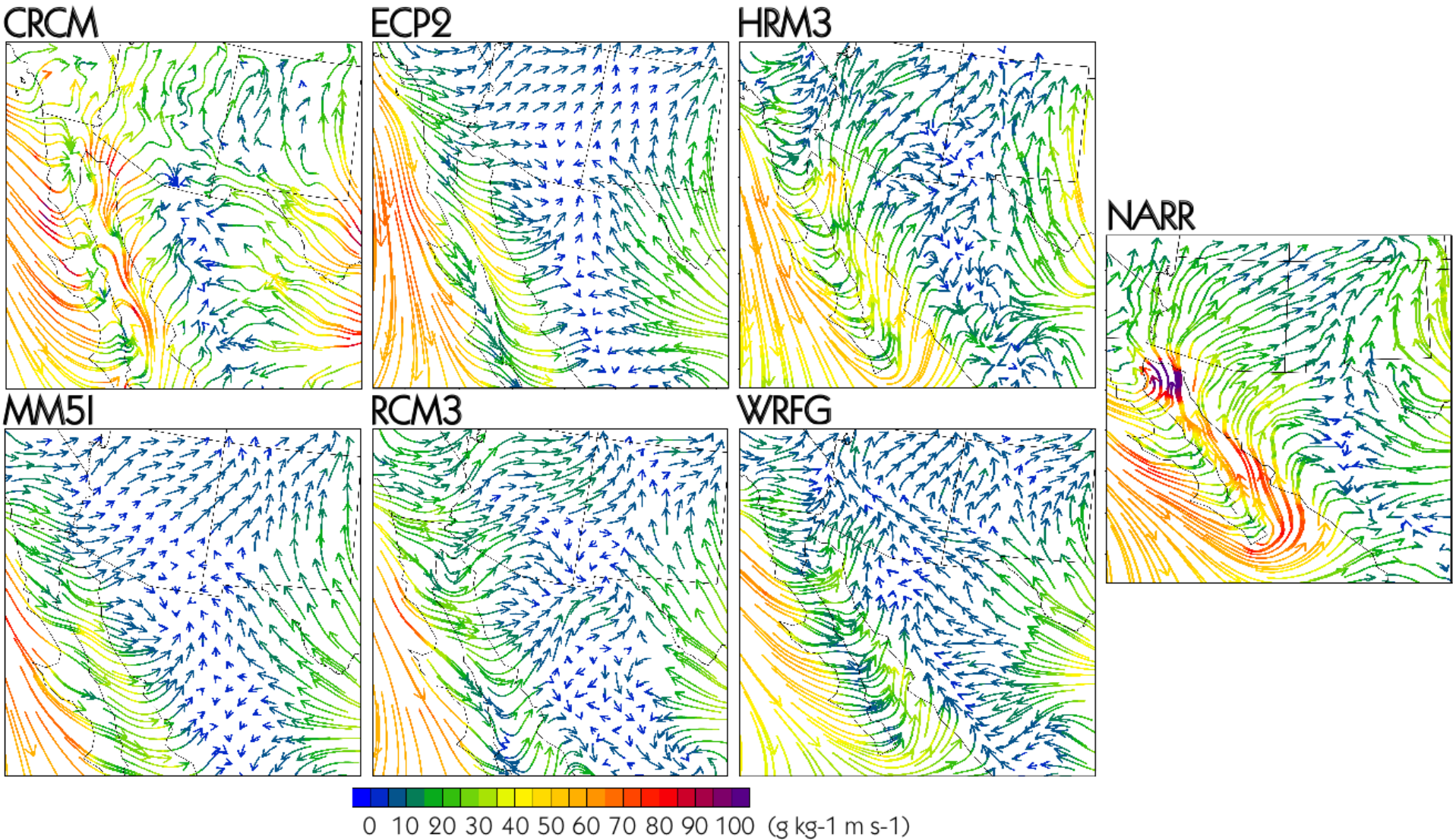
- Bias: -0.6 to -0.3 mm/day or -37% to -23%
- Spatial Correlation: 0.88 to 0.90

Why?...

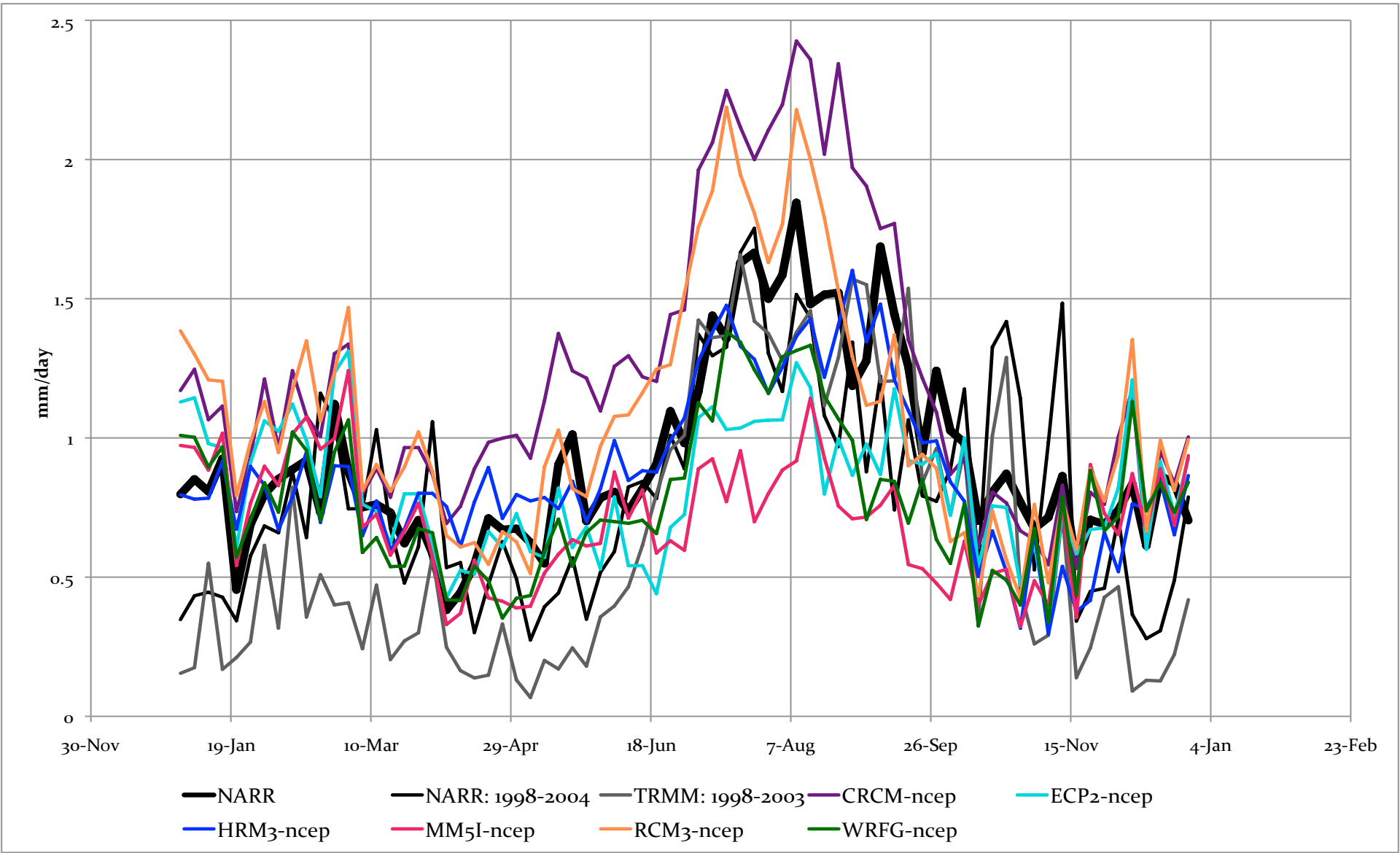
1980-2004 JJAS Average Precipitation Rate: NCEP-driven



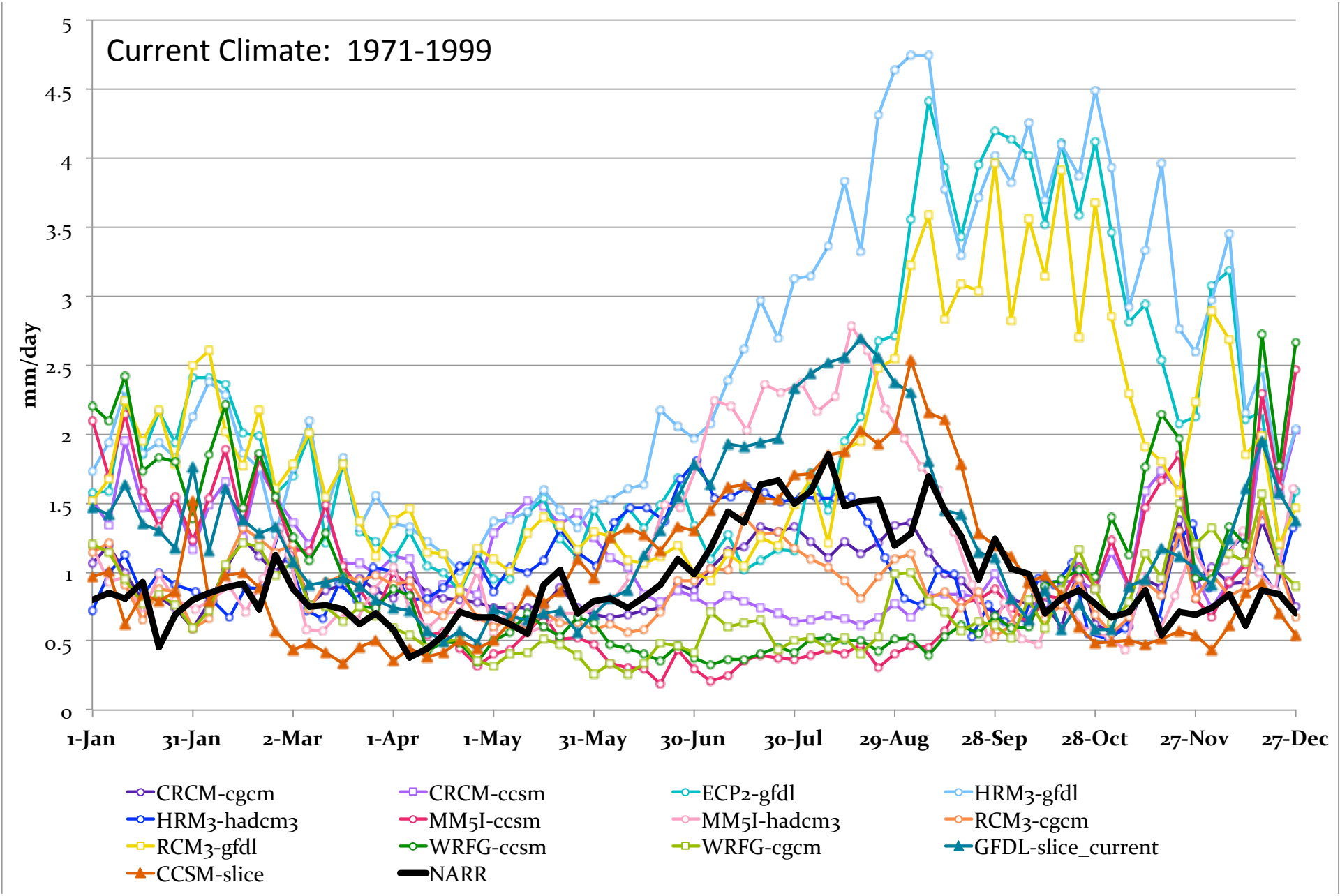
1980-2004 JJAS Average Near-Surface Moisture Flux: NCEP-driven Simulations

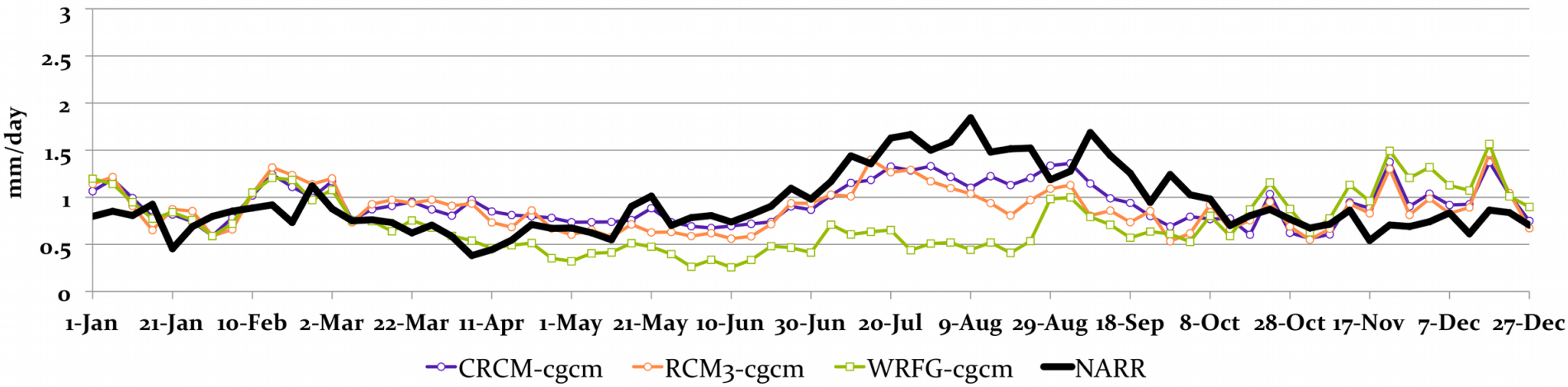


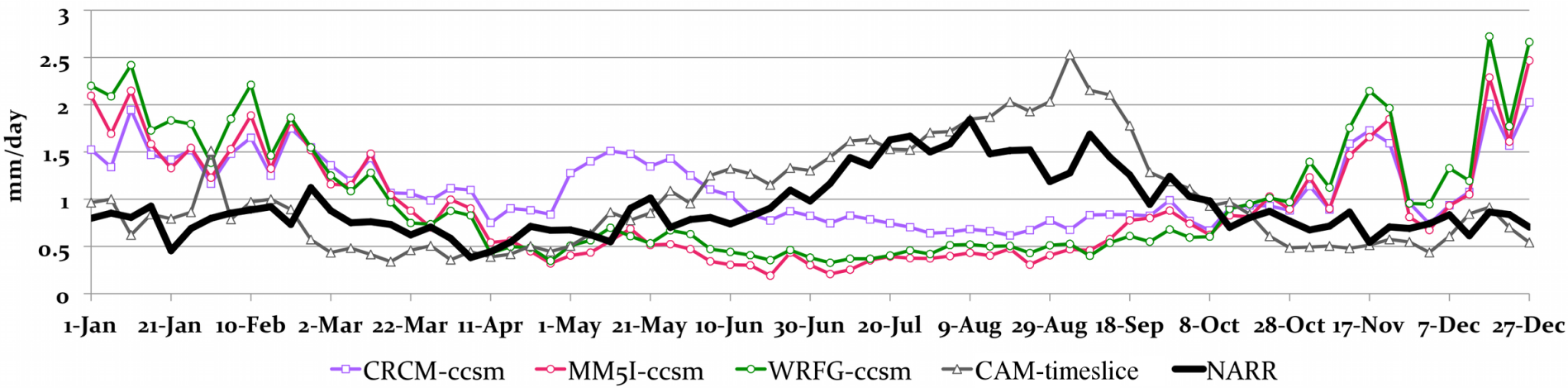
1980-2004 5-day Average Precipitation Climatology
NCEP-Driven Simulations



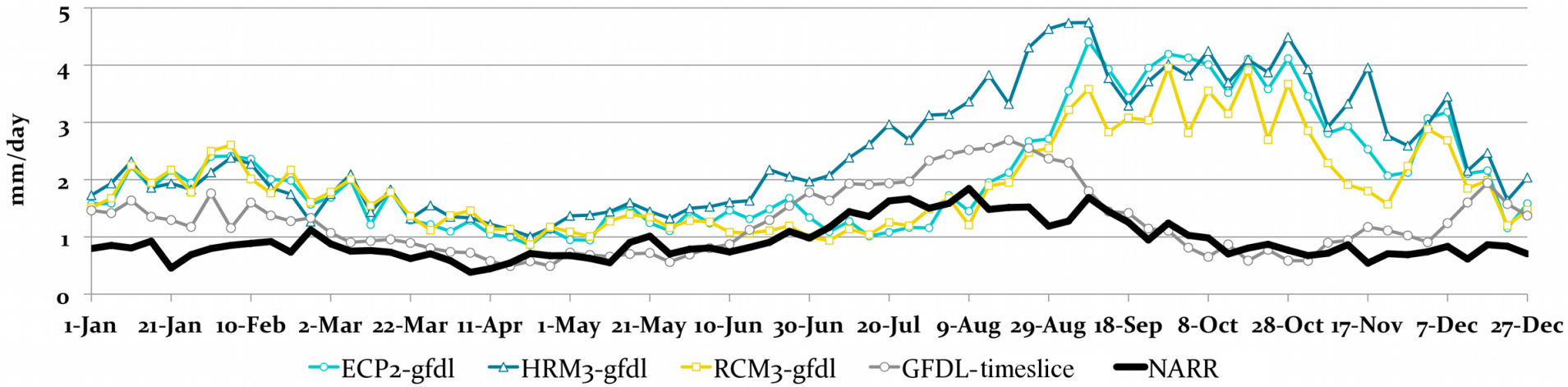
GCM-driven 5-day Average Precipitation Climatology

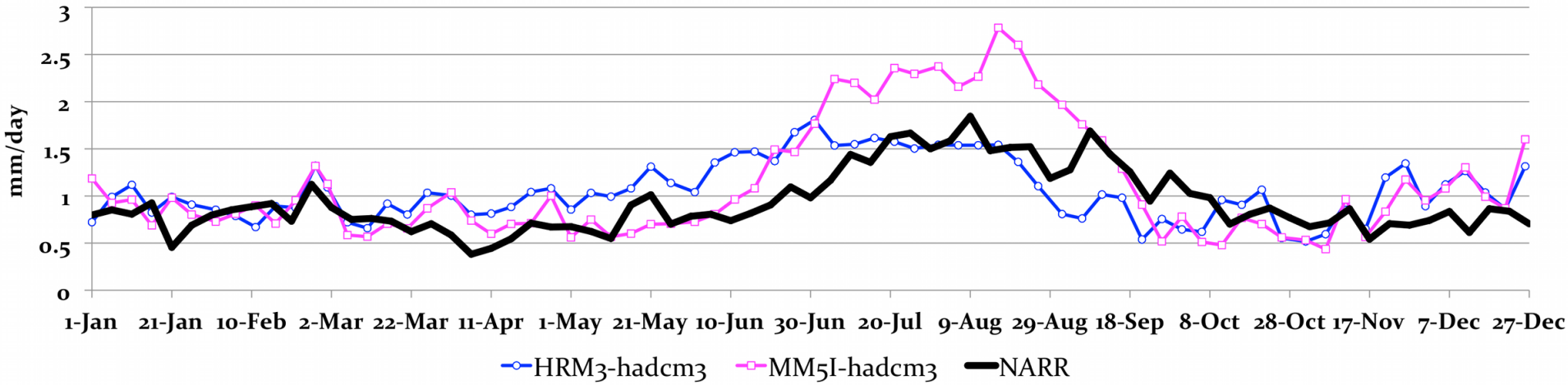




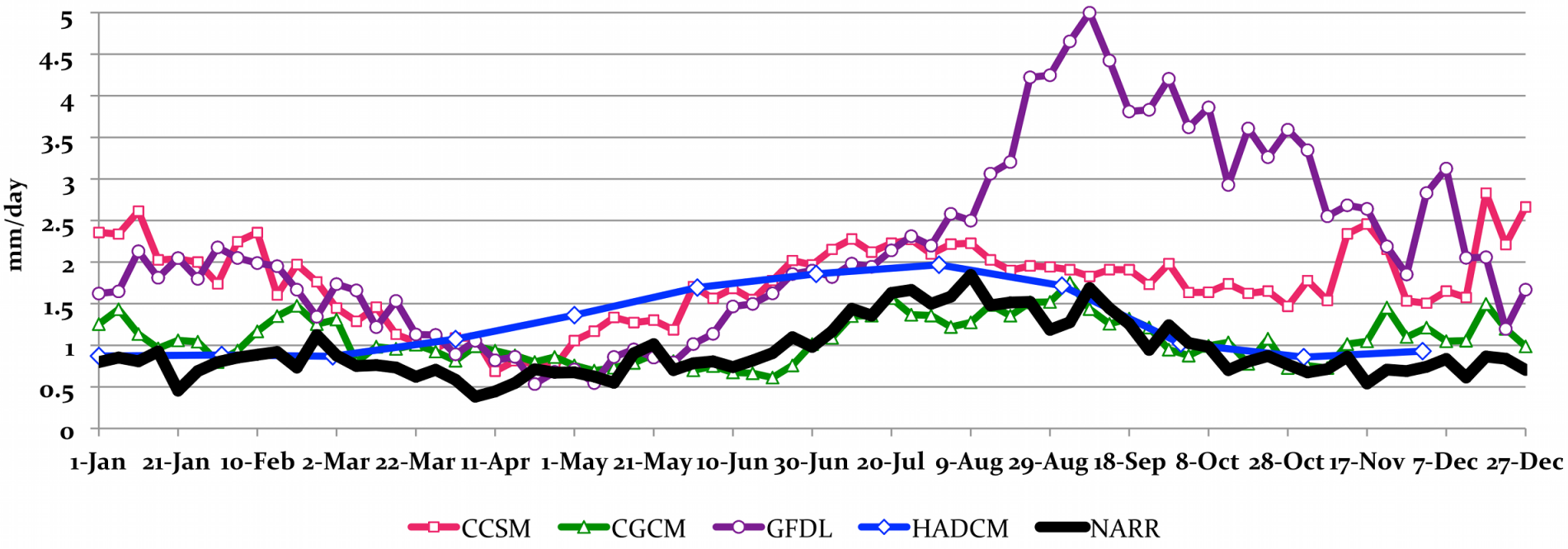


5-day Average Precipitation Climatology

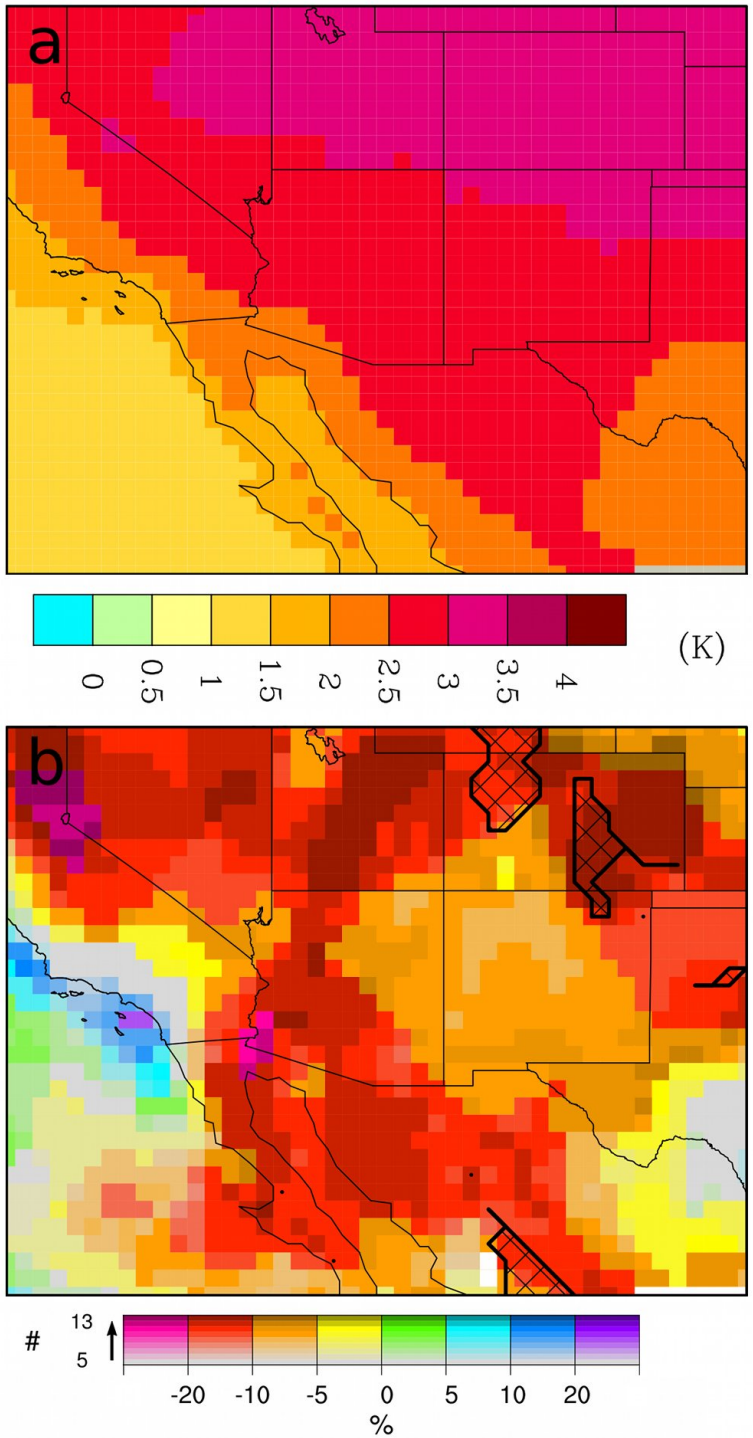




5-day Average Precipitation Climatology



5-day or Monthly Average GCM Precipitation Climatology



JJAS NARCCAP 13-Model Ensemble Mean Change

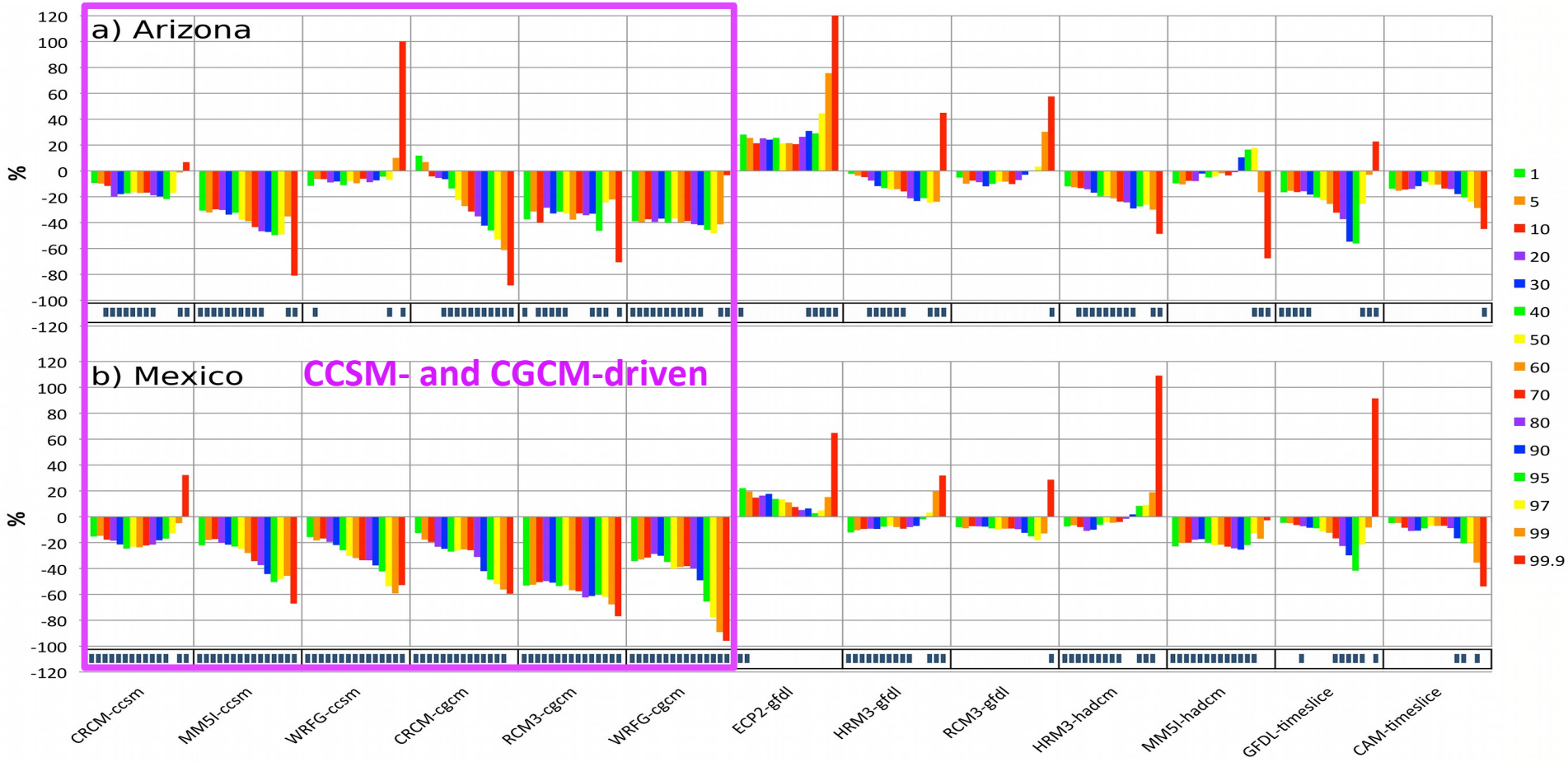
a) 2-m Temperature
b) Precipitation

In b) : Vertical color scale indicates model agreement on the sign of change. Hatching indicates where more than 50% of the models show change that is significant at the 0.10 level *and* where more than 75% of the models agree on the sign of change.

Impact of Bias on Precipitation Change

NAM Region	% Change	Absolute Change (mm/day)
Ensemble Average	-15.10	-0.13
CCSM-driven	-28.20	-0.15
CGCM-driven	-25.89	-0.22
GFDL-driven	-4.28	-0.09
HADCM-driven	-0.05	0.01

Left: mean change
Below: change in frequency of 3-hourly precipitation events by percentile.



Final Comments

- Work in Progress.
  - More to come on the processes driving changes in the Southwest.

- The ability of the models to capture monsoon system rainfall is heavily determined by driving GCM.
  - Good argument for continued improvement of AOGCMs!

- Projections for precipitation change in the Southwest are influenced by model bias, with the largest negative changes in the simulations with the poorest verification.

Bukovsky, M.S., D.J. Gochis, L.O. Mearns, 2013: Towards Assessing NARCCAP Regional Model Credibility for the North American Monsoon: Current Climate Simulations. *J. Climate,* doi: http://dx.doi.org/10.1175/JCLI-D-12-00538.1

Final Comments

- What would the ENSEMBLES metrics do to the ensemble mean projections?
- What would our expert judgment do to the ensemble mean projections?
- One might create metrics for the NAM system that are specific to the system and region that might be more meaningful for the NAM.
  - If you use them as weights in an ensemble mean though, they may or may not have a significant impact. (Statement made based on work using all possible weights in other regions.)
- Added value through higher resolution? Because the orography is better resolved, we have a better spatial distributions and simulations of wind, precipitation, etc. versus that in global models. (Not shown.)

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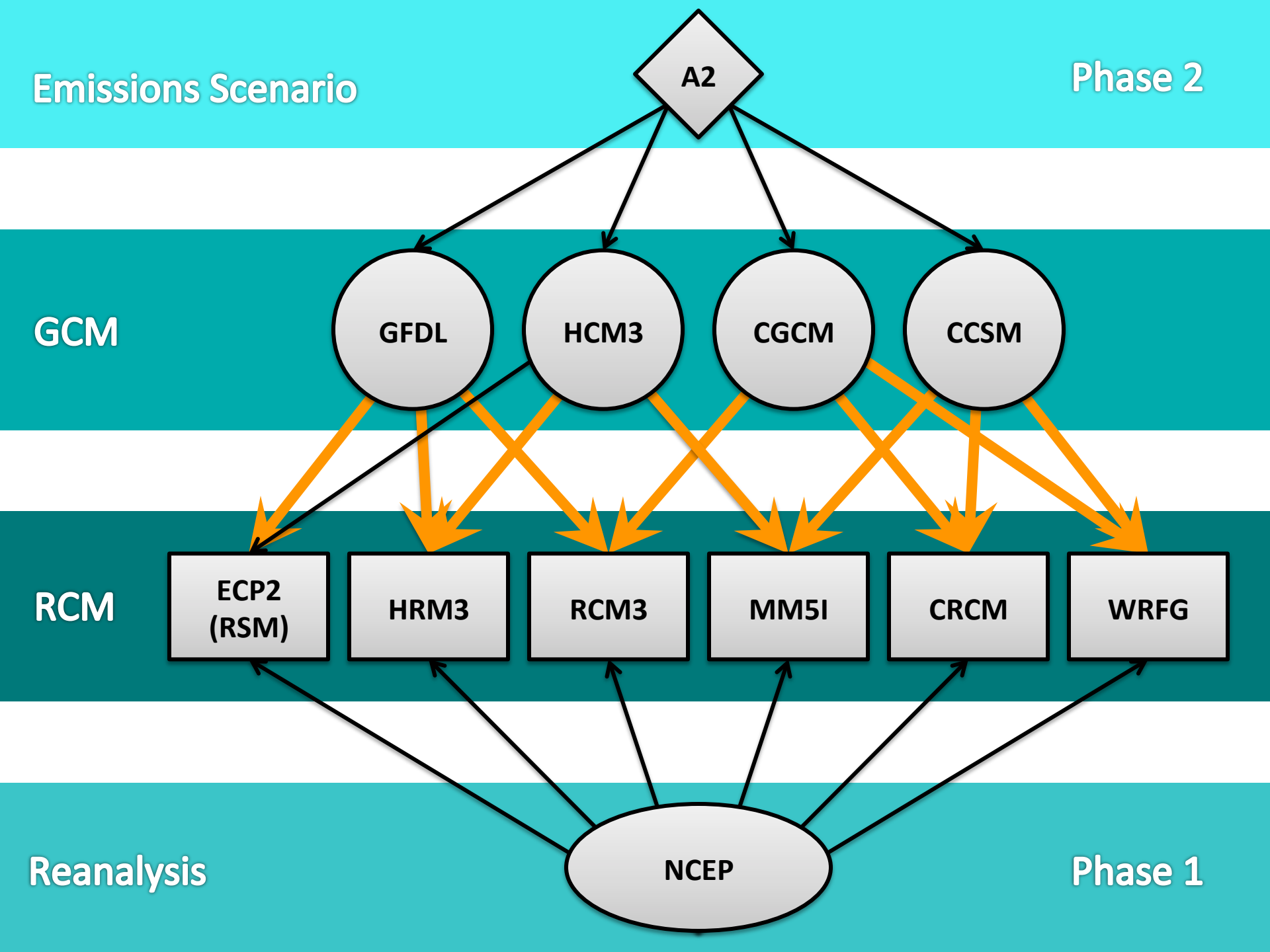
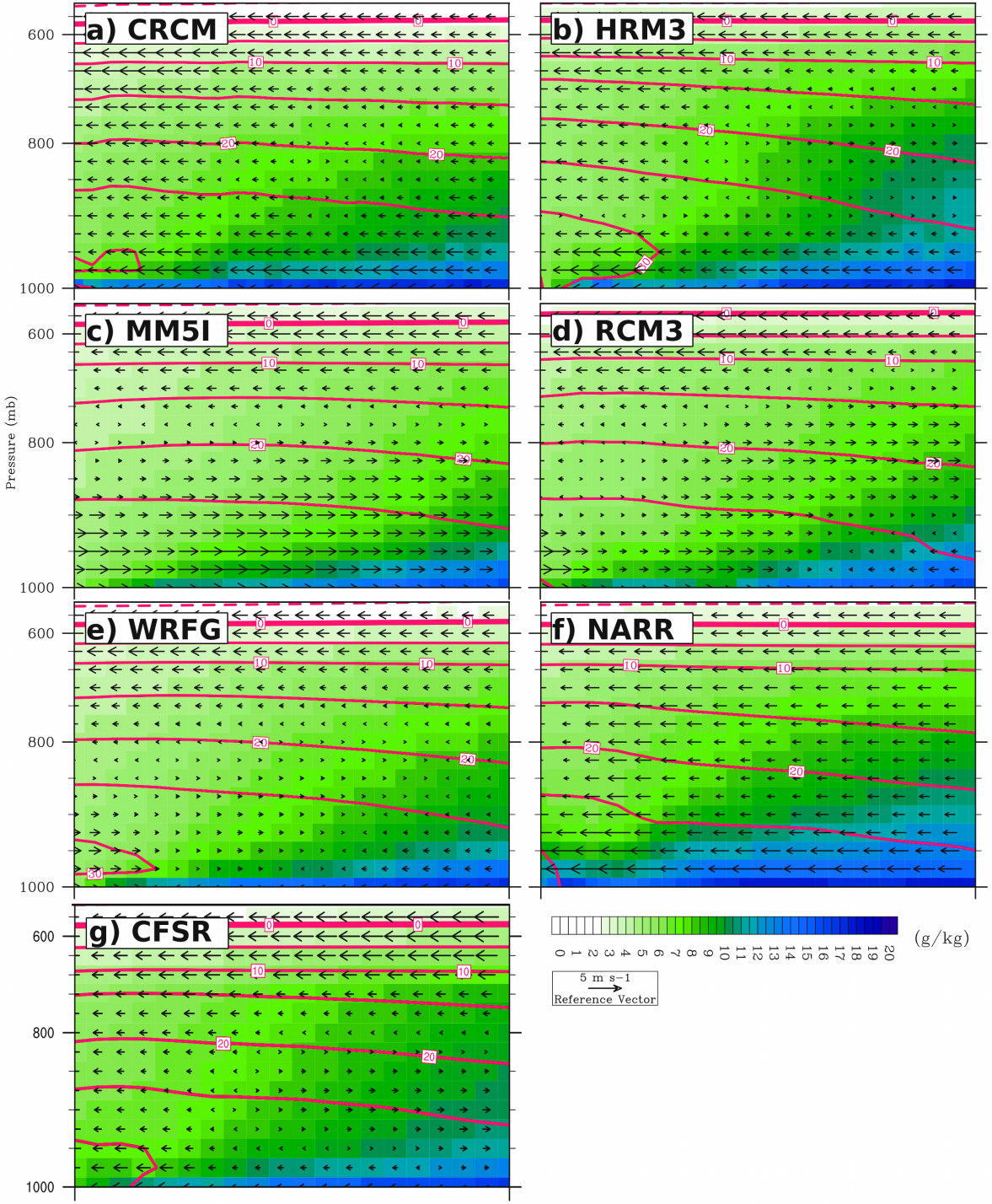

Emissions Scenario
A2
Phase 2
GCM
GFDL
HCM3
CGCM
CCSM
RCM
ECP2 (RSM)
HRM3
RCM3
MM5I
CRCM
WRFG
Reanalysis
NCEP
Phase 1

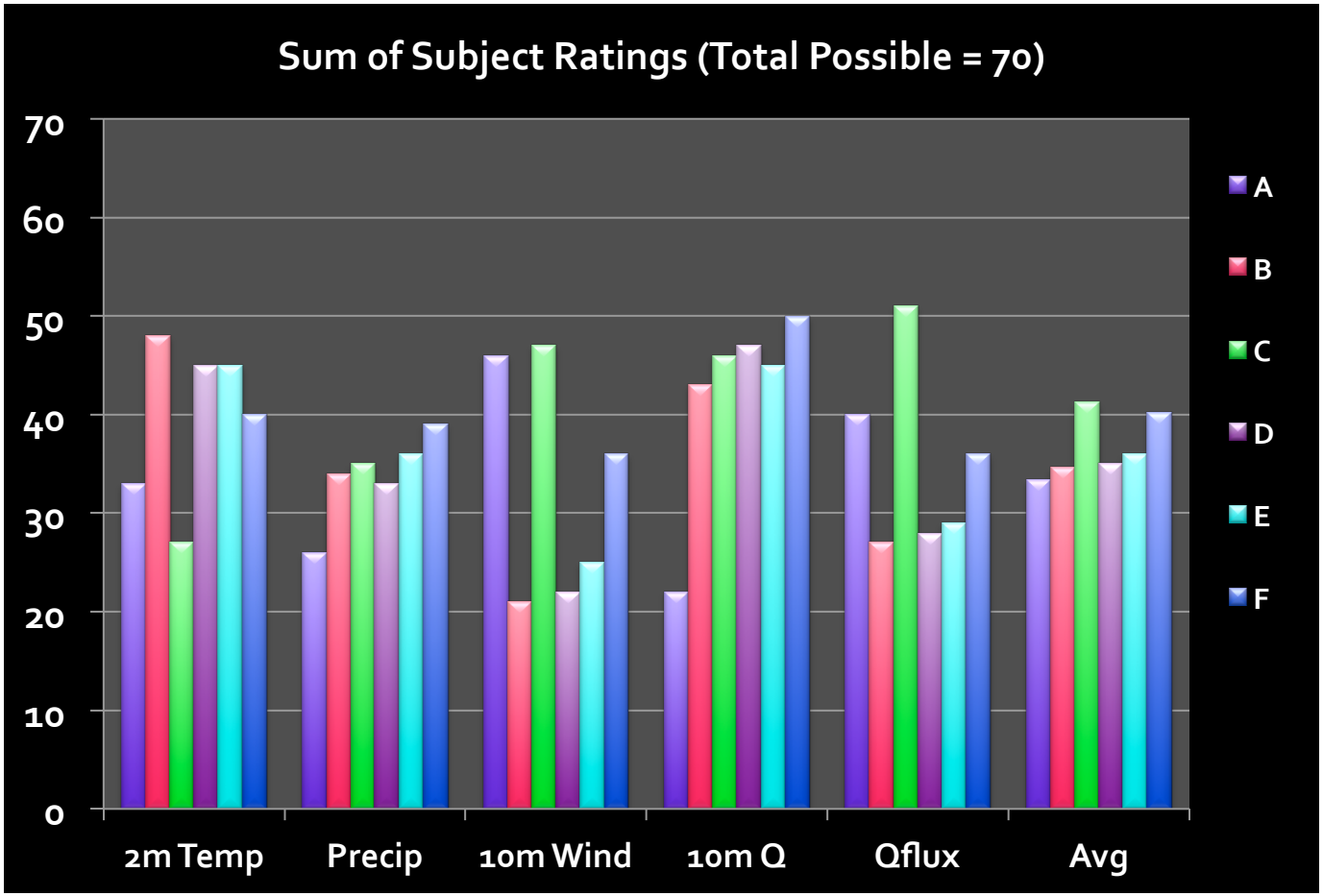


1980-2004 JJAS Along JoC Specific Humidity, Wind, and Temperature

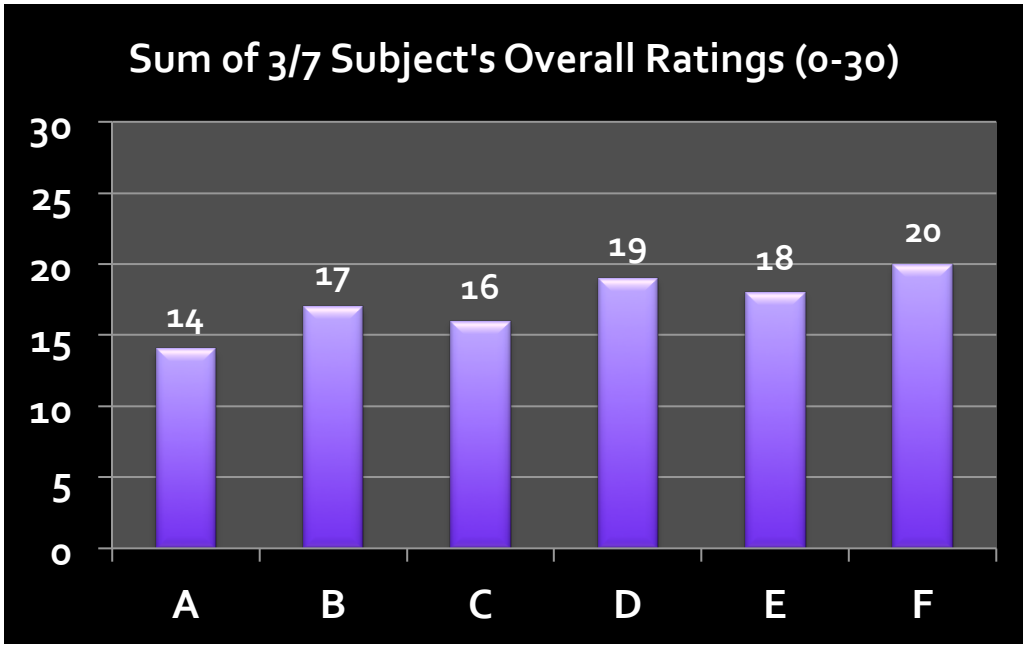
(Left = north end, right = south end)

Part B: Variable Ratings

Models	
A	CRCM
B	ECP2
C	HRM3
D	MM5I
E	RCM3
F	WRFG



Overall Ratings



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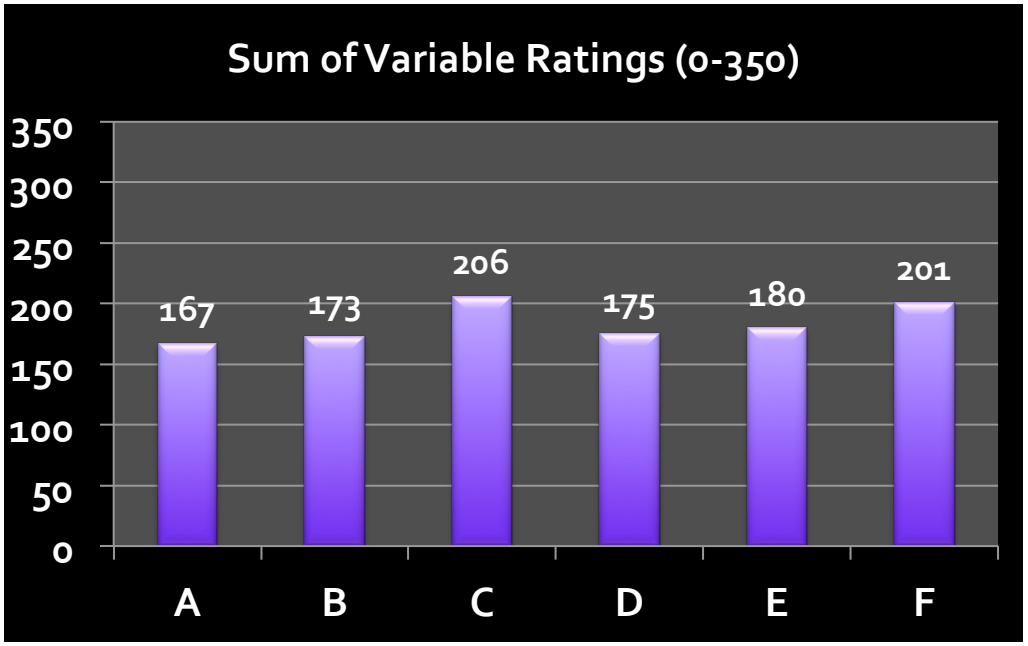
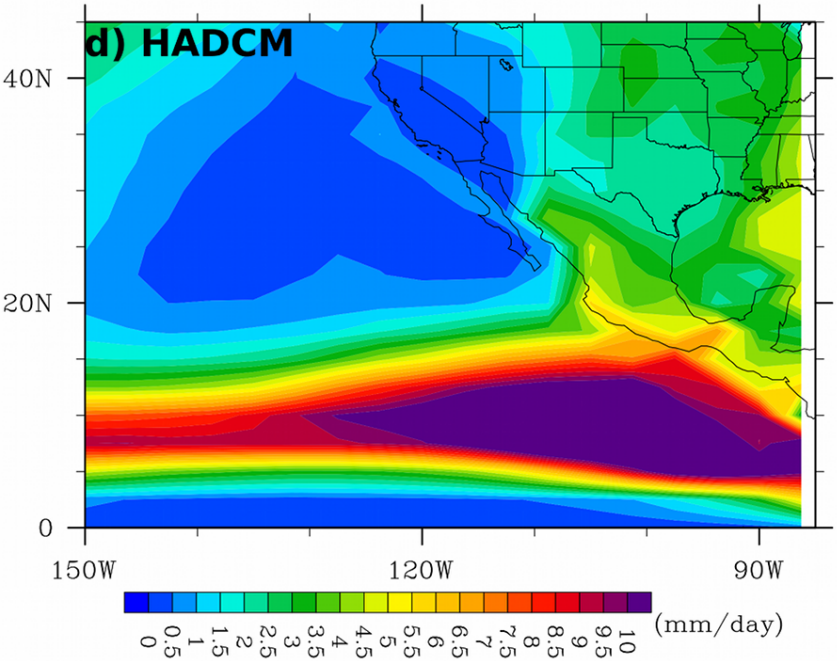
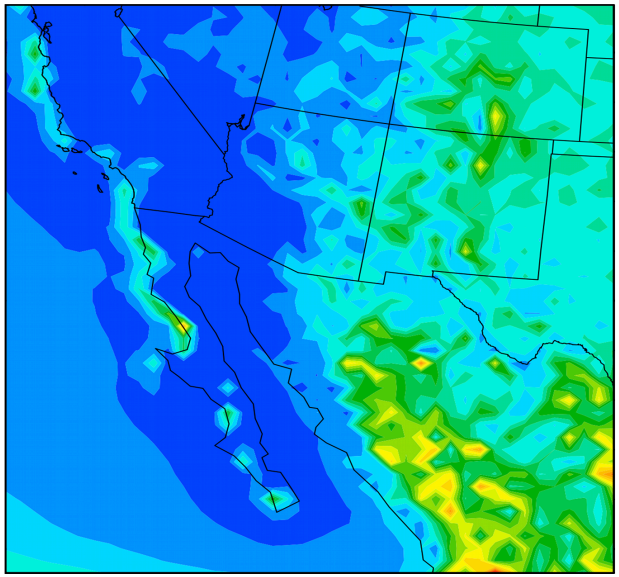


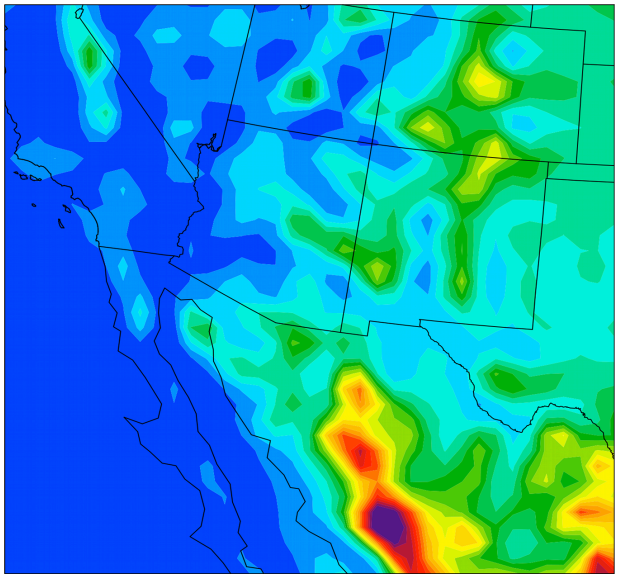


Added value through higher resolution.

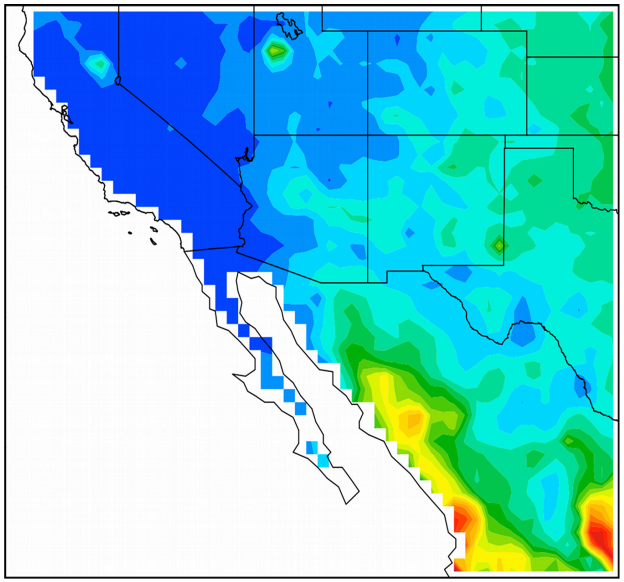
l) HRM3-hadcm

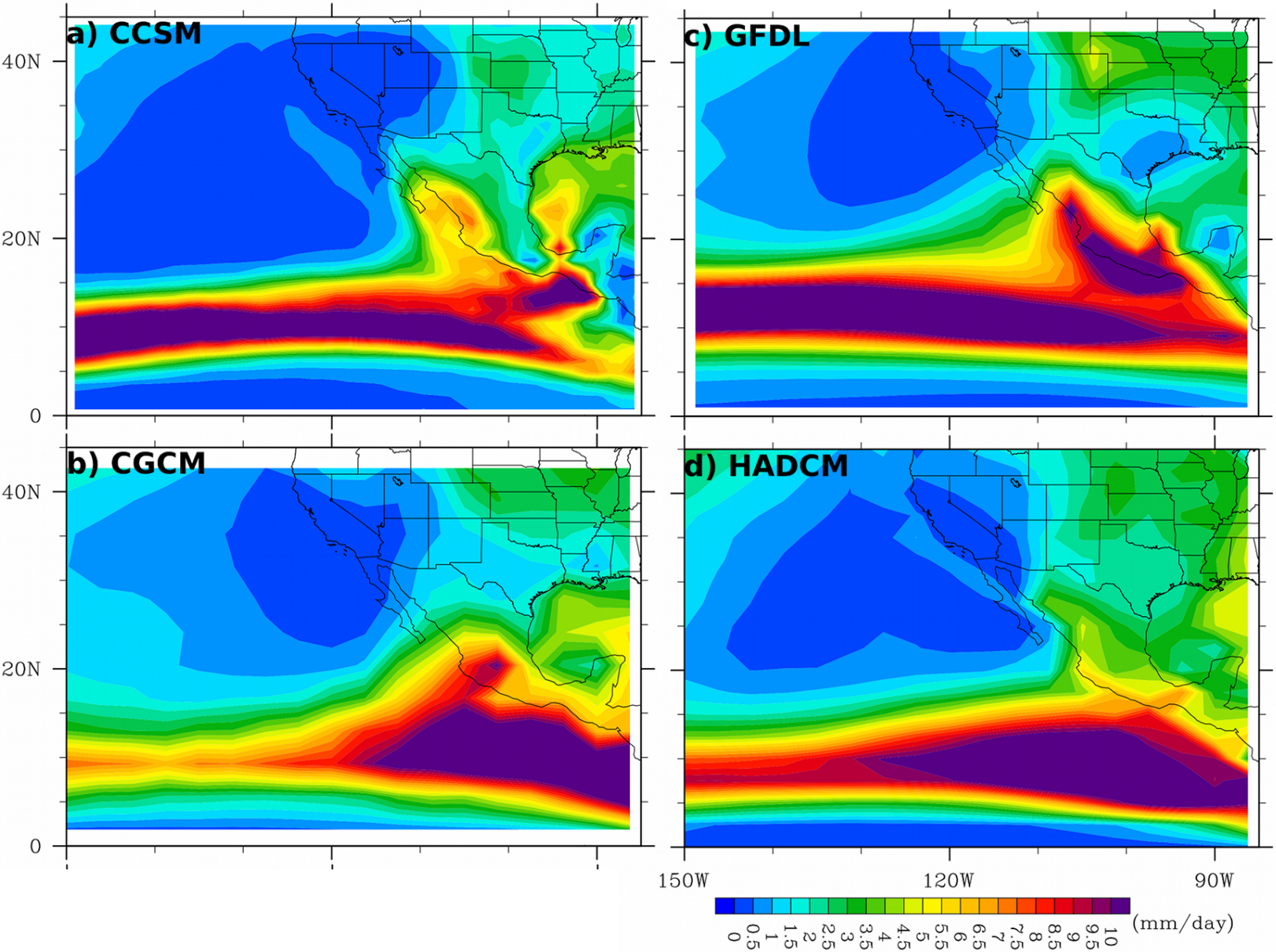


m) MM5I-hadcm

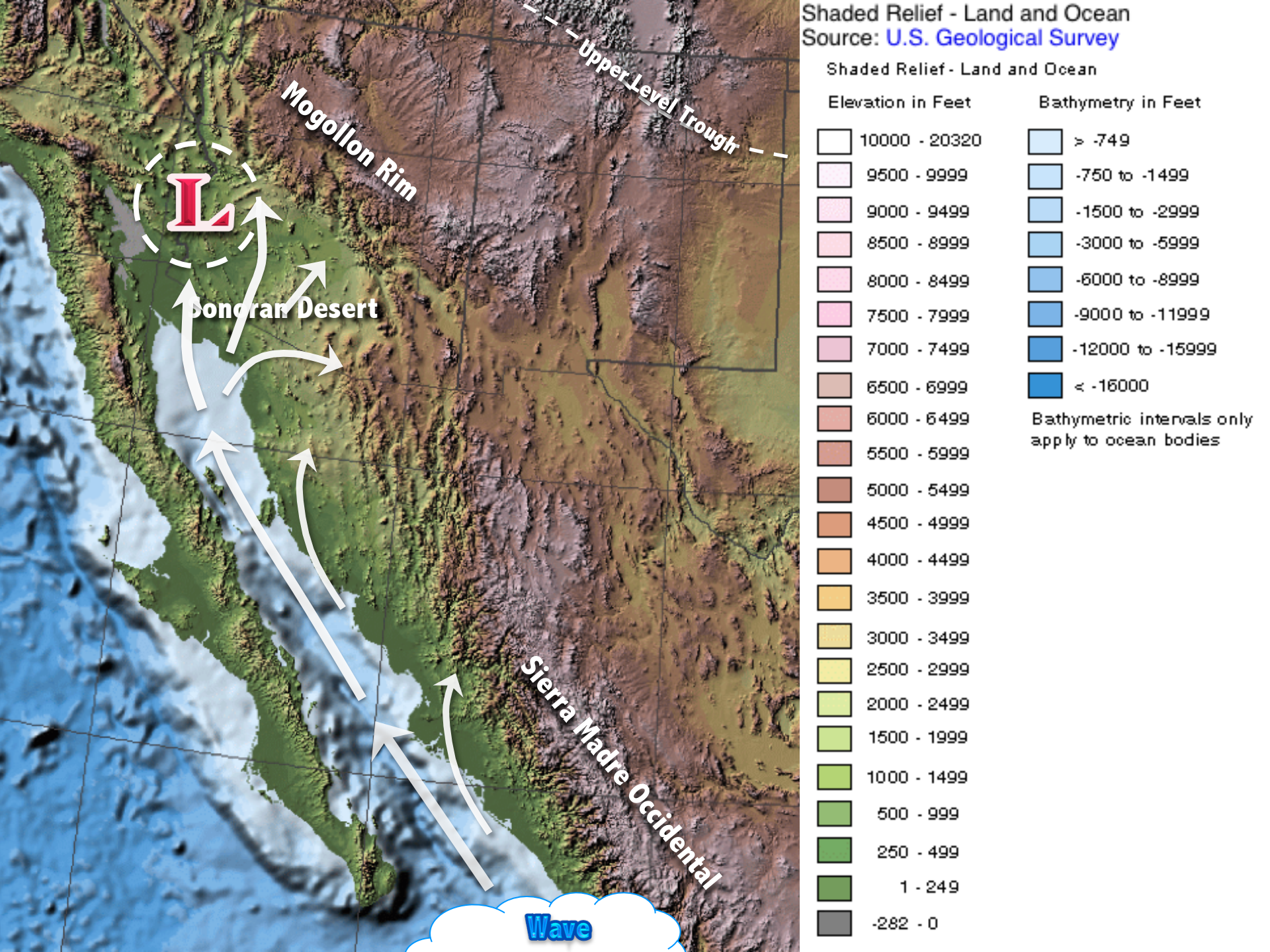


n) UDEL




a) CCSM
c) GFDL
b) CGCM
d) HADCM
40N
20N
0
150W
120W
90W
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
9
9.5
10
(mm/day)

Added Value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Mogollon Rim
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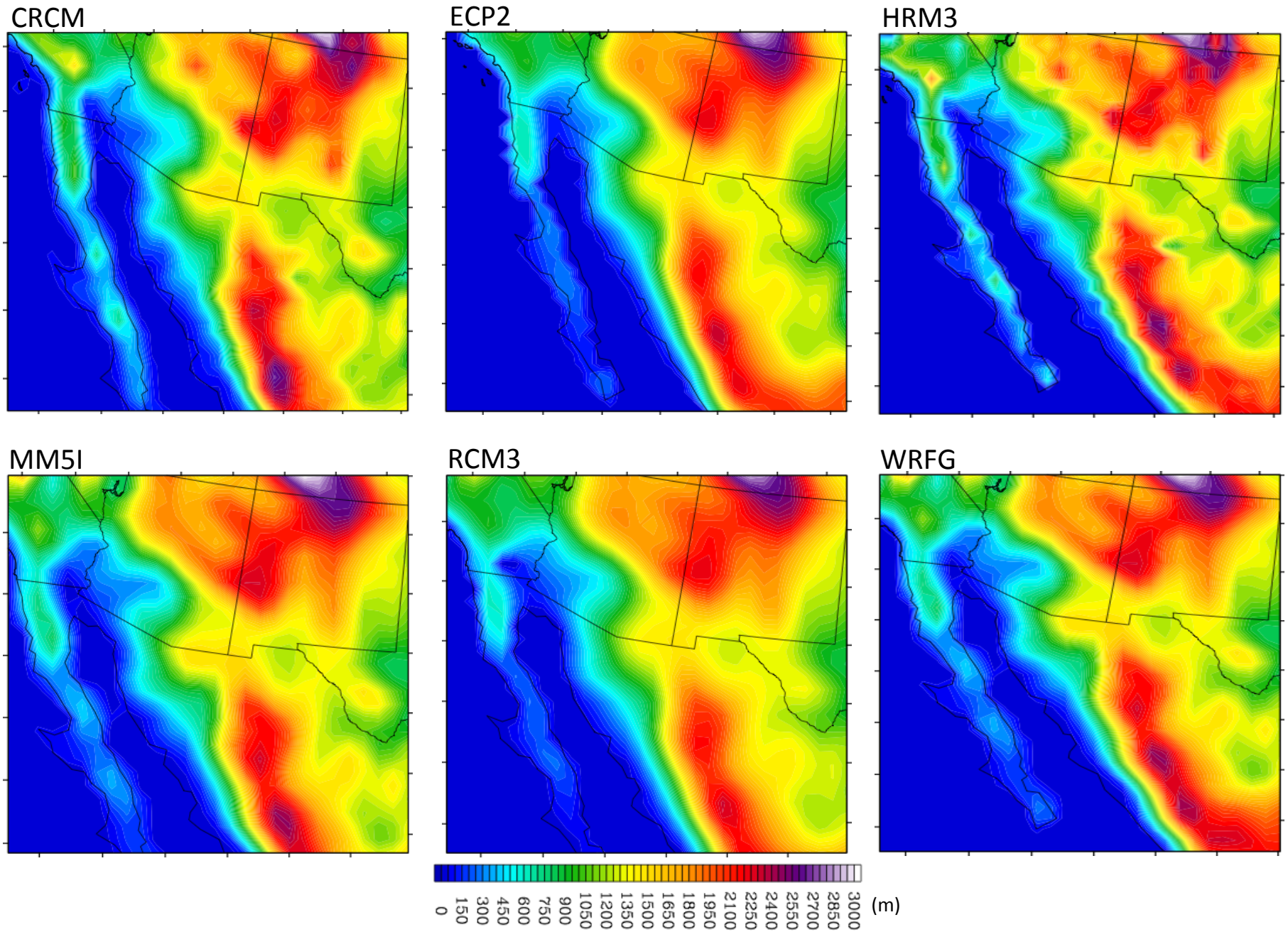
Wave

RCM Terrain


CRCM
ECP2
HRM3
MM5I
RCM3
WRFG
0
150
300
450
600
750
900
1050
1200
1350
1500
1650
1800
1950
2100
2250
2400
2550
2700
2850
3000
(m)