

The uneven nature of precipitation and its changes



Otkin et al., 2018

troyspro.com.au

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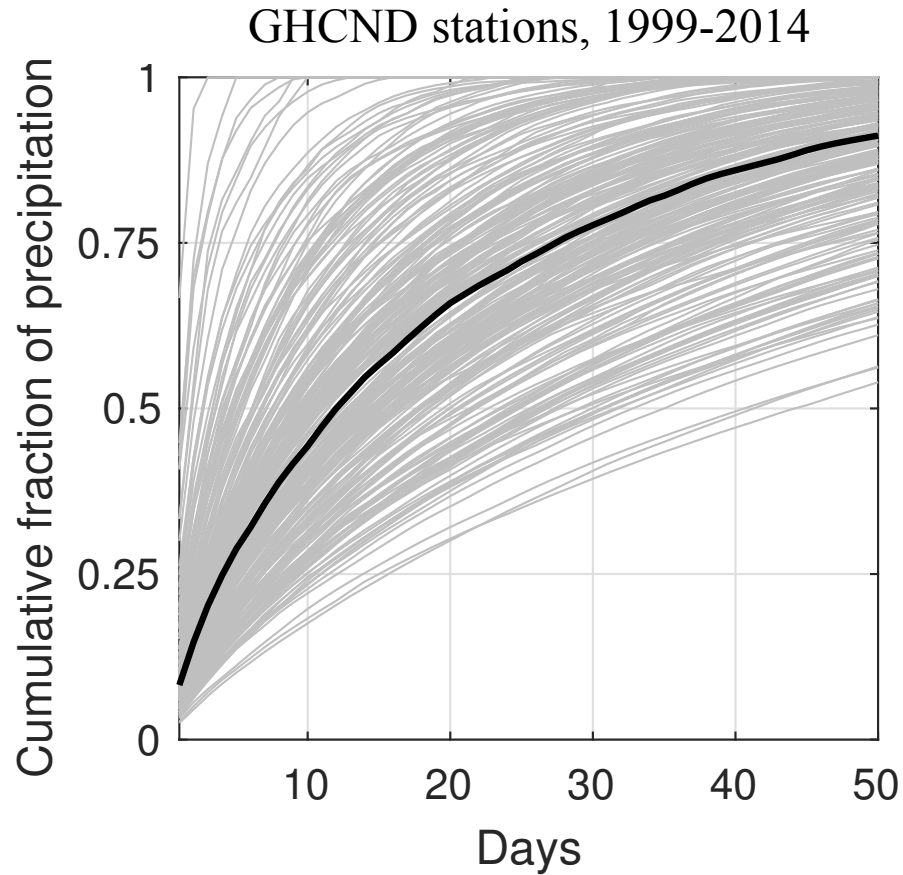
Motivation

- Precipitation falls unevenly, which is known but difficult to quantify
- Droughts and floods arise from this unevenness
- How uneven is precipitation?
- How well do climate models capture its unevenness?
- How might it change in the future?

Precipitation data (Daily)

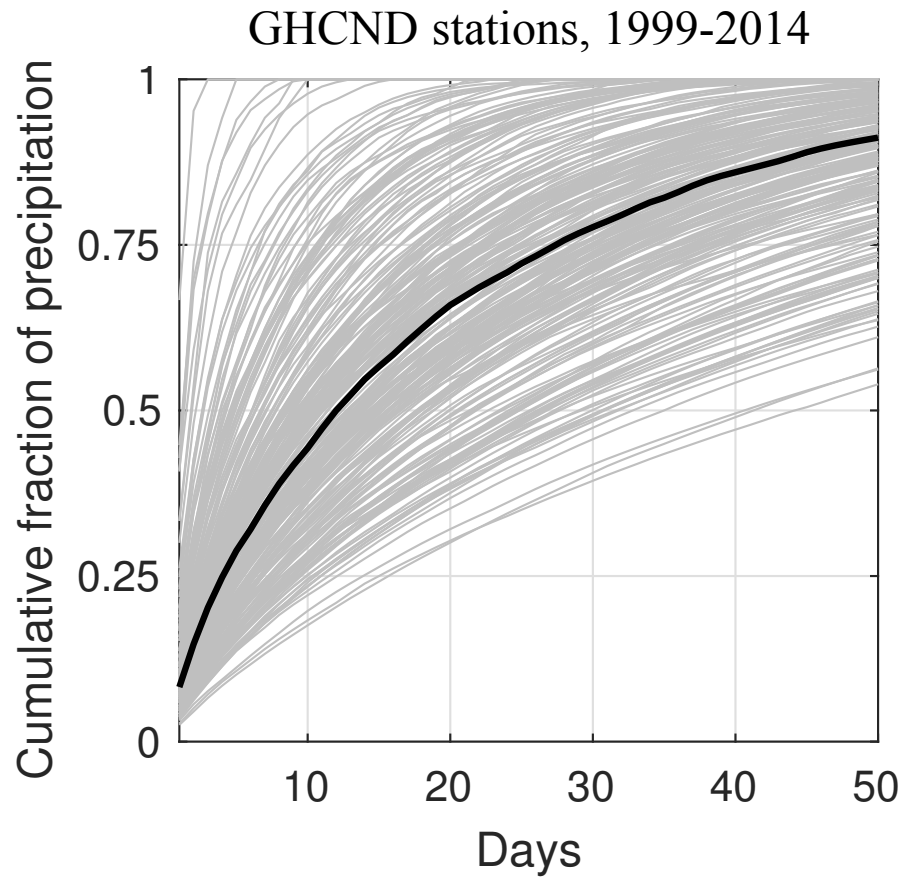
- **Station observations**
 - Global Historical Climatology Network – Daily (GHCN-D), Global Climate Observing System Surface Network
- **Satellite-based observations**
 - TRMM 3b42 gridded product
- **Climate model simulations**
 - CMIP5, historical and RCP8.5 (high emissions) scenarios
 - 1999-2014 and 2086-2100 periods

Cumulative fraction of precipitation



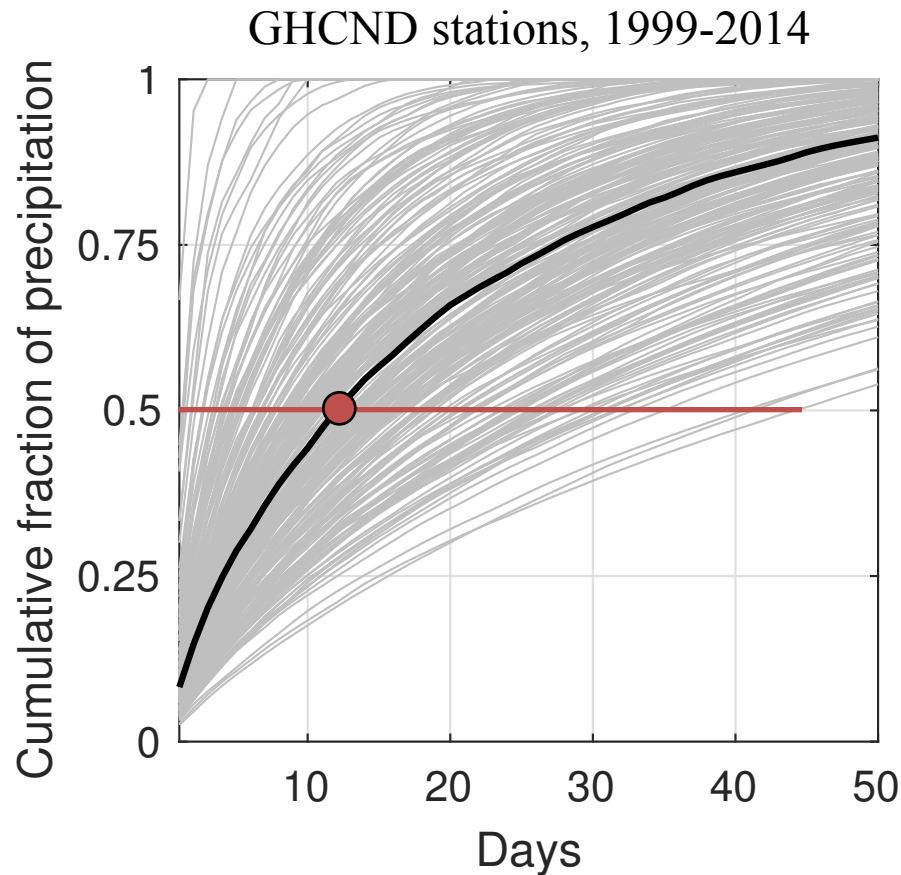
Each station
Median of stations

Cumulative fraction of precipitation



Each station
Median of stations

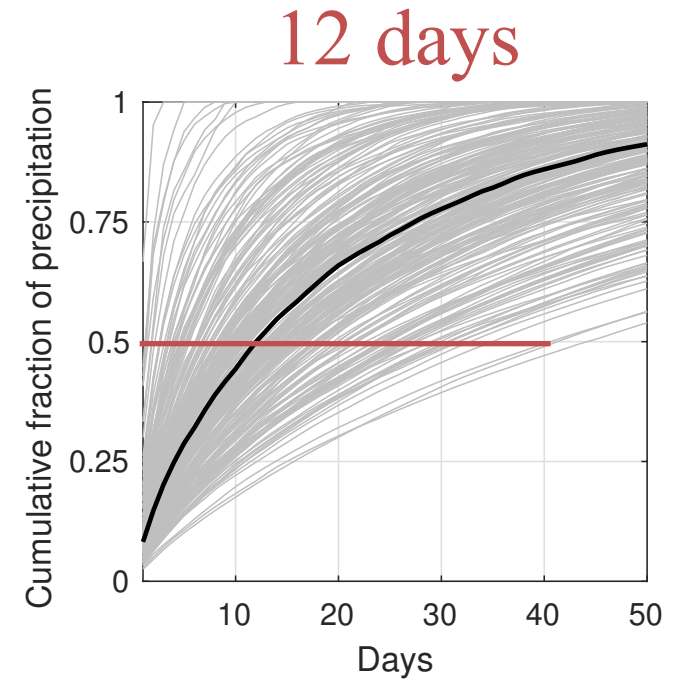
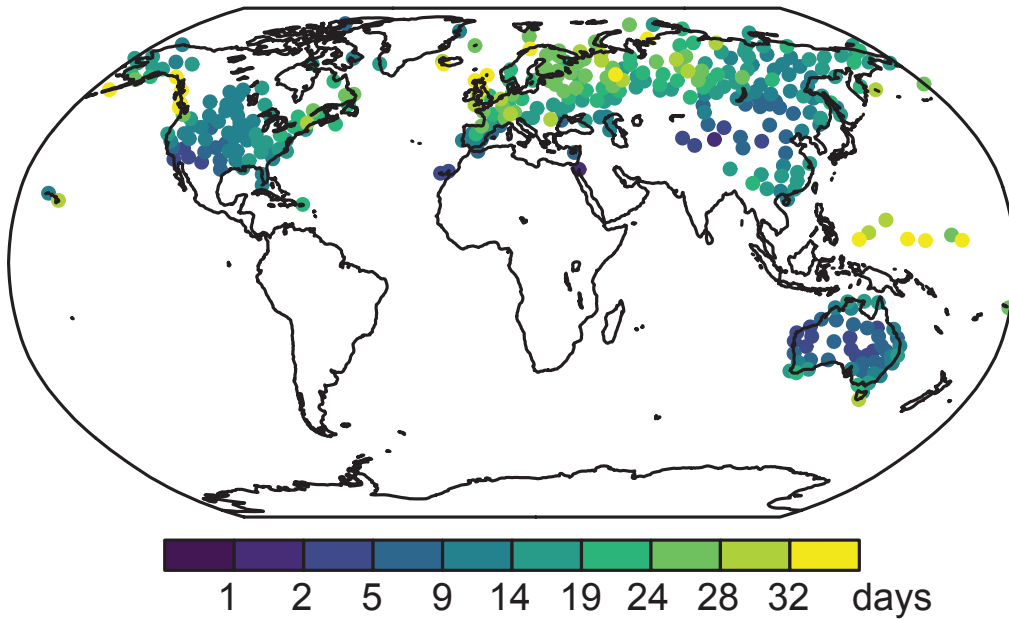
Days in which $\frac{1}{2}$ of precip falls



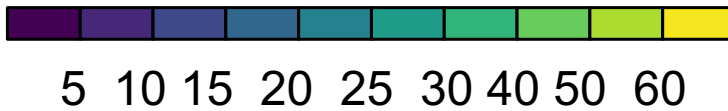
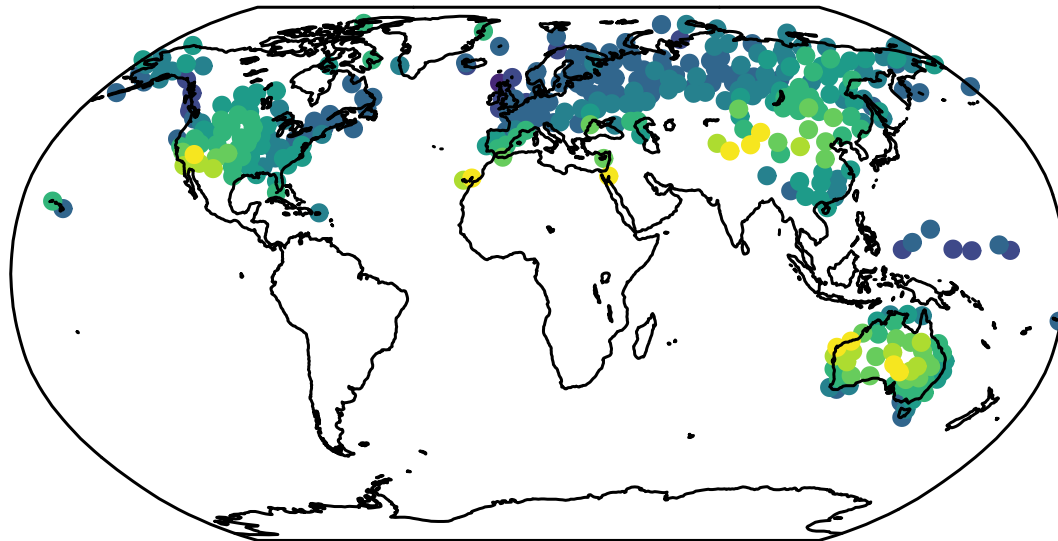
Median:
12 days

Each station
Median of stations

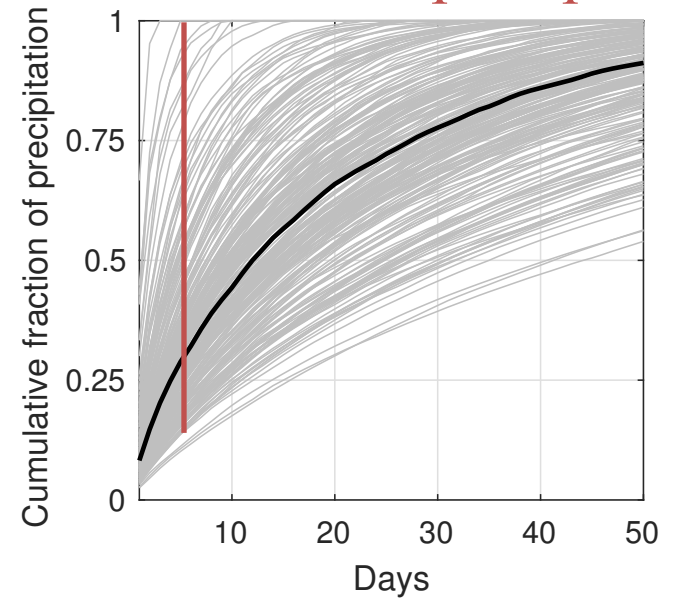
Days in which $\frac{1}{2}$ of precip falls



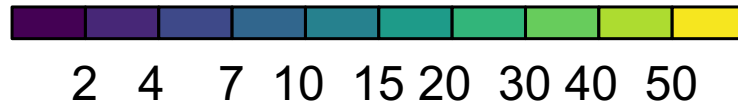
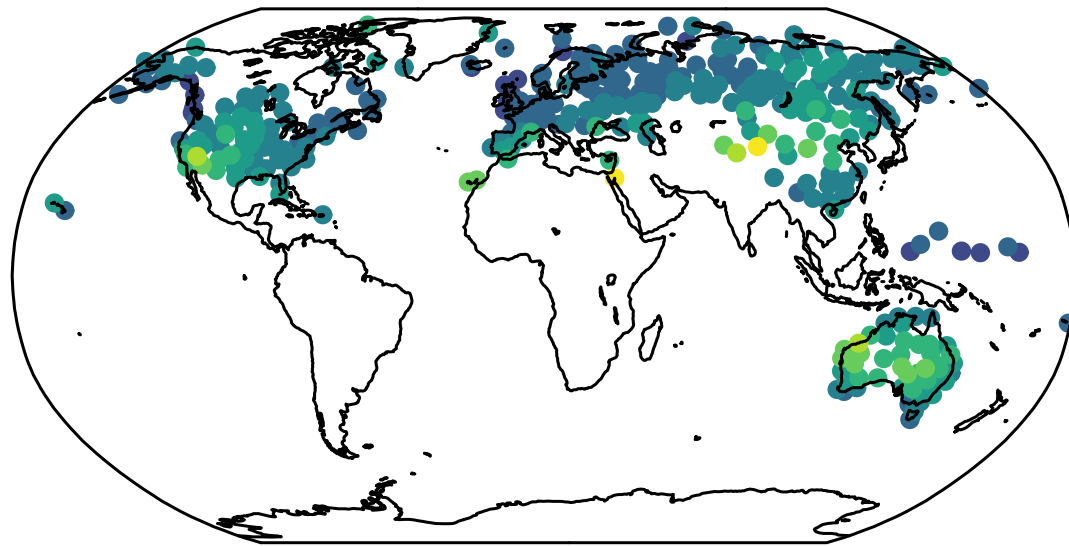
Wettest 5 days



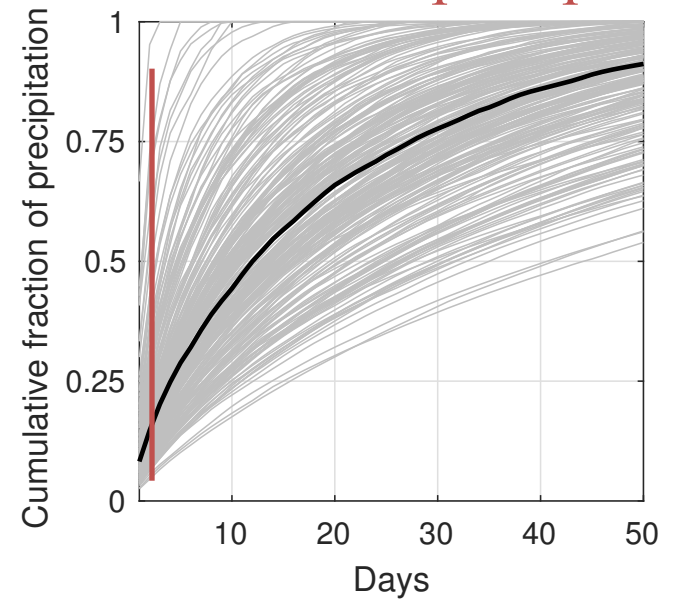
30%
of annual precip



Wettest 2 days

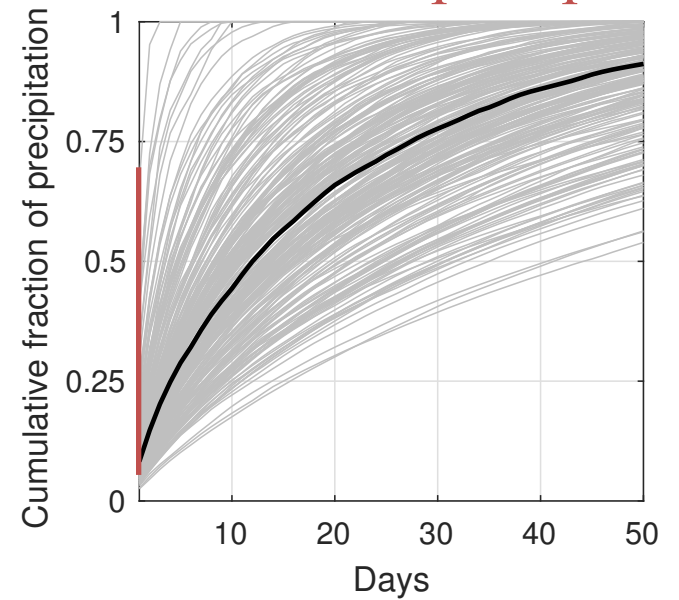
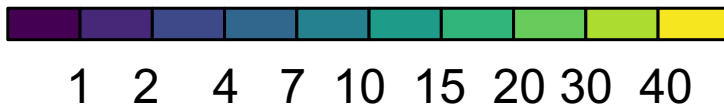
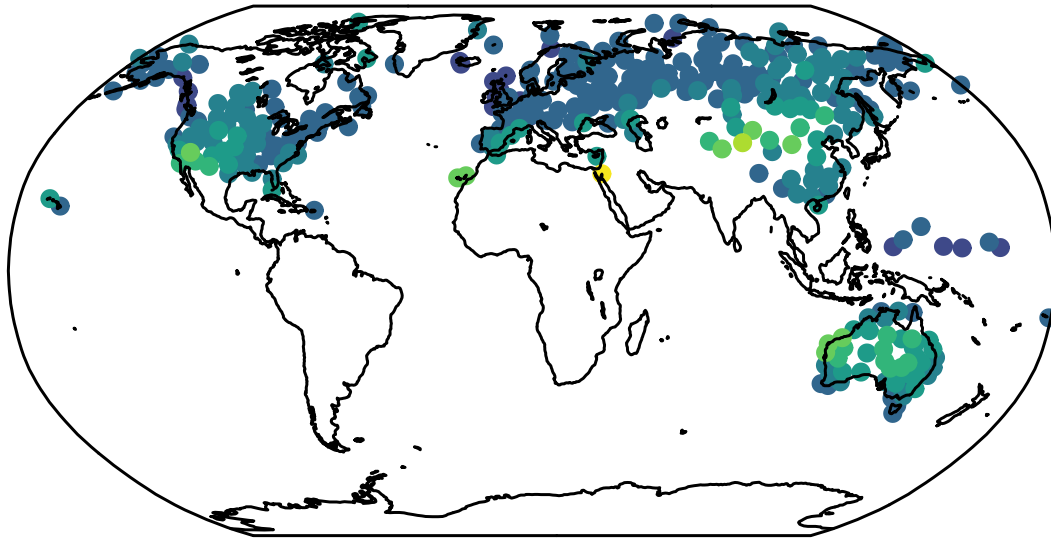


15%
of annual precip

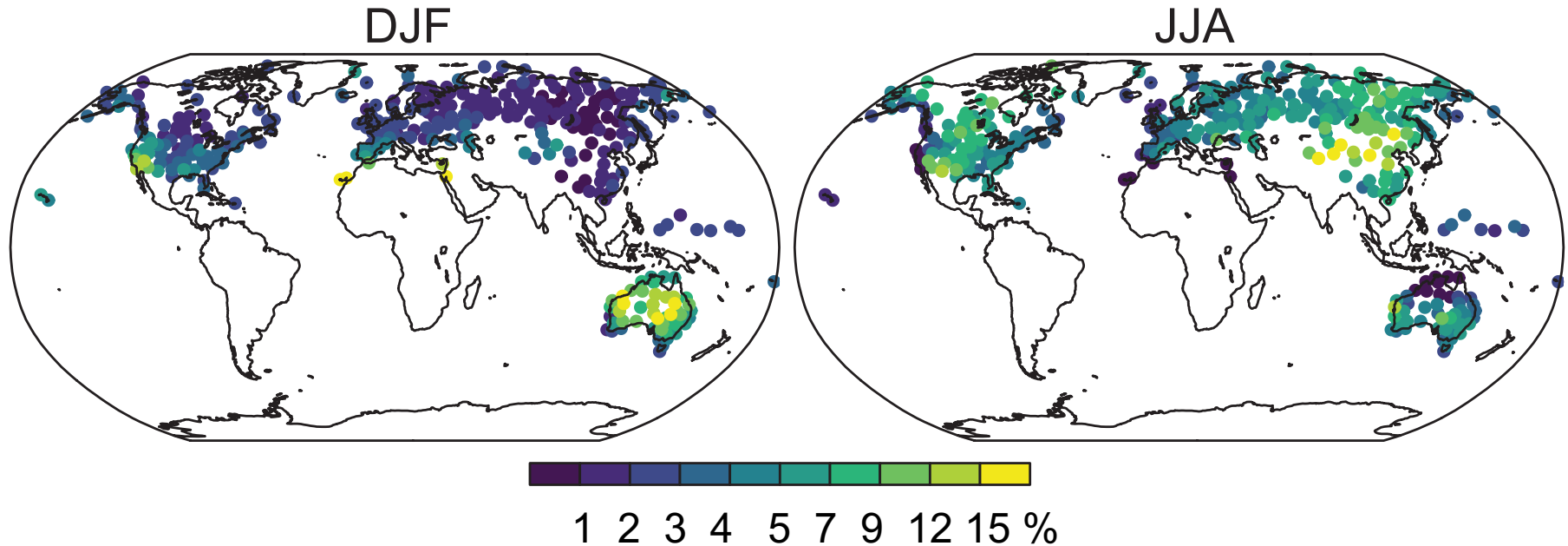


Wettest day

8.4%
of annual precip



Wettest day: by season



Winter

3.4% of annual precip

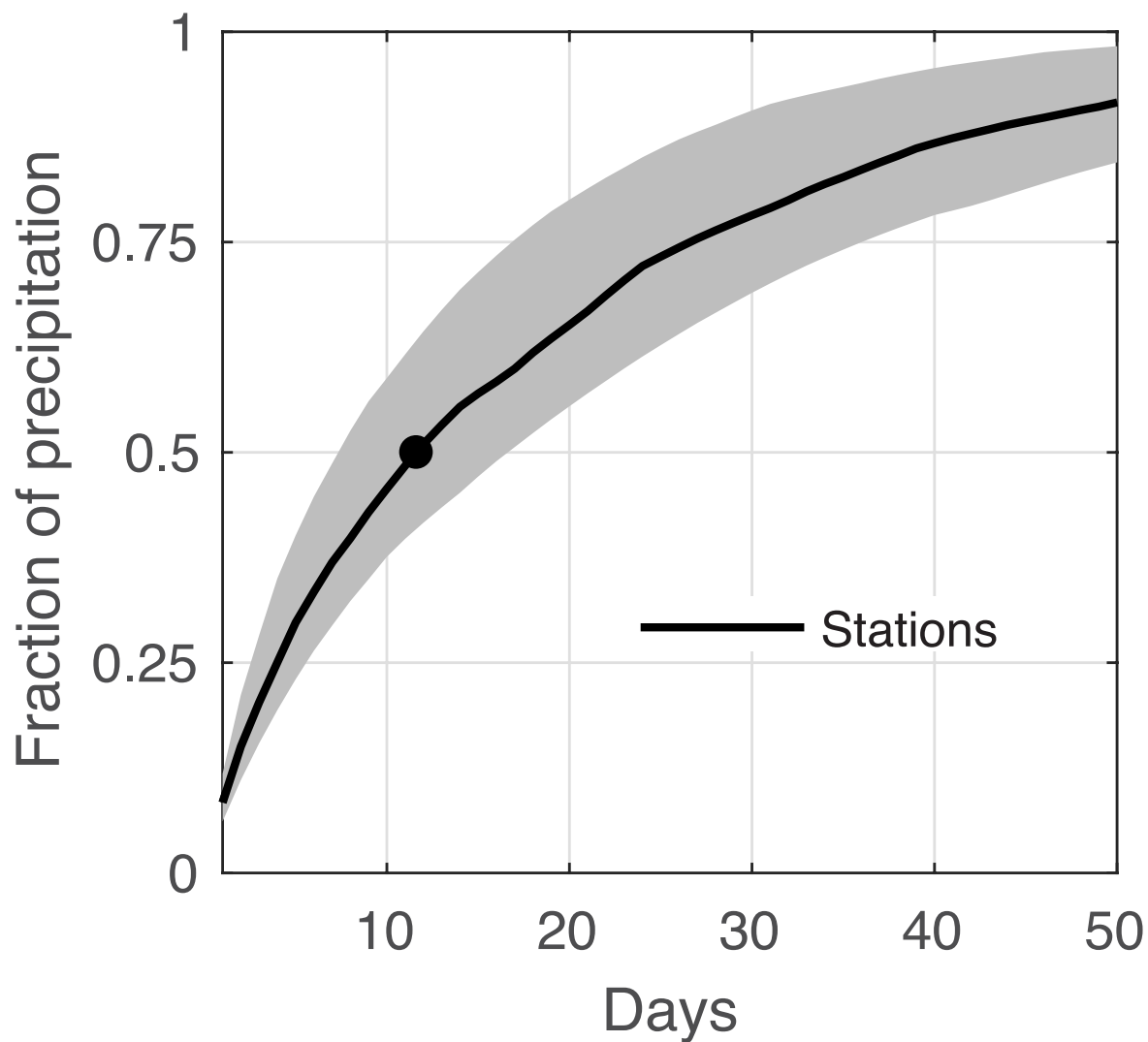
Summer

5.2 % of annual
precip

What Will Warming Mean
for unevenness of precipitation?

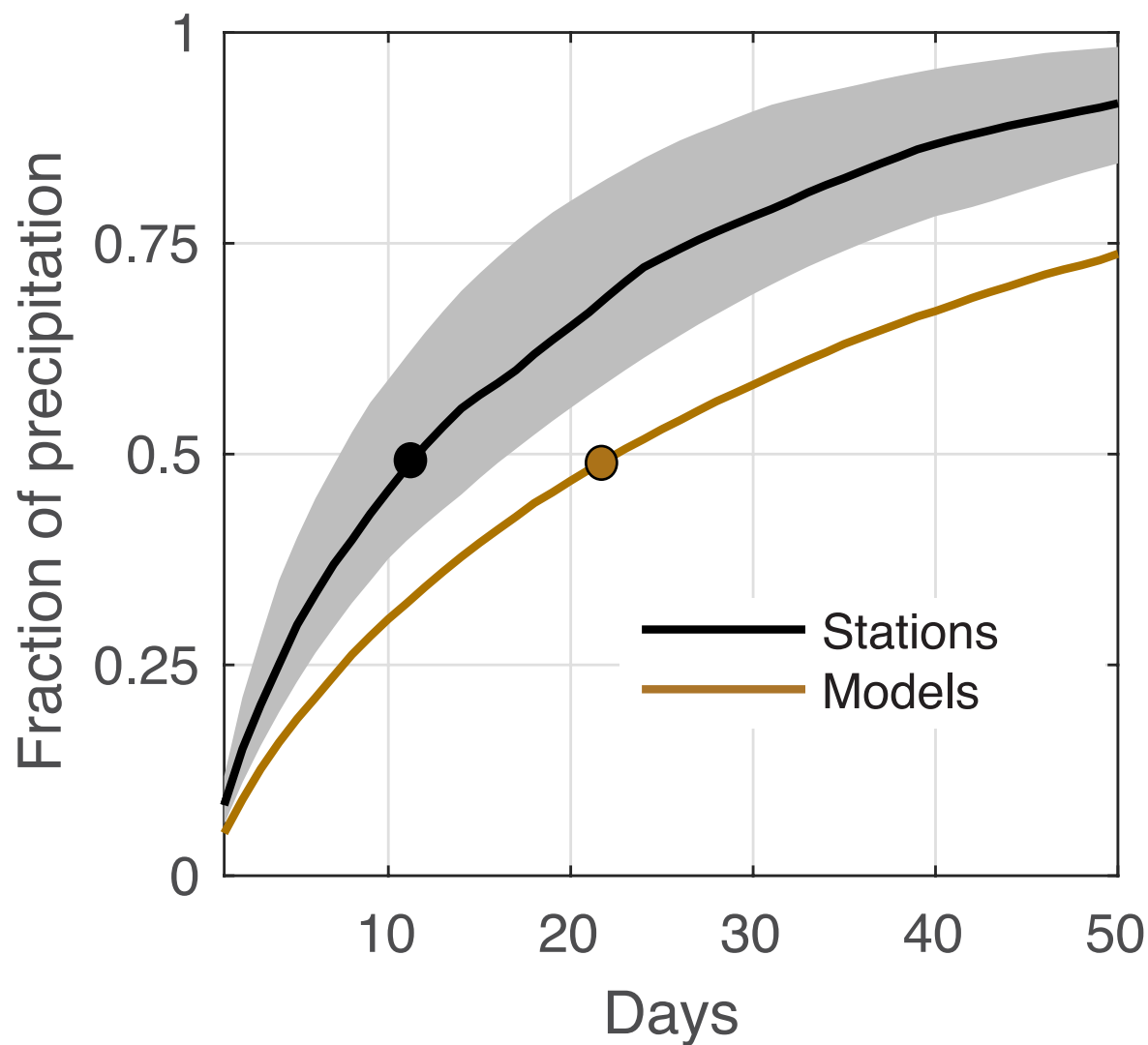
What Will Warming Mean for unevenness?

- Observations show and climate models project that mean and extreme precipitation increase in response to anthropogenic climate change
- Global annual mean precipitation increases following atmospheric and surface energy balance – 1-3 %/K
- Extreme precipitation increases faster
- ...



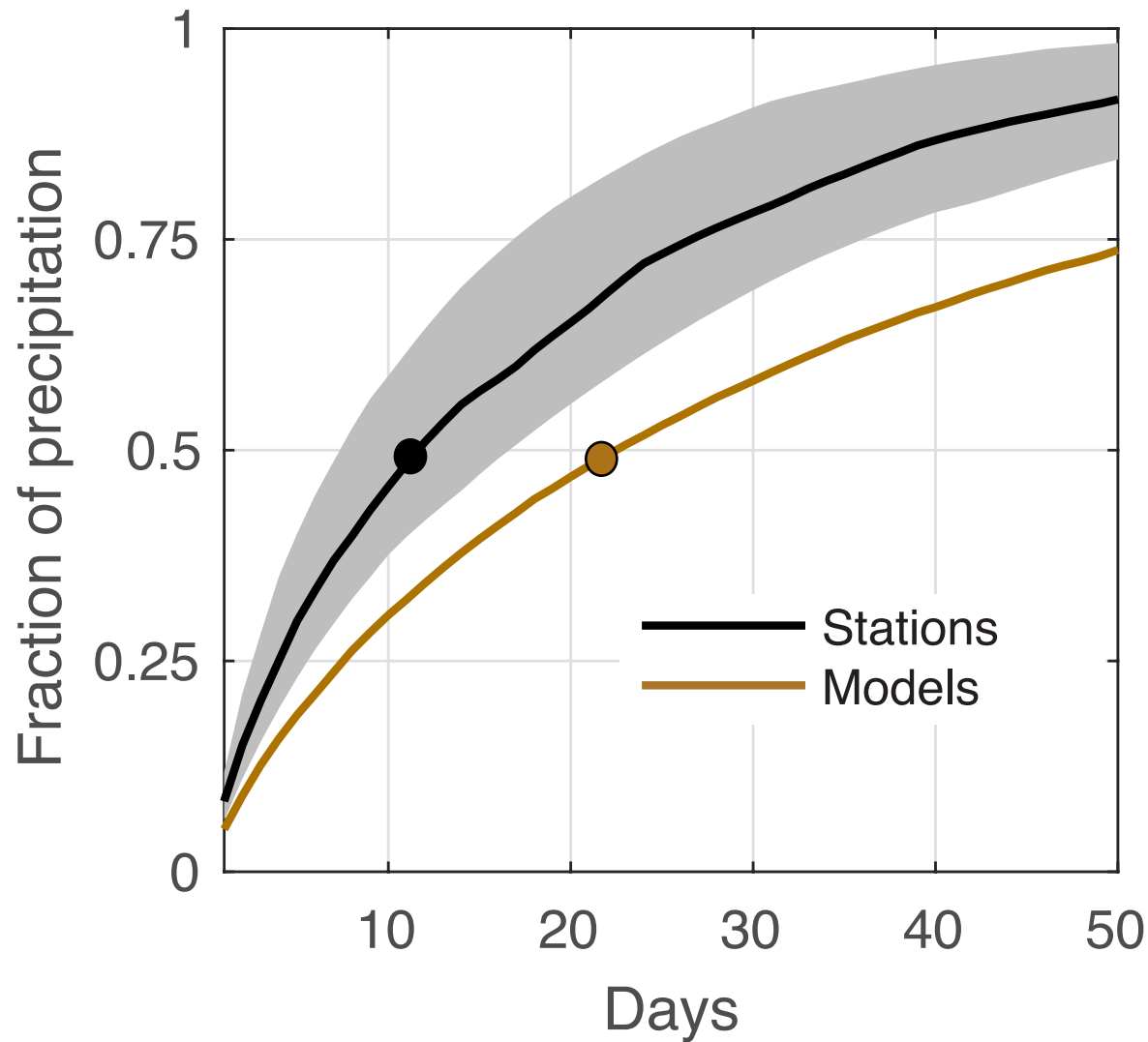
12 days

Multi-model median
Median of grid points corresponding to stations



12 days
23 days

Multi-model median
Median of grid points corresponding to stations

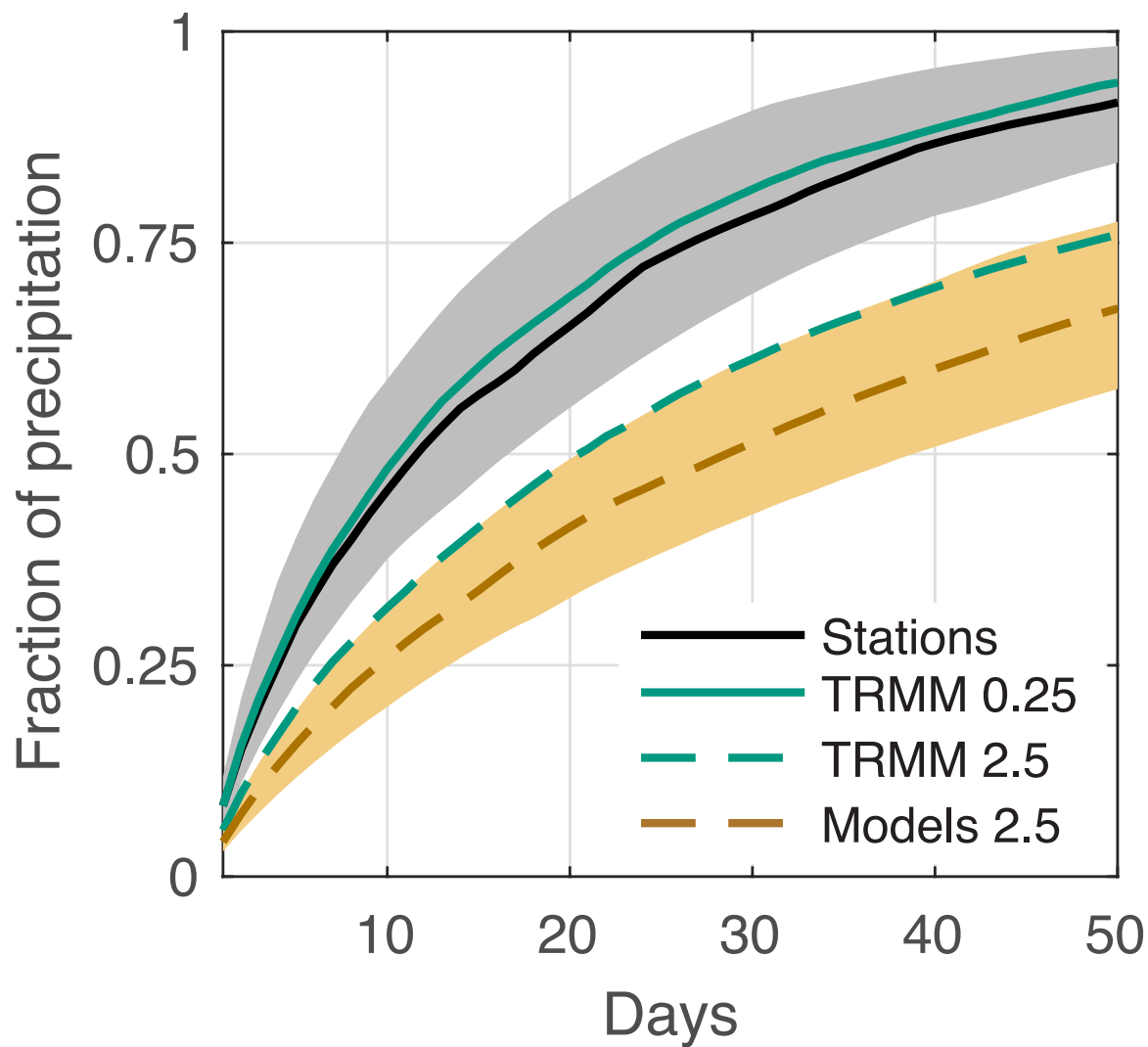


12 days

23 days

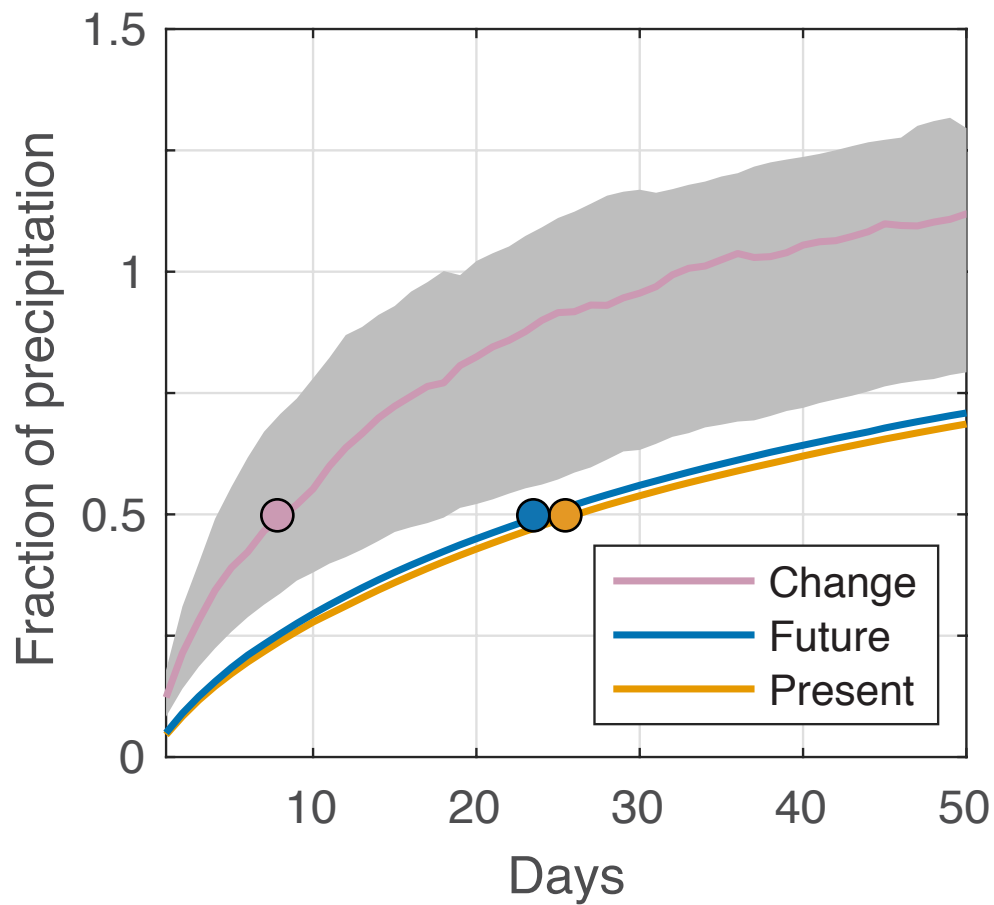
**Models
underestimate
unevenness**

Multi-model median
Median of grid points corresponding to stations



**Models
underestimate
unevenness
- Mostly due to
resolution**

Multi-model median
Median of grid points corresponding to stations

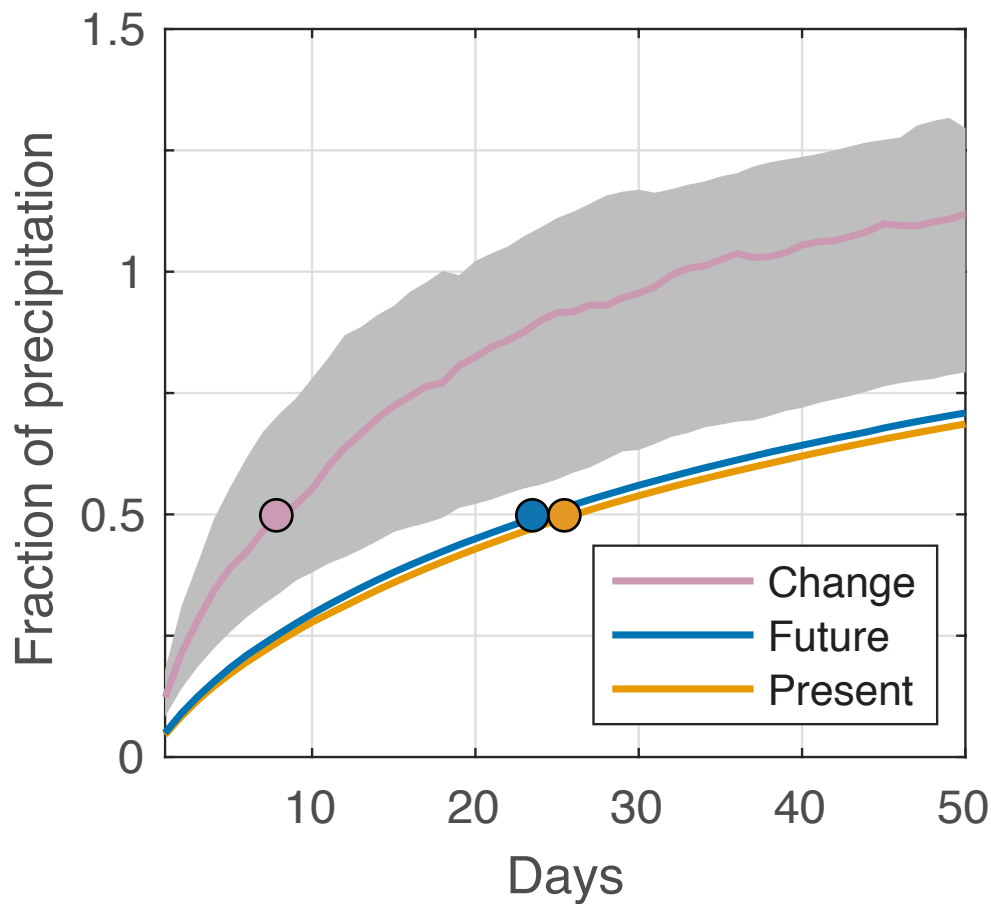


8.6 days

25 days

26 days

Multi-model median
Land median



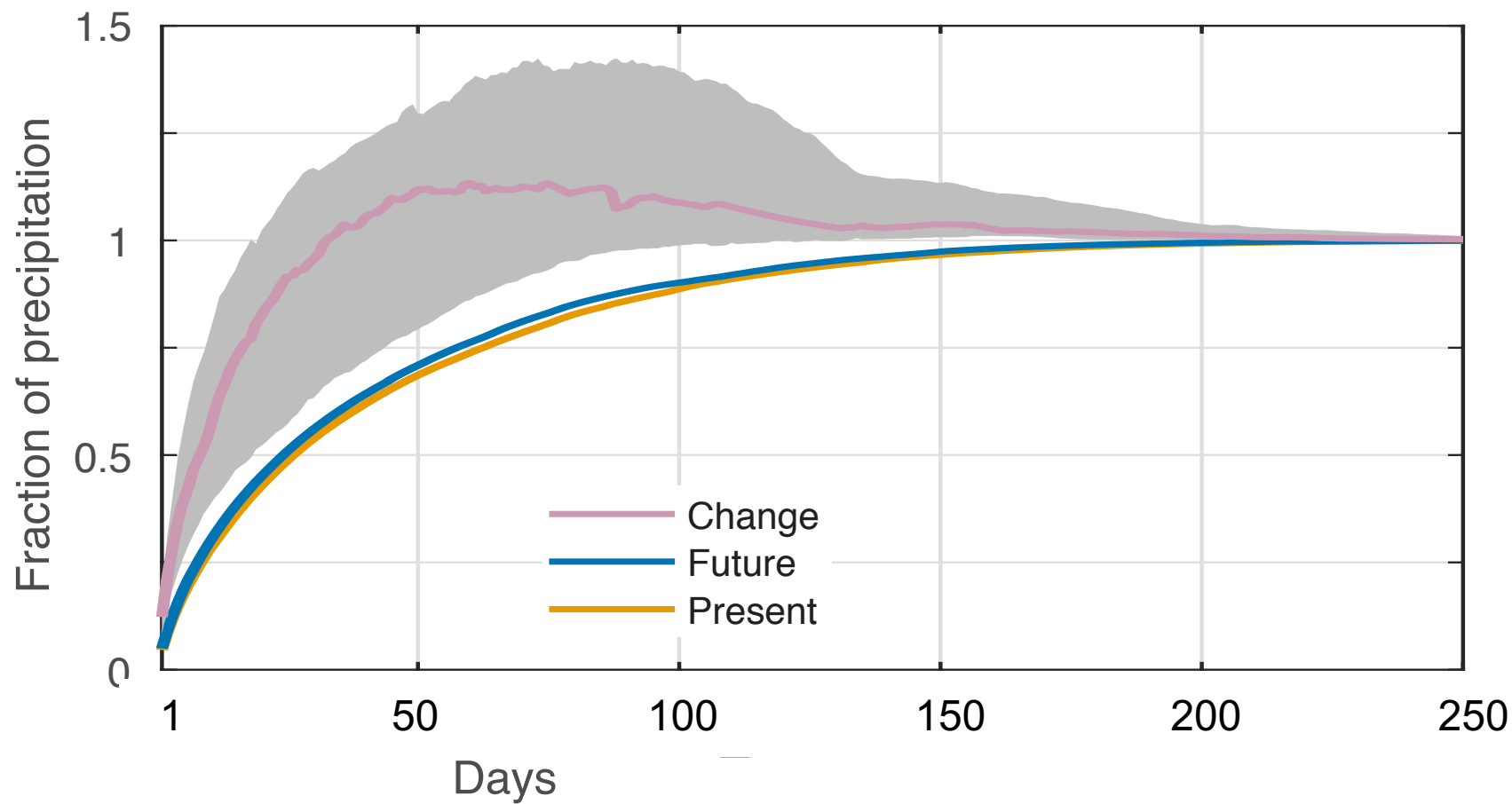
8.6 days

**Warming
increases
unevenness**

25 days

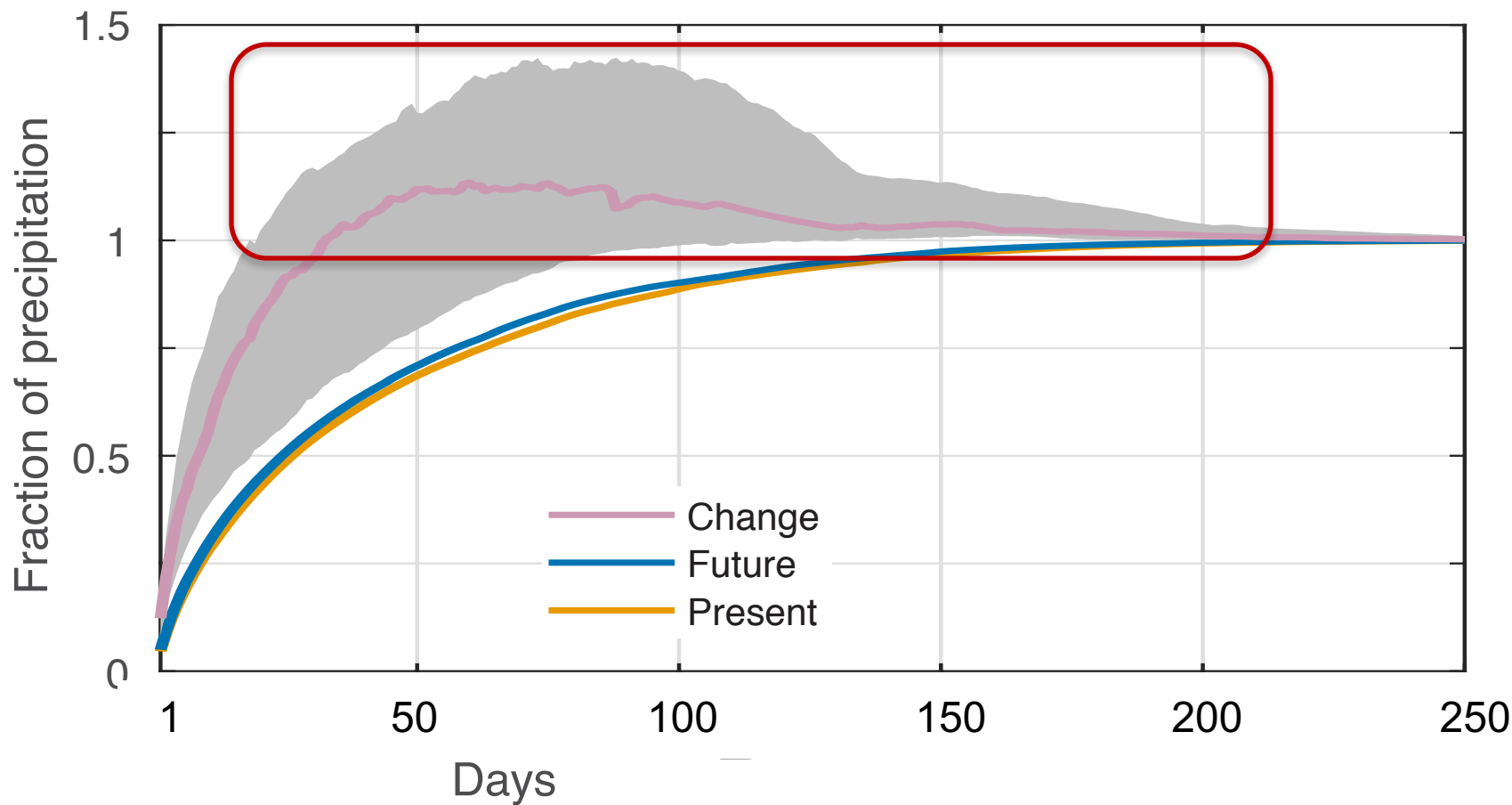
26 days

Multi-model median
Land median



Multi-model median
Land median

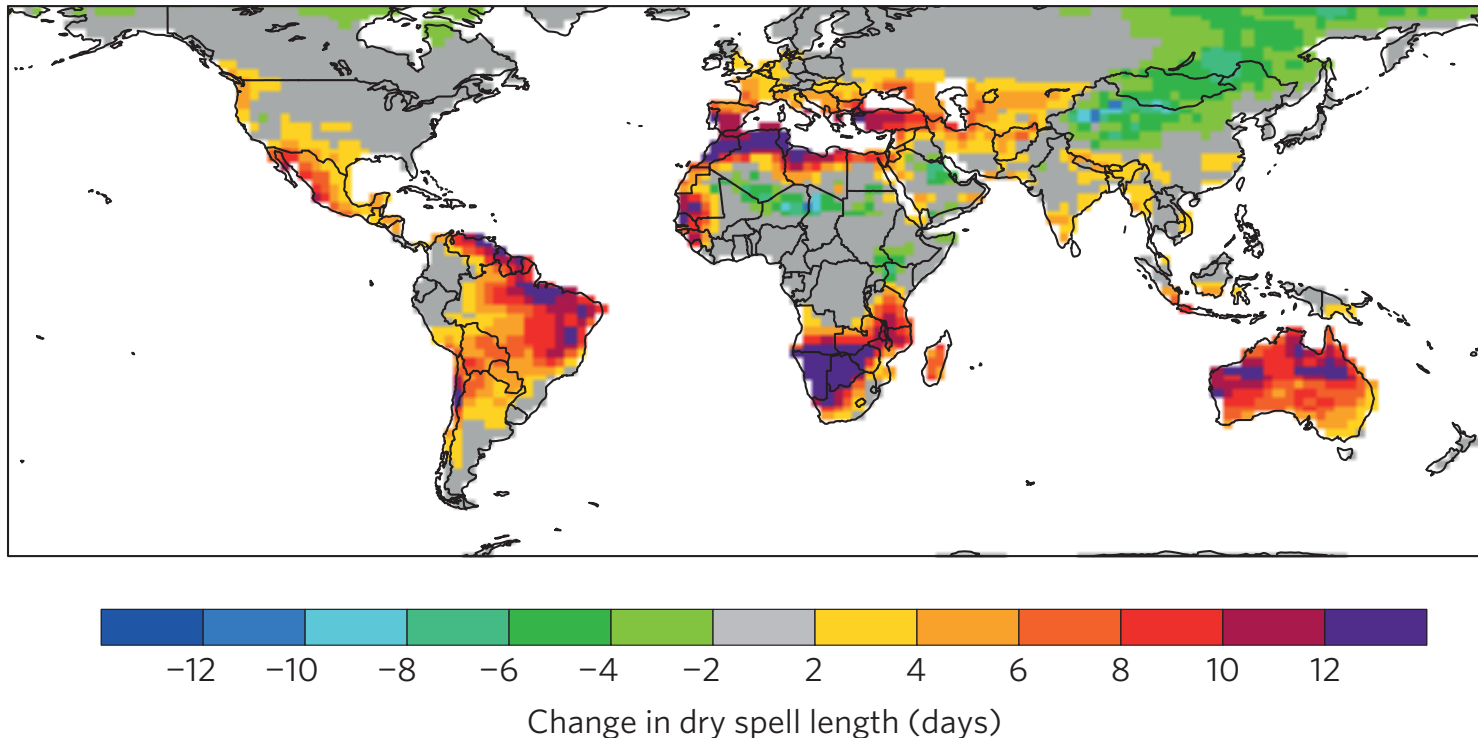
Less wet days get drier while more wet days get wetter



Multi-model median
Land median

Dry spells get longer

Change in number of consecutive dry days
CMIP5 model simulations, 2041-2060 - 1986-2005



Fischer, Beyerle, Knutti (2013) *Nature Climate Change*

Take-home messages

- Precipitation occurs unevenly
 - At observing stations, half of precipitation falls in the wettest 12 days each year
- In response to warming, models project increasing unevenness
- This is associated with increasing dry spell length in much of the world

Pendergrass and Knutti, submitted to *GRL*