CHAMP Climate Projections Update

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The Pennsylvania State University

CHAMP Team Meeting

October 30, 2019

Outline: What's new since the last meeting?

- Finalized model selection strategy
- Evaluation of models against training dataset
- Plans for daily MACA product for the CHAMP team

Finalized model selection strategy

- Select models that have the largest possible spread from each other, that is, to cover a widest range of model uncertainty that can be achieved with a small subset of GCMs

Katsavounidis, I., Kuo, C., Zhang, Z., 1994. A new initialization technique for generalized Lloyd iteration. IEEE Signal Processing Letters 1, 144–146.

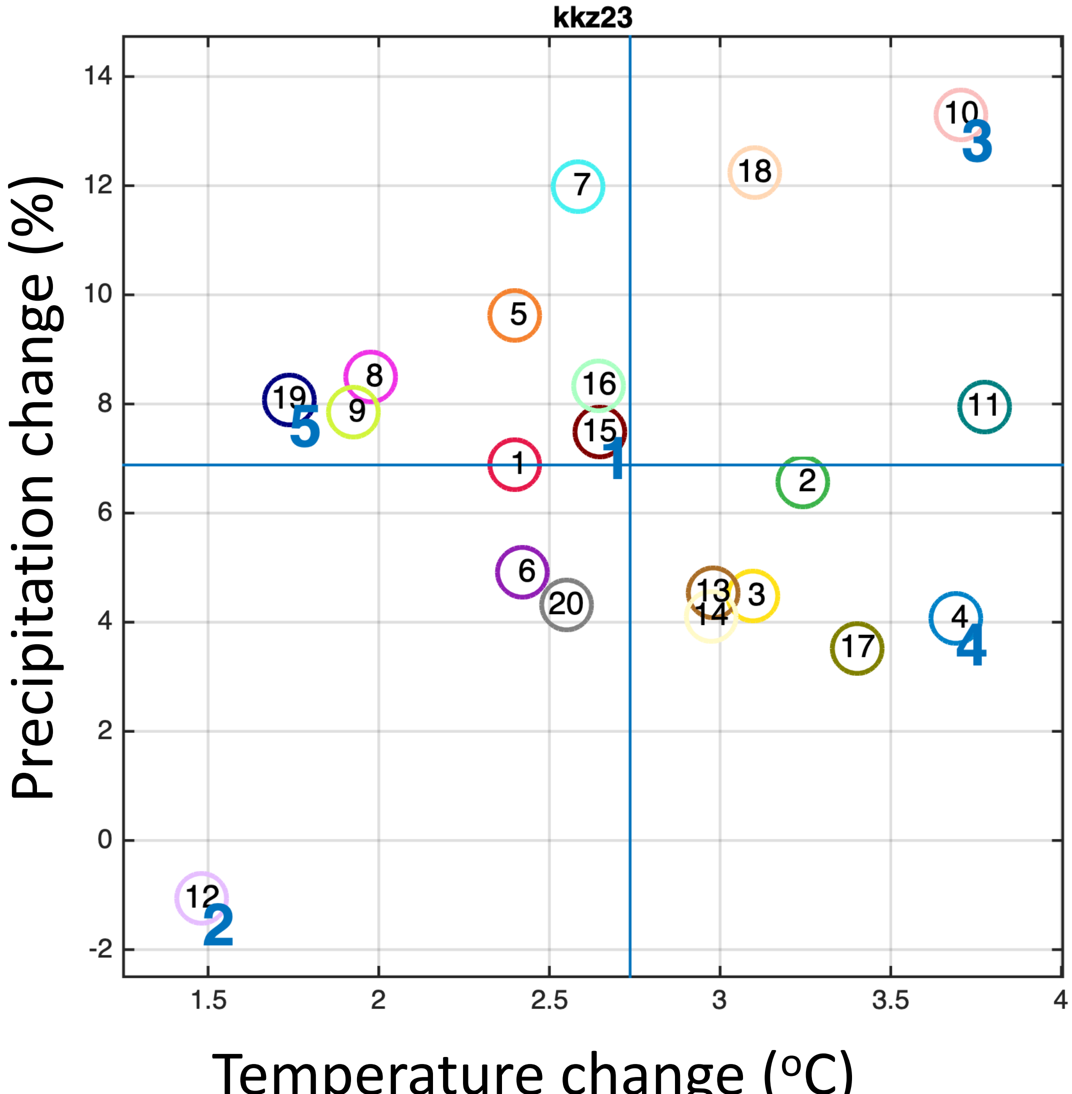
- Metrics most relevant to hypoxia: Nov-Jun P, May-Oct T
- Ross and Najjar 2019 in print

Climatic Change manuscript No.
(will be inserted by the editor)

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

Andrew C. Ross · Raymond G. Najjar

Model ranks based on 1995–2050 change in May-Oct temp. and Nov-Jun precip.



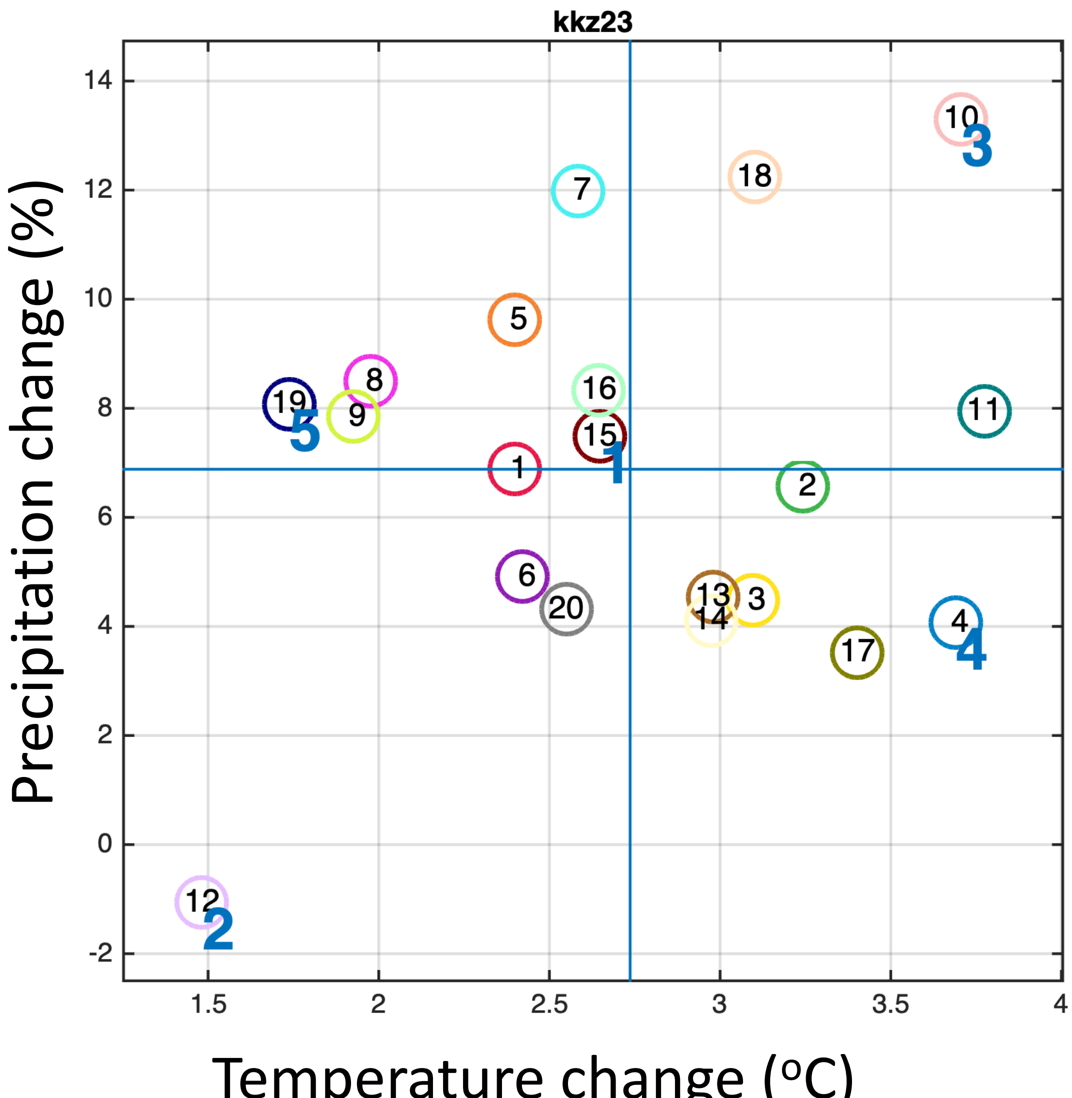
KKZ selection algorithm:

(1) Select model closest to the centroid (in Euclidean distance) as the first model;

(2) Select the model farthest away from the first model as the second;

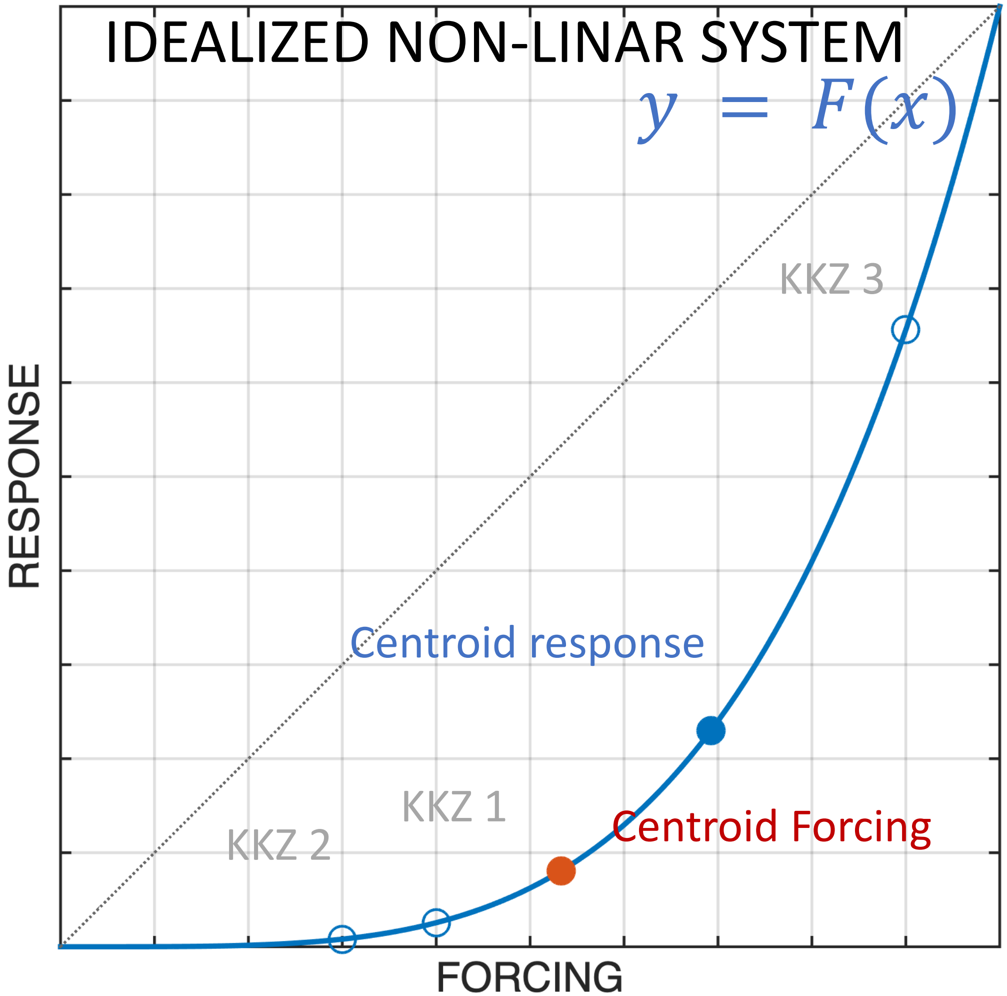
(3) Each subsequent selection is based on the model with the maximum distance from the nearest of any previously selected model.

Model ranks based on 1995–2050 change in May-Oct temp. and Nov-Jun precip.

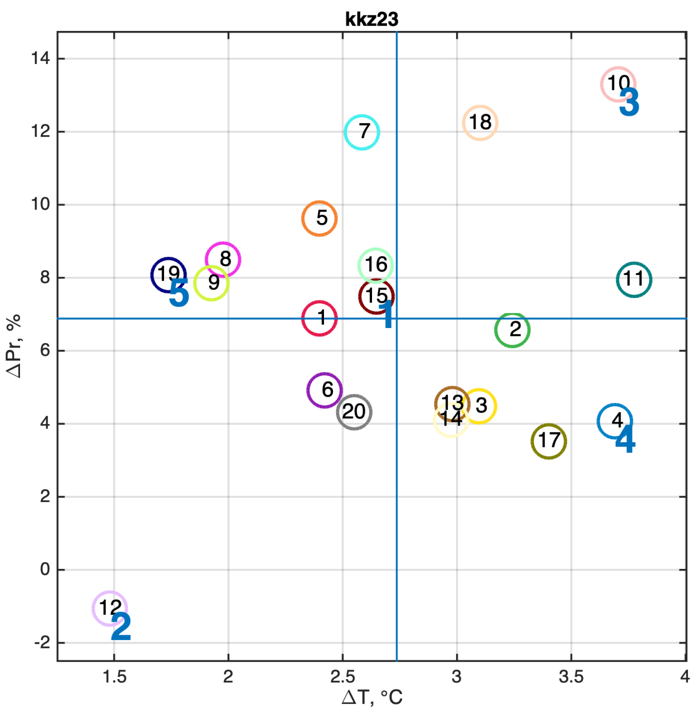


KKZ Rank	Model ID
1	15
2	12
3	10
4	4
5	19
6	7
7	11
8	14
9	2
10	6
11	18
12	5
13	17
14	1
15	8
16	20
17	16
18	3
19	9
20	13

MOTIVATION FOR KKZ ranking: RETAIN THE RANGE OF FUTURE CLIMATES , RATHER THAN USING THE MEAN



$$\overline{F(x)} \neq F(\overline{x})$$

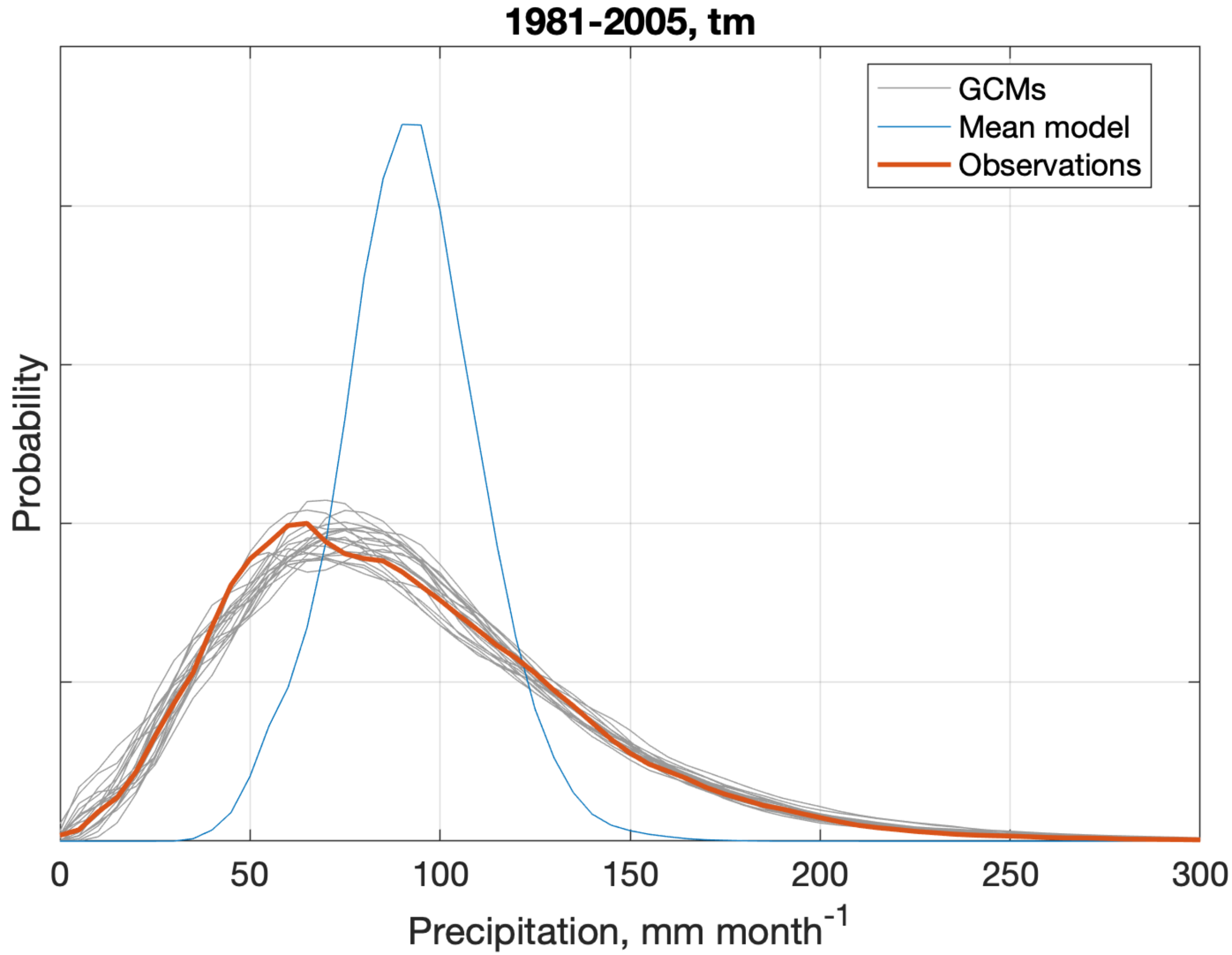


25-year time period (1981–2005) for evaluating against observations (METDATA training data)

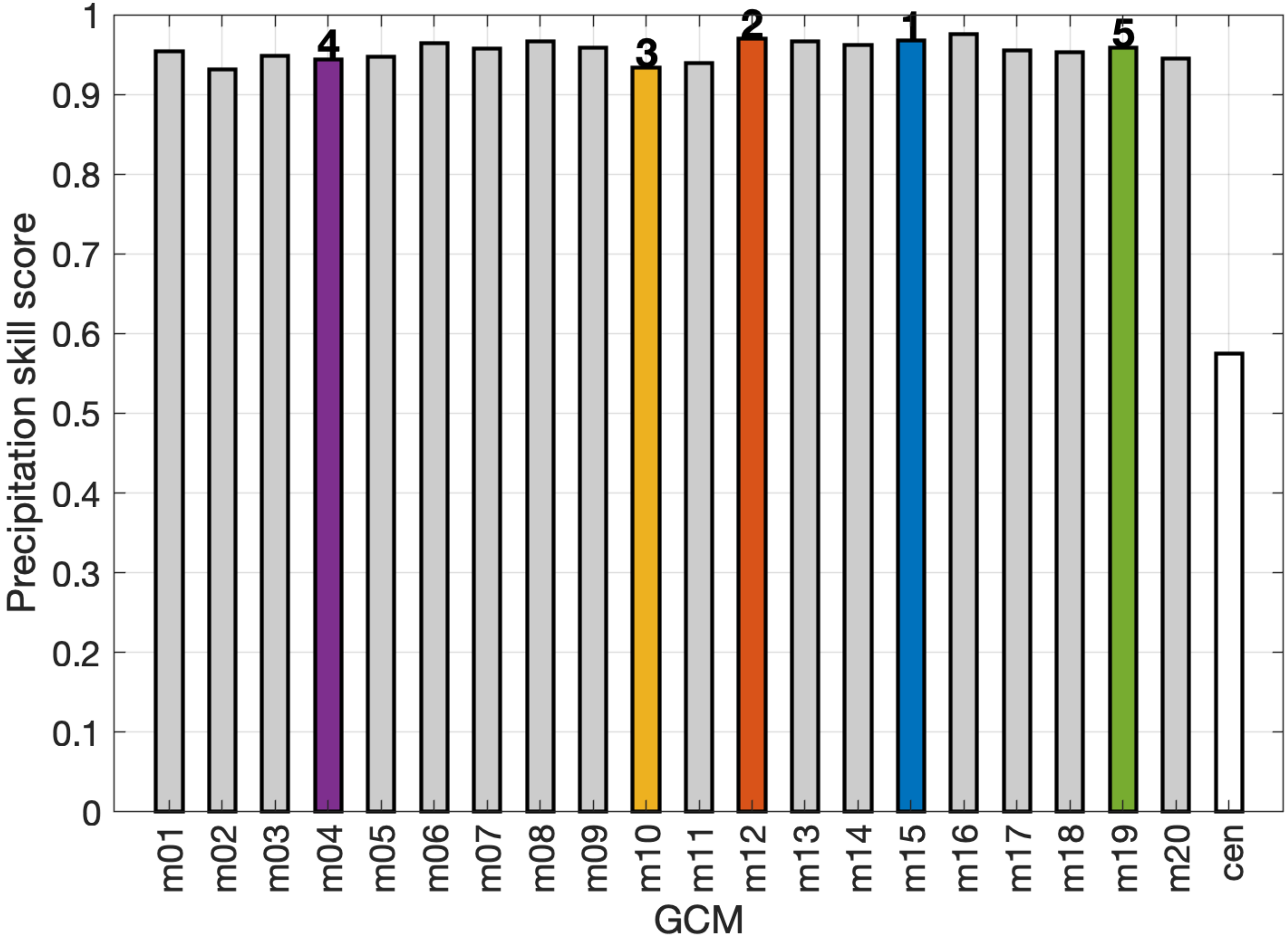
- Probability density functions (PDFs) constructed from all monthly values for all grid cells for temperature and precipitation
- Skill score is the area of overlap of the observed and model PDFs (Perkins et al. 2007)
- Also evaluated the “mean model”, calculated as the simple average of all 20 GCMs at each grid point and time step

Perkins, S.E., A.J. Pitman, N.J. Holbrook, and J. McAneney, 2007: Evaluation of the AR4 Climate Models’ Simulated Daily Maximum Temperature, Minimum Temperature, and Precipitation over Australia Using Probability Density Functions. J. Climate, 20, 4356–4376, https://doi.org/10.1175/JCLI4253.1

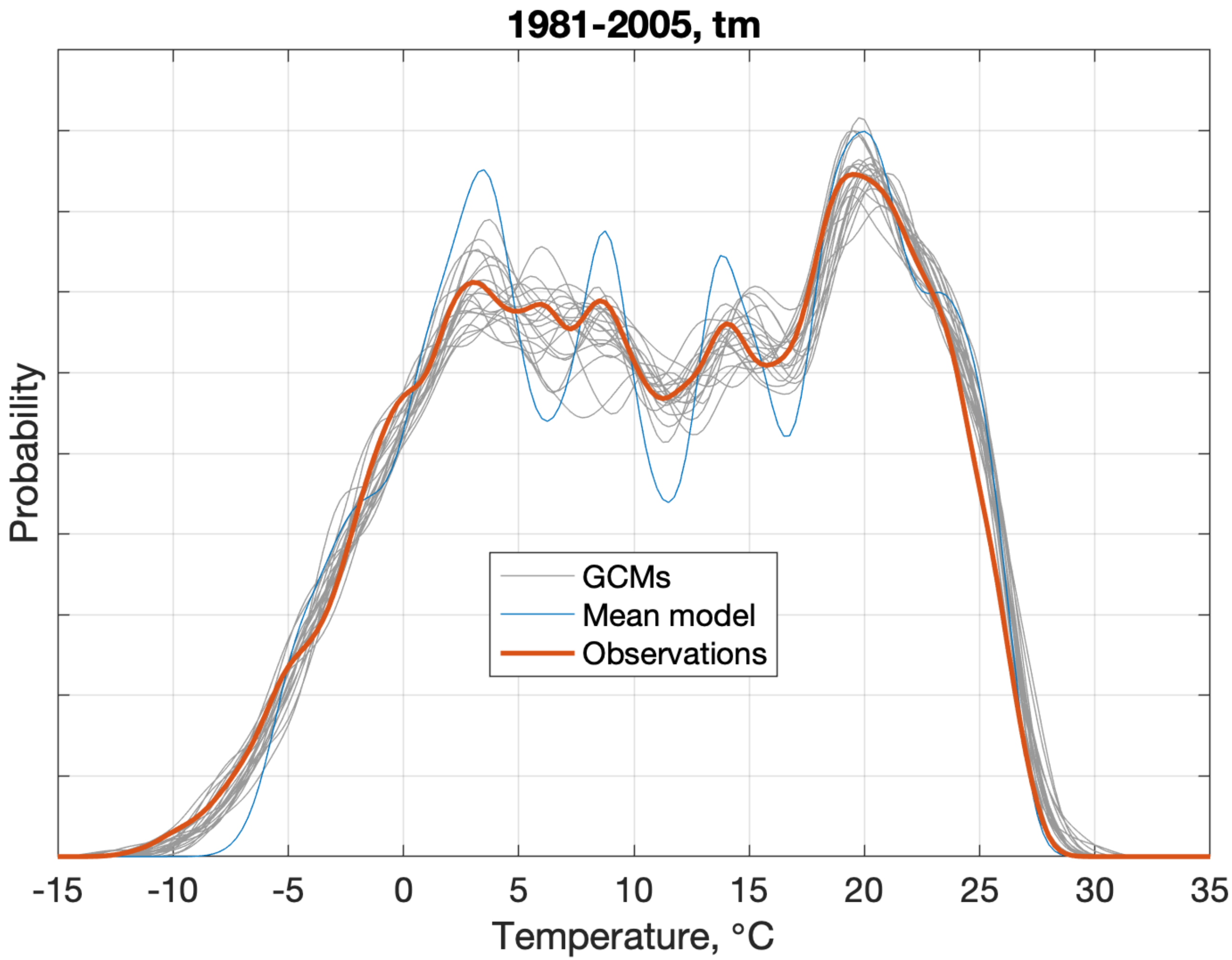
GCMs reproduce the PDF of the precipitation observations very well, but the mean model is inadequate in the tails of the PDF



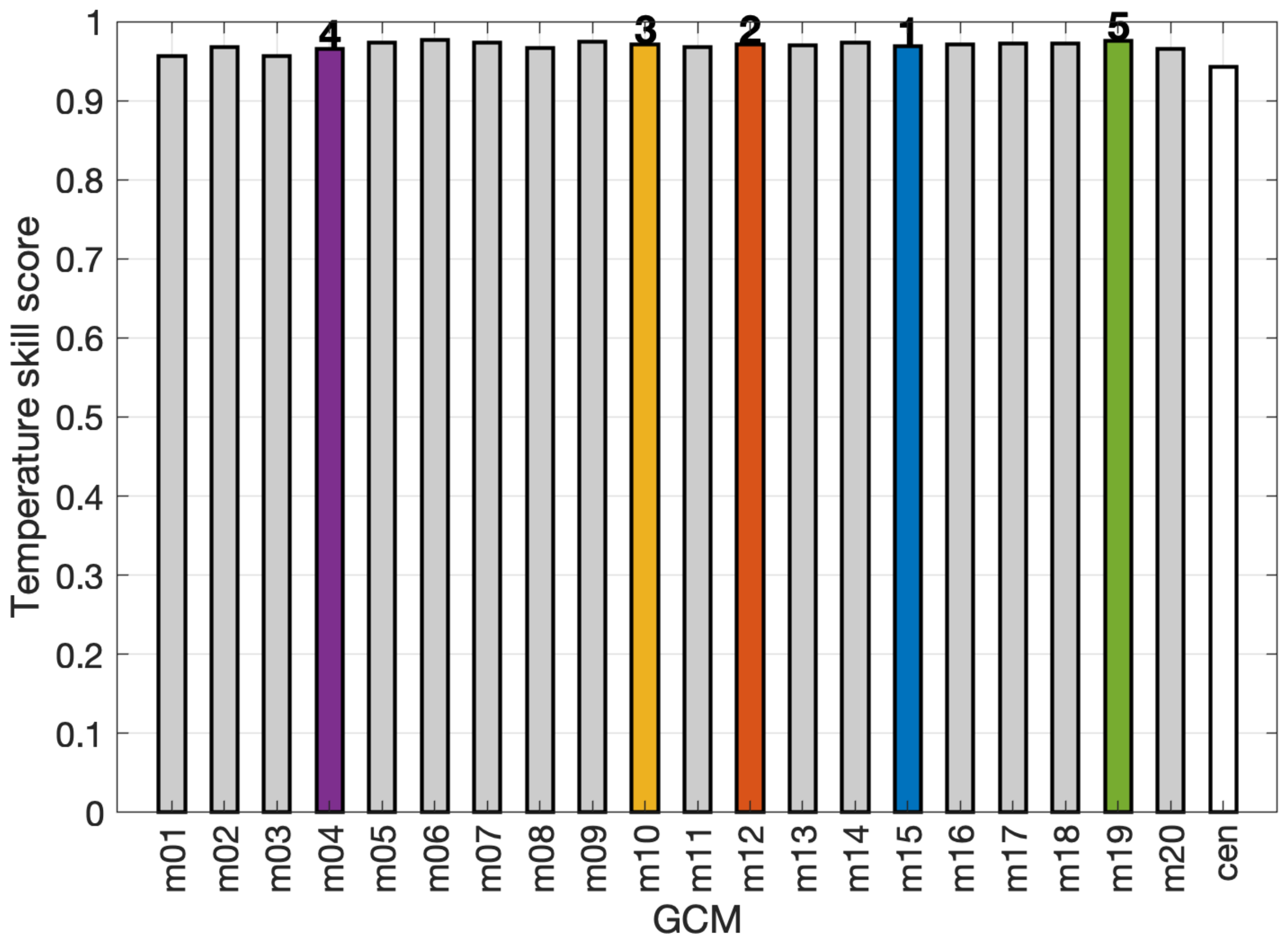
GCMs cover over 90% of the observed PDF of precipitation; the mean model covers less than 60%; KKZ rank 1-5 perform as well as any other GCM



GCMs reproduce the PDF of the temperature observations very well, but the mean model is much better than for precipitation



GCMs cover over 95% of the observed PDF of precipitation; the mean model covers slightly less than the individual models, but much better than for precipitation;
KKZ rank 1-5 perform as well as any other GCM

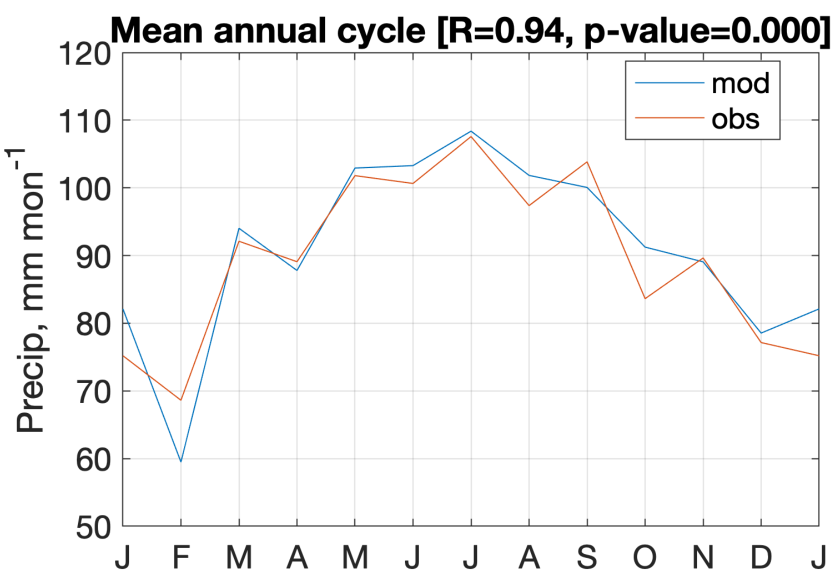


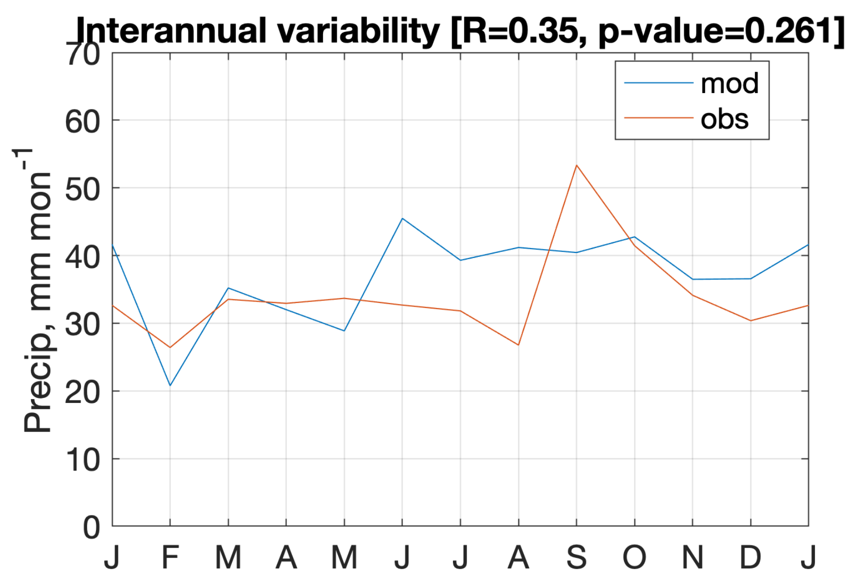
A closer look at KKZ rank 1 model

15 IPSL-CM5B-LR (France)

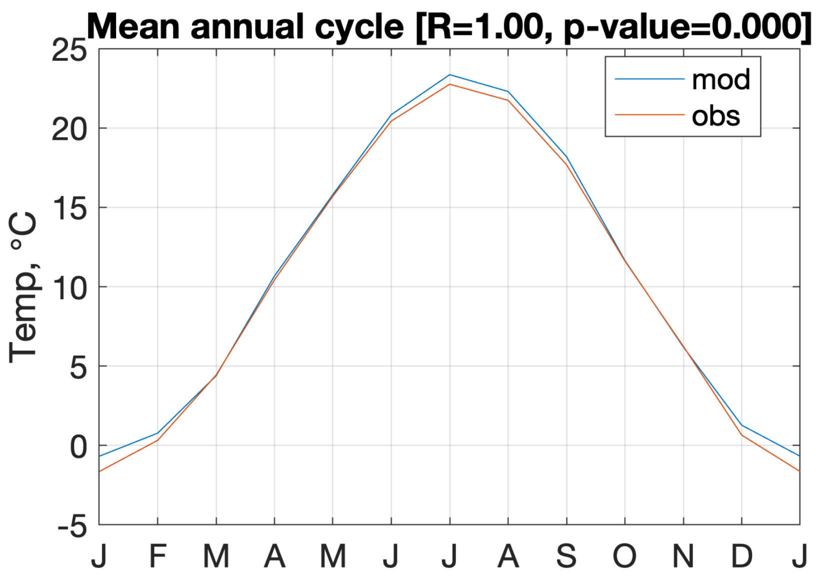
- annual cycle and spatial patterns in monthly temperature and precipitation
- extreme precipitation indices in daily precipitation

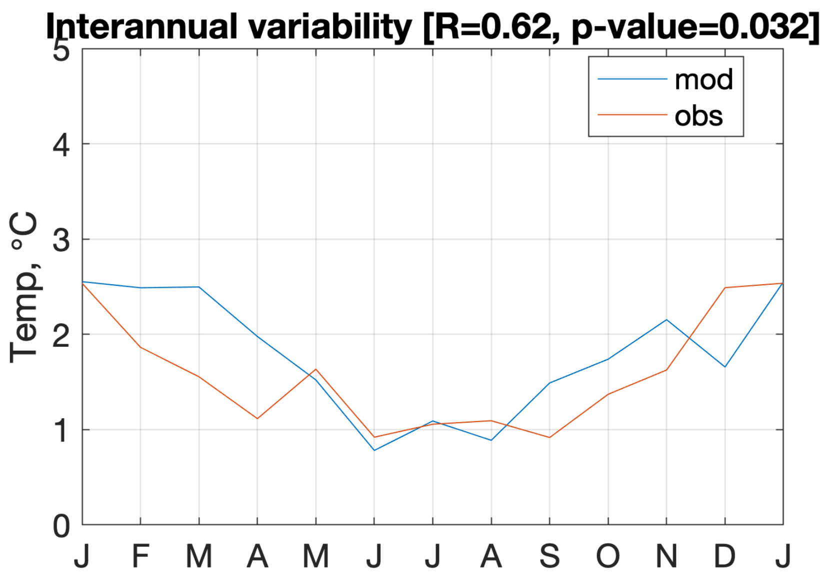
Annual cycle in precipitation: phase is captured well; amplitude slightly exaggarated; good agreement with the observations; no systematic bias in variability



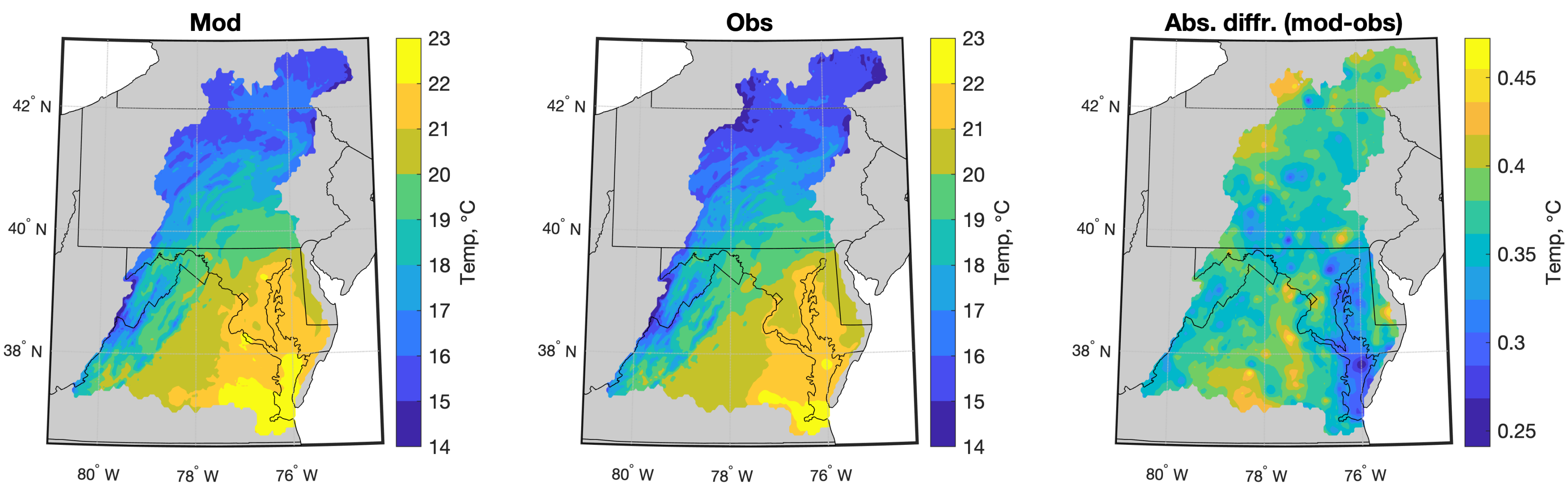


Annual cycle in temperature: better agreement than for precipitation

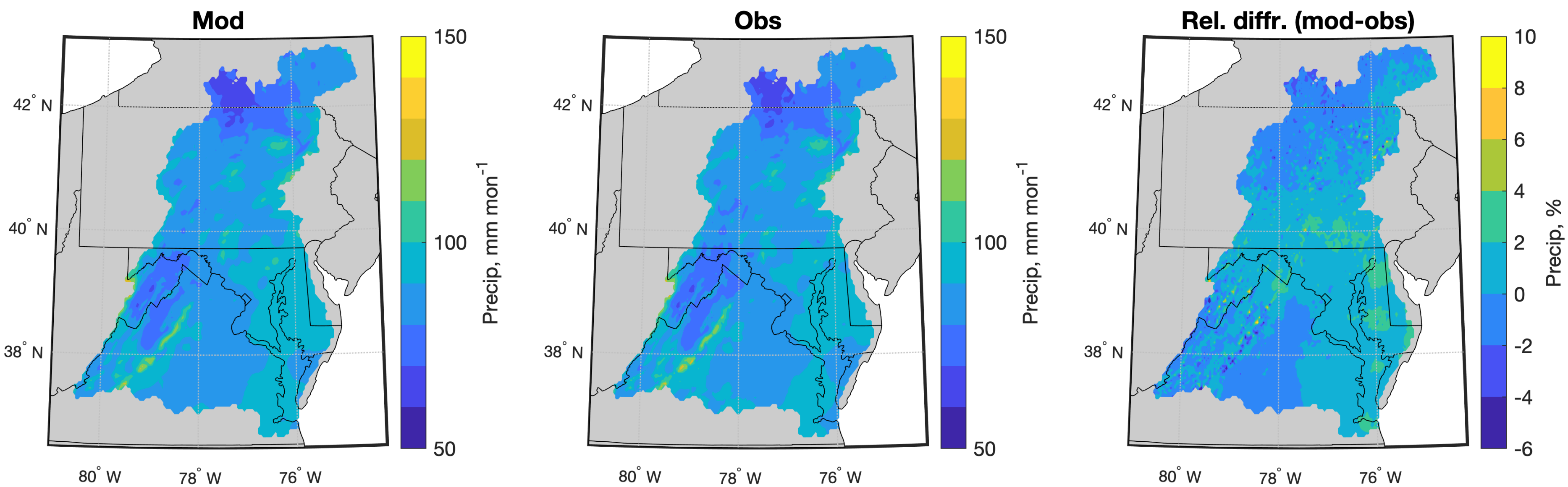




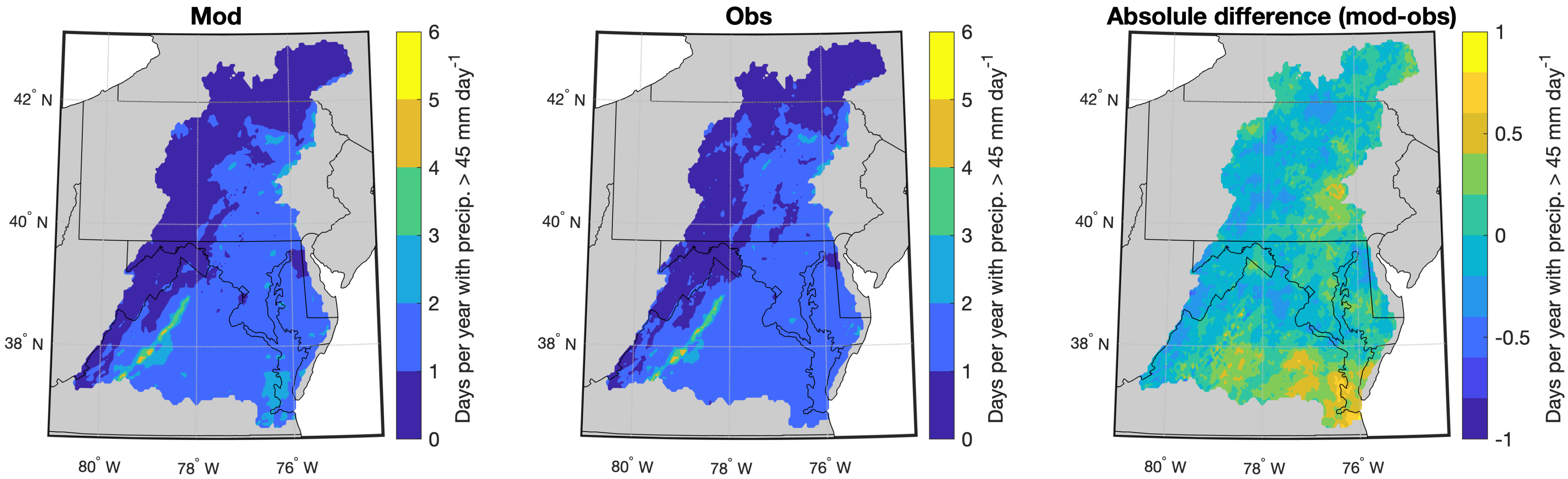
The spatial pattern in May through October temperature is captured very well; the model is slightly (<0.5 degC) warmer everywhere, more so over land



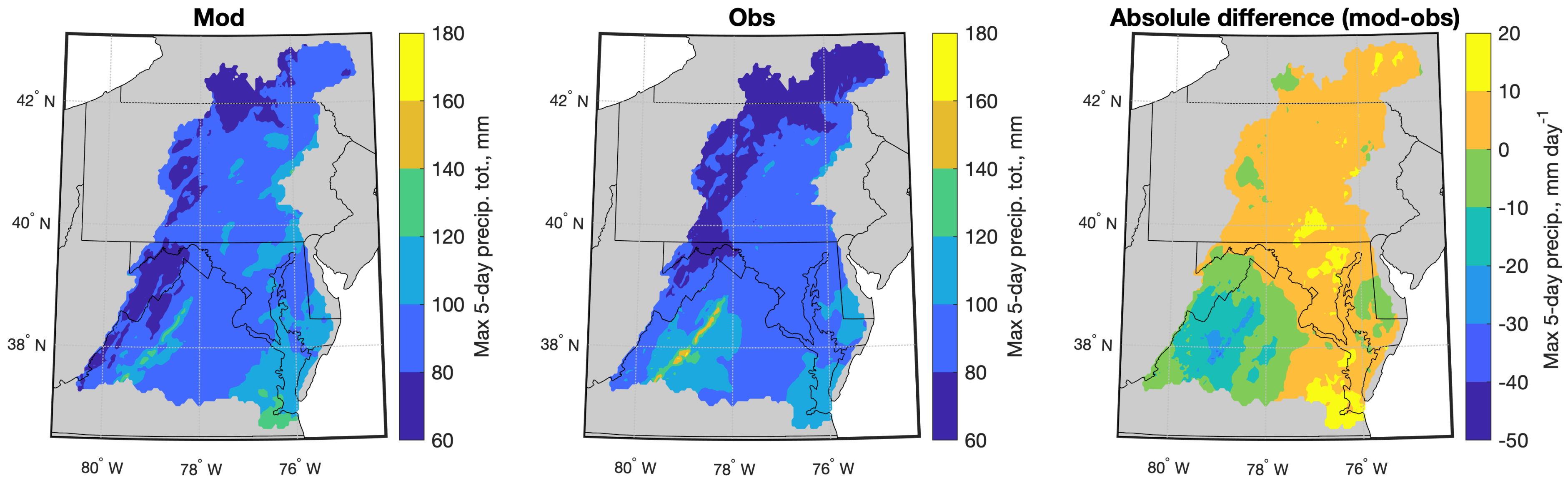
The spatial pattern in November through June precipitation is captured very well; good agreement with observations with the relative error below 10%



Days per year with precipitation > 45 mm/day; average over all years



Total maximum 5-day precipitation amount (mm); average over all years

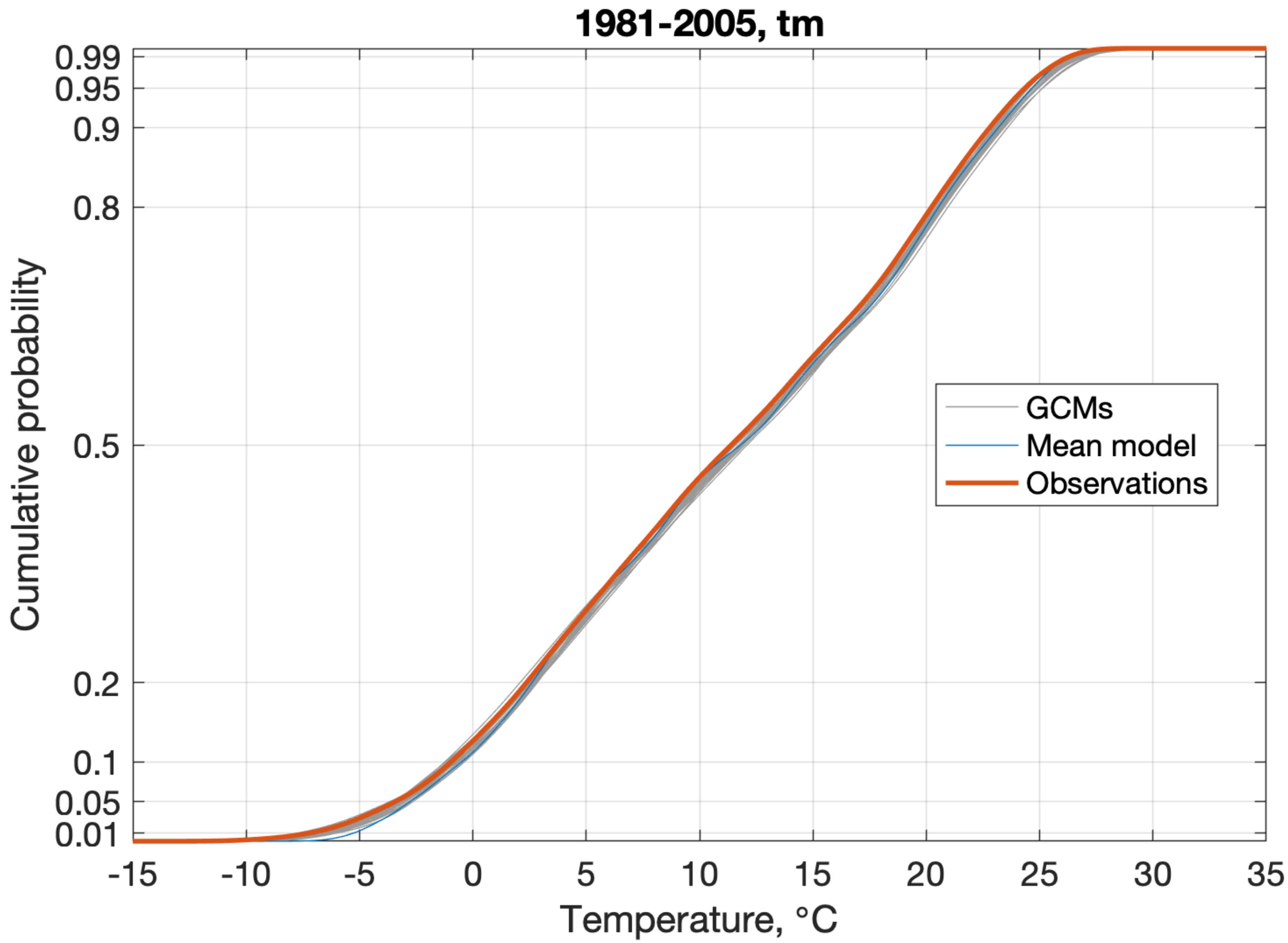


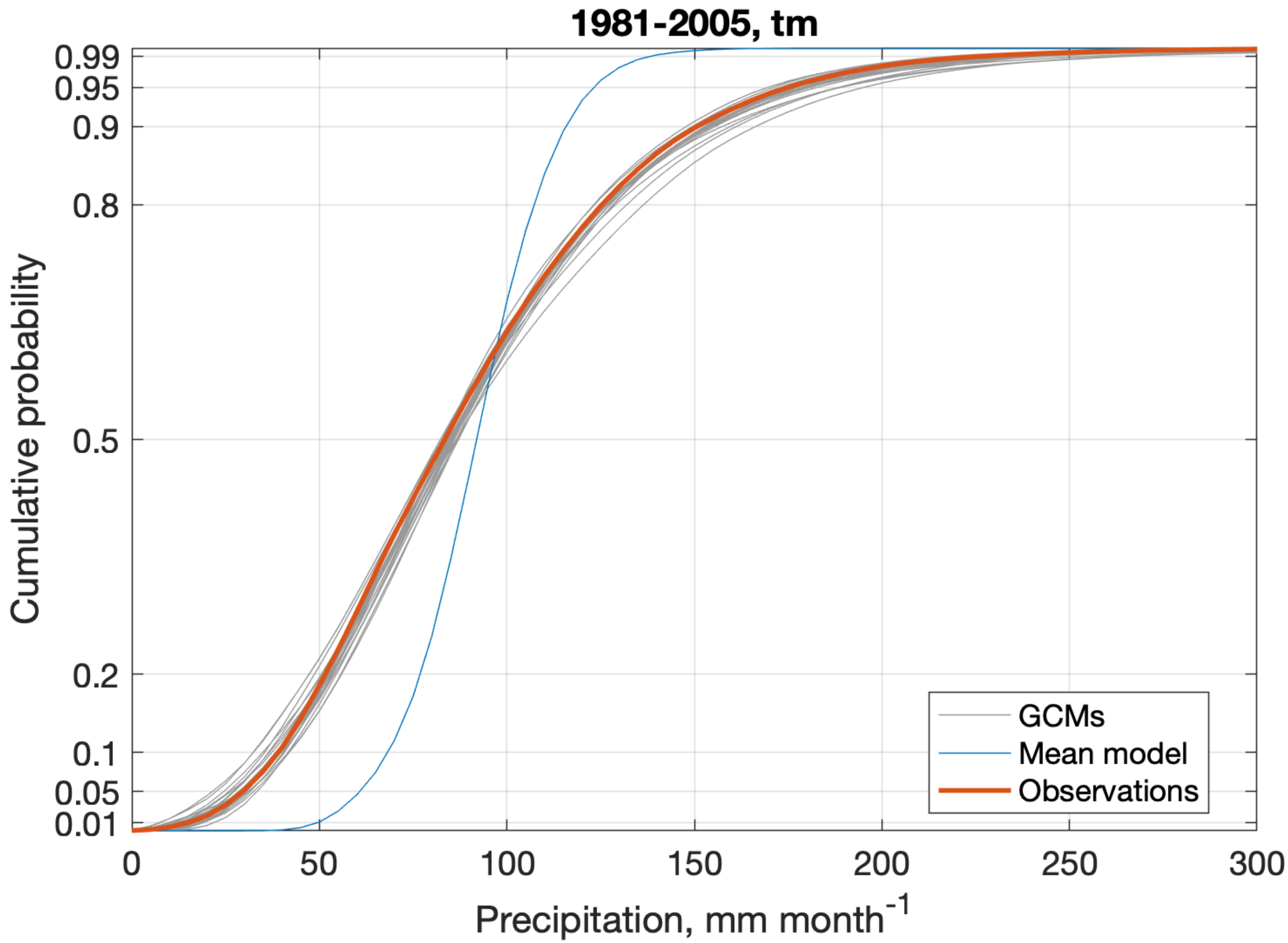
A closer look at KKZ rank 1 model

15 IPSL-CM5B-LR (France)

… suggests that it can be used as daily forcing for a potential sensitivity run to contrast the standard "delta forcing approach" used in all CHAMP simulations so far

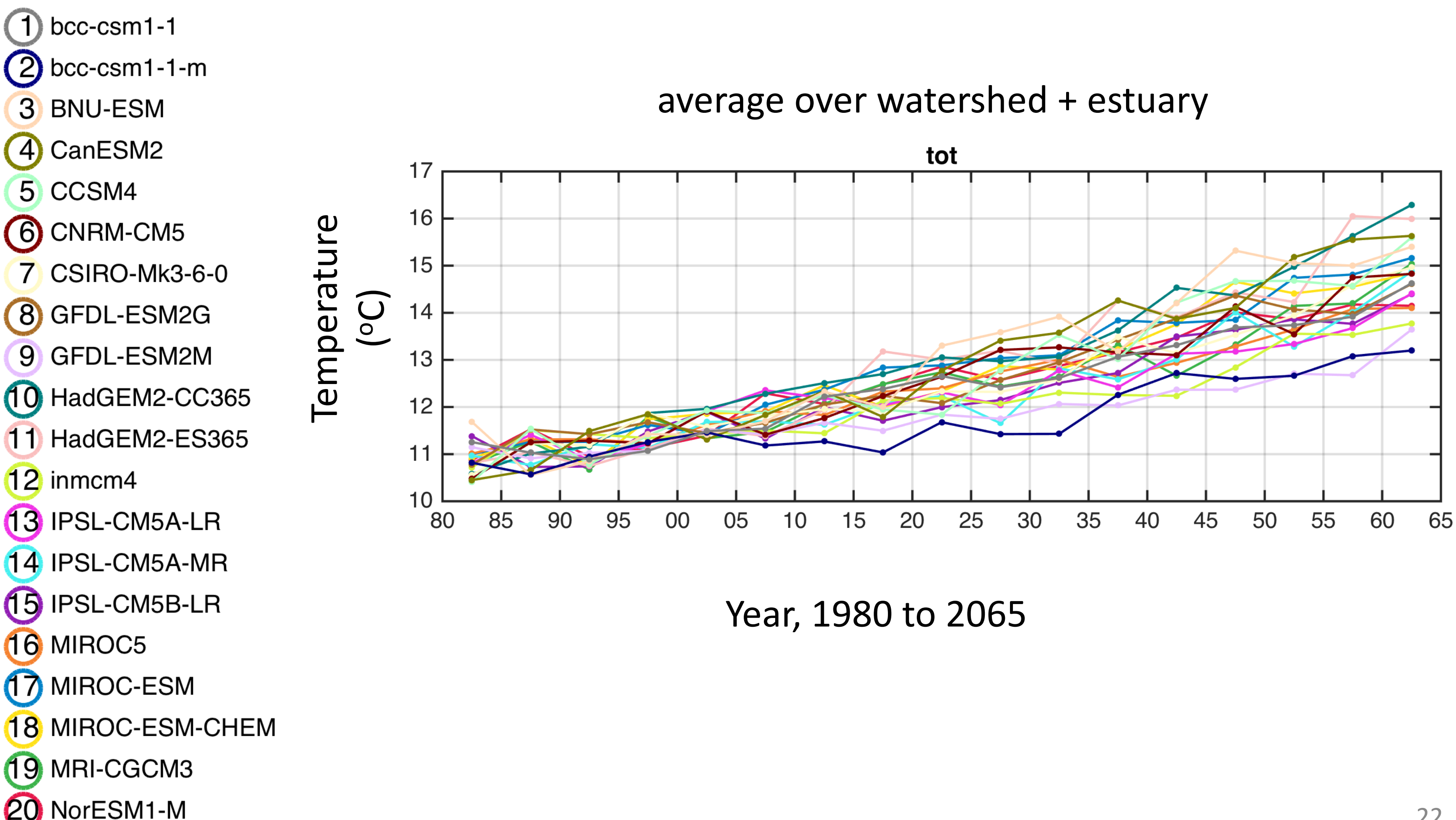
Extra slides


1981-2005, tm
Cumulative probability
0.99
0.95
0.9
0.8
0.5
0.2
0.1
0.05
0.01
-15
-10
-5
0
5
10
15
20
25
30
35
Temperature, °C
GCMs
Mean model
Observations

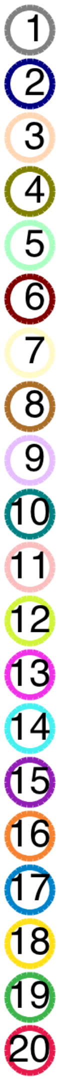


1981-2005, tm
0.99
0.95
0.9
0.8
0.5
0.2
0.1
0.05
0.01
Cumulative probability
0
50
100
150
200
250
300
Precipitation, mm month-1
GCMs
Mean model
Observations

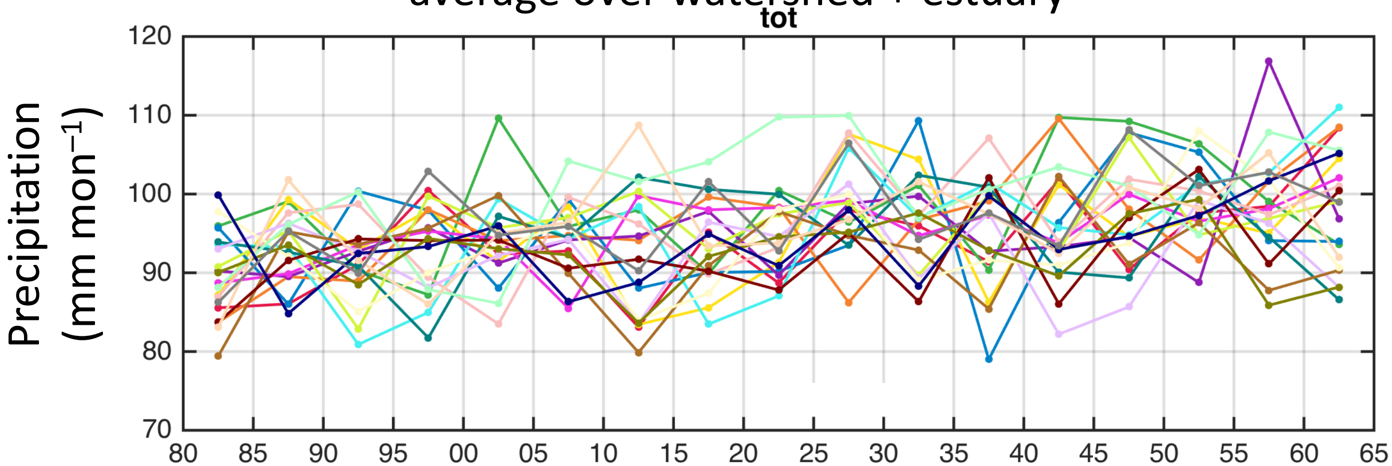
Models consistently simulate increases in temperature



Model precipitation secular change is small compared to natural variability



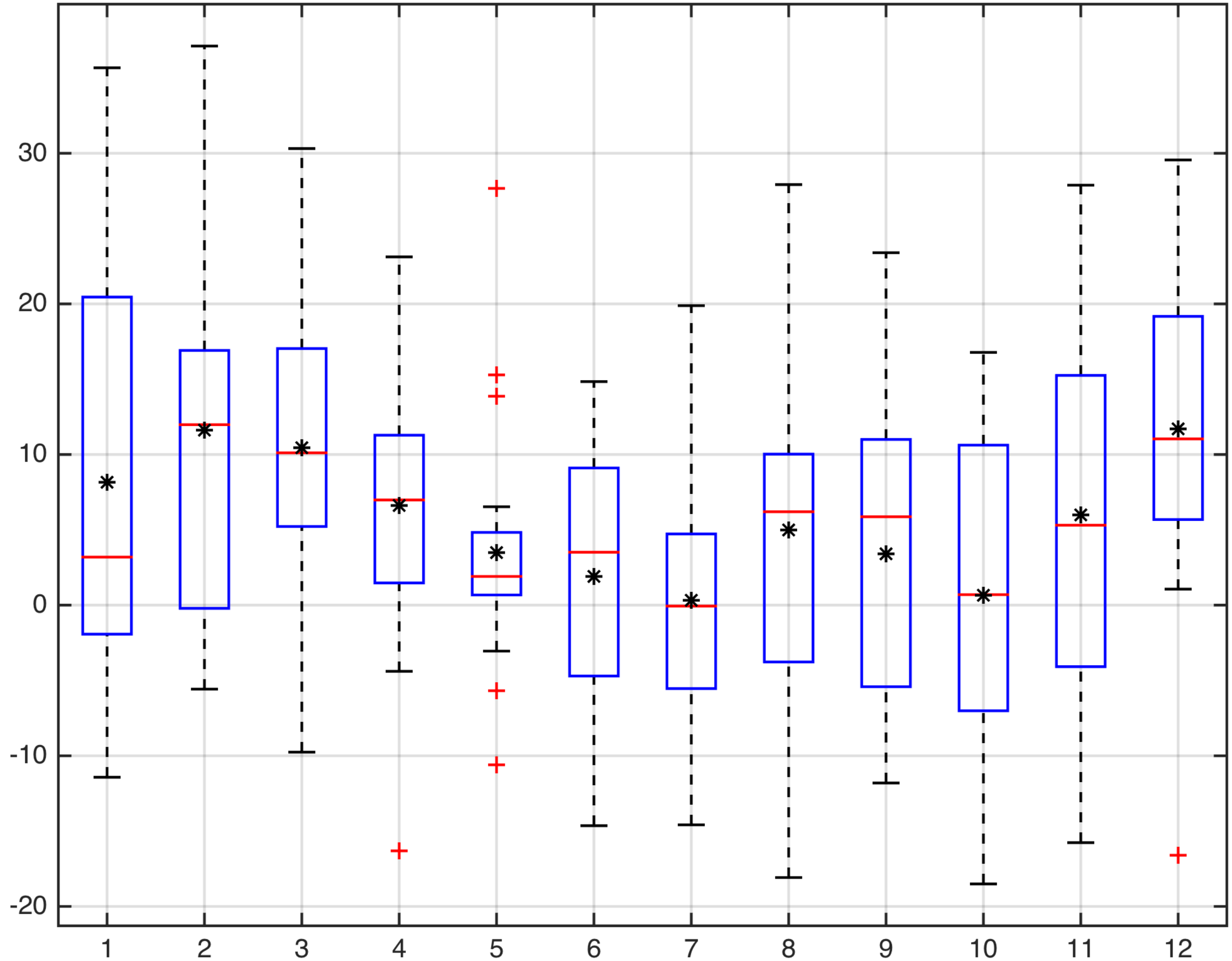
average over watershed + estuary



Year, 1980 to 2065

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

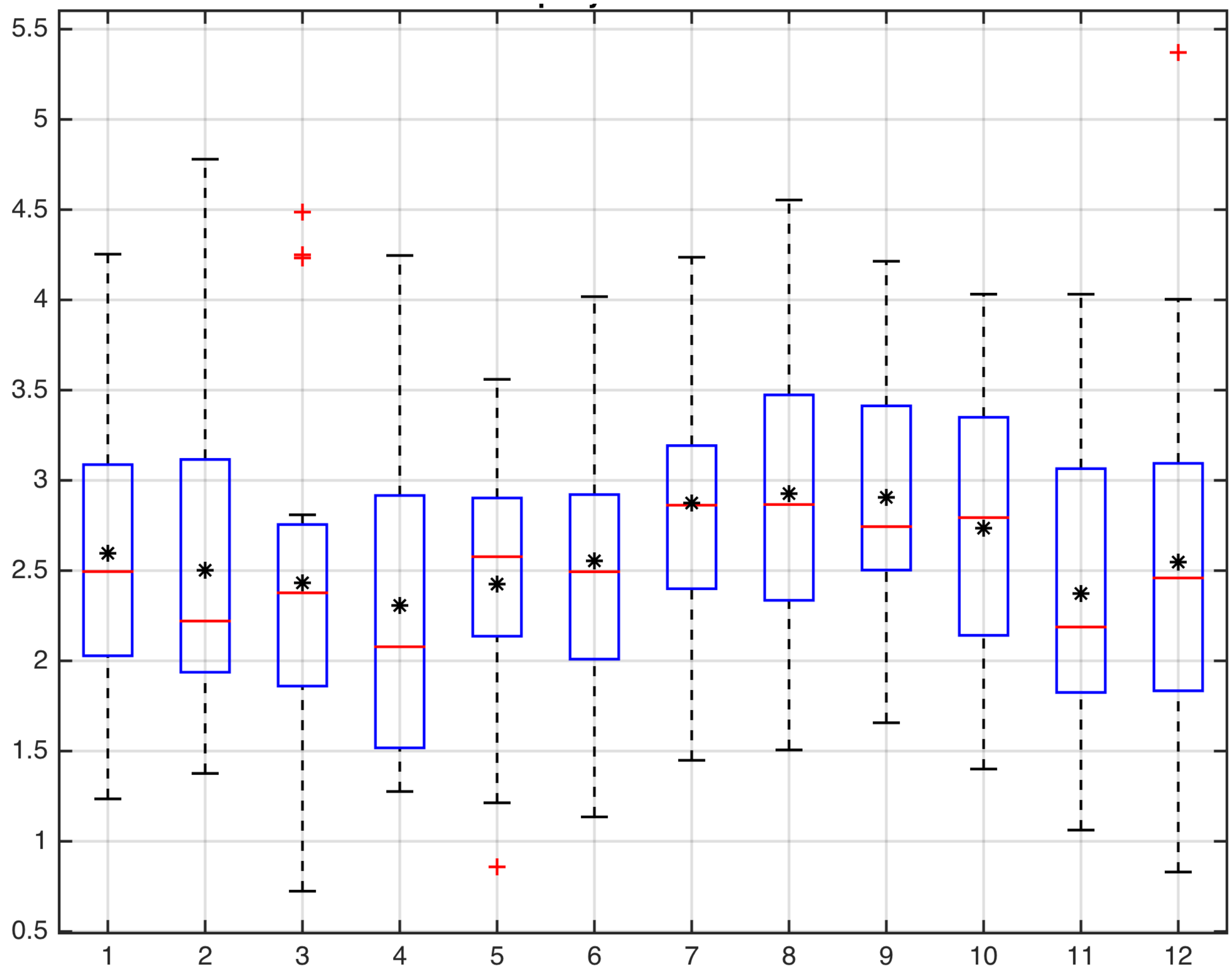
Precipitation change (%) from 1995 to 2050



month

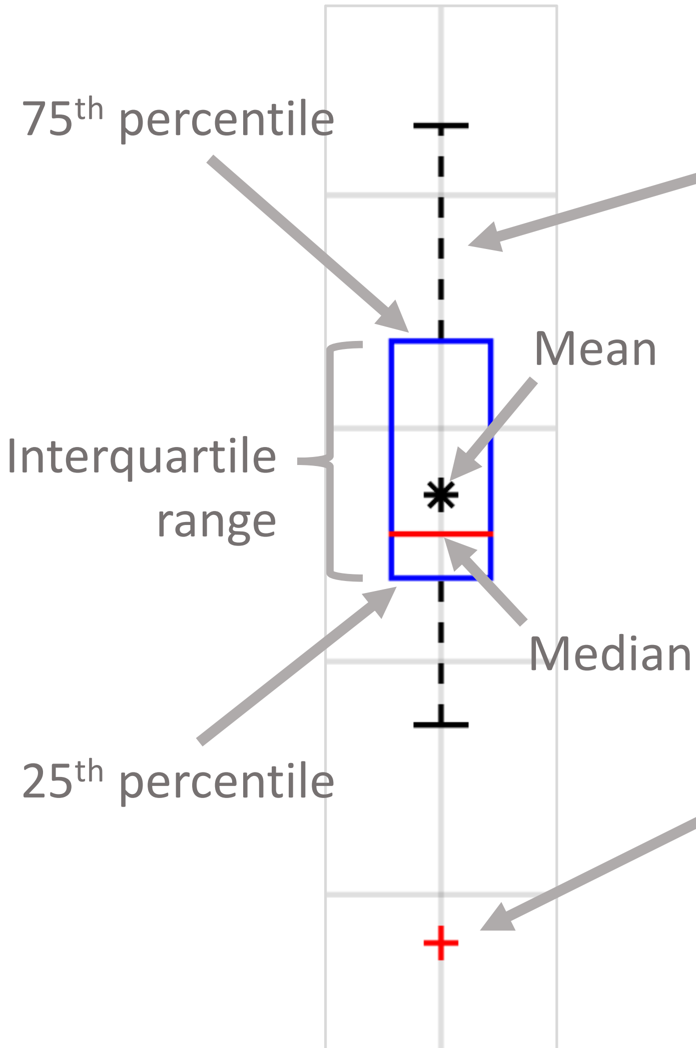
Warming is slightly greater in the summer

Temperature change (^oC) from 1995 to 2050



month

Box plot setup to summarize 20 GCMs



The whiskers extend to the most extreme data points not considered outliers

Data points outside 1.5 times the interquartile range from the 25th and 75th percentiles are plotted as individual points (outliers)

Summary of the Multivariate Adaptive Constructed Analogs (MACA) statistical downscaling product for CHAMP

- MACAv2 with METDATA training data
- $^{1}/_{4}$ ° (~4 km)
- RCP8.5
- All 20 models
- Air temperature, precipitation, vapor pressure, wind velocity, shortwave radiation, longwave radiation (computed)
- Mean annual cycles at monthly resolution in 5-year averages: 1981–1985, 1986–1990, … , 2061–2065
- Model ranking using the revised KKZ algorithm

GCM numbering

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

Summary of processed variables

Long Name	Name	Units
'vapor_pressure'	'vpres'	'Pa'
'atmospheric_pressure'	'pres'	'Pa'
'net_downwelling_short_wave_radiation'	'swr'	'W m-2'
'net_downwelling_long_wave_radiation'	'lwr'	'W m-2'
'precipitation_flux'	'precip'	'mm month-1'
'average_daily_air_temperature'	'temp'	'K'
'eastward_wind'	'uwind'	'm s-1'
'northward_wind'	'vwind'	'm s-1'
'wind_speed'	'wspd'	'm s-1'
'specific_humidity'	'shumidity'	'kg kg-1'
'min_daily_air_temperature'	'tempmin'	'K'
'max_daily_air_temperature'	'tempmax'	'K'

List of CMIP5 GCMs used in MACA product

Model Name	Model Country	Model Agency	Atmosphere Resolution(Lon x Lat)	Ensemble Used
bcc-csm1-1	China	Beijing Climate Center, China Meteorological Administration	2.8 deg x 2.8 deg	r1i1p1
bcc-csm1-1-m	China	Beijing Climate Center, China Meteorological Administration	1.12 deg x 1.12 deg	r1i1p1
BNU-ESM	China	College of Global Change and Earth System Science, Beijing Normal University, China	2.8 deg x 2.8 deg	r1i1p1
CanESM2	Canada	Canadian Centre for Climate Modeling and Analysis	2.8 deg x 2.8 deg	r1i1p1
CCSM4	USA	National Center of Atmospheric Research, USA	1.25 deg x 0.94 deg	r6i1p1
CNRM-CM5	France	National Centre of Meteorological Research, France	1.4 deg x 1.4 deg	r1i1p1
CSIRO-Mk3-6-0	Australia	Commonwealth Scientific and Industrial Research Organization/Queensland Climate Change Centre of Excellence, Australia	1.8 deg x 1.8 deg	r1i1p1
GFDL-ESM2M	USA	NOAA Geophysical Fluid Dynamics Laboratory, USA	2.5 deg x 2.0 deg	r1i1p1
GFDL-ESM2G	USA	NOAA Geophysical Fluid Dynamics Laboratory, USA	2.5 deg x 2.0 deg	r1i1p1
HadGEM2-ES	United Kingdom	Met Office Hadley Center, UK	1.88 deg x 1.25 deg	r1i1p1
HadGEM2-CC	United Kingdom	Met Office Hadley Center, UK	1.88 deg x 1.25 deg	r1i1p1
inmcm4	Russia	Institute for Numerical Mathematics, Russia	2.0 deg x 1.5 deg	r1i1p1
IPSL-CM5A-LR	France	Institut Pierre Simon Laplace, France	3.75 deg x 1.8 deg	r1i1p1
IPSL-CM5A-MR	France	Institut Pierre Simon Laplace, France	2.5 deg x 1.25 deg	r1i1p1
IPSL-CM5B-LR	France	Institut Pierre Simon Laplace, France	2.75 deg x 1.8 deg	r1i1p1
MIROC5	Japan	Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies,and Japan Agency for Marine-Earth Science and Technology	1.4 deg x 1.4 deg	r1i1p1
MIROC-ESM	Japan	Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies	2.8 deg x 2.8 deg	r1i1p1
MIROC-ESM-CHEM	Japan	Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies	2.8 deg x 2.8 deg	r1i1p1
MRI-CGCM3	Japan	Meteorological Research Institute, Japan	1.1 deg x 1.1 deg	r1i1p1
NorESM1-M	Norway	Norwegian Climate Center, Norway	2.5 deg x 1.9 deg	r1i1p1