CHAMP Climate Projections Update

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CHAMP Team Meeting

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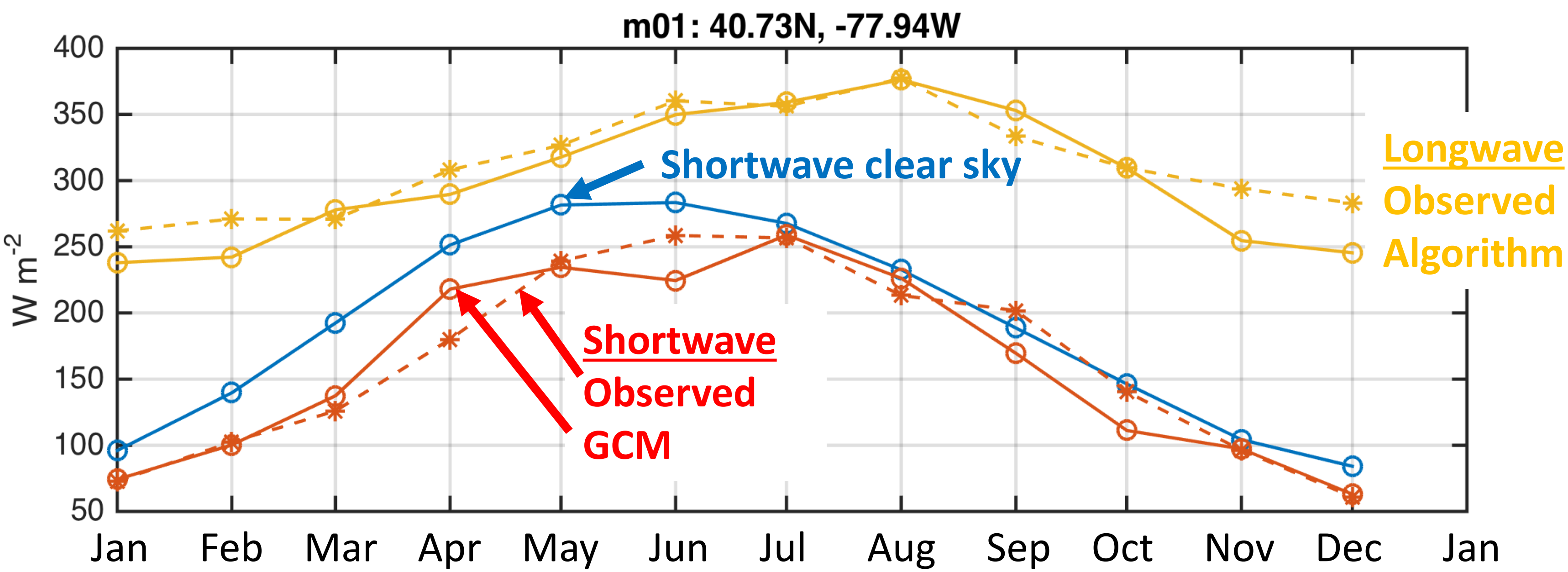
Outline: What’s new since the last meeting?

- Longer record
- Longwave radiation algorithm
- Model selection strategy
- Comparison of two downscaling products

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

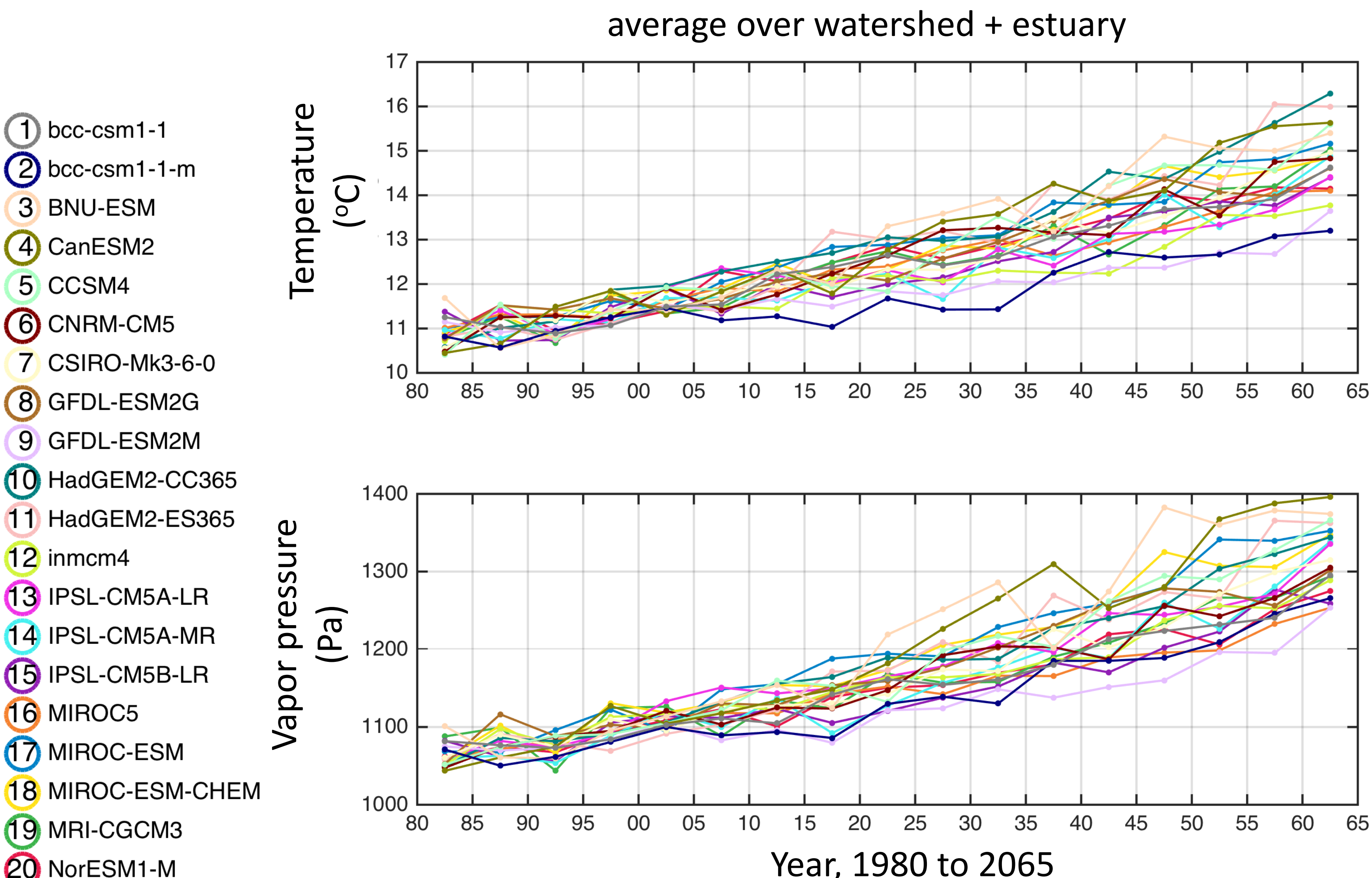
- MACAv2 with METDATA training data
- $^{1}/_{4}$ ° (~4 km)
- RCP8.5
- All 20 models
- Air temperature, precipitation, vapor pressure, wind velocity, shortwave radiation, longwave radiation (computed)
- Mean annual cycles at monthly resolution in 5-year averages: 1981–1985, 1986–1990, … , 2061–2065
-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

Longwave radiation algorithm works well

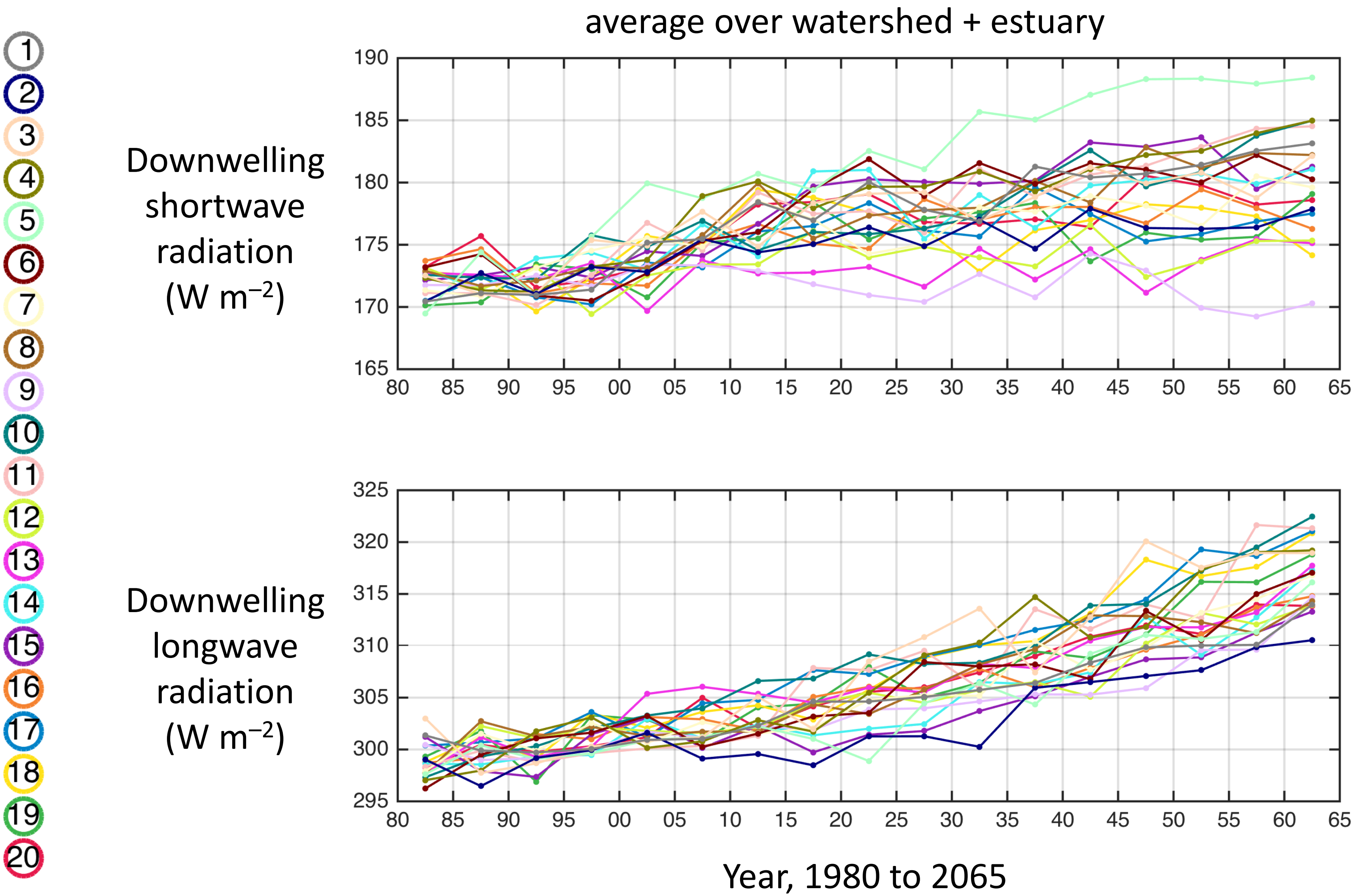


GCM is bcc-csm1-1, output is 2000-2004, observations from State College for 2001 from Global Baseline Surface Radiation Network (Bohn et al., 2013)

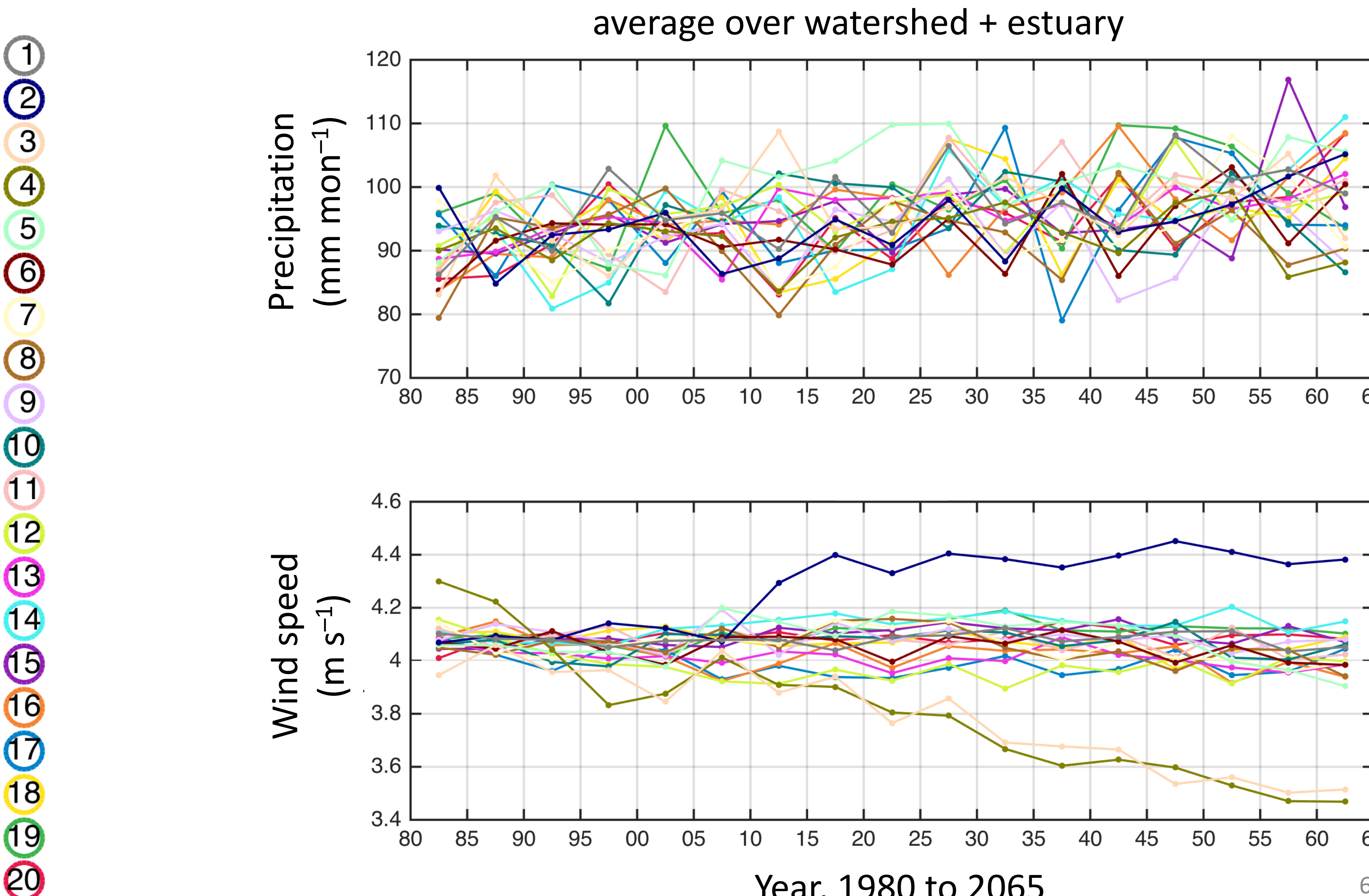
Models consistently simulate increases in temperature and humidity



Models consistently simulate increases in shortwave and longwave radiation



Model precip. and wind secular change is small compared to natural variability



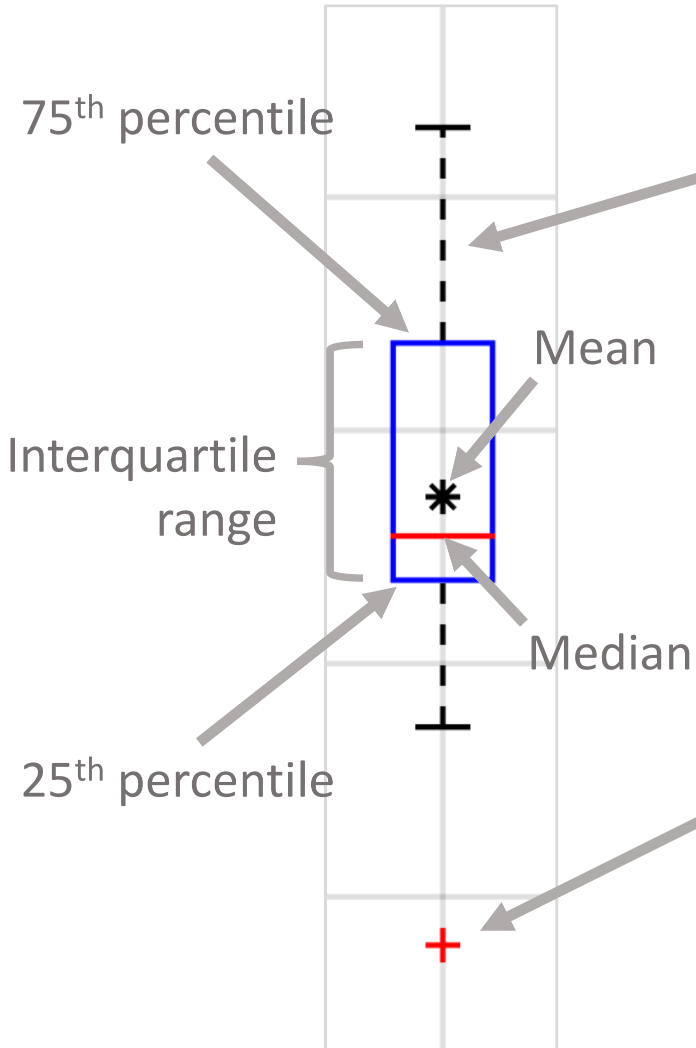
30-year time periods for calculating changes in climate variables

1981–2010 ➔ “1995” (HISTORIC)

2011–2040 ➔ “2025”

2036–2065 ➔ “2050”

Box plot setup to summarize 20 GCMs

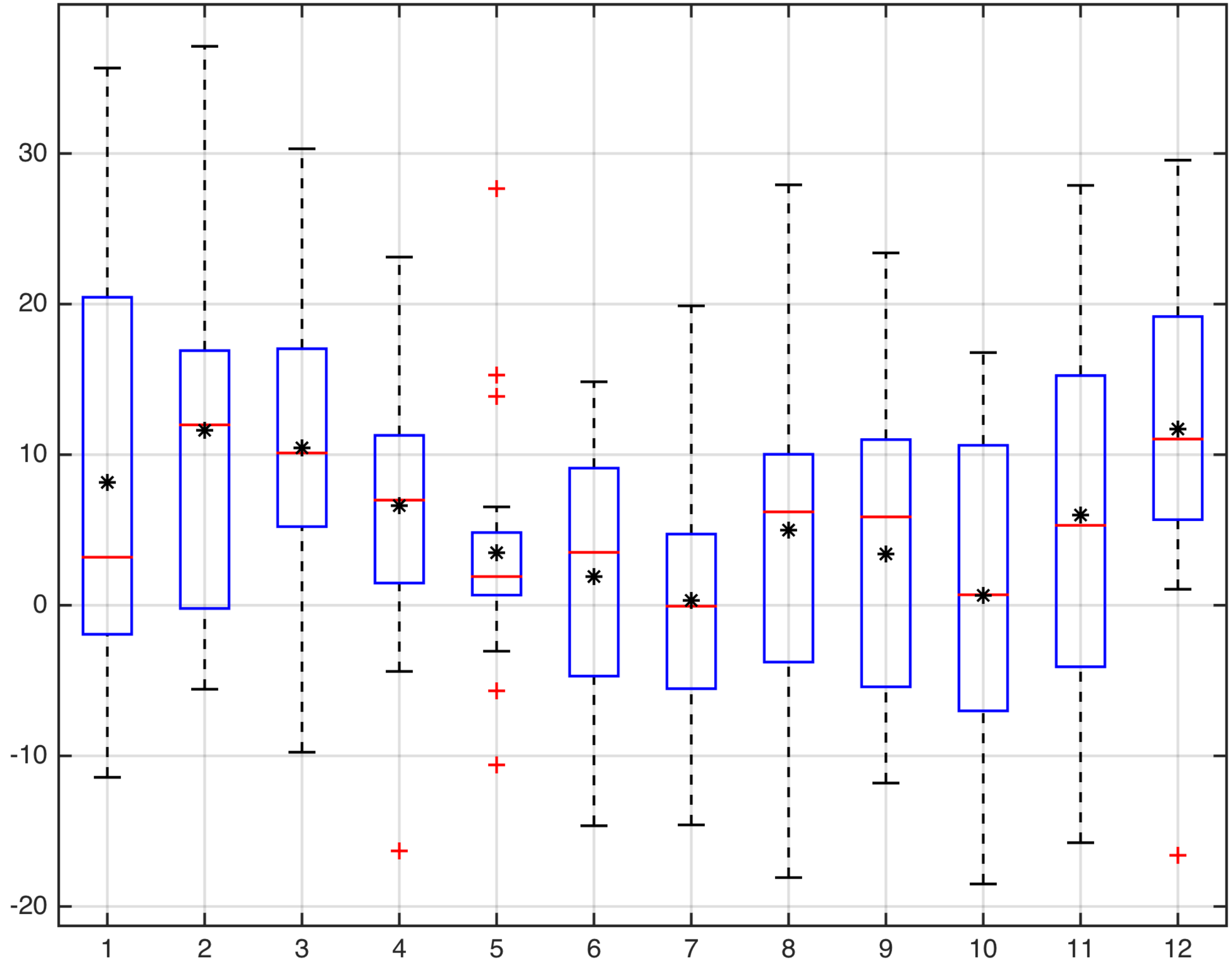


The whiskers extend to the most extreme data points not considered outliers

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

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

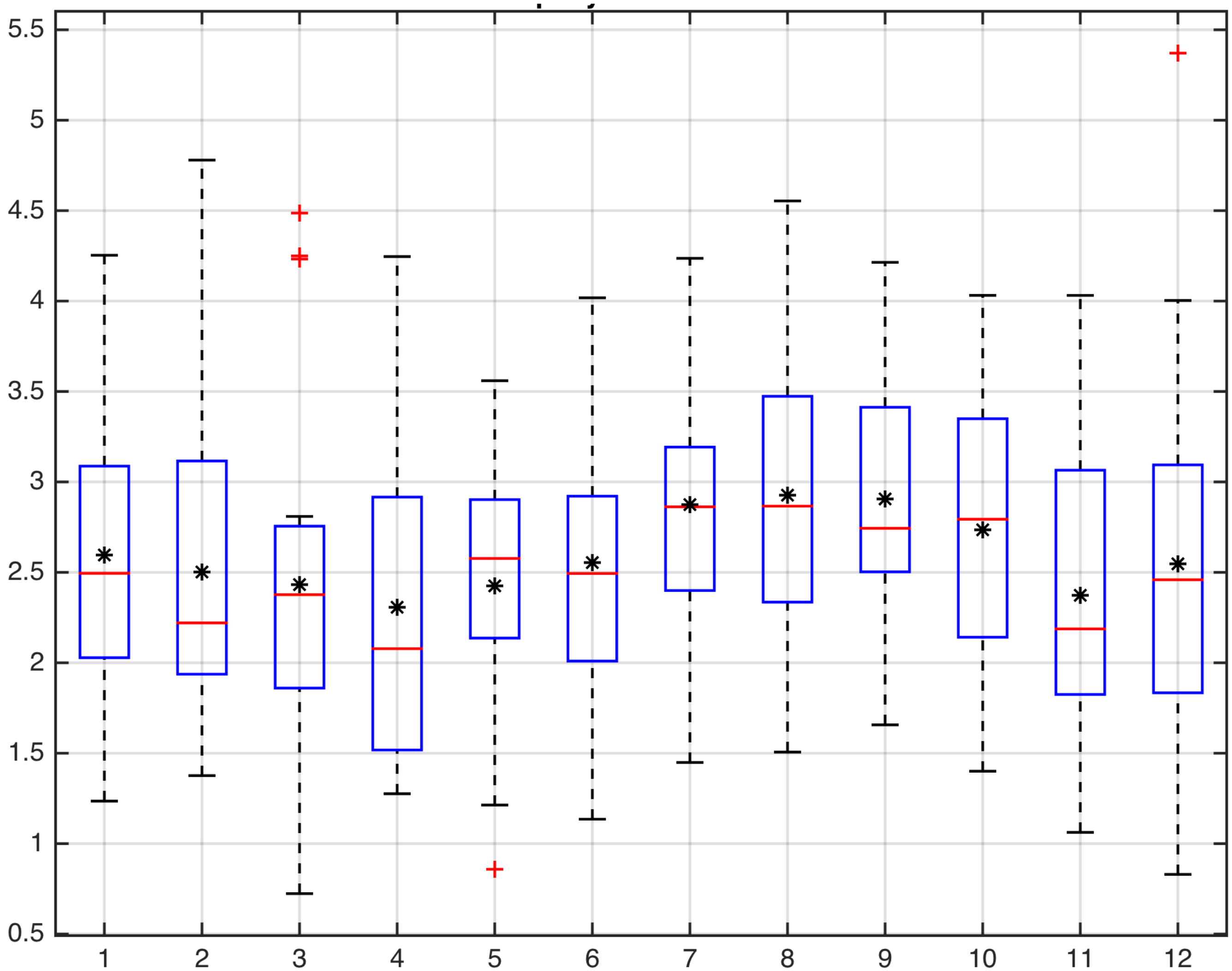
Precipitation change (%) from 1995 to 2050



month

Warming is slightly greater in the summer

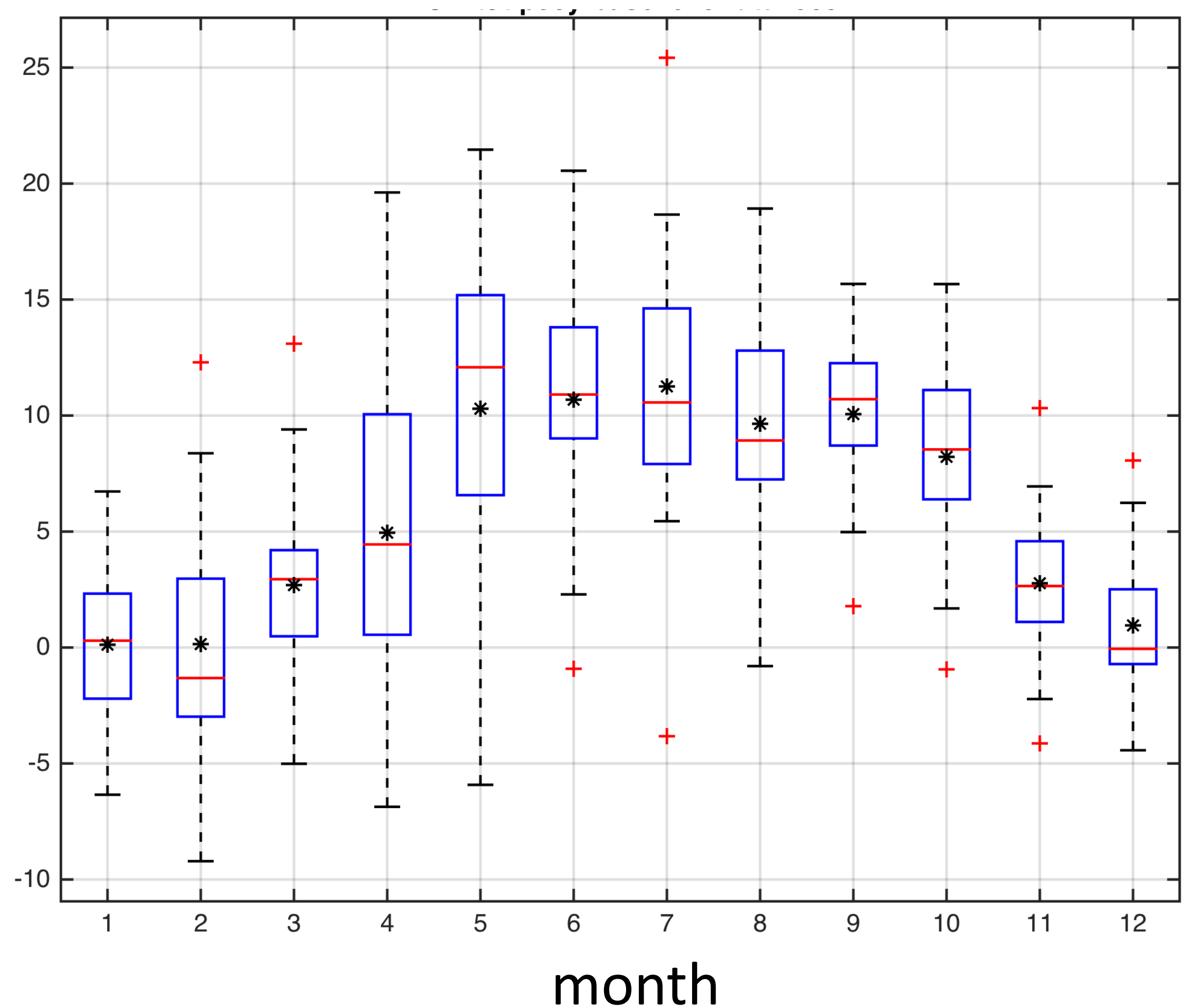
Temperature change (°C) from 1995 to 2050



month

Absolute increases in solar radiation are greatest in the summer

Solar radiation change (W m^{-2}) from 1995 to 2050



Similar changes seen in longwave radiation and vapor pressure

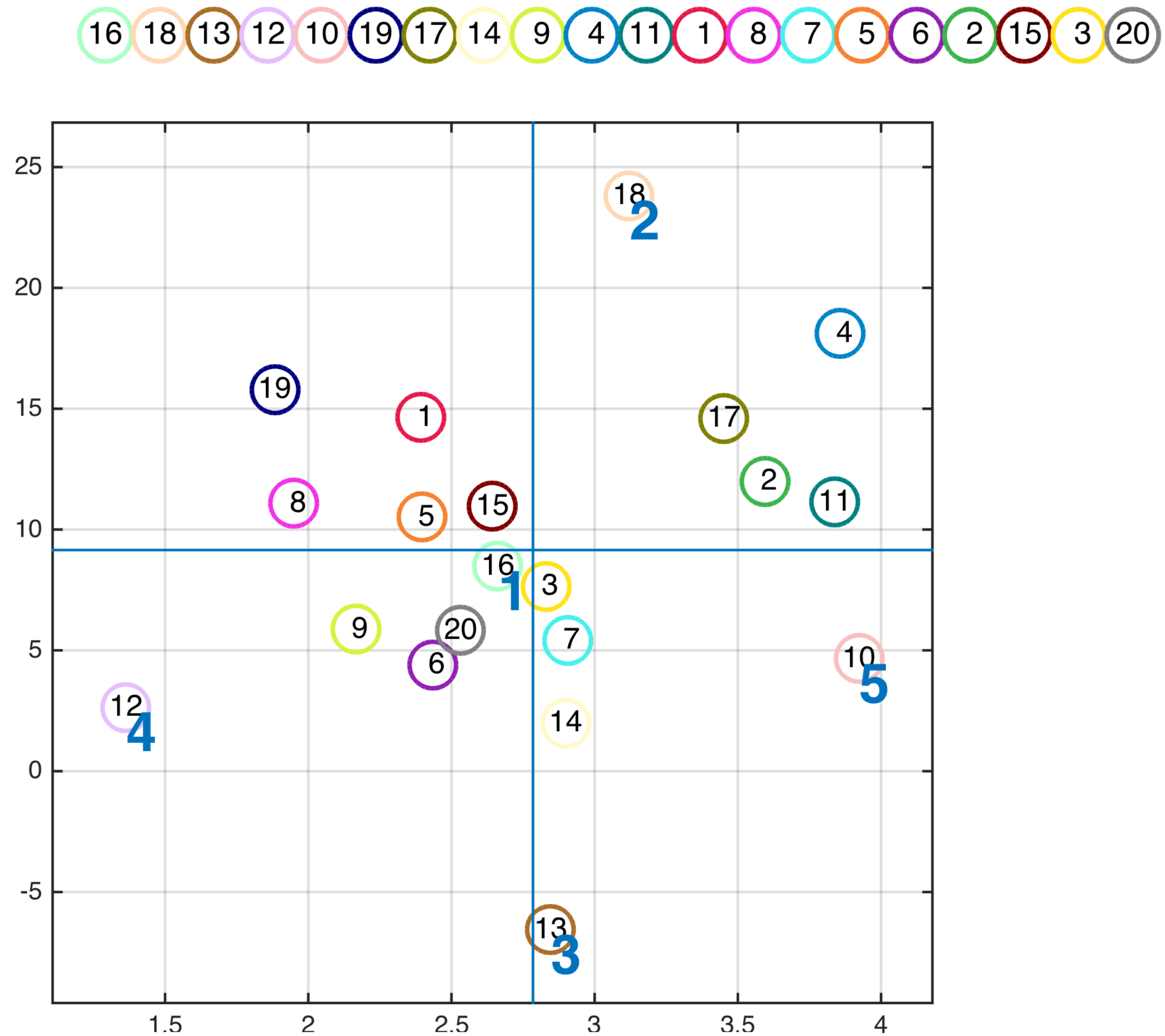
Katsavoundis–Kuo–Zhang (KKZ) algorithm for GCM selection

1. The first GCM lies closest to the ensemble centroid*
2. The second GCM lies farthest from the first GCM
3. To select the next GCM,
   A. calculate distances from each remaining GCM to the previously selected GCMs;
   B. associate each remaining GCM with the minimum distance calculated in step 3.A
   C. choose the GCM with the maximum distance in step 3.B
4. Repeat step 3 until all GCMs have been selected

*Variables are first standardized to zero mean and unit standard deviation (*Z*-scores)

Katsavounidis et al. (1994)

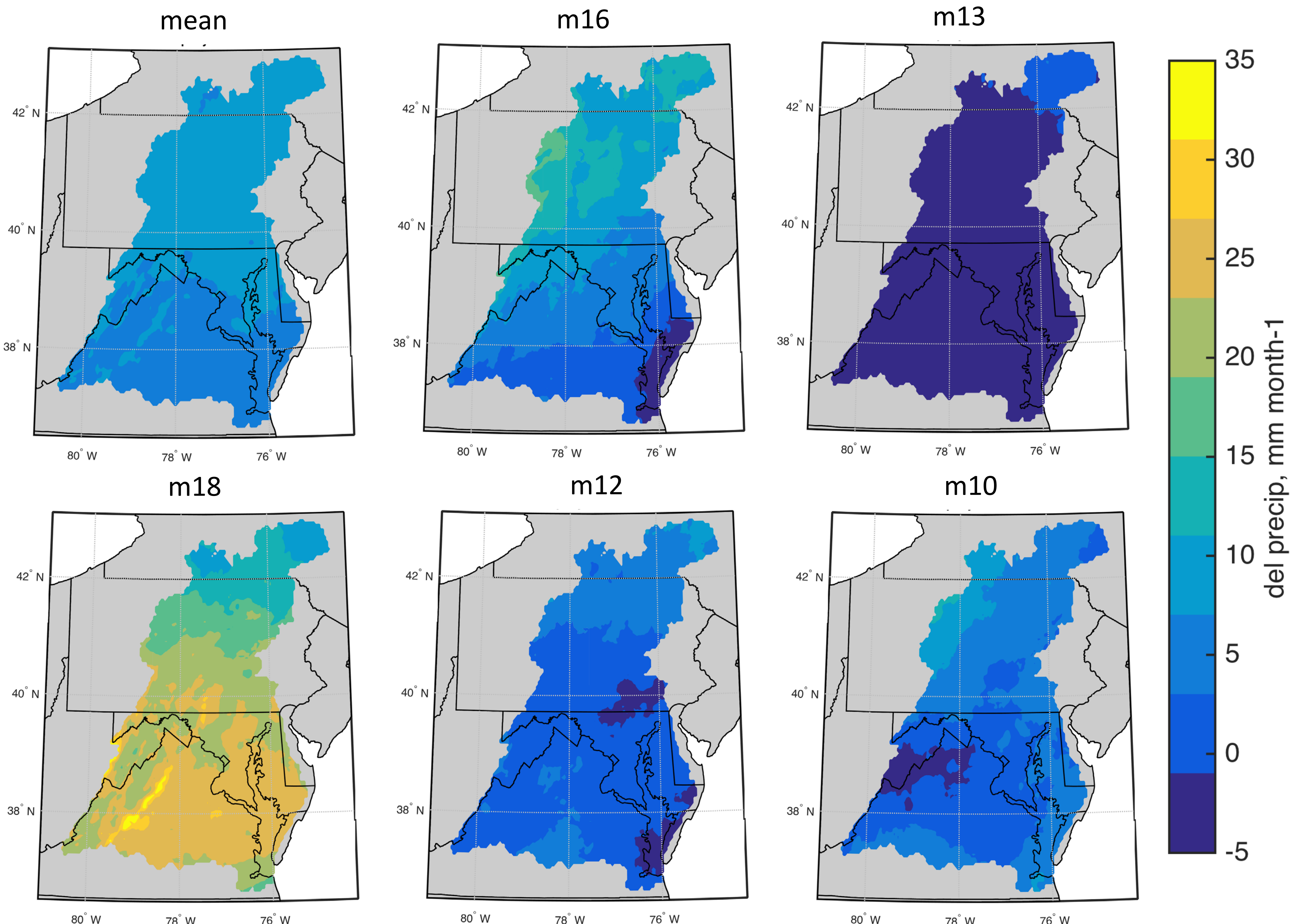
Model ranks based on 1995–2050 change in JJA temperature and FMA precipitation



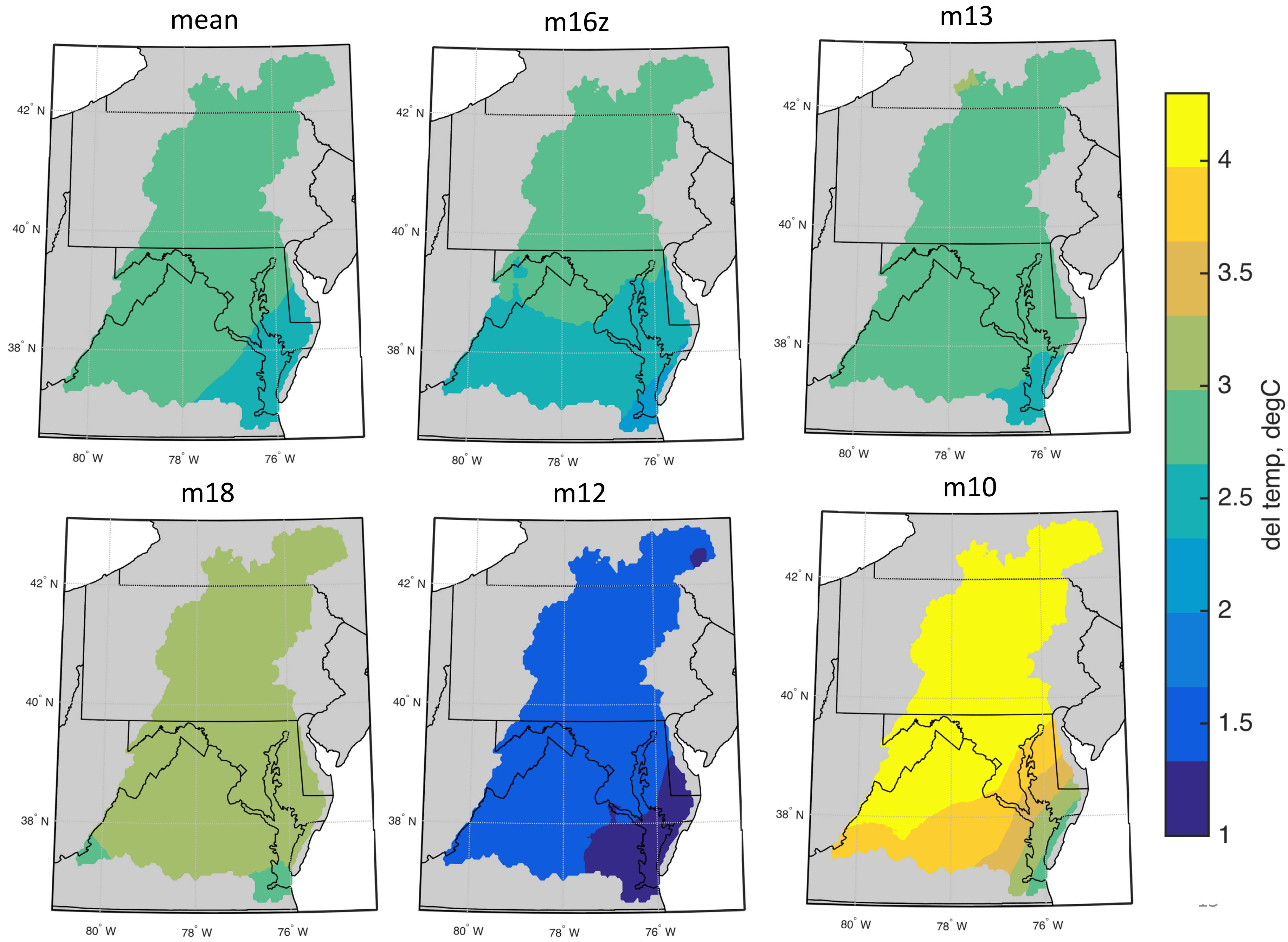
Precipitation change (%)

Temperature change (°C)

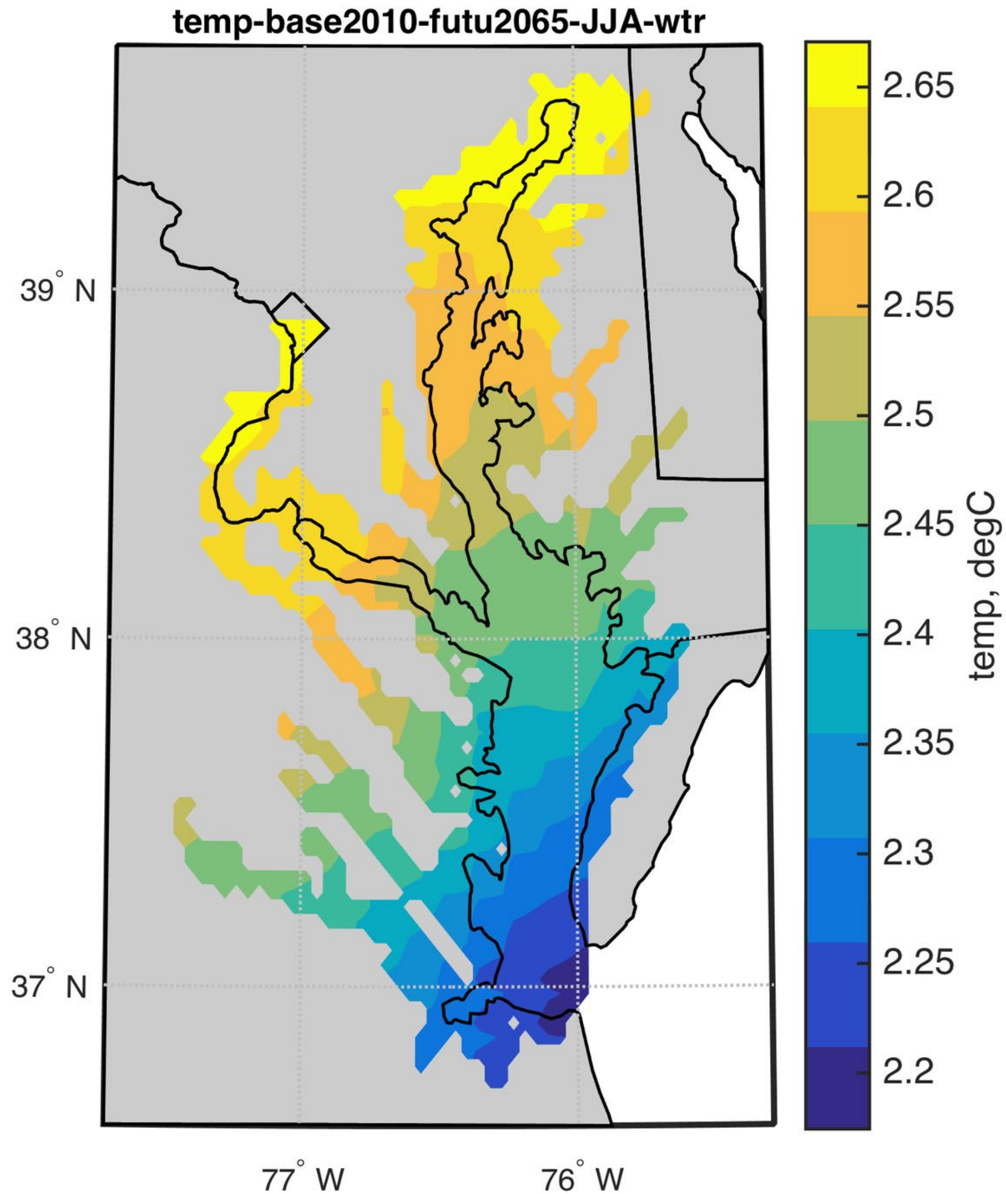
1995–2050 FMA ΔP for the 20-model and the first 5 KKZ



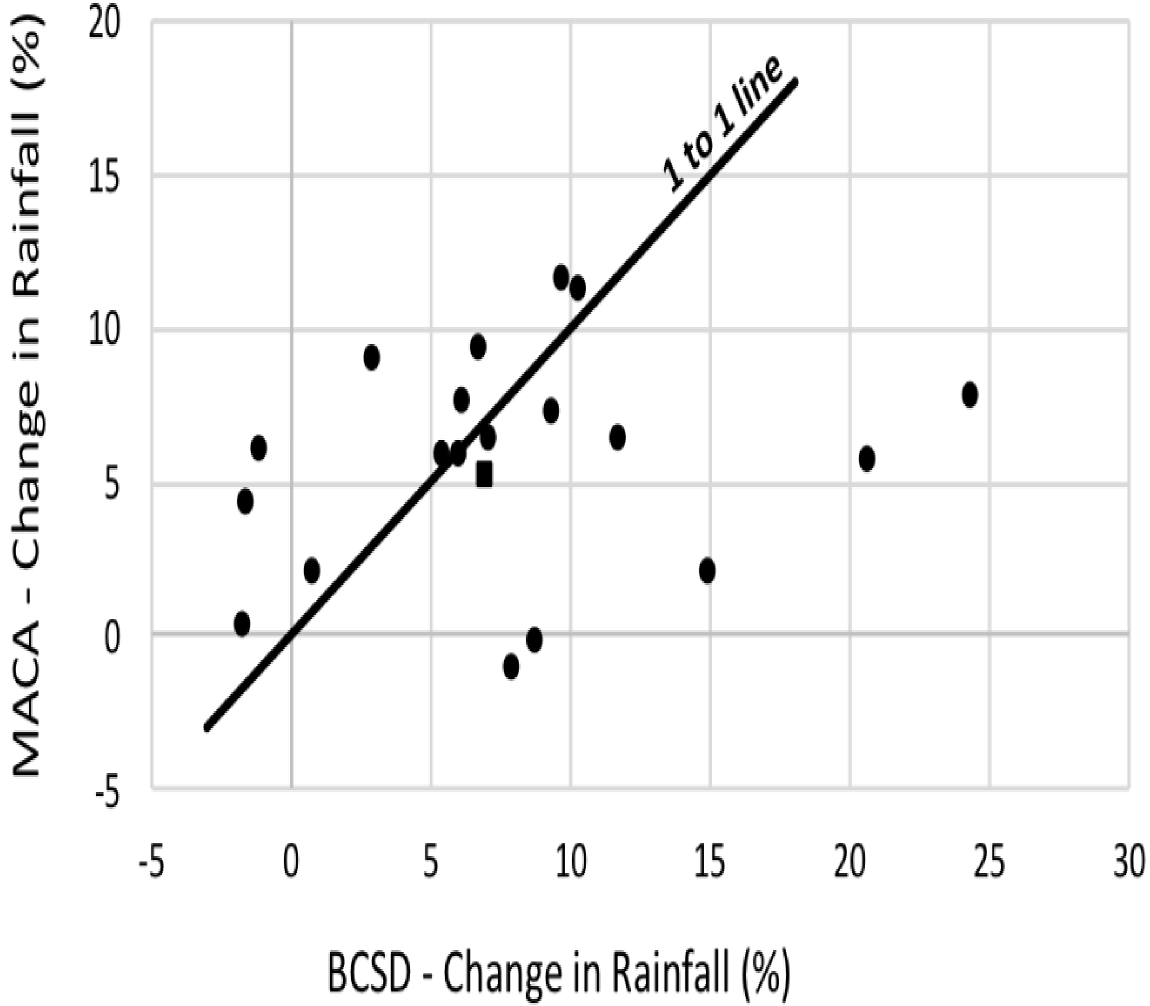
1995–2050 JJA ΔT for the 20-model mean and the first 5 KKZ



1995–2050 JJA ΔT for the 20-model mean

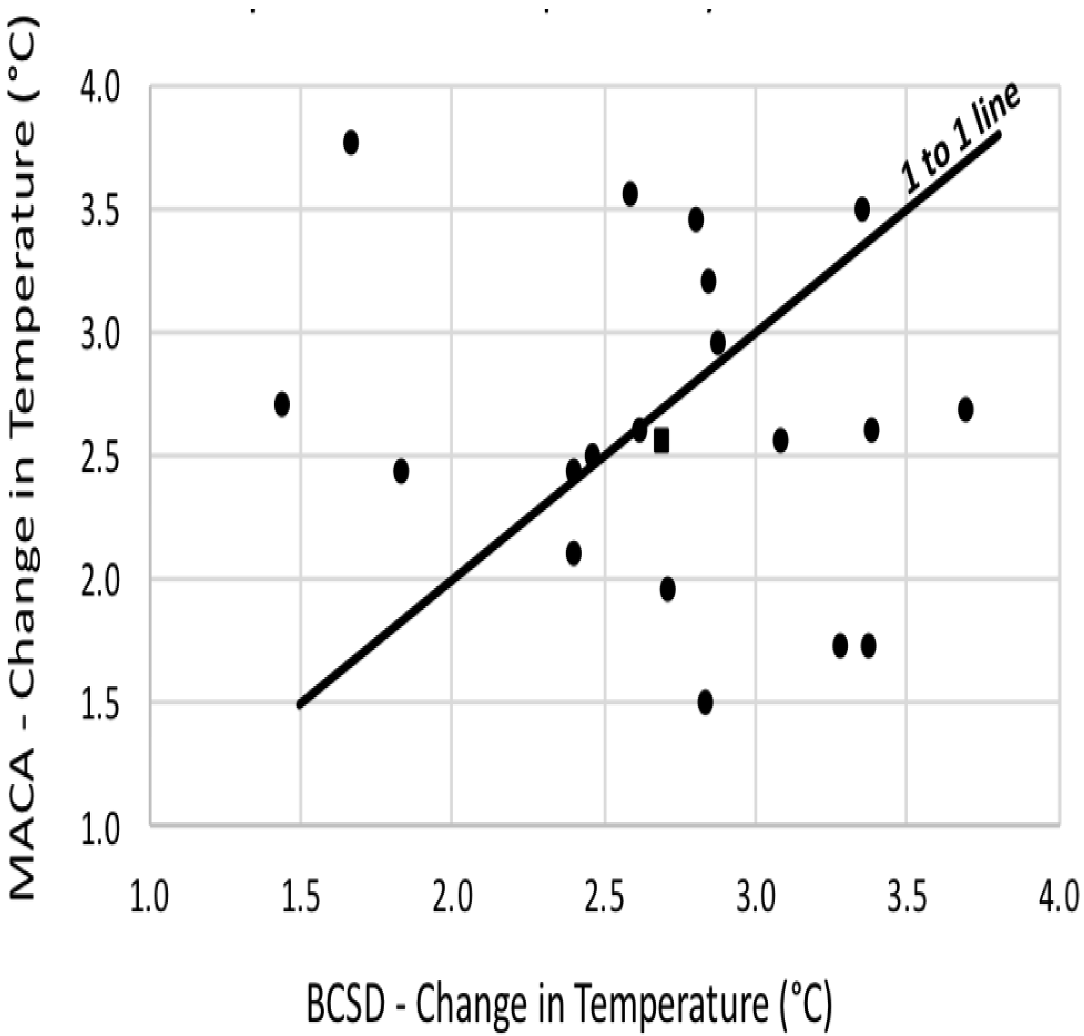


The projected precipitation is very sensitive to the downscaling technique



Change is 1995 to 2050, averaged over watershed

Same goes for temperature



Change is 1995 to 2050, averaged over watershed

Extra slides

GCM numbering

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

Summary of Penn State products

- Mean annual cycles in 5-year averages from 1981 to 2065 of climate variables for 20 GCMs on CHAMP BOX

  data_p5y_mat ➔ in Matlab format: see metadata.m
  data_p5y_nc ➔ NetCDF format: see attributes

  Calculated: vapor pressure (also air pressure and average daily temperature as intermediate variables), long wave radiation, wind speed

- 20 GCMs ranked using KKZ algorithm (maximizes spread among the sub-set of models) base on JJA temperature and FMA precipitation changes between 30-year periods centered on
  (1) 2050 and 1990 16 18 13 12 10 19 17 14 9 4 11 1 8 7 5 6 2 15 3 20
  (2) 2025 and 1990 14 13 4 8 12 17 18 3 9 16 20 11 10 6 5 7 19 15 1 2

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