

New Views on Future Northwest Climate

How will extremes change in
relationship to changes in means?

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Extremes vs. Means

In general (Kharin et al. 2013):

Changes in **warm** extremes follow changes in
mean summer temperature

Extremes vs. Means

In general (Kharin et al. 2013):

Changes in warm extremes follow changes in
mean summer temperature

Changes in **cold** extremes exceed changes in
mean winter temperature*

*Where snow and sea ice retreat.

Extremes vs. Means

In general (Kharin et al. 2013):

Changes in warm extremes follow changes in
mean summer temperature

Changes in cold extremes exceed changes in
mean winter temperature*

Changes in intensity of **precipitation** extremes
exceed changes in mean precipitation
intensity

Objective

**Examine projected changes in daily temperature
and precipitation extremes vs. means over the
Northwest from a new statistically downscaled
dataset**

Questions

How do patterns of change vary across space?

**Are patterns of change consistent across global
climate models (GCMs)?**

Data

Daily output from 20 CMIP5* global climate models

**Statistically downscaled GCM output using
MACA* (1/16° ,~6 km)**

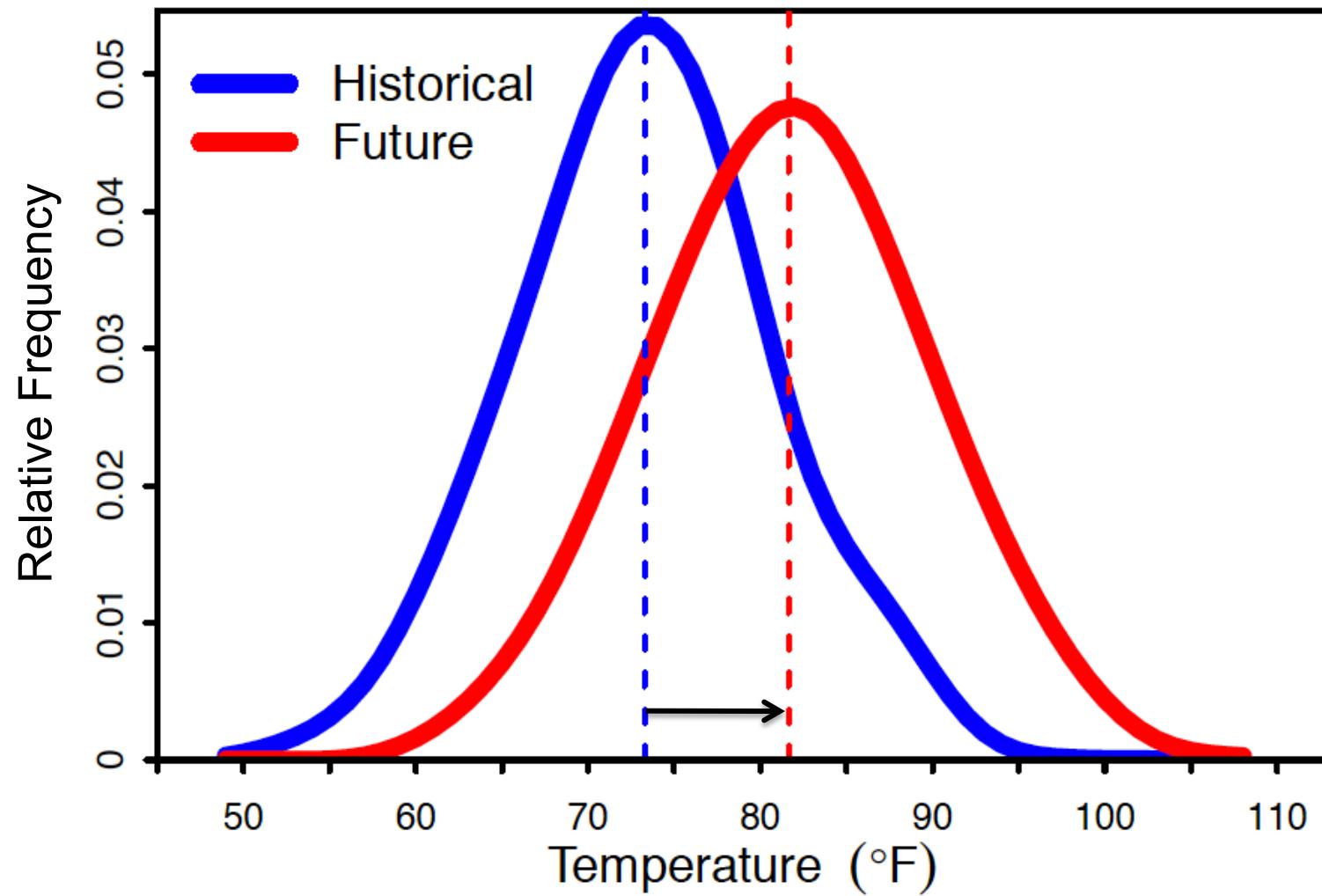
*Couple Model Intercomparison Project Phase 5.

**Multivariate Adaptive Constructed Analogs.

MACA*-Downscaled CMIP5 Models

Model	Country	Model	Country
CSIRO-Mk3-6-0	Australia	MIROC-ESM	Japan
CanESM2	Canada	MIROC-ESM-CHEM	Japan
BCC-CSM1-1	China	MRI-CGCM3	Japan
BCC-CSM1-1-M	China	NorESM1-M	Norway
BNU-ESM	China	INMCM4	Russia
CNRM-CM5	France	HadGEM2-CC	U.K.
IPSL-CM5A-LR	France	HadGEM2-ES	U.K.
IPSL-CM5A-MR	France	CCSM4	U.S.
IPSL-CM5B-LR	France	GFDL-ESM2M	U.S.
MIROC5	Japan	GFDL-ESM2G	U.S.

Changing probability distributions



JJA Tmax, western WA/OR, RCP8.5, CCSM4

Ensemble average changes

Average changes in means and 1st- or 99th-percentile daily extremes across 20 GCMs

1950-1999 vs. 2050-2099, RCP8.5

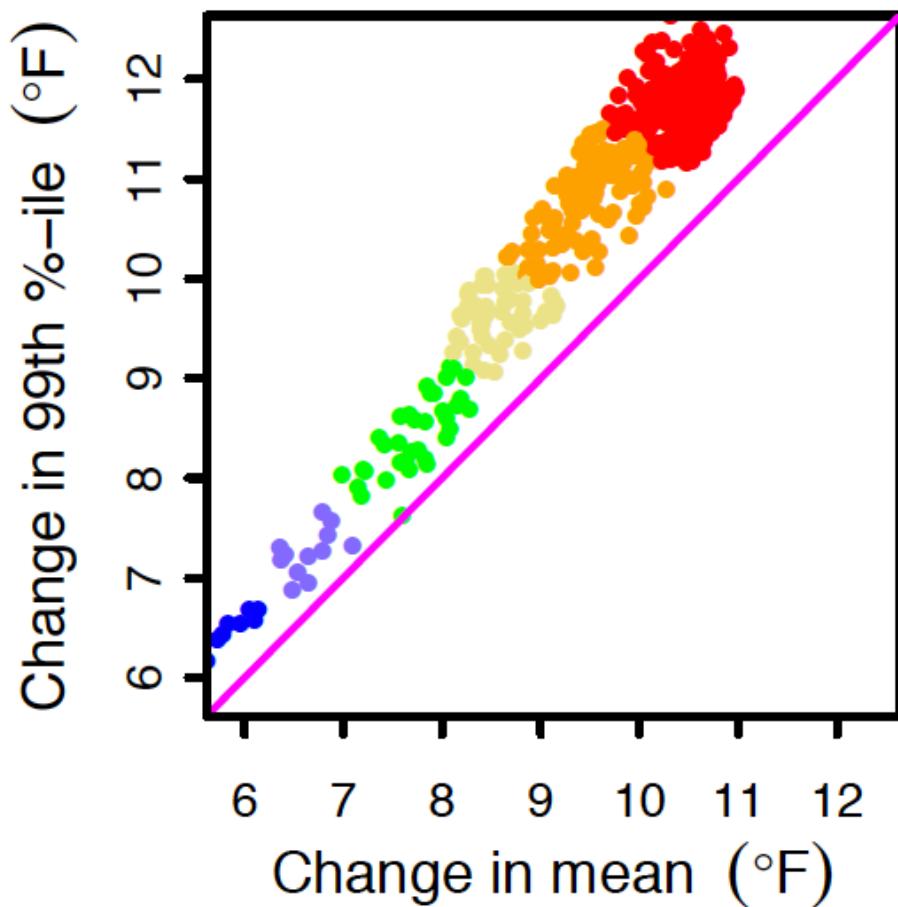
JJA Tmax: Summer daily maximum temperature

DJF Tmin: Winter daily minimum temperature

DJF Precip: Winter daily precipitation

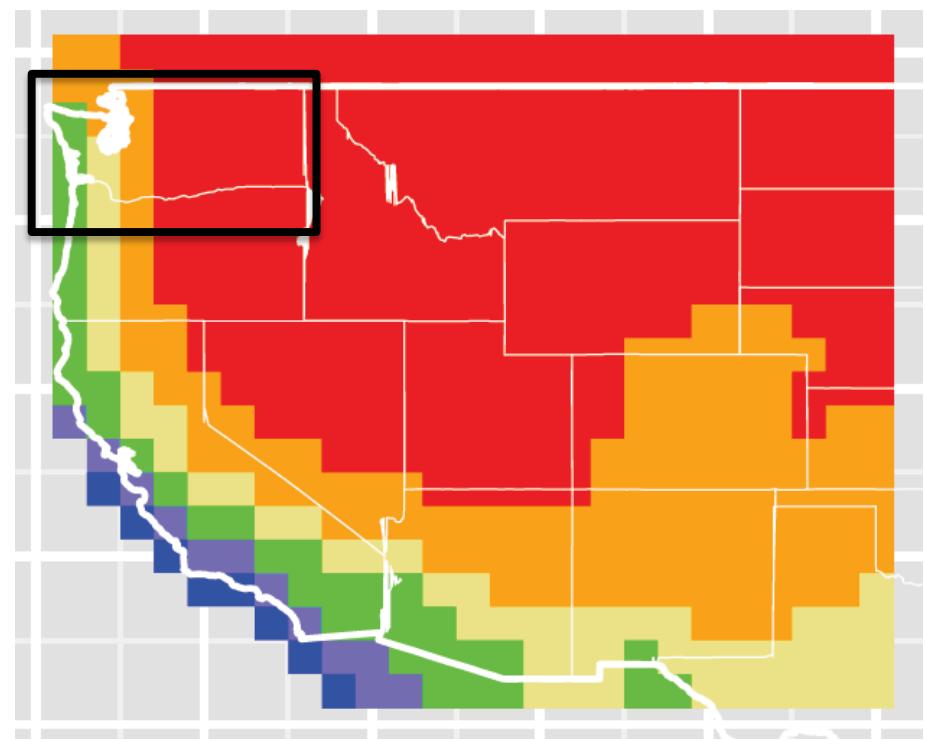
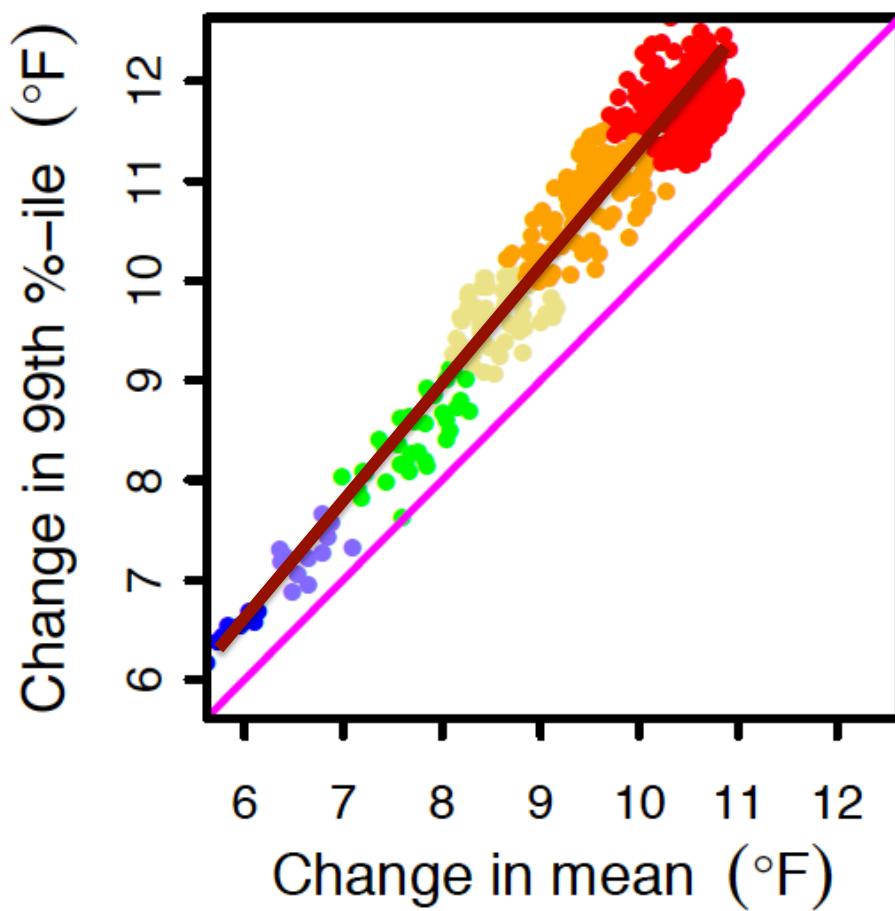
CMIP5 JJA Daily Tmax

1950-1999 to 2050-2099, RCP8.5, Ensemble mean



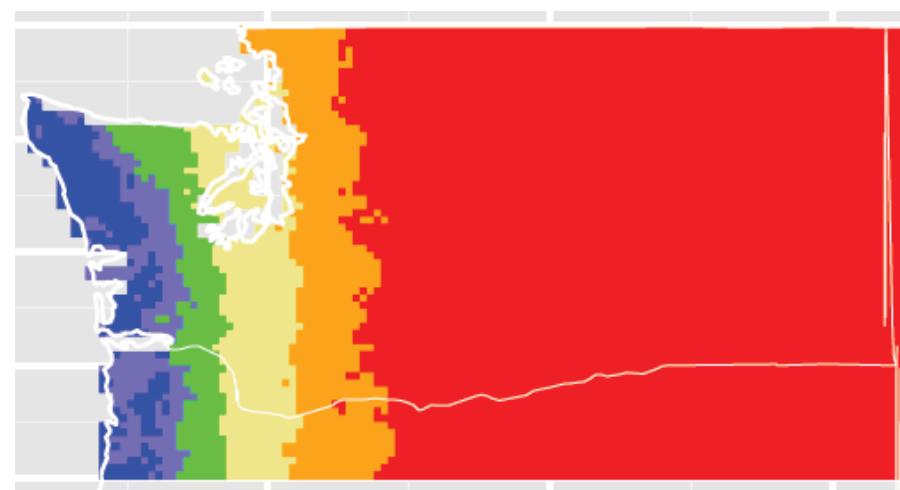
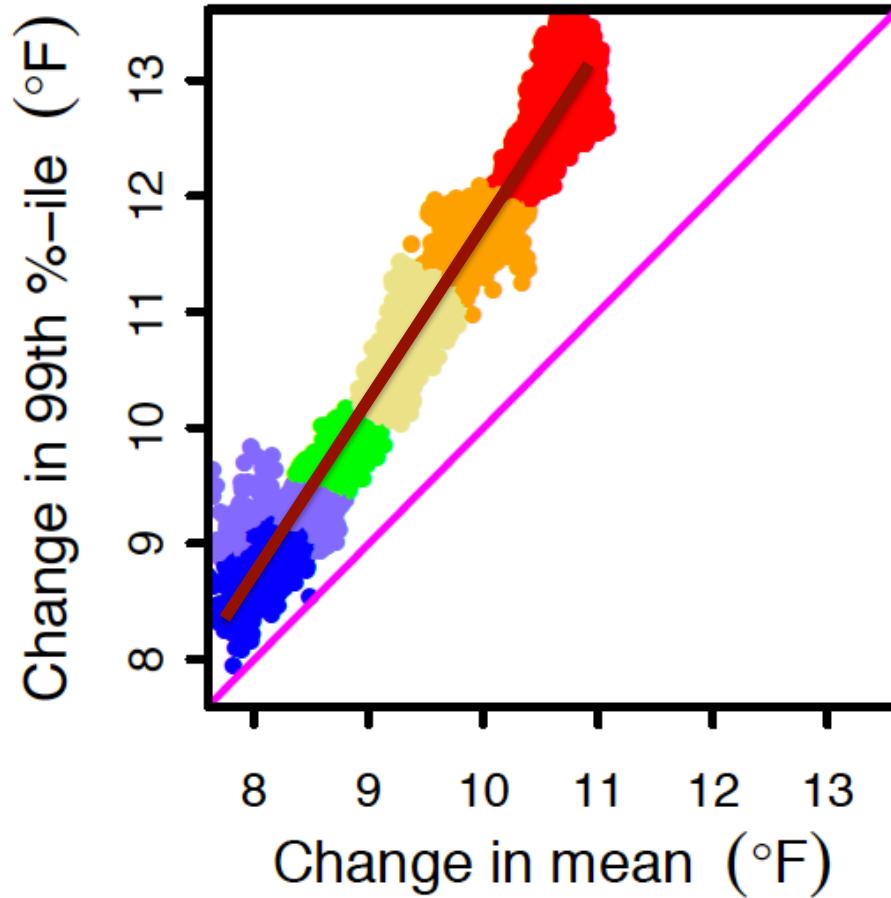
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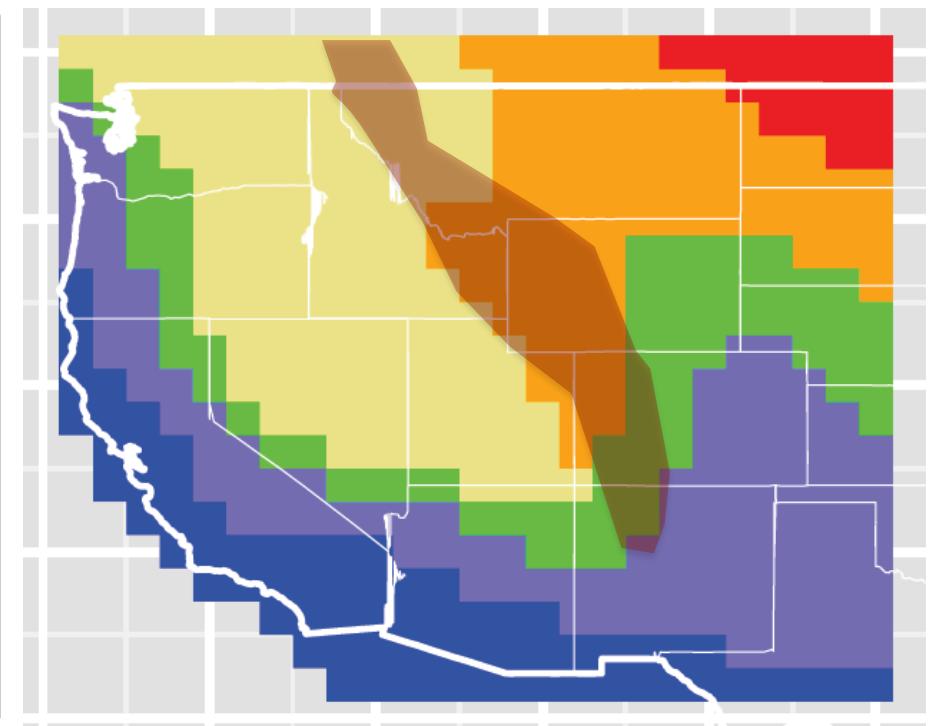
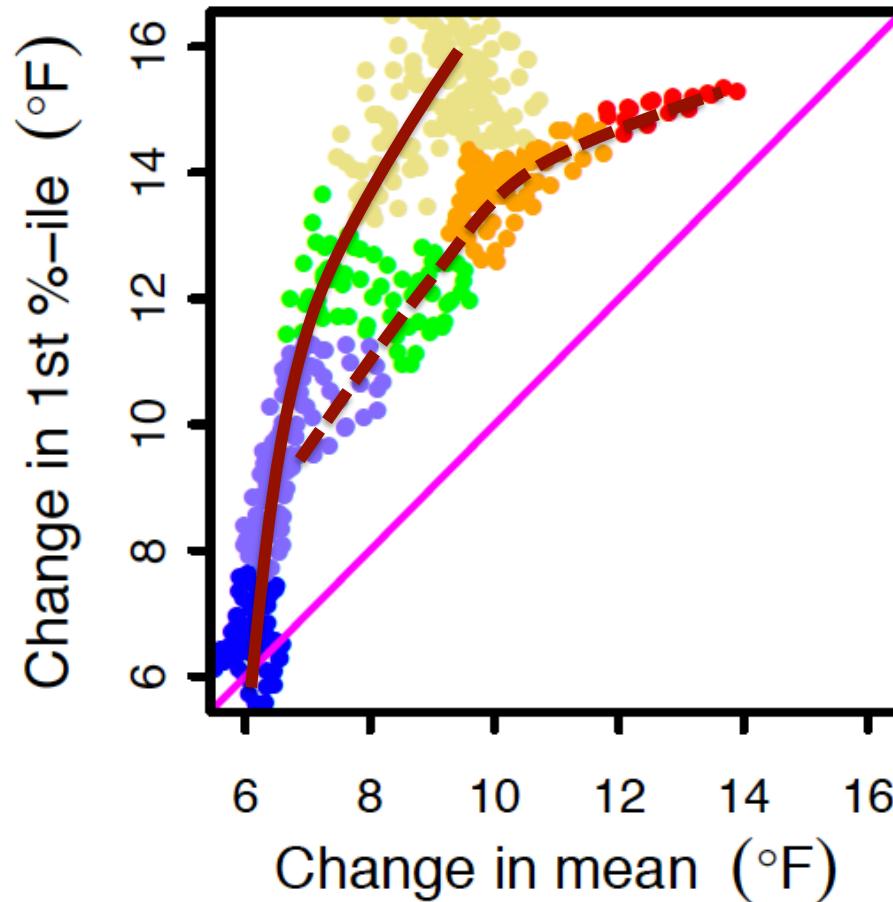
MACA JJA Daily Tmax

1950-1999 to 2050-2099, RCP8.5, Ensemble mean



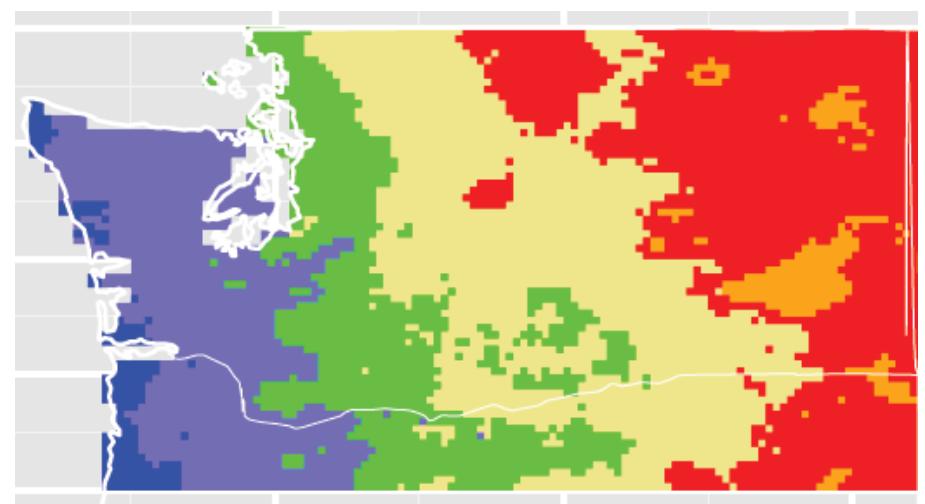
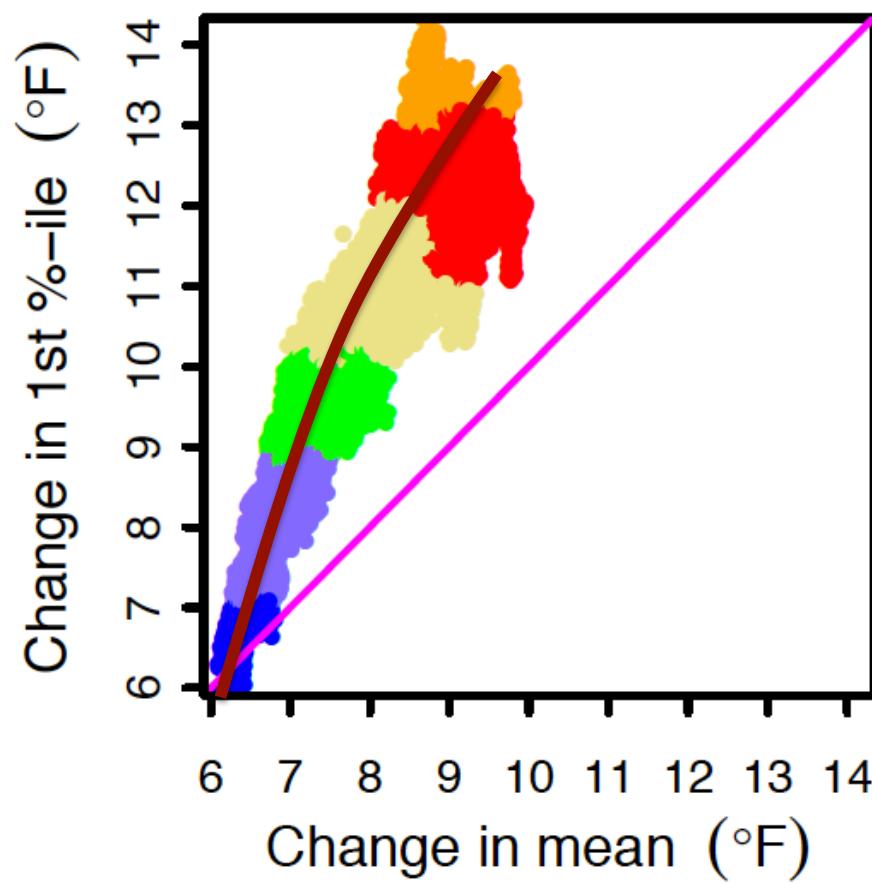
CMIP5 DJF Daily Tmin

1950-1999 to 2050-2099, RCP8.5, Ensemble mean



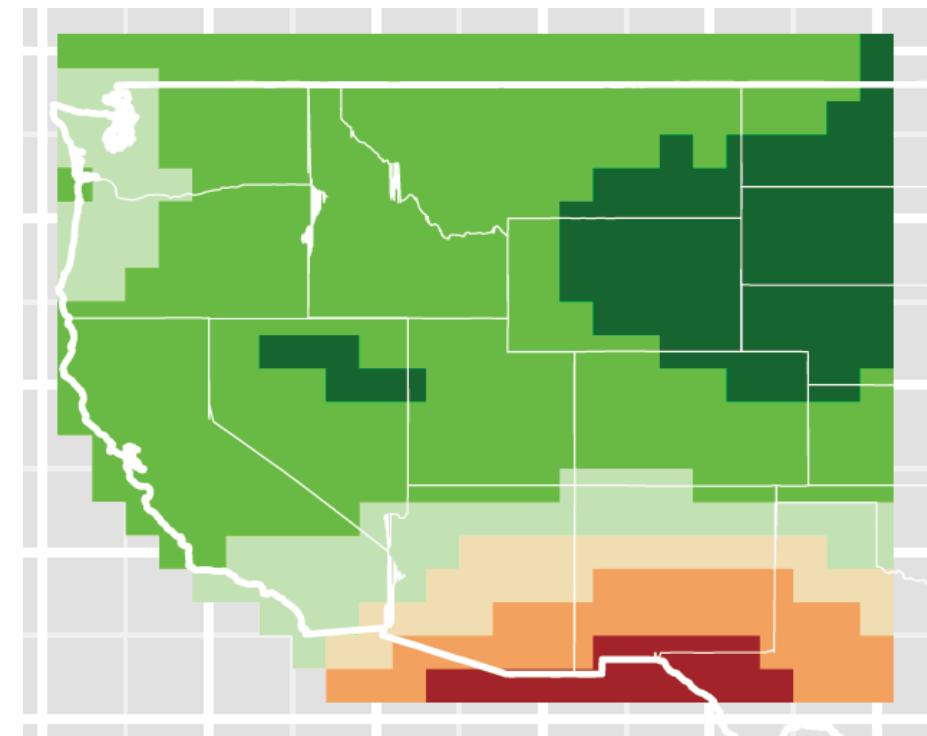
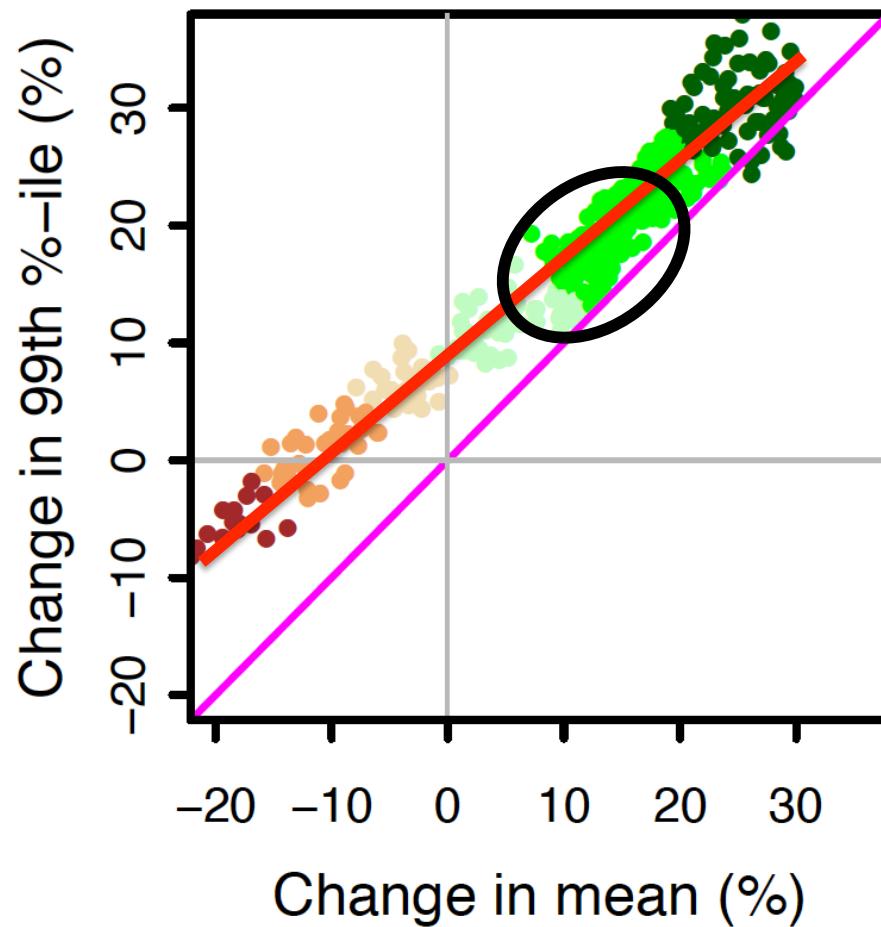
MACA DJF Daily Tmin

1950-1999 to 2050-2099, RCP8.5, Ensemble mean



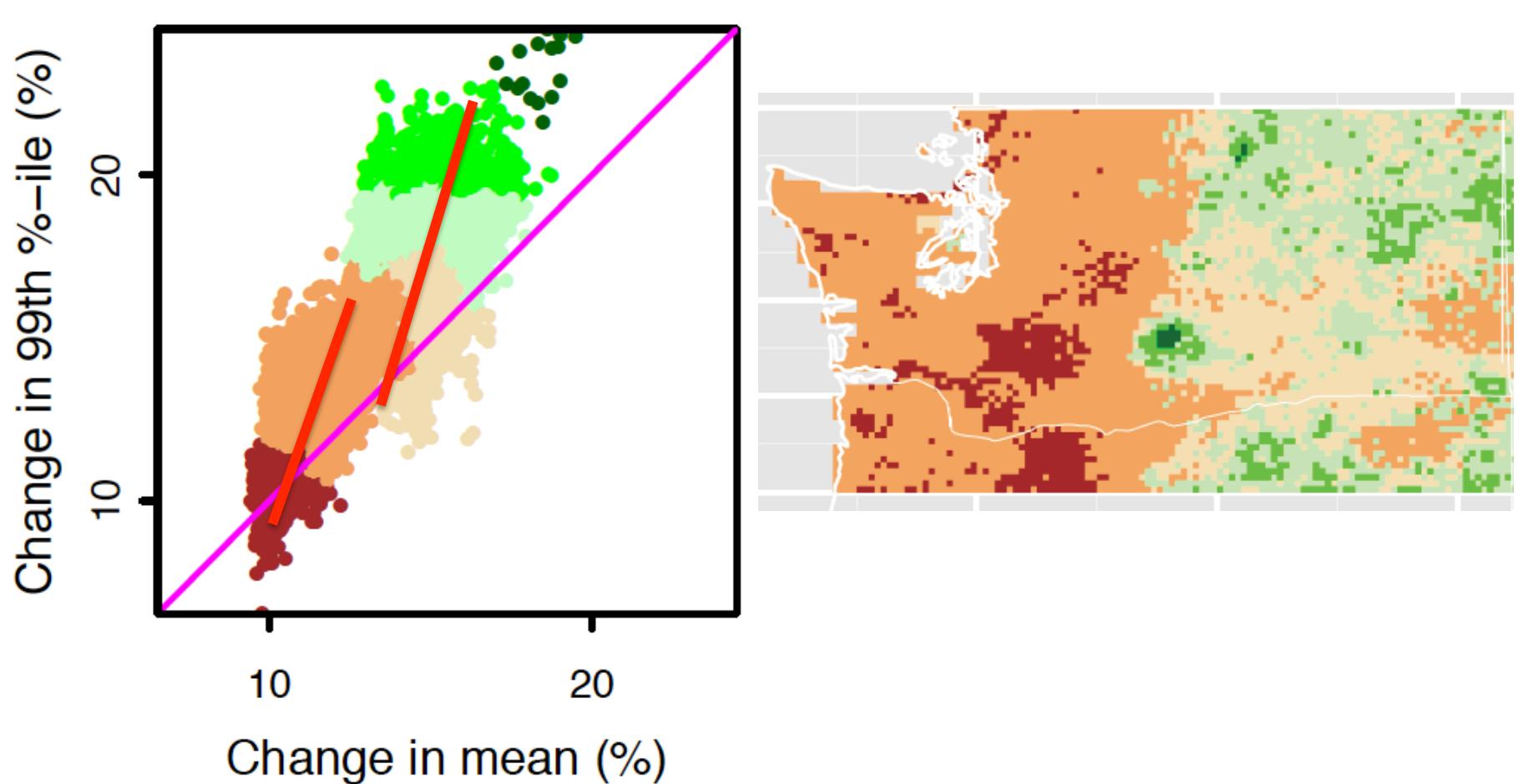
CMIP5 DJF Daily Precipitation

1950-1999 to 2050-2099, RCP8.5, Ensemble mean



MACA DJF Daily Precipitation

1950-1999 to 2050-2099, RCP8.5, Ensemble mean

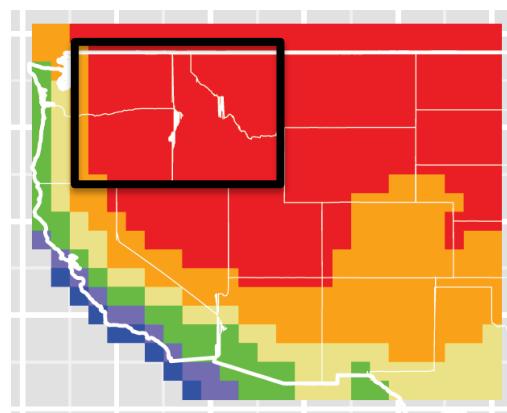


Inter-model variability

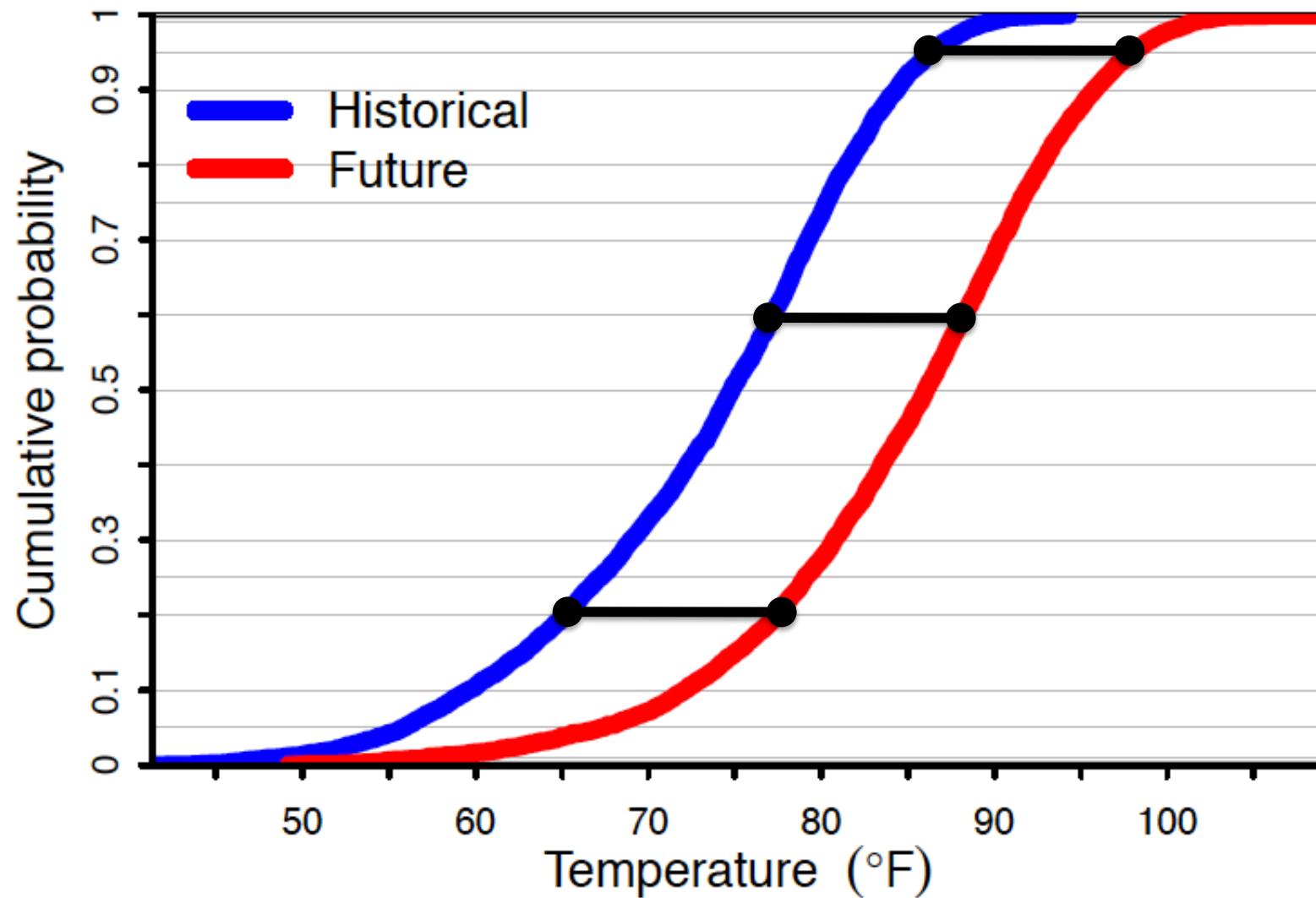
**Changes in probability distributions for each of
20 GCMs**

1950-1999 vs. 2050-2099, RCP8.5

Average over PNW east of Cascades



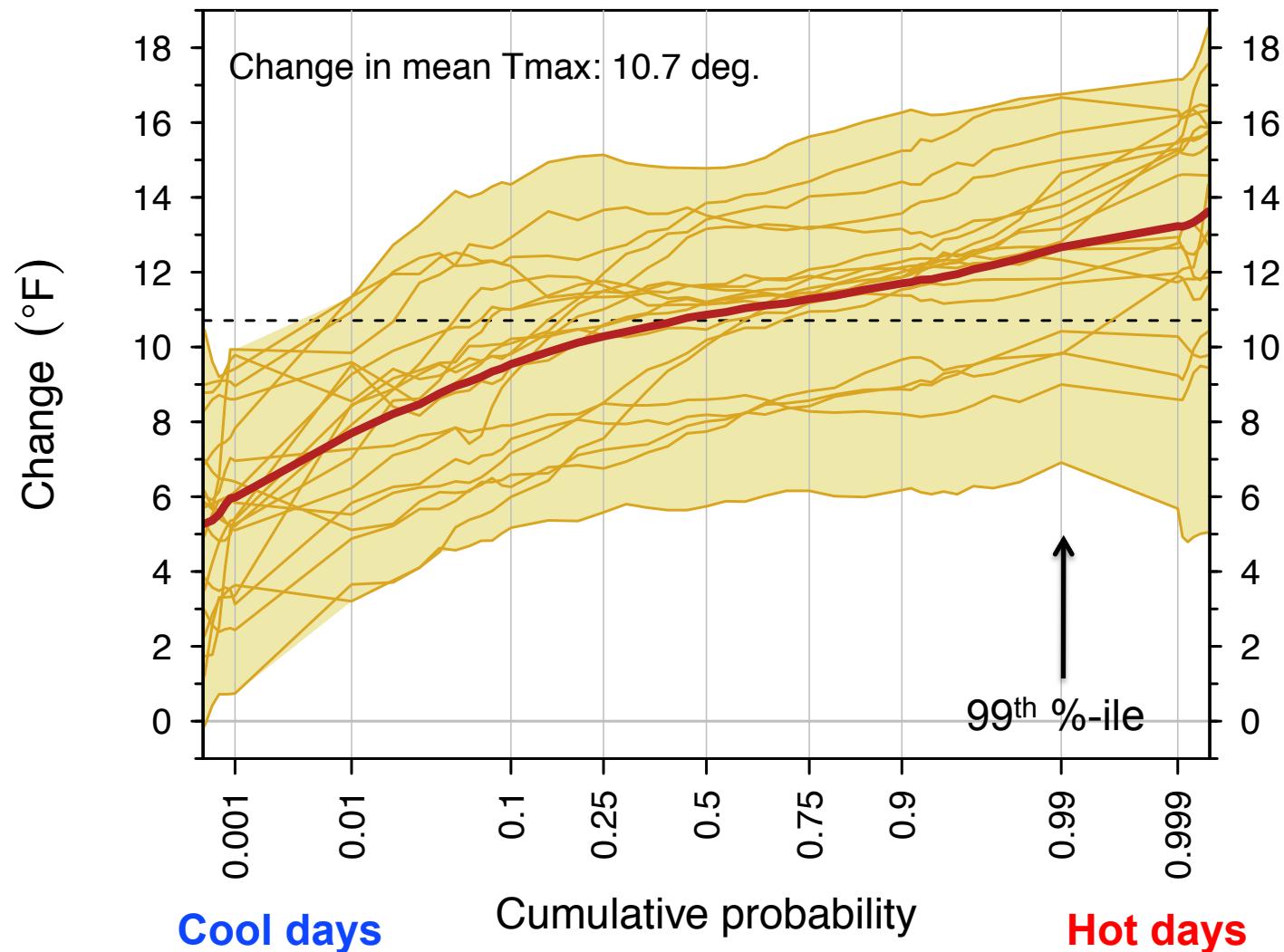
Calculating Changes in Probability



JJA Tmax, eastern PNW, RCP8.5, BCC-CSM1-1

Change in Tmax distribution, JJA

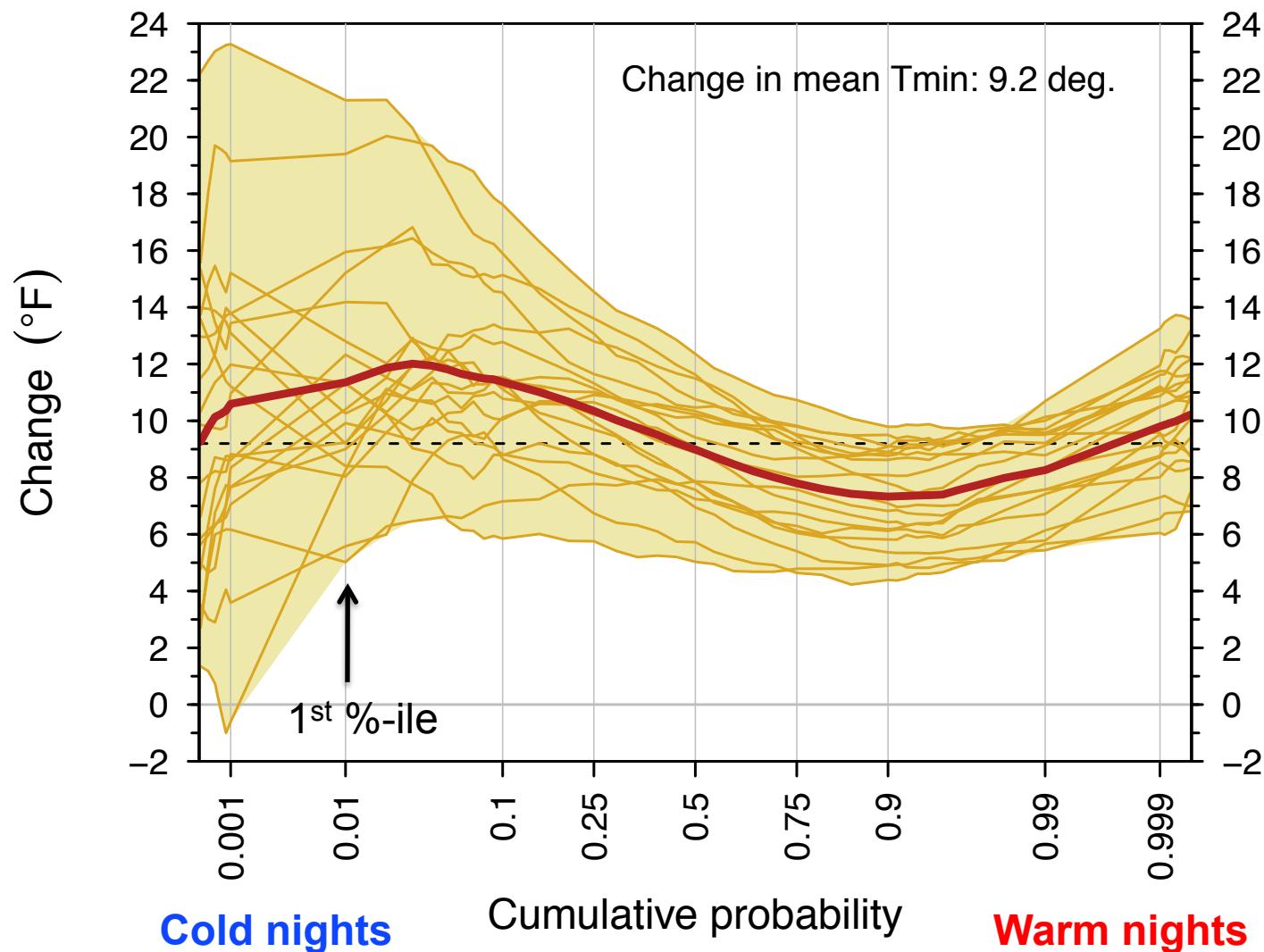
PNW east of Cascades divide, 20 downscaled GCMs



RCP8.5, change from 1950–1999 to 2050–2099.

Change in Tmin distribution, DJF

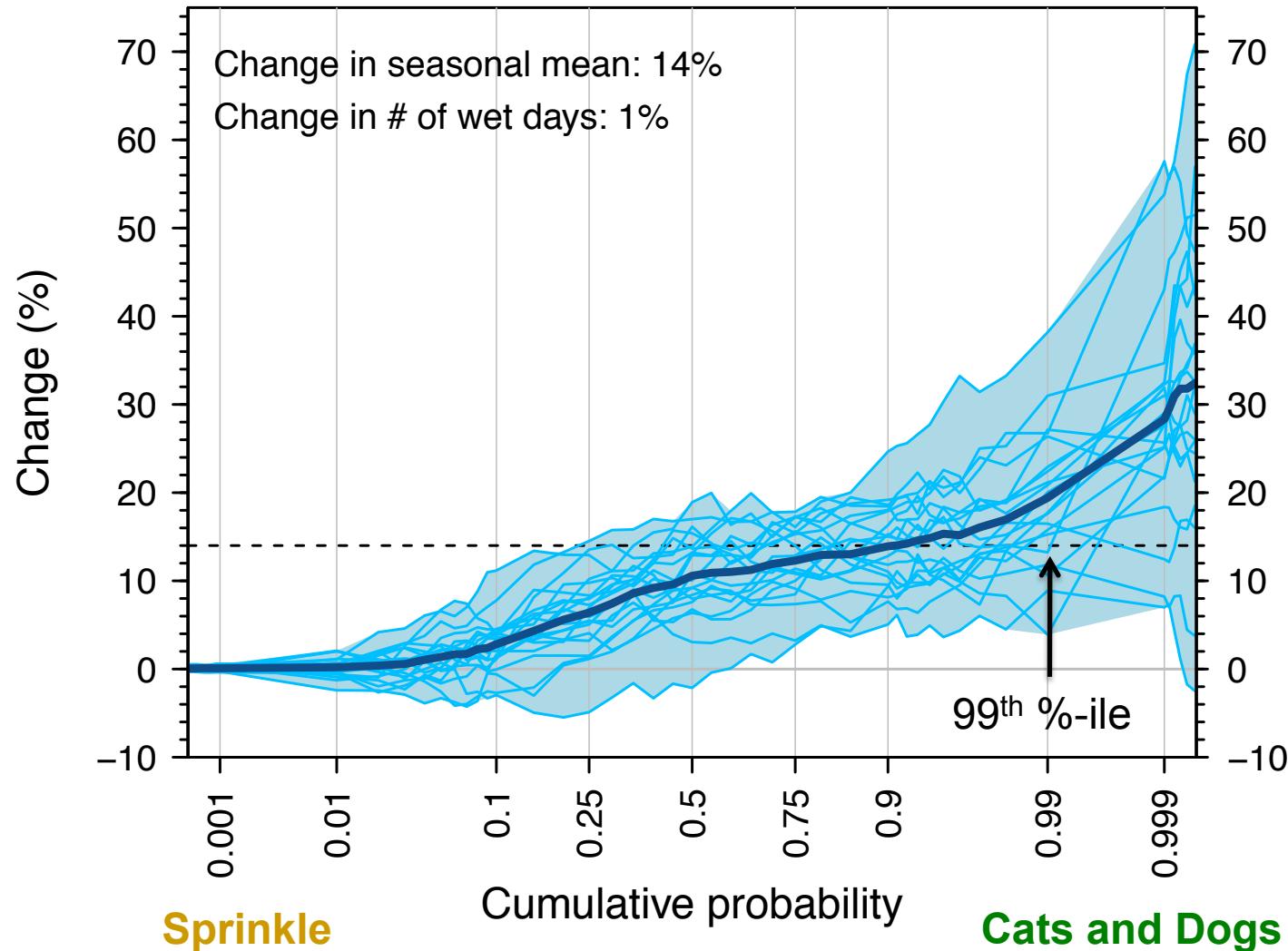
PNW east of Cascades divide, 20 downscaled GCMs



RCP8.5, change from 1950–1999 to 2050–2099.

Change in wet-day precipitation, NDJFM

PNW east of Cascades divide, 20 GCMs



RCP8.5, change from 1950–1999 to 2050–2099.

Summary

Extremes change at rates faster than the means.

By latter half of 21st century in the PNW*....

Hottest days of summer warm an extra +1-2 °F

Coldest nights of winter warm an extra +1-5 °F

Wettest days of winter rain/snow an extra +0-5%

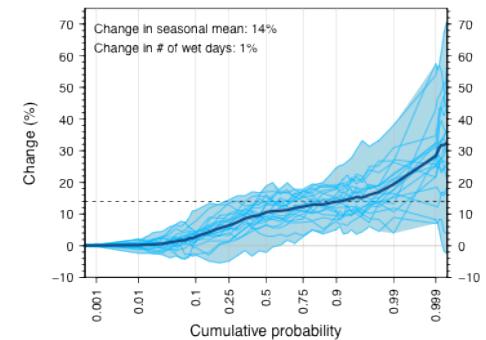
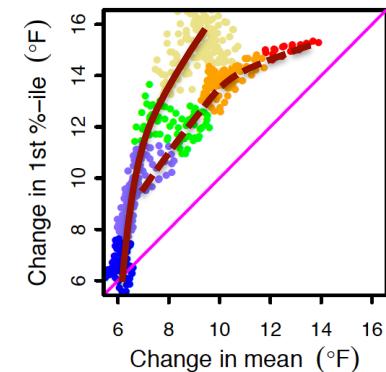
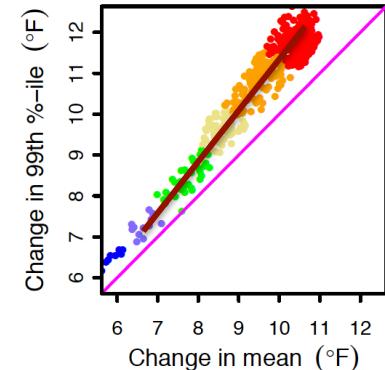
**Rates increase with distance from coast. Estimates based on ensemble average under RCP8.5.*

Summary cont.

Changes in extremes can be related to changes in means (approx. linear)...

... but relationship may be region specific

Large uncertainty in changes in cold extremes and extreme precipitation intensities

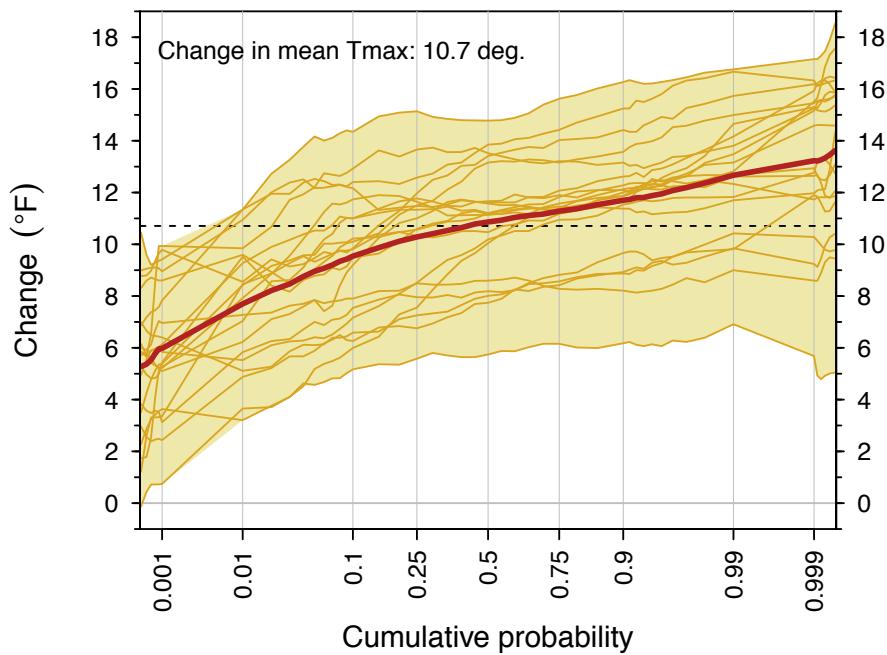


Extra slides

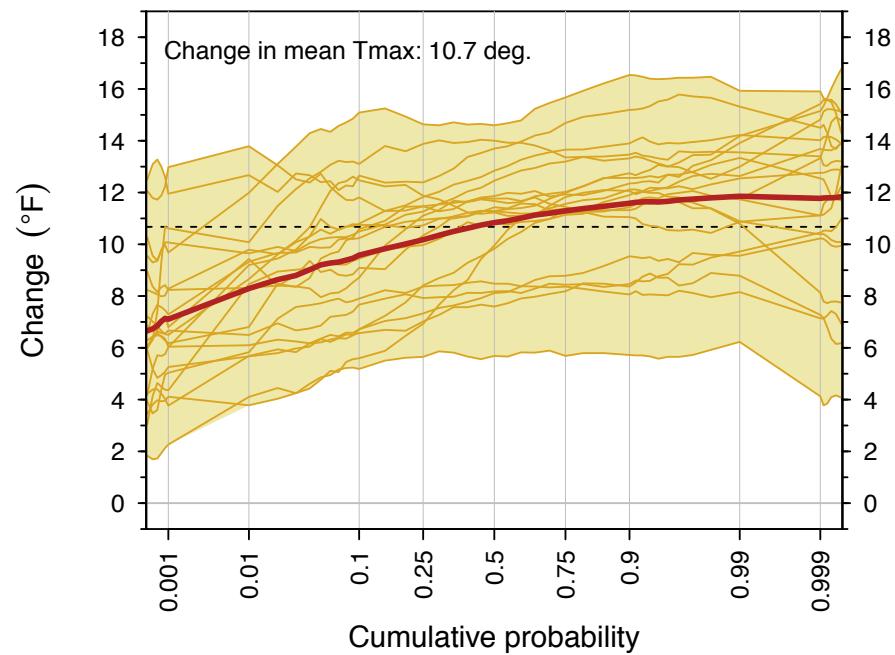
Change in Tmax distribution, JJA

PNW east of Cascades divide, 20 GCMs

MACA



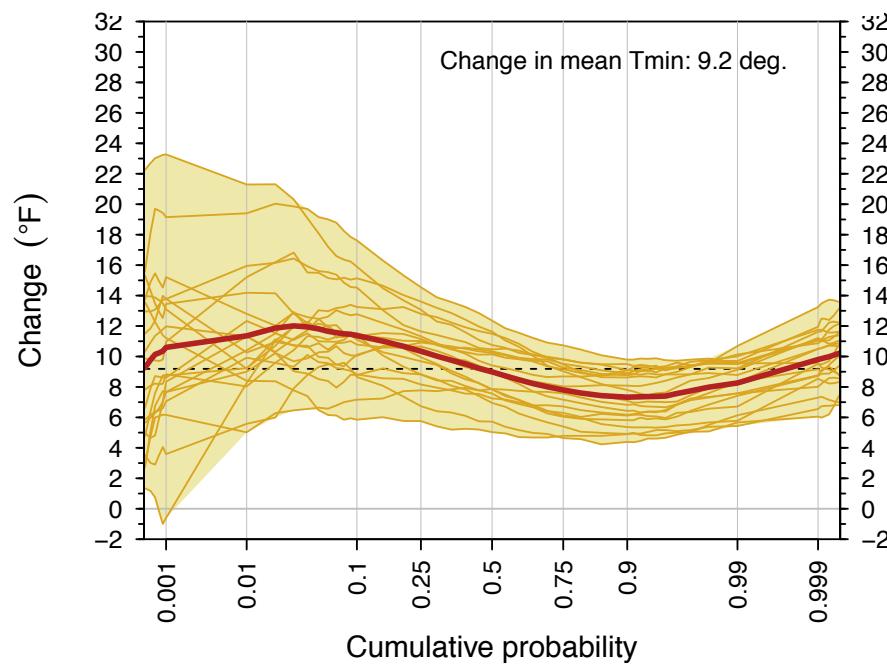
CMIP5



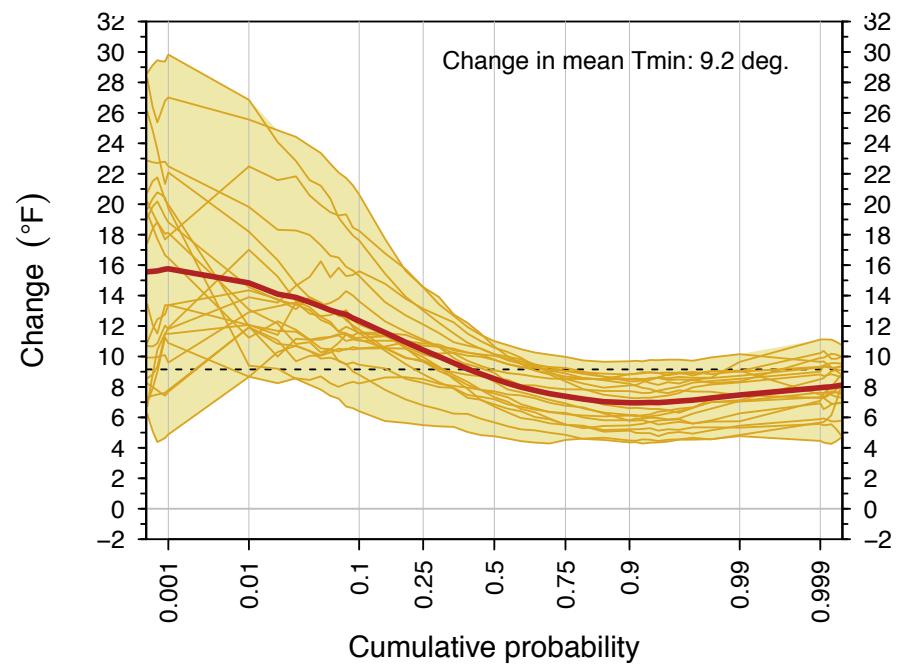
Change in Tmin distribution, DJF

PNW east of Cascades divide, 20 GCMs

MACA



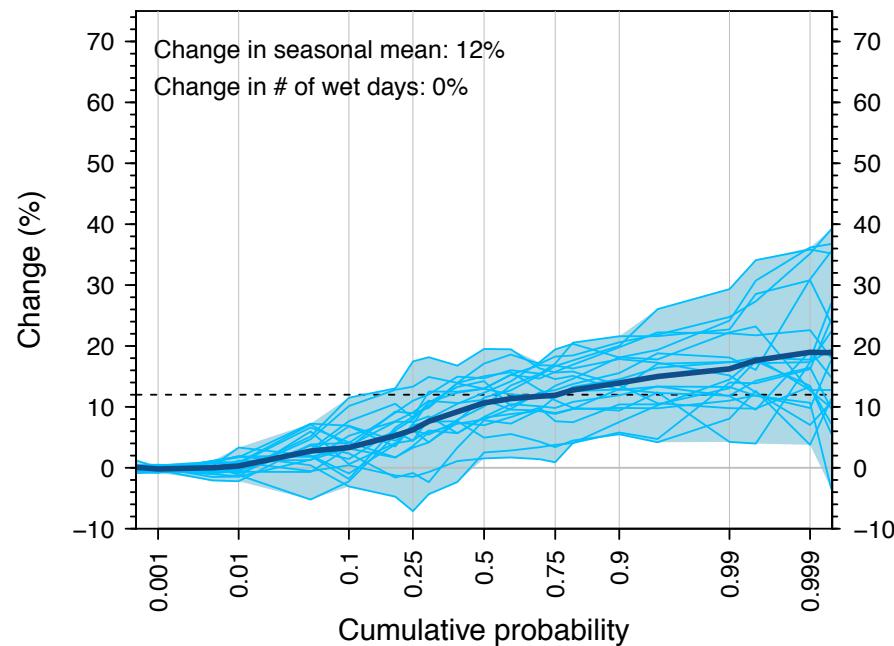
CMIP5



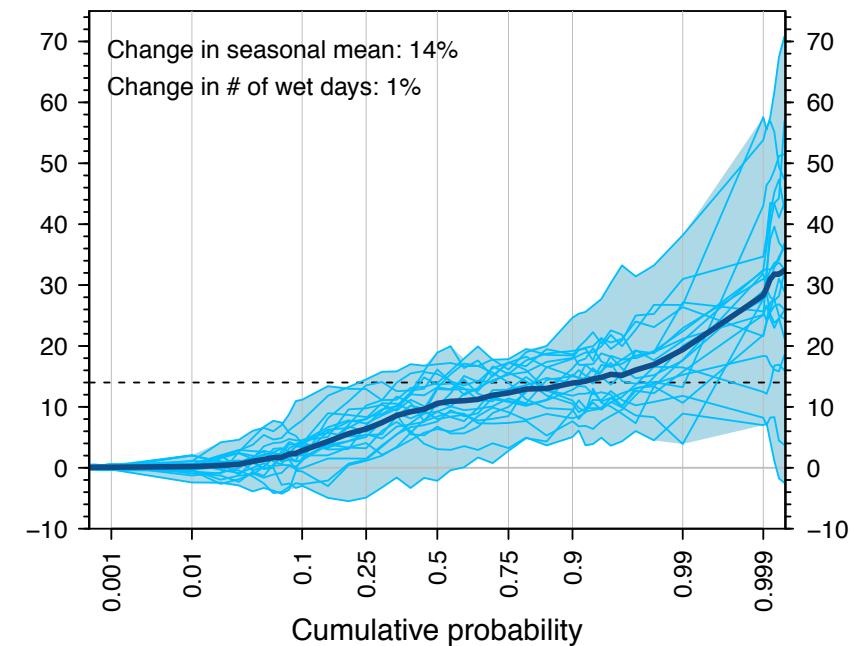
Change in wet-day precipitation, NDJFM

PNW east of Cascades divide, 20 GCMs

MACA



CMIP5



CMIP5

Coupled Model Intercomparison Project, Phase 5

An international, coordinated set of global
modeling experiments

World Climate Research Programme

Cosponsors: World Meteorological Organization (WMO), International Council for Science (ICSU), Intergovernmental Oceanographic Commission (IOC of UNESCO)