# Lower Santa Cruz River Basin Future Climate Assessment
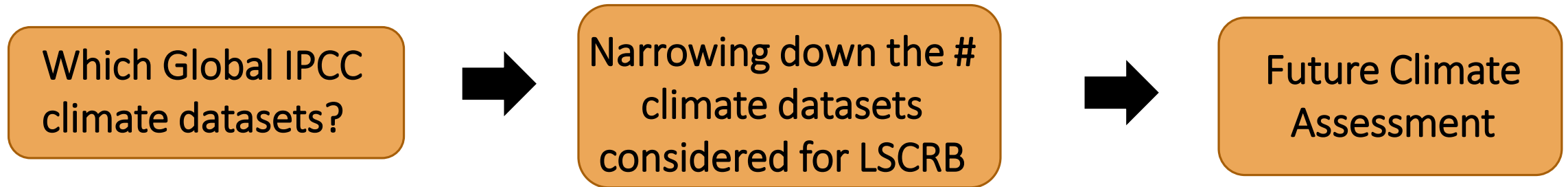
HSIN-I CHANG

UNIVERSITY OF ARIZONA, HYDROLOGY AND ATMOSPHERIC SCIENCES

hchang05@email.arizona.edu

# Climate Model Selection Overview

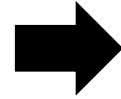| Which Global IPCC climate datasets? | → | Narrowing down the # climate datasets considered for LSCRB | → | Future Climate Assessment |
|---|---|---|---|---|

Lower Santa Cruz River Basin Study
- Climate Change Scenarios:
  - **Worse Case / High Risk (UA)**
  - **Best Case/Low Risk (Reclamation)**
- Climate Downscaling Methodology:
  - Physics-based (UA)
  - Statistics-based (Reclamation)
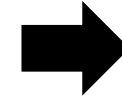
# Climate Data Evaluation Process:

**Which Global IPCC climate datasets?**

➜

**Narrowing down the # climate datasets considered for LSCRB**

➜

**Future Climate Assessment**

- 20+ climate models
- 2 climate scenarios (RCP 4.5 (lower) and RCP 8.5 (higher) emission scenarios)

- **Historic: IPCC climate performance in LSCRB**
- Statistical downscaling (SD), based on observation [best and worse case scenarios]
- Dynamical downscaling (DD), based on model physics [worse case scenario]

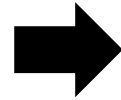- Best vs worse case scenario
- Climate analysis matrix
- 2030s: (2020-2049)
- 2060s: (2050-2079)

**IPCC stands for Intergovernmental Panel on Climate Change**
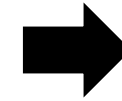
# Flow Chart Box One:
# Which global IPCC climate datasets?

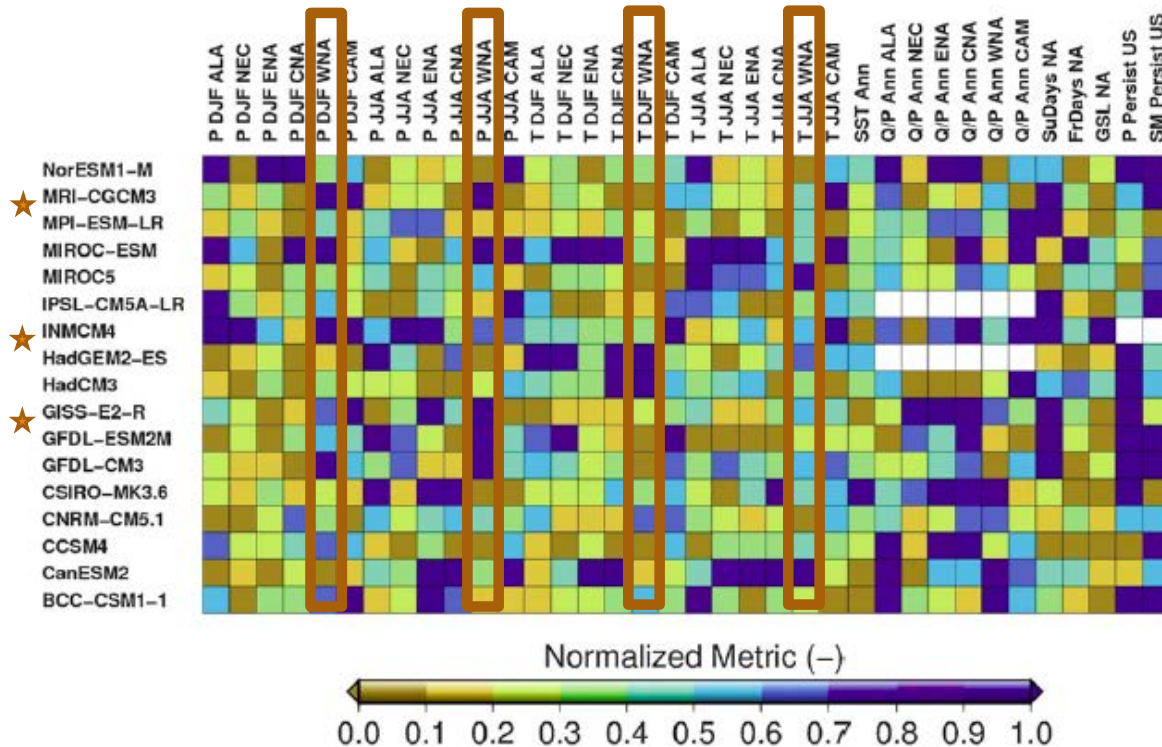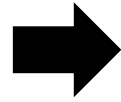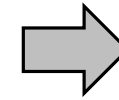| Which Global IPCC climate datasets? | → | Narrowing down the # climate datasets considered for LSCRB | → | Future Climate Assessment |
|---|---|---|---|---|



- Evaluation of the latest IPCC climate datasets at worse case scenario (IPCC CMIP5)
- Sub-regions in <u>North America</u>
- Temperature, precipitation, sea surface temperature, length of summer, length of growing degree days
- **Global climate data recommendation: MPI, HadGEM2, GFDL**

Sheffield et al. 2013

# Flow Chart Box Two:
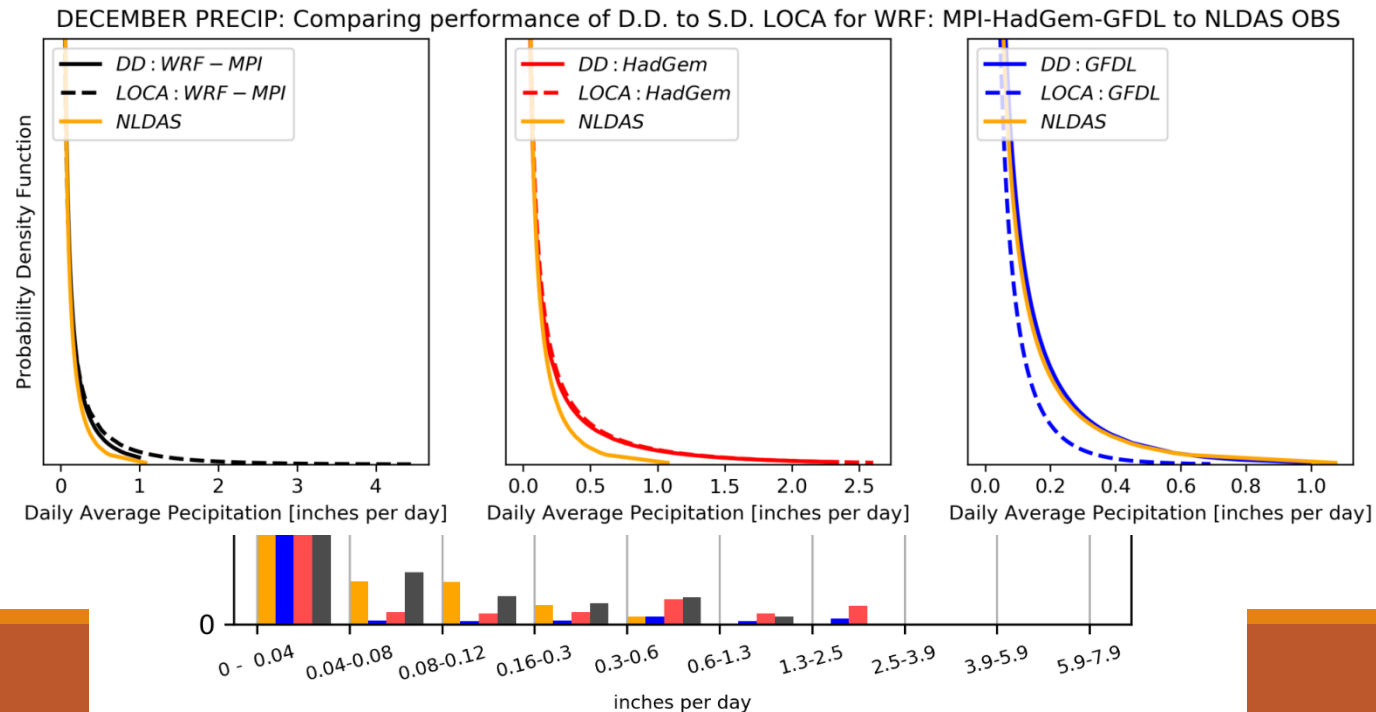# Narrowing Down the number of climate datasets
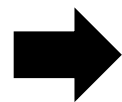
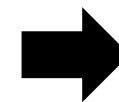Which Global IPCC climate datasets? → Narrowing down the # climate datasets considered for LSCRB ⇒ Future Climate Assessment
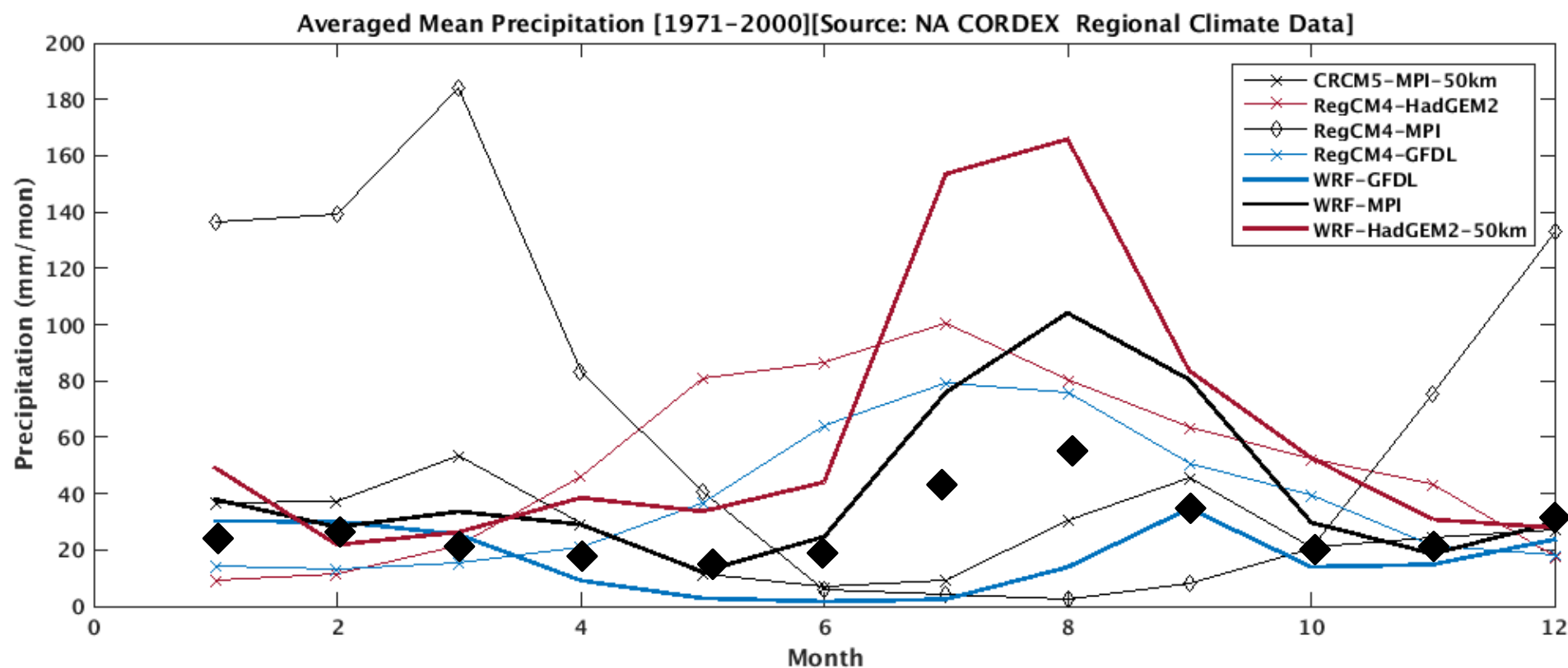
DECEMBER PRECIP: Comparing performance of D.D. to S.D. LOCA for WRF: MPI-HadGem-GFDL to NLDAS OBS



Probability Density Function

DD : WRF − MPI
LOCA : WRF − MPI
NLDAS

DD : HadGem
LOCA : HadGem
NLDAS

DD : GFDL
LOCA : GFDL
NLDAS

Daily Average Pecipitation [inches per day]

0    1    2    3    4

0.0   0.5   1.0   1.5   2.0   2.5

0.0   0.2   0.4   0.6   0.8   1.0

0 - 0.04   0.04-0.08   0.08-0.12   0.16-0.3   0.3-0.6   0.6-1.3   1.3-2.5   2.5-3.9   3.9-5.9   5.9-7.9

inches per day

# Historic Mean Precipitation Verification (1971-2000)



Averaged Mean Precipitation [1971-2000][Source: NA CORDEX Regional Climate Data]

# Historic Mean Precipitation Verification (2001-2040)



Averaged Mean Precipitation [2001-2040][Source: NA CORDEX Regional Climate Data]
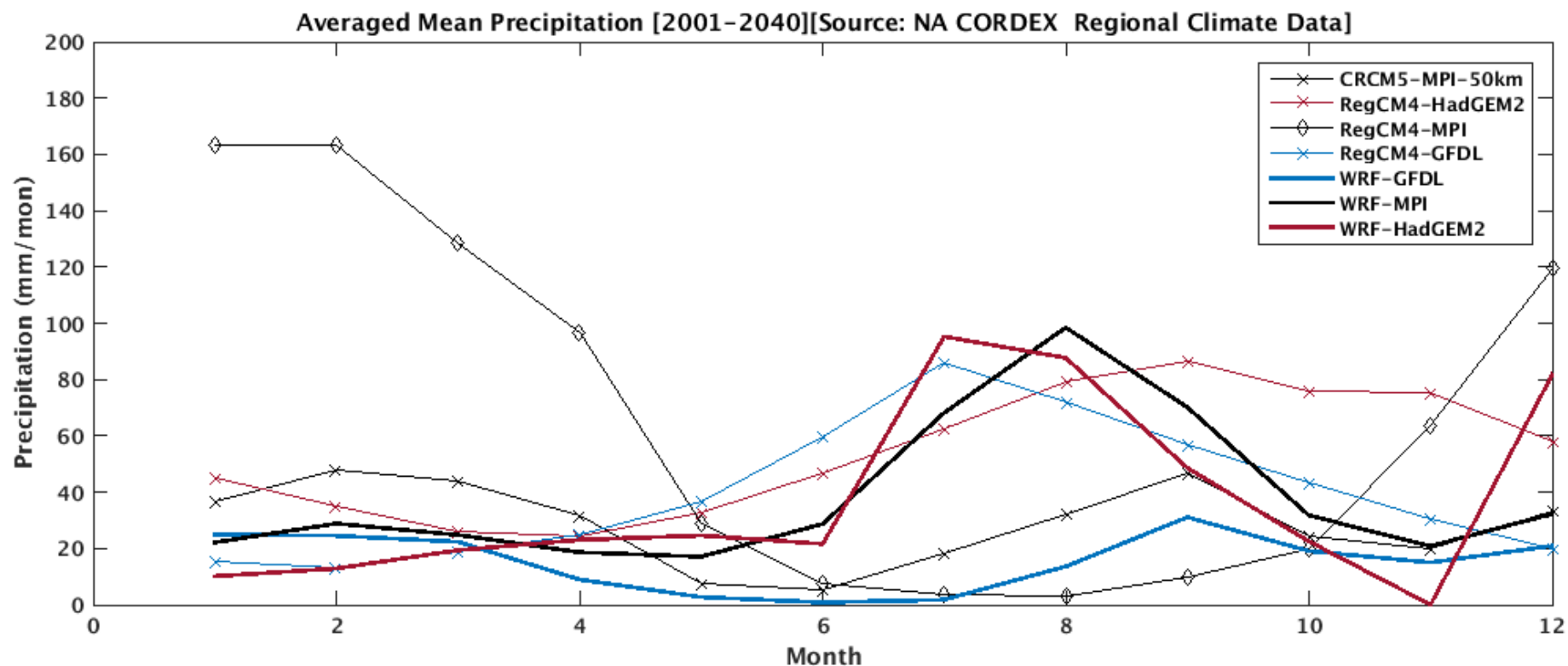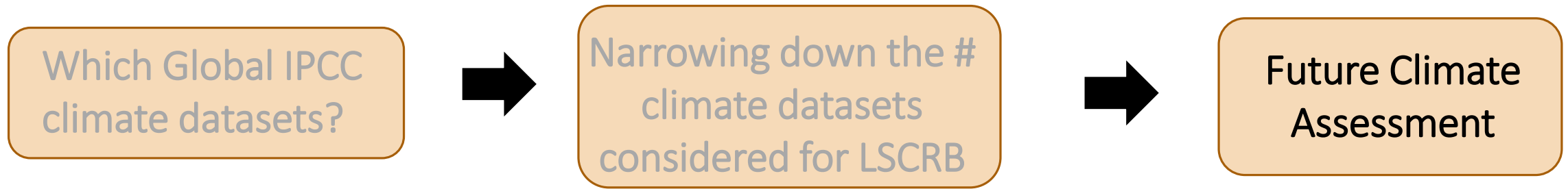
# Climate Analysis Metrics

1. Monsoon onset: what is the timing?
2. Extreme event: what is the intensity and frequency, temperature and precipitation of an extreme event?
3. Dry period: what is the length of time between the last day of winter storm to the first day of spring?

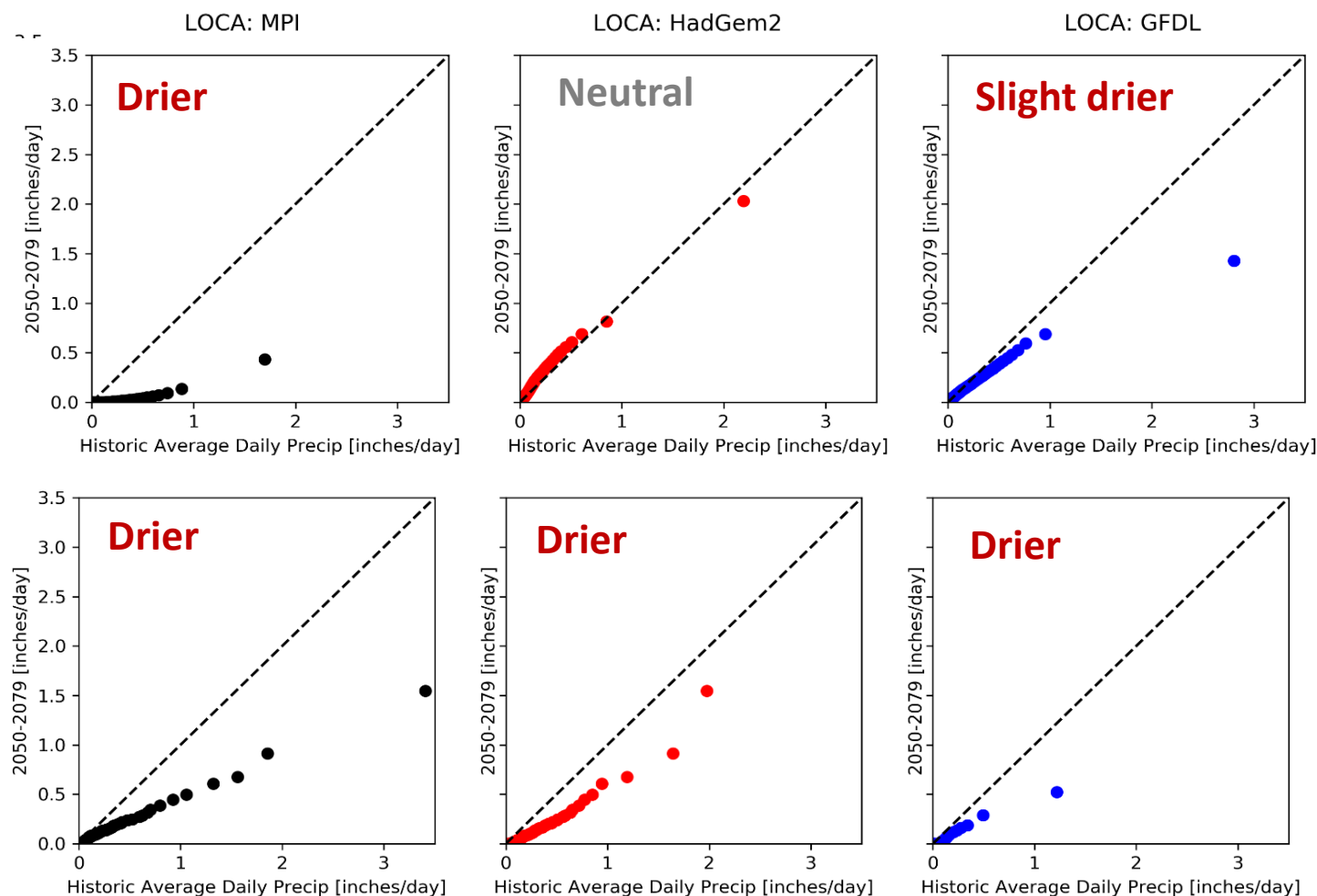# August <u>historic</u> daily precipitation distribution
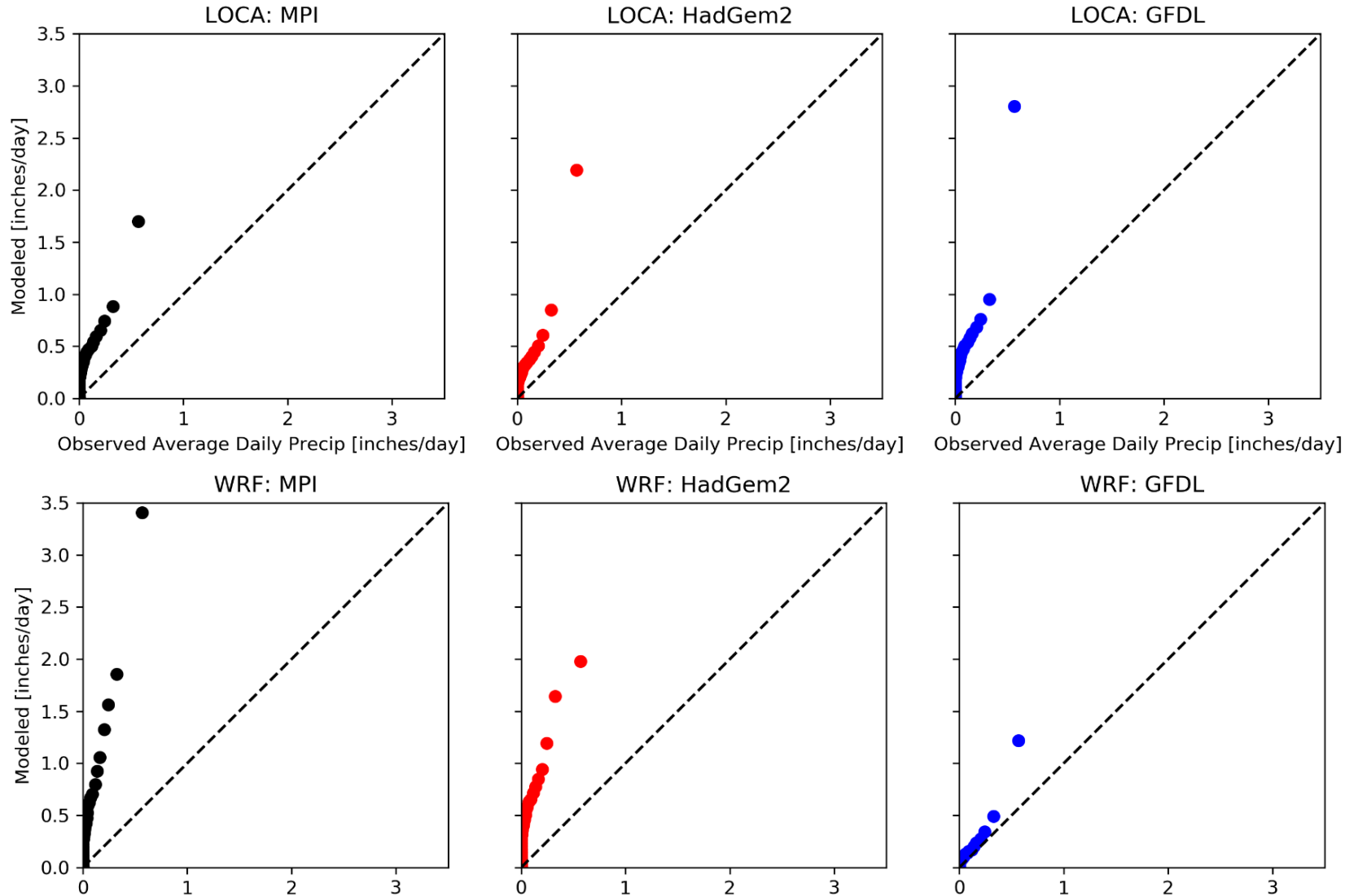


**All SD/DD historic August precipitation has large wet bias.**
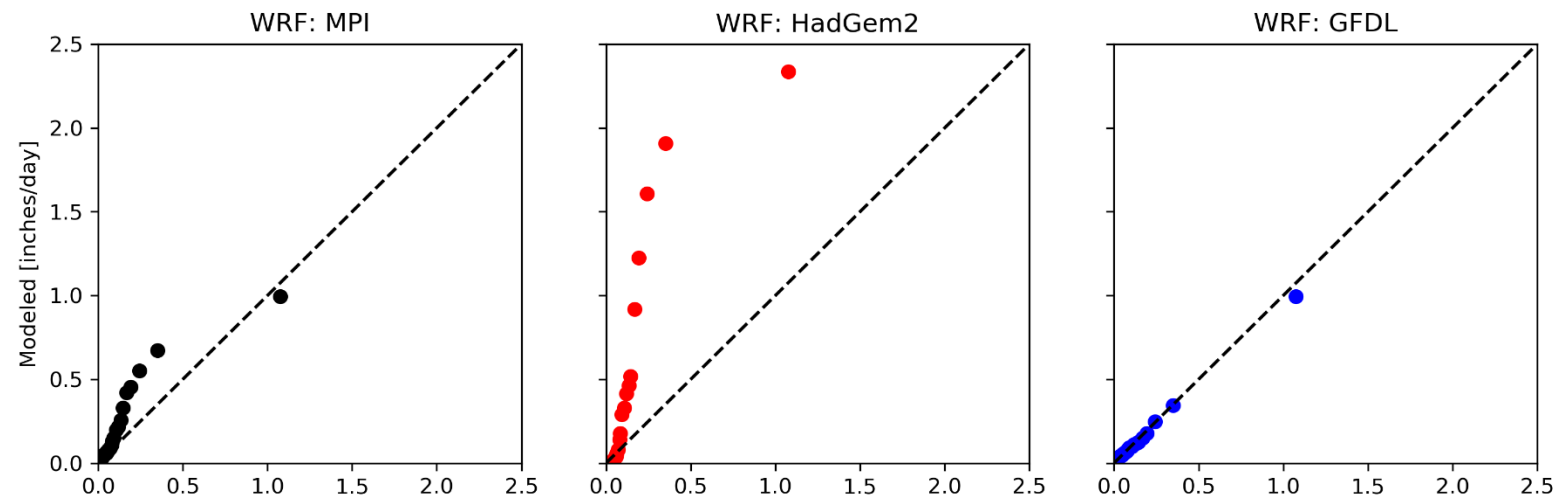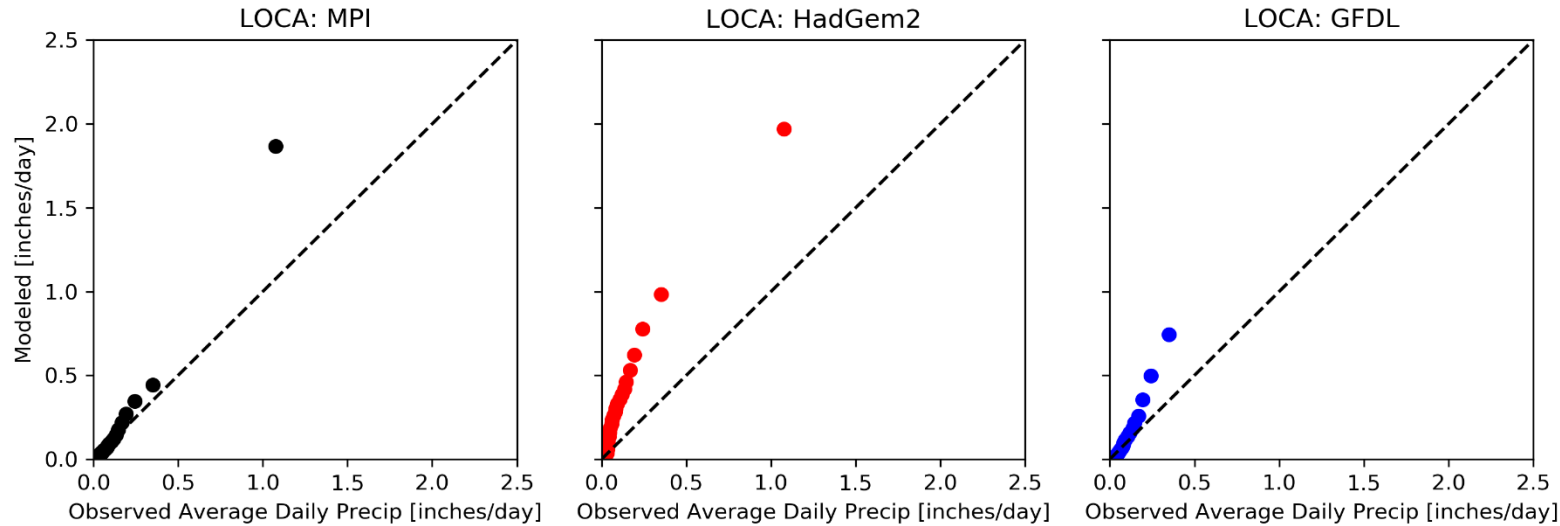
# August <u>future</u> daily precipitation distribution (2030s)
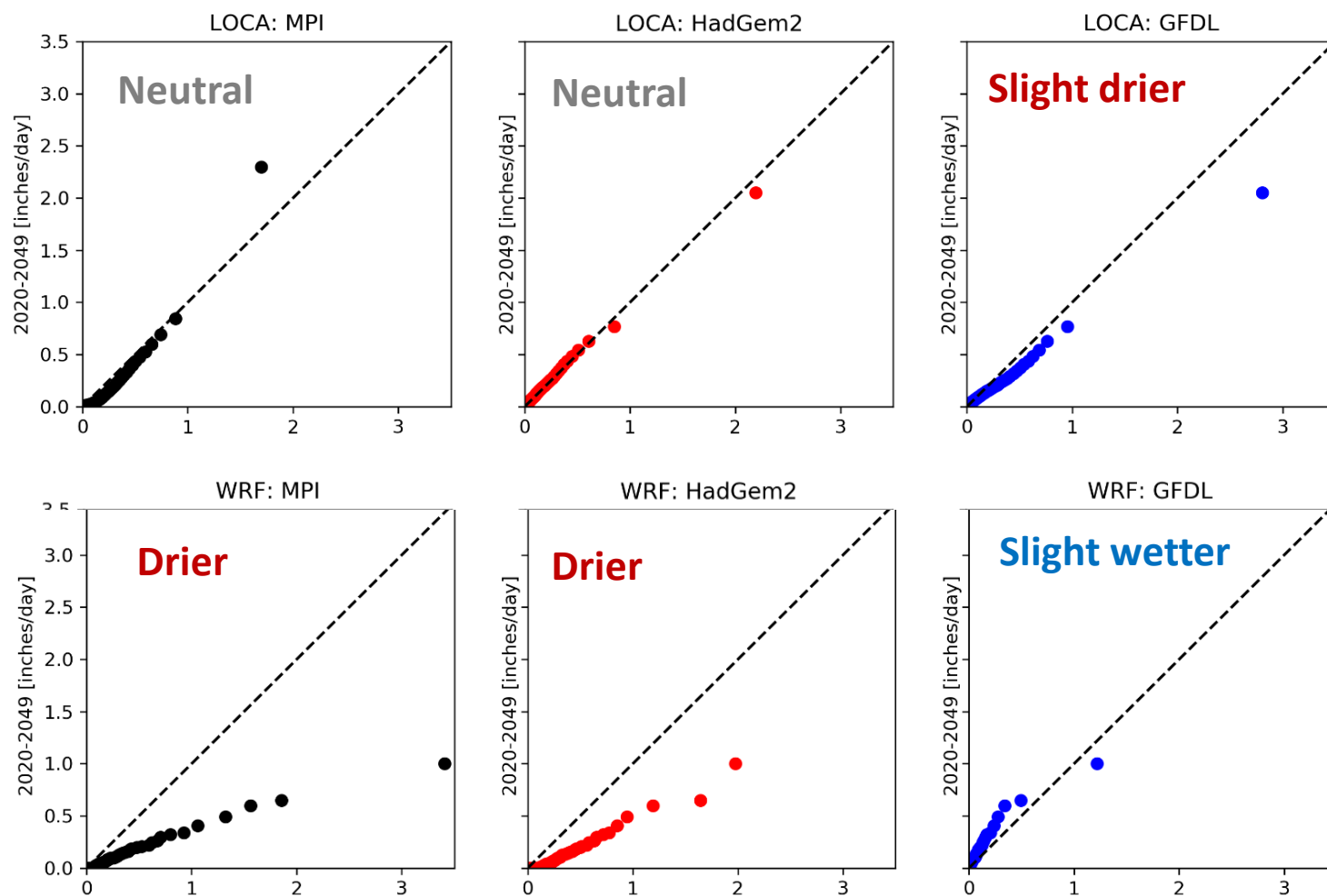
# August <u>future</u> daily precipitation distribution (2060s)
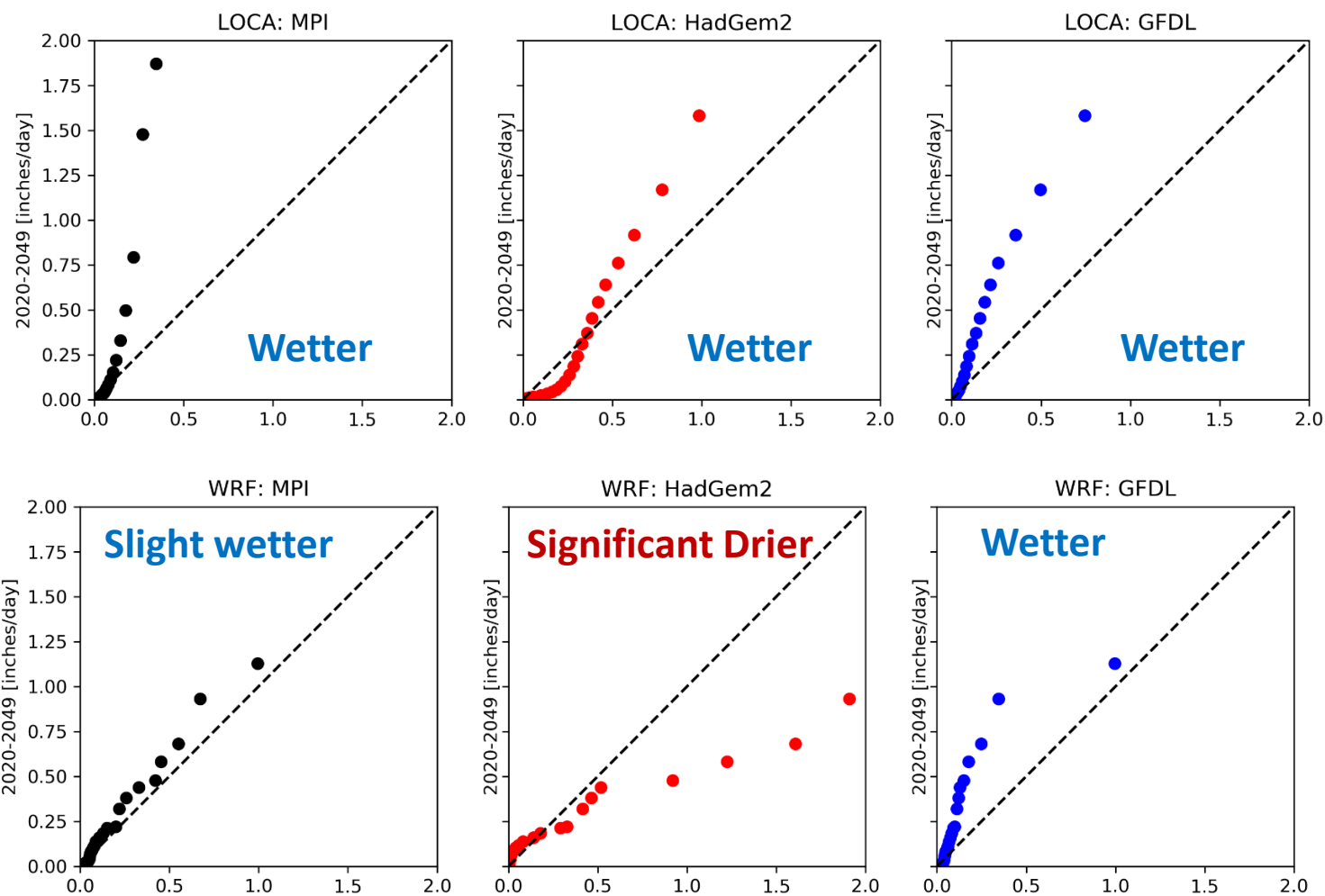
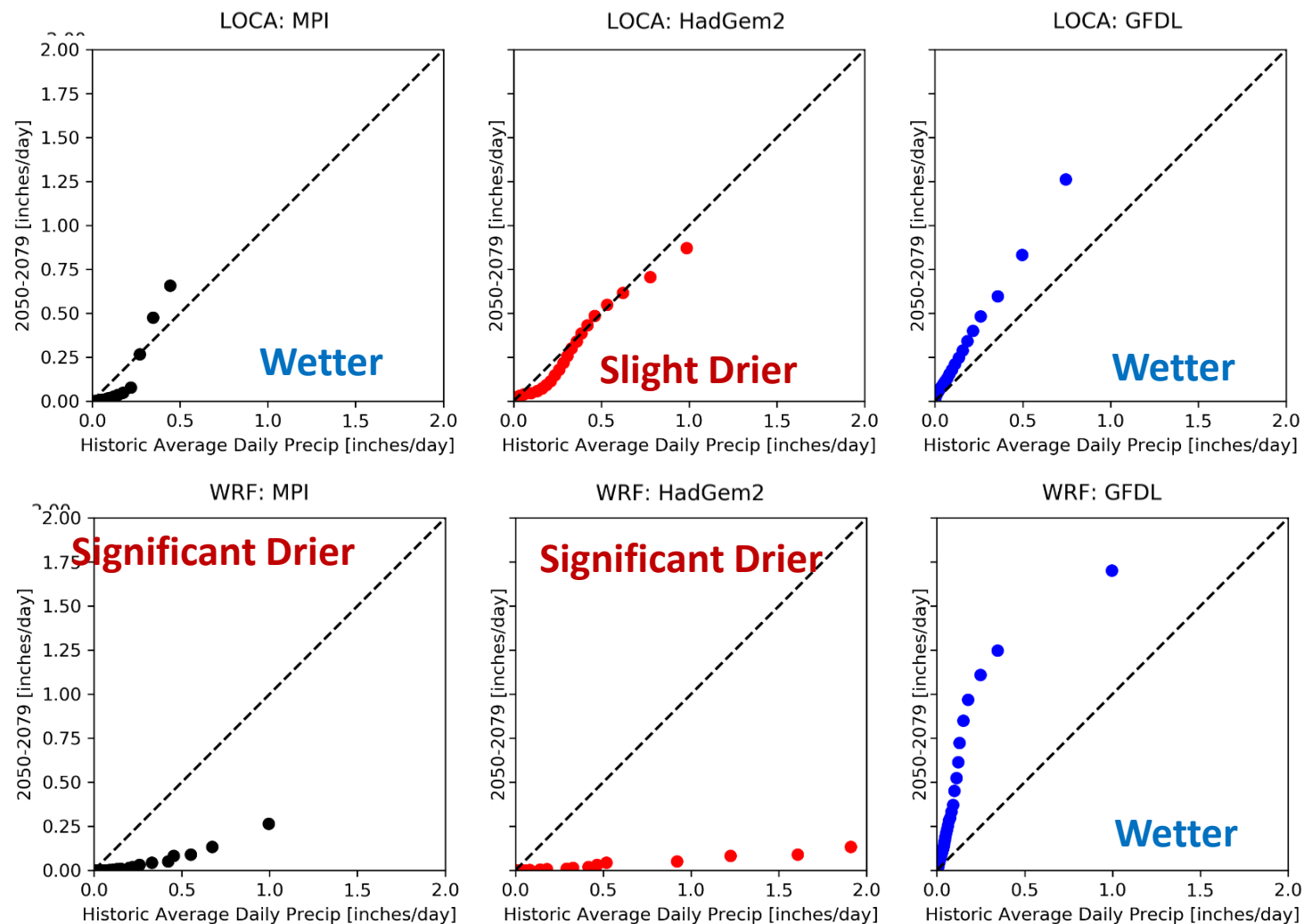# December <u>historic</u> daily precipitation distribution



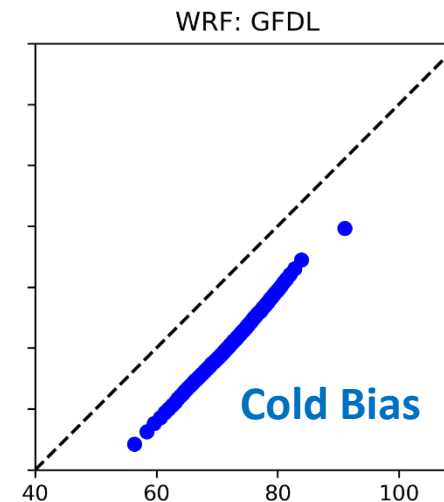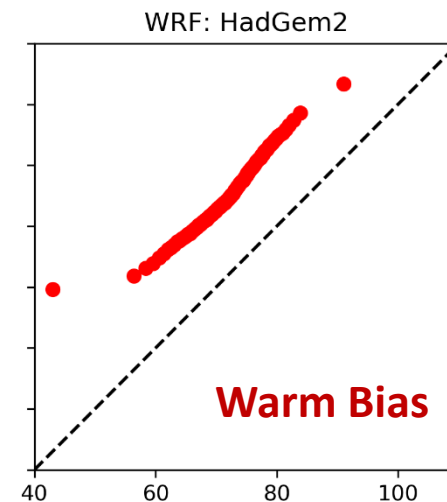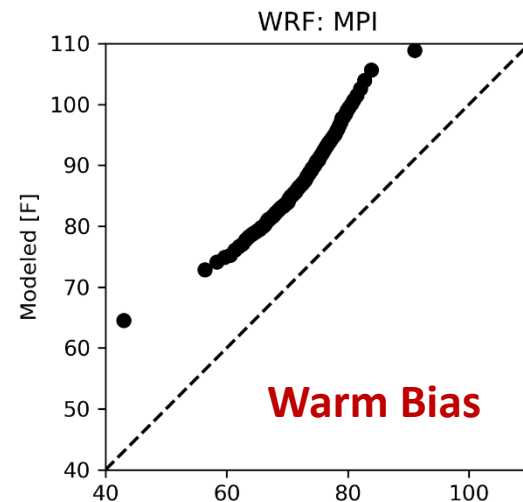**Most of the SD/DD historic December precipitation has large wet bias.**
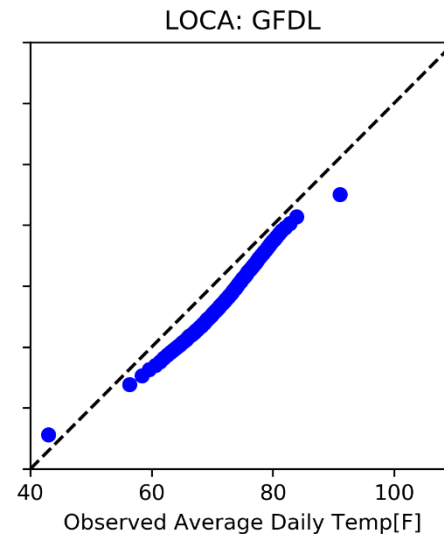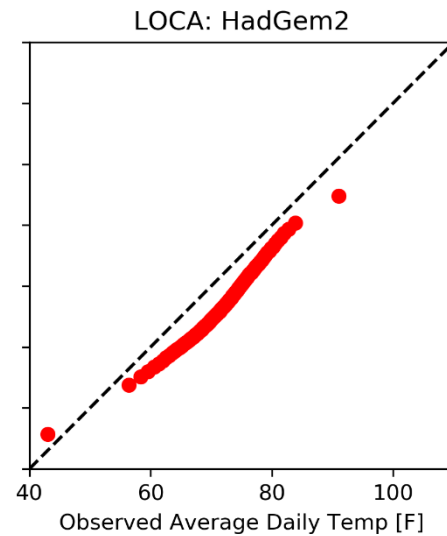
# December <u>future</u> daily precipitation distribution (2030s)

# December <u>future</u> daily precipitation distribution (2060s)
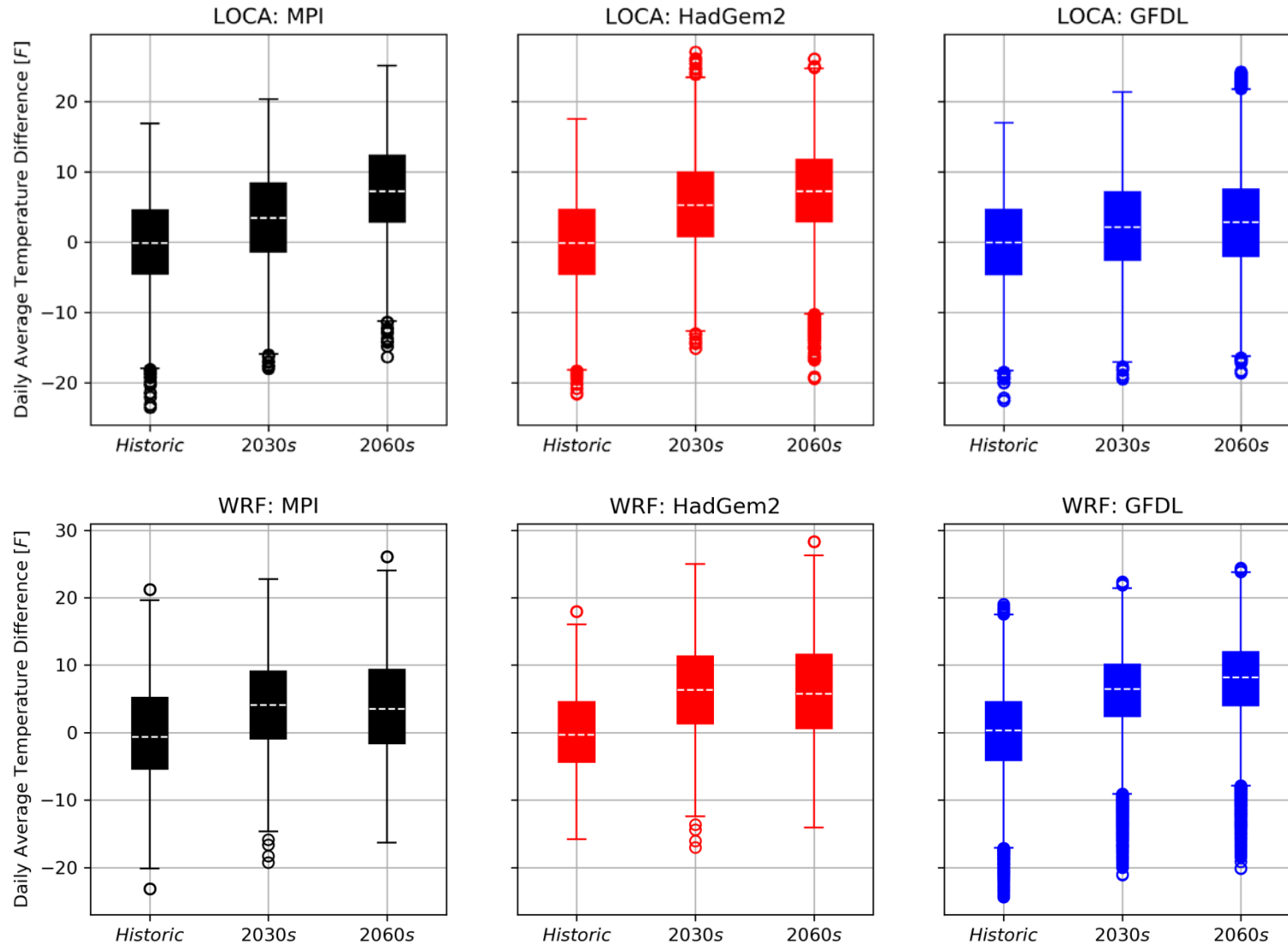
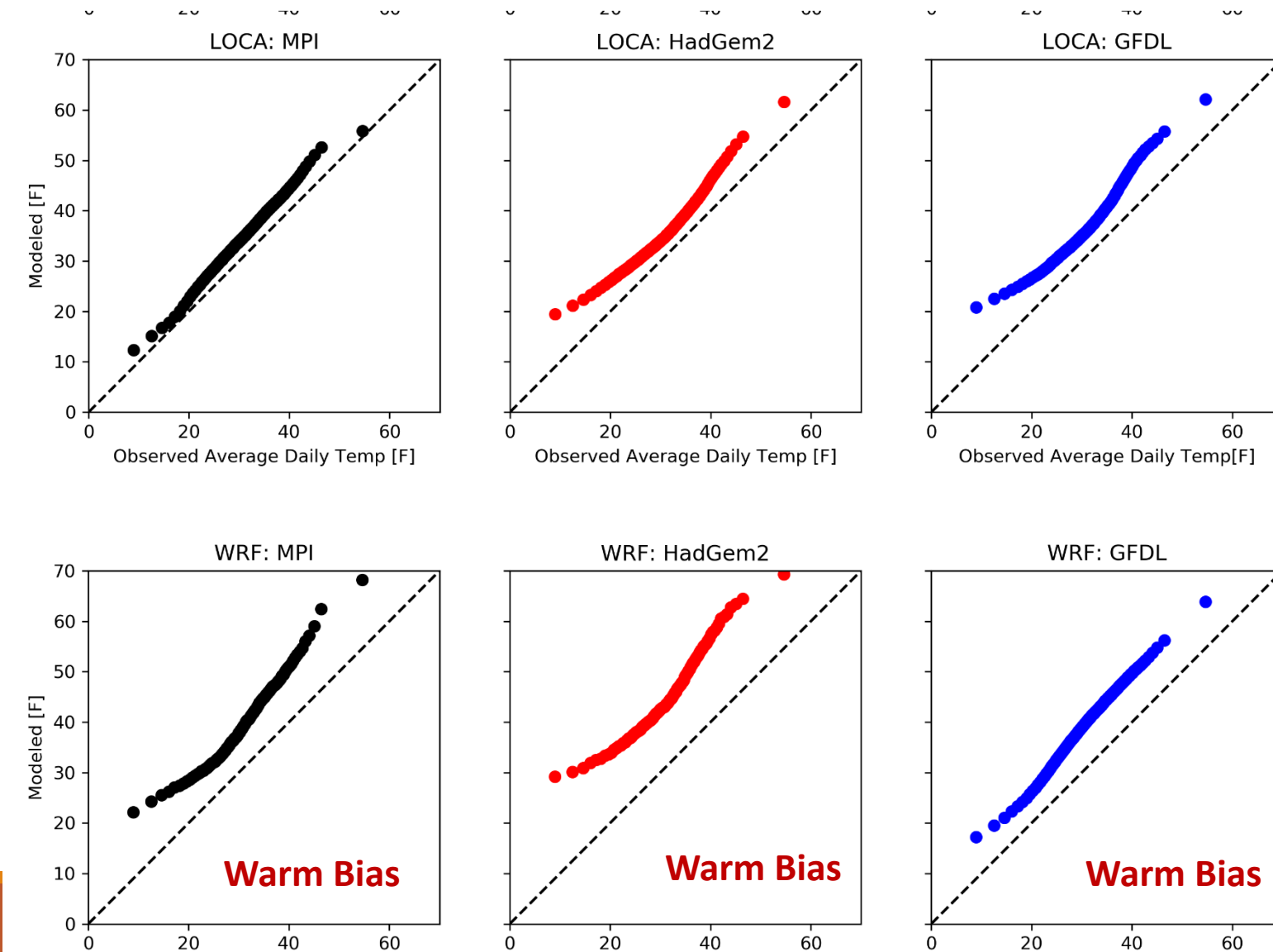# August <u>historic</u> daily temperature distribution
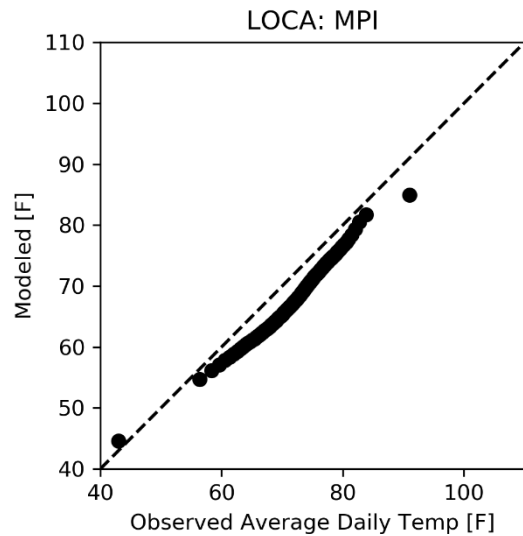


**(1) DD Historic August climatology: 2 warm bias, 1 cold bias**

# August <u>future</u> daily temperature distribution



**(2) Consistent warming trend in 2030s and 2060s, across all projection datasets (SD, DD)**

# December <u>historic</u> daily temperature distribution

# December <u>future</u> daily temperature distribution
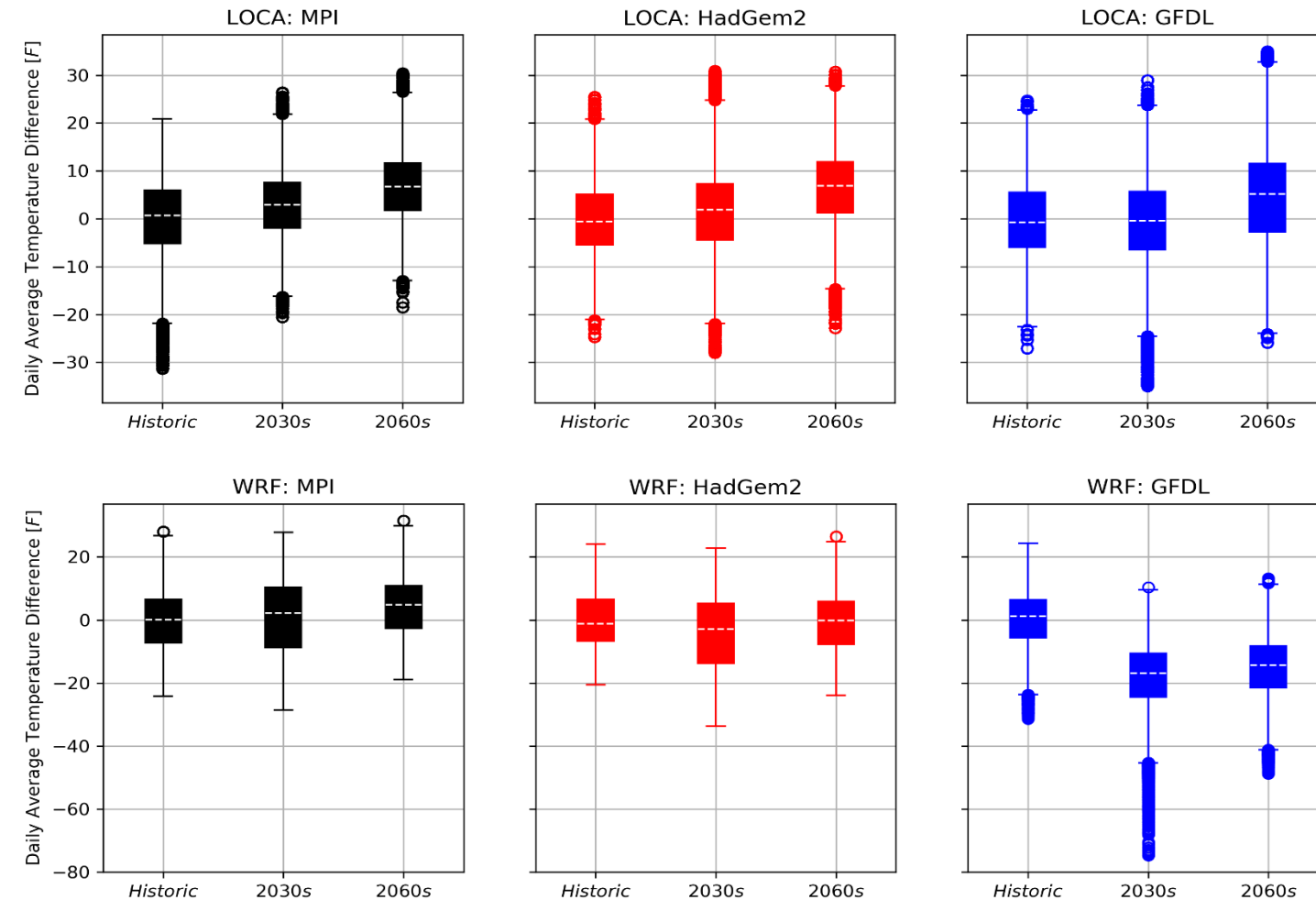


(1) DD Historic December climatology: 2 warm bias, 1 cold bias
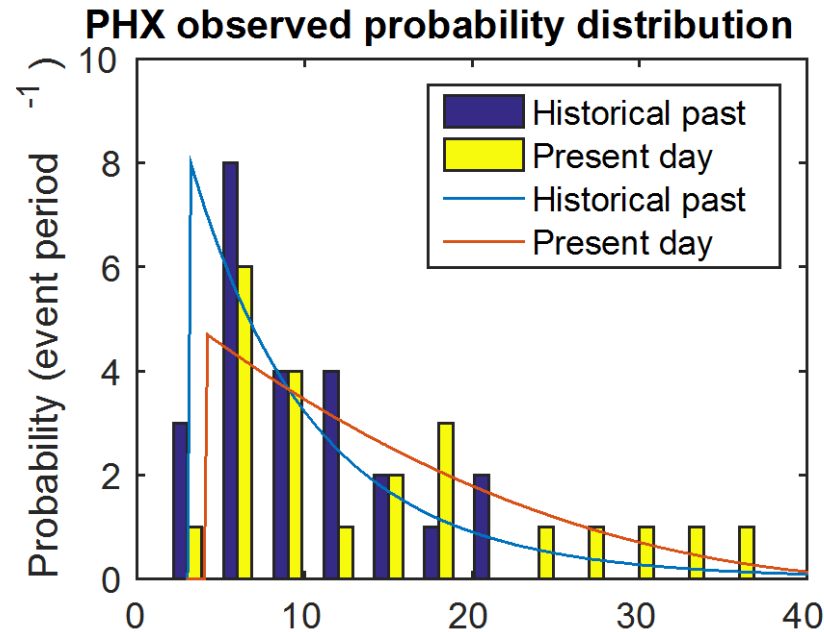(2) SD: Consistent warming trend in 2030s and 2060s, with more significant increase in the 2060s
(3) DD:
WRF-MPI: warming in 2030s and 2060s
WRF-HadGEM: slightly cooling or no change
WRF-GFDL: significant cooling

# Changes in extreme daily precipitation (top 10%, July/August) Phoenix, Arizona [1950 – 1970] vs. [1990 – 2010]



PHX observed probability distribution

**The distribution of extreme events in [1990-2010] is broader and flatter.**
**Frequency of extreme precipitation is less, but the precipitation amount during those events is more intense**

*Luong et al. (2017)*

# August <u>future</u> extreme precipitation trend:
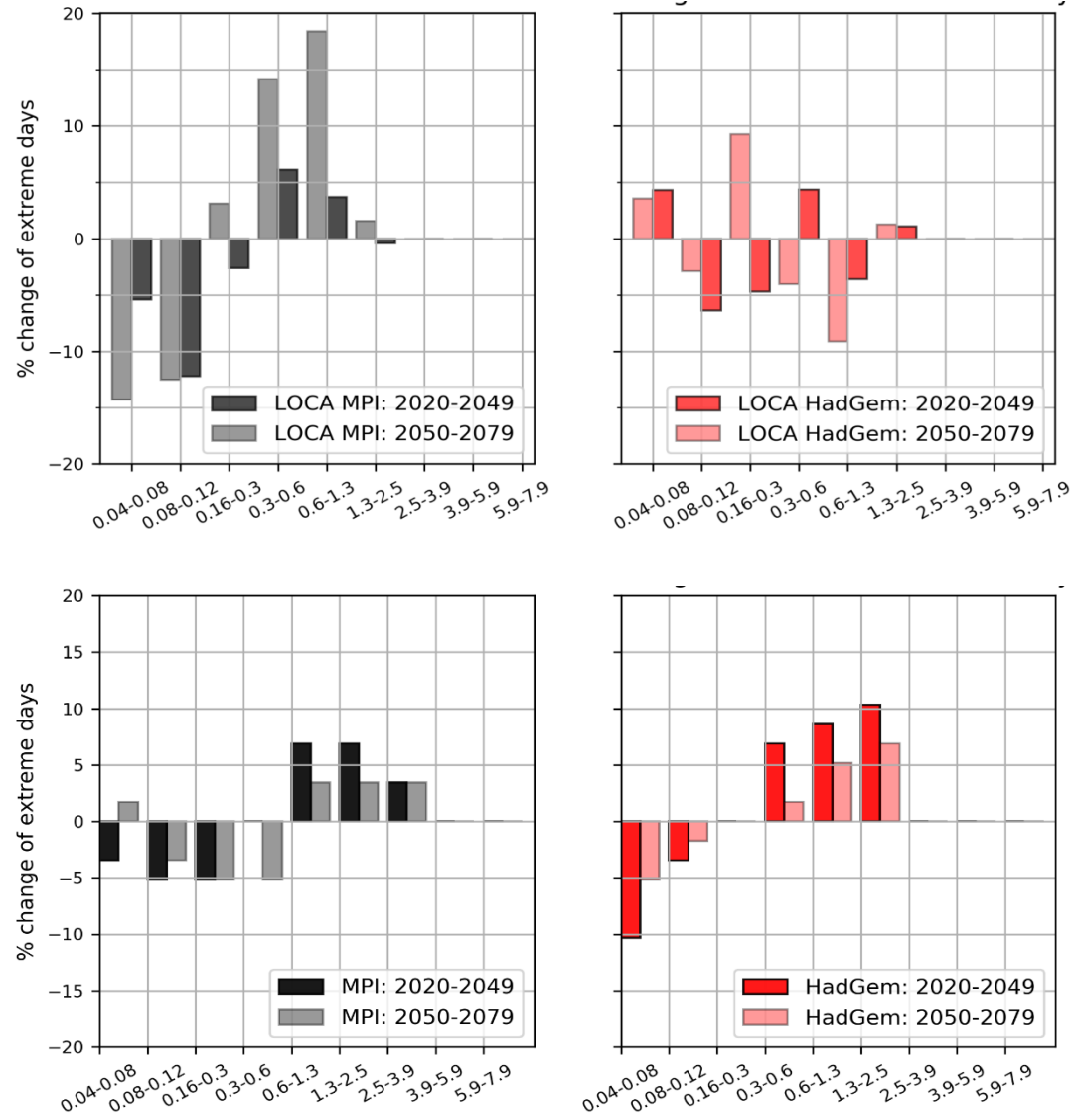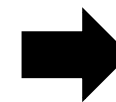


(1) **The two recommended DD future August presentation trend follows the last 60-yr observation record: <u>more heavy rain events, less mild events</u>**

(2) **SD also shows similar future August precipitation trend from the same global climate model (MPI)**

# Monsoon Onset Timing [End of dry spell]

| | Monsoon Onset Date |
|---|---|
| Observation | July 03 |
| WRF-MPI (worse case, DD) | July 02 |
| WRF-HadGEM2 (worse case, DD) | June 30 |
| MPI (worse case, SD) | July 03 |
| HadGEM2 (worse case, SD) | June 30 |
| GFDL (worse case, SD) | July 02 |

# Pre-monsoon Dry Spell Calculation
## [Identify the last winter precipitation event, begin of the dry spell]

(1) CLIMAS definition: Rainfall < 0.1 inch over 2 weeks

(2) Accumulative precipitation over an updated threshold for an extended period

(3) Identify length of dry spell based on <u>monsoon onset date (end of dry spell)</u>, trace back to the length of days with rainfall less than 0.01 inch

# Next Steps

(1) Pre-monsoon dry spell calculation

(2) Where does the DD (worse case/high risk) projection fall within Reclamation SD projections ?

(3) Recommend best/worse case climate

(4) Prepare climate projections for weather generator (data received by Reclamation)