KLIMA DIGITAL°

Norwegian Meteorological Institute

The rain check

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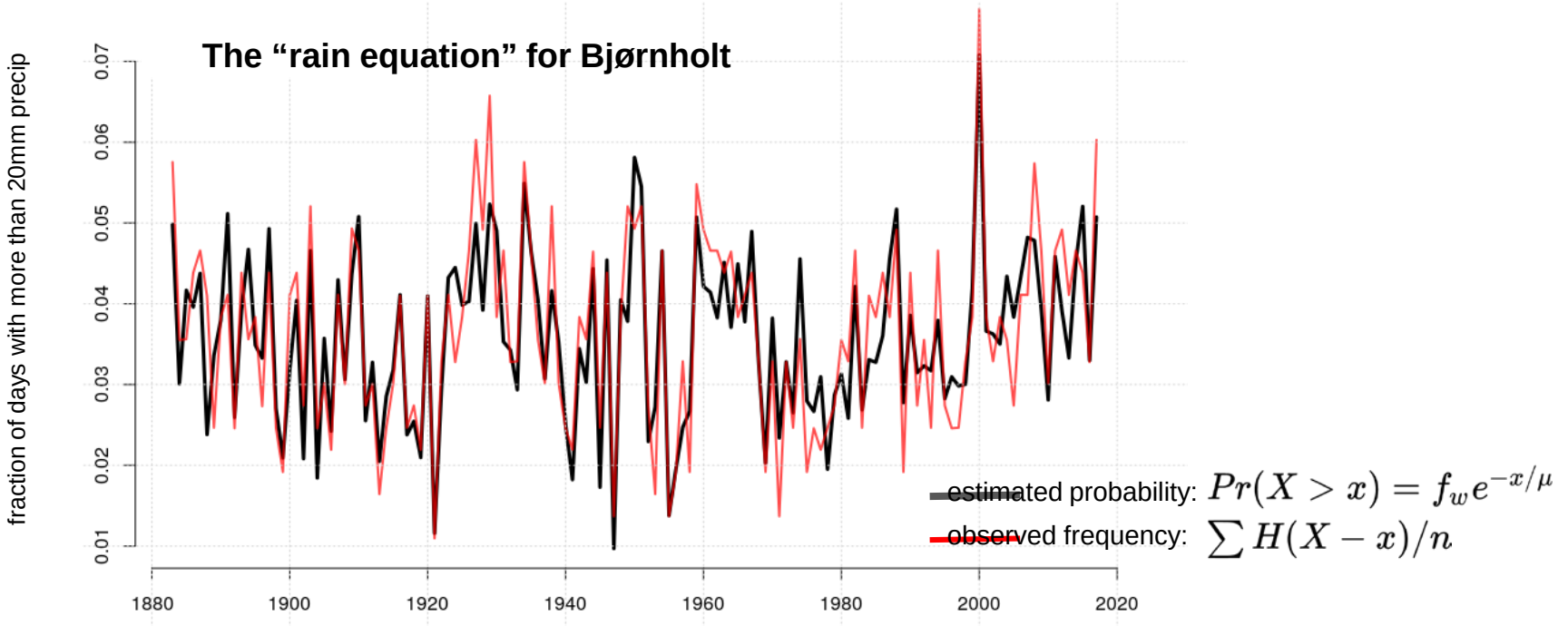
The probability for heavy rainfall:

$$Pr(X > x) = f_w e^{-x/\mu}$$

“A simple equation to study changes in rainfall statistics"
DOI: 10.1088/1748-9326/ab2bb2

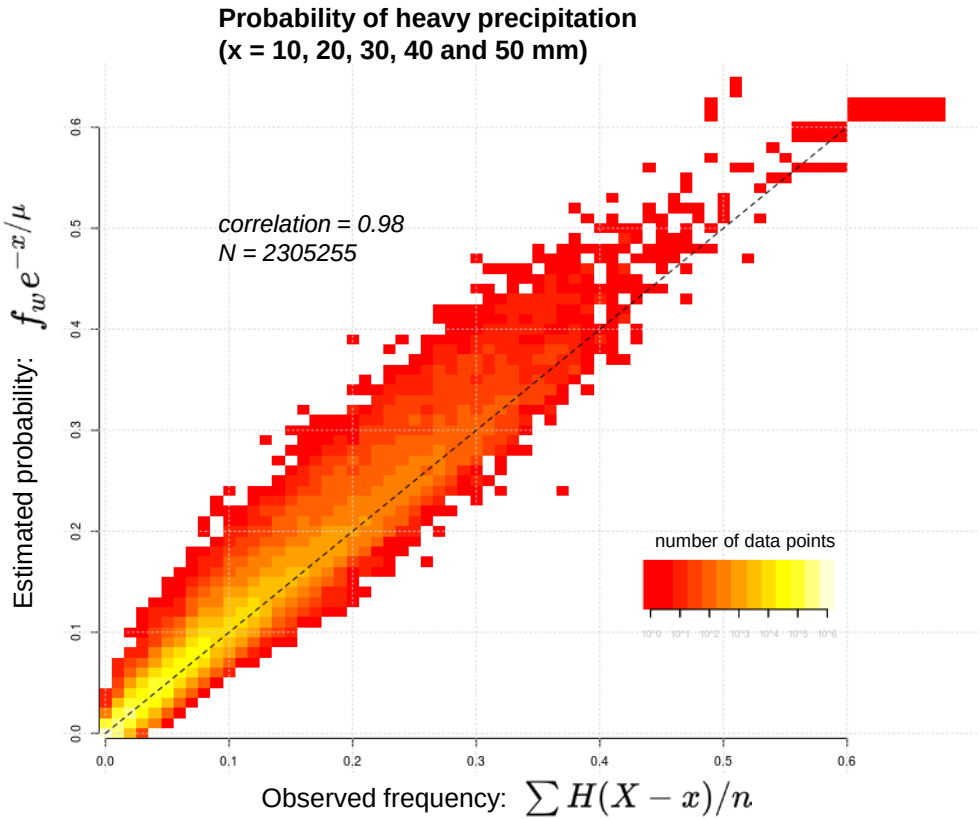
The probability for heavy rainfall:

$$Pr(X > x) = f_w e^{-x/\mu}$$



How well does the equation correspond with reality?

$$Pr(X > x) = f_w e^{-x/\mu}$$



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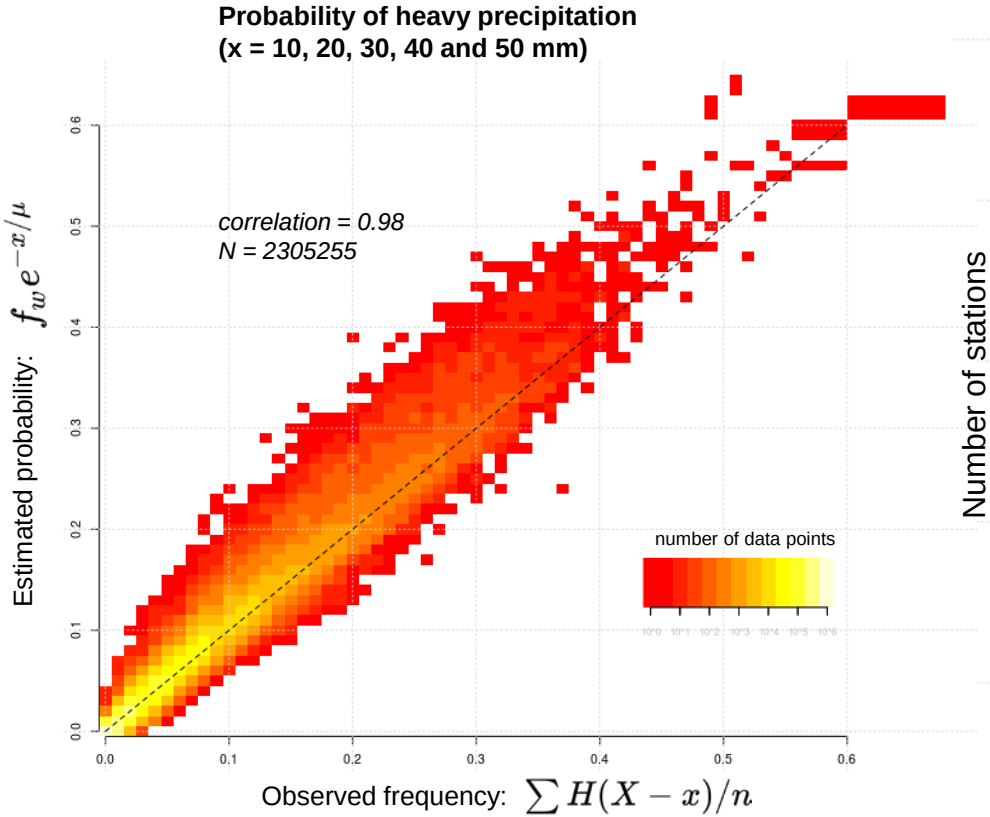
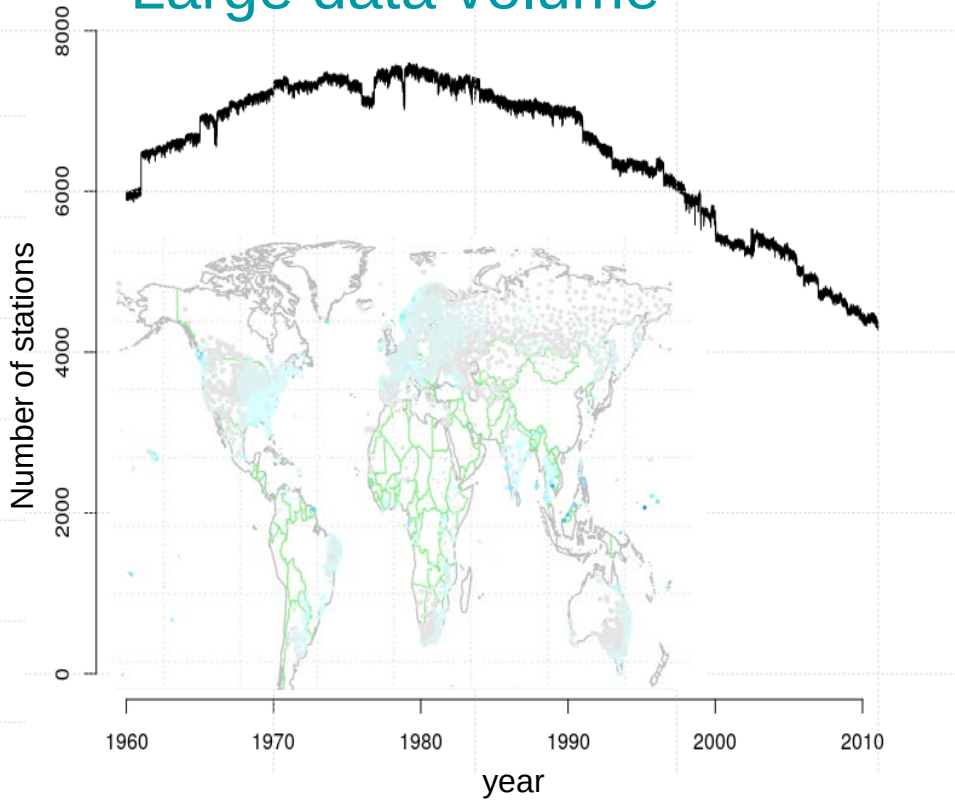
Correspondence with reality?

$$Pr(X > x) = f_w e^{-x/\mu}$$



Large data volume



The formula

$$Pr(X > x) = f_w e^{-x/\mu}$$

opens for a range of opportunities ...

$$Pr(X > x) = f_w e^{-x/\mu}$$

The mean:

$$\overline{x} = f_w \mu$$

Return values:

$$x_\tau = \mu \ln(\tau f_w)$$

$$Pr(X > x) = f_w e^{-x/\mu}$$

Causes for changes in the rainfall statistics

The mean:

$$\overline{x} = f_w \mu$$

Trend:

$$\frac{d\overline{x}}{dt} = \mu \frac{df_w}{dt} + f_w \frac{d\mu}{dt}$$

Return values:

$$x_\tau = \mu \ln(\tau f_w)$$

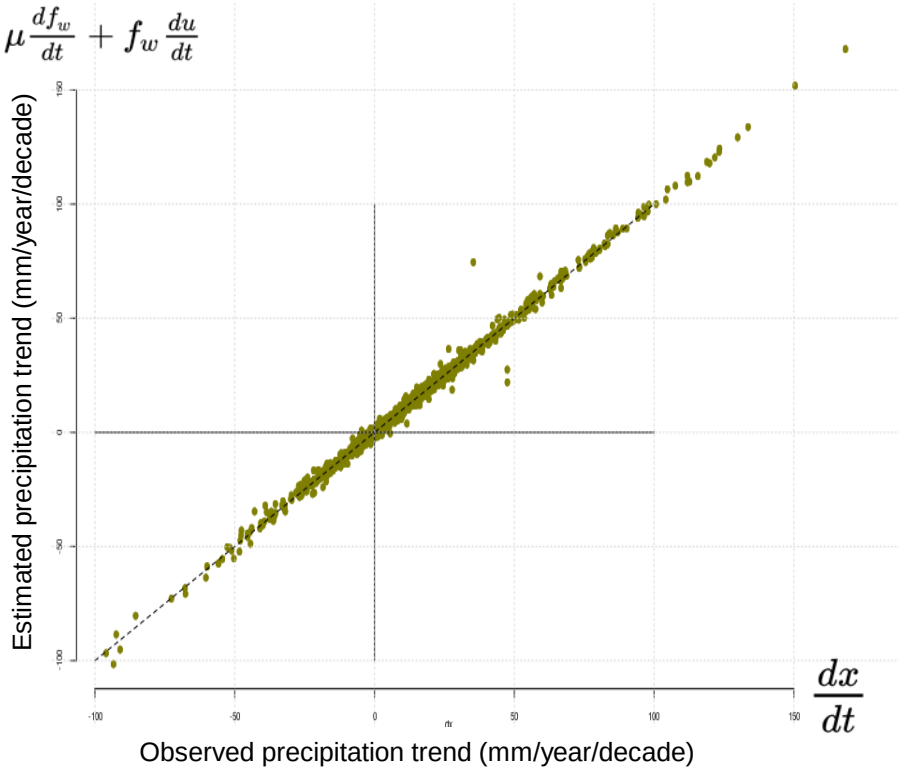
More rainy days

More intense rainfall

$$\frac{dx_\tau}{dt} = \frac{\mu}{f_w} \frac{df_w}{dt} + \ln(f_w \tau) \frac{d\mu}{dt}$$

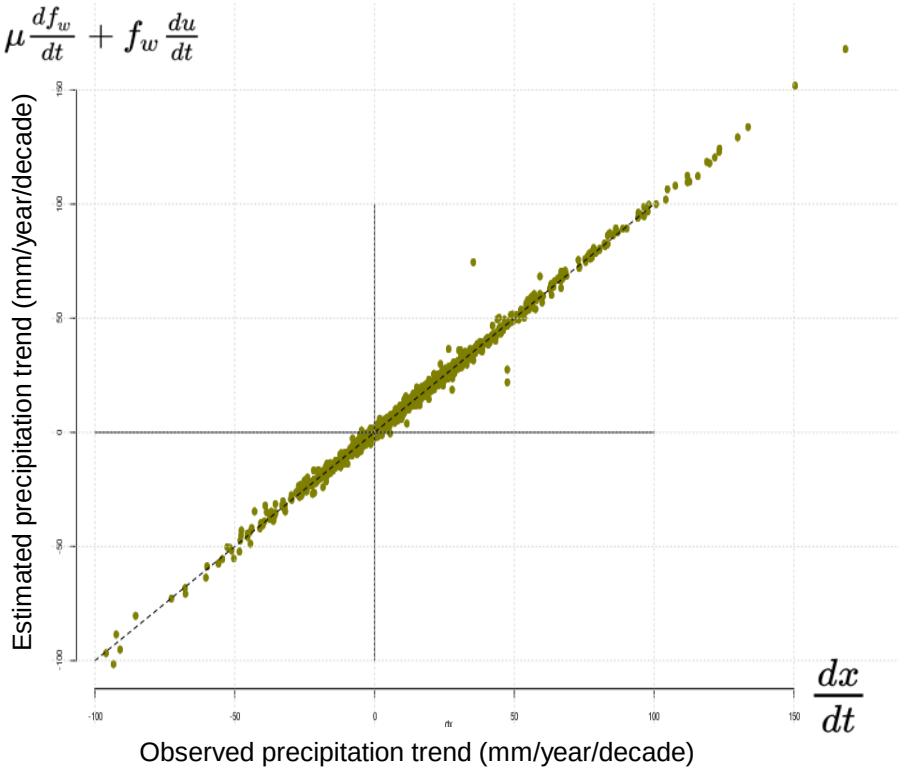
Trend in year totals : $x = 365.25 f_w \mu$

Trends in mean precipitation, observed vs estimated

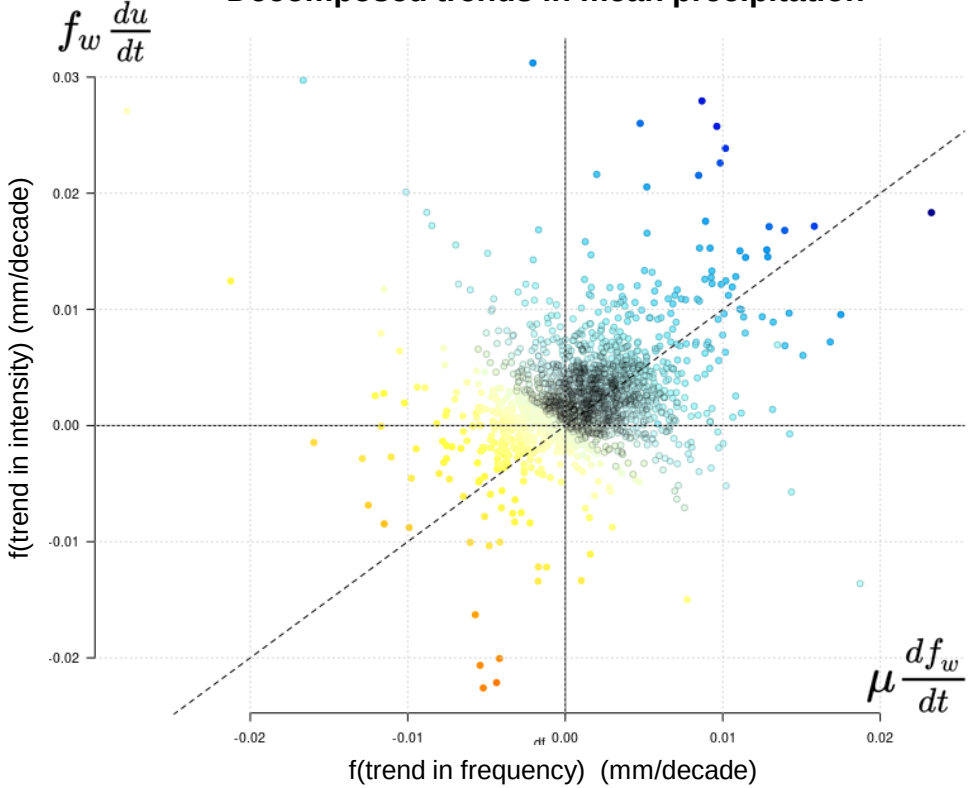


Trend in year totals : $x = 365.25 f_w \mu$

Trends in mean precipitation, observed vs estimated



Decomposed trends in mean precipitation



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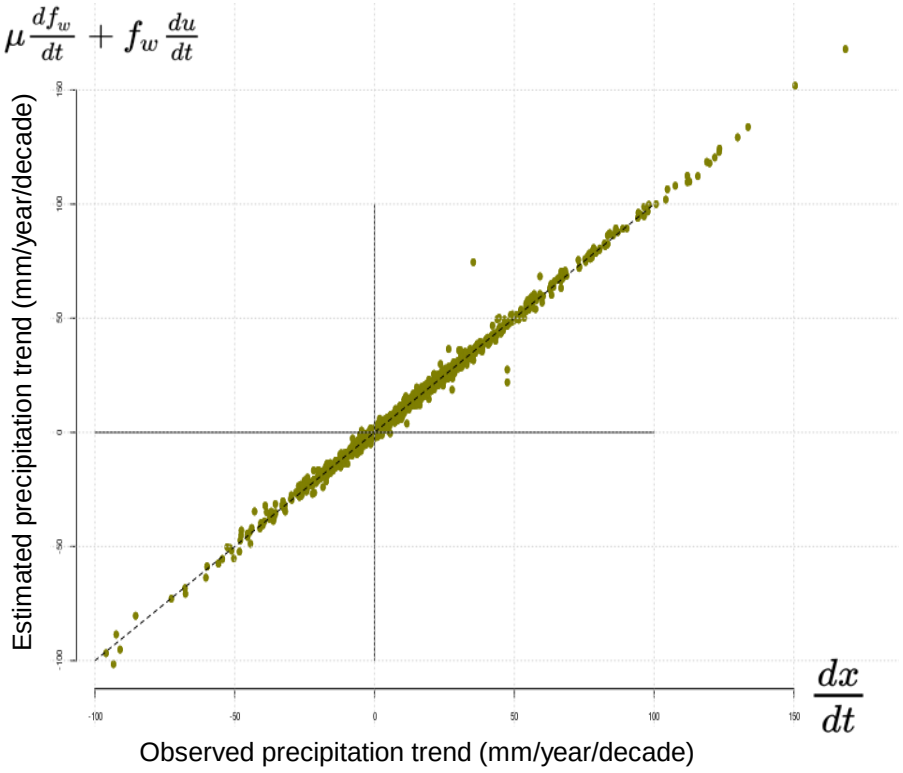

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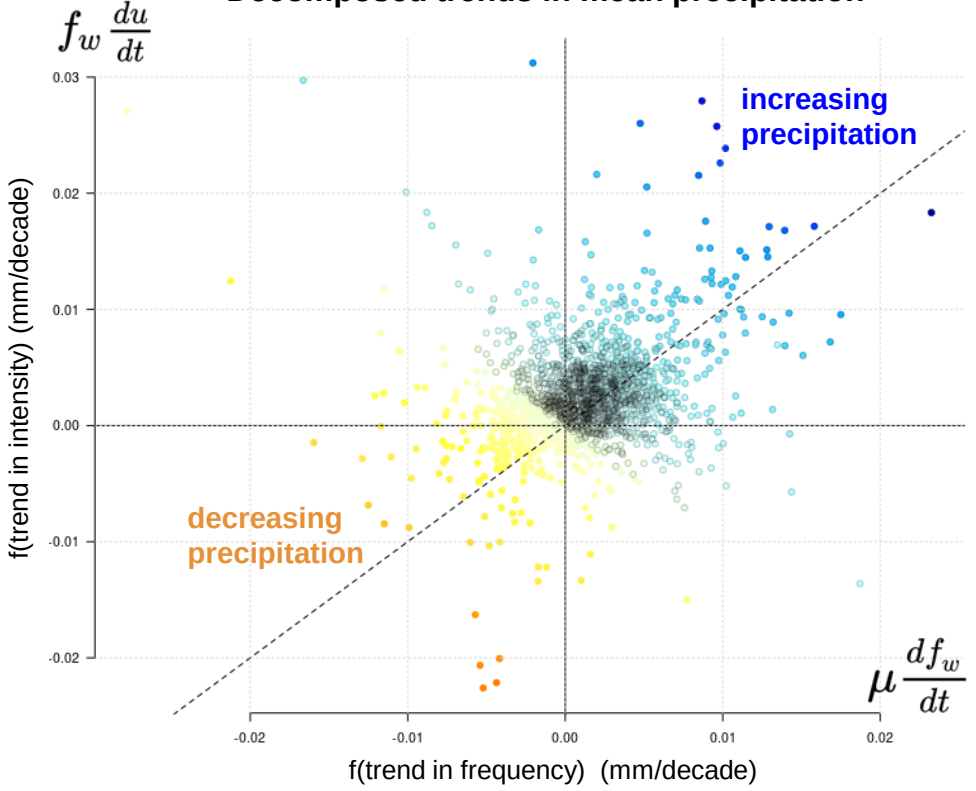
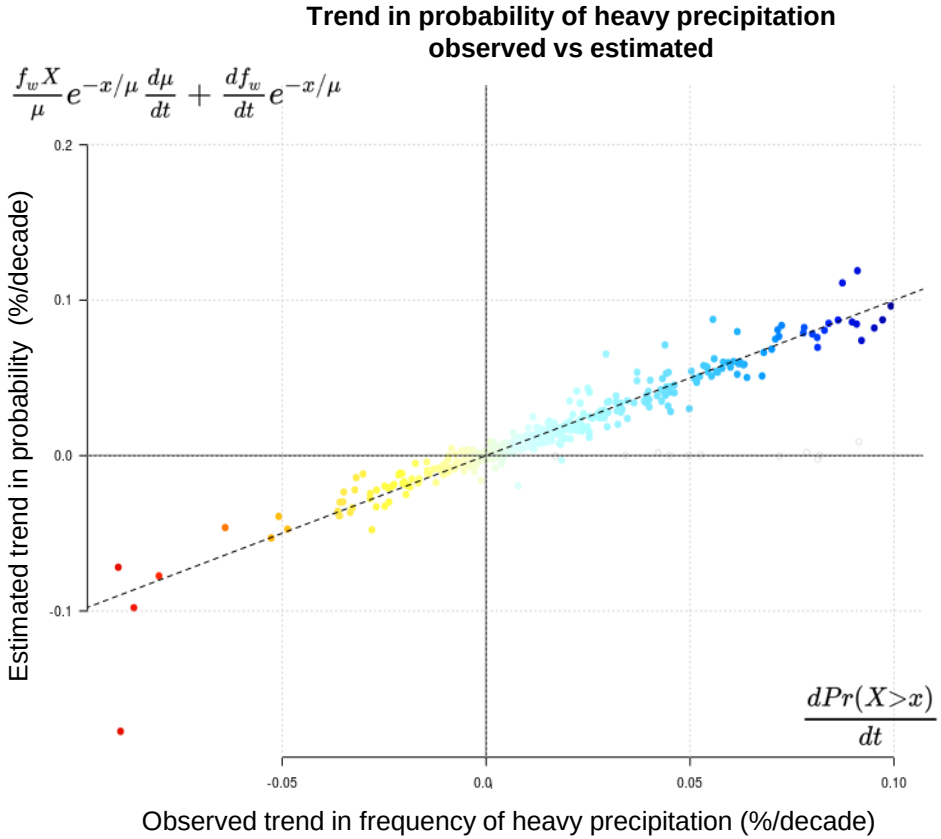


The probability for heavy rainfall:

$$Pr(X > x) = f_w e^{-x/\mu}$$

$$\frac{dPr(X>x)}{dt} = \frac{df_w}{dt} e^{-x/\mu} + \frac{f_w x}{\mu} e^{-x/\mu} \frac{d\mu}{dt}$$

Trend in probability Pr(X>50mm/døgn)



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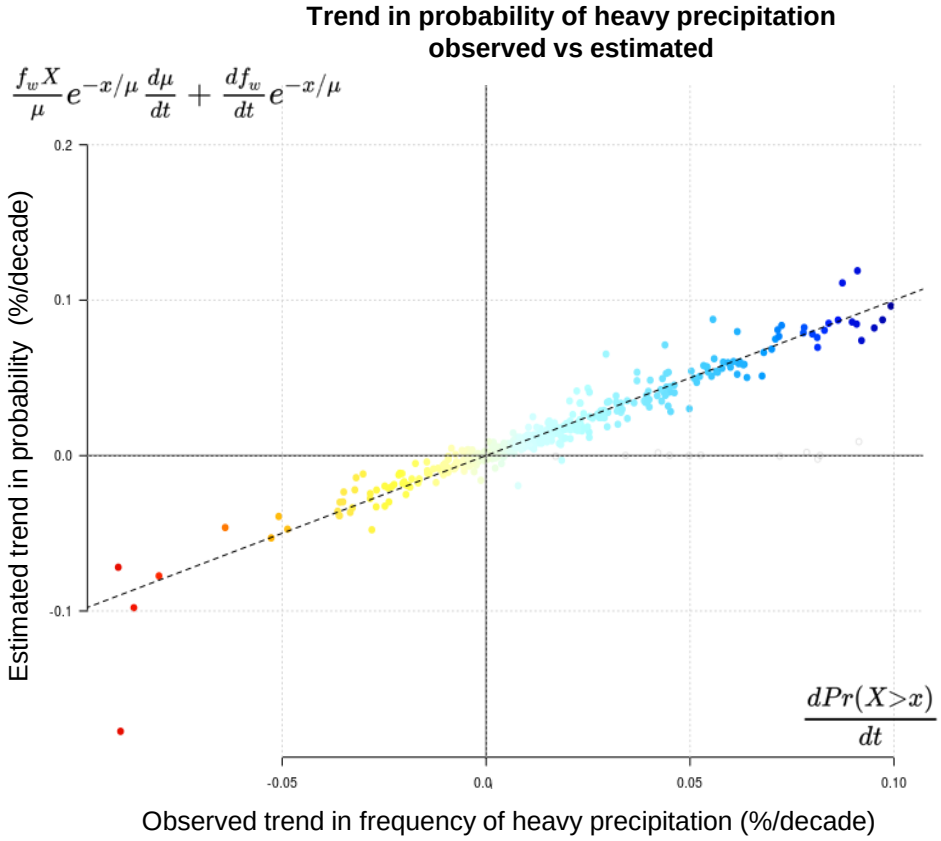
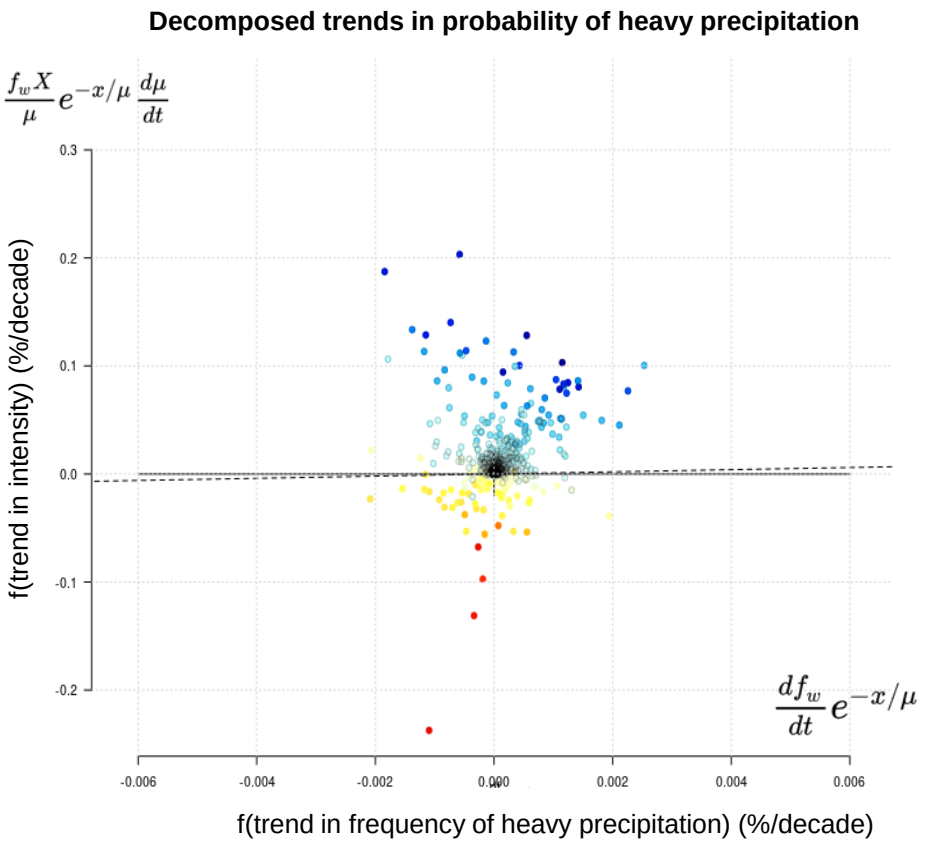
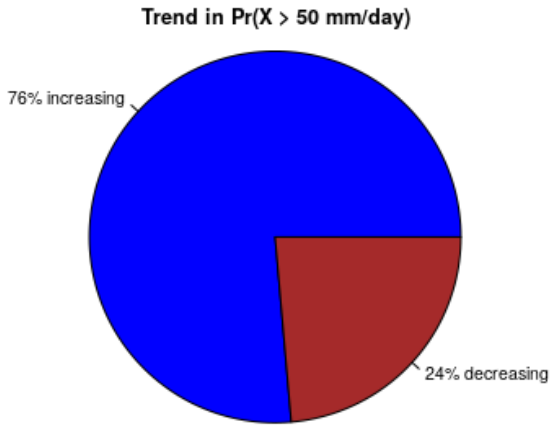
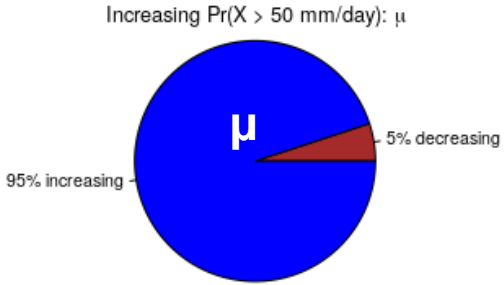


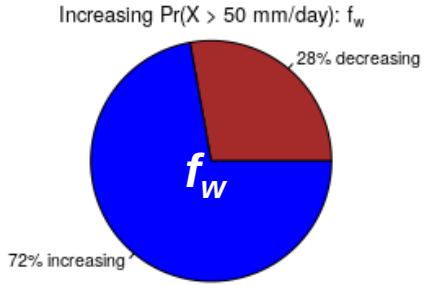


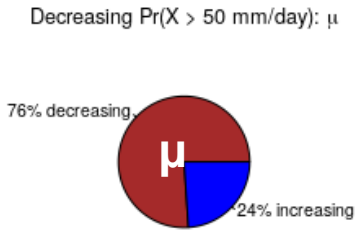
The cause of increased probability of heavy rainfall?

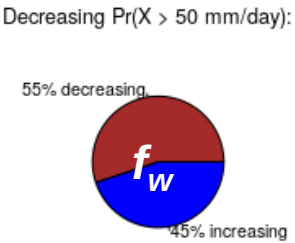
Primary increasing amounts falling on rainy days on average but also more days with rain.











$$Pr(X > x) = f_w e^{-x/\mu}$$

The cause of increased probability of heavy rainfall?

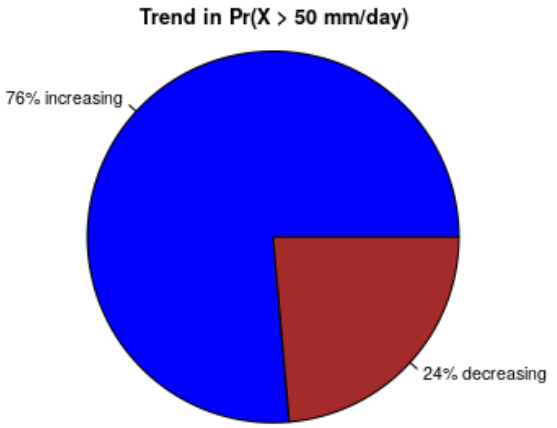
Primary increasing amounts falling on rainy days on average but also more days with rain.

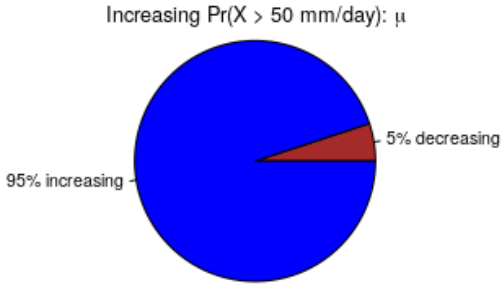
Increased probability: 76%

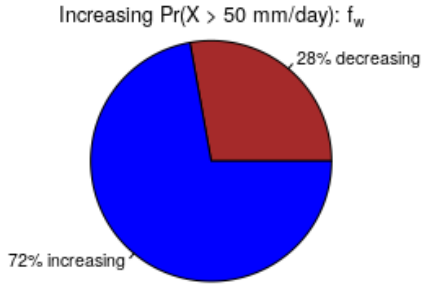
increased intensity: 95%
decreased intensity: 5%

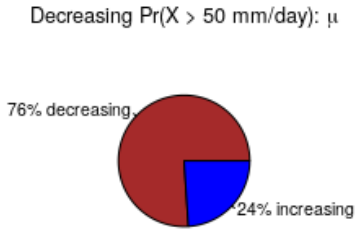
higher frequency: 72%
lower frequency: 28%

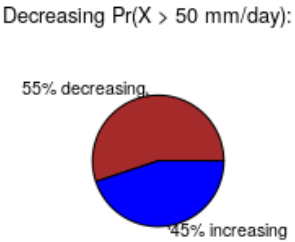
$$Pr(X > x) = f_w e^{-x/\mu}$$





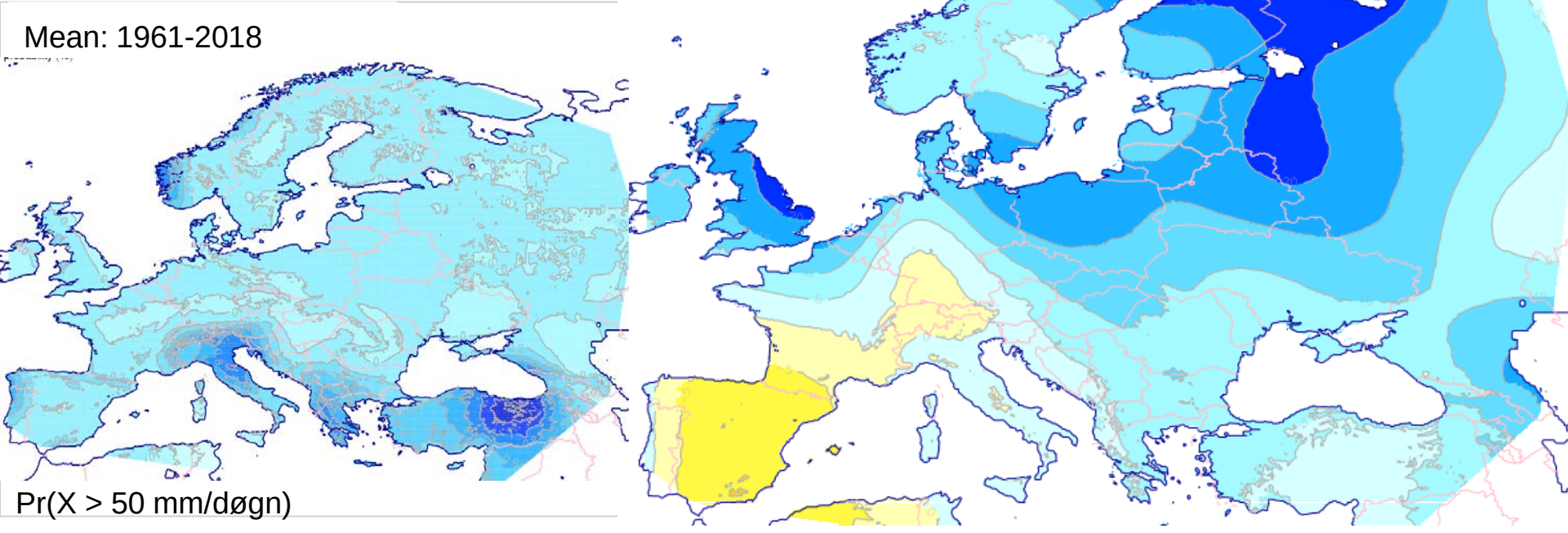






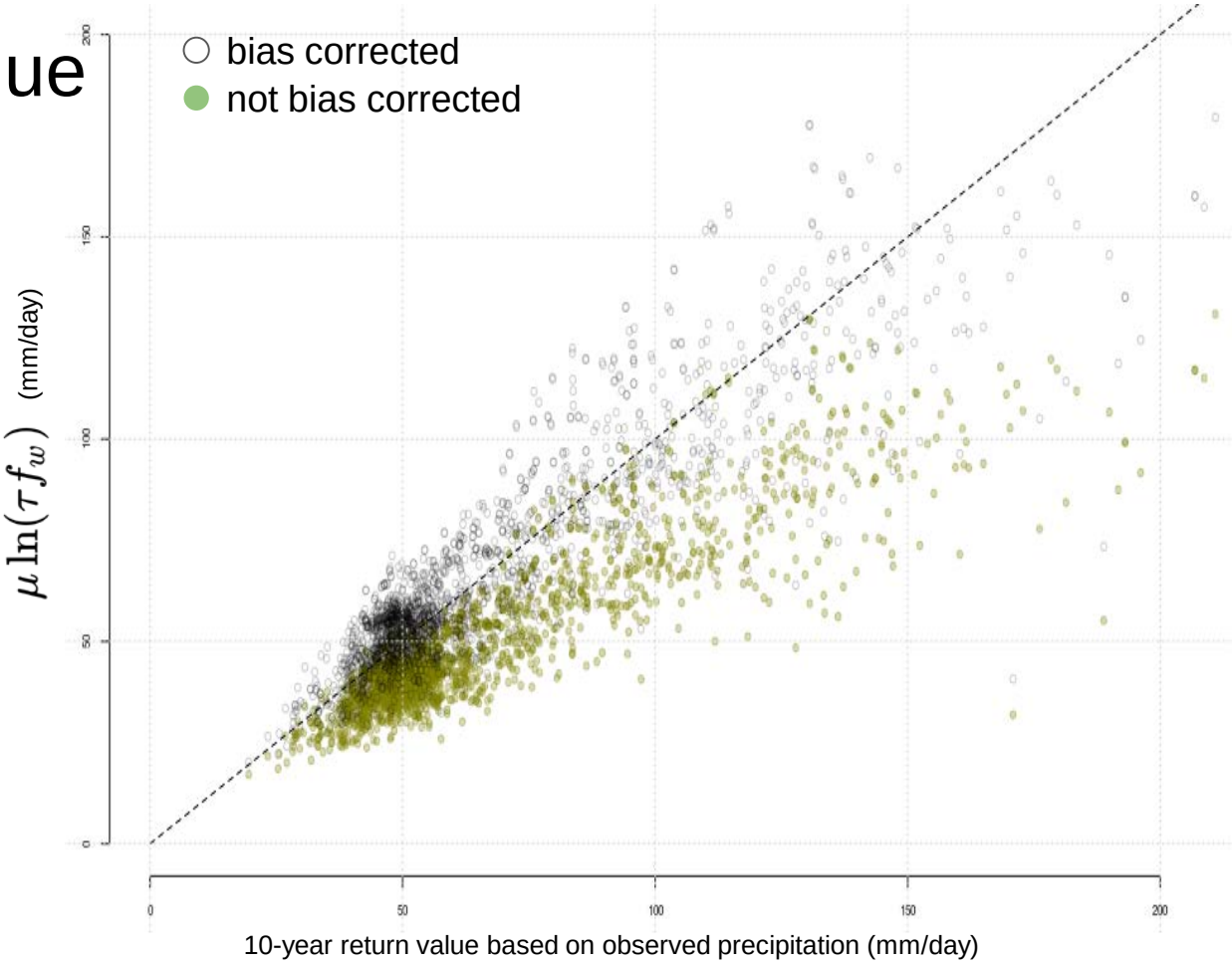
Trend in probability for more than 50 mm/day

% relative change: 1961-2018



10-year return value

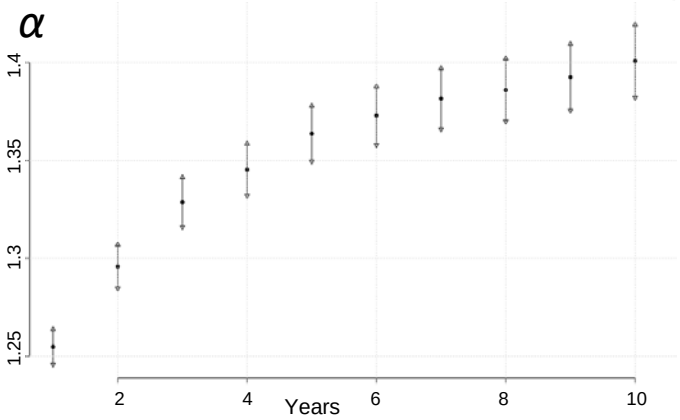
$$x_\tau = \mu \ln(\tau f_w)$$

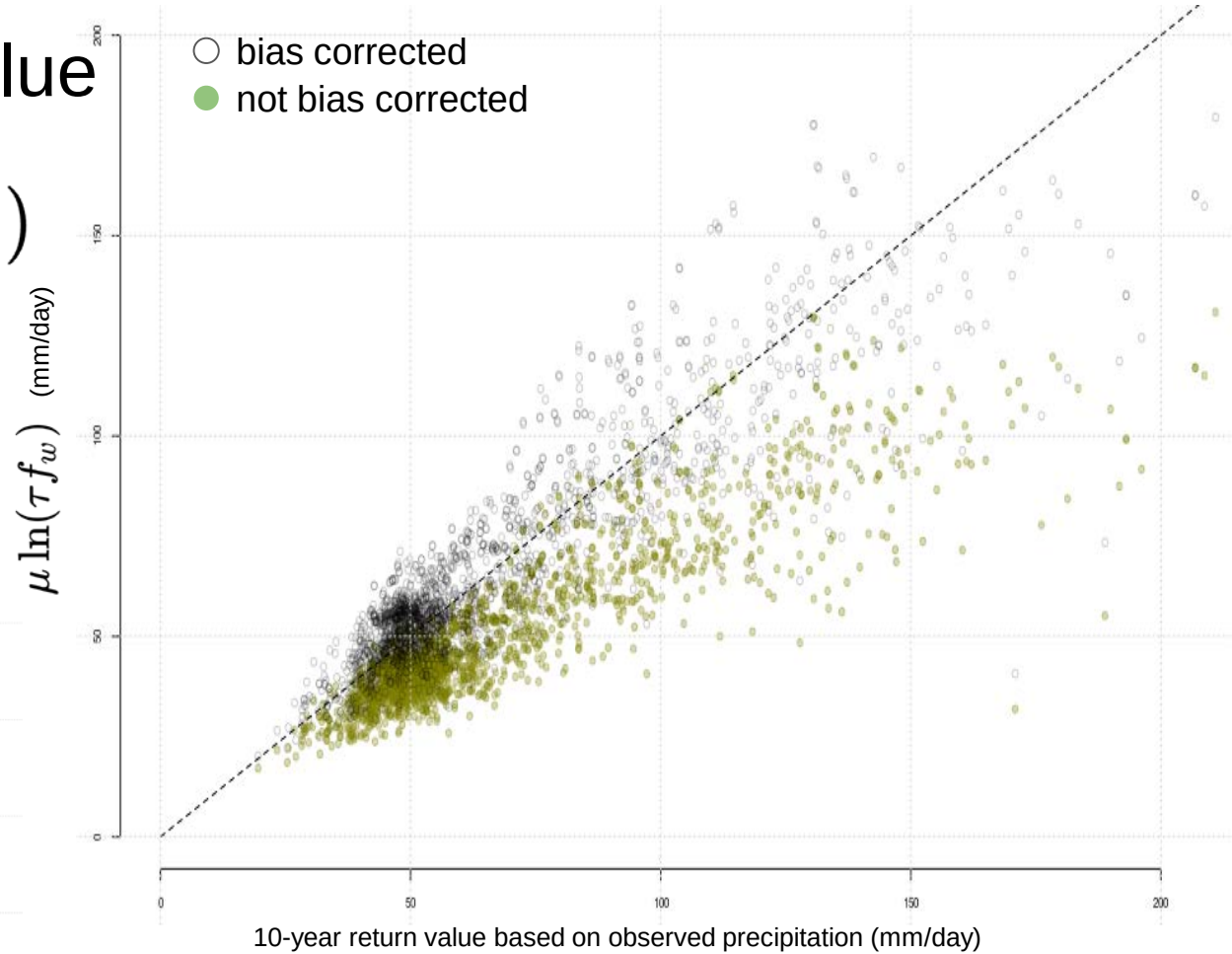


10-year return value

$$x_T = \alpha\, \mu\, \ln(\tau f_w)$$

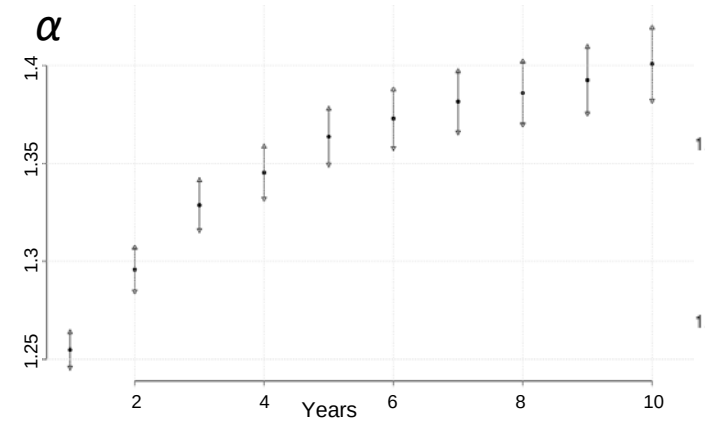
Scale factor for bias correction

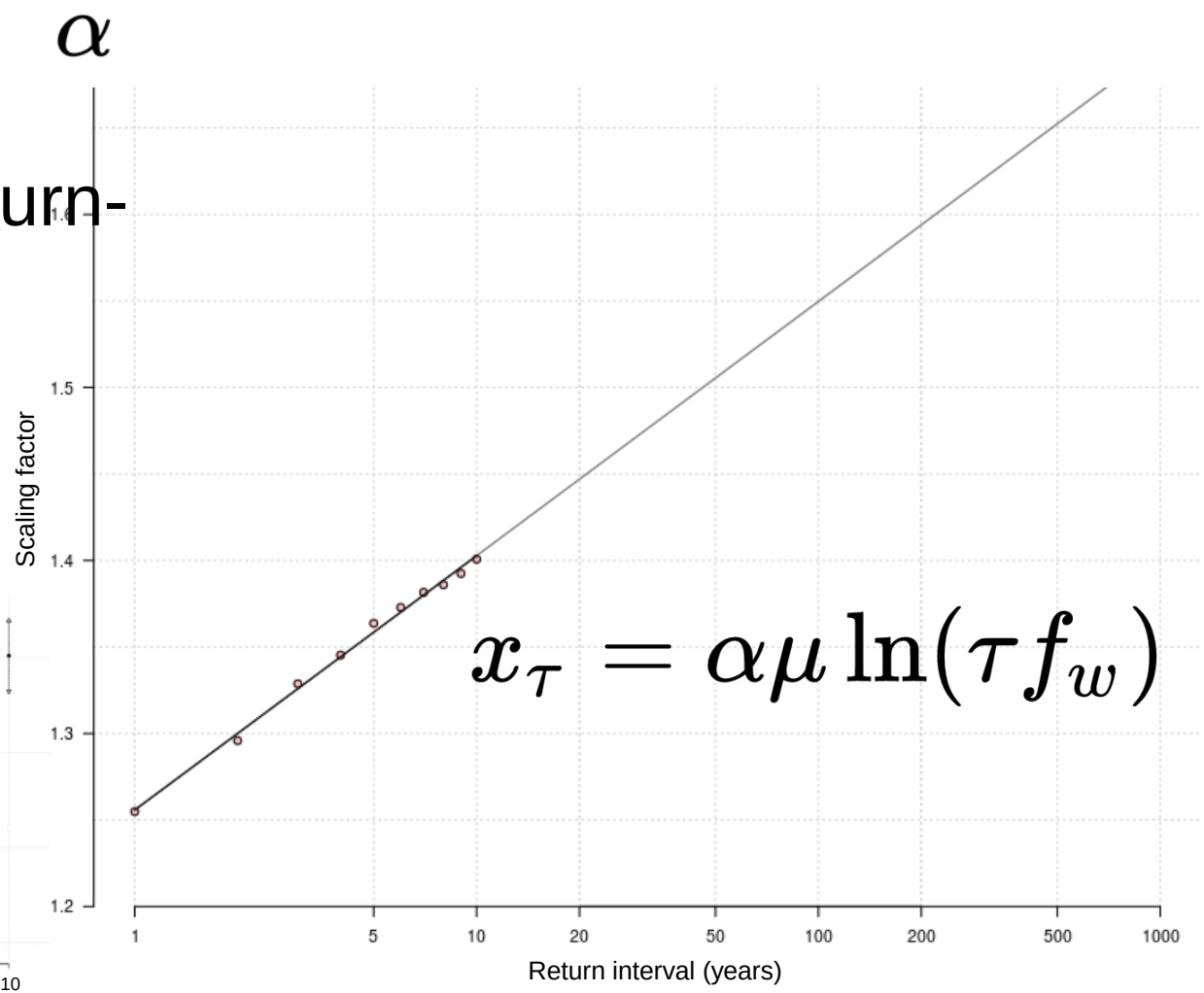




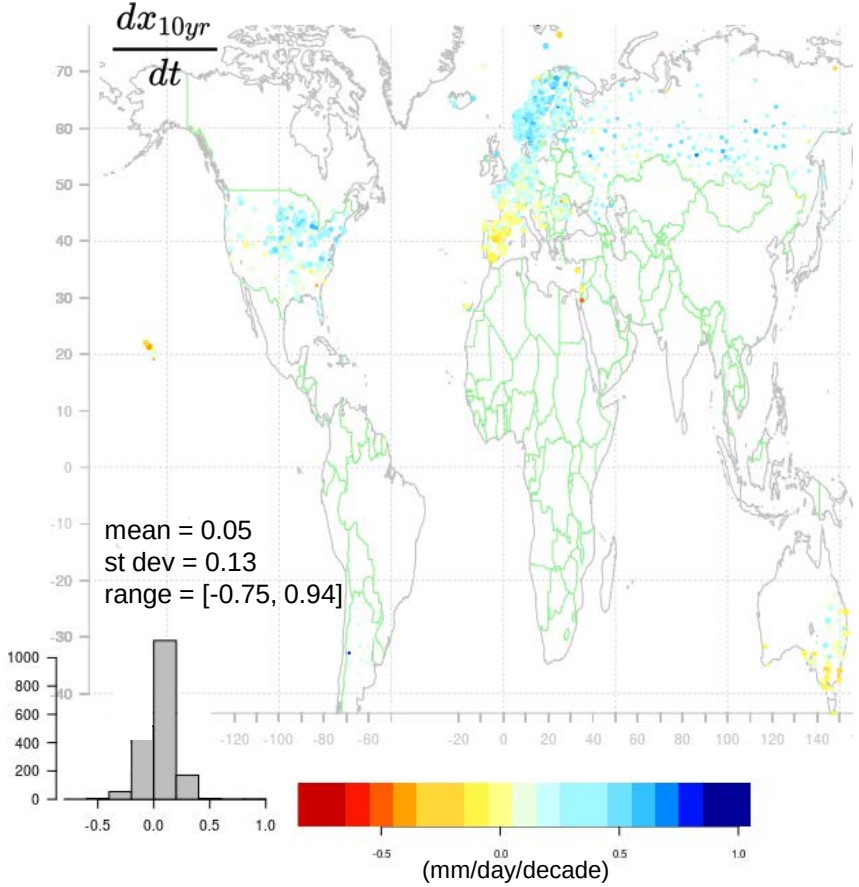
Extrapolate adjustment of return-values?

Almost linear with log of year.

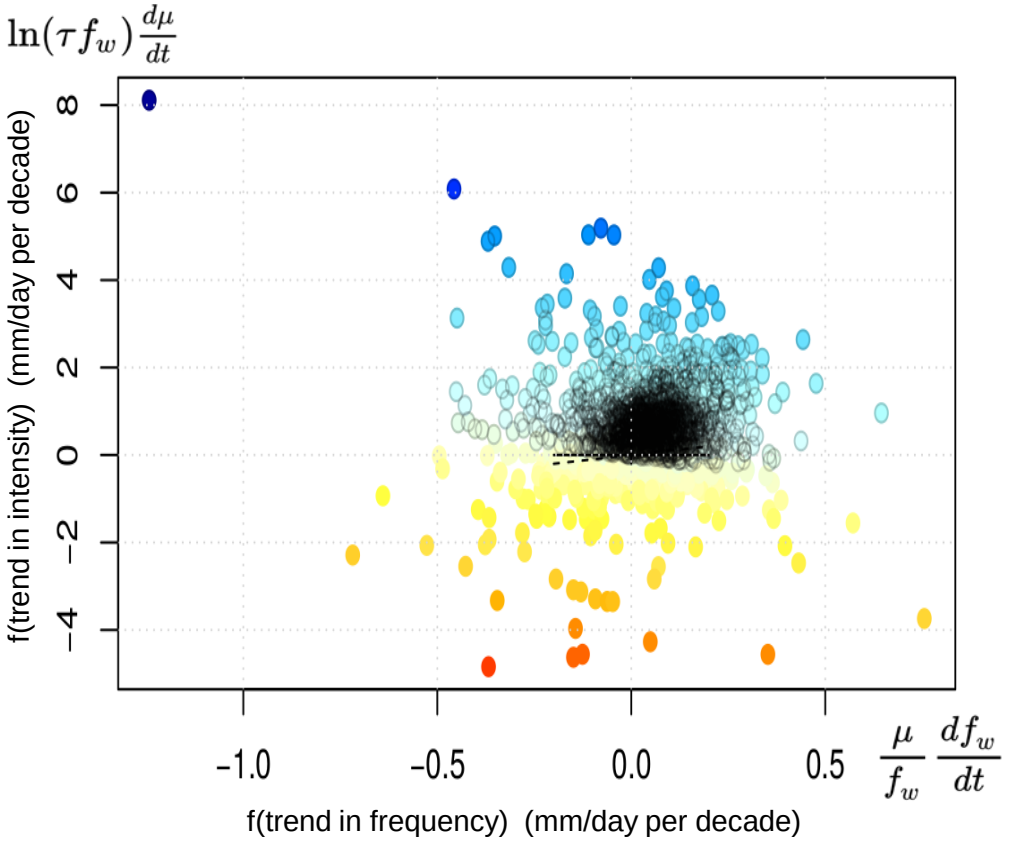




Trend in 10-year-return-value

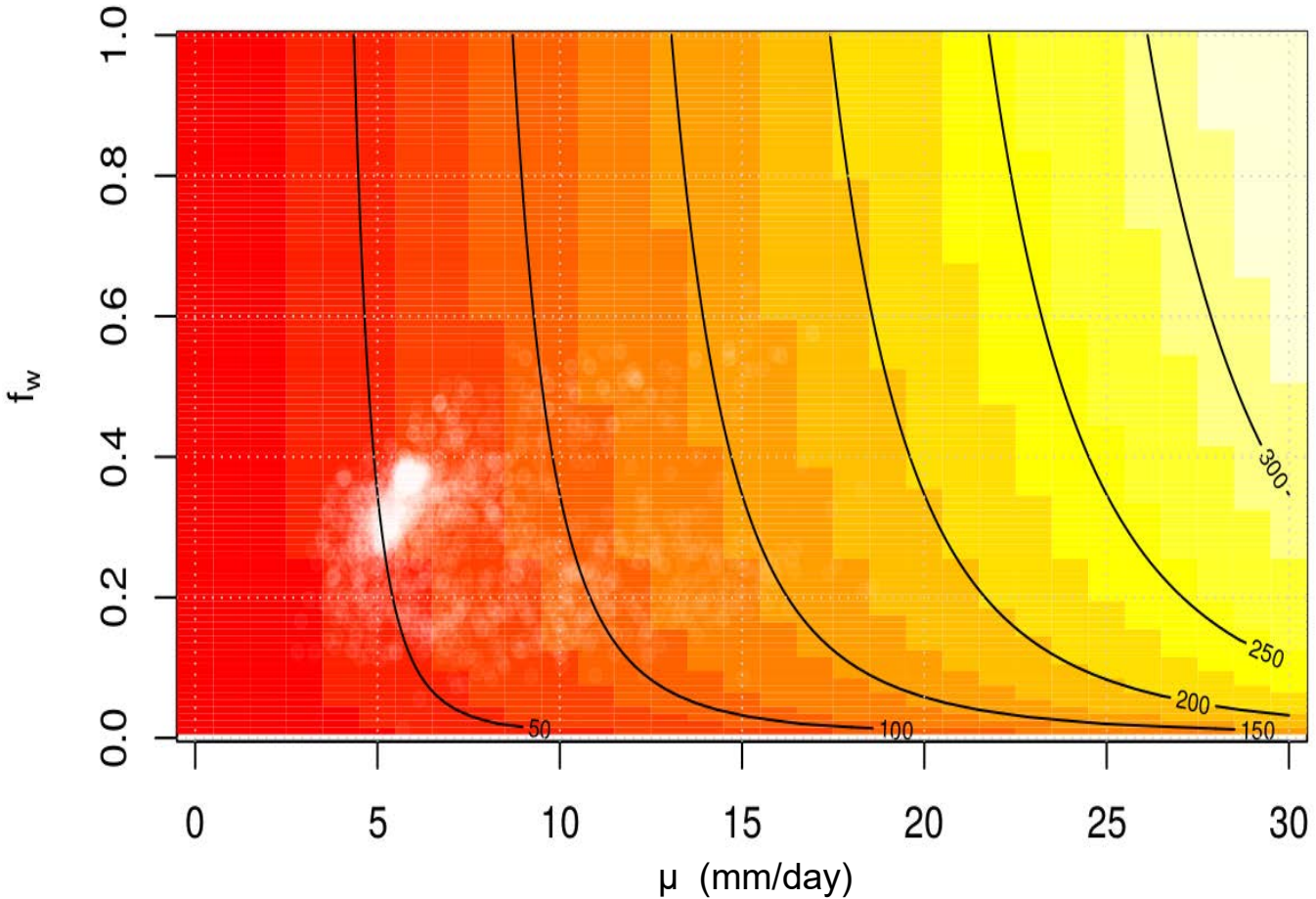


Decomposed trends in return-value x_T



Mapping of 10-year-return-value

Most locations have ~50 mm/day based on the wet-day mean precipitation and frequency (white smudges).



The variance is more complicated...

Because the PDF is discontinuous.

$$\sigma^2 = f_w \left[\mu^2 + \left(x_0^2 + 2\mu x_0 + 2\mu^2\right) e^{-x_0/\mu}\right]$$

$$d\frac{\sigma^2}{dt} = \left[\mu^2 + \left(x_0^2 + 2\mu x_0 + 2\mu^2\right) e^{-x_0/\mu}\right] \frac{df_w}{dt} +$$

$$f_w \left[2\mu + \left(4x_0 + 4\mu + x_0^3/\mu^2 + 2x_0^2/\mu\right) e^{-x_0/\mu}\right] \frac{d\mu}{dt}$$

Merits - low hanging fruits

- Simple mathematical expressions - unlocking a spectre of information.
- **KlimaDigital**-prosject for mapping risk of landslide in near Trondheim.
- **H2020**?
- Useful for foreign aid projects where data is limited.
  - Mozambique
  - Bangladesh?

`github.com/metno/esd`
`https:ocdp.met.no`

Benestad et al. (2019), “A simple equation to study changes in rainfall statistics", Environ. Res. Lett. https://doi.org/10.1088/1748-9326/ab2bb2