Climate projections for the Chesapeake Bay and its watershed

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Outline:

- Review of downscaling and climate model selection
- Changes in extreme precipitation
- Proposed future work

Statistical downscaling solves two problems presented by GCMs:

- Spatial resolution is too coarse
- The models are biased

Why we use MACA among the many statistical downscaling choices:

- It has all the variables we need, except for downwelling longwave radiation
- It has the highest spatial resolution available (1/24^{o})

Projected climate change (review)

- warmer
- wetter
- more humid
- more downwelling radiation (shortwave and longwave)
- little or no change in winds

MACA downscales 20 GCMs

We cannot run simulate the impact on hypoxia for each GCM

How do we choose a small set of GCMs?

Climatic Change
https://doi.org/10.1007/s10584-019-02512-8

Evaluation of methods for selecting climate models to simulate future hydrological change

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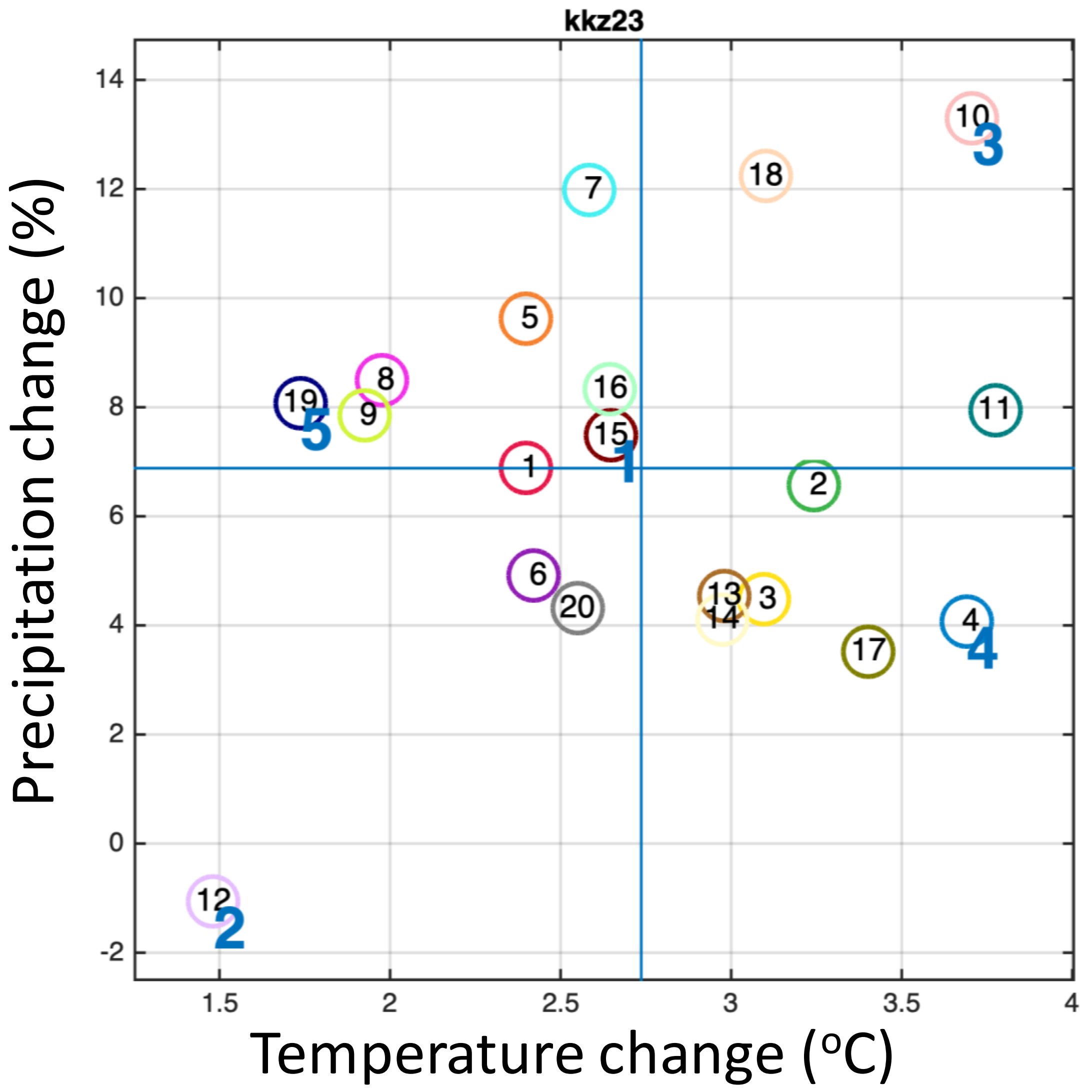
Best method: KKZ (Katsavounidis, Kuo, and Zhang, 1994)

Review of GCM ranks based on changes in May–Oct temp. and Nov–Jun precip. between historical (1995) and future (2050) 30-year periods

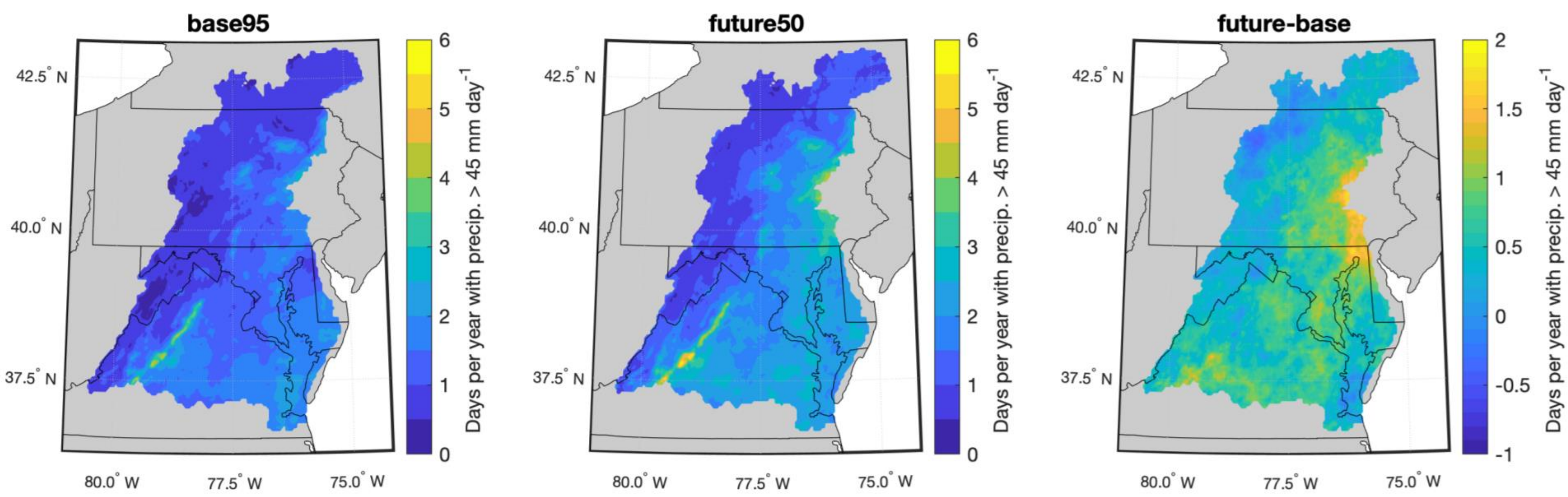


KKZ Rank	Model ID	Model Nama	Model origin
1	m15	IPSL-CM5B-LR	France
2	m12	inmcm4	Russia
3	m10	HadGEM2-CC365	UK
4	m4	CanESM2	Canada
5	m19	MRI-CGCM3	Japan
6	m07	CSIRO-Mk3-6-0	Australia
7	m11	HadGEM2-ES365	UK
8	m14	IPSL-CM5A-MR	France
9	m02	bcc-csm1-1-m	China
10	m06	CNRM-CM5	France
11	m18	MIROC-ESM-CHEM	Japan
12	m05	CCSM4	USA – NCAR
13	m17	MIROC-ESM	Japan
14	m01	bcc-csm1-1	China
15	m08	GFDL-ESM2G	USA
16	m20	NorESM1-M	Norway
17	m16	MIROC5	Japan
18	m03	BNU-ESM	China
19	m09	GFDL-ESM2M	USA
20	m13	IPSL-CM5A-LR	France

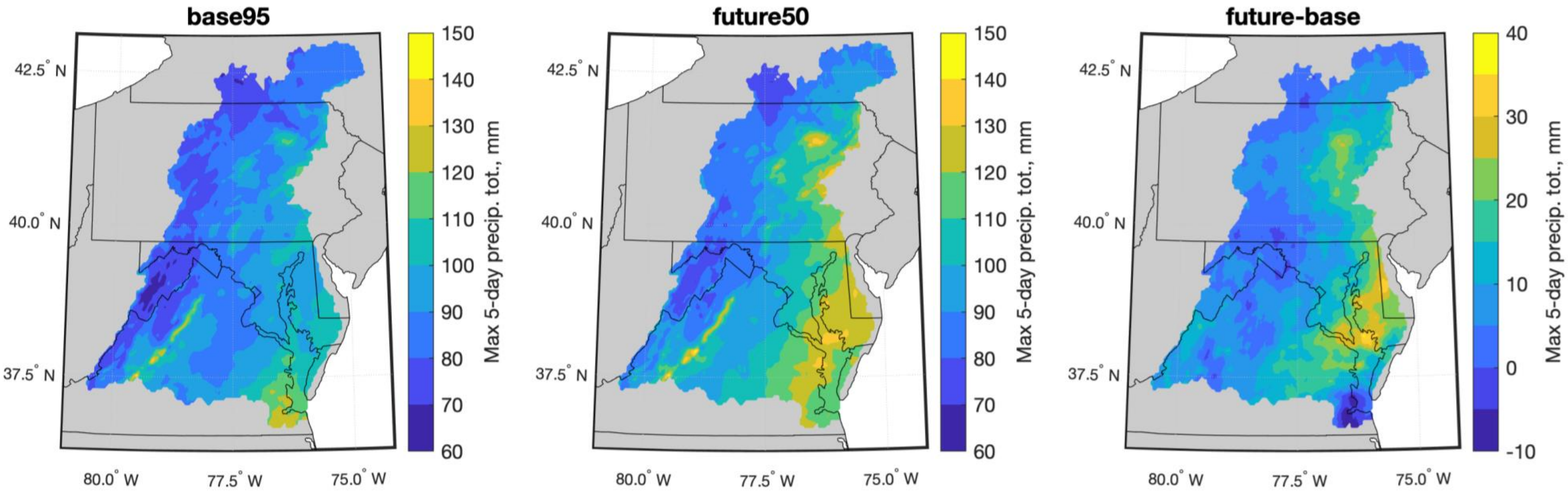
Extreme precipitation indices: rank-one model

15 IPSL-CM5B-LR (France)

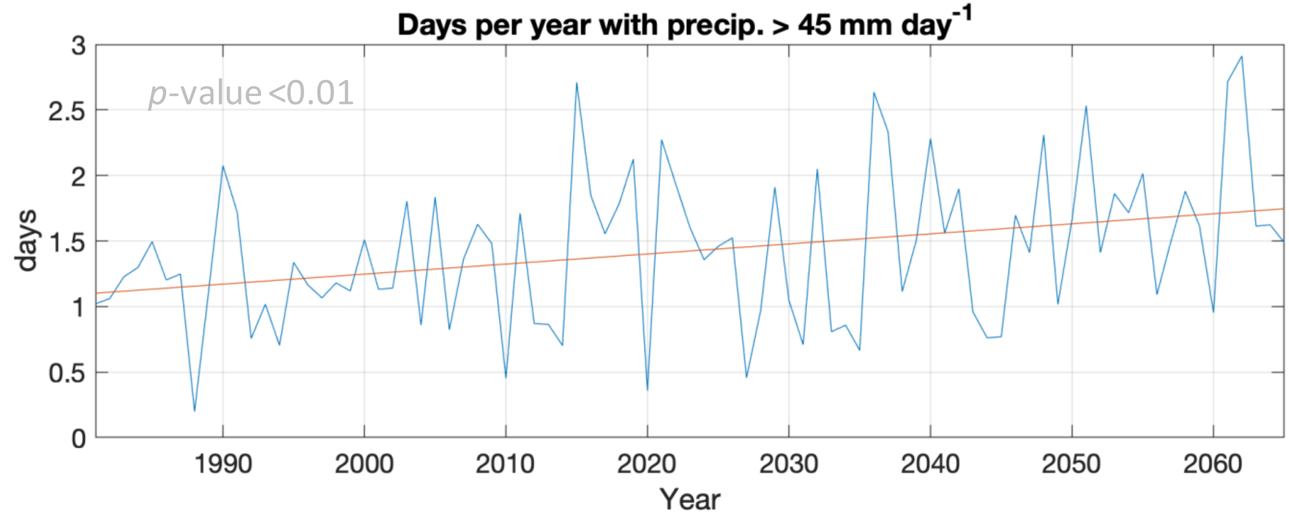
Projected days per year with precipitation > 45 mm/day; averages over 1995 base period (1981-2010) vs. 2050 future (2036-2065); the spatial pattern does not change; magnitude increases on average (by up to 2d)

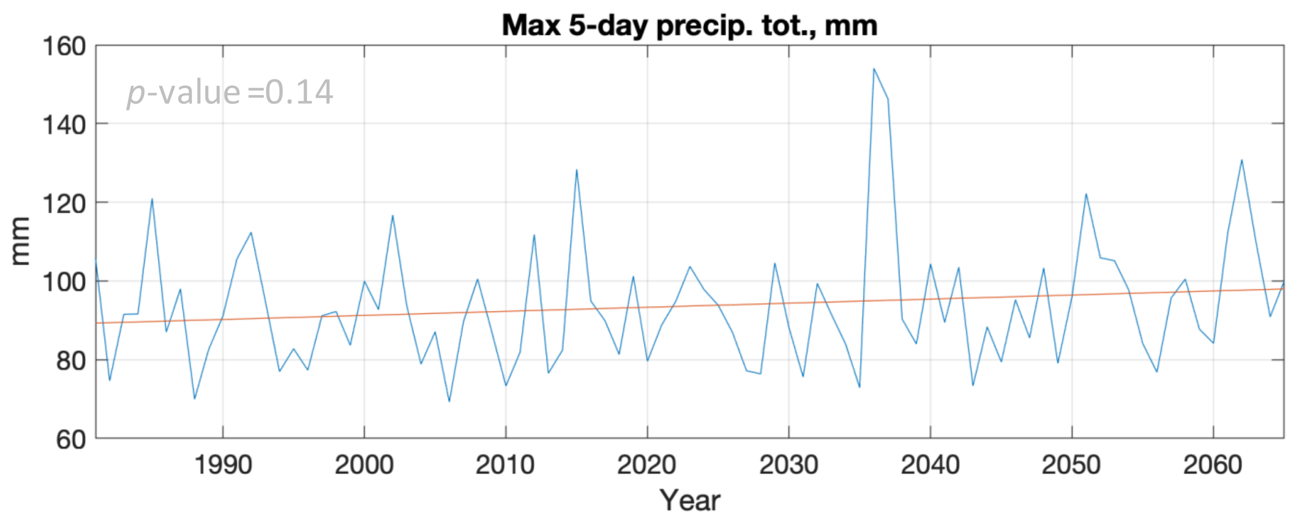


Projected total maximum 5-day precipitation amount (mm); averages over 1995 base period (1981-2010) vs. 2050 future (2036-2065); similar spatial pattern; magnitude slightly increased in the eastern parts of the watershed and bay



The same extreme precipitation metrics shown as 1981–2065 time series averaged over the spatial domain





Possible work for remainder of project

- Publish longwave algorithm
- Investigate causes of projected increases in downwelling radiation
- Look at changes in extreme precipitation for other models (other than the central model)
- Investigate possible changes in interannual variability

Extra slides

KKZ algorithm for GCM subset selection

1. Select the case that lies closest to the ensemble centroid as the first scenario.

2. Select the case that lies farthest from the first scenario as the second scenario.

3. To select the next scenario:
    3.1 calculate distances from each remaining case to the previously selected scenarios;
    3.2 associate each remaining case with the minimum distance calculated in step 3.1
    3.3 select the case with the maximum distance from step 3.2 as the next scenario

4. Repeat from step 3.

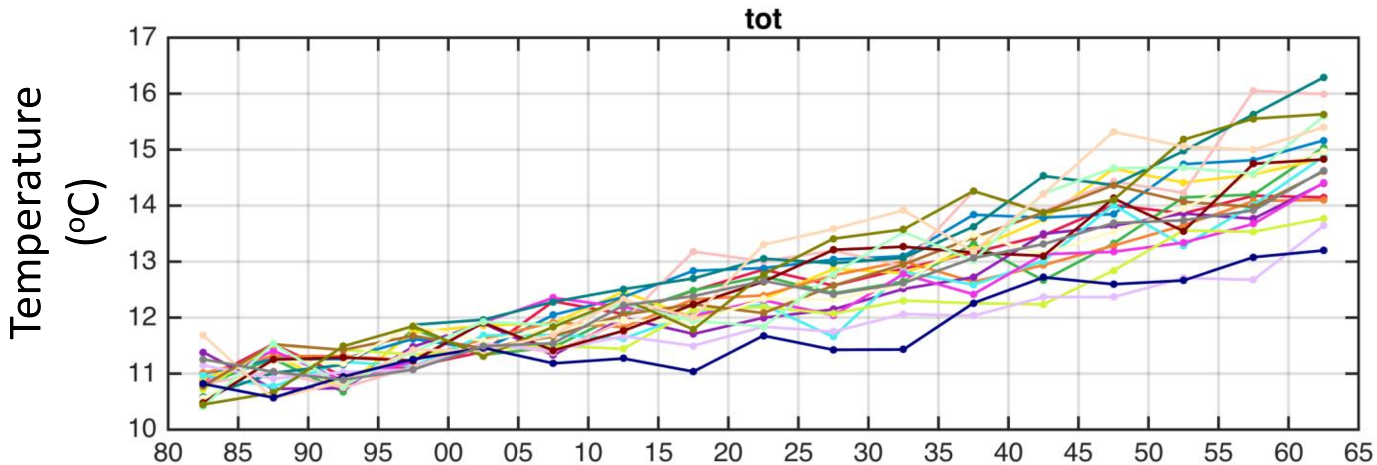
* Variables were standardized to zero mean and unit standard deviation (z-scores)

(Katsavounidis, Kuo, Zhang 1994)

Models consistently simulate increases in temperature

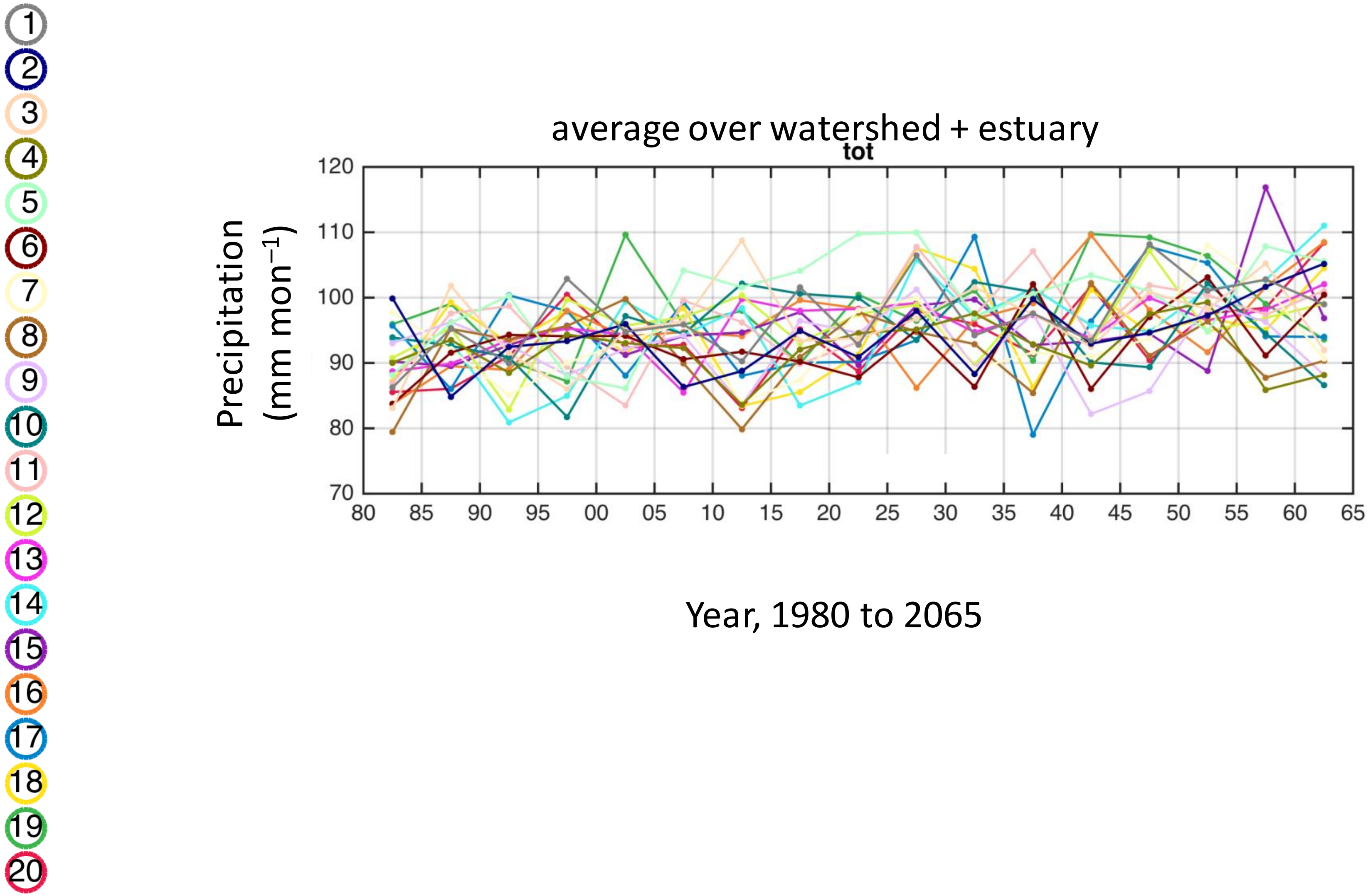
1. bcc-csm1-1
2. bcc-csm1-1-m
3. BNU-ESM
4. CanESM2
5. CCSM4
6. CNRM-CM5
7. CSIRO-Mk3-6-0
8. GFDL-ESM2G
9. GFDL-ESM2M
10. HadGEM2-CC365
11. HadGEM2-ES365
12. inmcm4
13. IPSL-CM5A-LR
14. IPSL-CM5A-MR
15. IPSL-CM5B-LR
16. MIROC5
17. MIROC-ESM
18. MIROC-ESM-CHEM
19. MRI-CGCM3
20. NorESM1-M

average over watershed + estuary



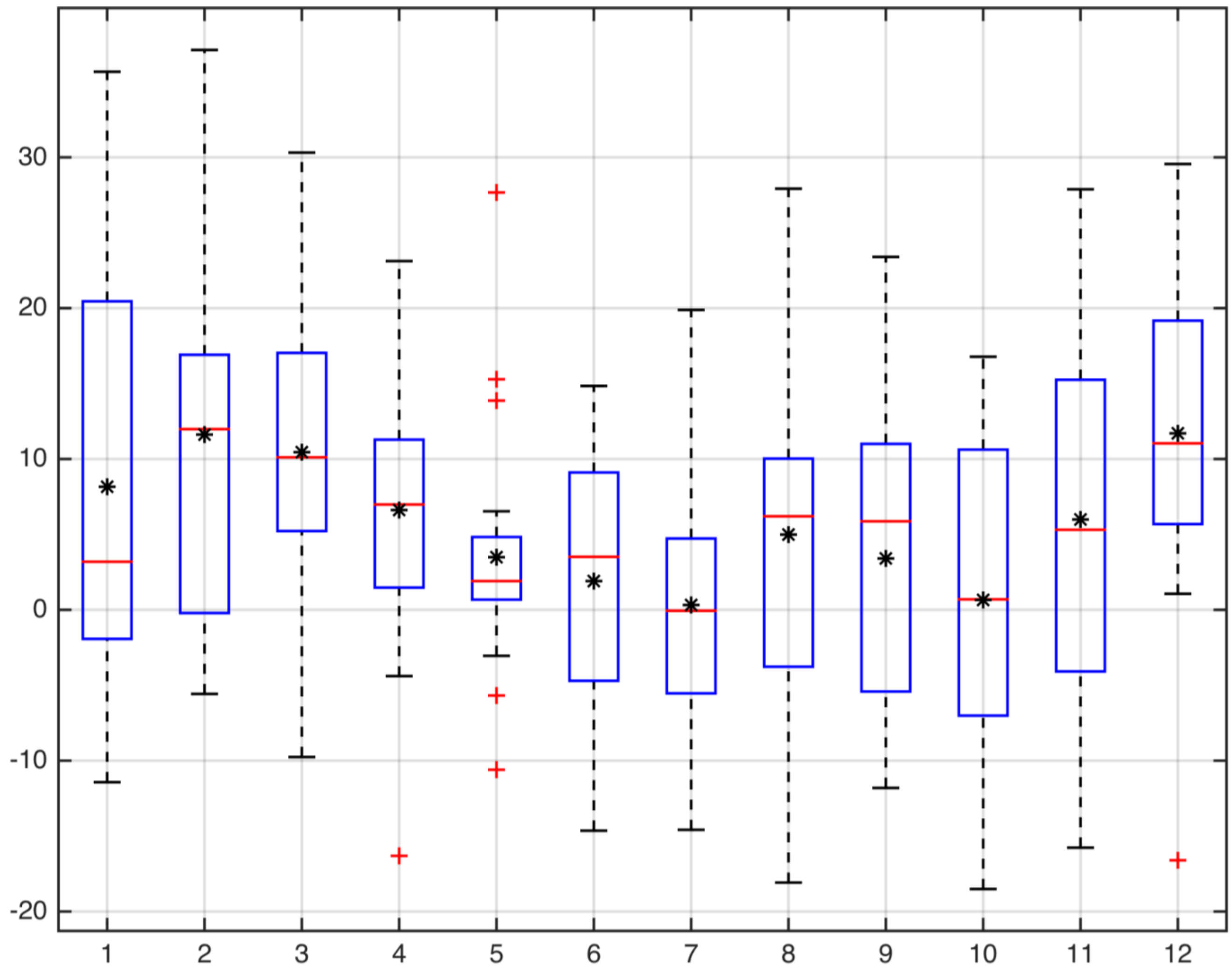
Year, 1980 to 2065

Model precipitation secular change is small compared to natural variability



Model-mean precipitation increases every month; largest increases in winter

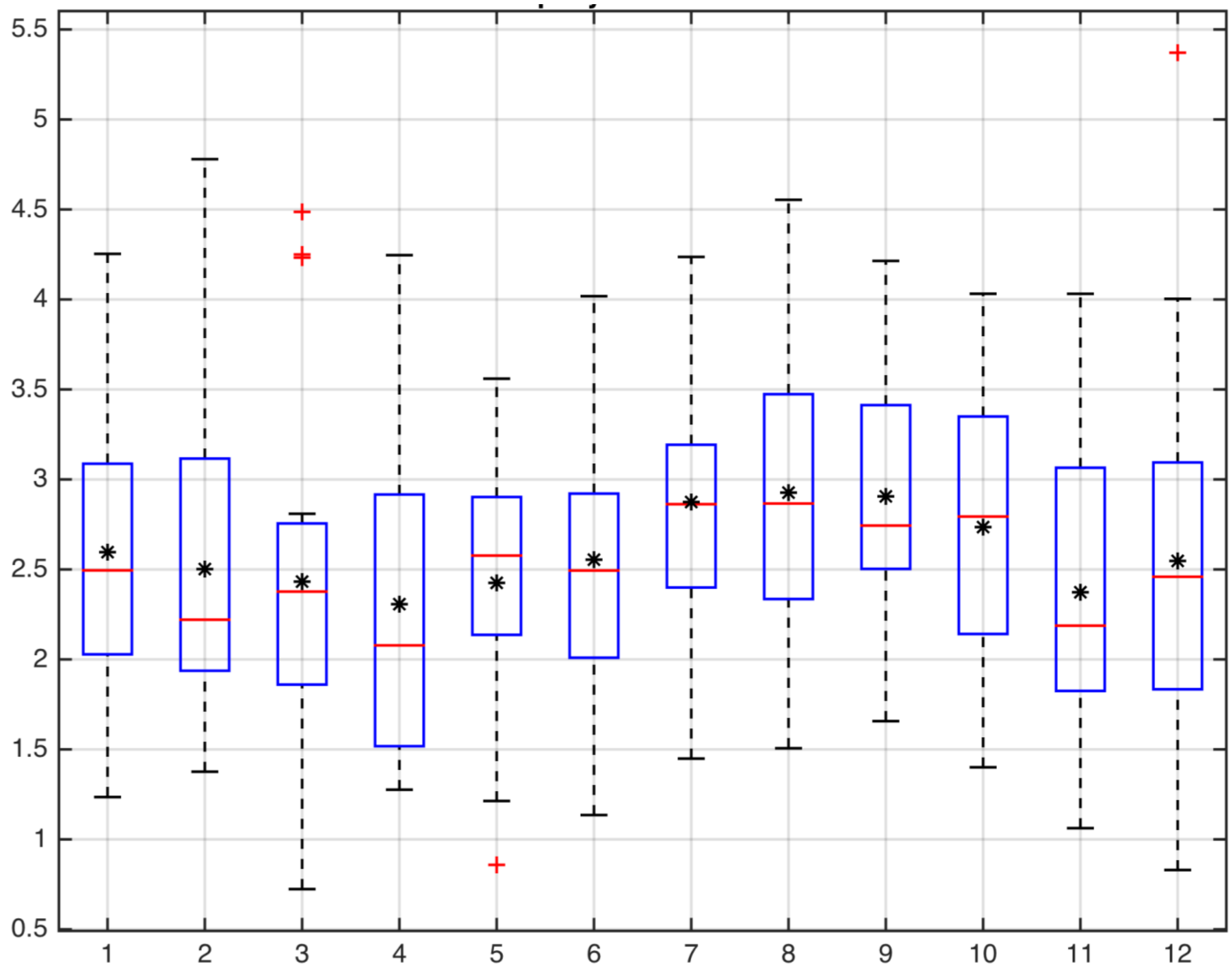
Precipitation change (%) from 1995 to 2050



month

Warming is slightly greater in the summer

Temperature change (°C) from 1995 to 2050



month

Box plot setup to summarize 20 GCMs