

# Why you need an umbrella on hot days



Master thesis defense Berry Boessenkool, May 2015

Title: Statistical Analysis of Temperature Effects on Extreme Precipitation Intensities

Supervisors: Dr. Maik Heistermann, Dr. Gerd Bürger

# Overview

- ▶ Motivation

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  - ▶ Fit distributions
  - ▶ Simulations to quantify sample size effect

## Motivation: Flash floods

### India, Indore, Patalpani waterfall



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famous picnic spot

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famous picnic spot 2011: Flash flood

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### India, Indore, Patalpani waterfall



famous picnic spot 2011: Flash flood  
*small scale, sudden, dangerous* (Boessenkool, 2013)

## Motivation: Flash floods

[Open video in external viewer](#)

[Watch complete video on youtube](#)

For once, we don't complain about data shortage

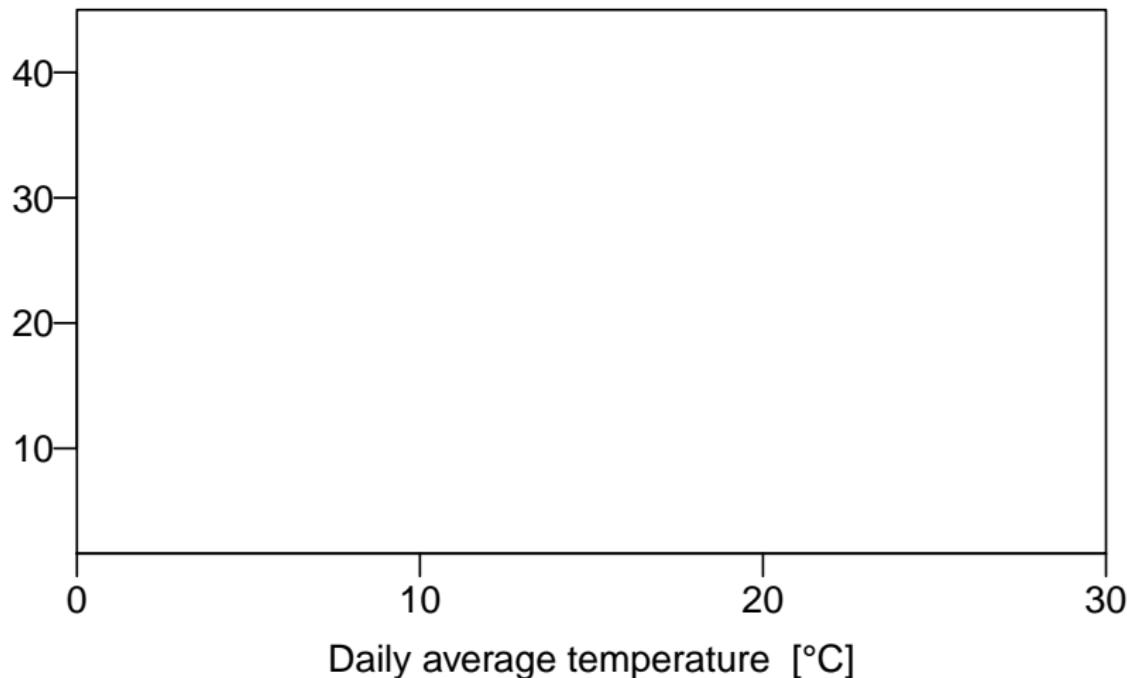
For once, we don't complain about data shortage

Precipitation [mm/h]



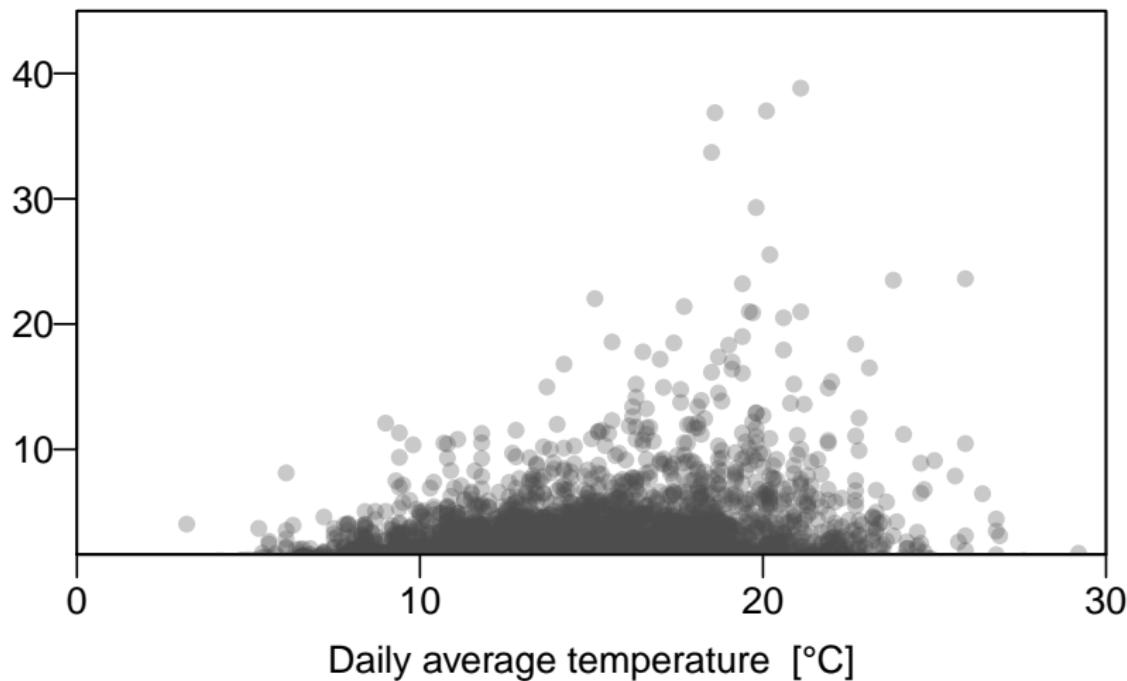
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**Source:** German Weather Service (DWD)

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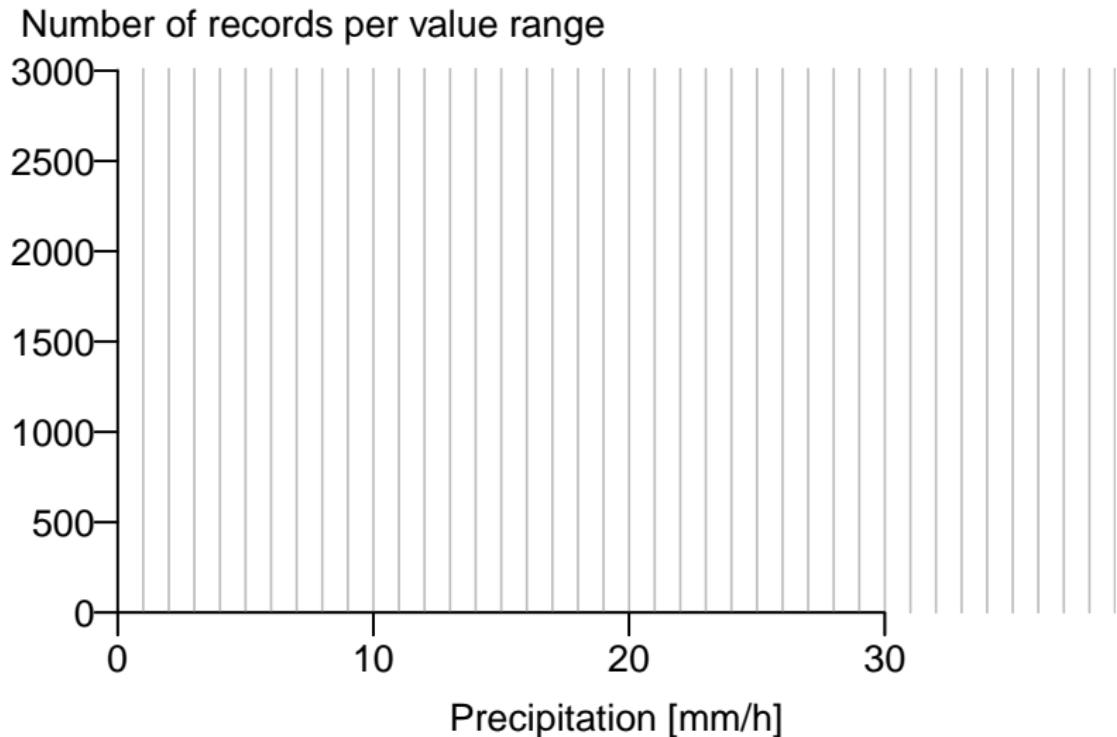
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**daily temperature average:** computed from hourly measurements at  
2 m above ground

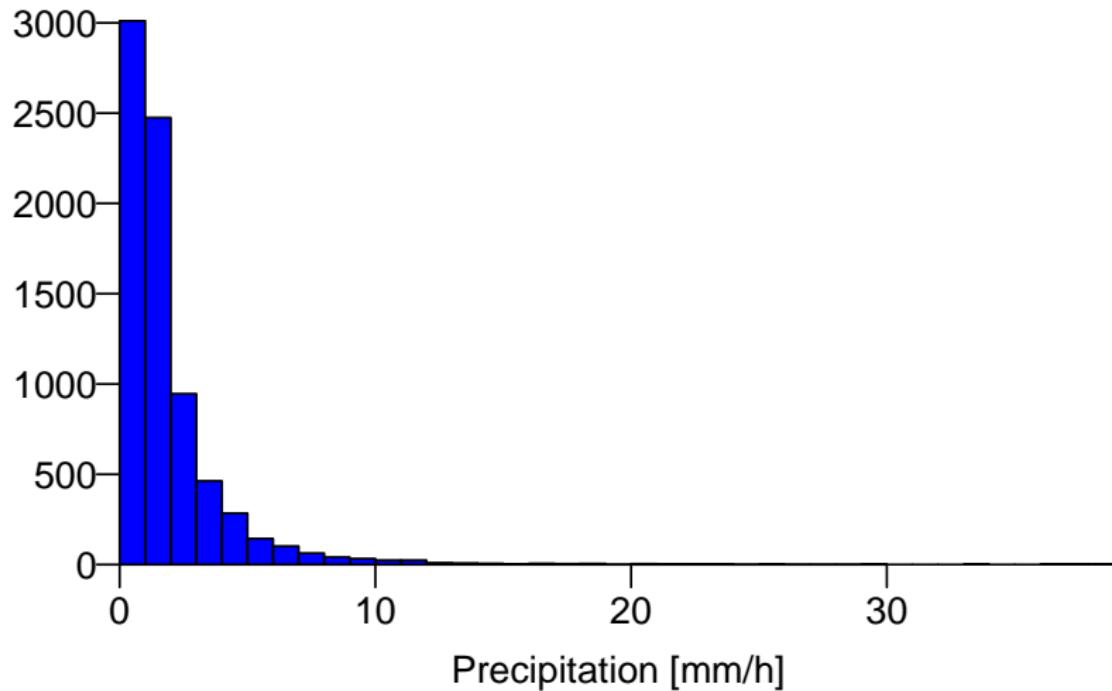
Logtransformation is the best thing since sliced bread

## Logtransformation is the best thing since sliced bread - Reason 1



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Number of records per value range

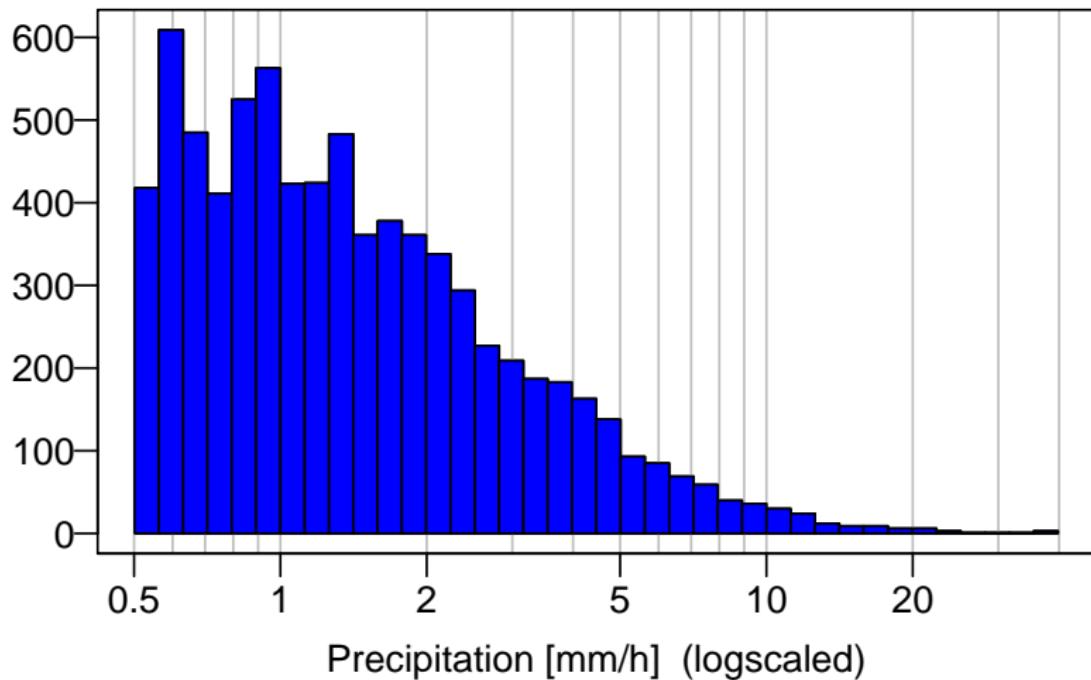


## Logtransformation is the best thing since sliced bread - Reason 1

Open histogram animation in external viewer  
credits: FFmpeg + R package animation (Yihui)

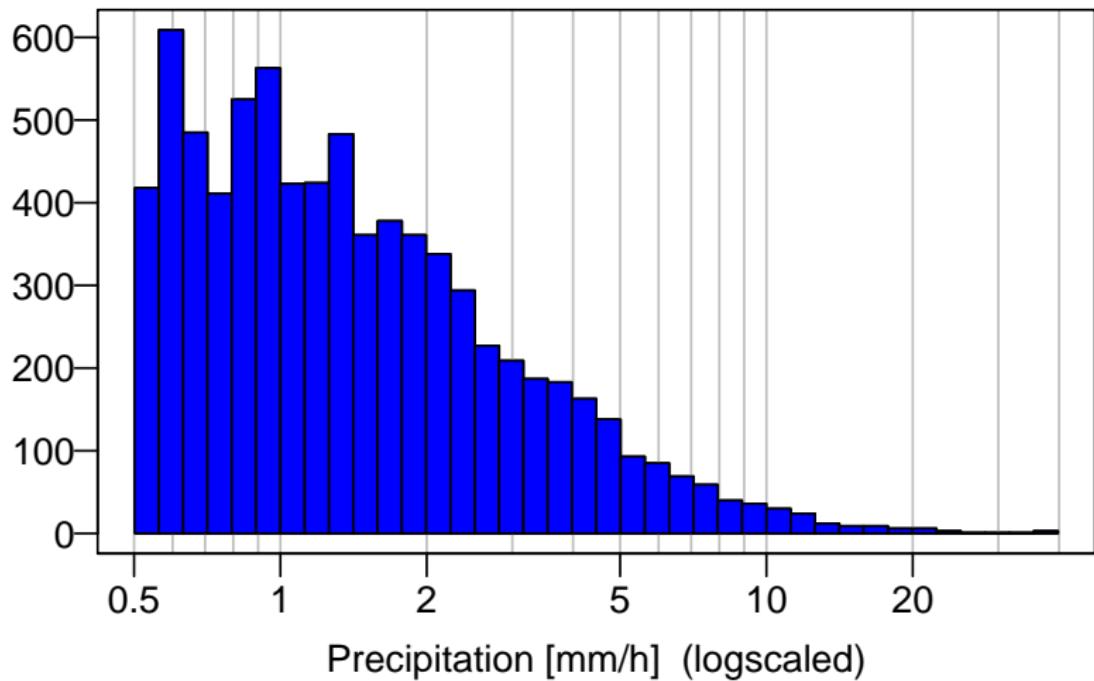
## Logtransformation is the best thing since sliced bread - Reason 1

Number of records per value group



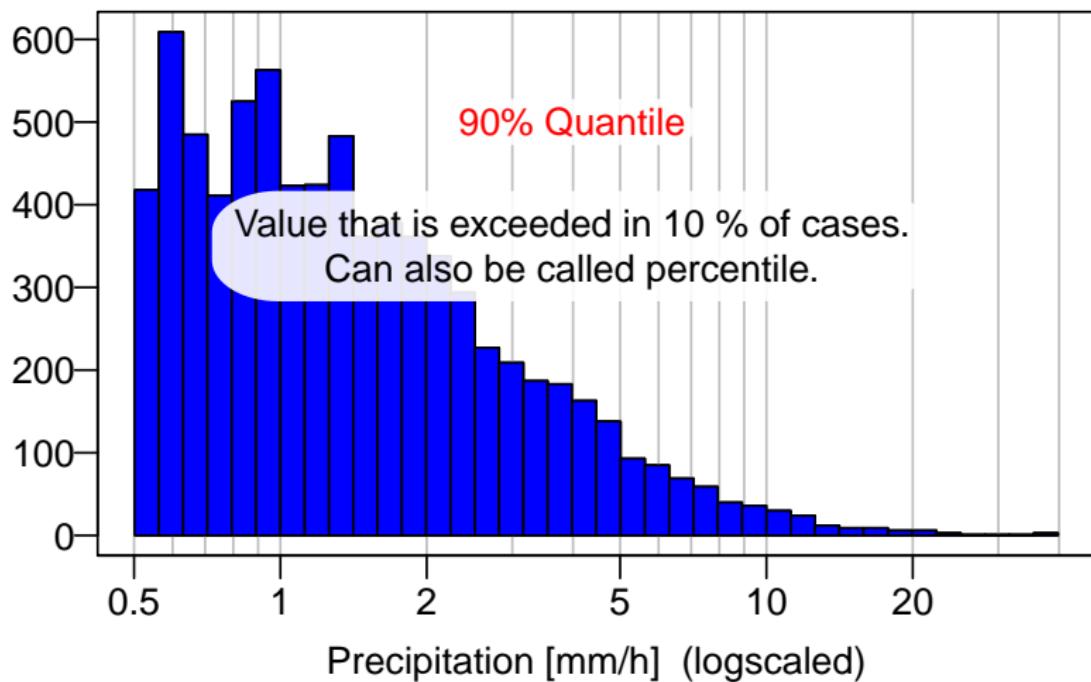
## Quantile explanation

Number of records per value group



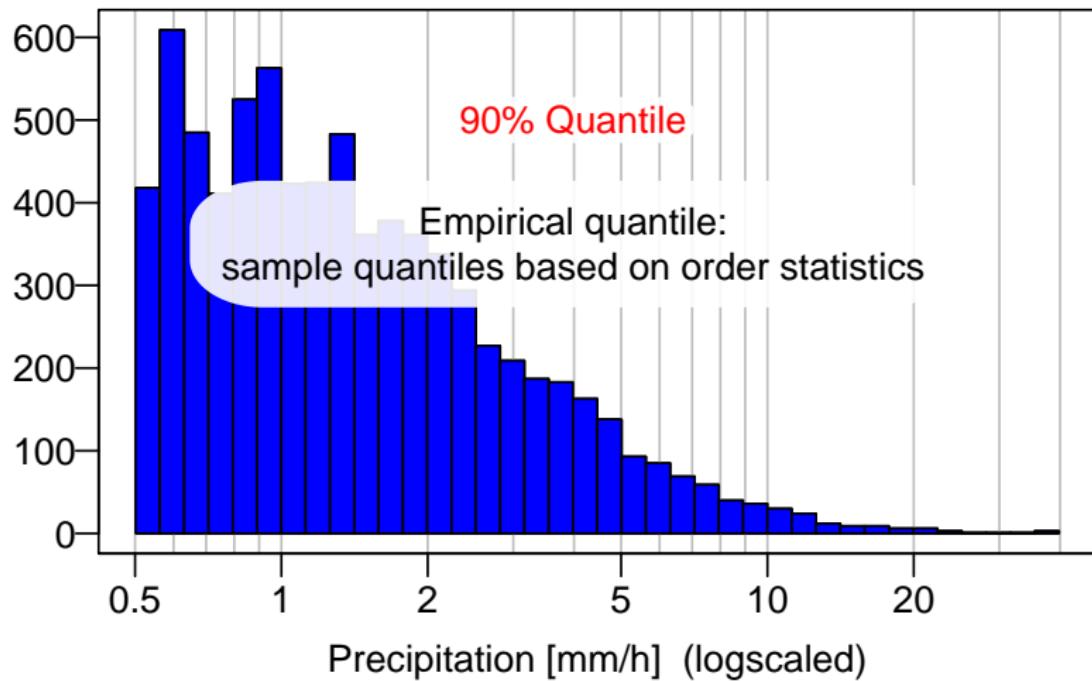
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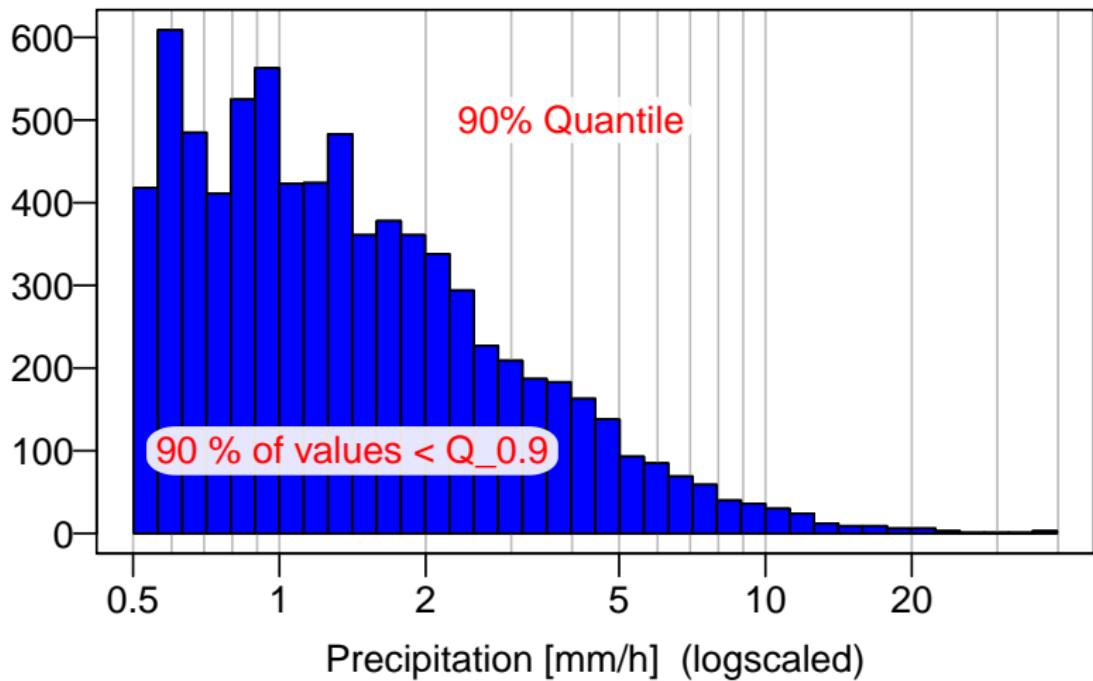
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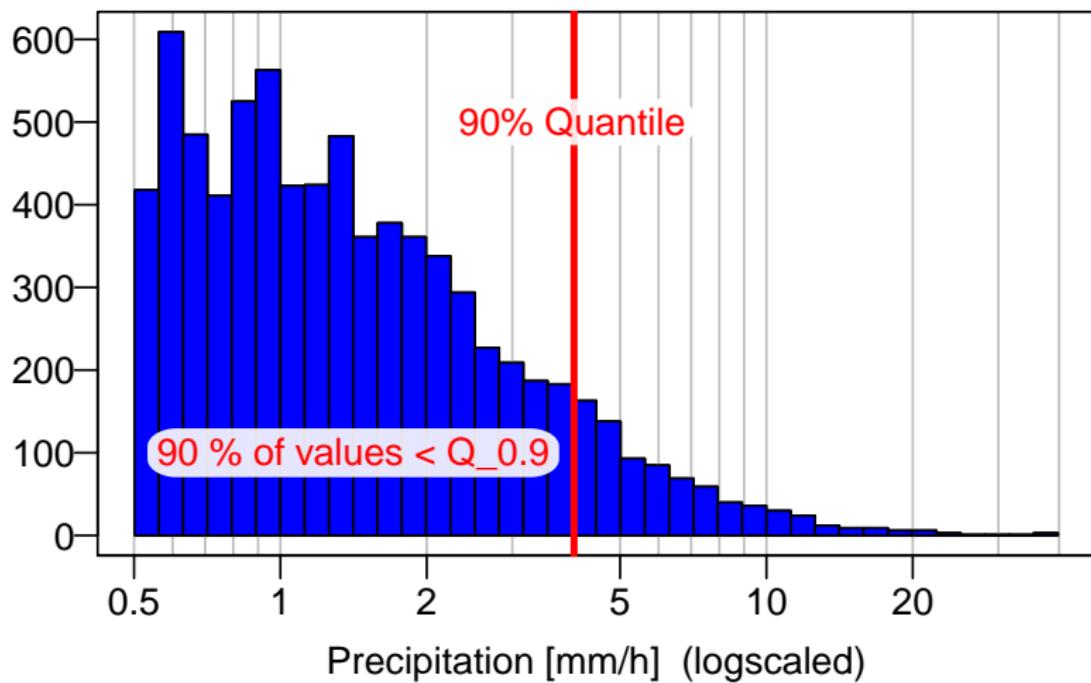
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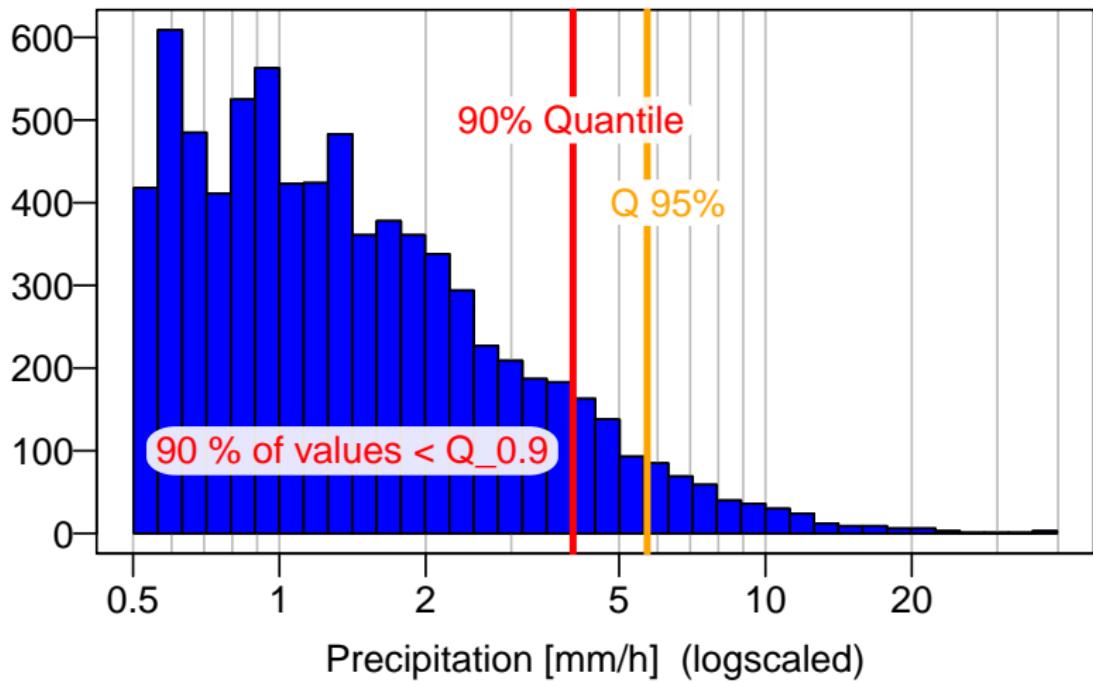
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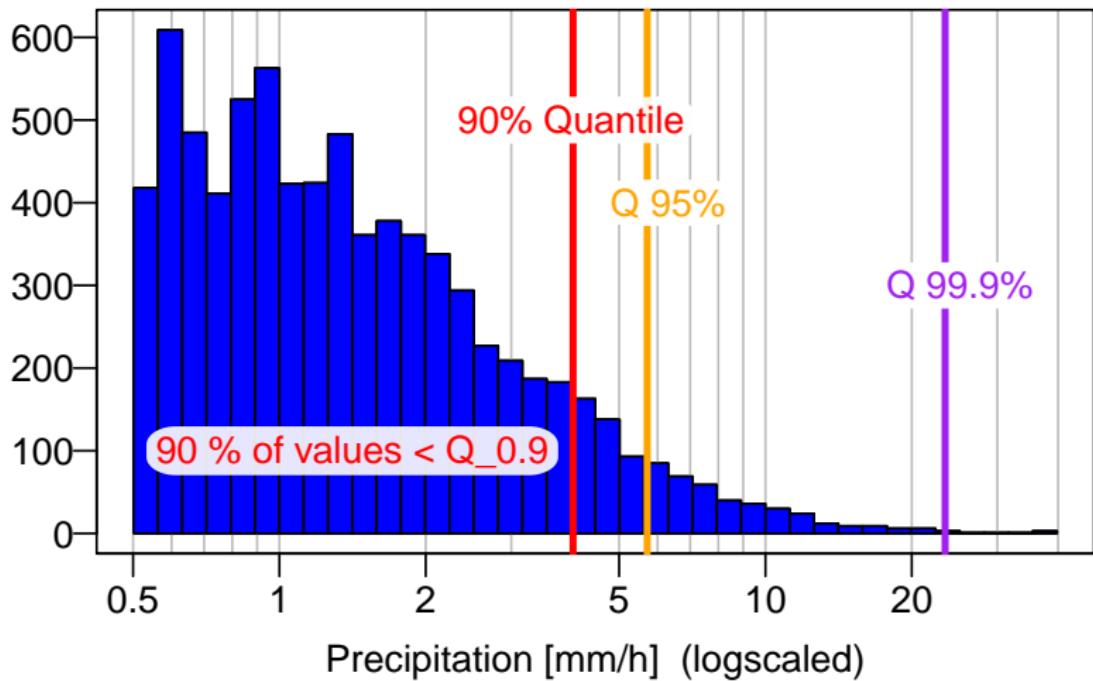
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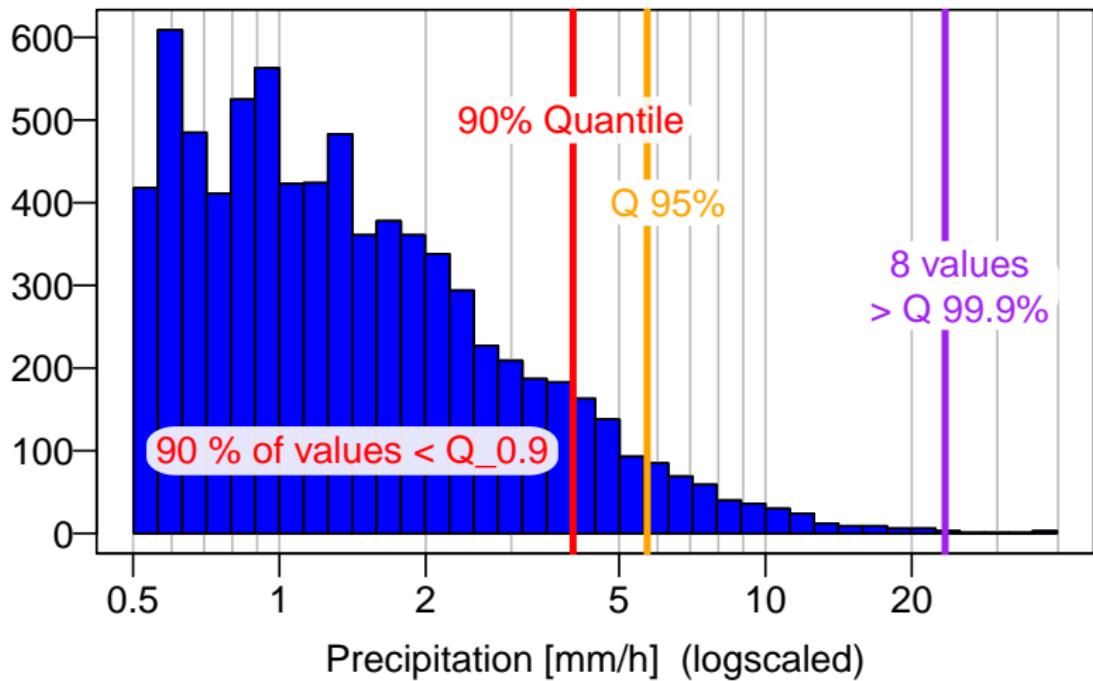
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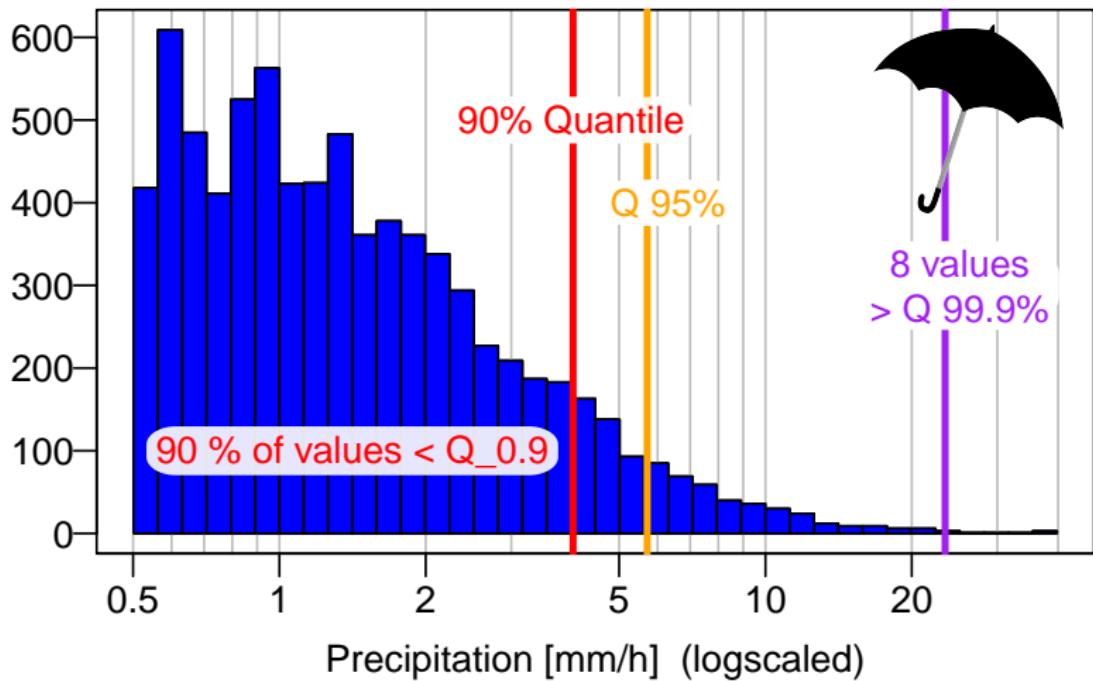
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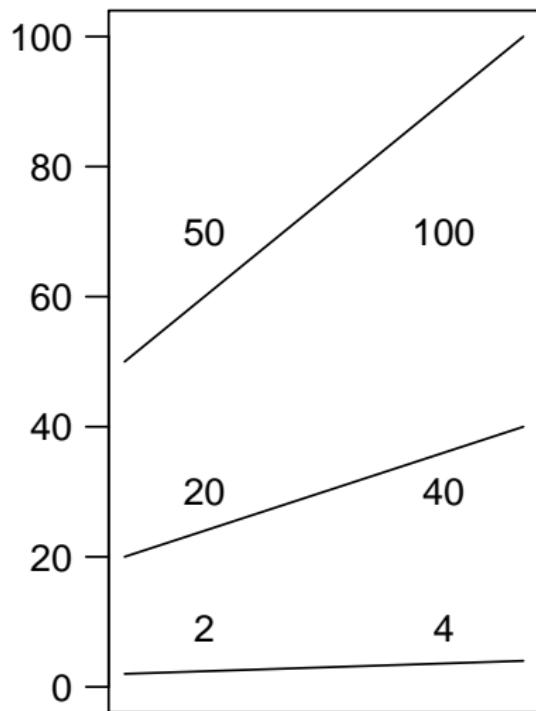


Logtransformation is the best thing since sliced bread - Reason 2

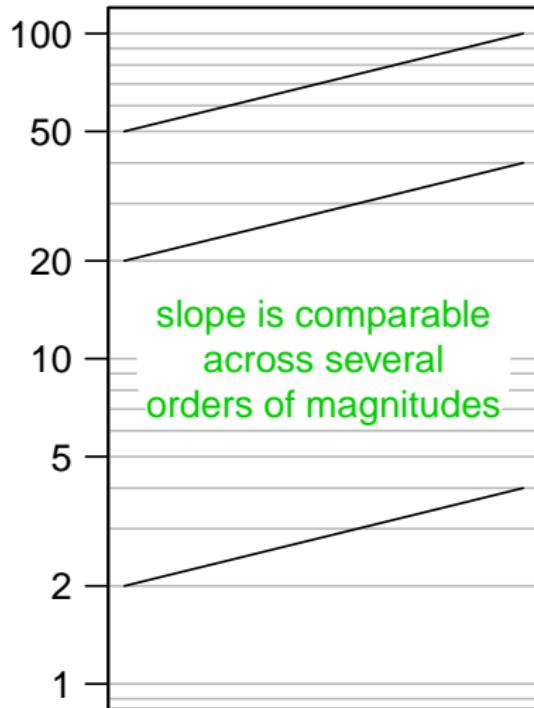
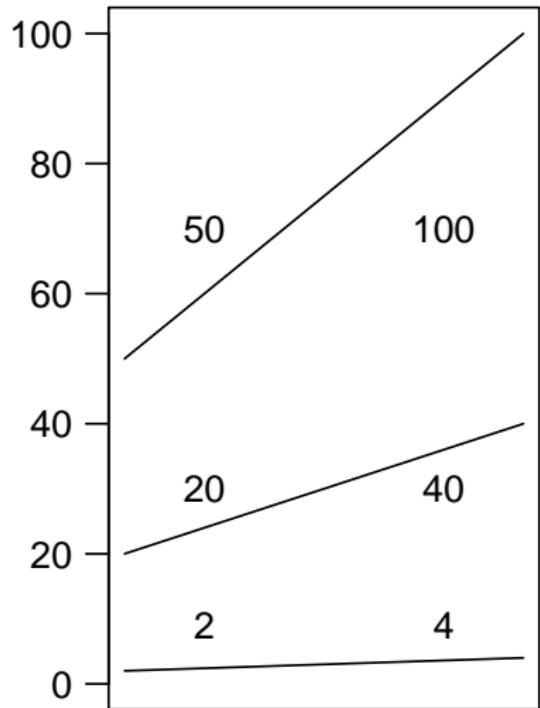
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It's the only way to compare rates of change.

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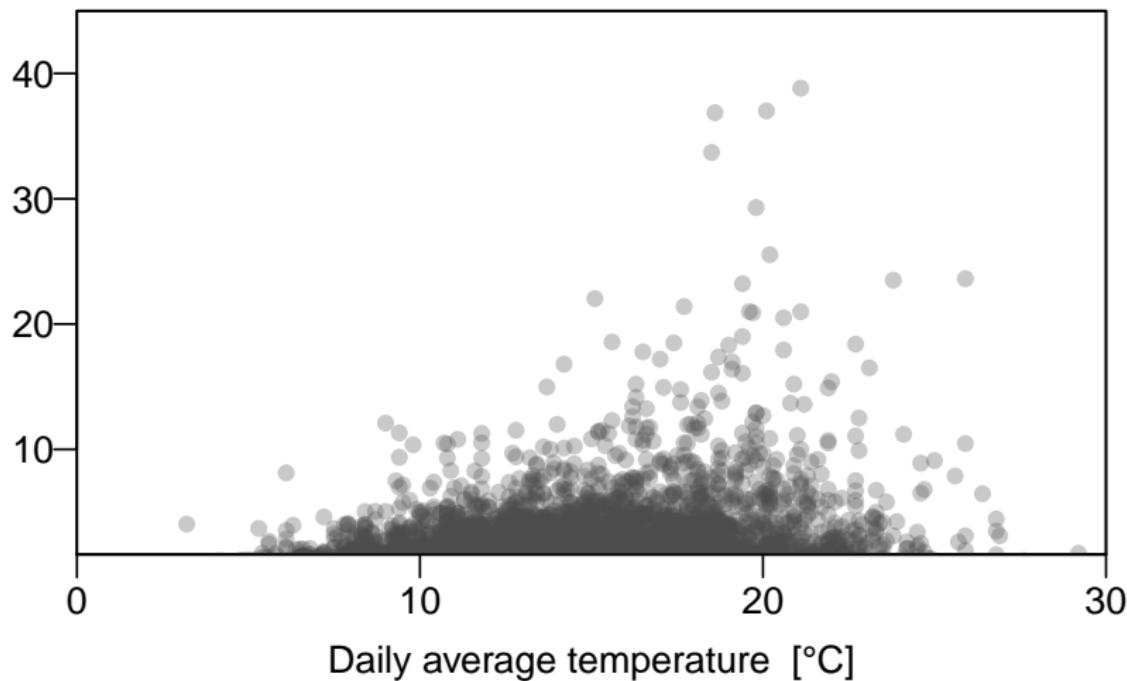


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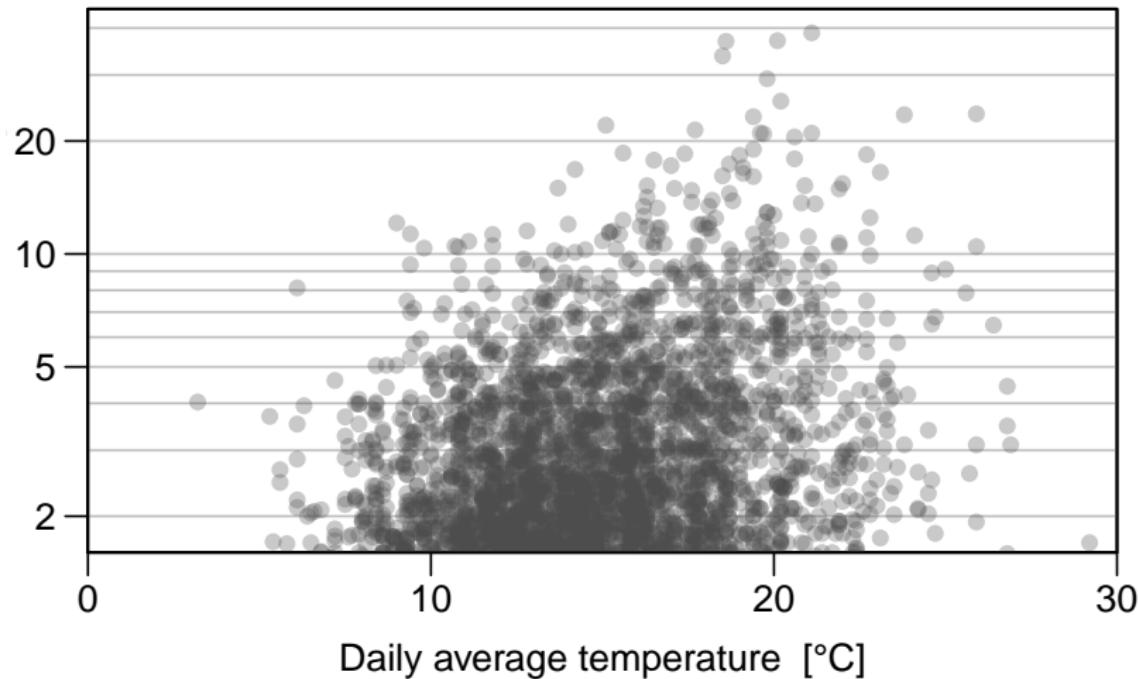


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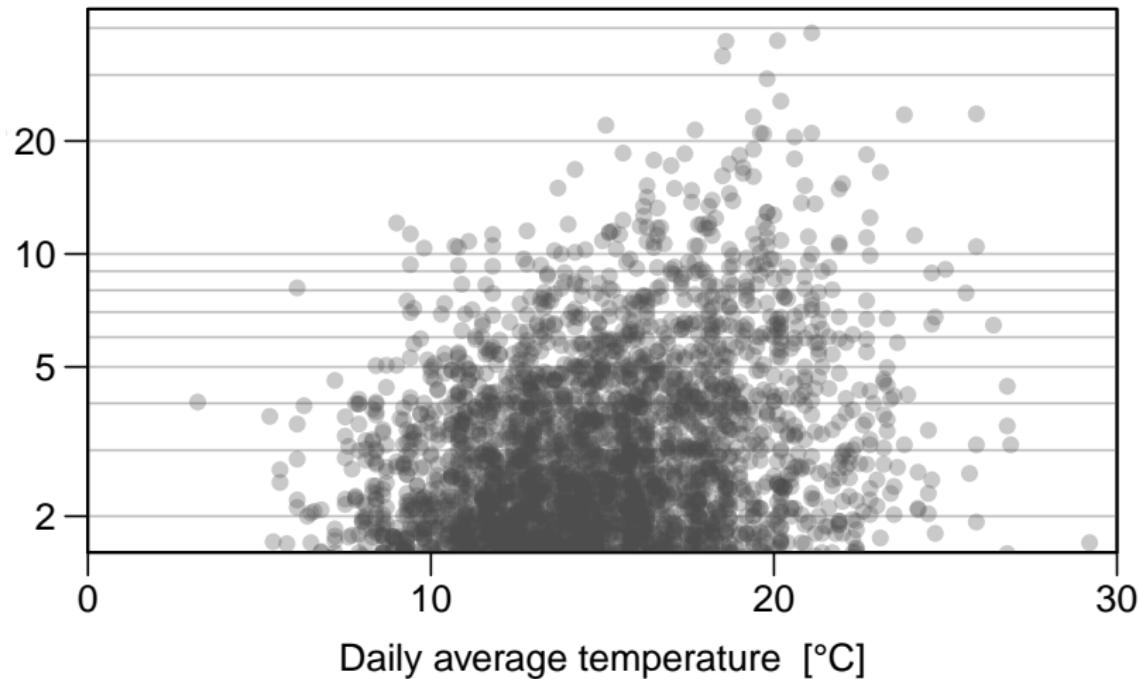
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Precipitation [mm/h] (logscale)



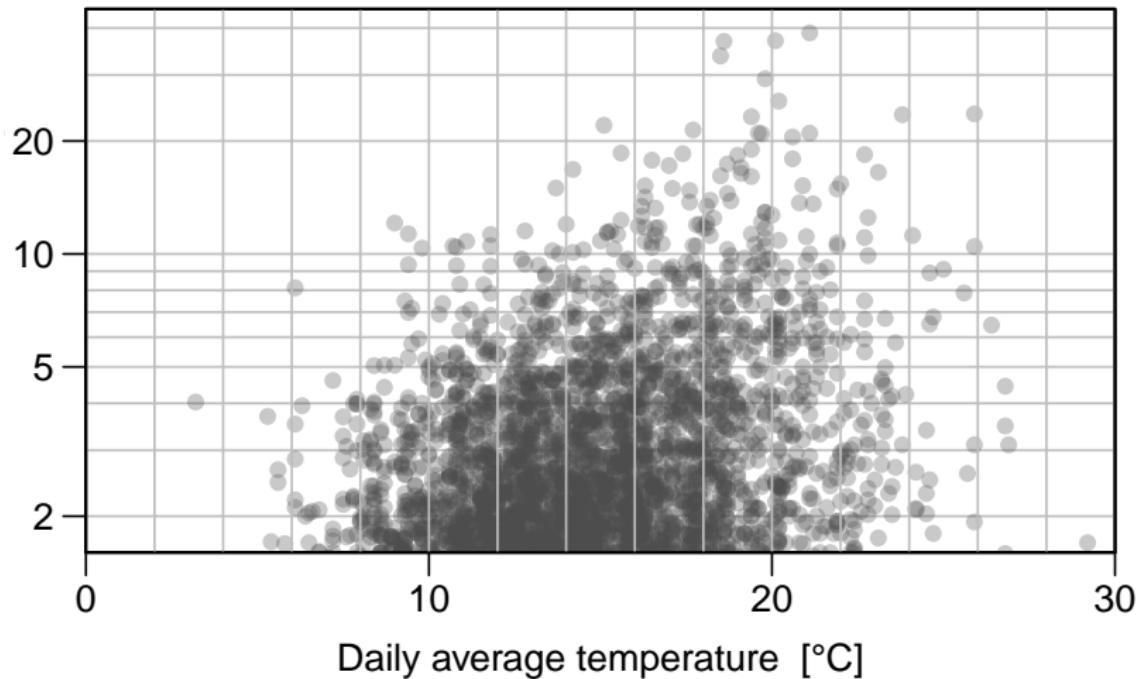
## High precipitation quantiles drop at high temperatures

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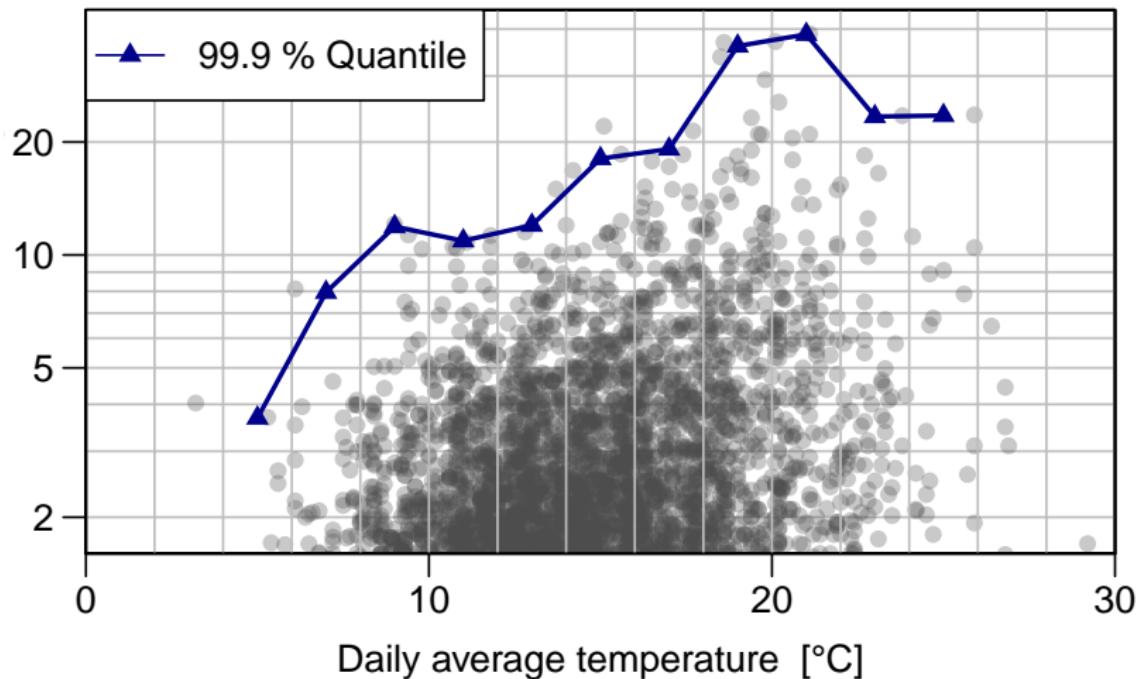
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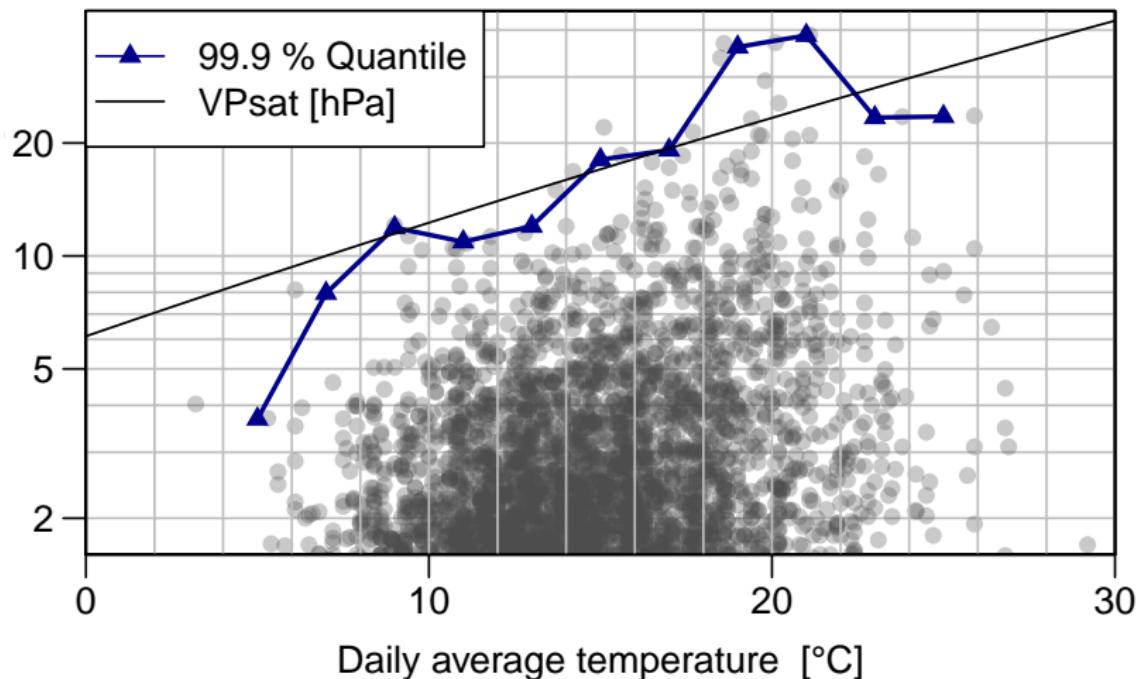
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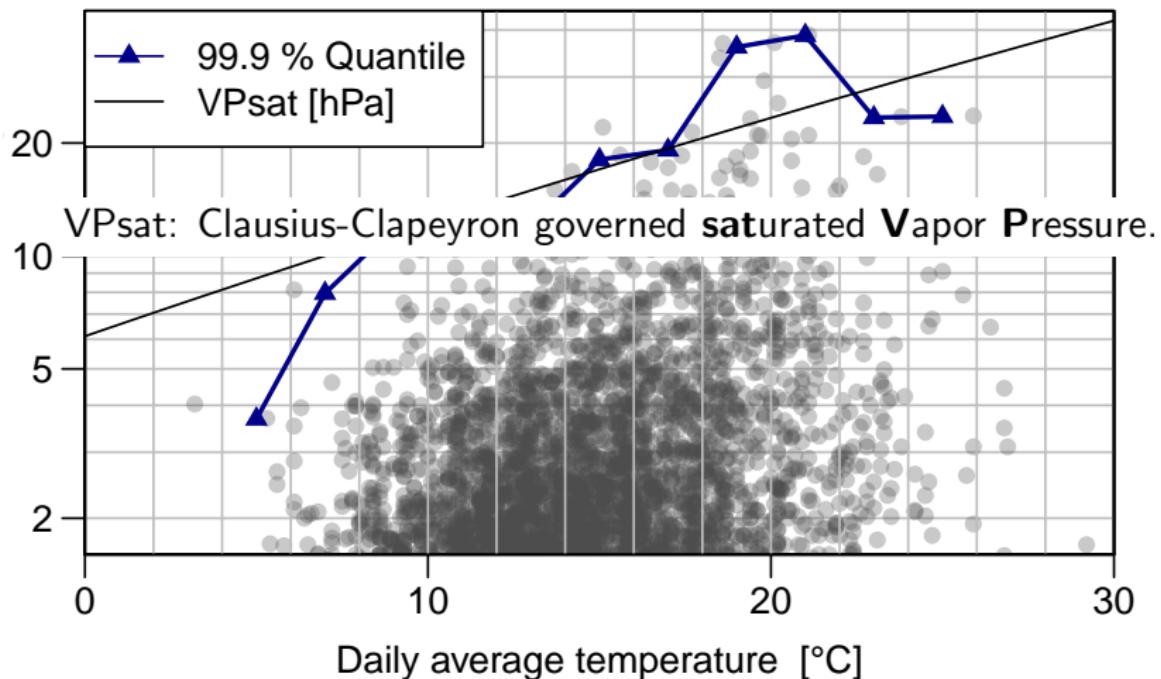
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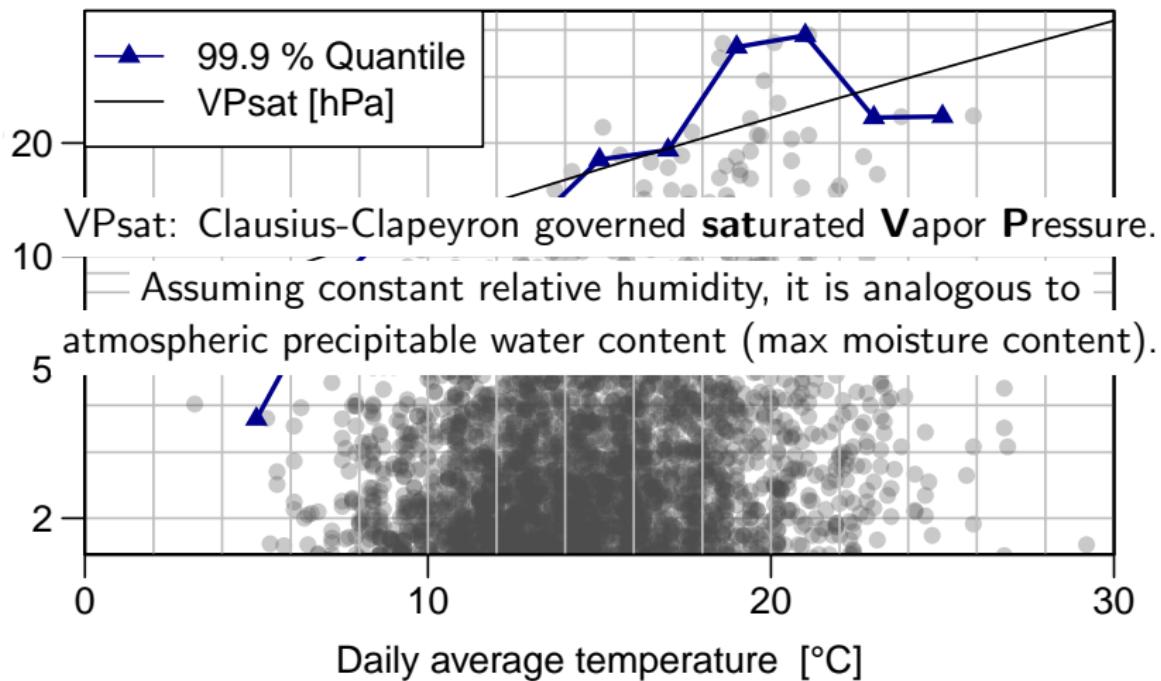
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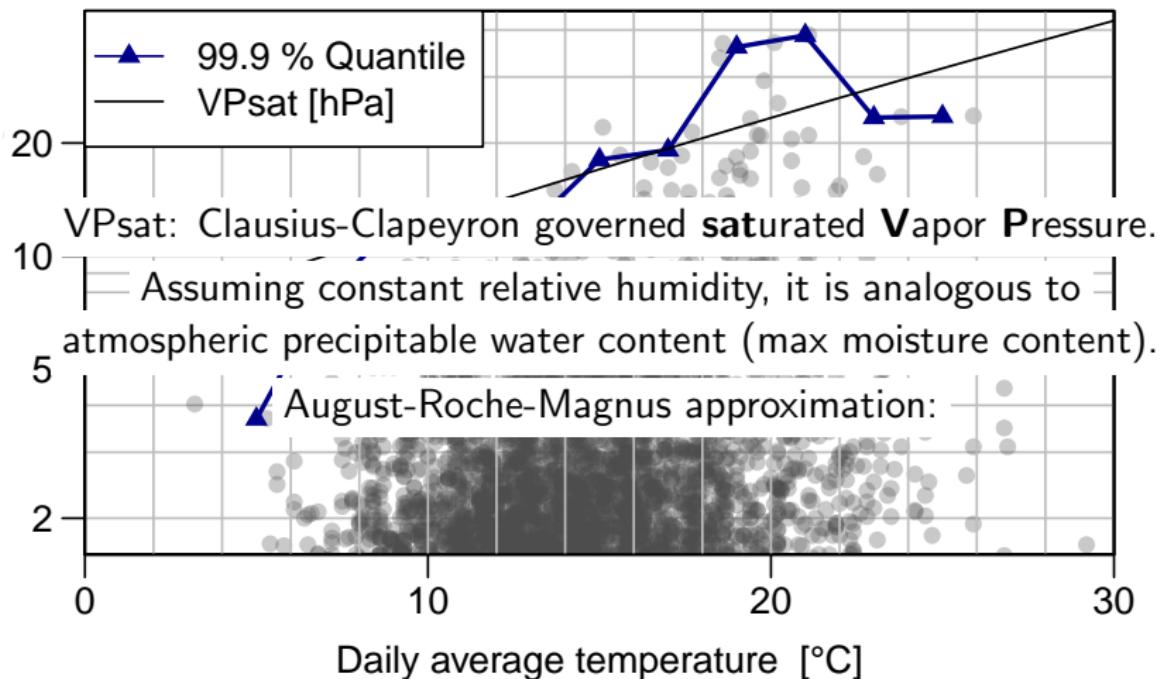
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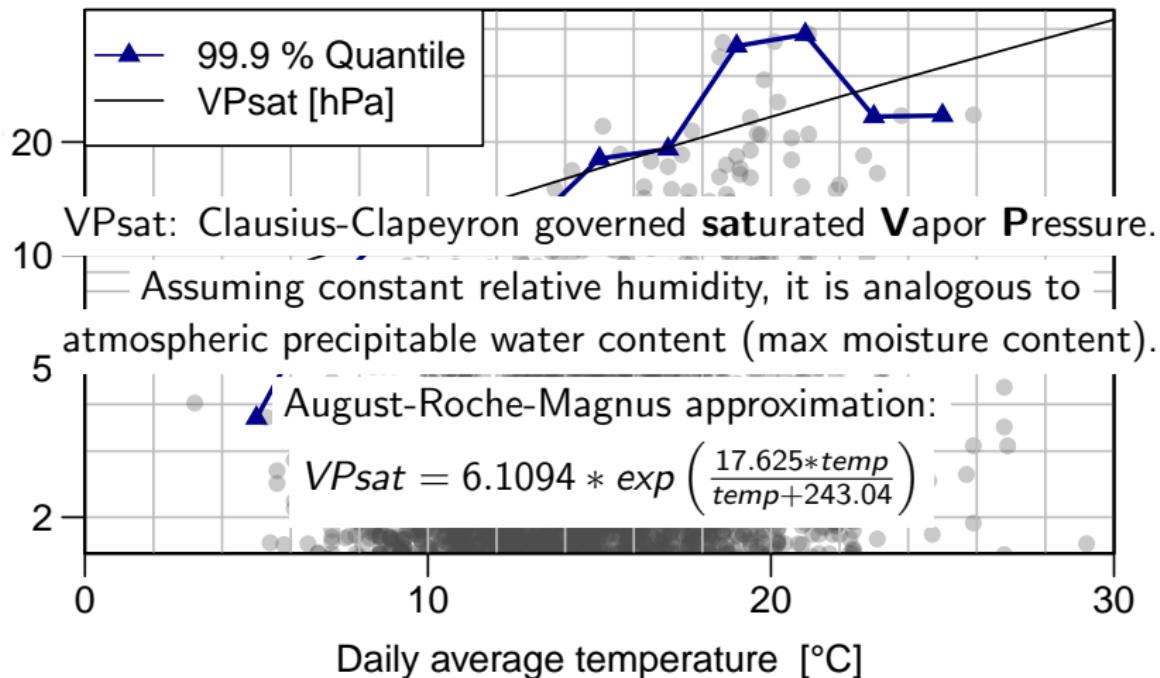
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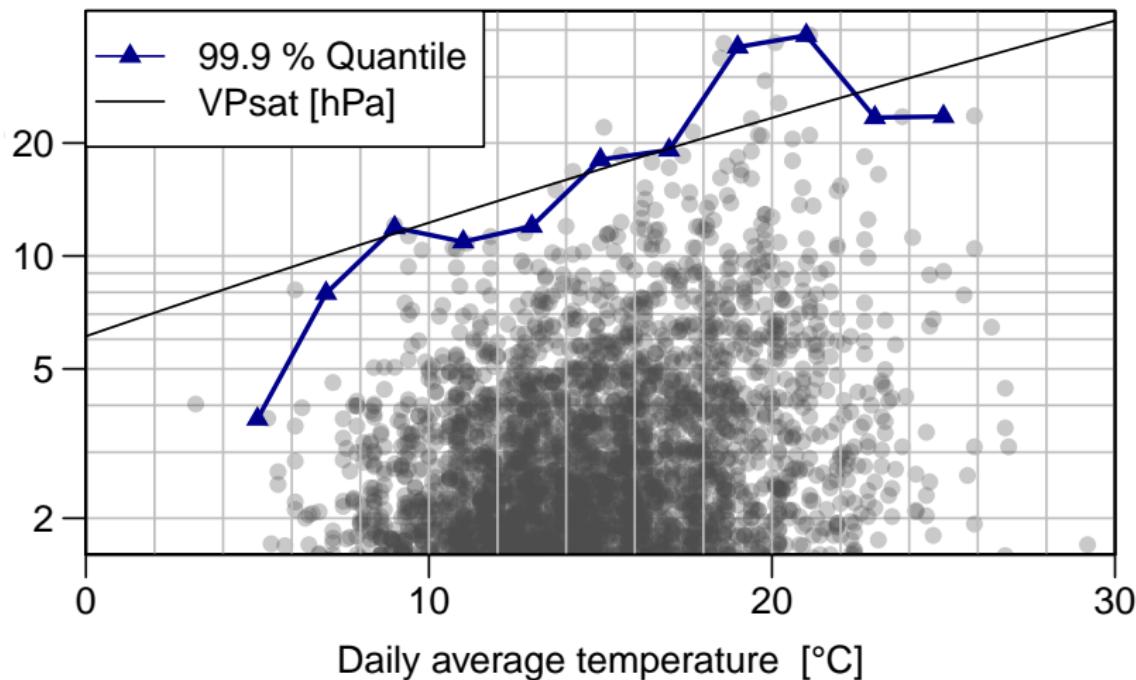
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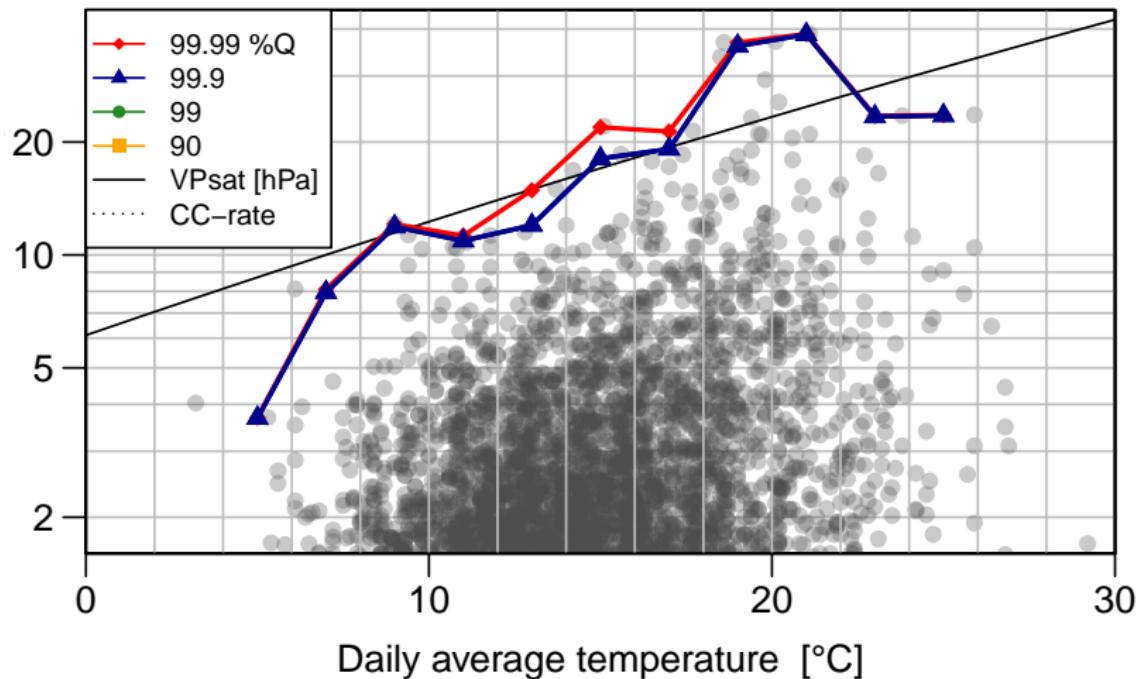
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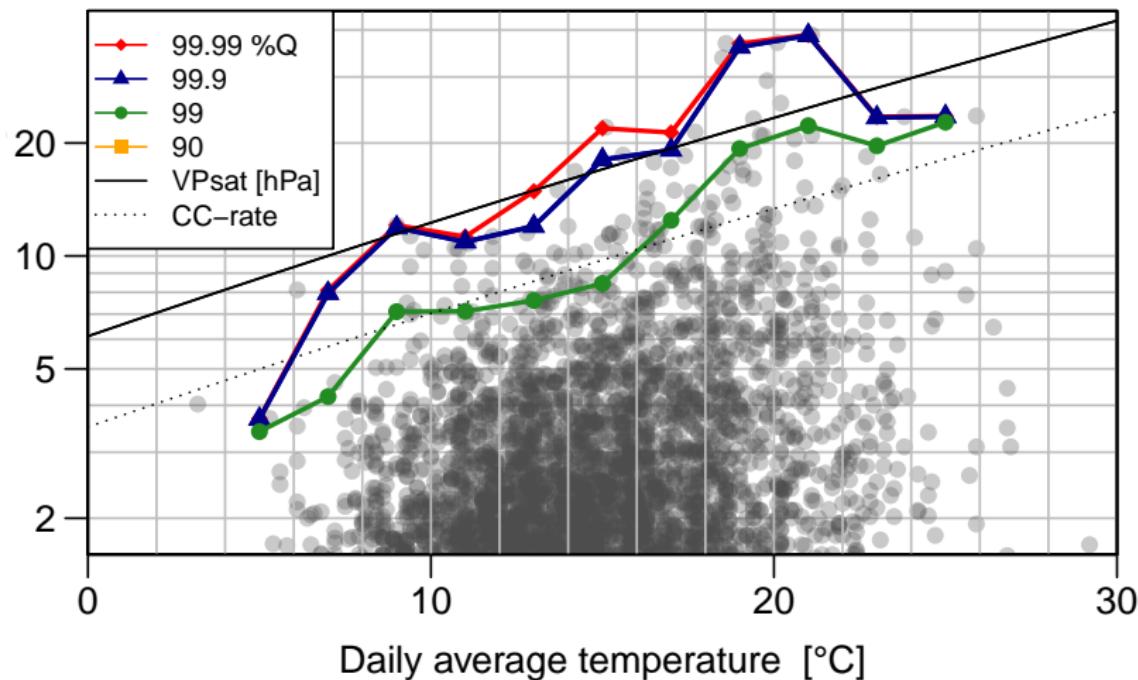
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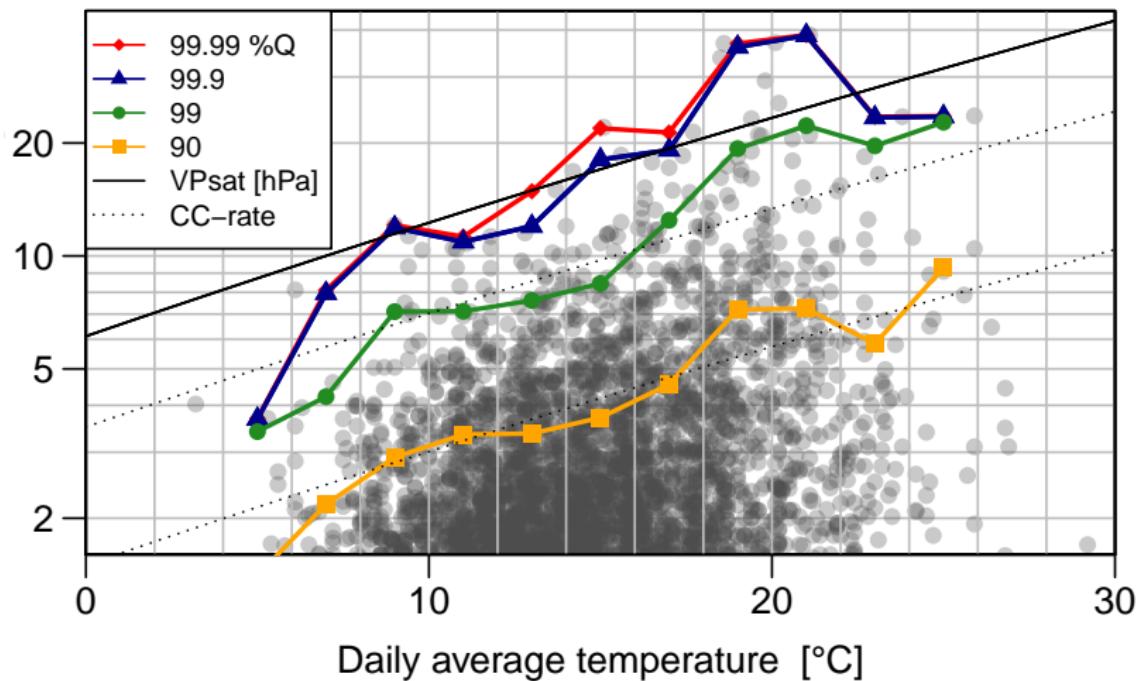
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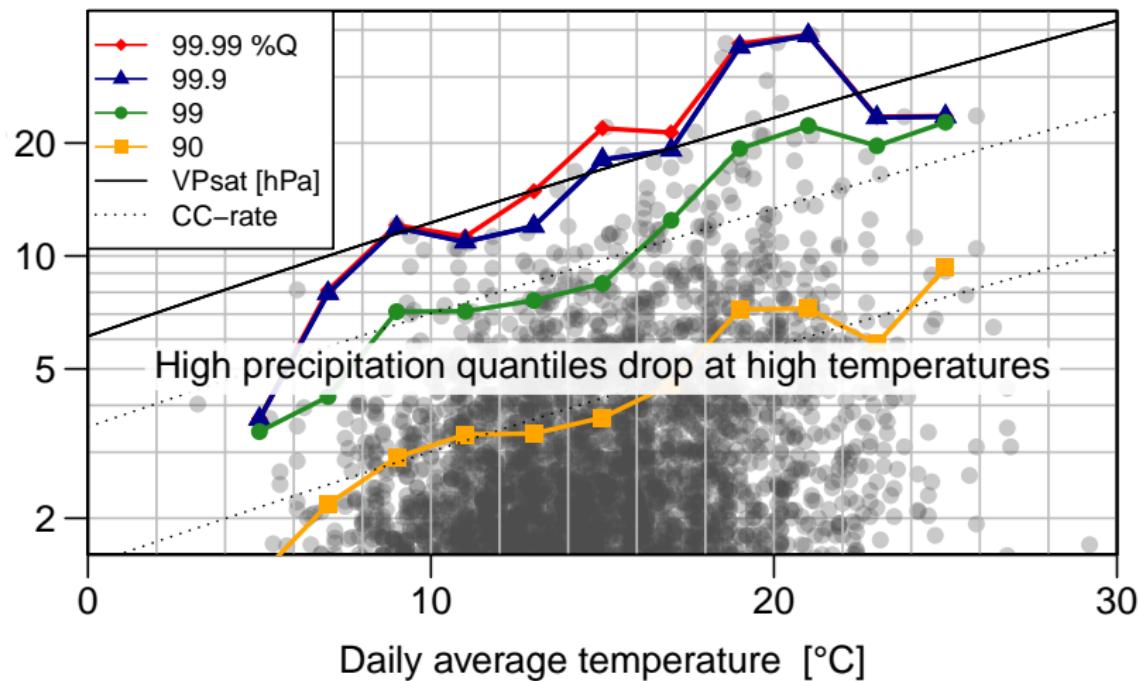
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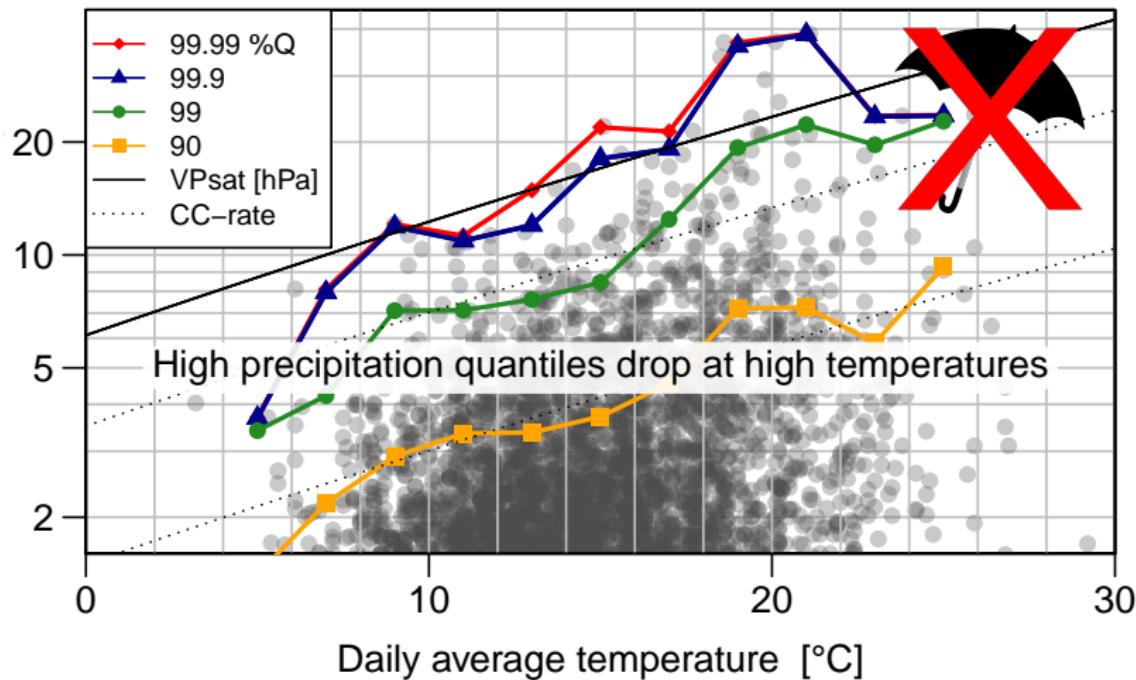
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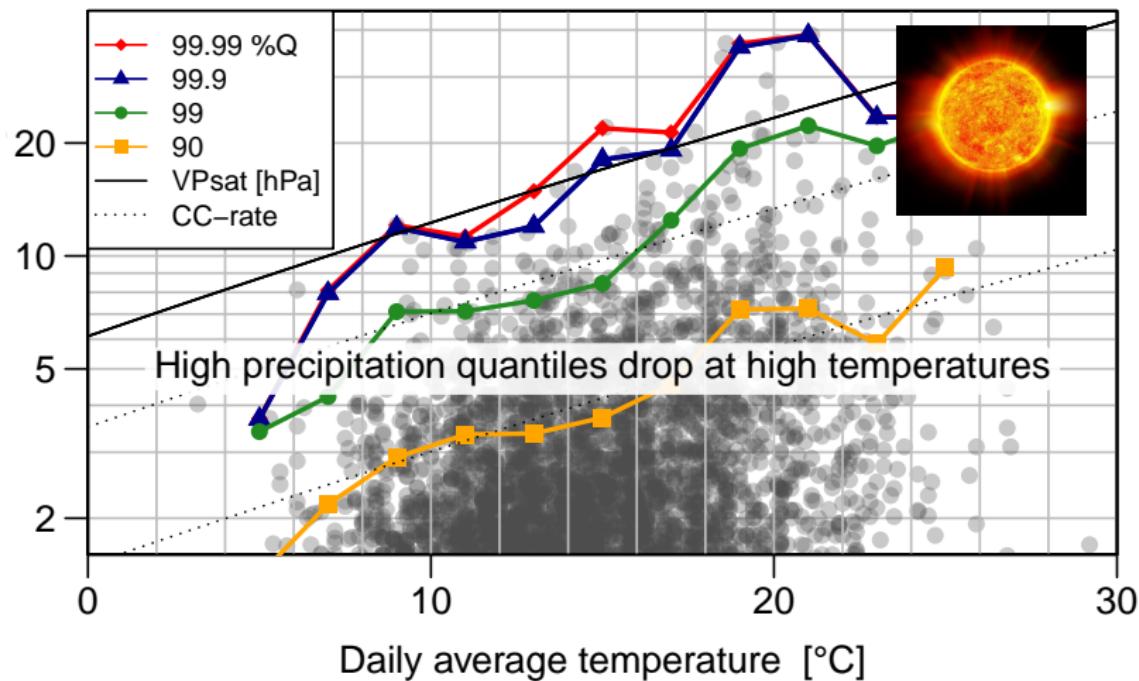
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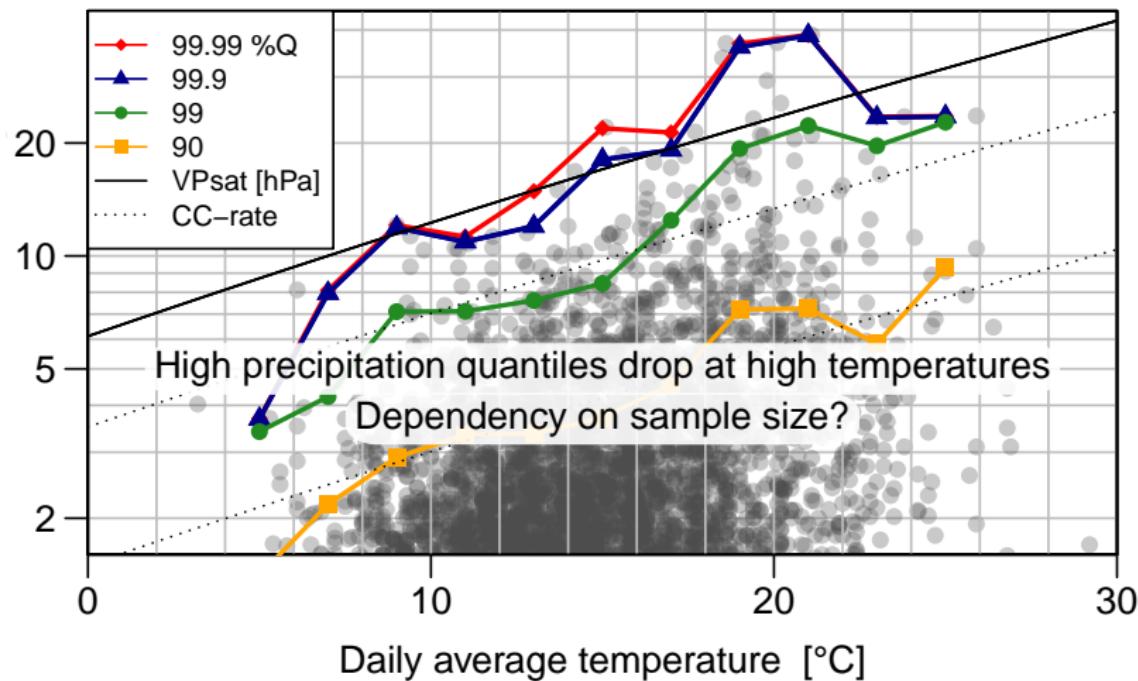
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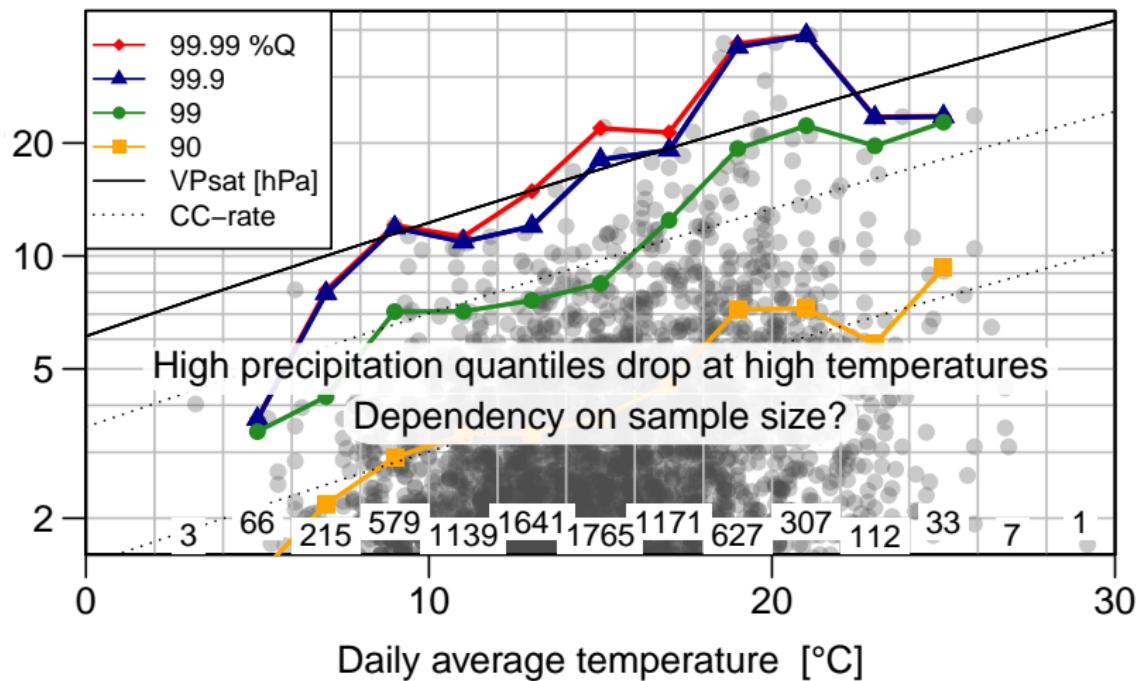
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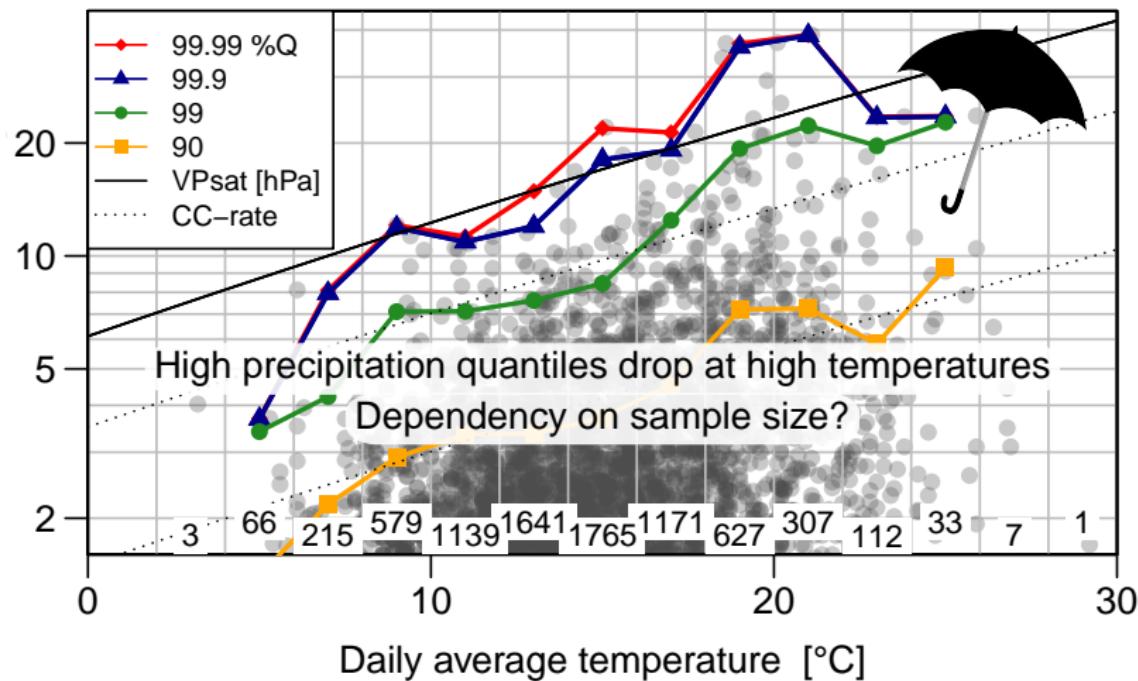
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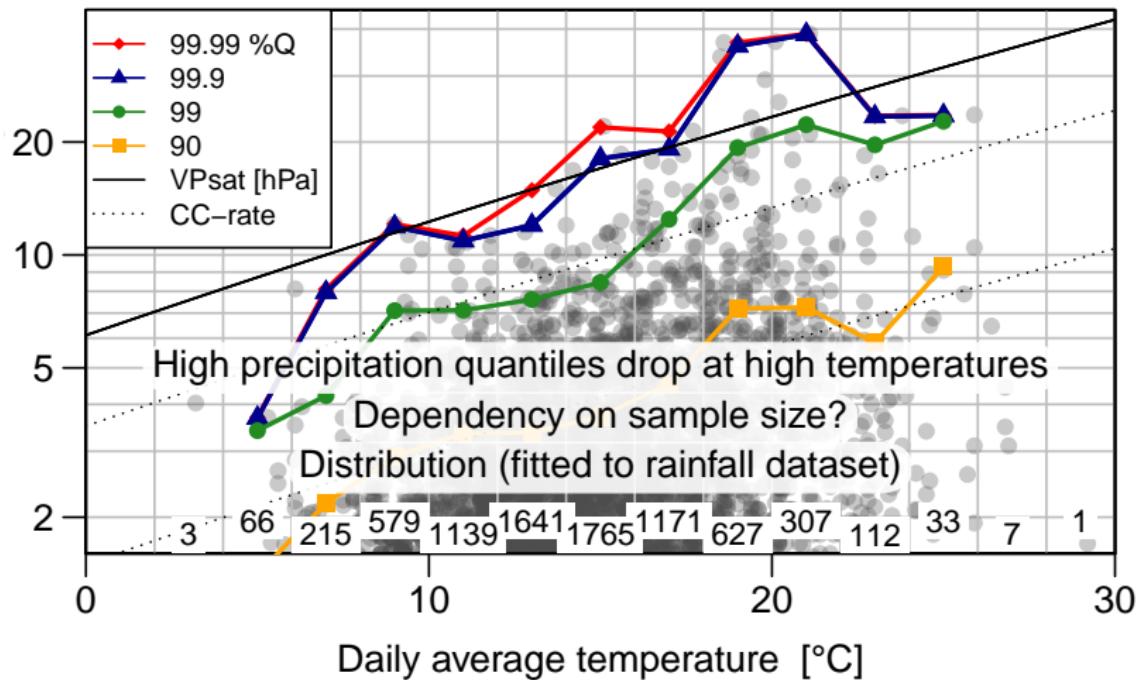
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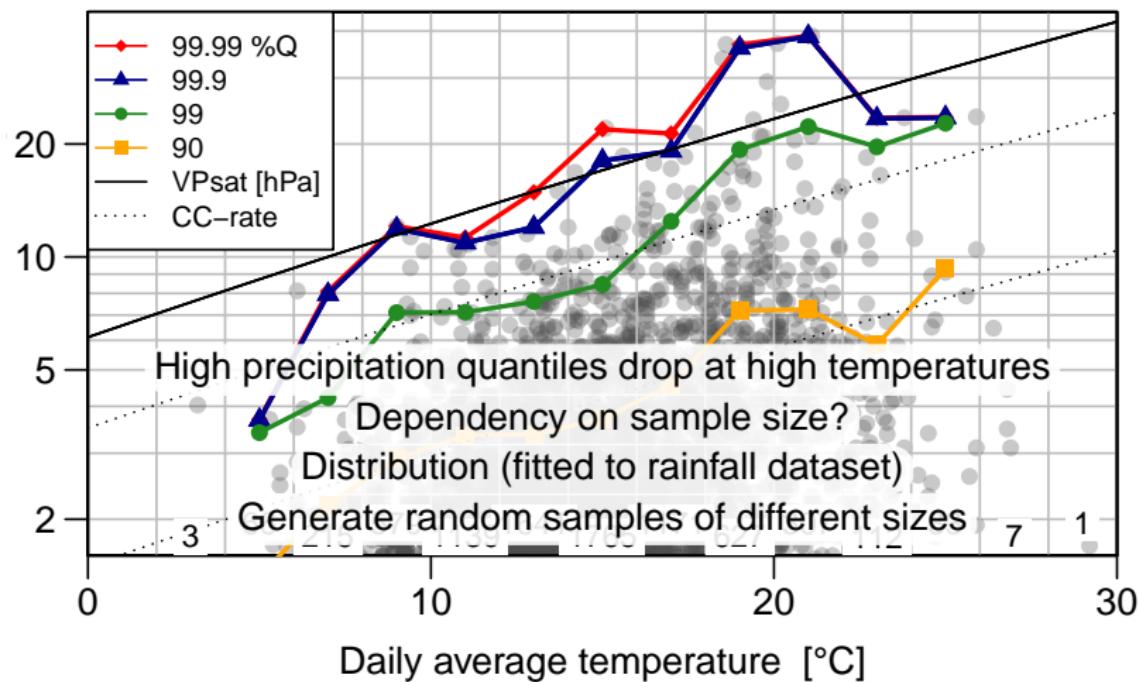
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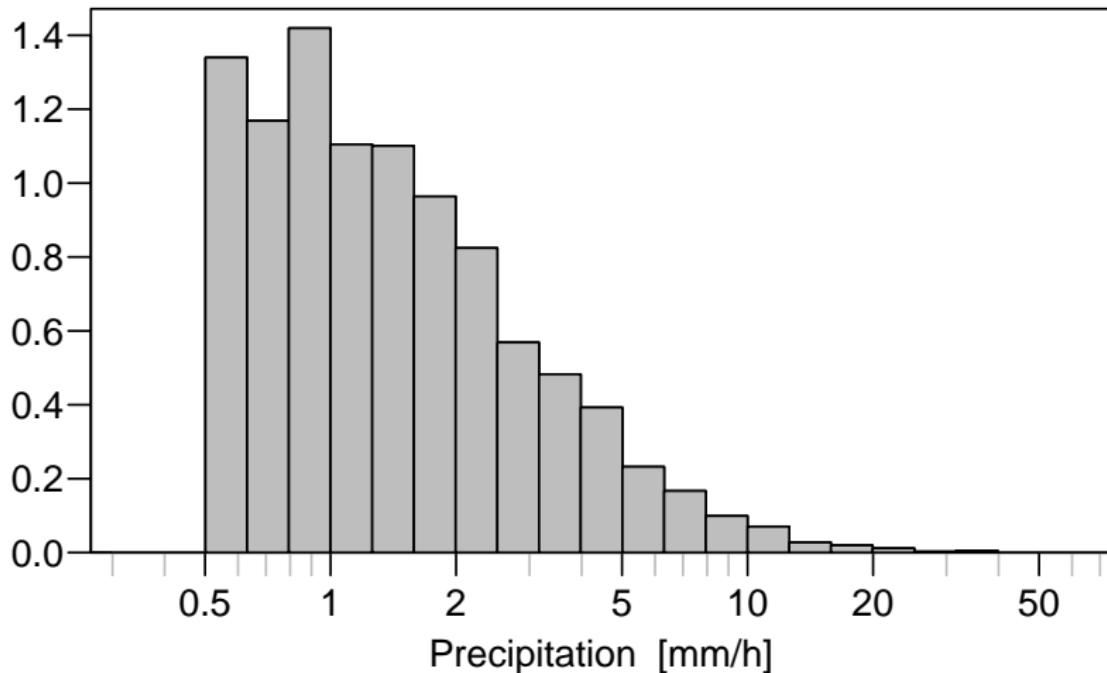
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Distributions must be fitted carefully

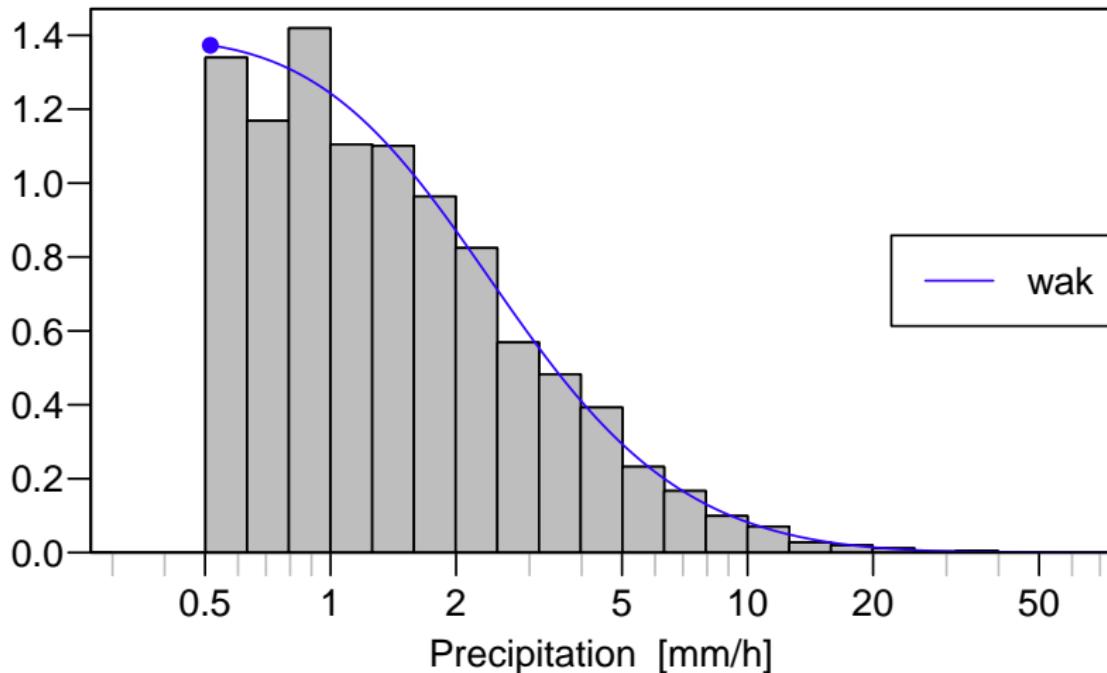
Distributions must be fitted carefully

### Empirical Probability Density (Histogram)



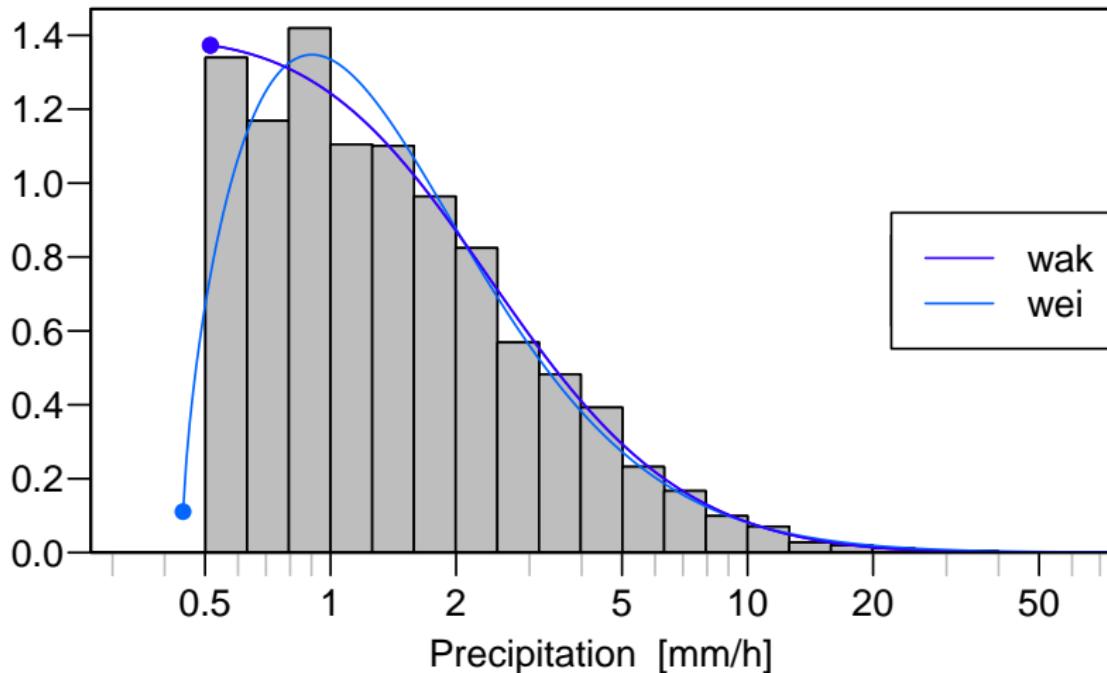
Distributions must be fitted carefully

Probability Density Function (PDF)



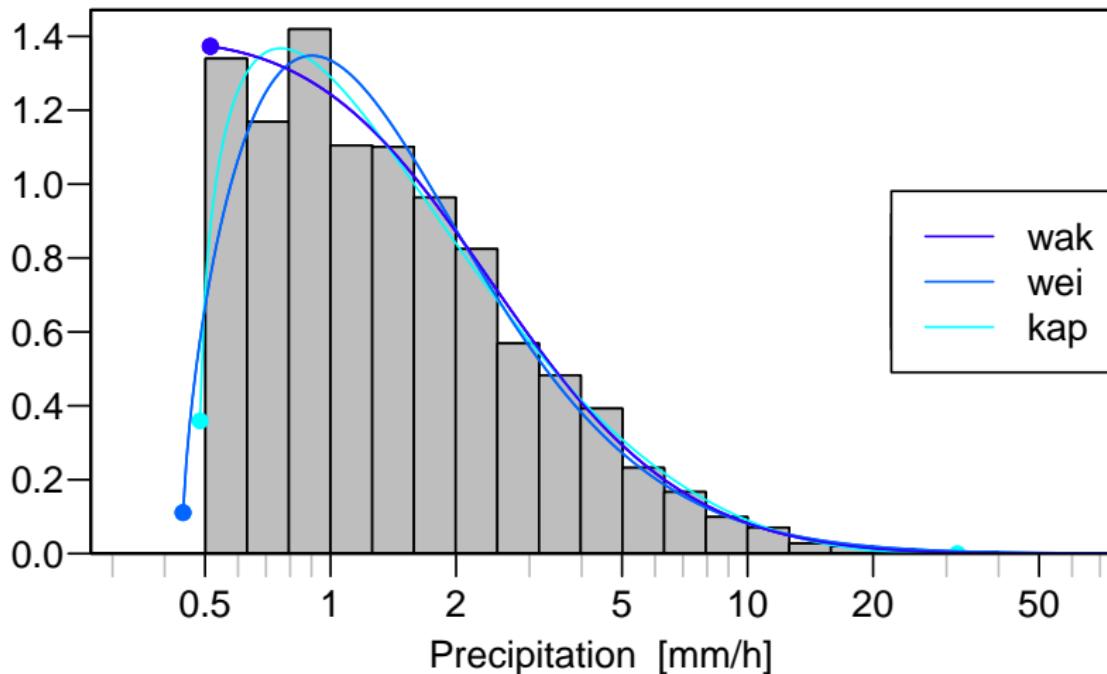
Distributions must be fitted carefully

Probability Density Function (PDF)



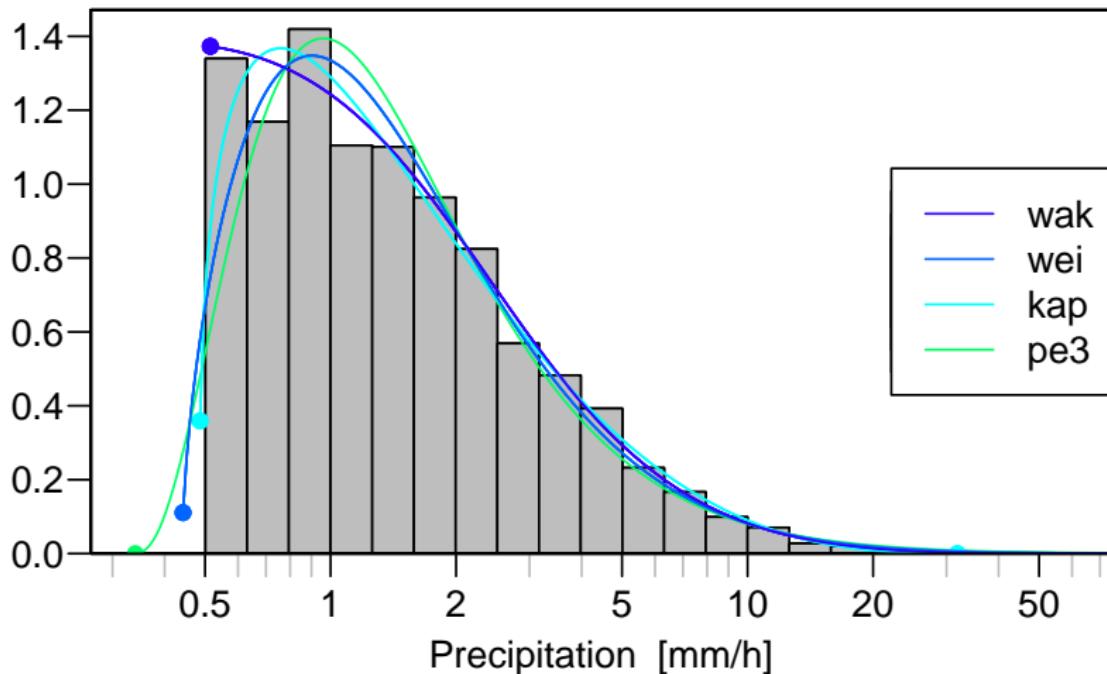
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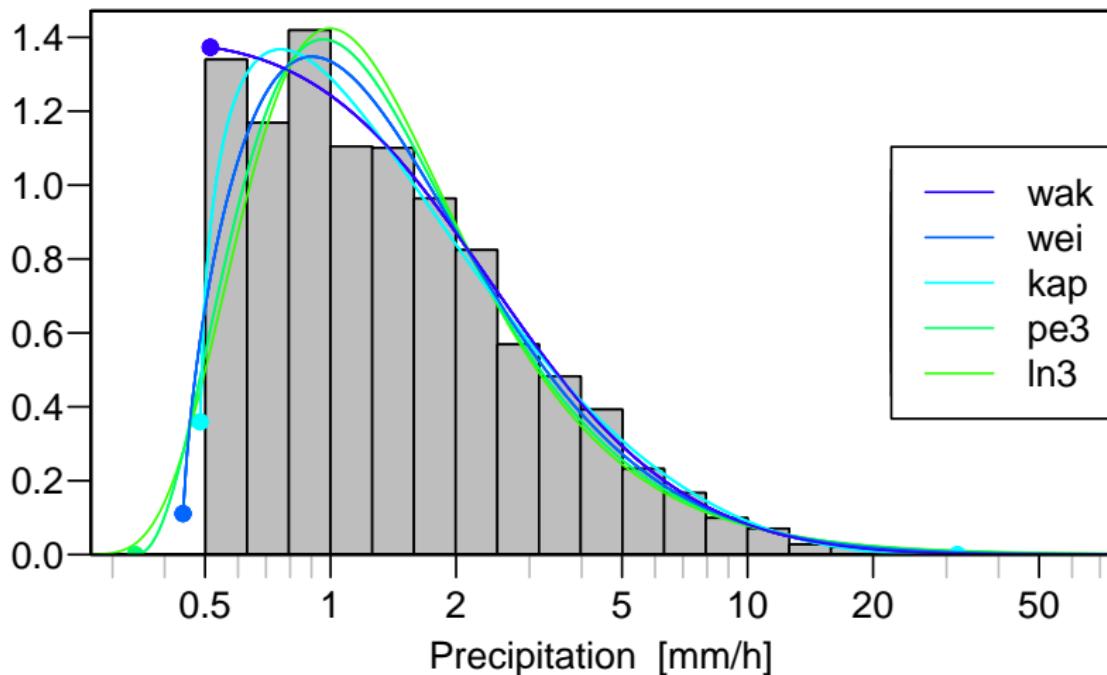
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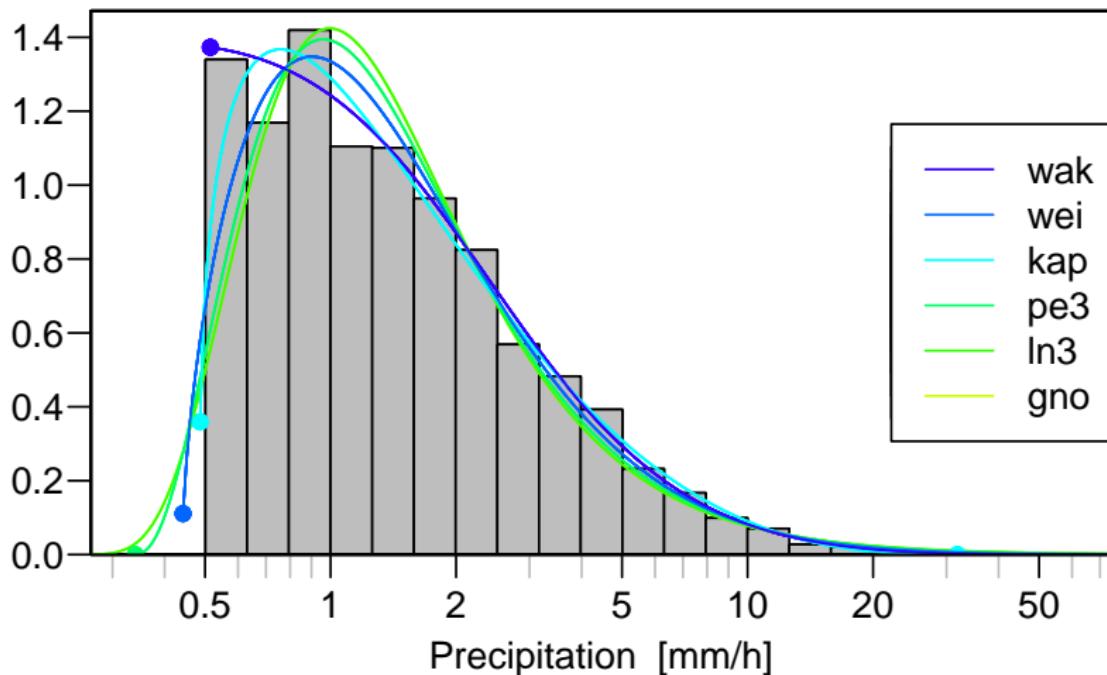
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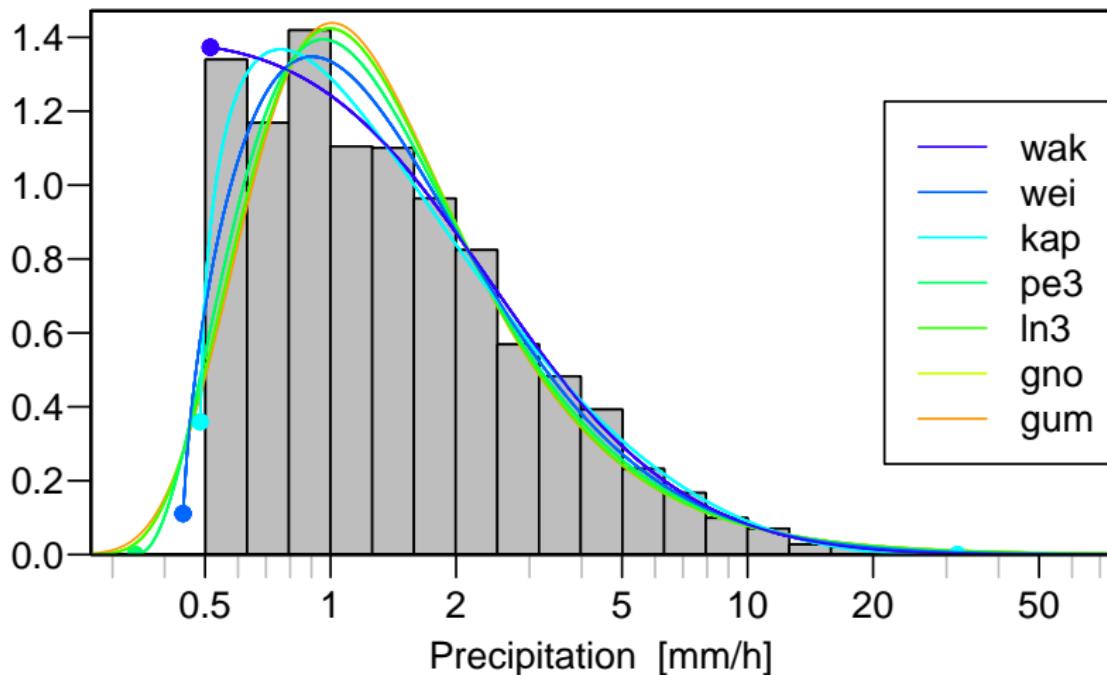
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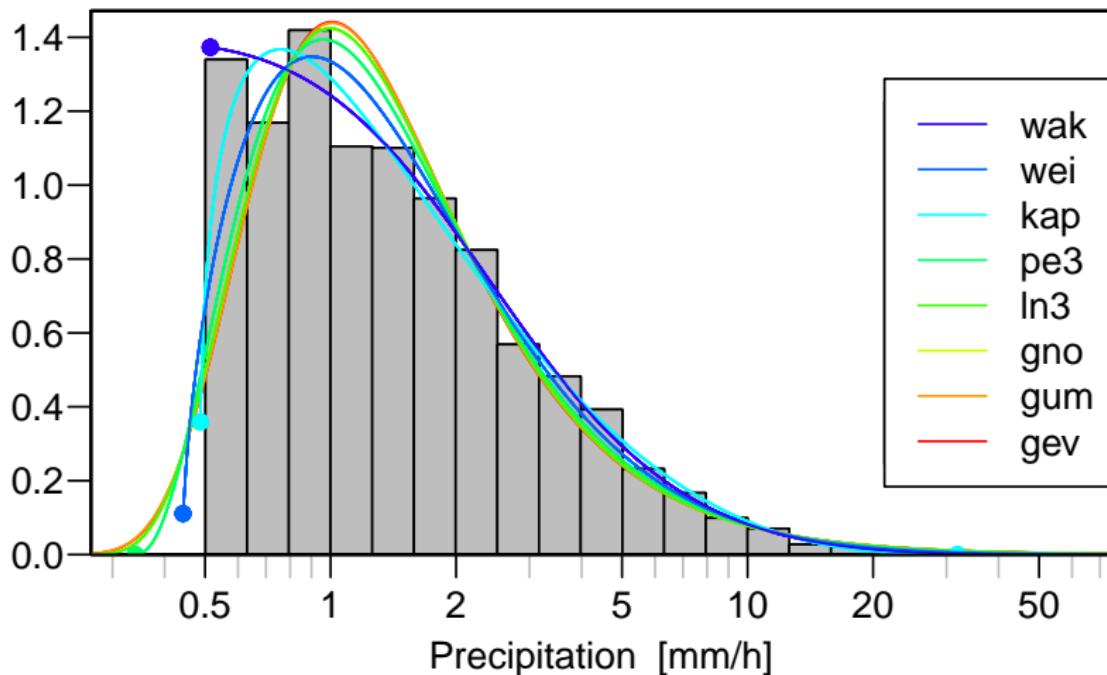
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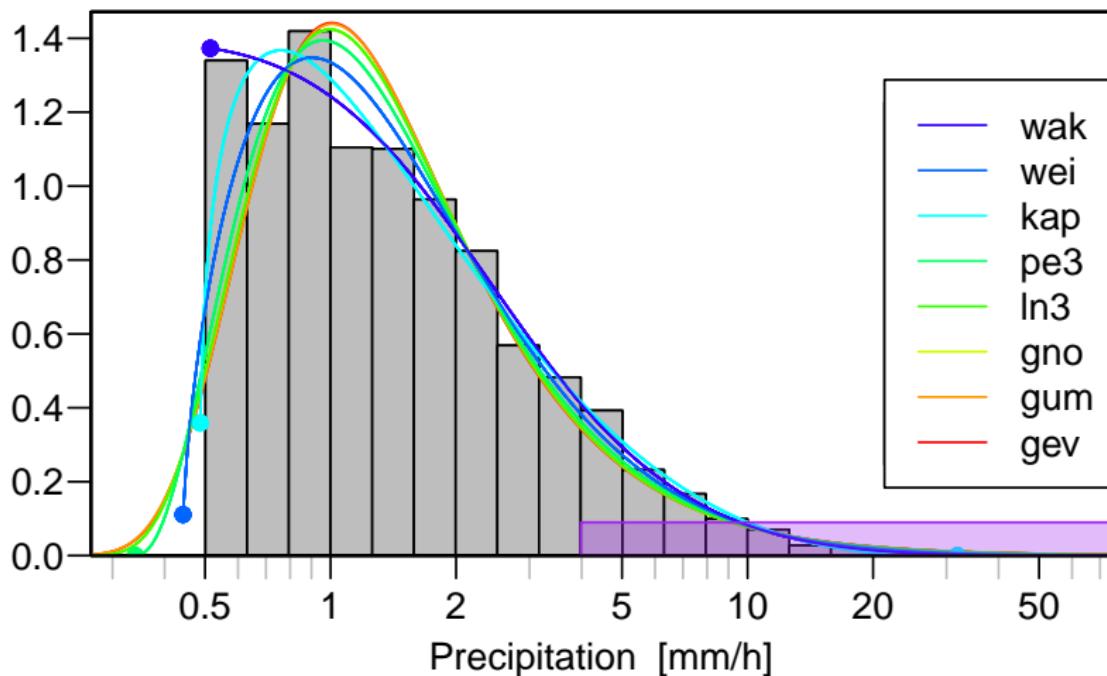
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Probability Density Function (PDF)



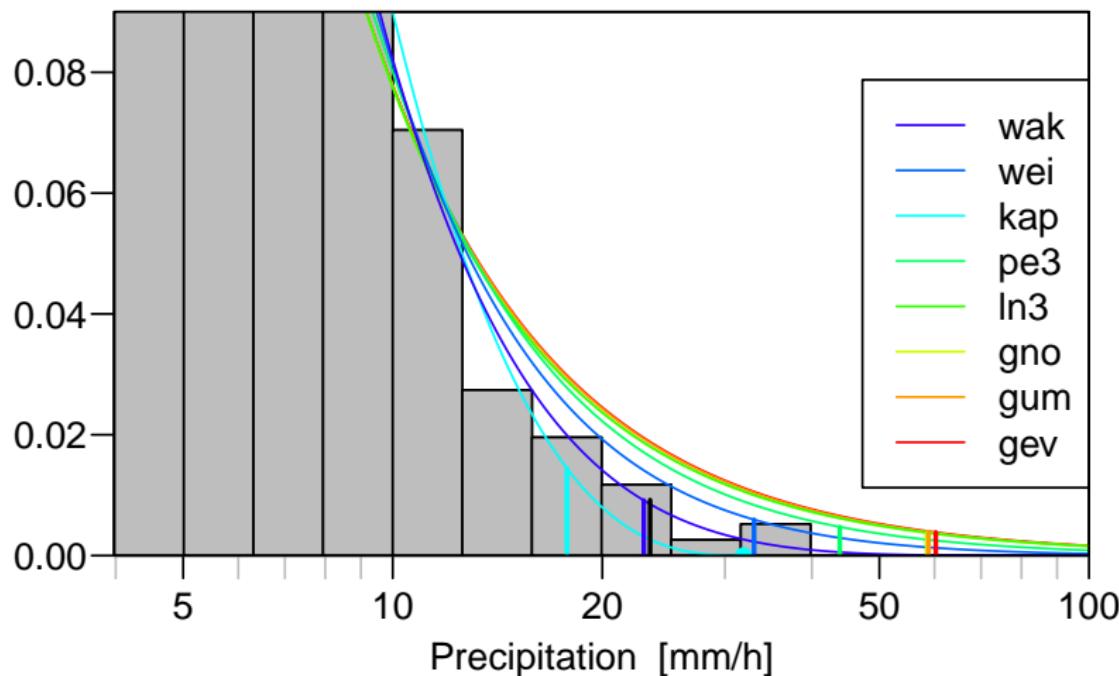
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Probability Density Function (PDF)



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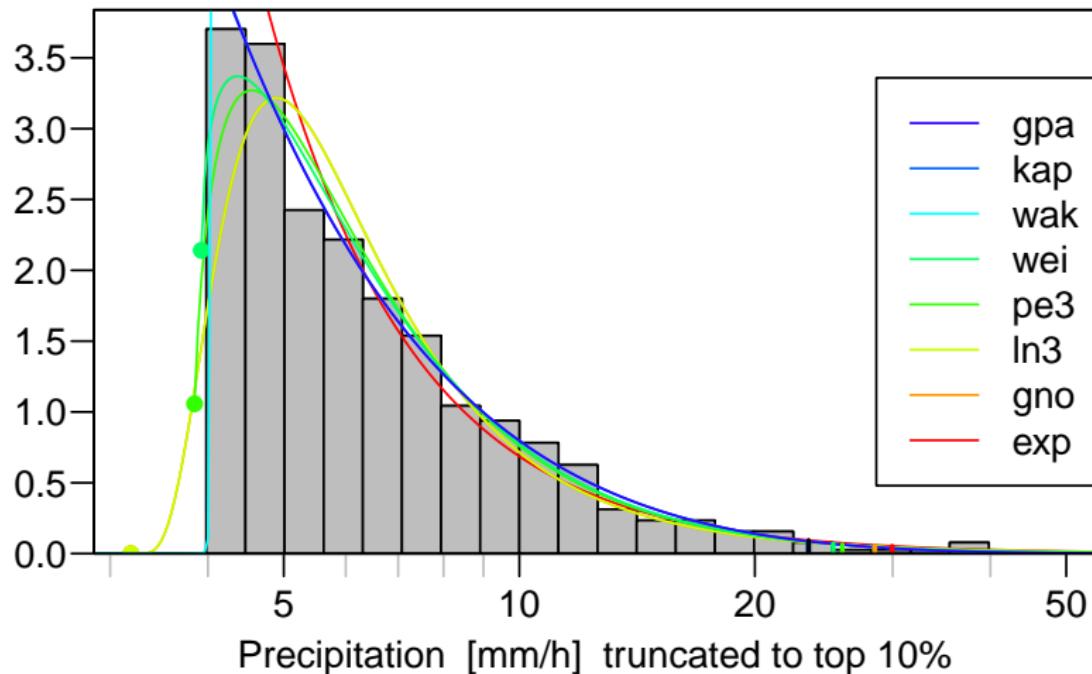


Distributions must be fitted carefully

Extreme value statistics to the rescue!

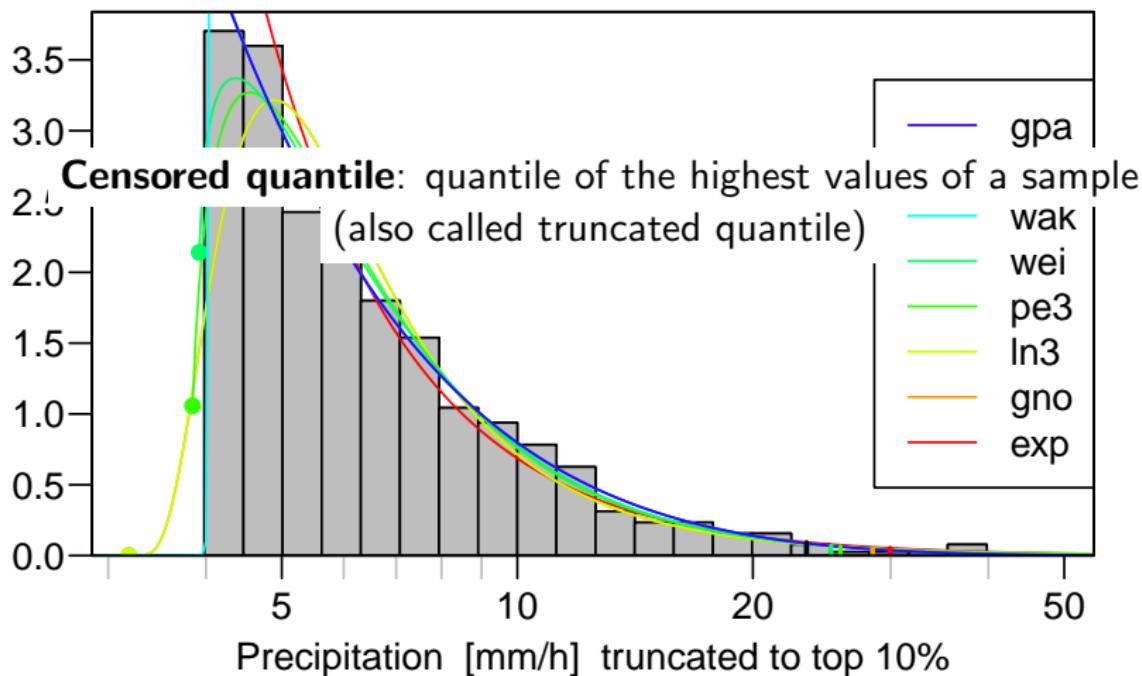
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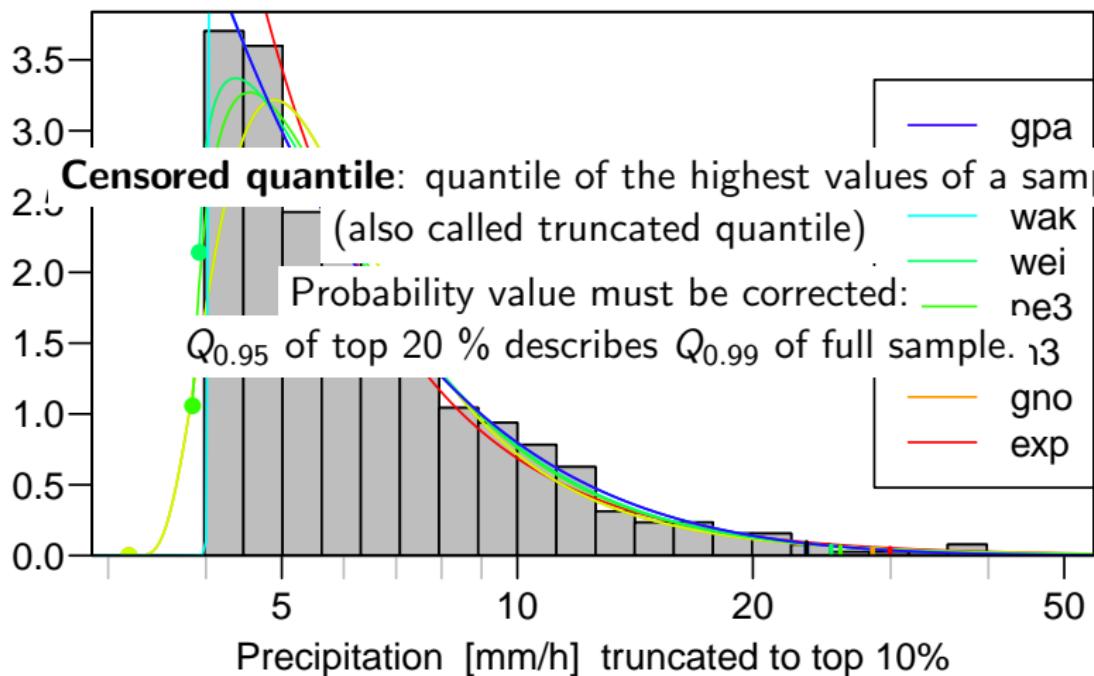
## Distributions must be fitted carefully

Probability Density Function (PDF)



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Distributions must be fitted carefully

Science should strive for reproducibility:

# R Code available on [github.com/brry/extremeStat](https://github.com/brry/extremeStat)

```
devtools::install_github("brry/extremeStat")
```

 [brry / extremeStat](https://github.com/brry/extremeStat)

Fit, plot and compare several (extreme value) distributions by means of a plot with return periods on a linear scale — Edit

71 commits · 1 branch · 0 releases · 1 contributor

branch: master +

links updated in readme

Author	Commit Message	Date
 brry	authored 32 seconds ago	latest commit f8c3b5a9cf
 R	distLgof: ellipsis option for customizing distLgoffPlot	12 days ago
 man	distExtreme: Examples improved significantly, Goodness-of-fit stuff ...	12 days ago
 .Rbuildignore	Moving development of extremeStat to github.	7 months ago
 .gitignore	Moving development of extremeStat to github.	7 months ago
 ChangeLog	quiet argument added throughout the package	25 days ago
 DESCRIPTION	distExtreme: Examples improved significantly, Goodness-of-fit stuff ...	12 days ago
 NAMESPACE	dependency instead of a bunch of functions in two packages, which is ...	5 months ago
 README.md	links updated in readme	31 seconds ago
 extremeStat.Rproj	Moving development of extremeStat to github.	7 months ago

 README.md

## extremeStat

Fit, plot and compare several (extreme value) distributions and draw a plot with return periods on a linear scale.

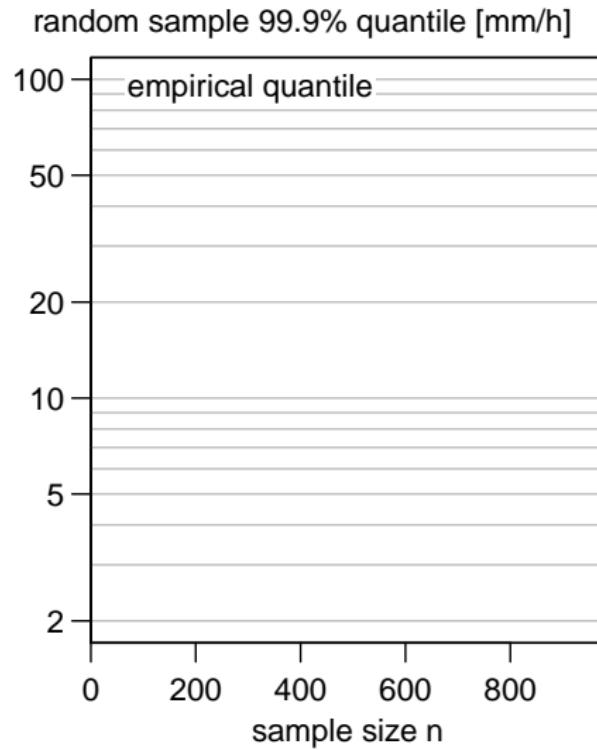
Code Issues Pull requests Wiki Pulse Graphs Settings

HTTPS clone URL <https://github.com/brry/extremeStat> You can clone with HTTPS, SSH, or Subversion.

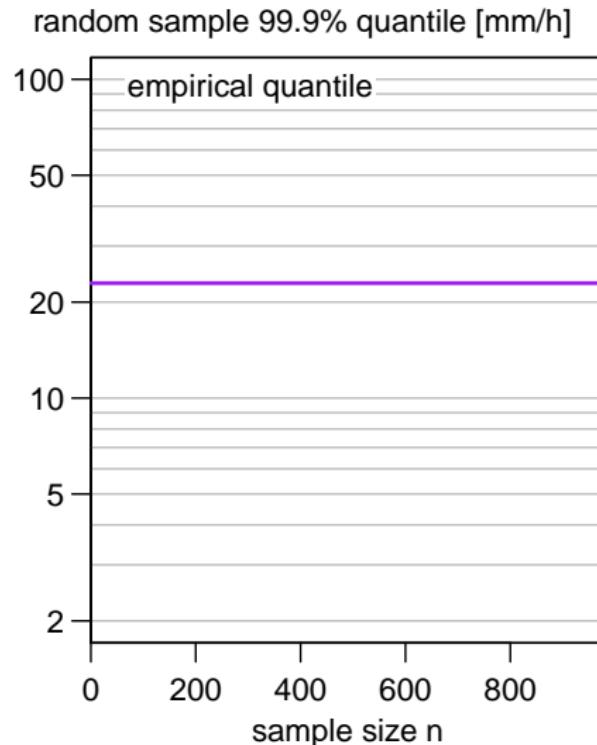
Clone in Desktop Download ZIP

Low sample size could explain quantile drop

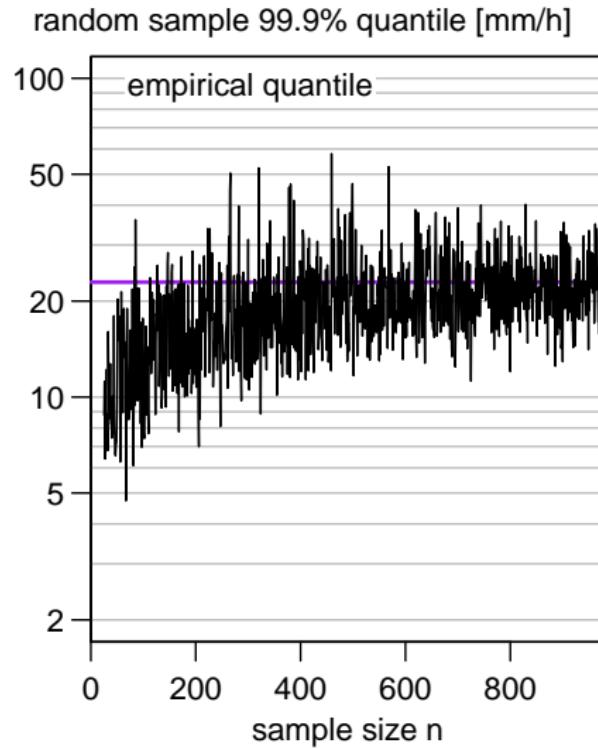
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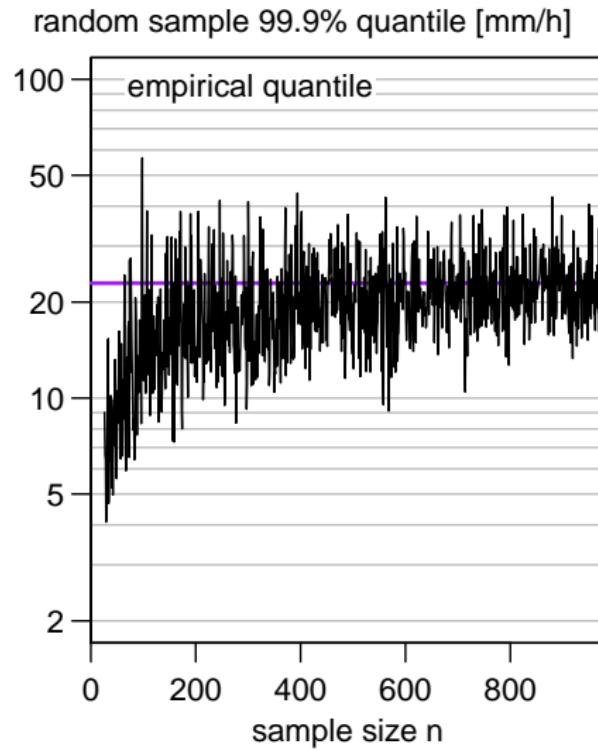
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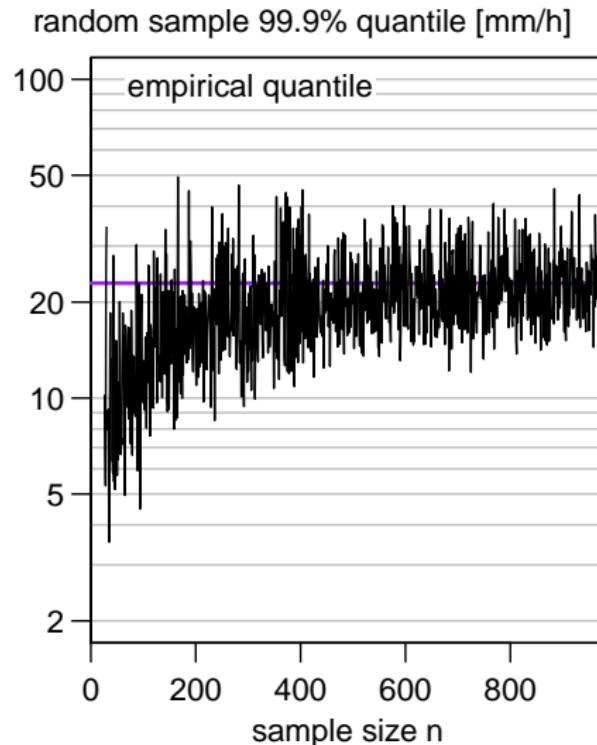
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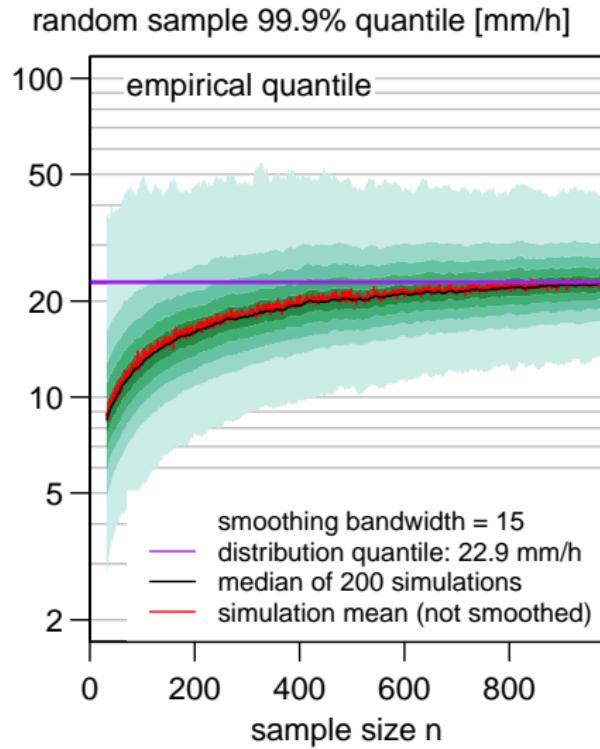
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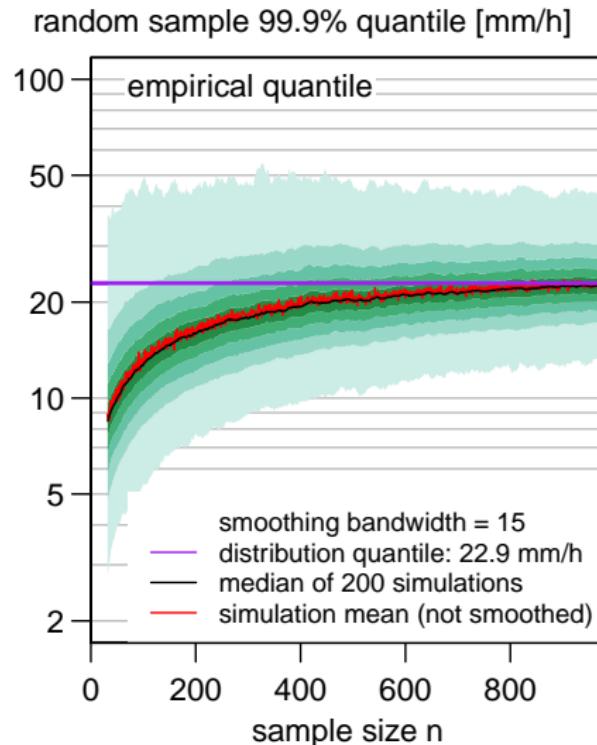
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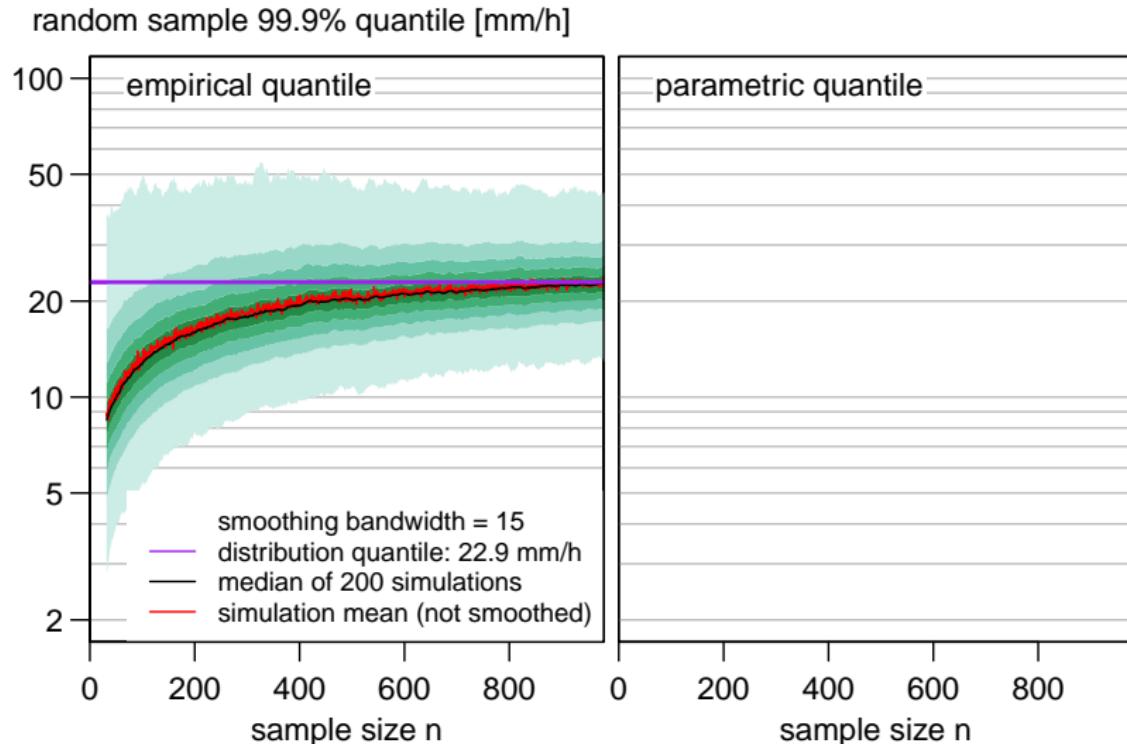


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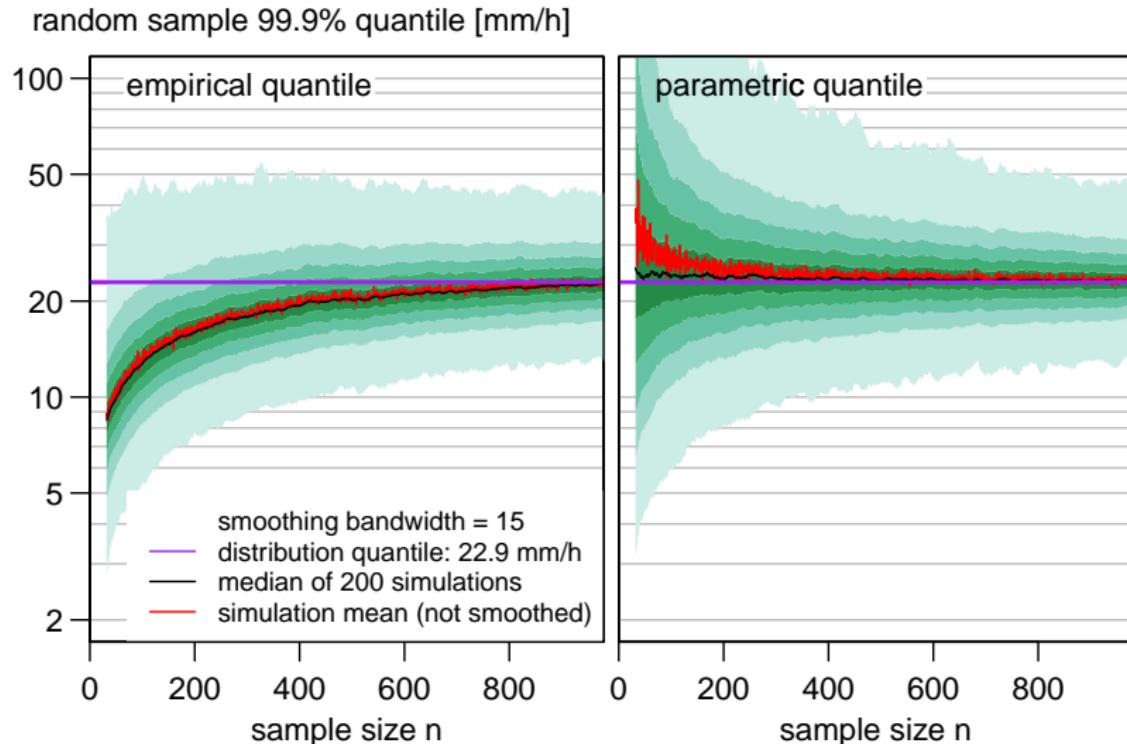


**Parametric quantile:**  
quantile from distribution  
fitted to sample

## Low sample size could explain quantile drop



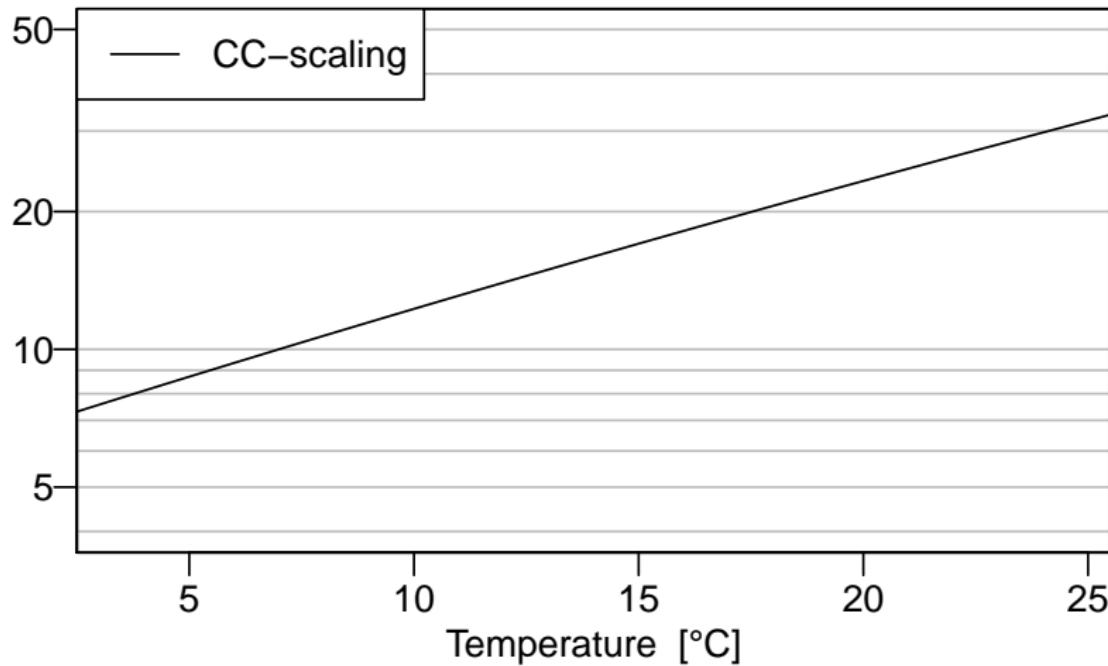
## Low sample size could explain quantile drop



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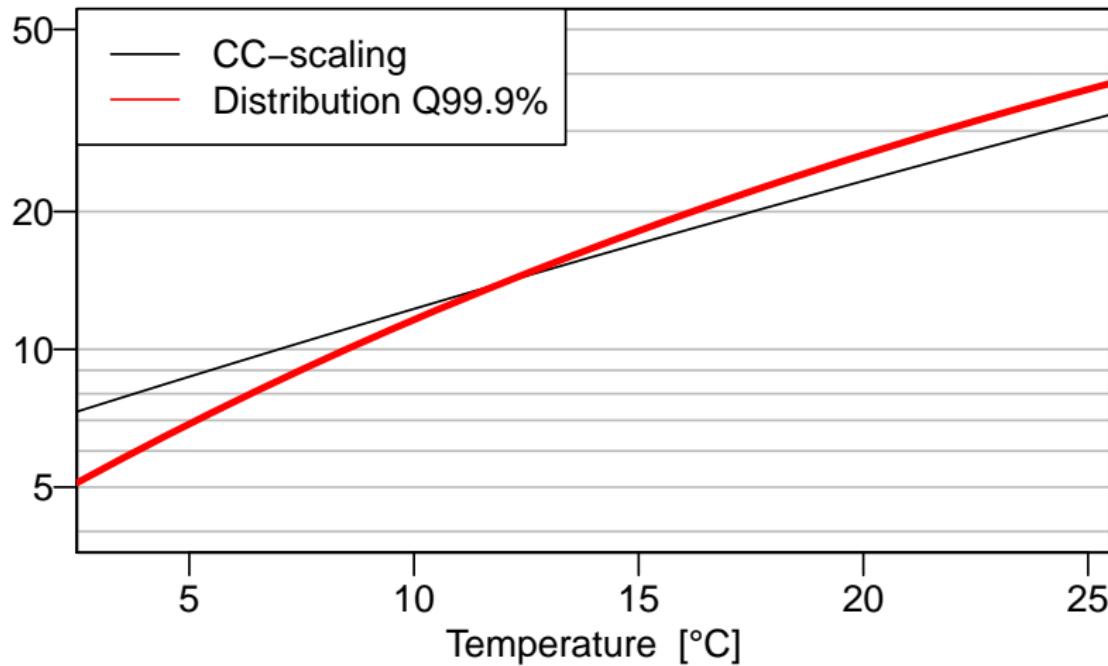
Low sample size could explain quantile drop

Precipitation [mm/h]



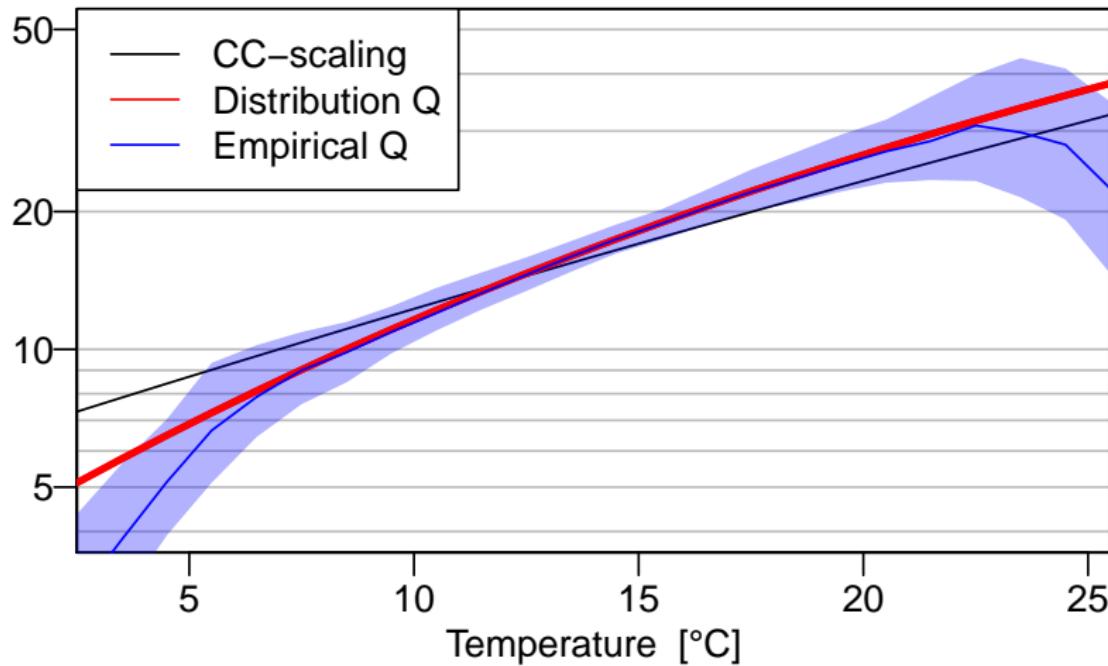
Low sample size could explain quantile drop

Precipitation [mm/h]



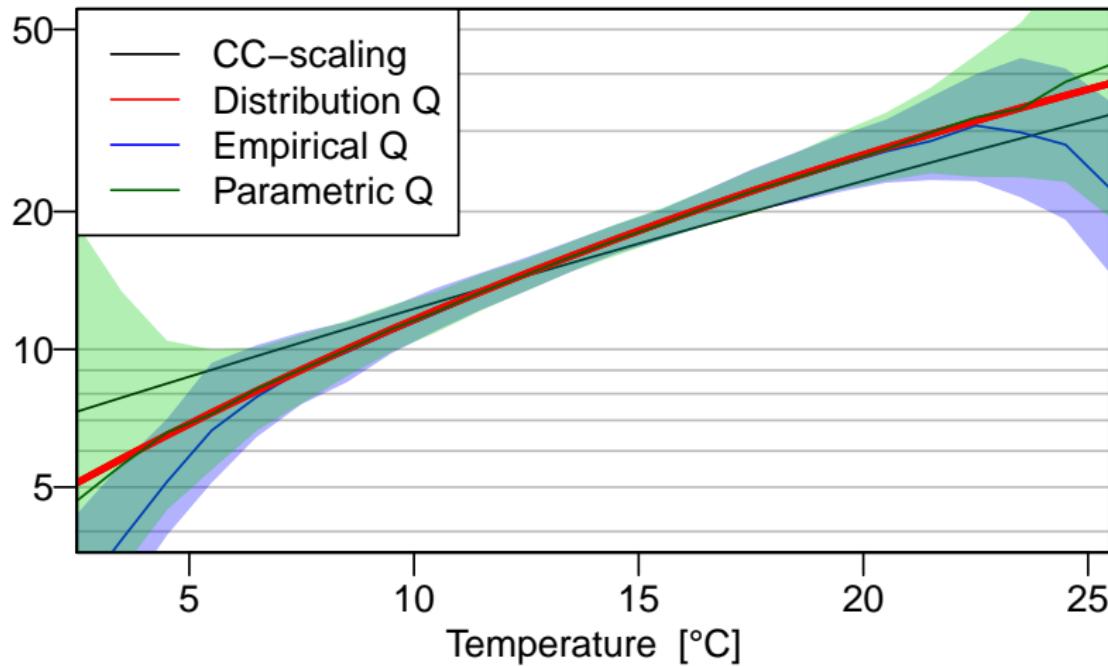
Low sample size could explain quantile drop

Precipitation [mm/h]



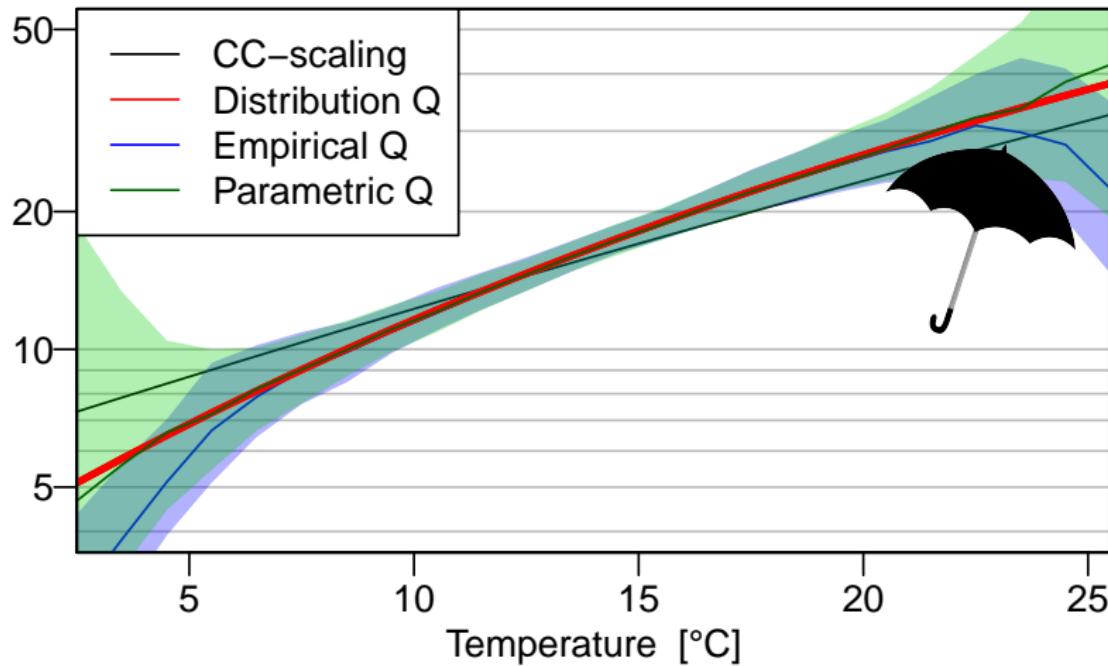
Low sample size could explain quantile drop

Precipitation [mm/h]



Low sample size could explain quantile drop

Precipitation [mm/h]



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precipitation intensity quantile drop at high temperatures  
may be an effect of sample size

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source code slides, references and materials: [github.com/brry/prectemp](https://github.com/brry/prectemp)

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Image credits:

<http://7-themes.com/7024707-child-with-umbrella.html>

<http://pngimg.com/download/494>

[http://dreamatico.com/data\\_images/sun/sun-5.jpg](http://dreamatico.com/data_images/sun/sun-5.jpg)

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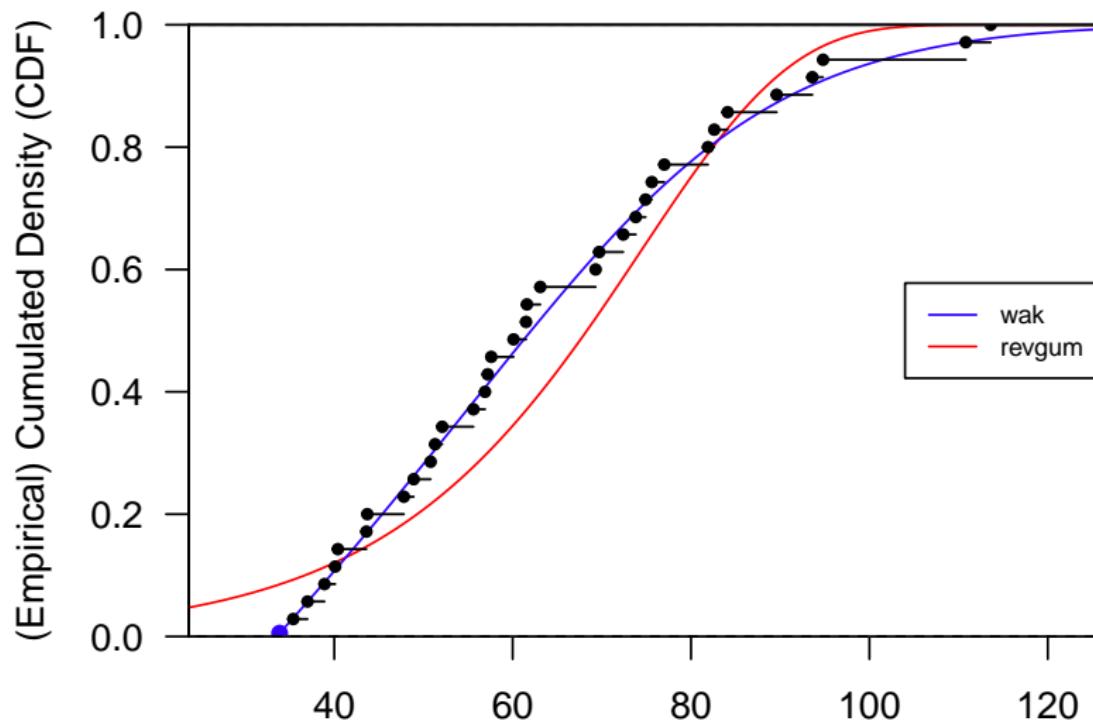
Thanks to many proofreaders  
and my supervisors

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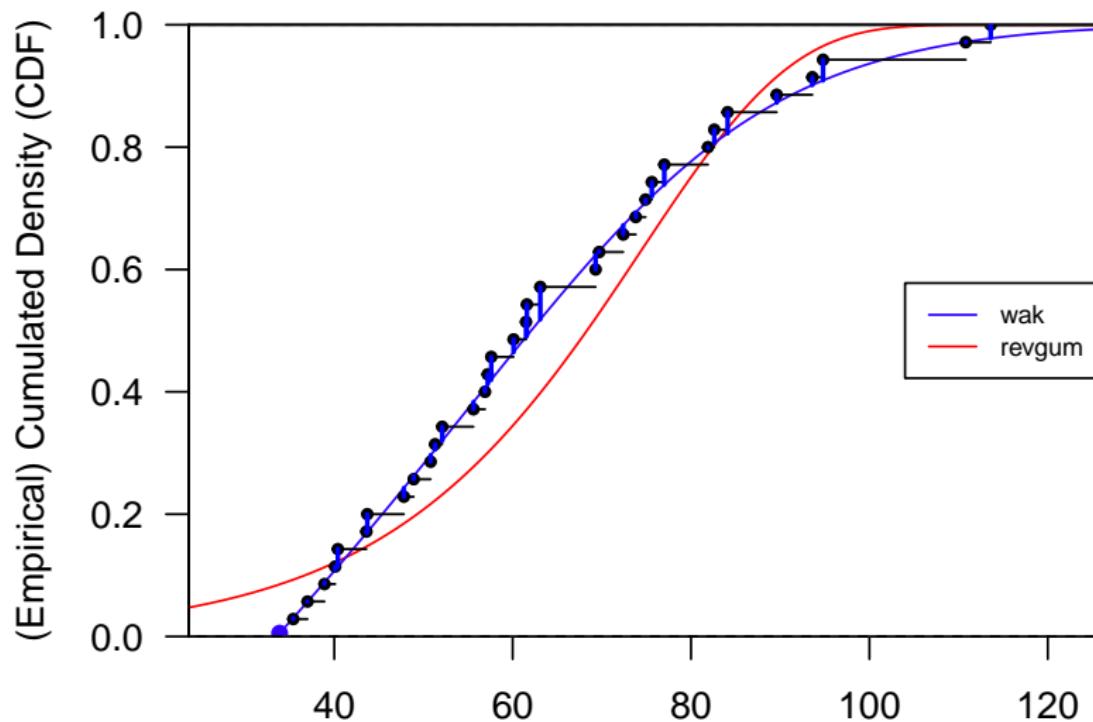
## Goodness of Fit

measured by RMSE of cumulated distribution function and ecdf



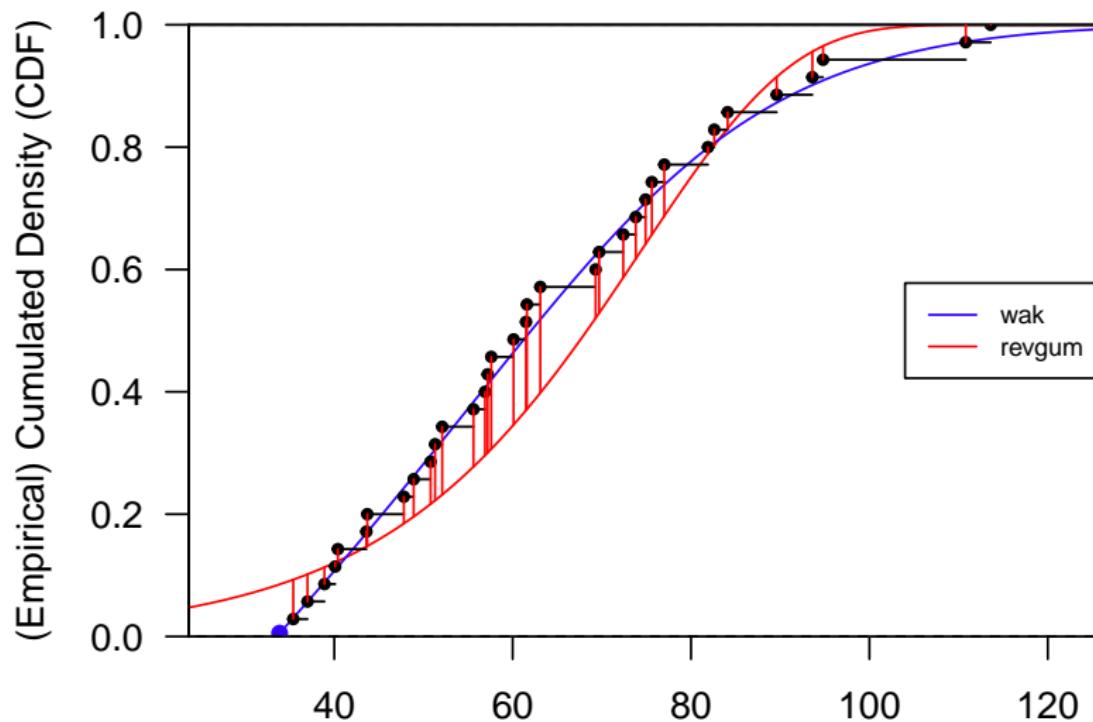
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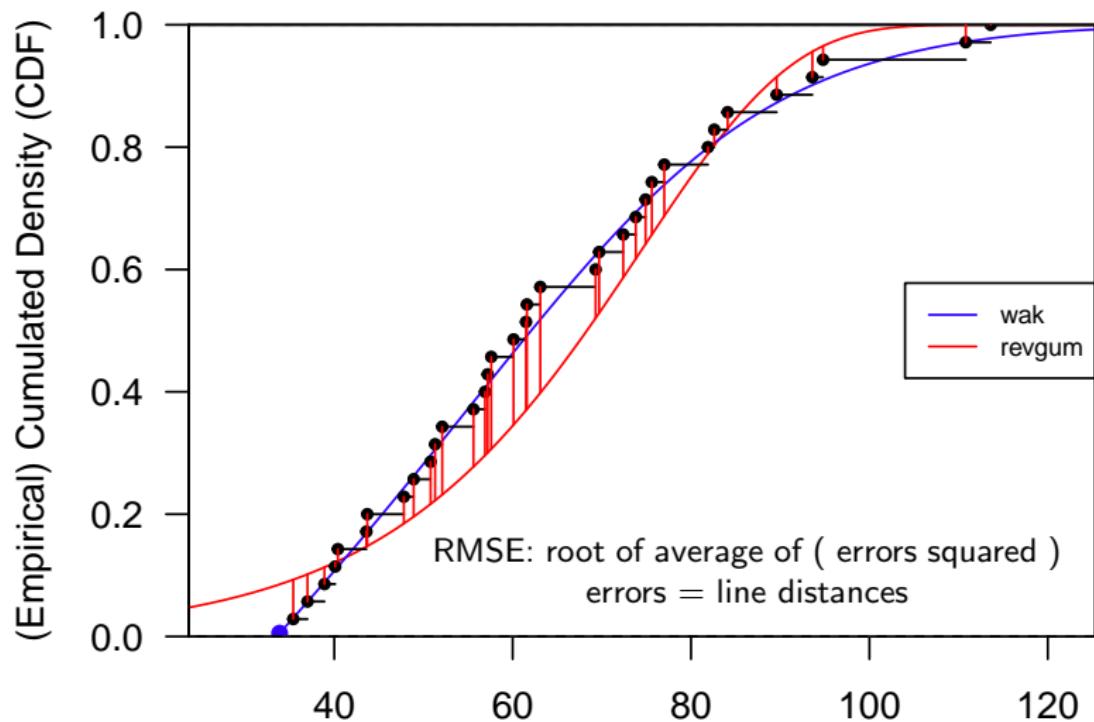
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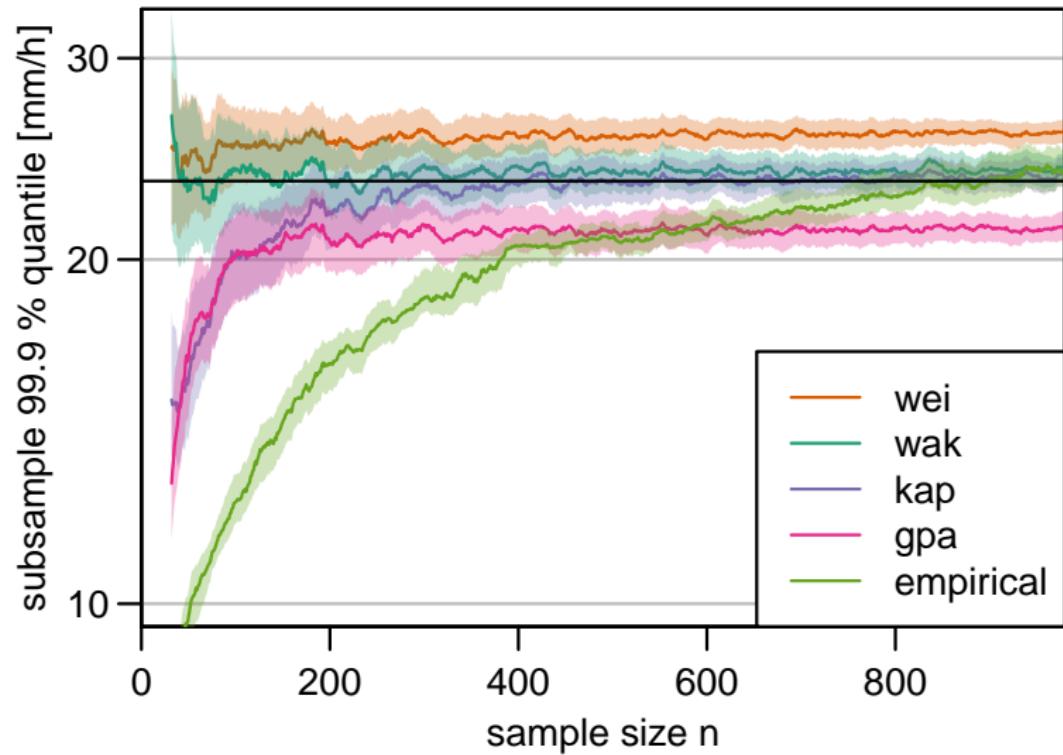
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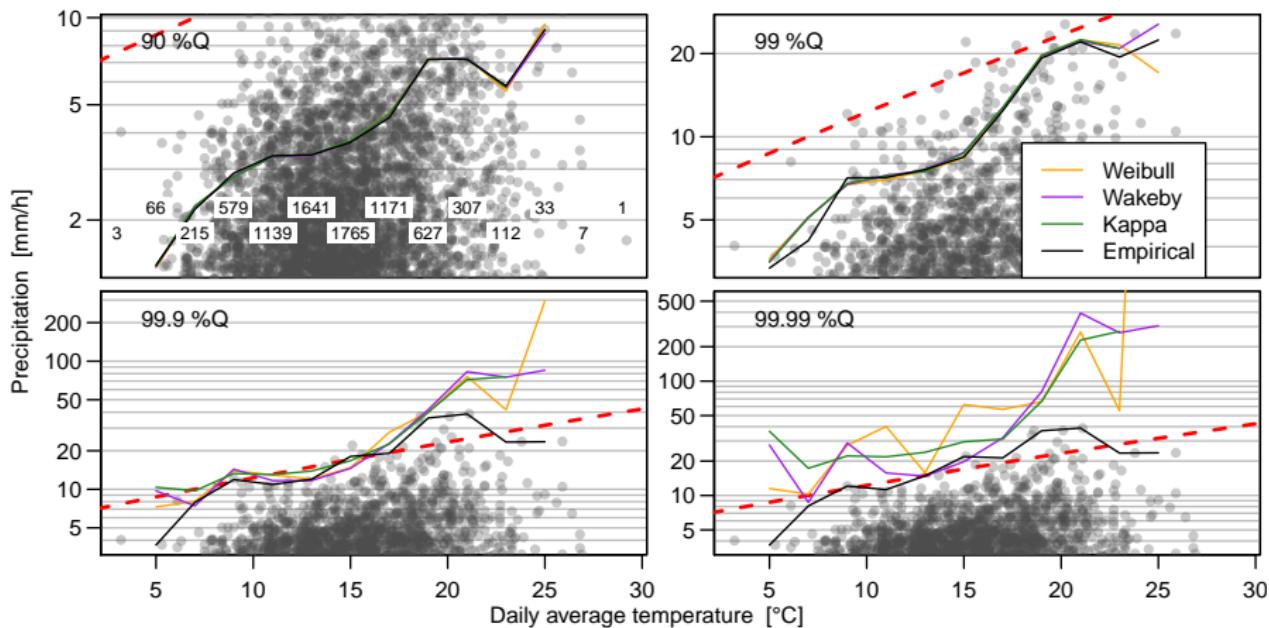


Random subsamples drawn from real data (observations)

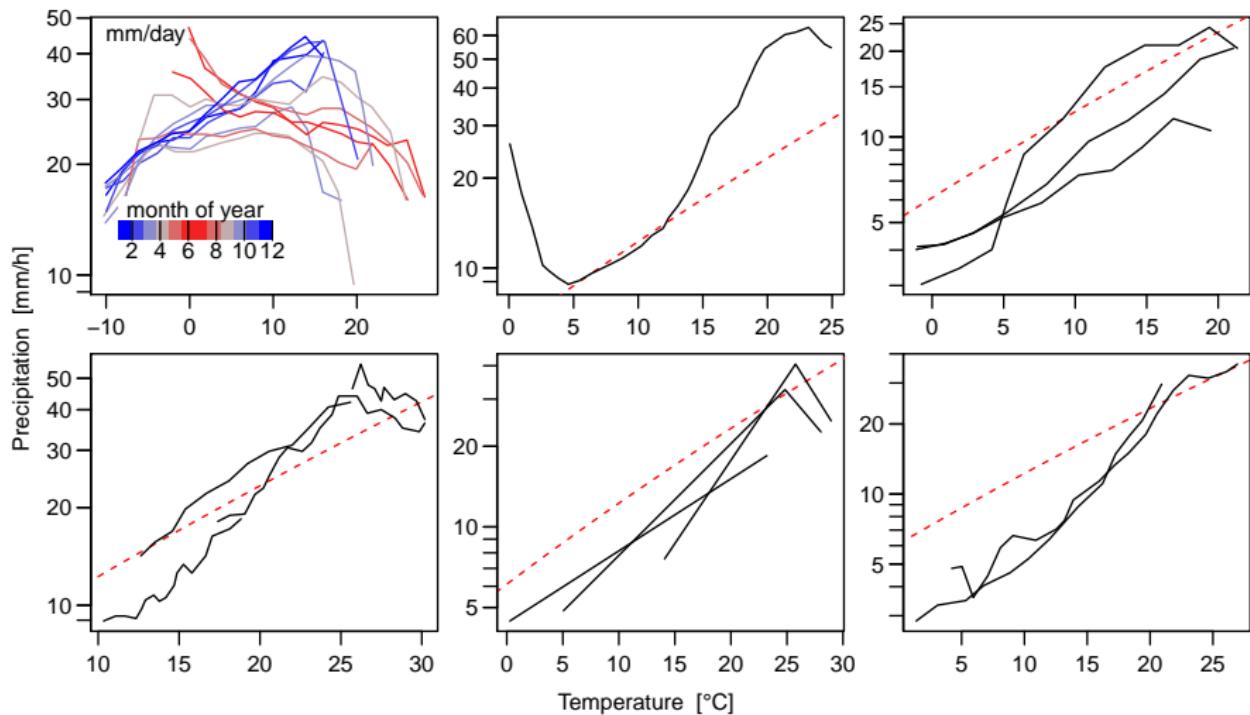
Truncated parametric quantiles (fitted to top 20%) still depend (a little bit)



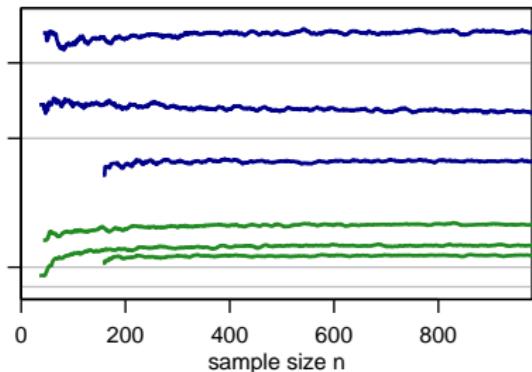
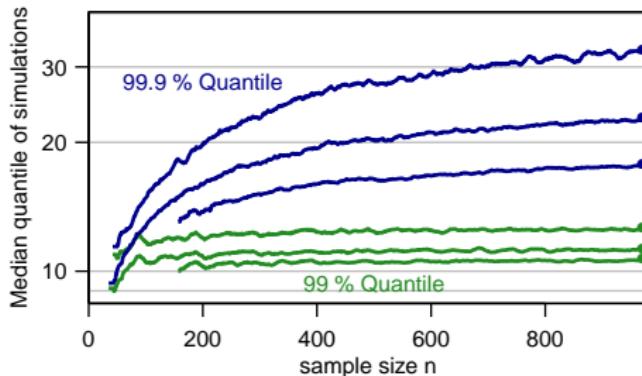
# parametric truncated quantiles applied to original Potsdam dataset



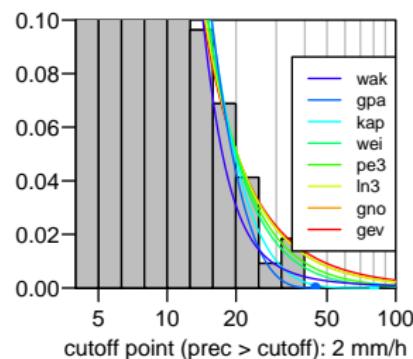
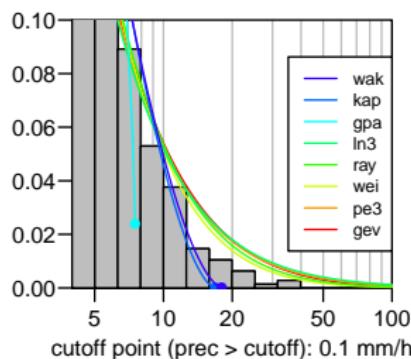
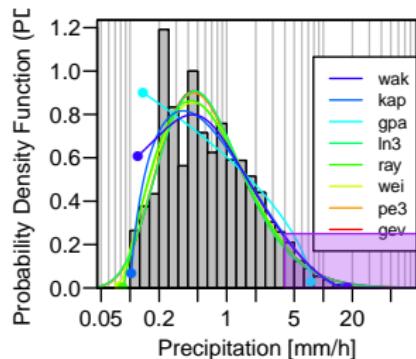
## PT relationships in literature



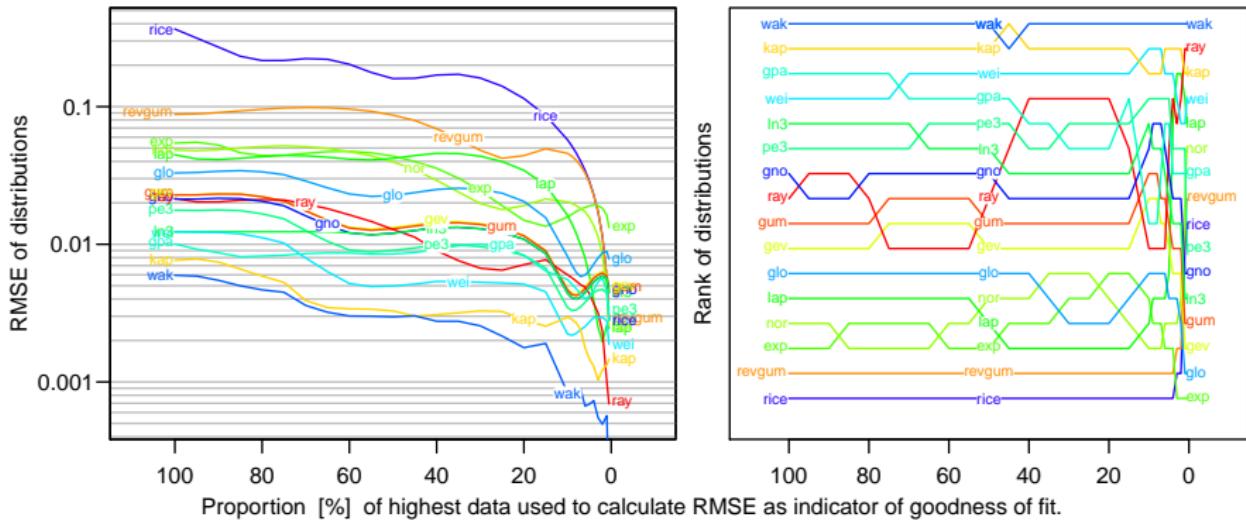
## simulations with other distributions



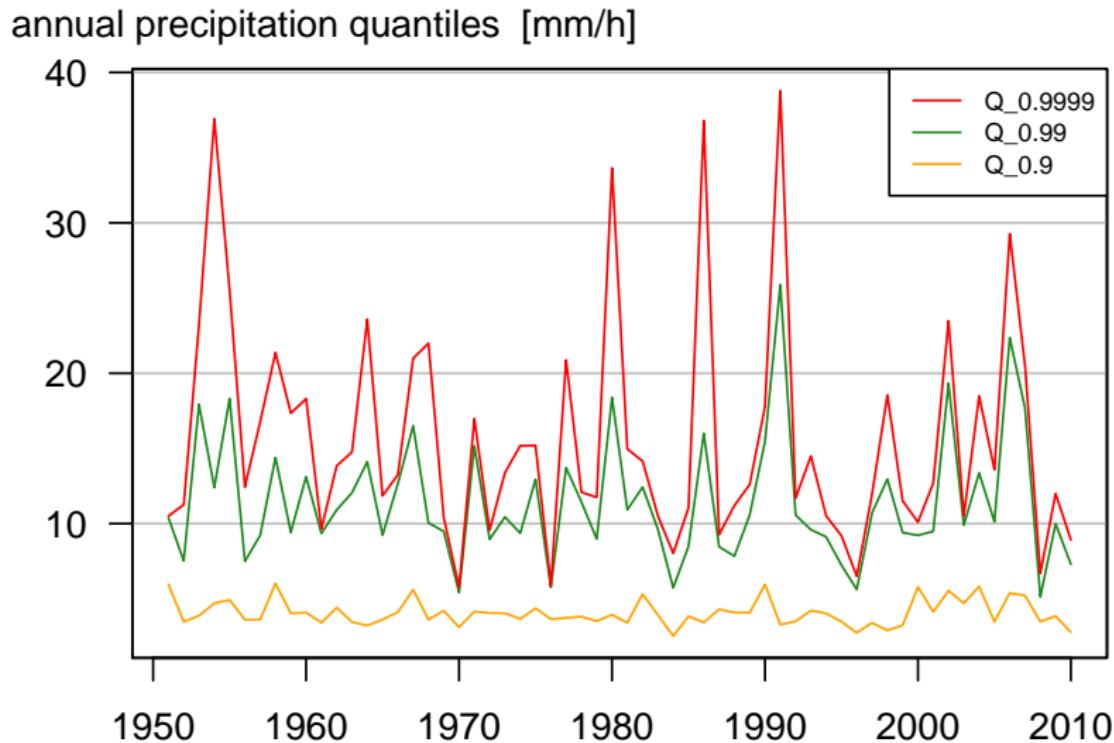
## cutoff effect



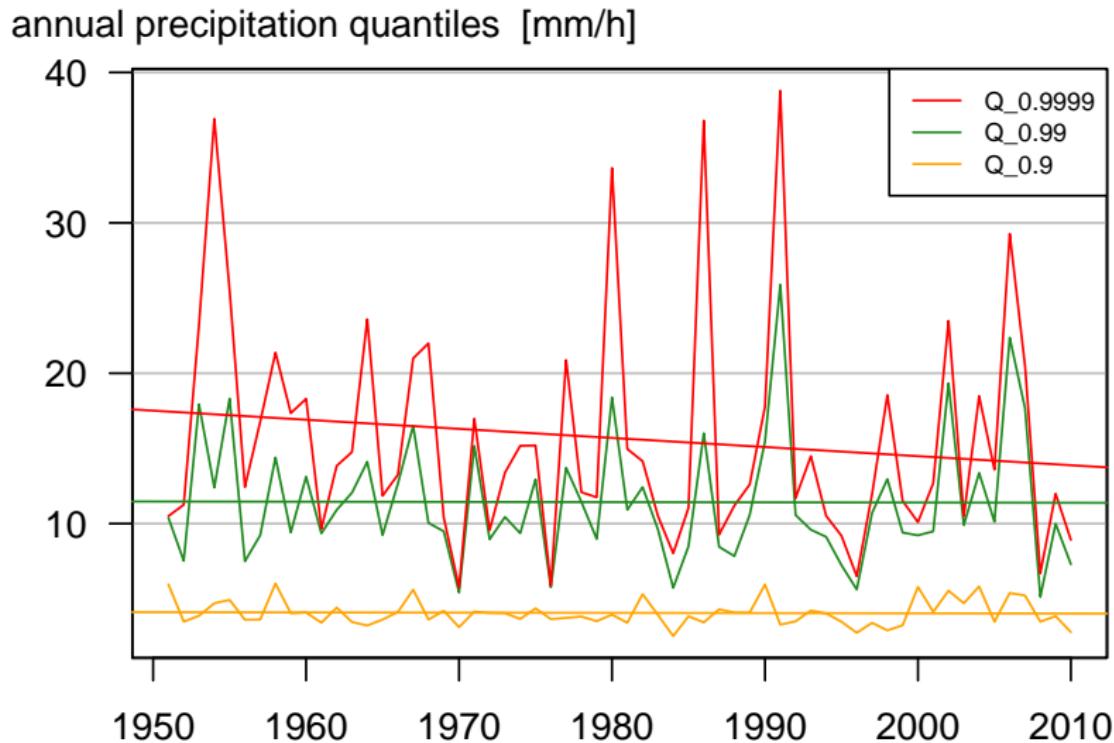
## gofprop effect



No real temporal trend observed with empirical quantiles



No real temporal trend observed with empirical quantiles



## parametric Quantiles (Average of 3 closest dists)

annual precipitation quantiles [mm/h]

