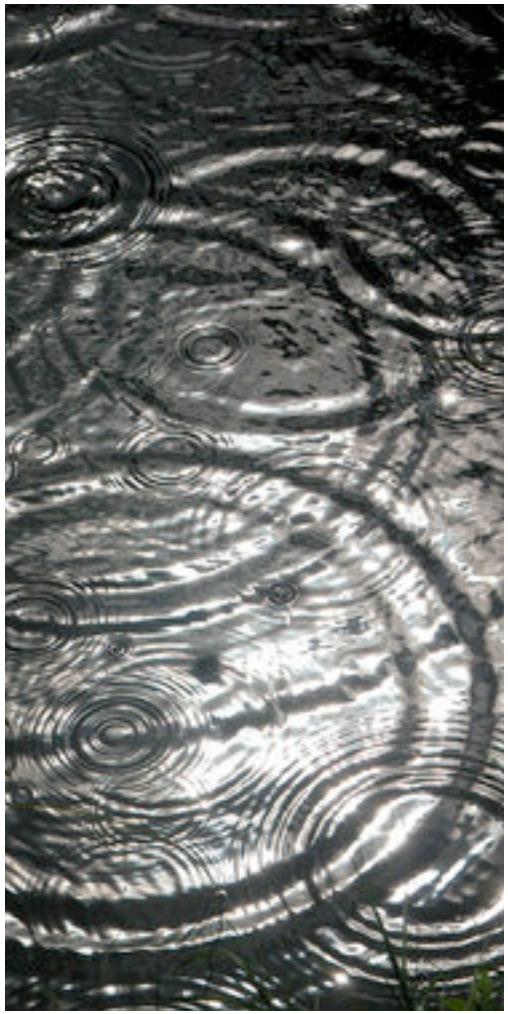
NARCCAP Regional Climate Model Simulations of the North American Monsoon

Melissa S. Bukovsky
NCAR/IMAGe
October 25, 2011

NCAR
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

Introduction



- Examine credibility of an ensemble of RCM simulations and their projections for the North American Monsoon System.
- Establish the differential credibility of the RCM/ GCM combinations.
- Extend analysis beyond temperature and precipitation and the use of basic metrics.
  - Establish whether or not the *processes* that make up the monsoon system are credibly simulated.
- Identify bias in monsoon processes and establish the potential impact of that bias on projections.

NARCCAP

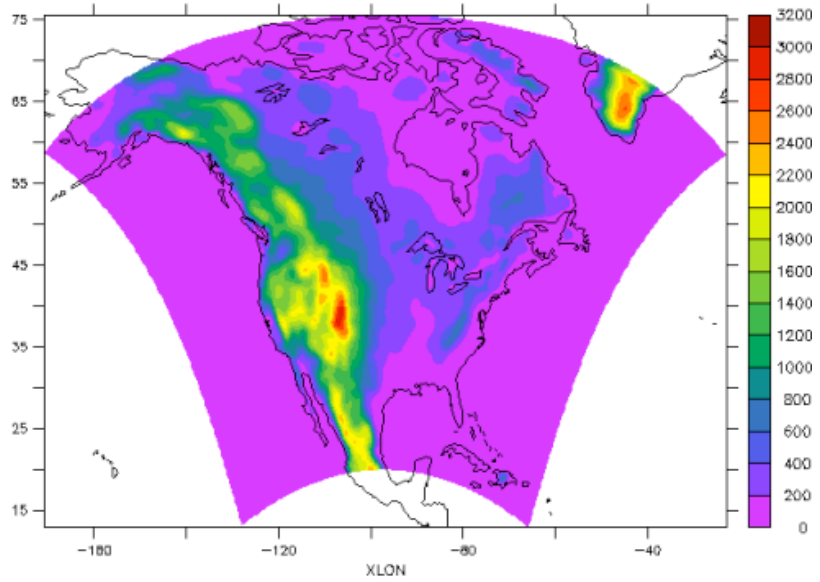
North American Regional Climate Change Assessment Program

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

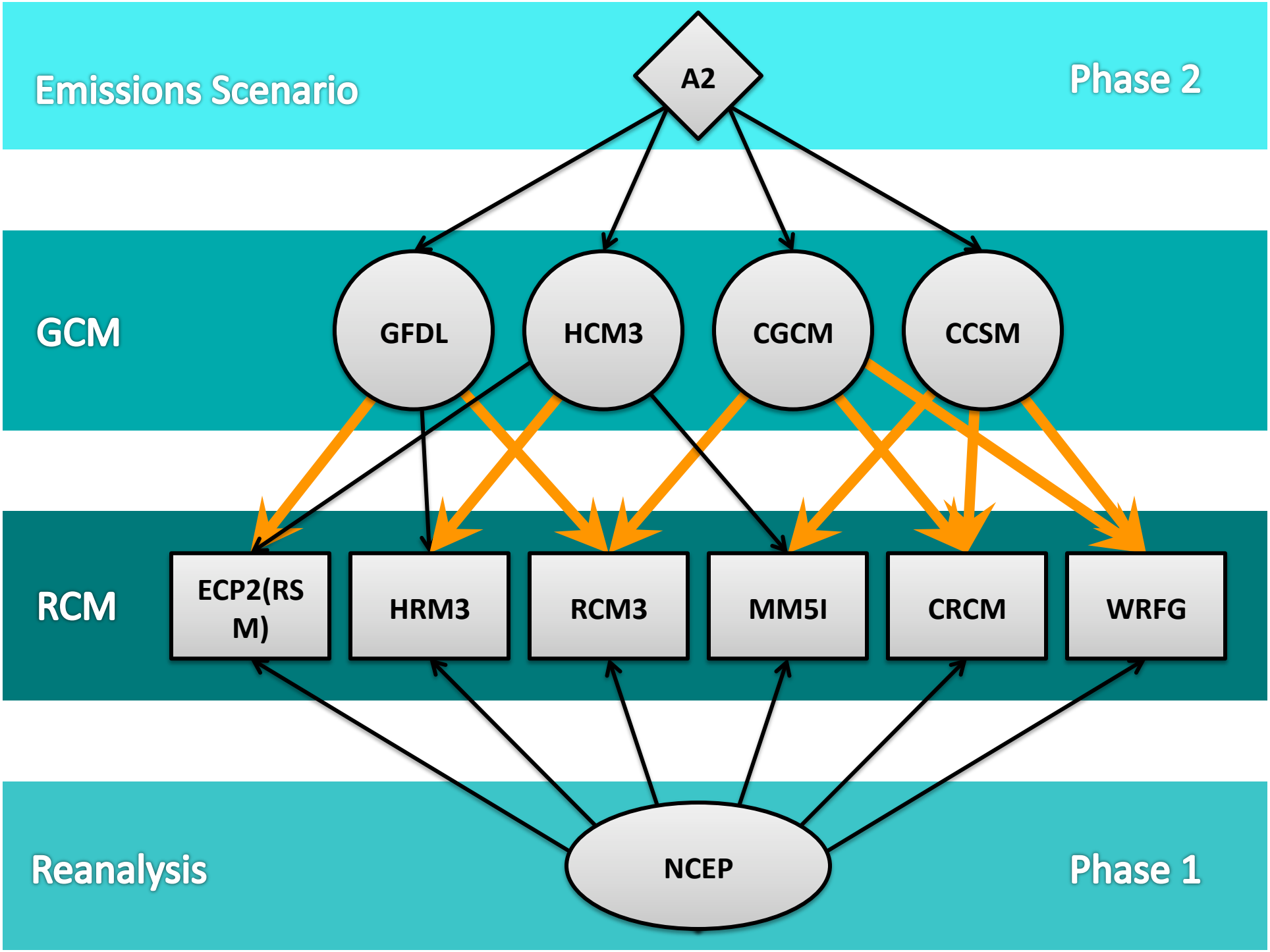
- RCMs are also being used to dynamically downscale the NCEP/DOE Reanalysis 2
  - 1980-2004

- 50-km horizontal resolution over most of North America

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



www.narccap.ucar.edu


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

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.

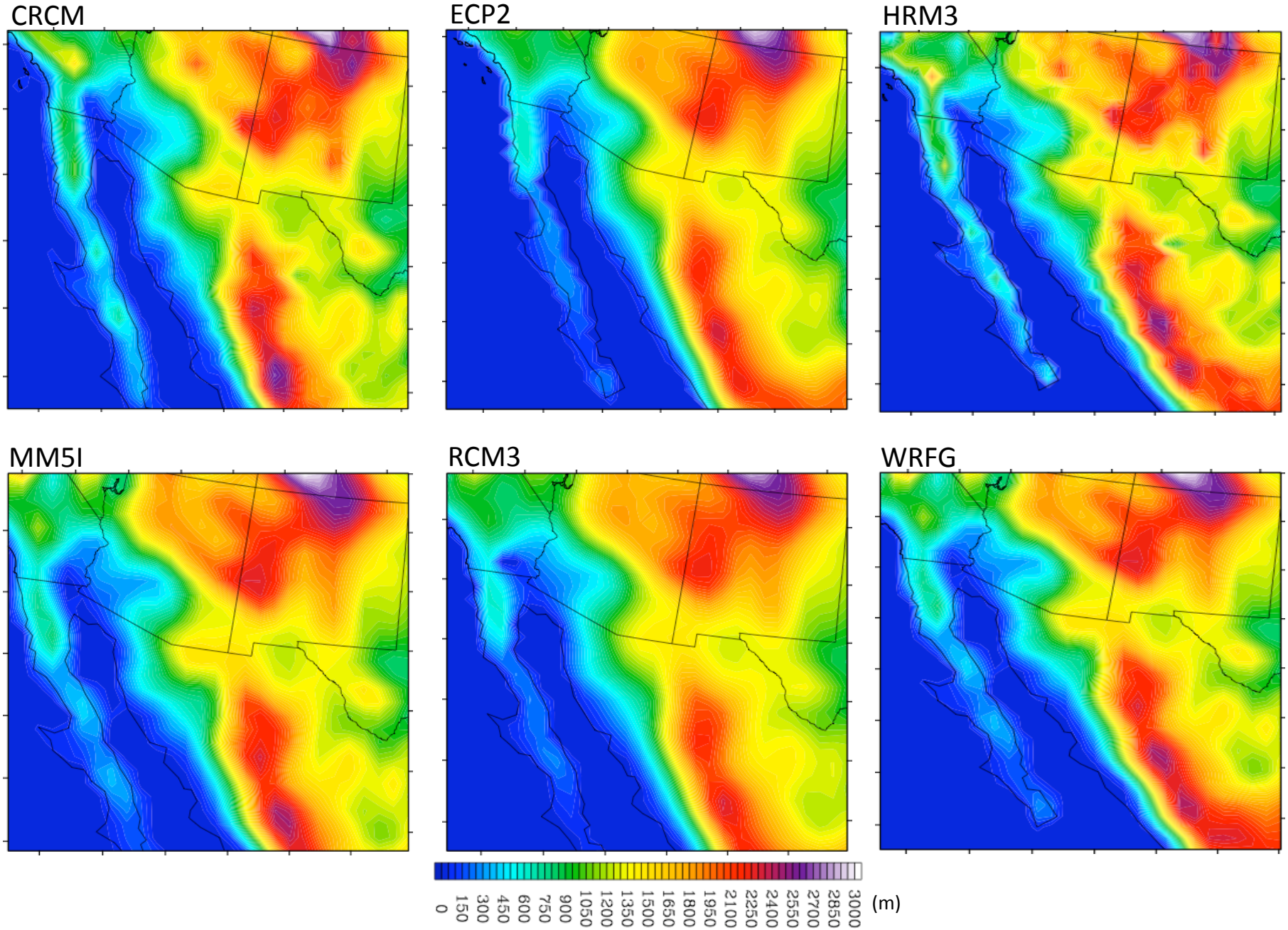
Shaded Relief - Land and Ocean
Source: U.S. Geological Survey

Shaded Relief - Land and Ocean

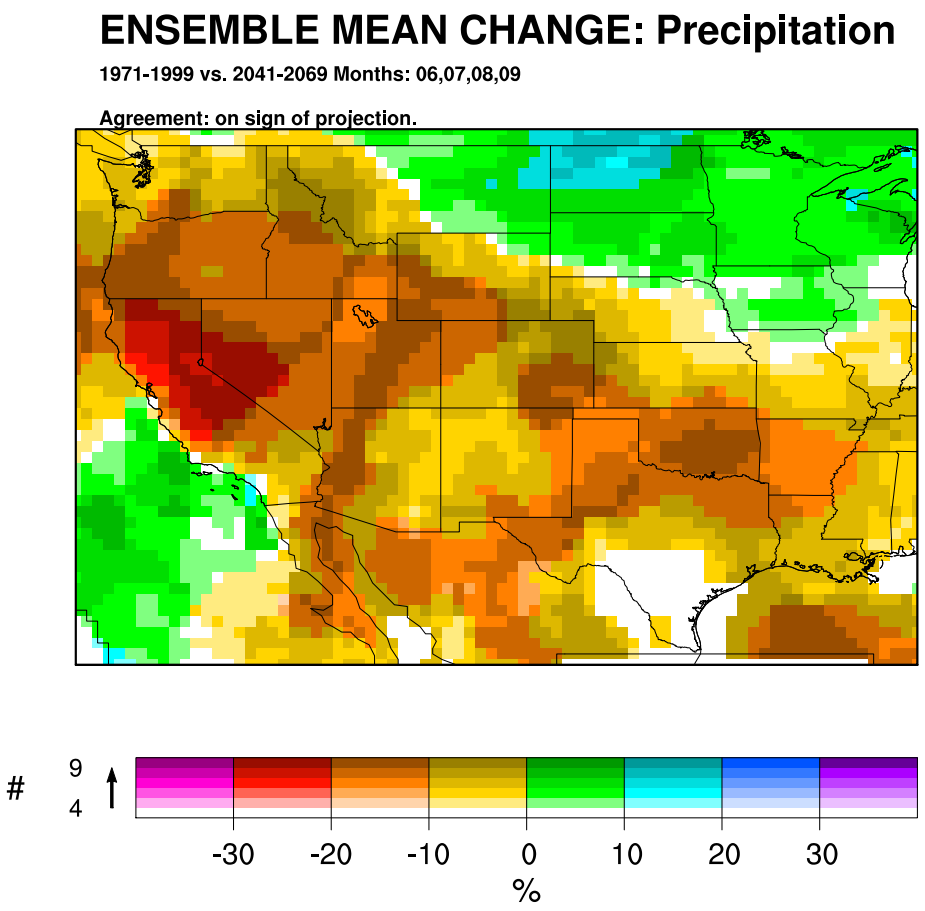
Elevation in Feet	Bathymetry in Feet
10000 - 20320	> -749
9500 - 9999	-750 to -1499
9000 - 9499	-1500 to -2999
8500 - 8999	-3000 to -5999
8000 - 8499	-6000 to -8999
7500 - 7999	-9000 to -11999
7000 - 7499	-12000 to -15999
6500 - 6999	< -16000
6000 - 6499	
5500 - 5999	
5000 - 5499	
4500 - 4999	
4000 - 4499	
3500 - 3999	
3000 - 3499	
2500 - 2999	
2000 - 2499	
1500 - 1999	
1000 - 1499	
500 - 999	
250 - 499	
1 - 249	
-282 - 0	

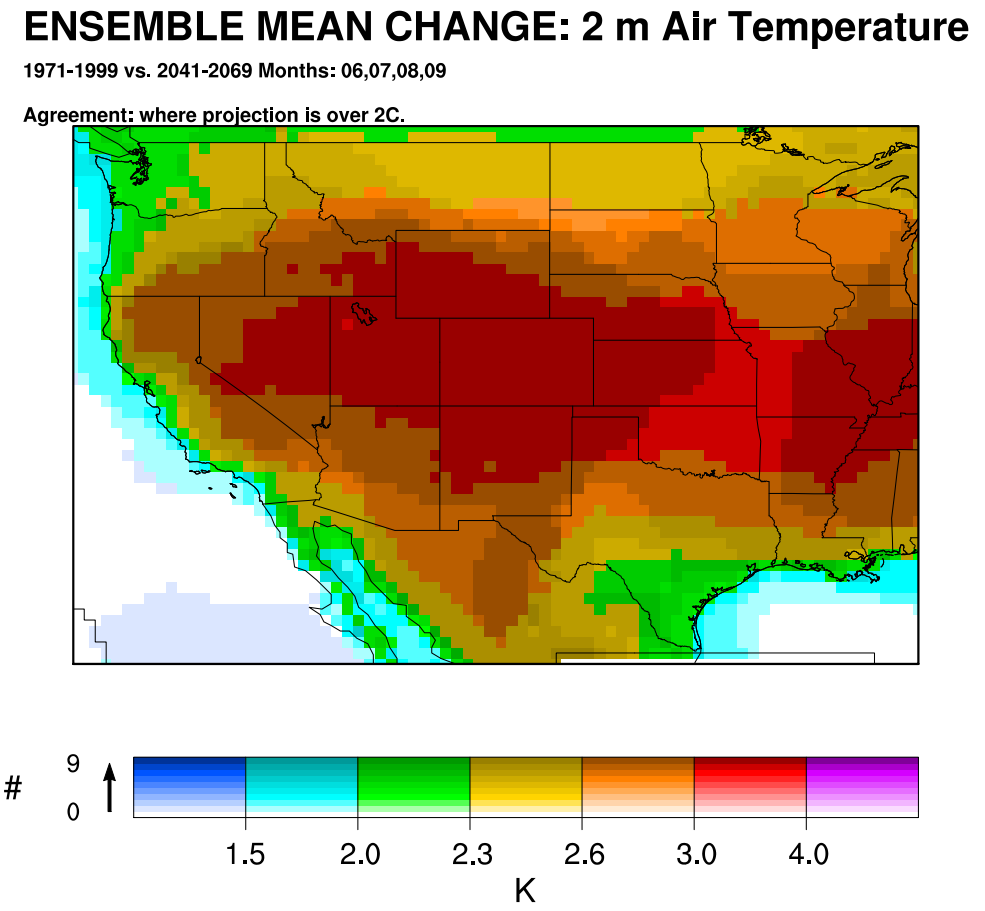
Bathymetric intervals only apply to ocean bodies

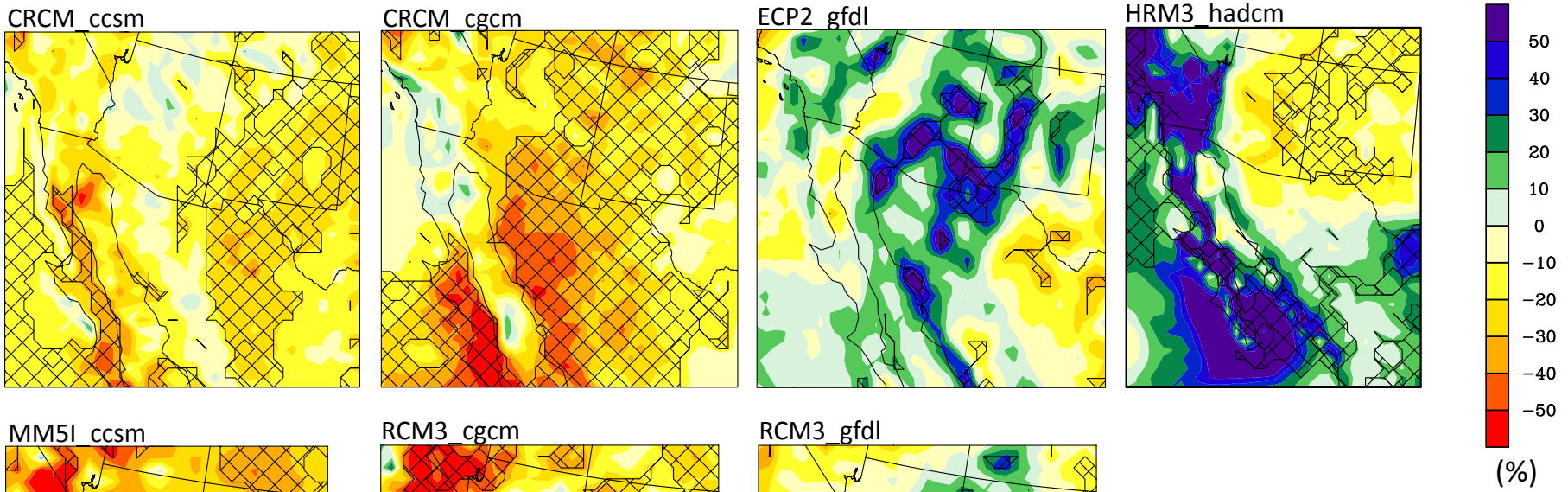
RCM Terrain


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)

9 RCM JJAS Mean Change + Agreement

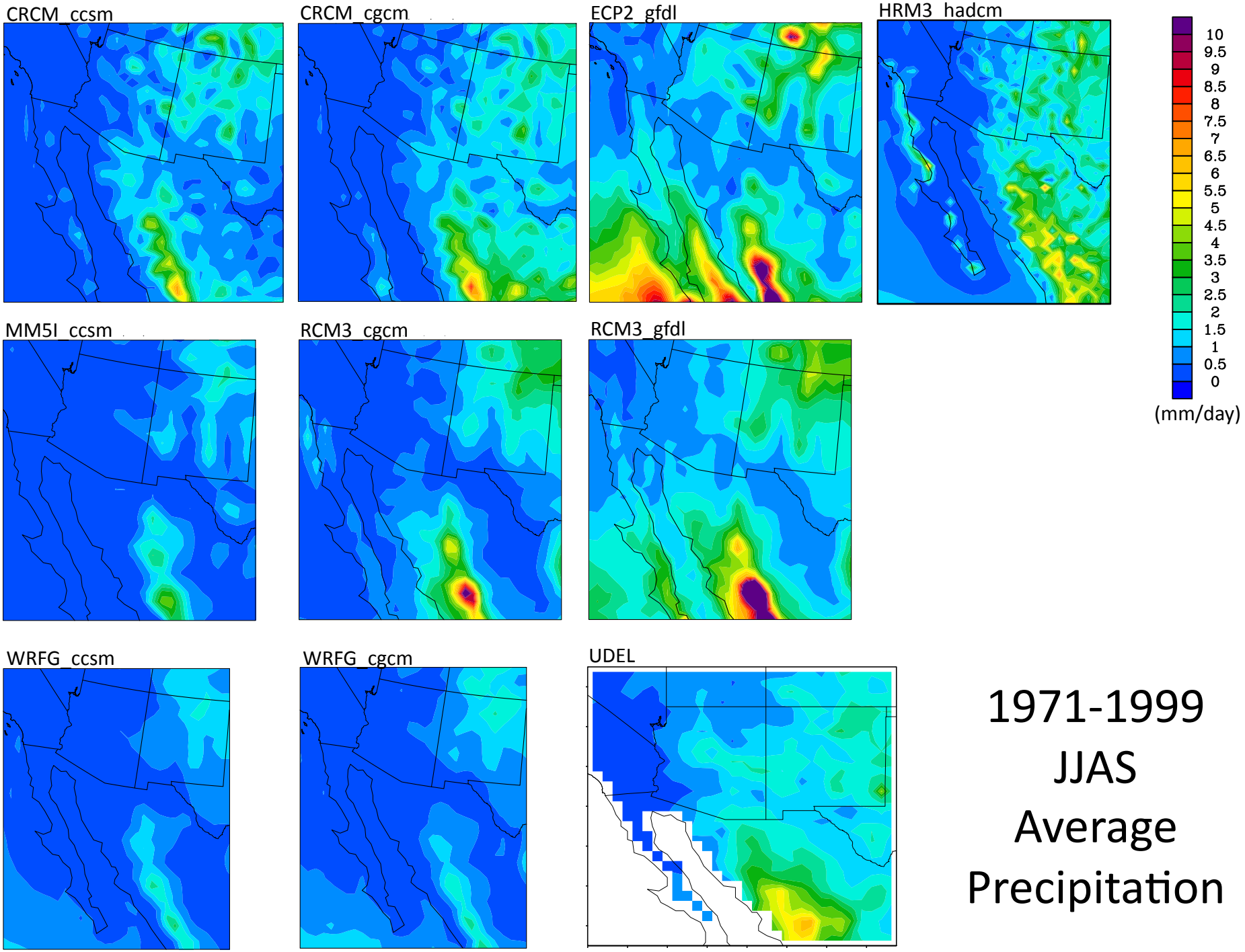






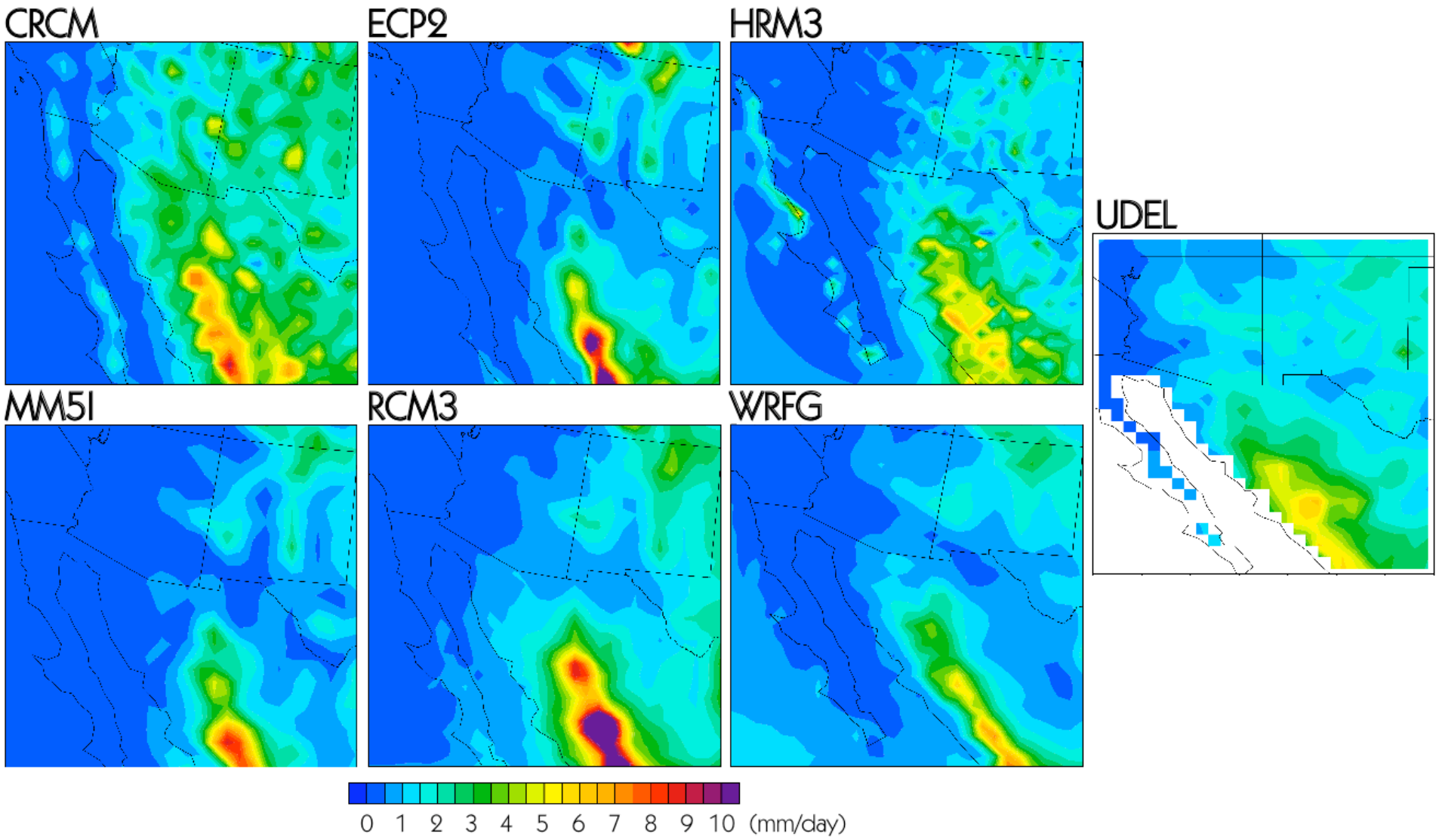
2041-2069 : 1971-1999
JJAS
Average Precipitation
Percent Difference

Hatching indicates statistically significant changes at the 0.1 level. Method = bootstrapping.

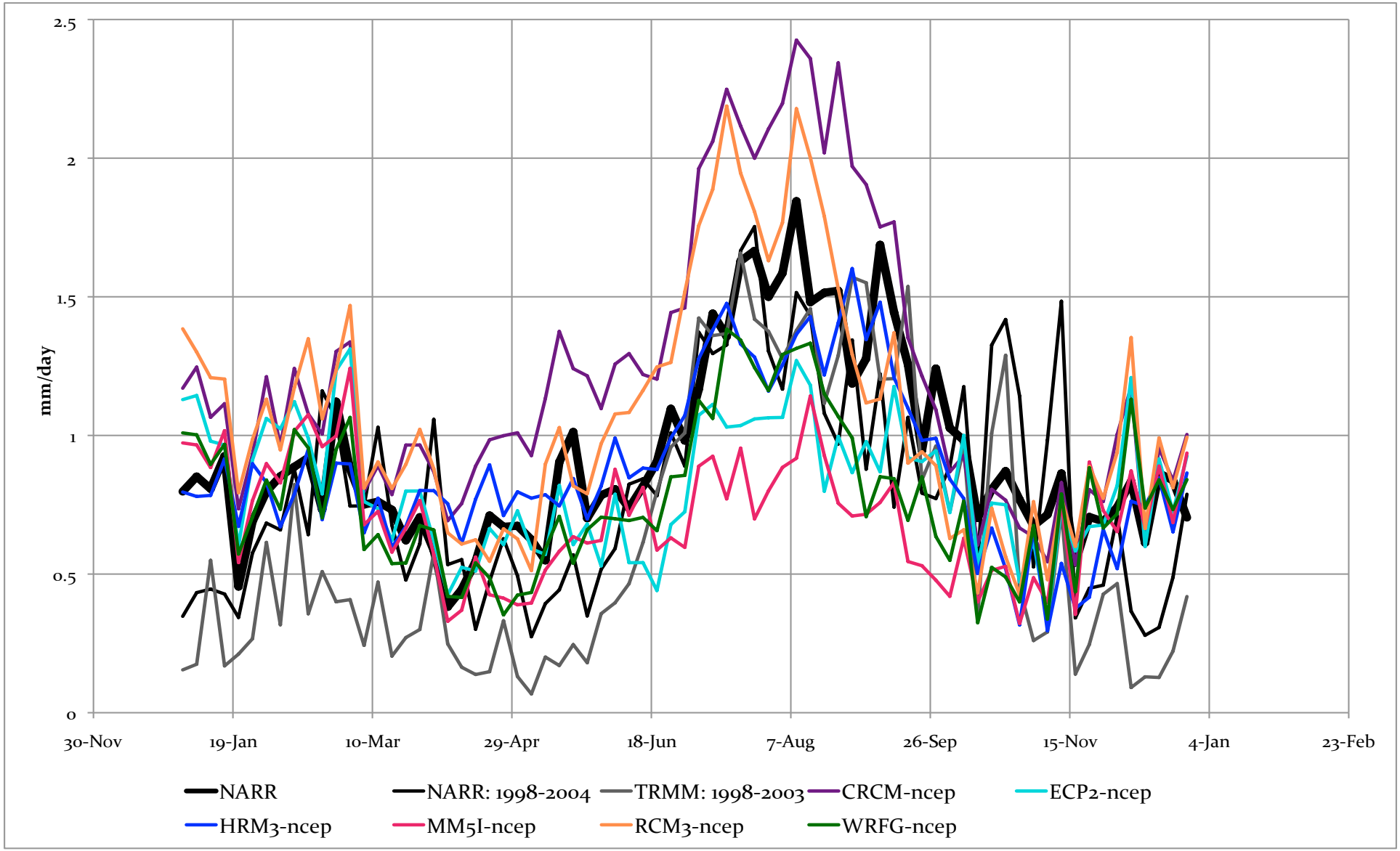


1971-1999 JJAS Average Precipitation

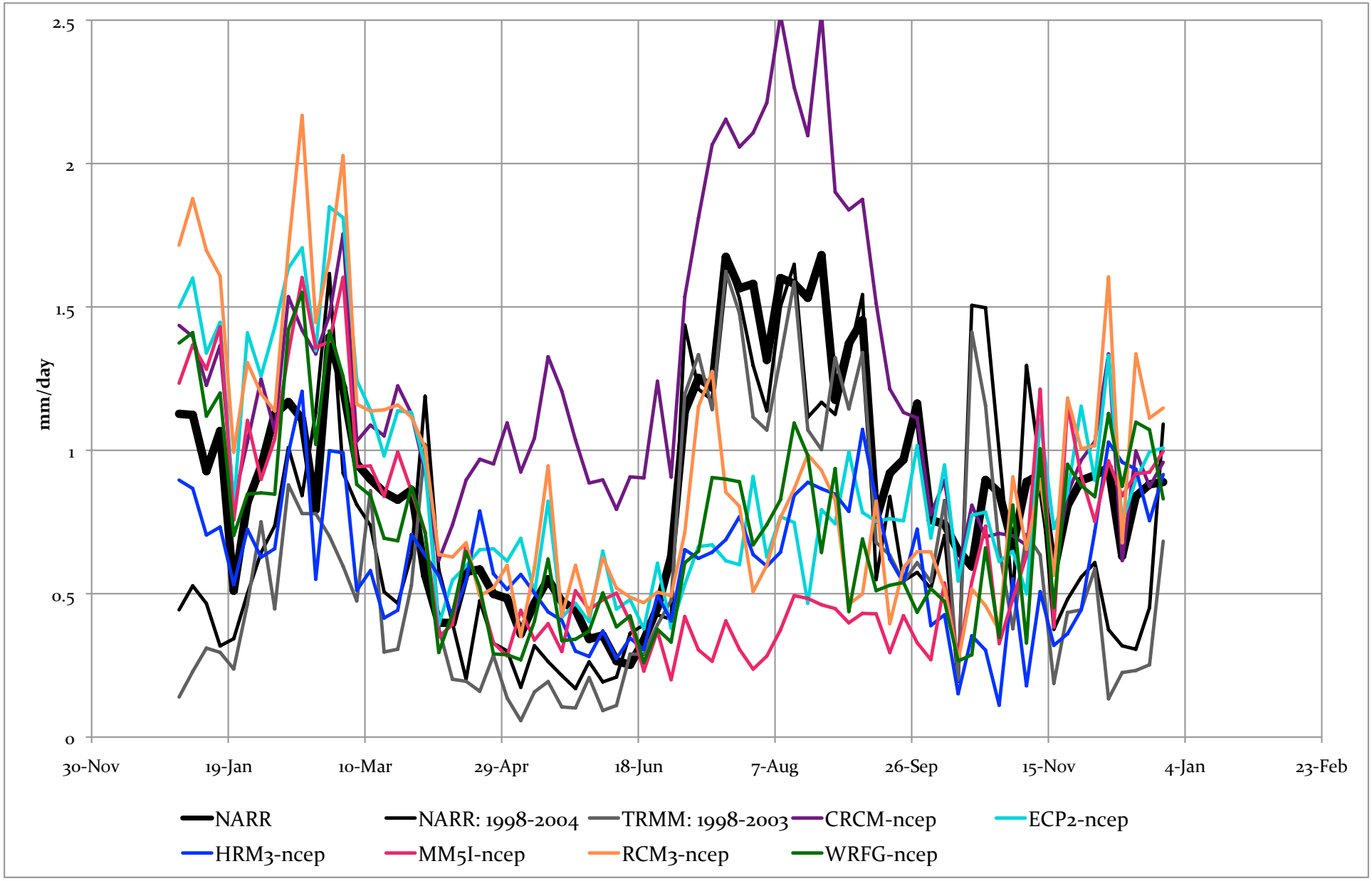
1980-2004 JJAS Average Precipitation Rate: NCEP-driven



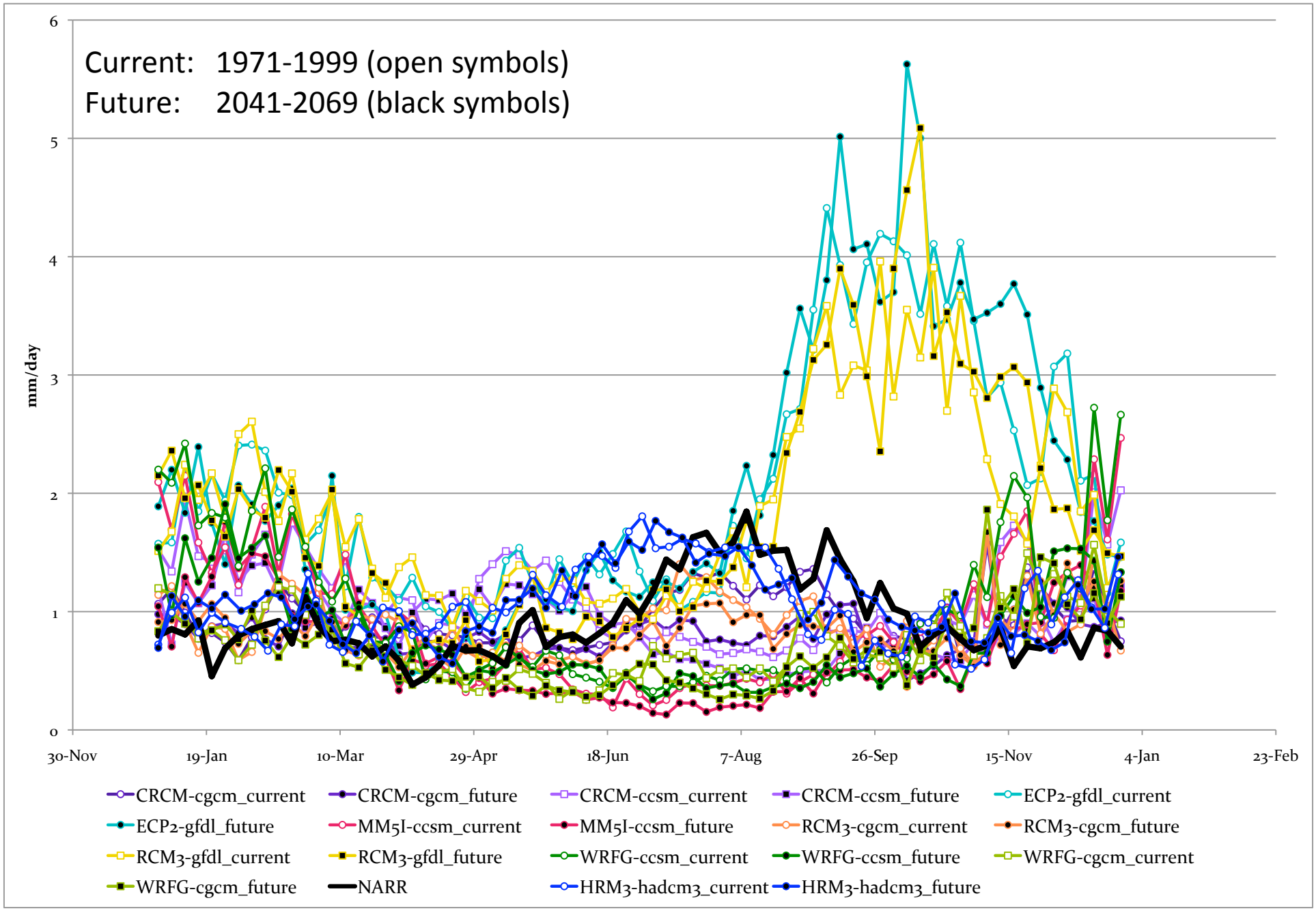
1980-2004 5-day Average Precipitation Climatology
NCEP-Driven Simulations

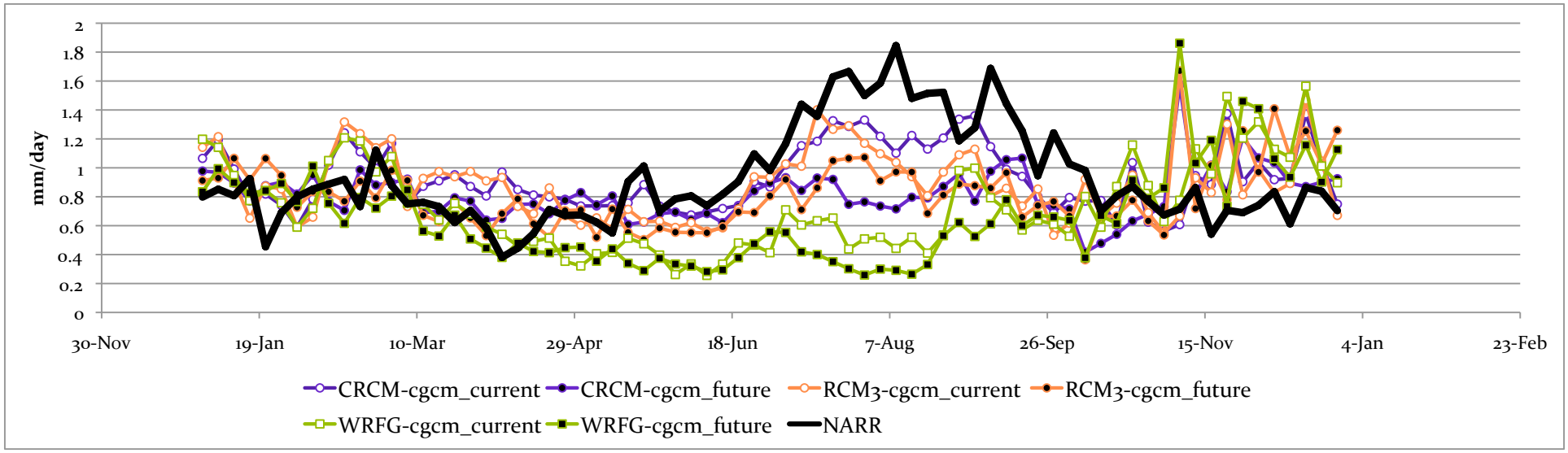


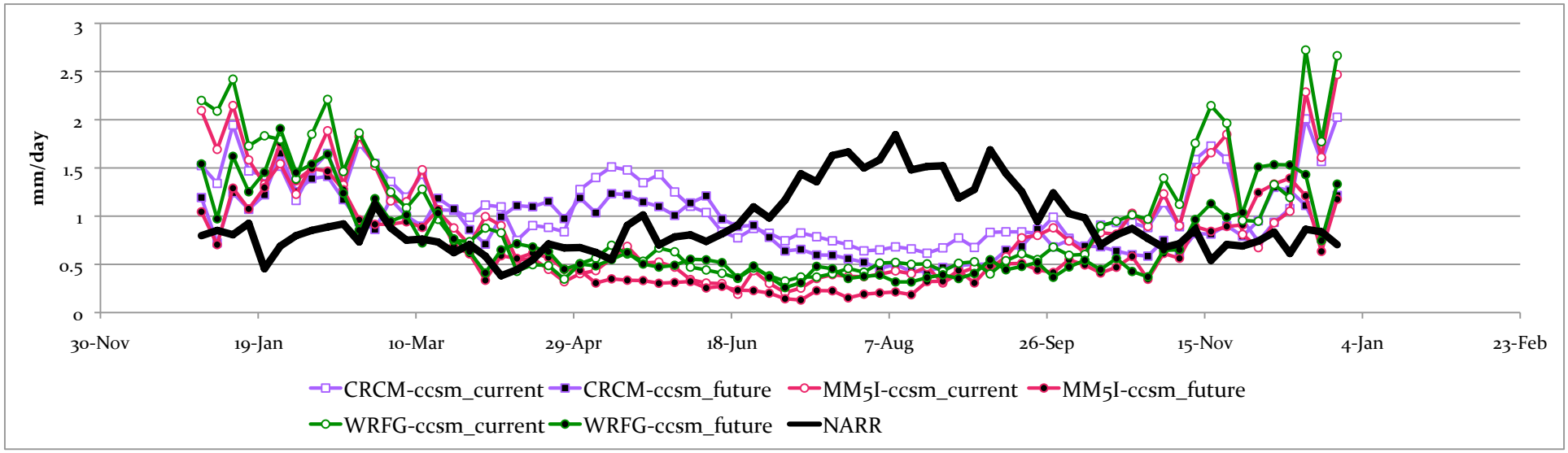
1980-2004 5-day Average Precipitation Climatologies: AZ Only



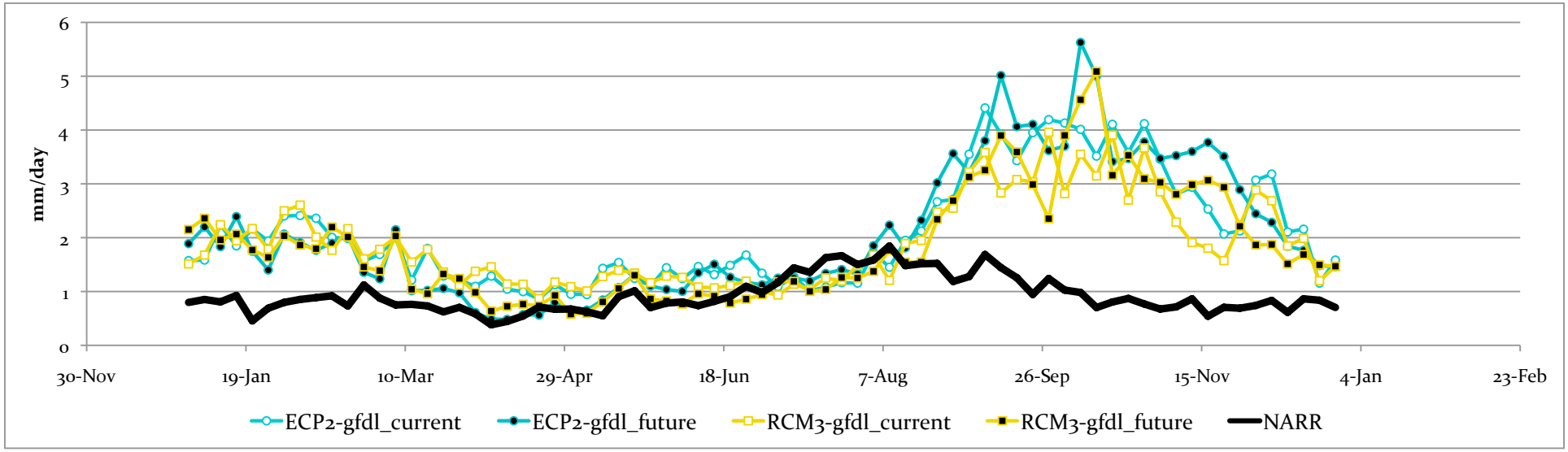
GCM-driven 5-day Average Precipitation Climatology

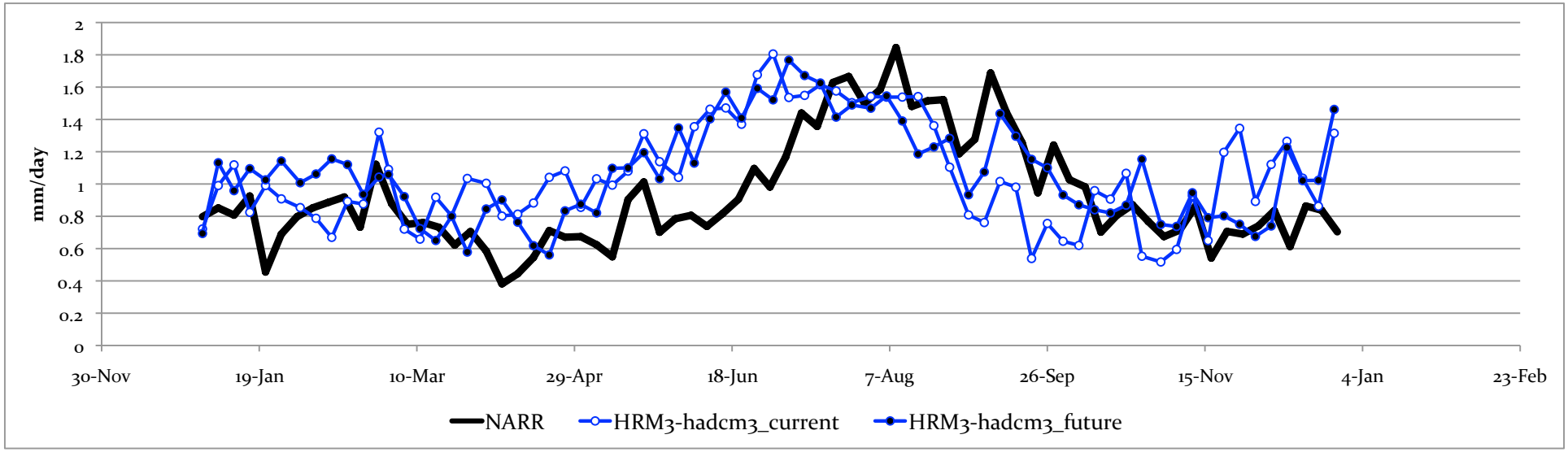






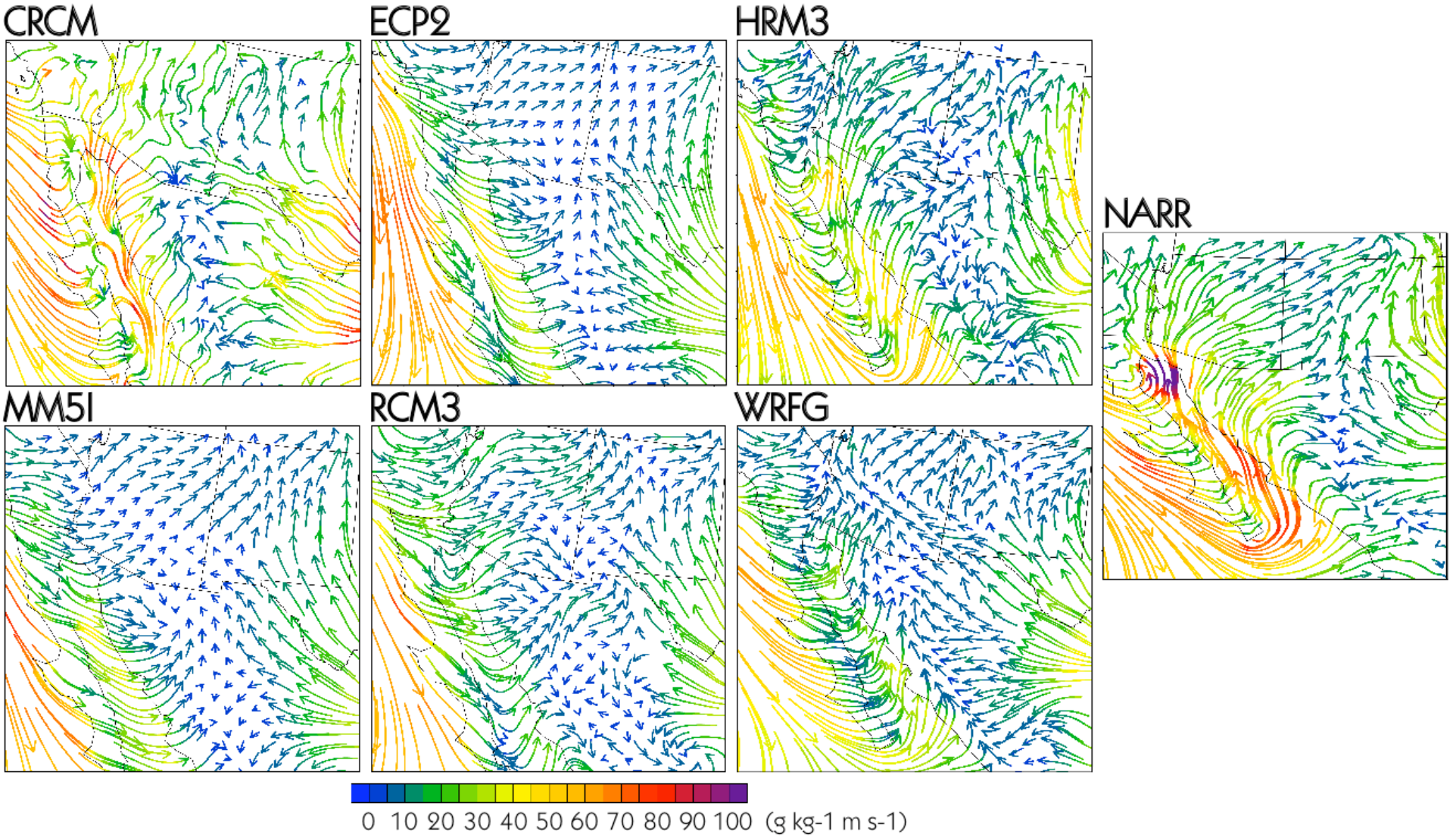
5-day Average Precipitation Climatology

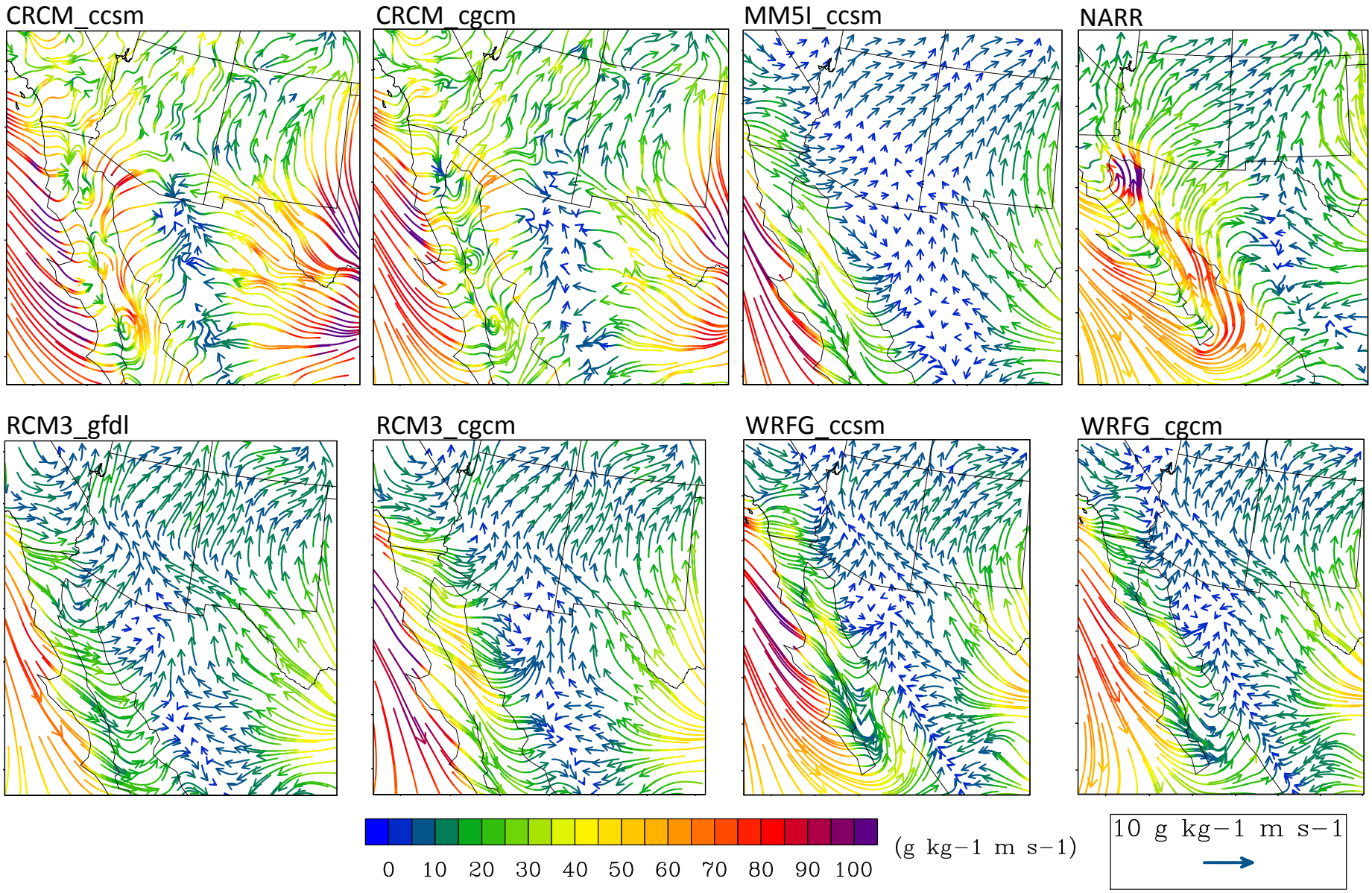




5-day Average Precipitation Climatology

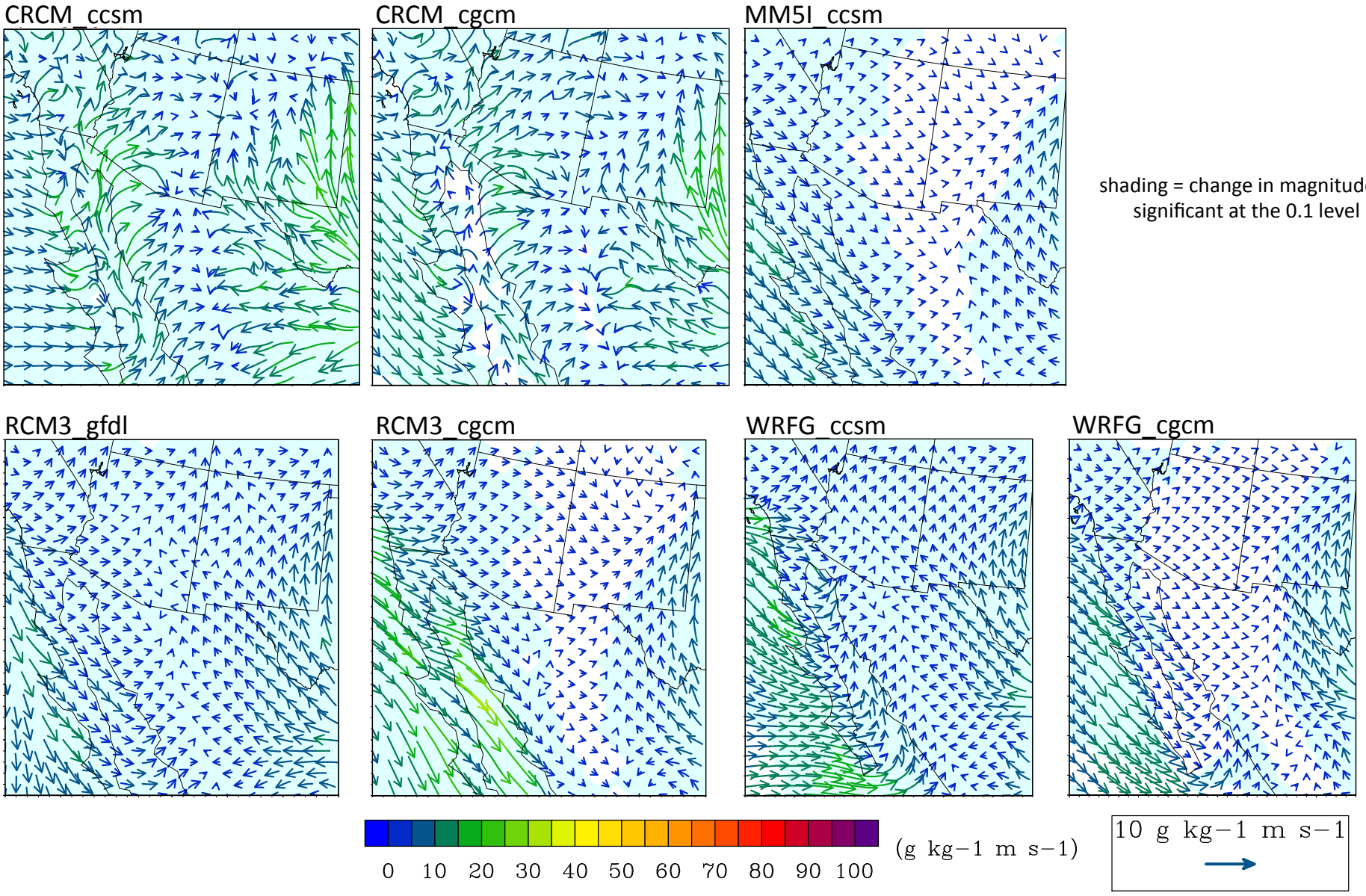
1980-2004 JJAS Average Near-Surface Moisture Flux: NCEP-driven Simulations





1971-1999 JJAS Near-Surface Moisture Flux: GCM-driven

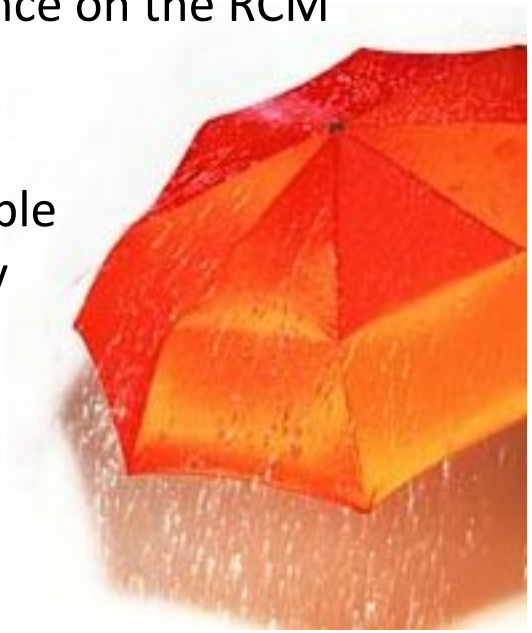
(NARR 1980-2004)

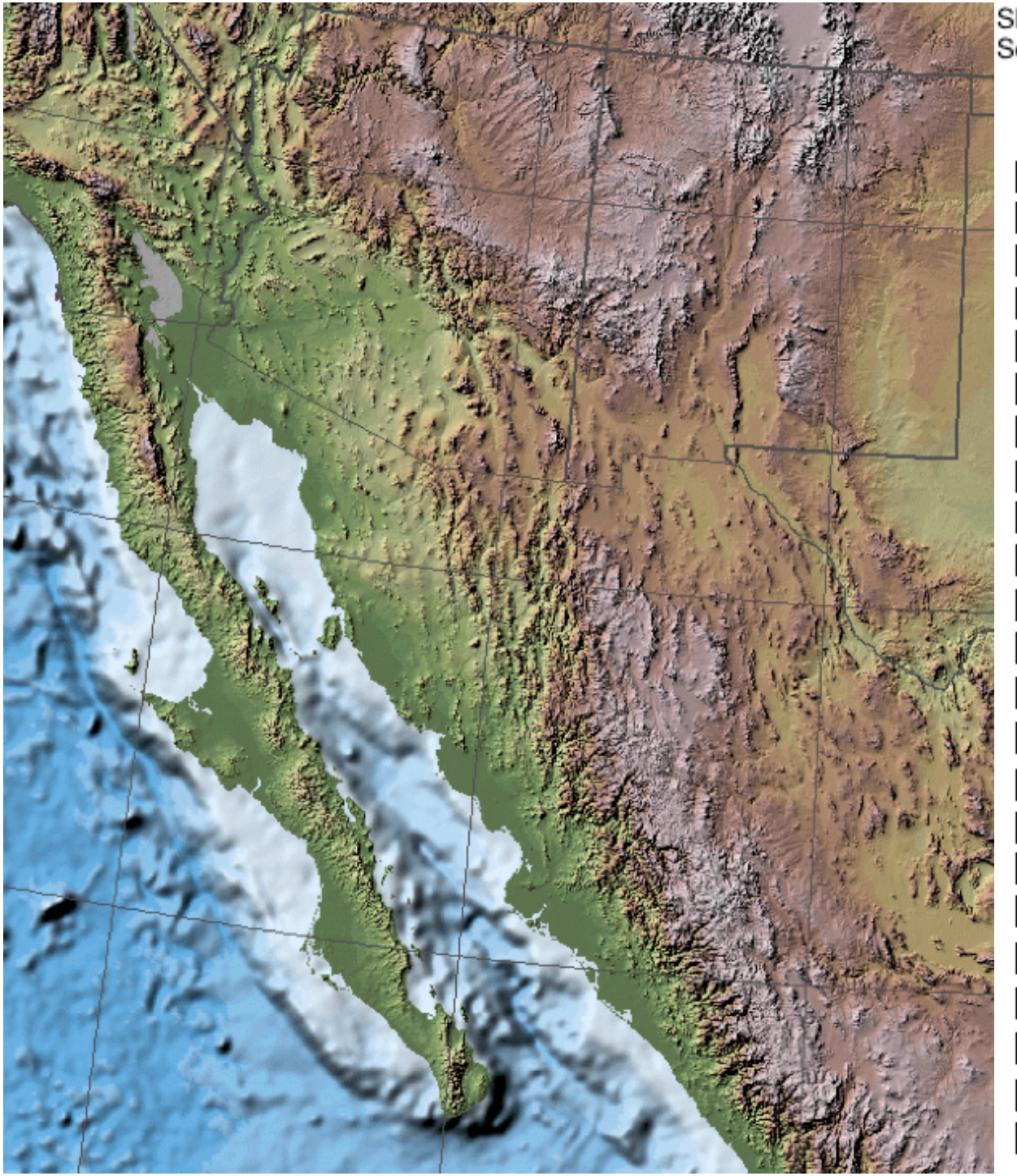


2041-2069 : 1971-1999 JJAS
Near-Surface Moisture Flux Difference

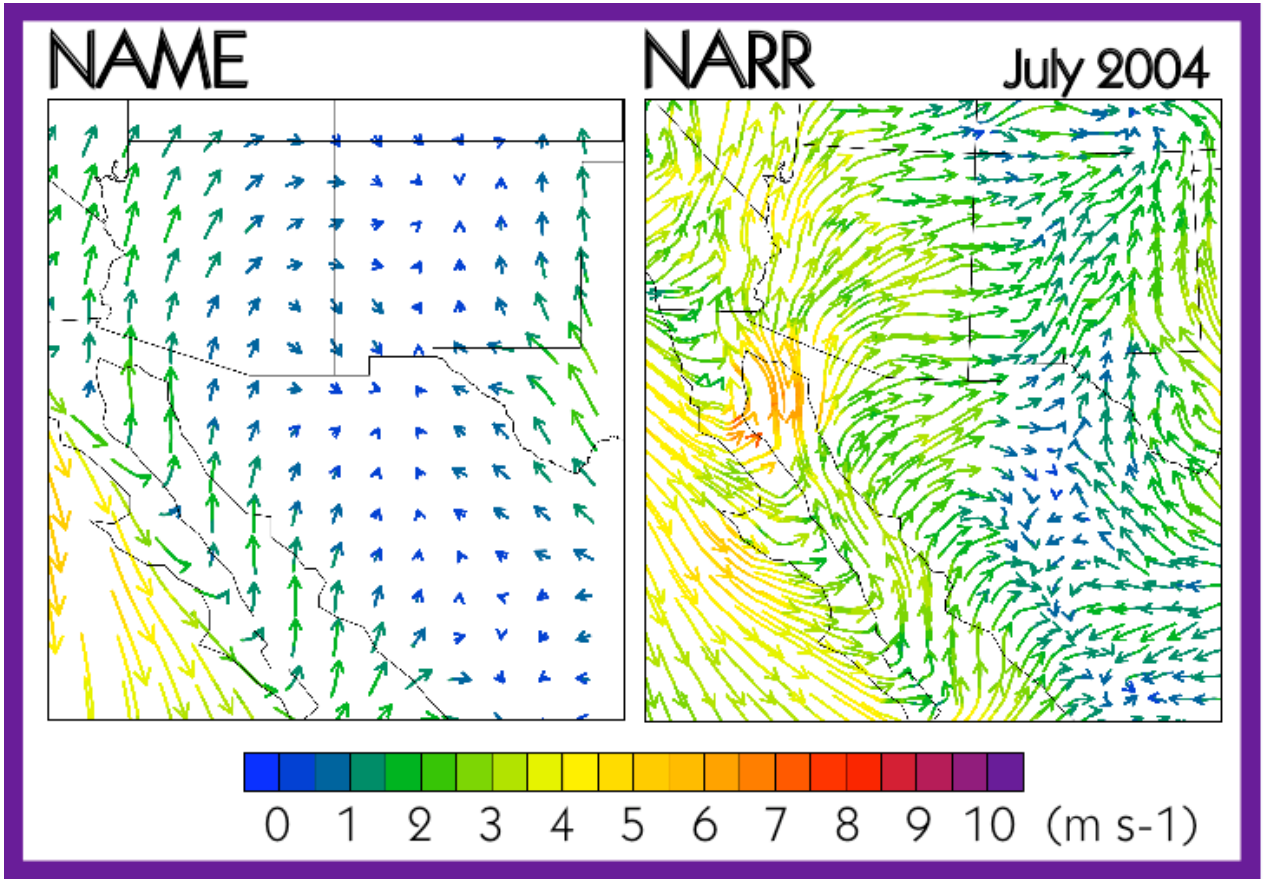
Final Comments

- The ability of the models to capture monsoon system rainfall is heavily determined by driving GCM.
- Bias in near surface moisture flux/wind fields is heavily determined by the RCM.
- Future work will include examining the driving GCMs to determine, more specifically, how they are influencing the RCMs in terms of their ability to simulate a monsoon system and in terms of their influence on the RCM projections. RCM analysis will follow suit.
- Clearly, for this region, this will be an interesting ensemble of models to work with for this process-based credibility analysis. The projections may be similar, but the differences in the RCMs and GCMs are striking.



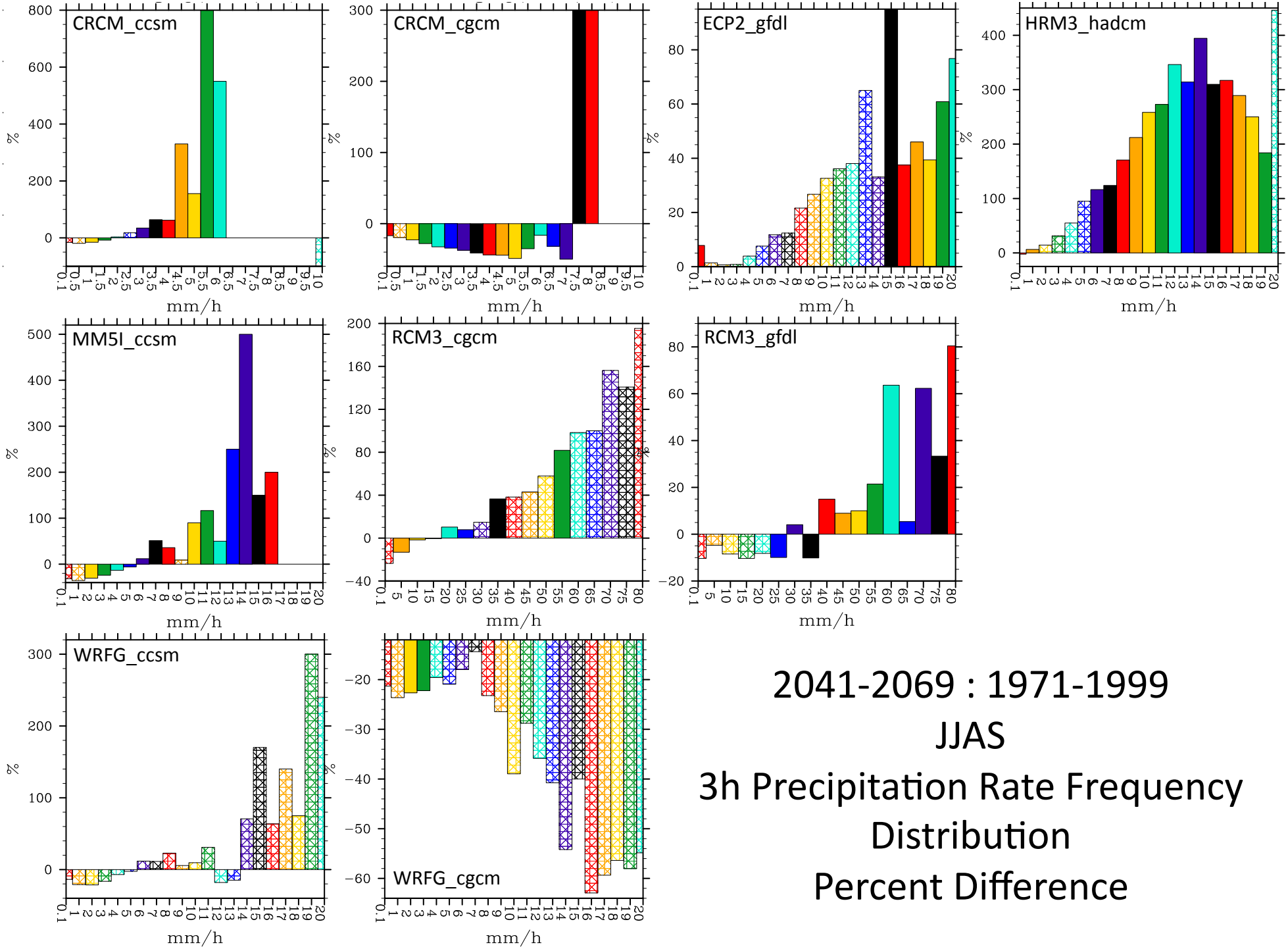

Shaded Relief - Land and Ocean
Source: U.S. Geological Survey
Shaded Relief - Land and Ocean
Elevation in Feet
10000 - 20320
9500 - 9999
9000 - 9499 2743.2-2895.3 m
8500 - 8999
8000 - 8499
7500 - 7999
7000 - 7499 2133.6-2285.7 m
6500 - 6999
6000 - 6499
5500 - 5999
5000 - 5499 1524-1676.1 m
4500 - 4999
4000 - 4499
3500 - 3999
3000 - 3499 914.4-1066.9 m
2500 - 2999
2000 - 2499
1500 - 1999
1000 - 1499 304.8-456.9 m
500 - 999
250 - 499
1 - 249
-282 - 0

NARR Wind Bias



The NARR has a strong wind bias over the Gulf of California into AZ relative to the 2004 July average gridded NAME observations (shown right and in above chart), particularly in the northern Gulf.

A version of NARR run for July of 2004 enhanced with more of the NAME observations contains a nearly identical error (not shown here; Ciesielski and Johnson, J. Climate, 2008), implying that this is a systematic problem in the NARR.

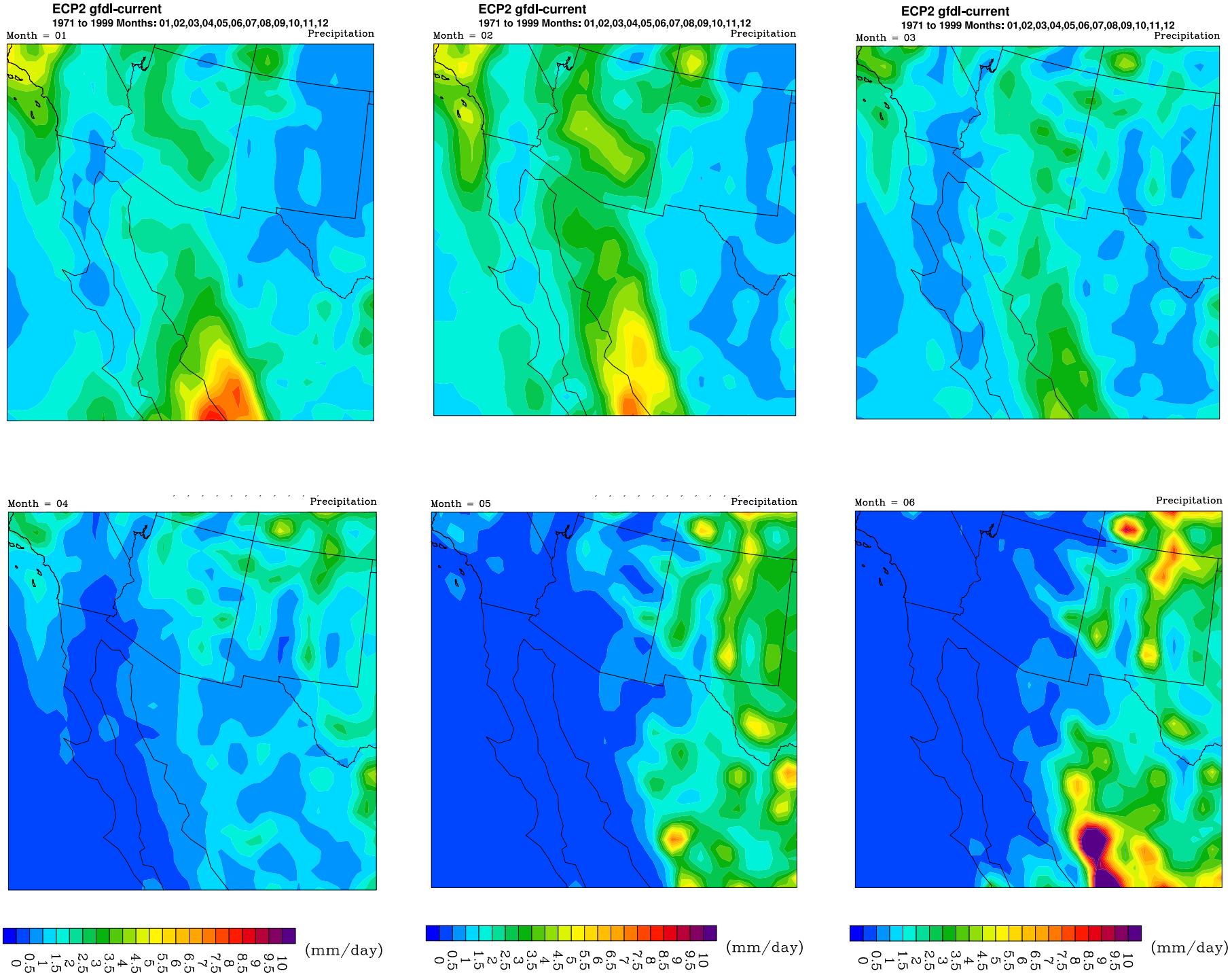


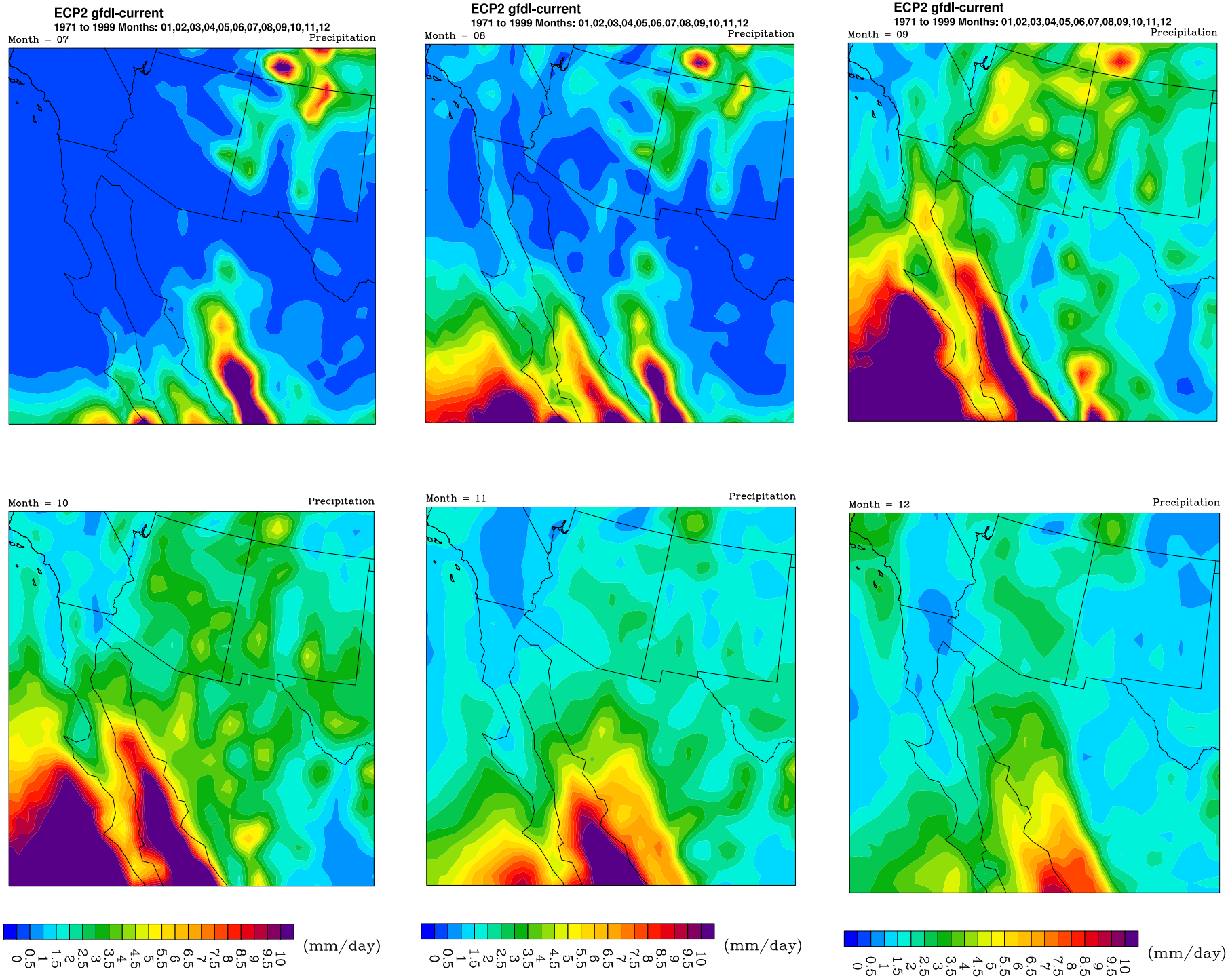
2041-2069 : 1971-1999

JJAS

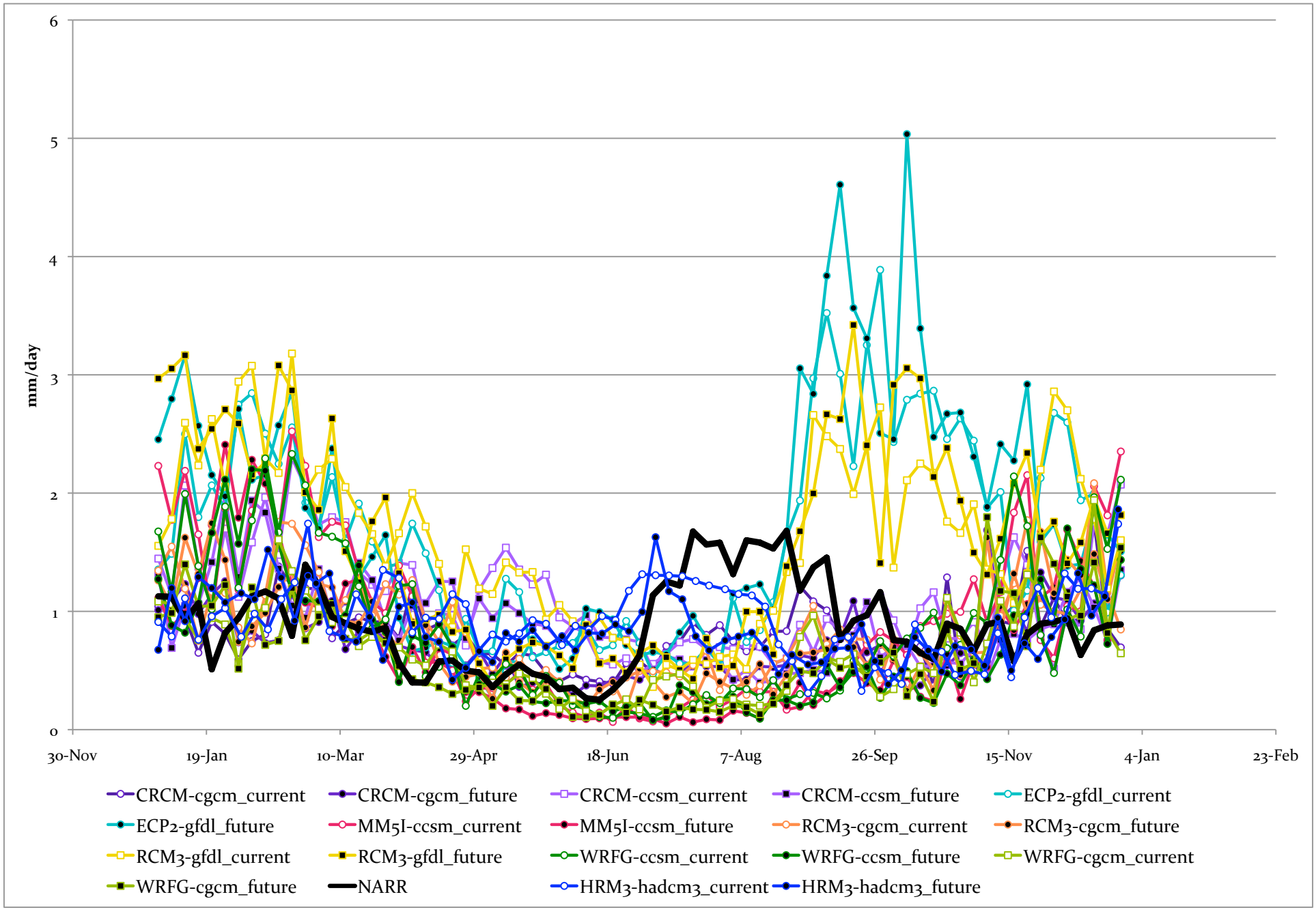
3h Precipitation Rate Frequency Distribution

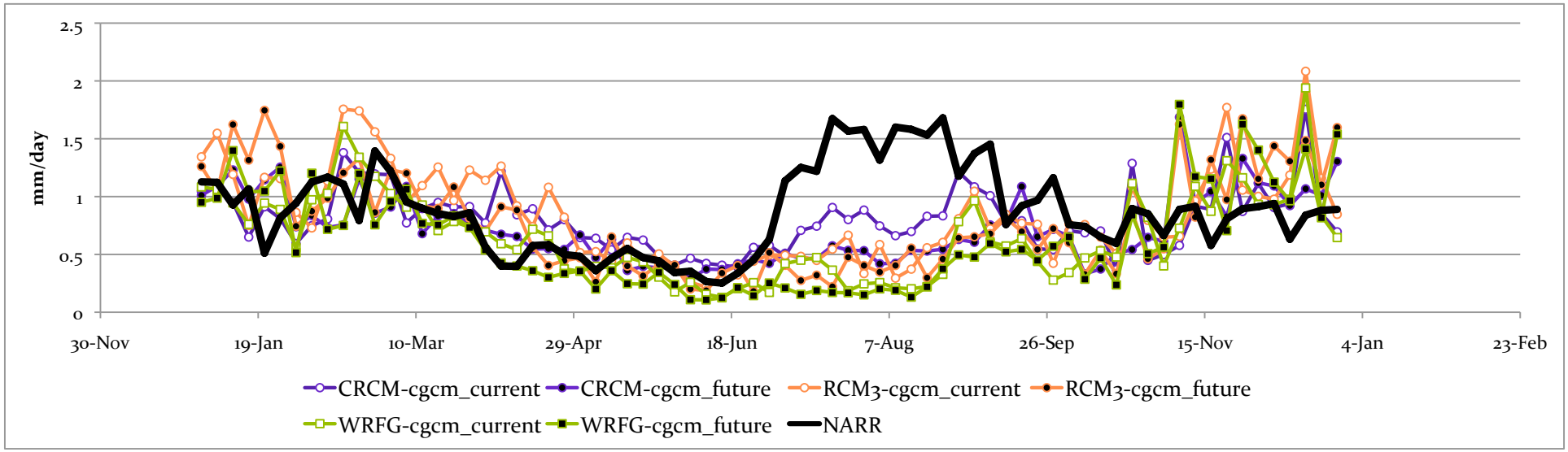
Percent Difference

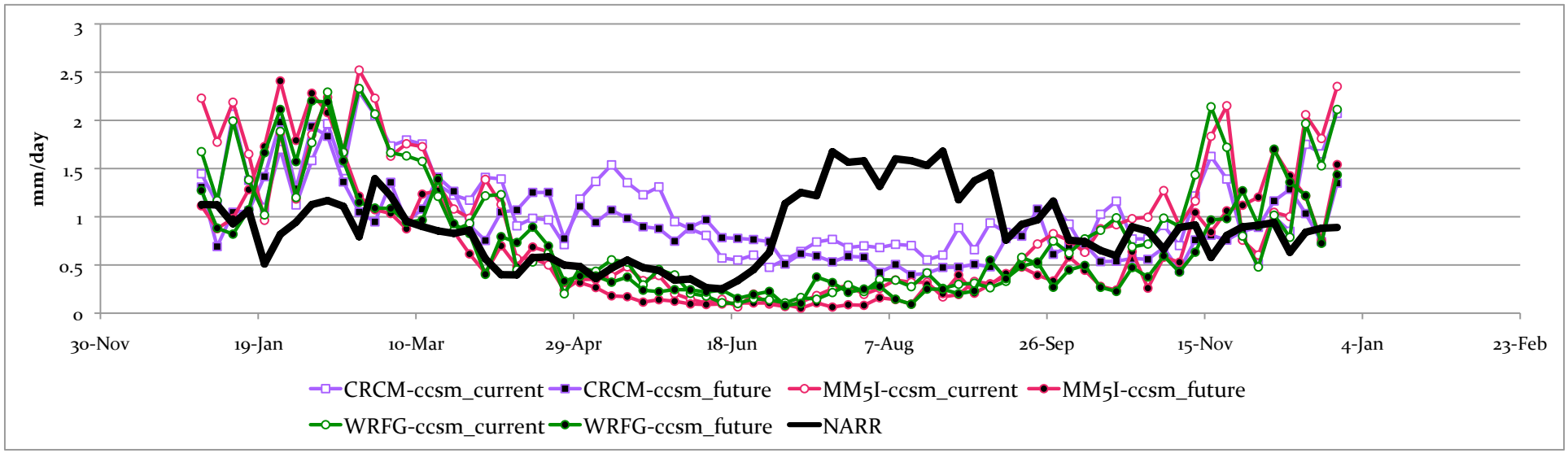

ECP2 gfdl-current
1971 to 1999 Months: 01,02,03,04,05,06,07,08,09,10,11,12
Month = 01
Precipitation
ECP2 gfdl-current
1971 to 1999 Months: 01,02,03,04,05,06,07,08,09,10,11,12
Month = 02
Precipitation
ECP2 gfdl-current
1971 to 1999 Months: 01,02,03,04,05,06,07,08,09,10,11,12
Month = 03
Precipitation
Month = 04
Precipitation
Month = 05
Precipitation
Month = 06
Precipitation
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)
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)
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)


ECP2 gfdl-current
1971 to 1999 Months: 01,02,03,04,05,06,07,08,09,10,11,12
Month = 07
Precipitation
ECP2 gfdl-current
1971 to 1999 Months: 01,02,03,04,05,06,07,08,09,10,11,12
Month = 08
Precipitation
ECP2 gfdl-current
1971 to 1999 Months: 01,02,03,04,05,06,07,08,09,10,11,12
Month = 09
Precipitation
Month = 10
Precipitation
Month = 11
Precipitation
Month = 12
Precipitation
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)

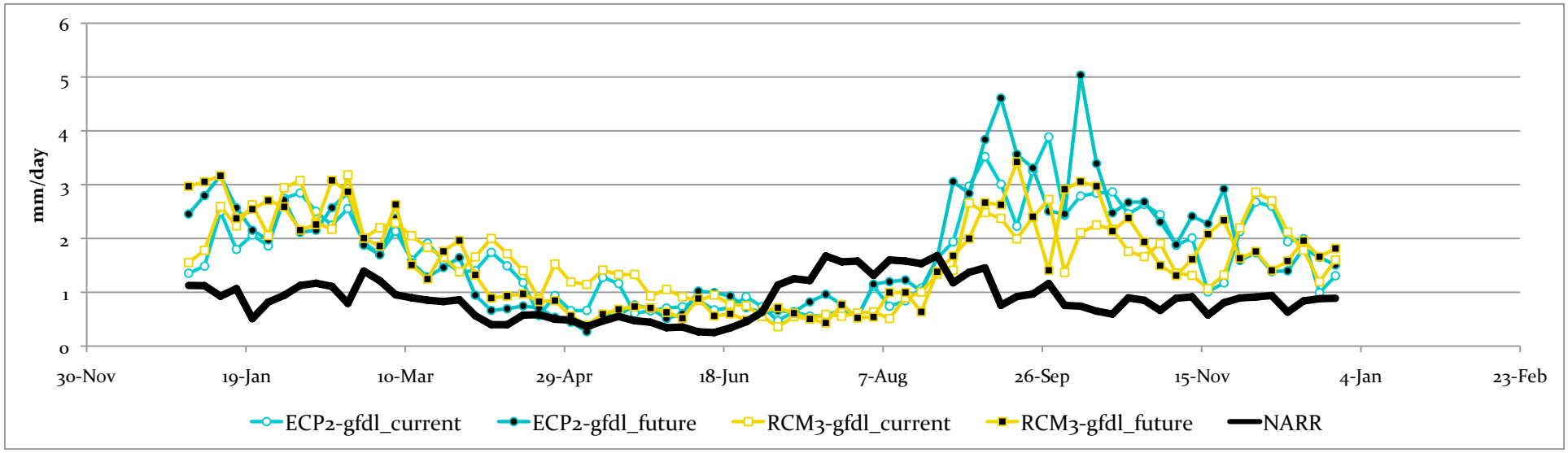
GCM-driven 5-day Average Precipitation Climatology: AZ Only

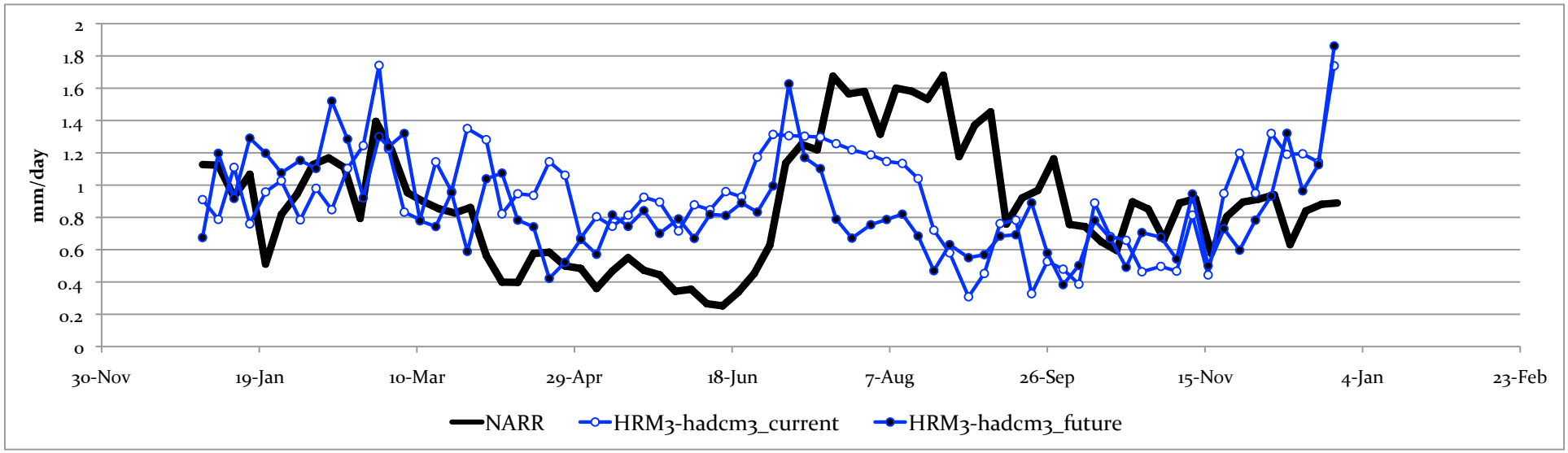






5-day Average Precipitation Climatology: AZ Only





5-day Average Precipitation Climatology: AZ Only