NCAR

U.S. DEPARTMENT OF ENERGY | Office of Science

Boulder, Colorado, US

(ETH-Zurich)

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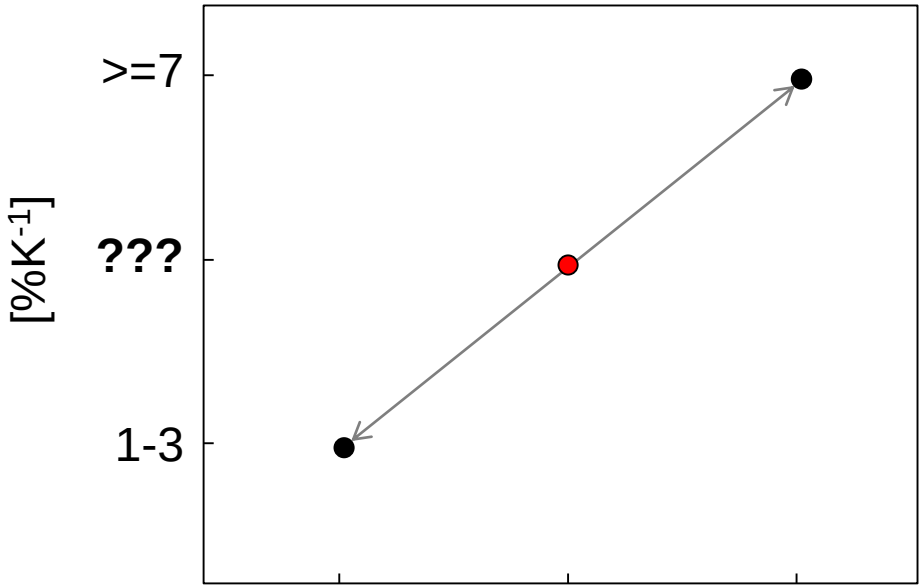
CGD Climate & Global Dynamics a Laboratory of NCAR

Grass in the central US during a flash drought - Otkin et al., 2018

Boulder Creek

troyspro.com.au



Mitchell et al (1987)
Boer (1993)
Held and Soden (2006)
many others

Trenberth (1999)
Allen and Ingram (2002)
many others

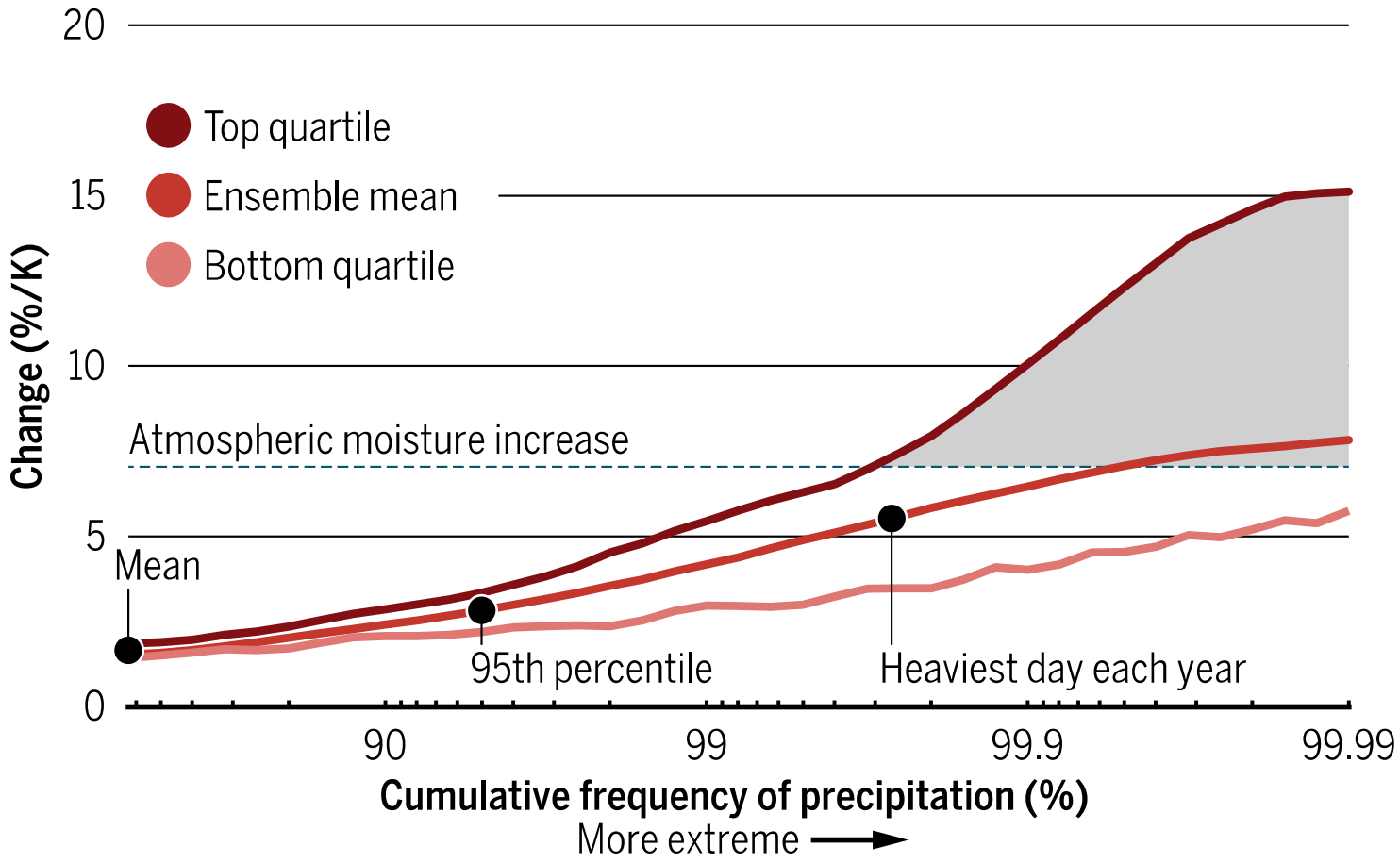
What do we talk about when we're talking about extreme precipitation?

- Impactful ?

- Meets a statistical definition ?
  - 90-something percentile of cdf: 95^{th}, 99^{th}, 99.9^{th}…
    - Wet days or all days (Schär et al 2016)
  - Maximum day per year (rx1day)

[interesting discussion by Stephenson 2008]

The definition of extreme precipitation matters when we quantify how it responds to global warming



Pendergrass (2018) *Science*

What do we talk about when we're talking about extreme precipitation?

- How uneven is precipitation?
  - We will quantify this
- You will see that the lines are blurred – a large fraction of precipitation volume falls in events sometimes considered extreme

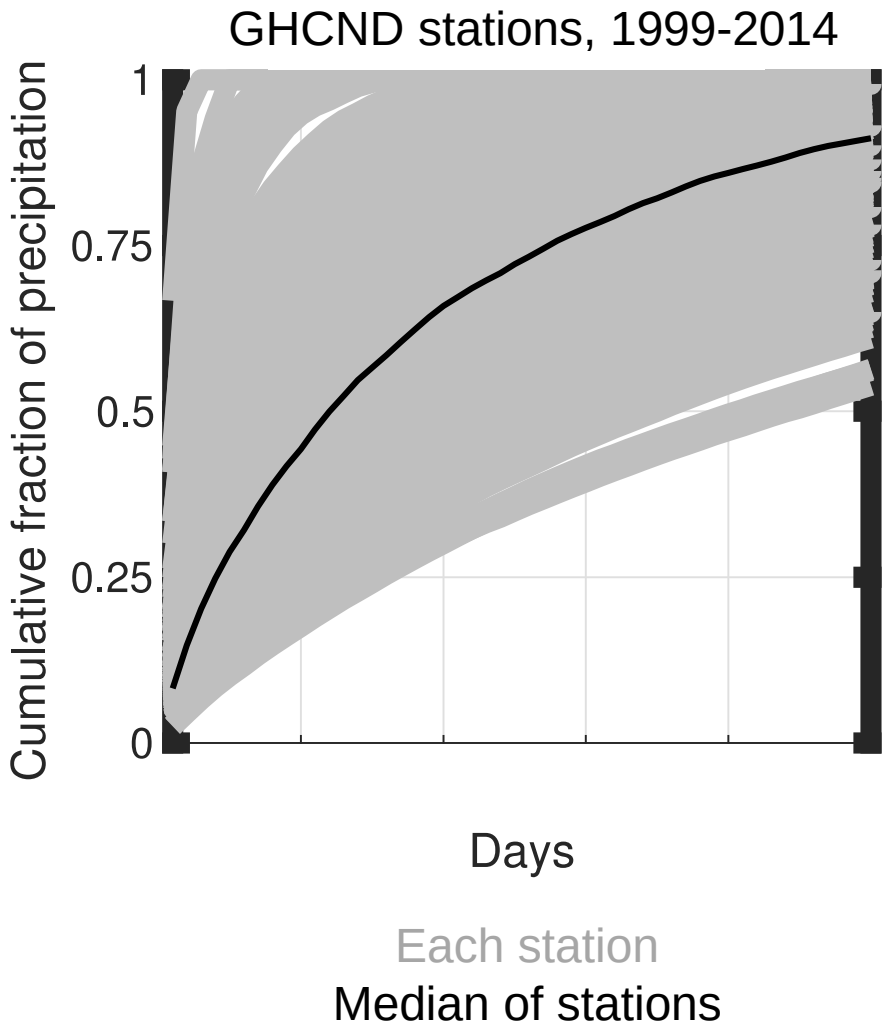
Some previous work

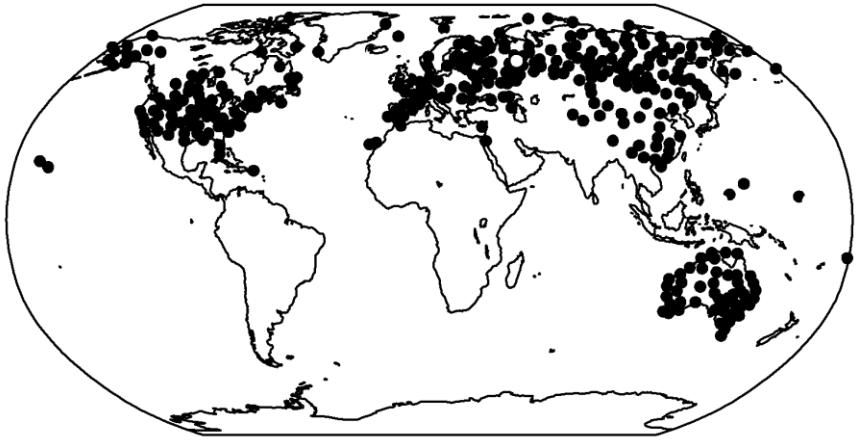
- Observed trends in the contribution of extremes to total precipitation (US focused)
  - Karl and Knight (1998), Semenov and Bengtsson (2002), Groisman et al (2005), …
- Unevenness of precipitation – Detection & Attribution
  - Quantified by Gini coefficient – Konapala et al (2017)

Precipitation data (Daily)

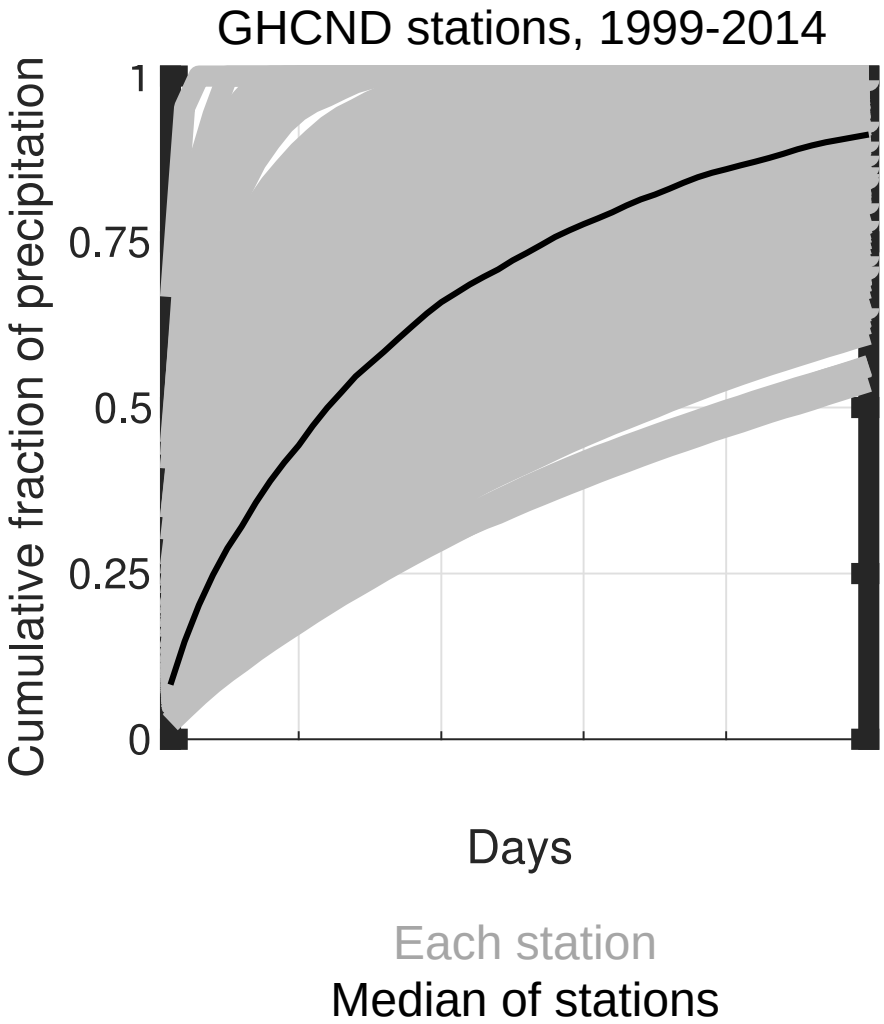
- **Station observations**
  - Global Historical Climatology Network – Daily (GHCN-D), Global Climate Observing System Surface Network
- Satellite-based observations
  - TRMM 3b42 gridded product
- **Climate model simulations**
  - CMIP5, historical and RCP8.5 (high future emissions) scenarios
  - 1999-2014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

Cumulative fraction of precipitation

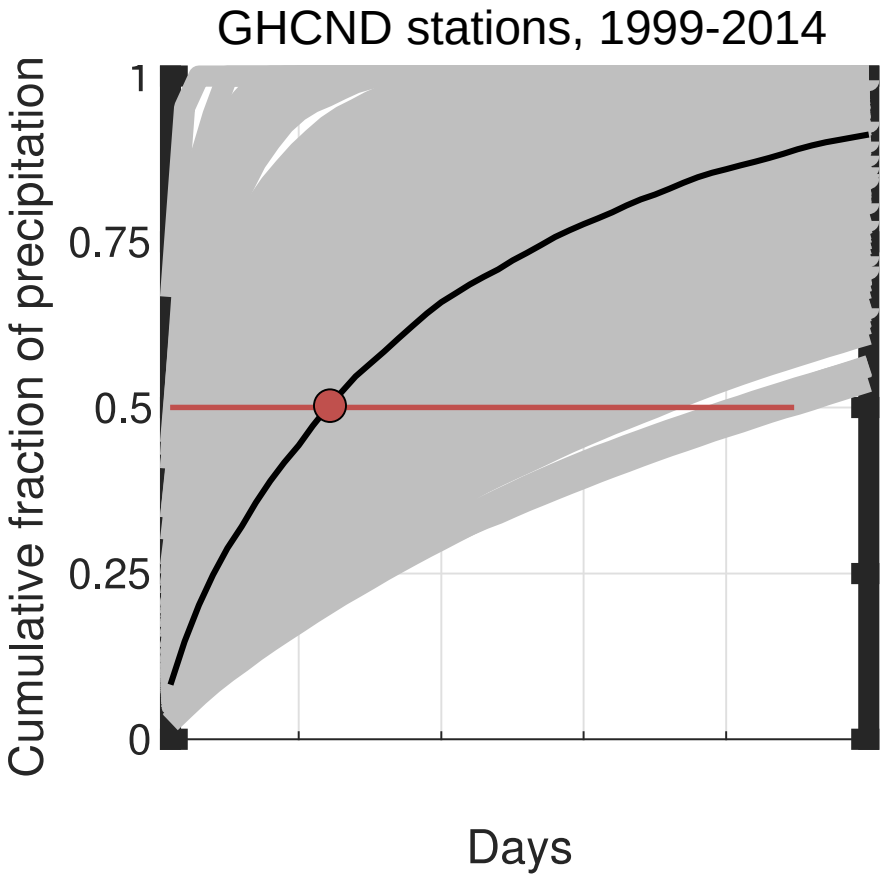




Cumulative fraction of precipitation



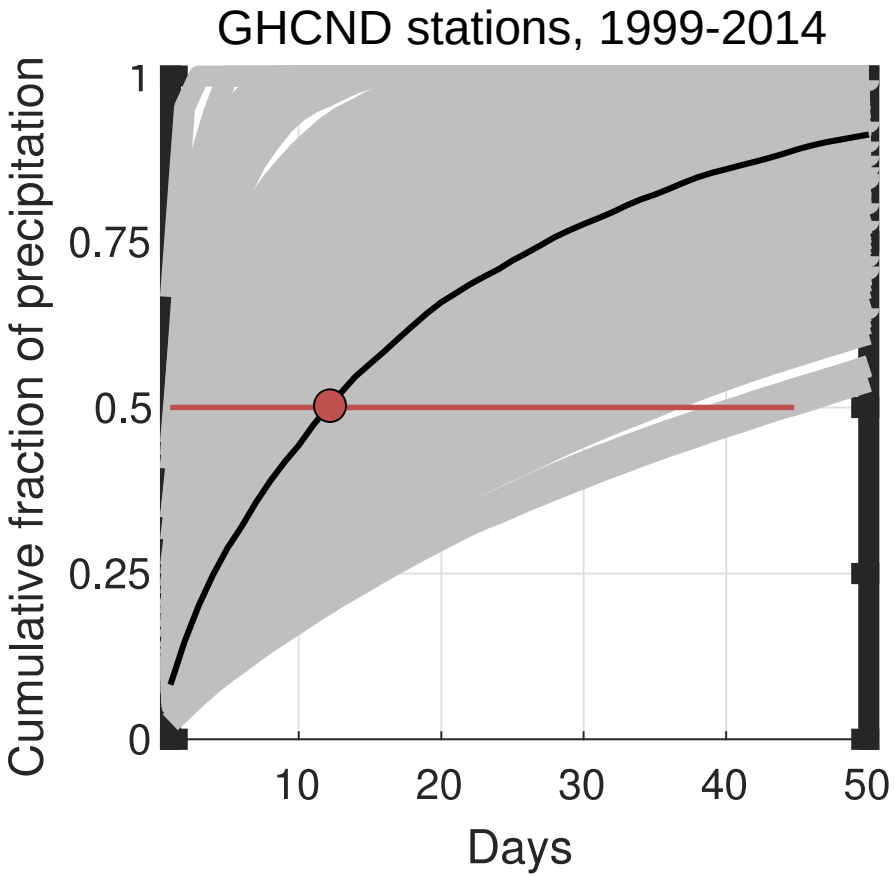
Days in which ½ of precip falls



How many days do you think it takes for half of annual precipitation to fall?

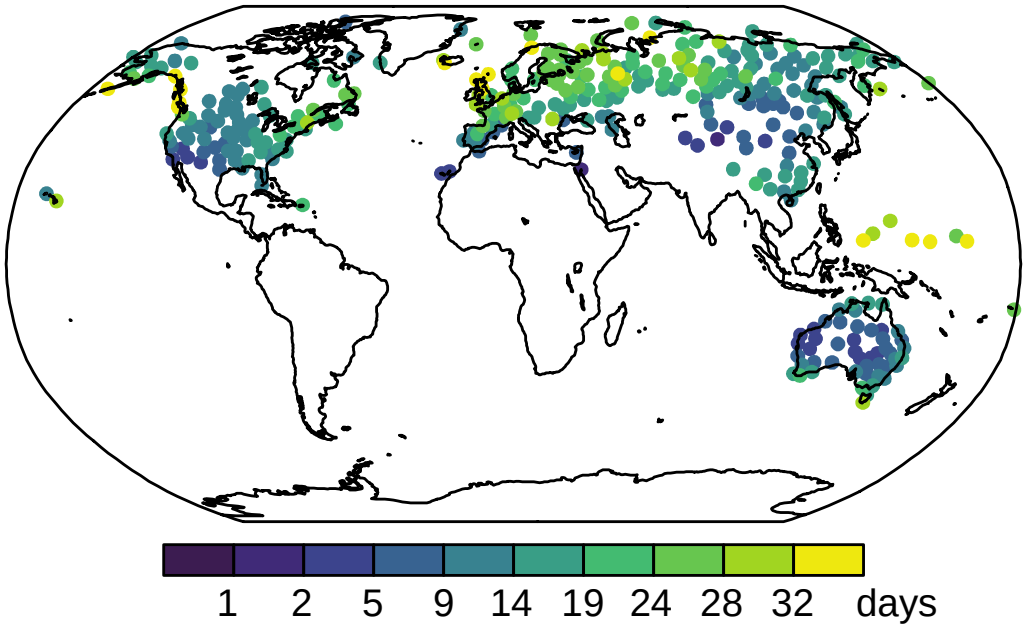
5?
15?
50?
150?

Days in which ½ of precip falls

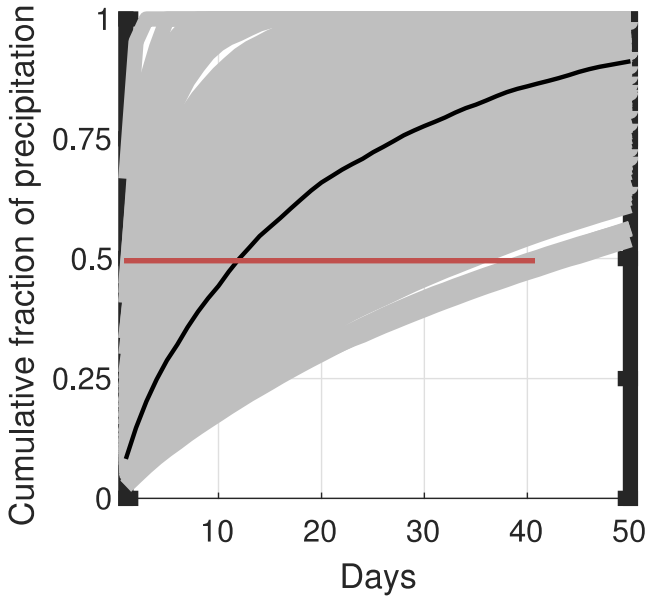


Median:
12 days

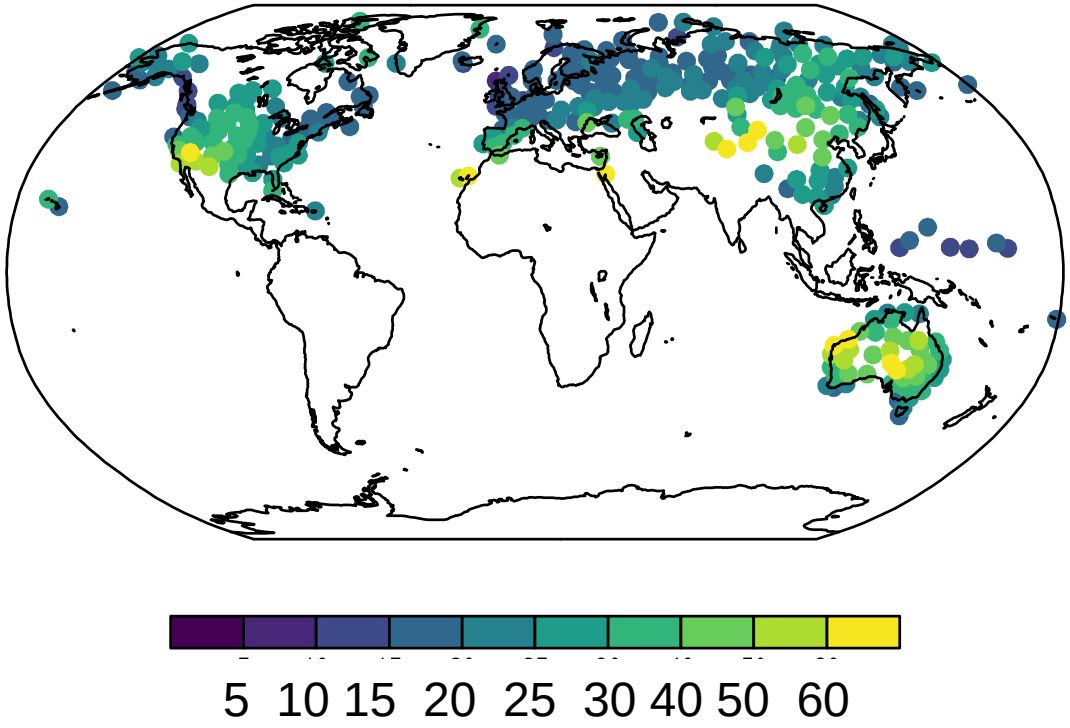
Days in which ½ of precip falls



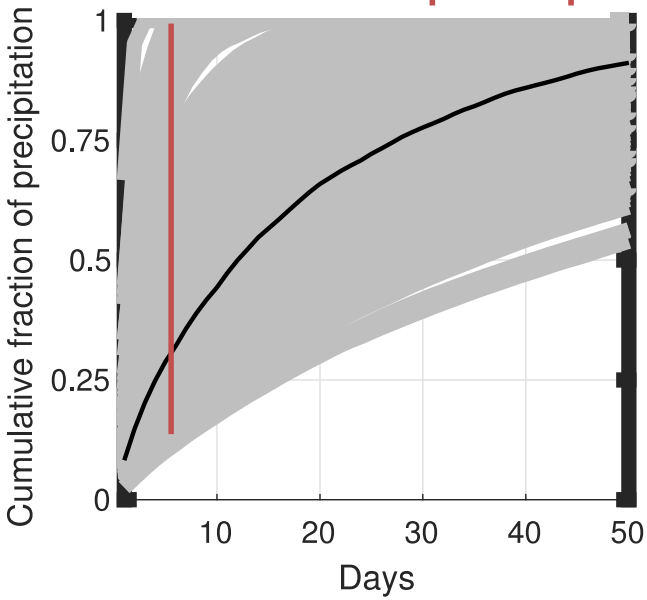
12 days



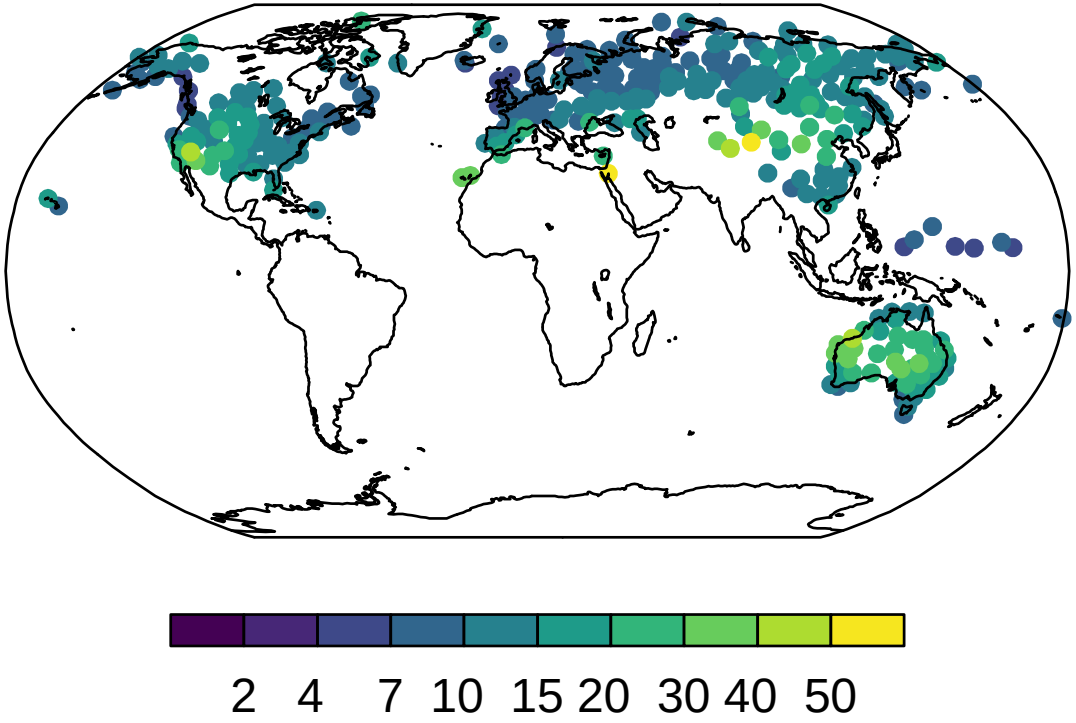
Wettest 5 days



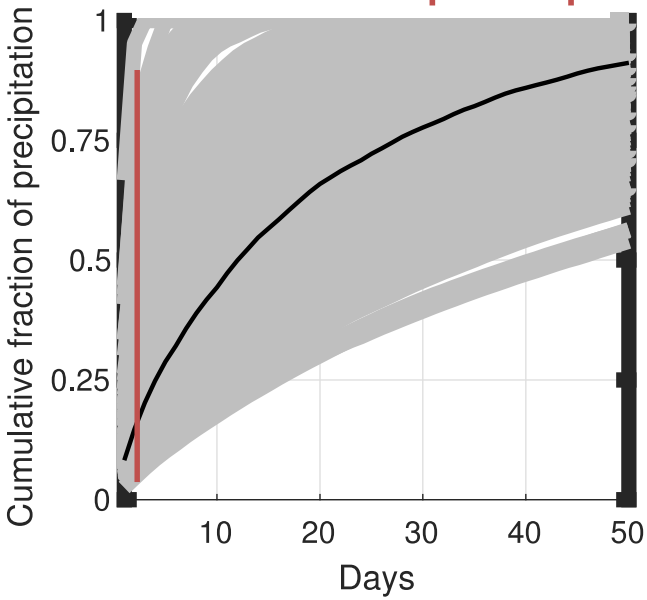
30%
of annual precip



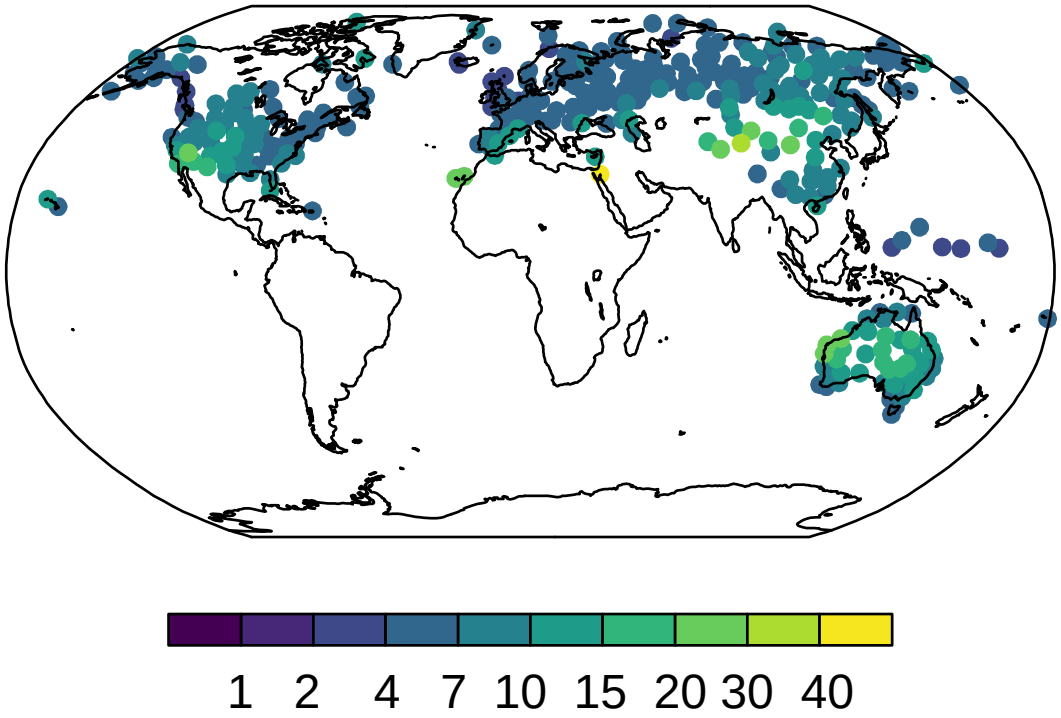
Wettest 2 days



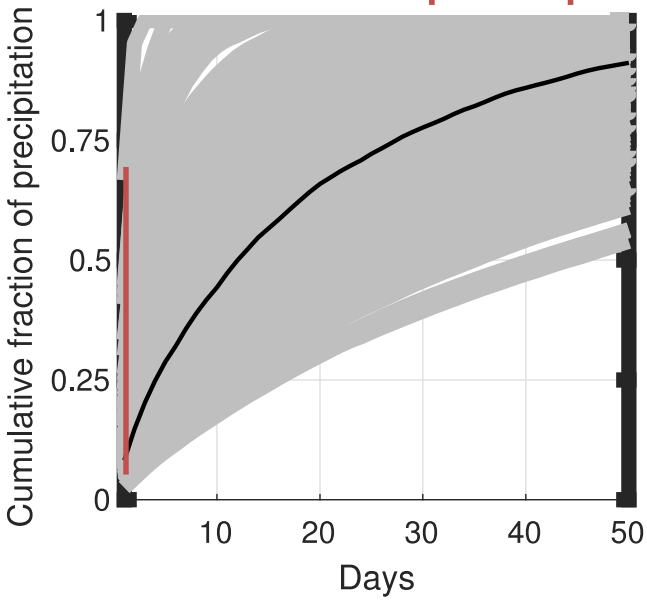
15%
of annual precip



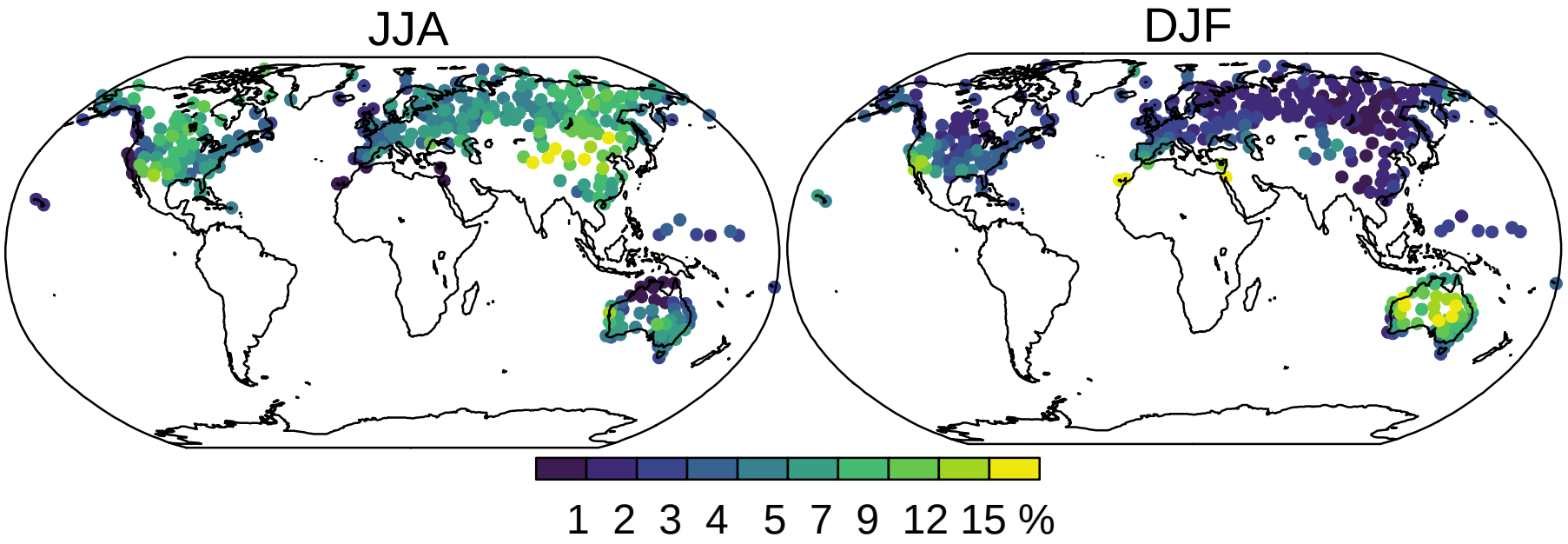
Wettest day



8.4%
of annual precip



Wettest day: **by season**



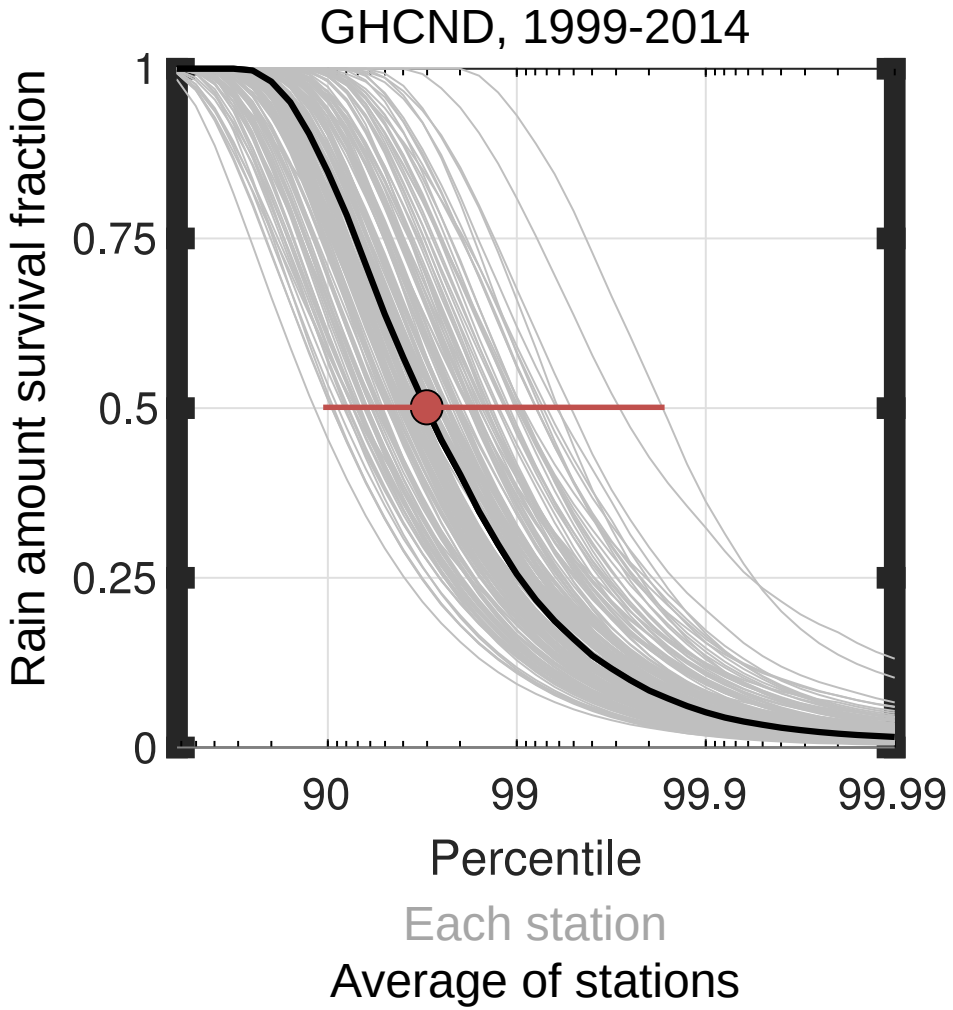
Winter

3.4% of annual precip

Summer

5.2 % of annual precip

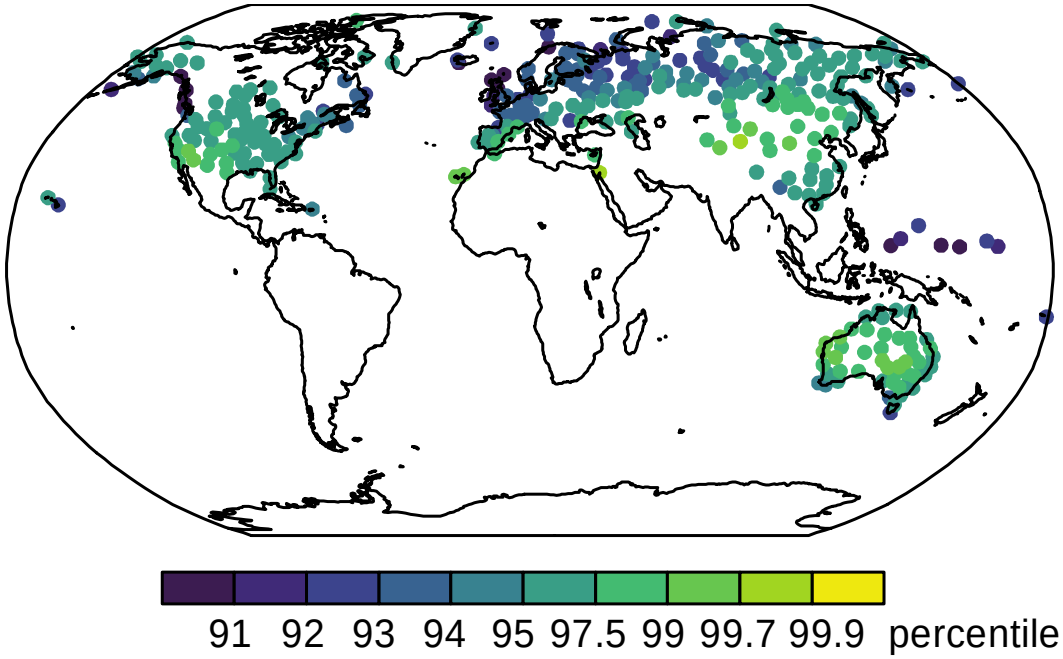
Percentile above which half of precip falls



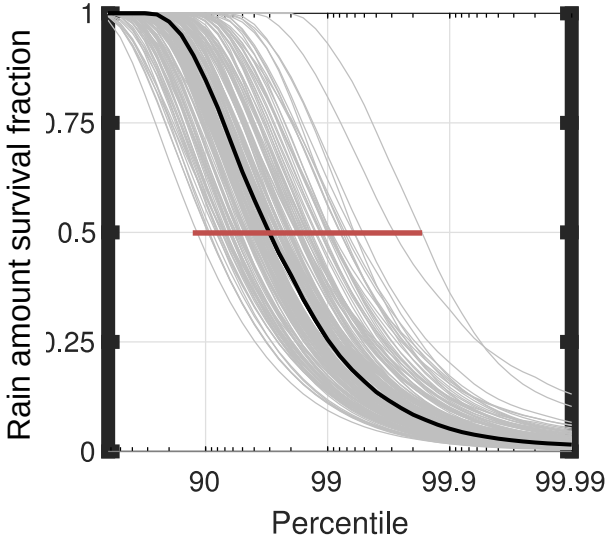
Median: 97.0 percentile

Rain amount survival function
or 1- cumulative rain amount distribution

Percentile above which ½ of precip falls

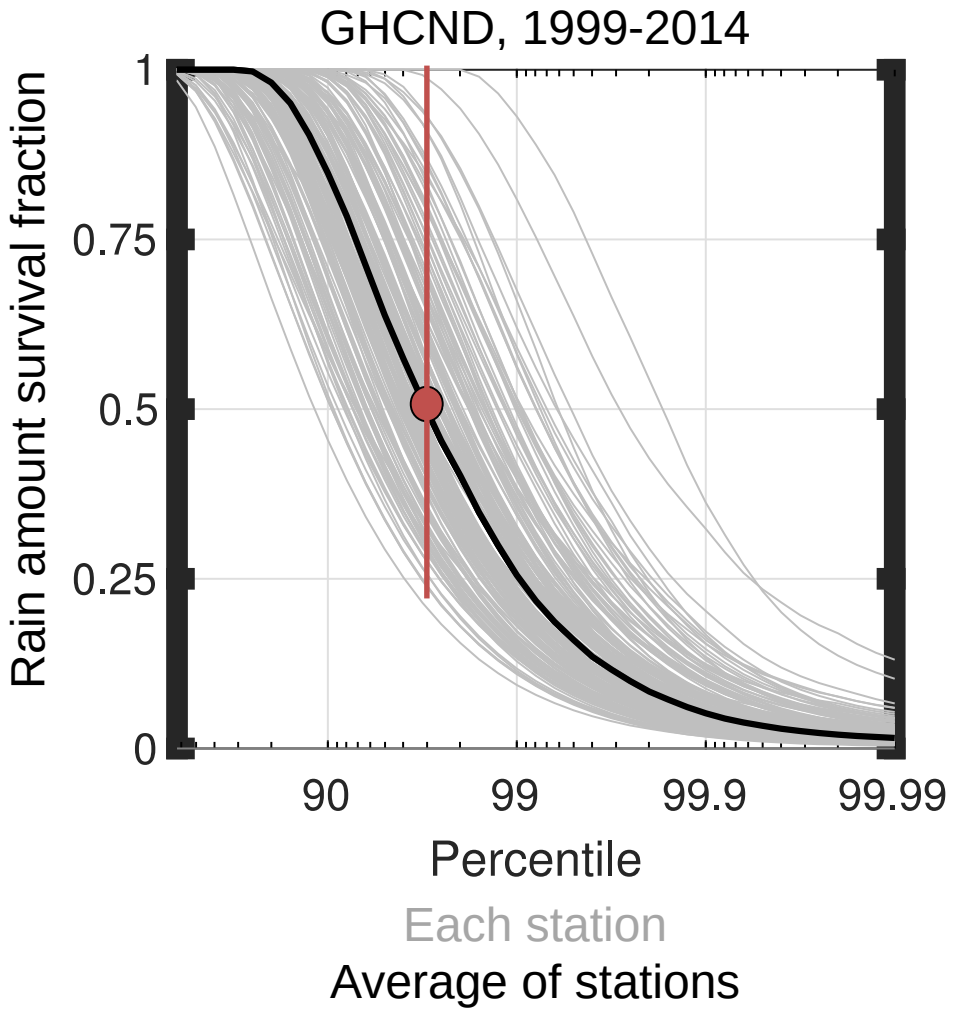


Median:
97.0 percentile



Rain amount survival function

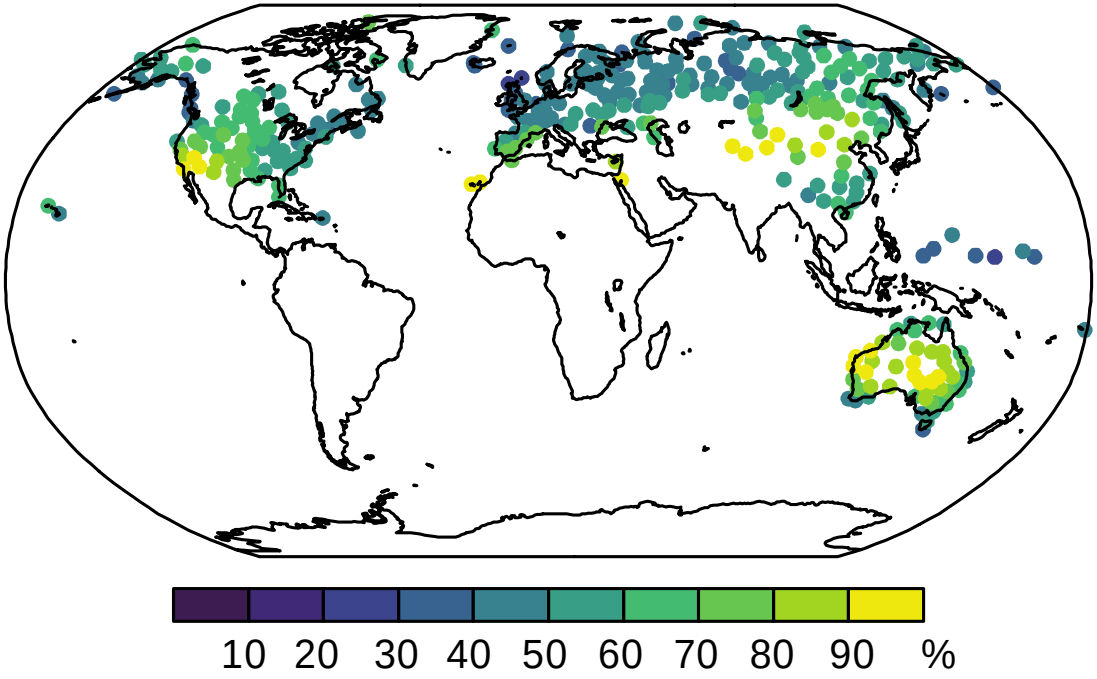
Fraction of precip falling above the 95th percentile

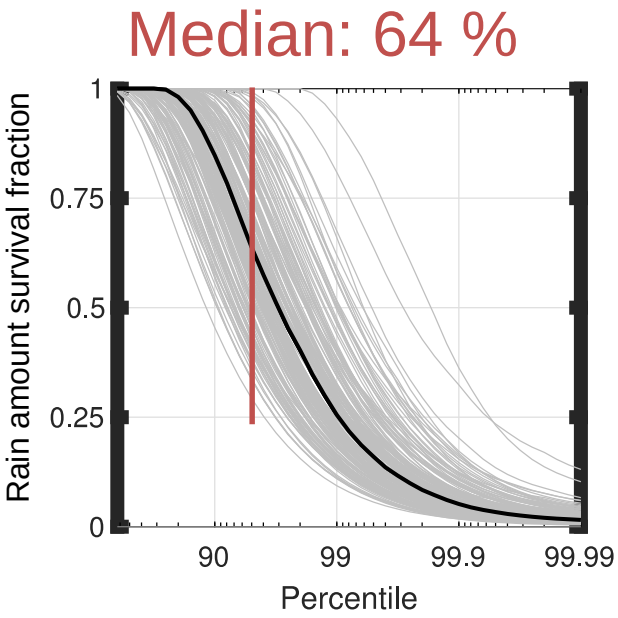


Median:
64 %

Rain amount survival function

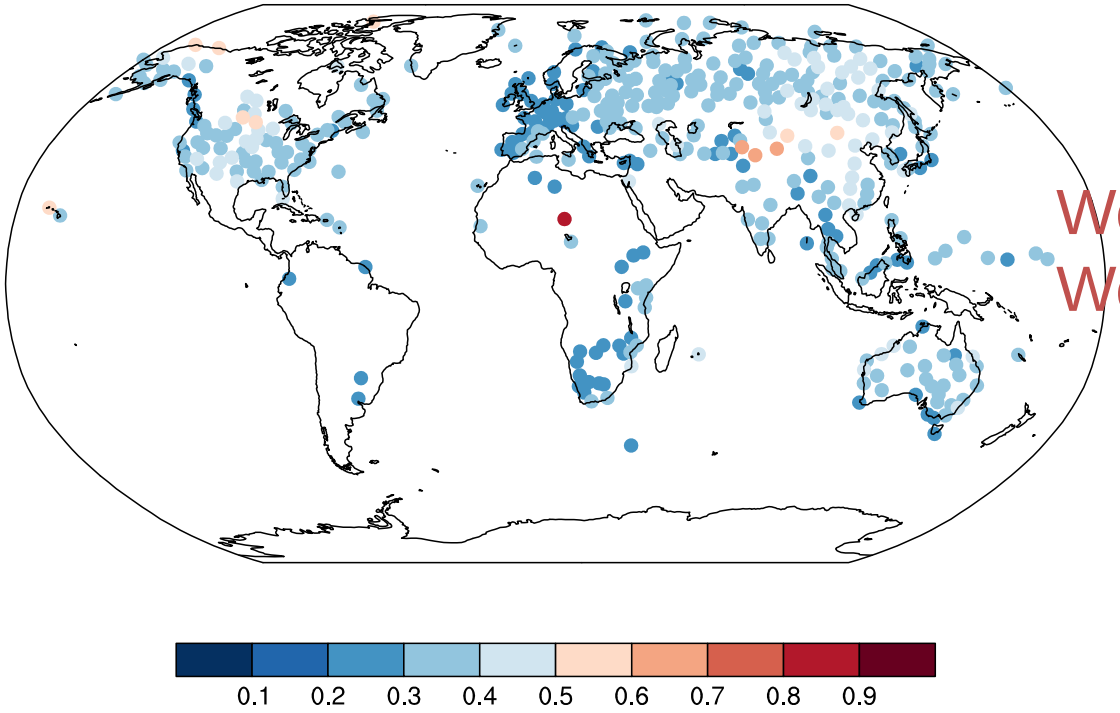
Fraction of precip falling above the 95th percentile



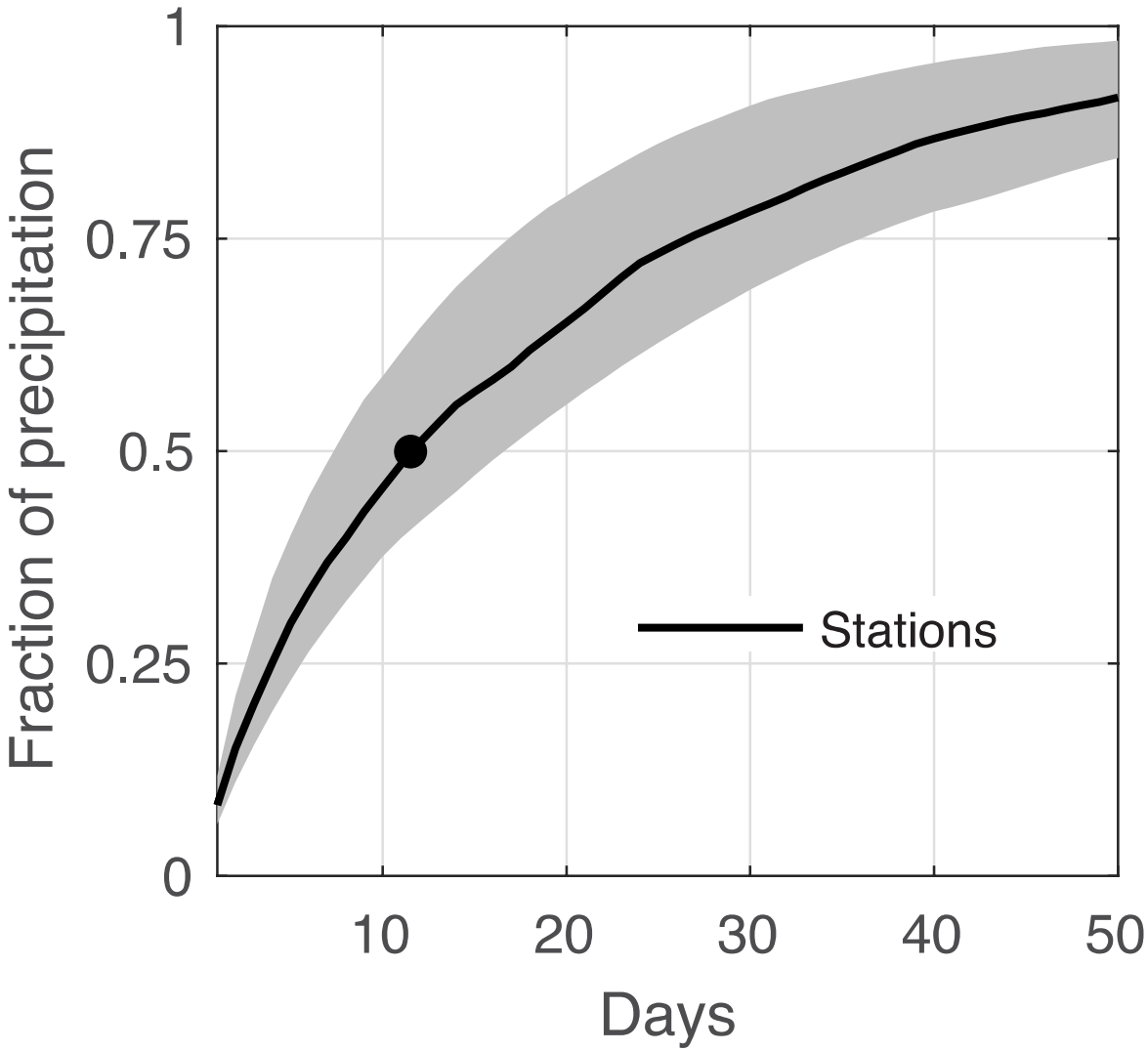


Rain amount survival function

Fraction of precip falling above the 95th **wet-day** percentile

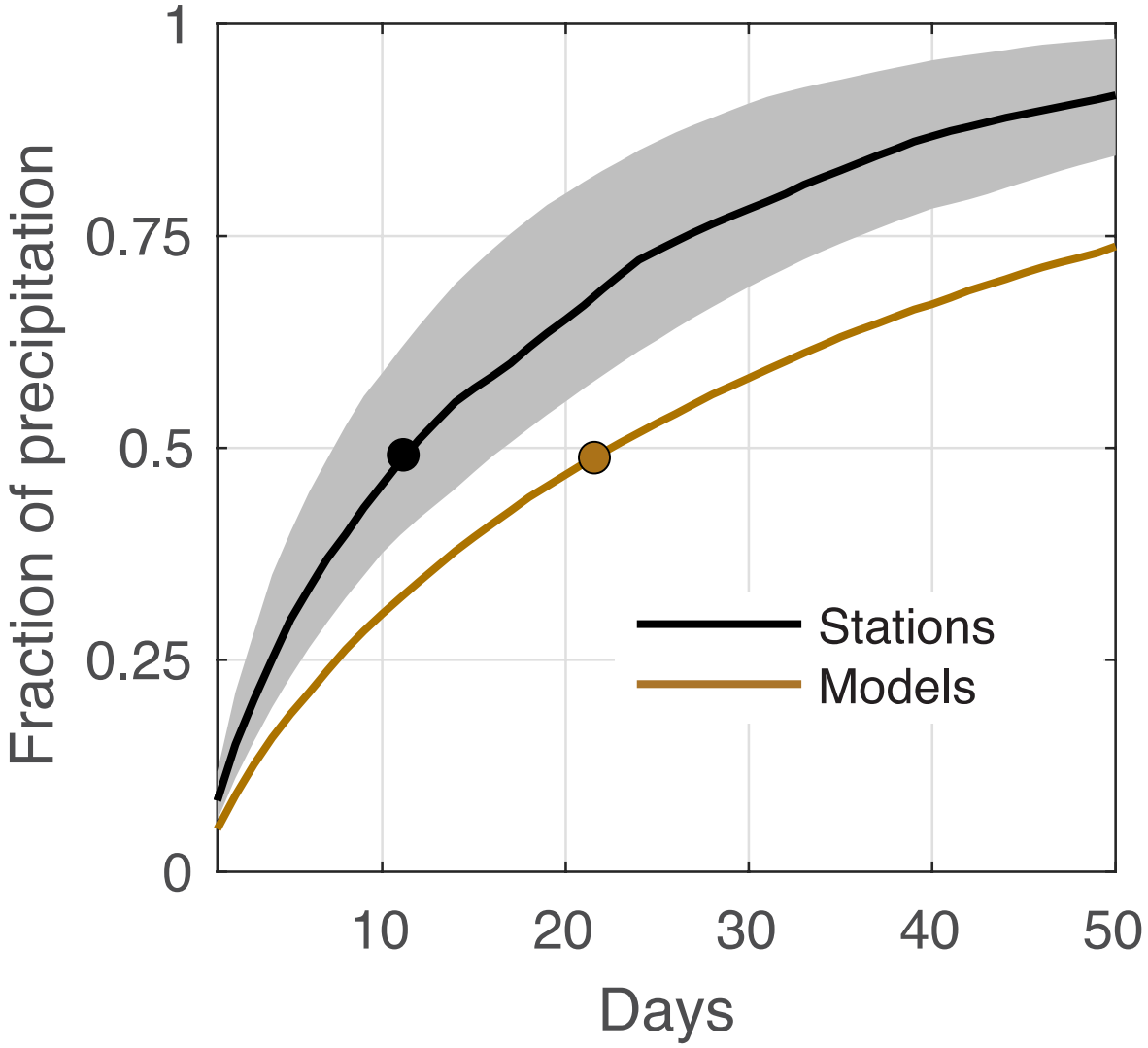


Wet days > 0 mm/d: 36 %
Wet days > 1 mm/d: 24 %



12 days

Multi-model median
Median of grid points corresponding to stations

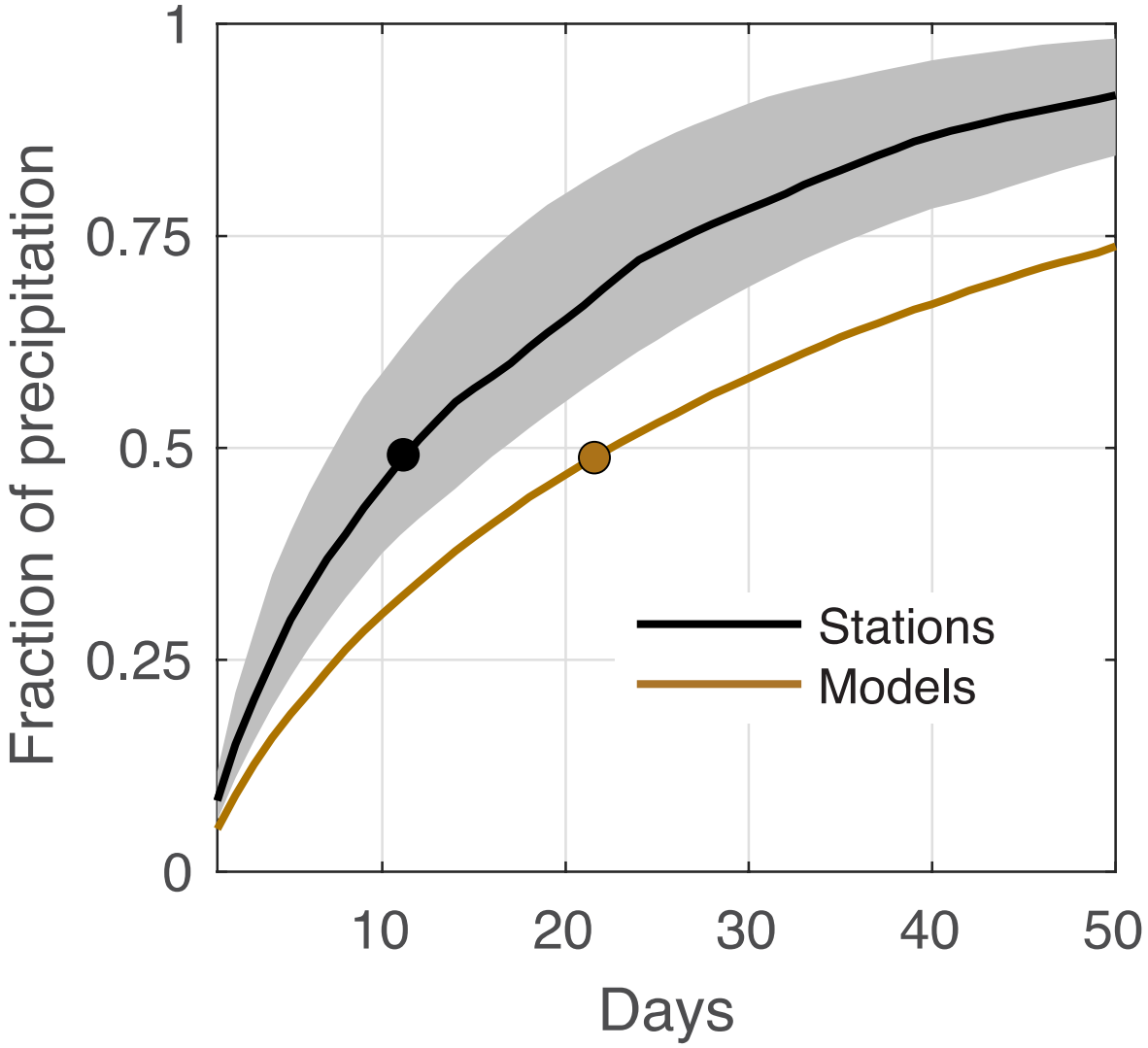


12 days

23 days

Multi-model median

Median of grid points corresponding to stations

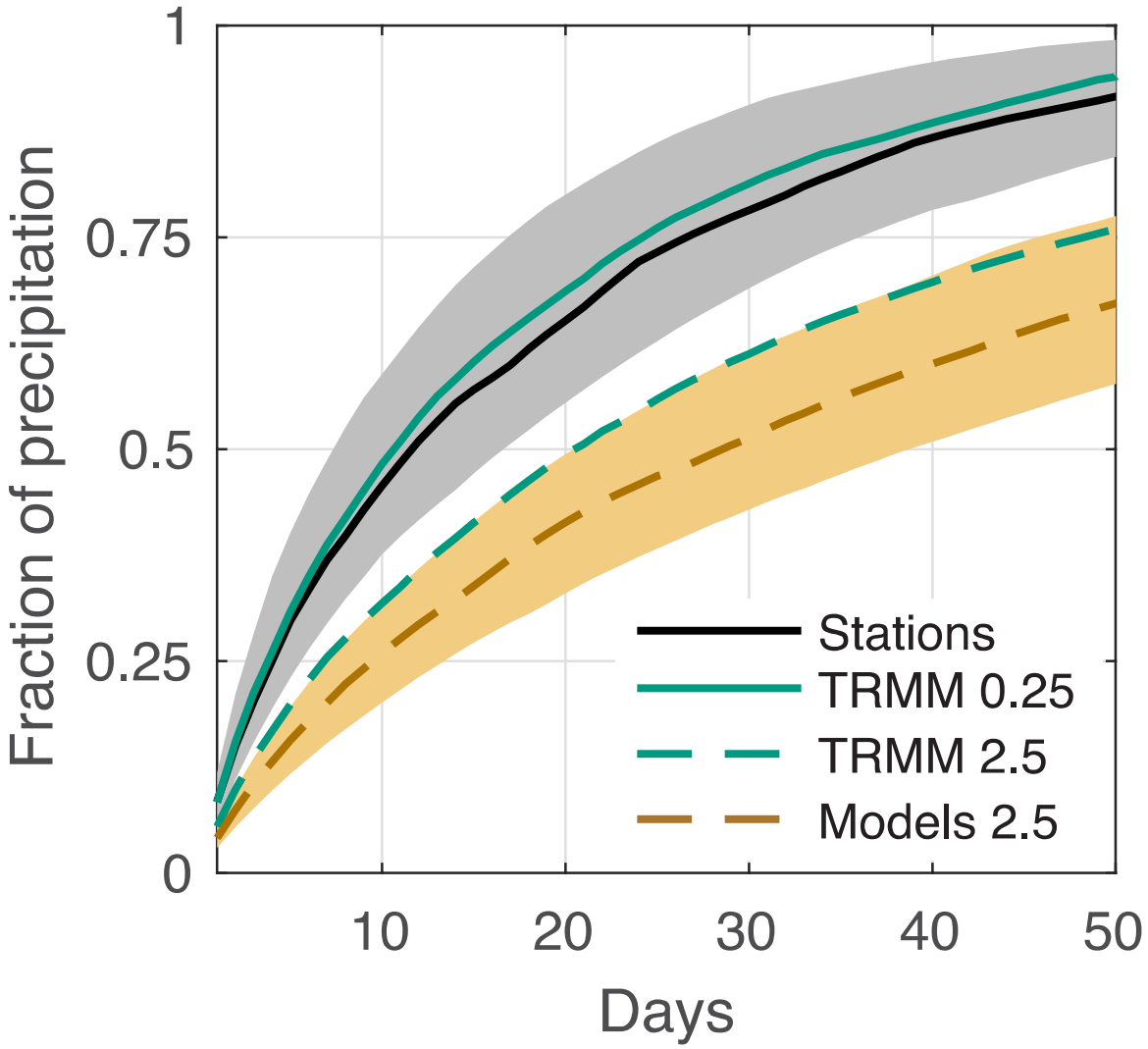


12 days

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

How will unevenness respond to warming?

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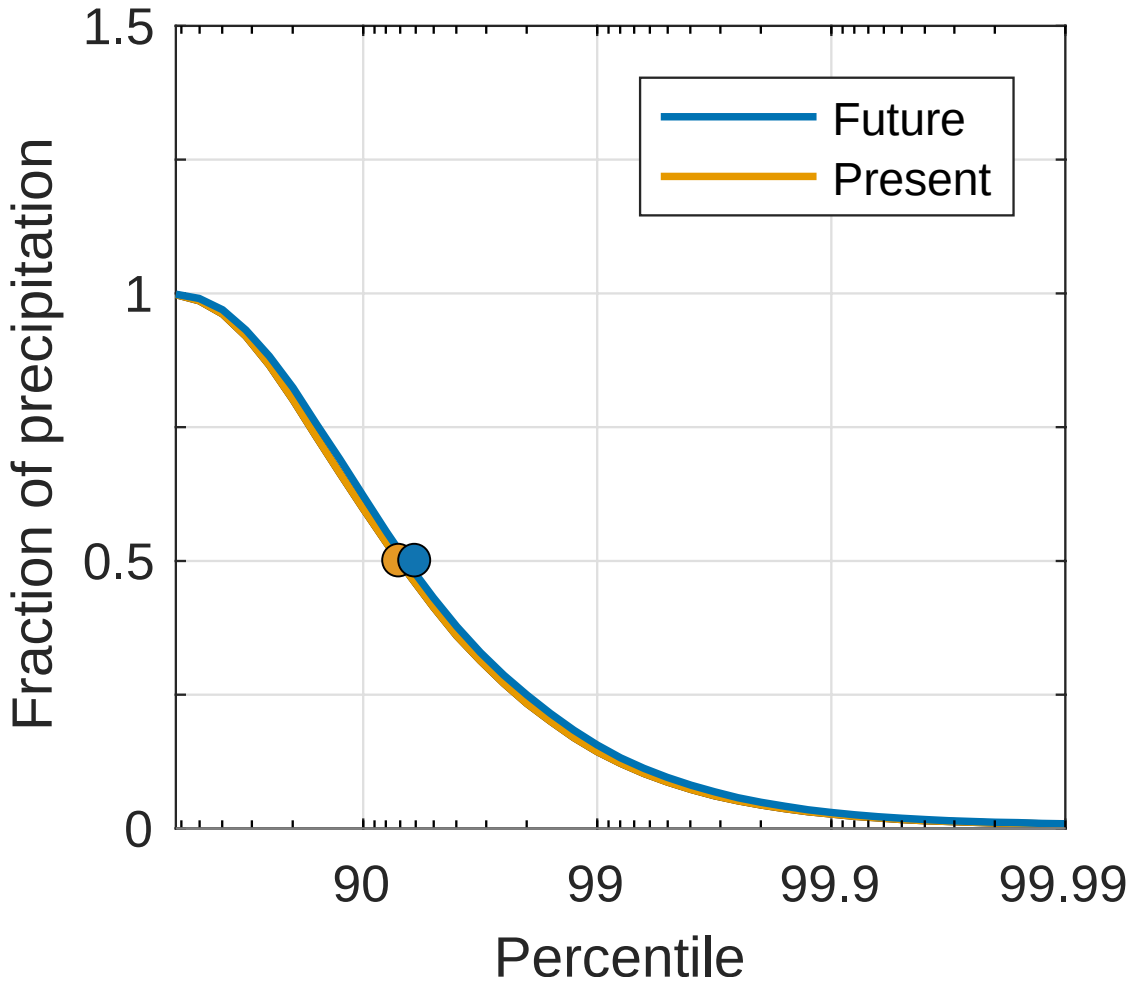

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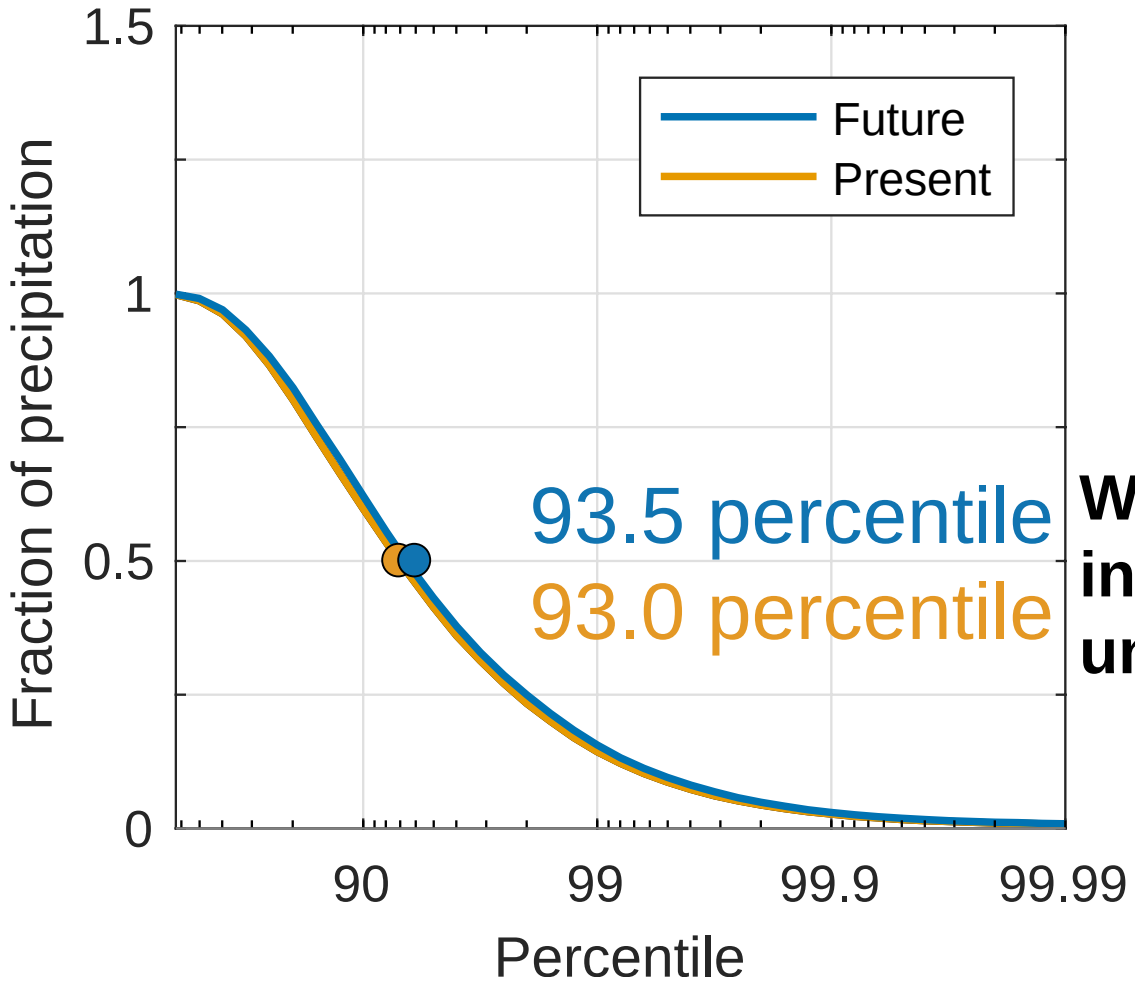
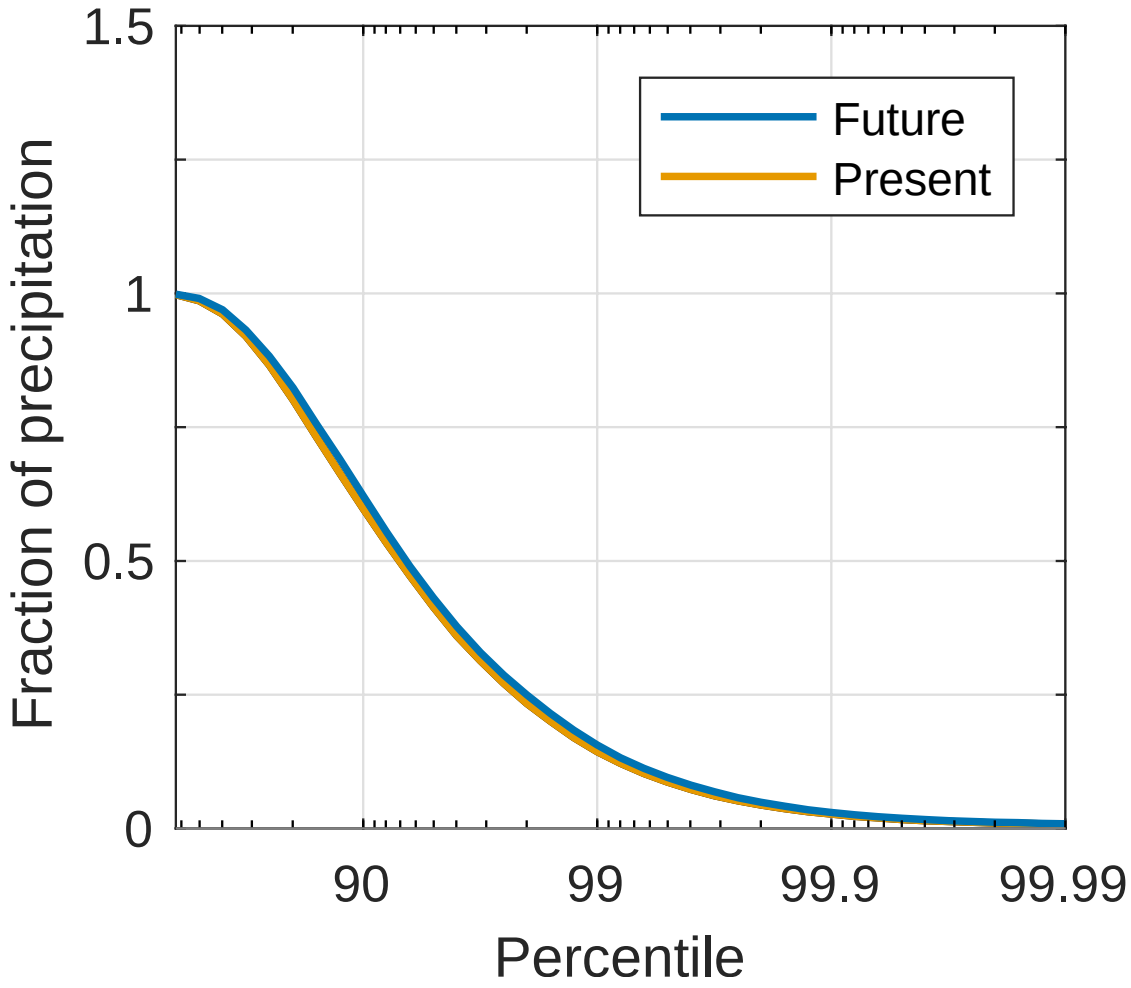


Warming increases unevenness

How will unevenness respond to warming?



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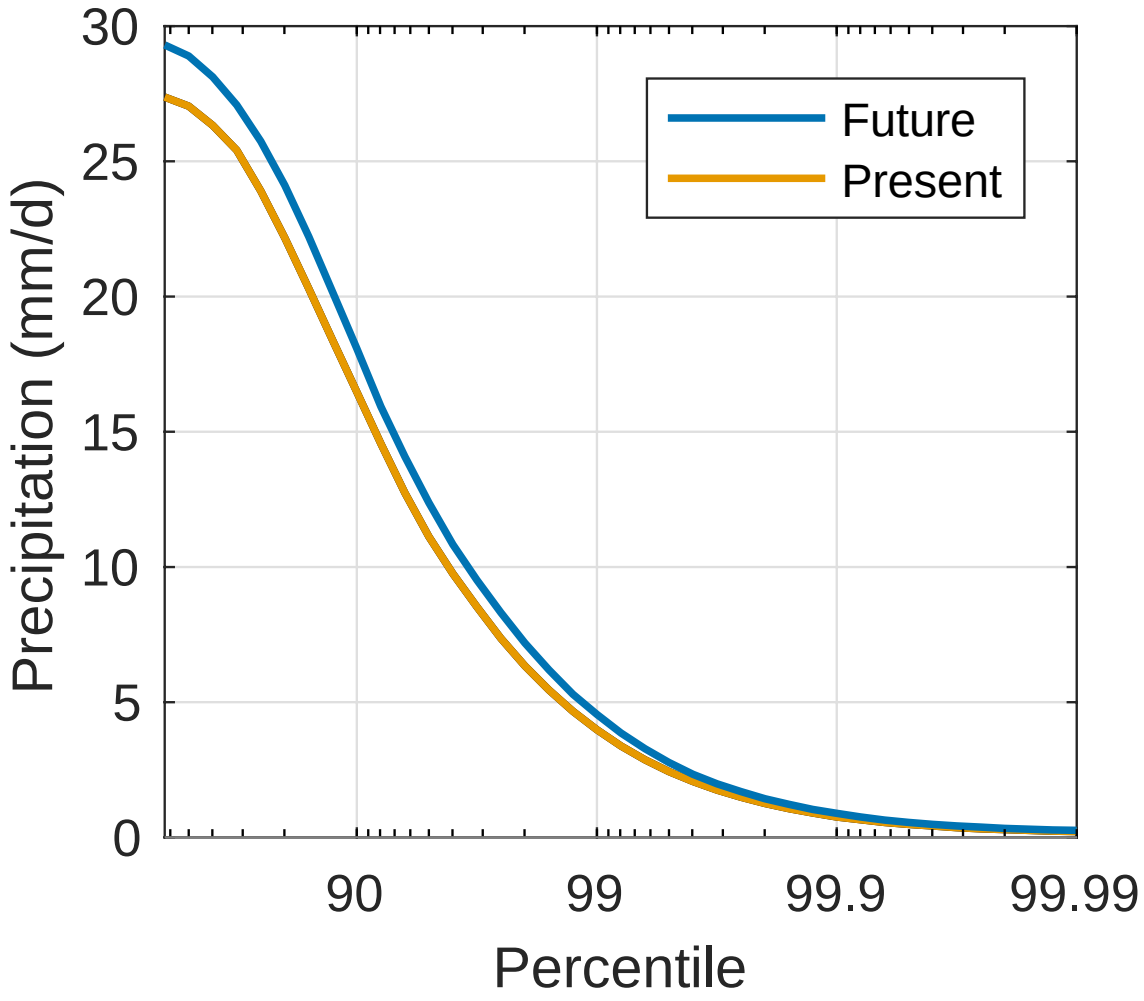

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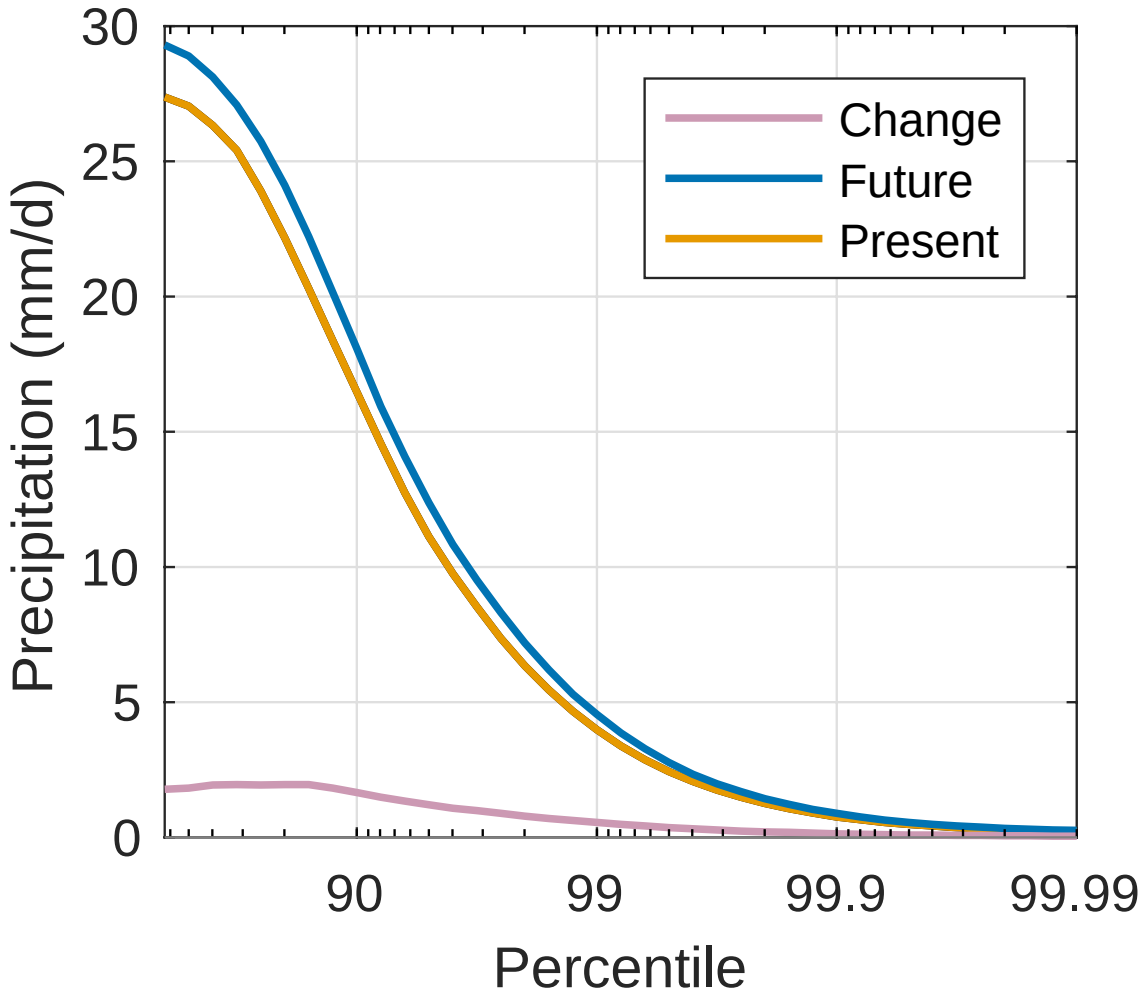

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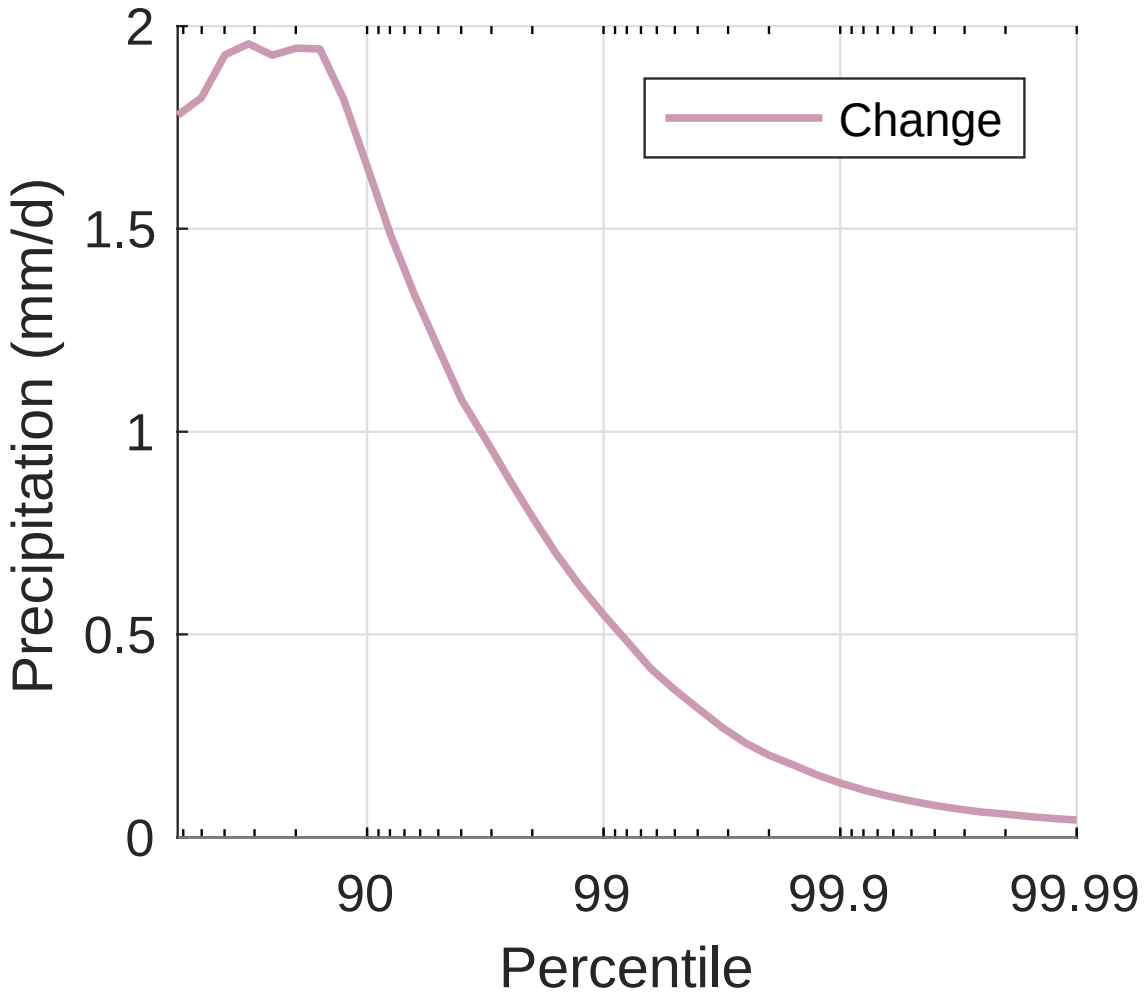

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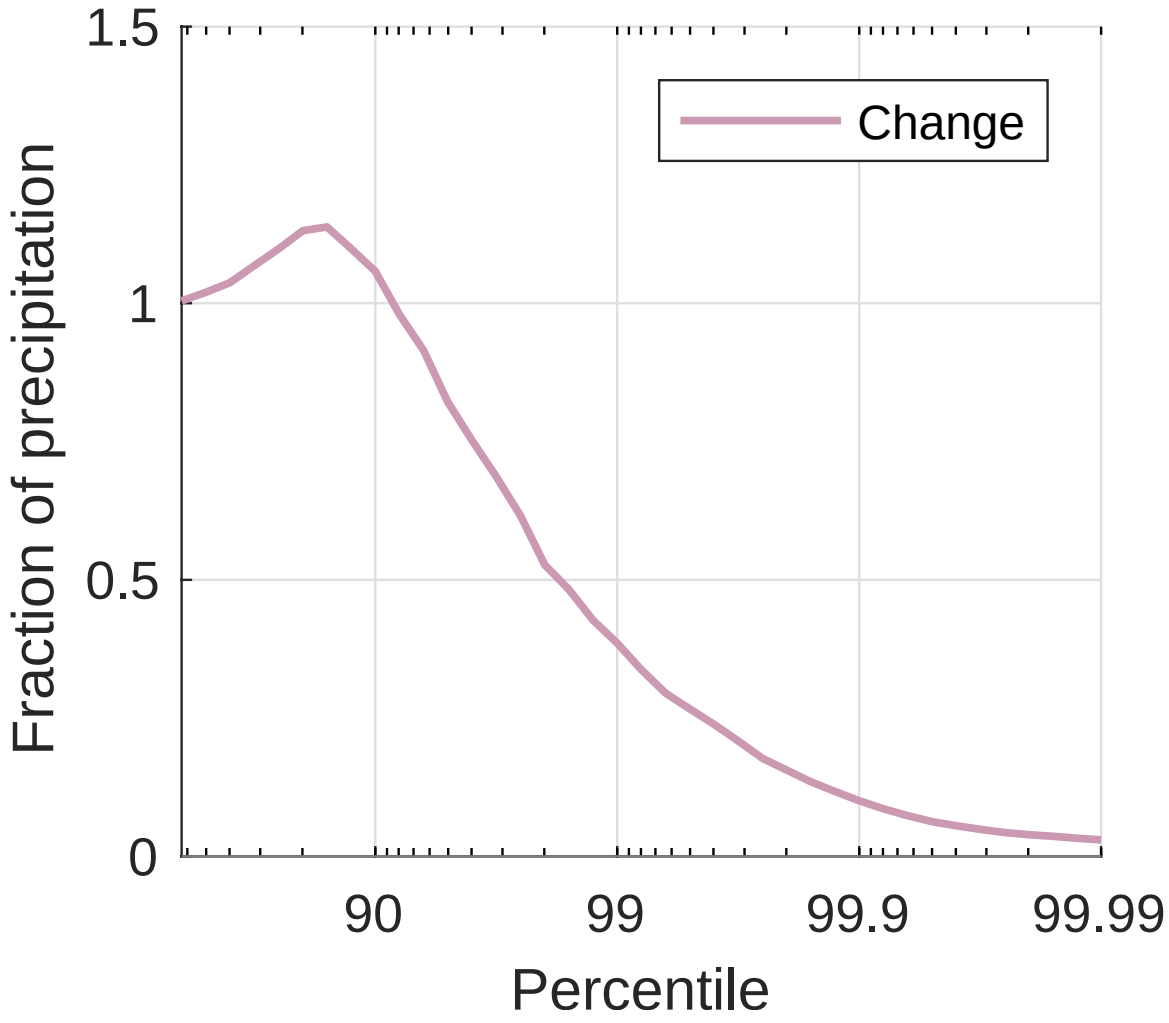
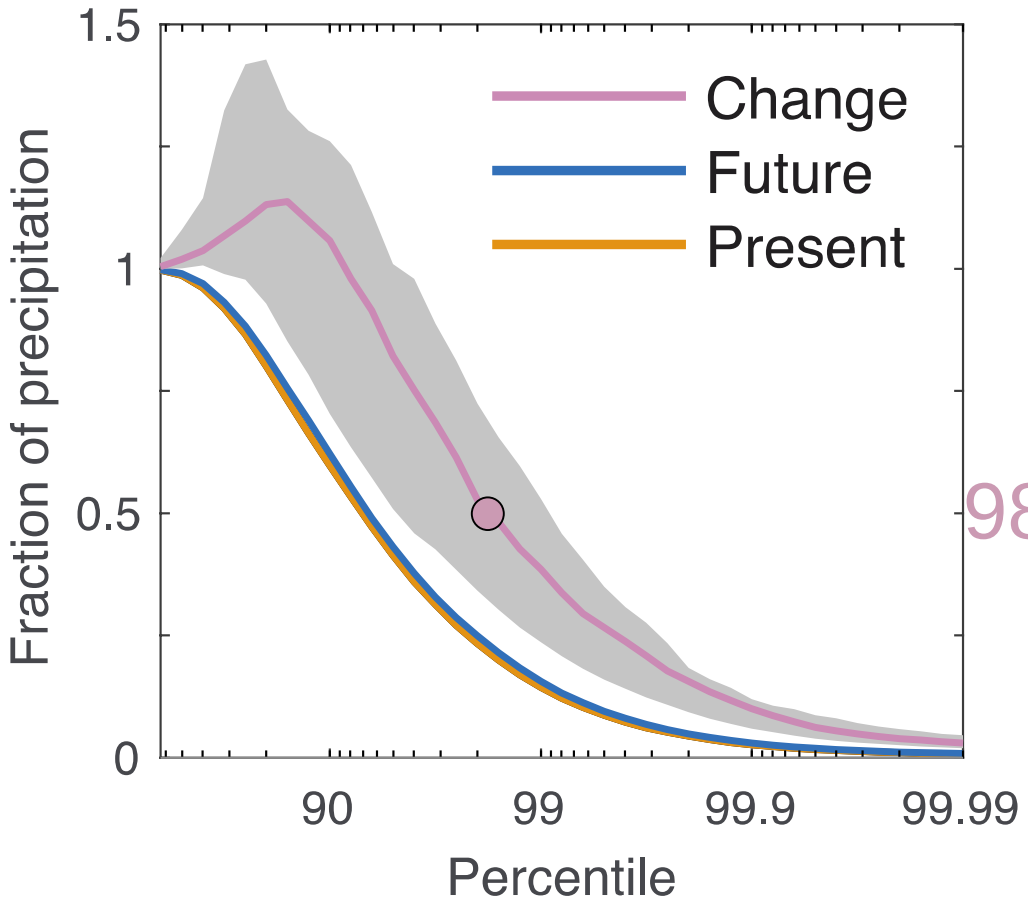
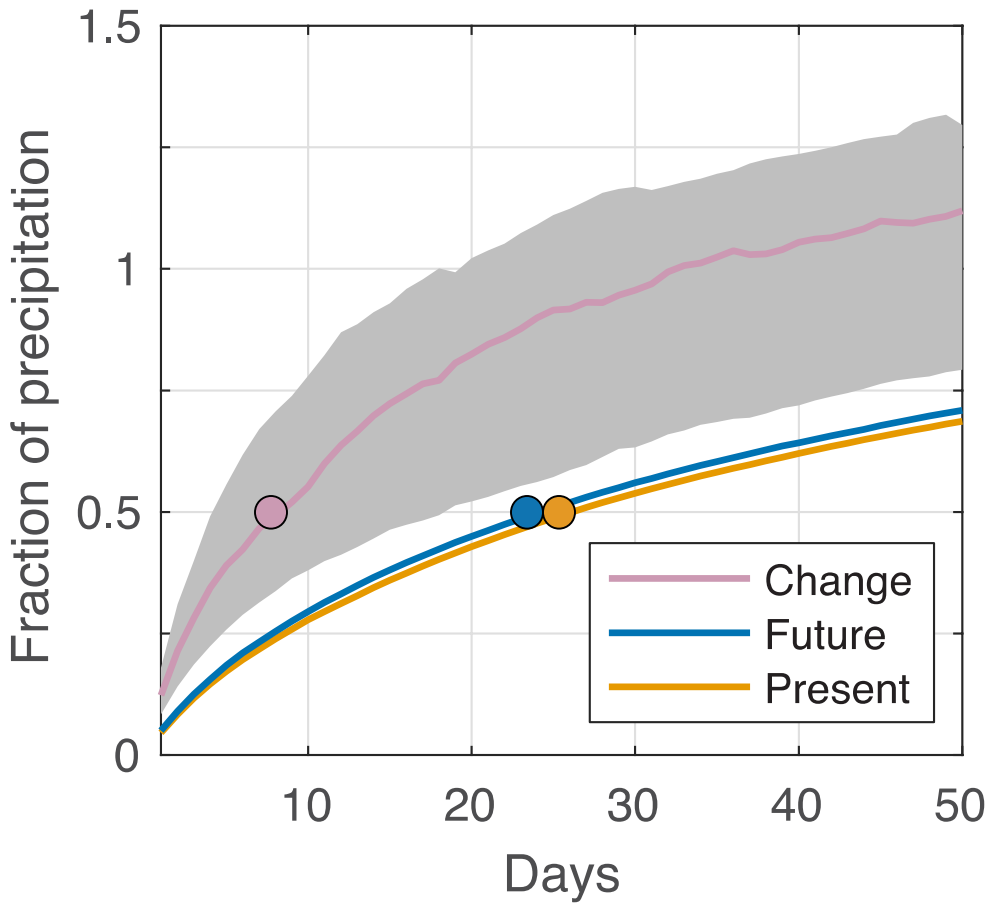




98.2 percentile

Multi-model median
Land median



8.6 days

25 days

26 days

Warming increases unevenness

Multi-model median
Land median

Take-home messages

- Precipitation falls unevenly
  - At observing stations, half of precipitation falls in the wettest 12 days each year
- In response to warming, 97% of models project increasing unevenness
- A large fraction of precipitation and its change fall in events often considered extreme
- We should work on reconciling our narratives for precipitation change by considering the distribution

Pendergrass and Knutti (2018) *GRL*

Questions / Comments?

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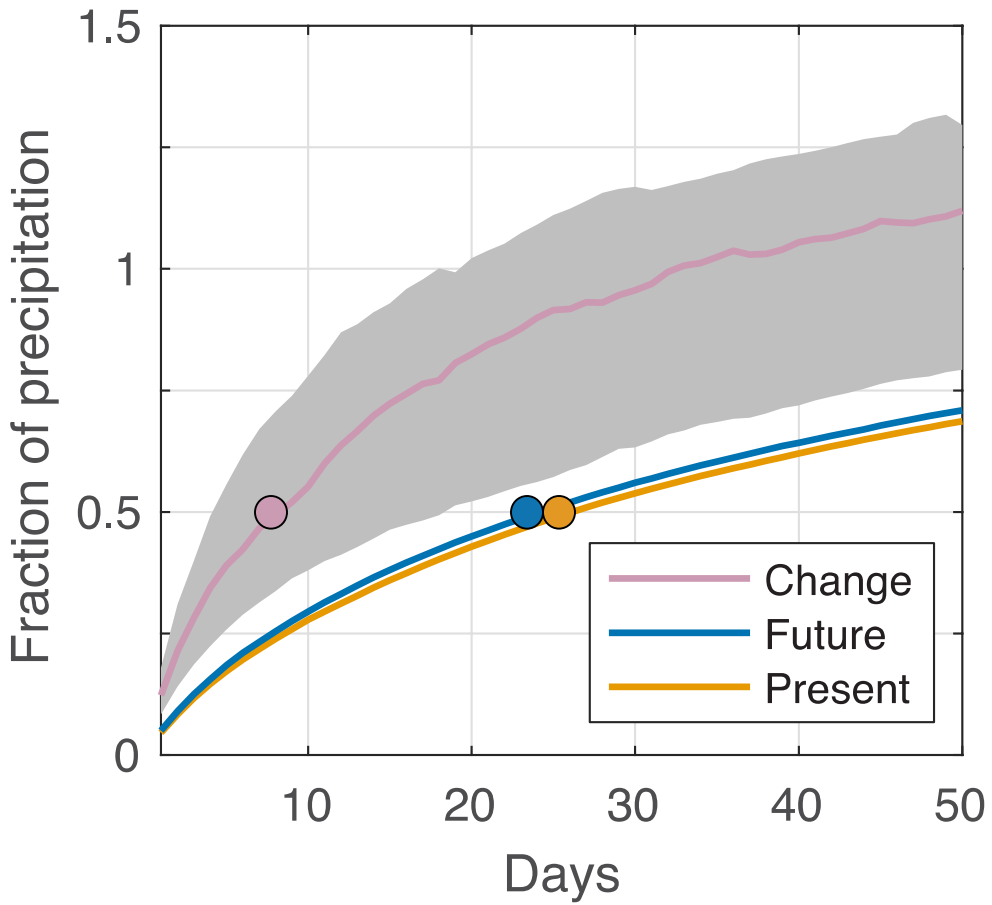

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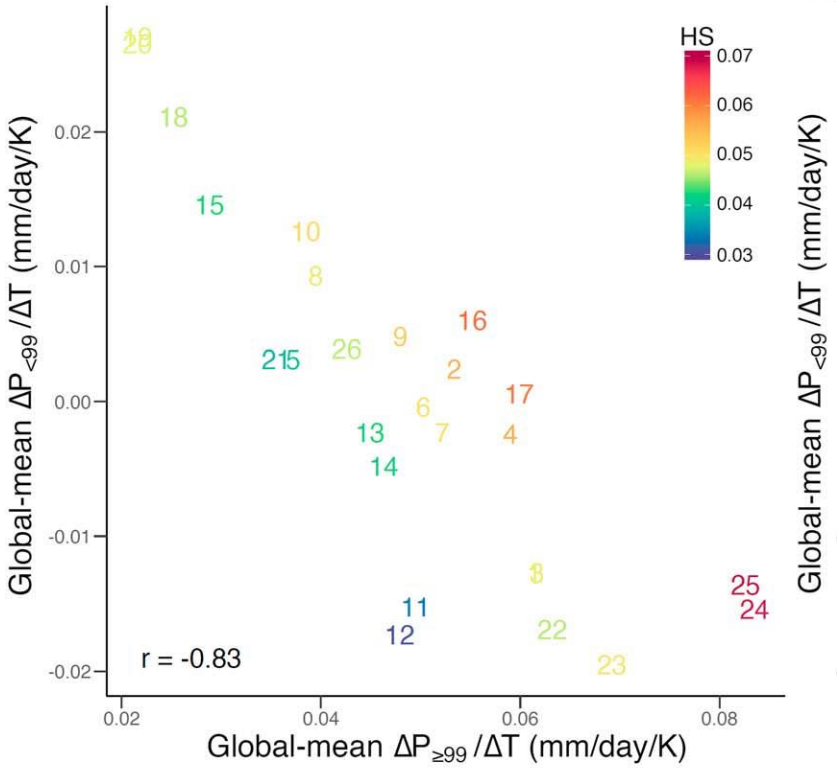
Multi-model median
Land median



There is compensation between extreme and non-extreme precipitation across CMIP5 models

Models with larger increases in extreme precipitation have smaller increases (or decreases) in non-extreme precipitation

Highlights importance of global energetics for studying precipitation change

Thackeray et al., (2018), *GRL*