A formula for downscaling extreme sub-daily rainfall intensities

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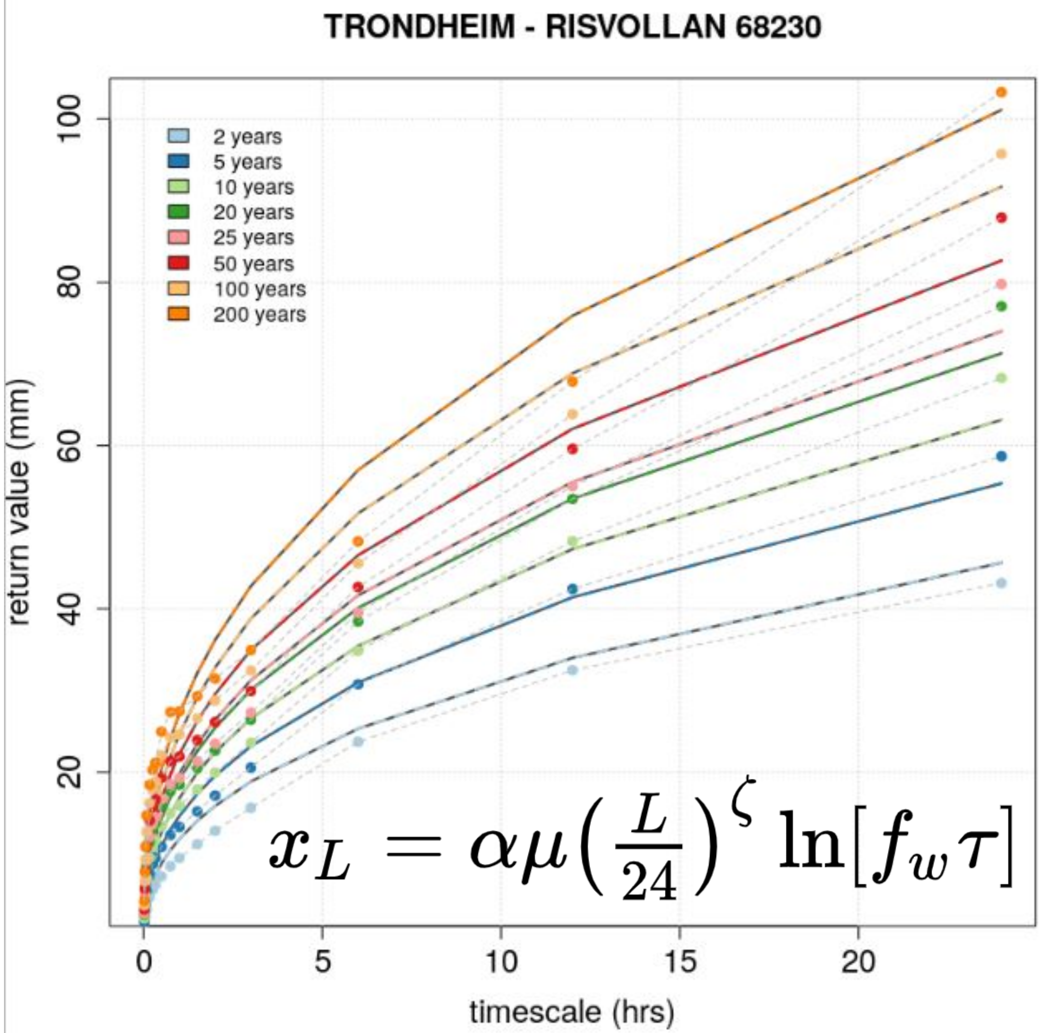
Sub-daily rainfall

Approximate formula for intensity-duration-frequency (IDF).

IDF for sites with daily rain gauge data but not hourly?

Perhaps very useful...



$$x_L = \alpha\mu\left(\frac{L}{24}\right)^{\zeta} \ln[f_w \tau]$$

Simple formula for sub-daily rainfall intensity

$$x_L = \alpha\mu\left(\frac{L}{24}\right)^{\zeta}\ln[f_w\tau]$$

α= *correction factor* - divergence from exponential distribution (~universal; ~ 1.2);

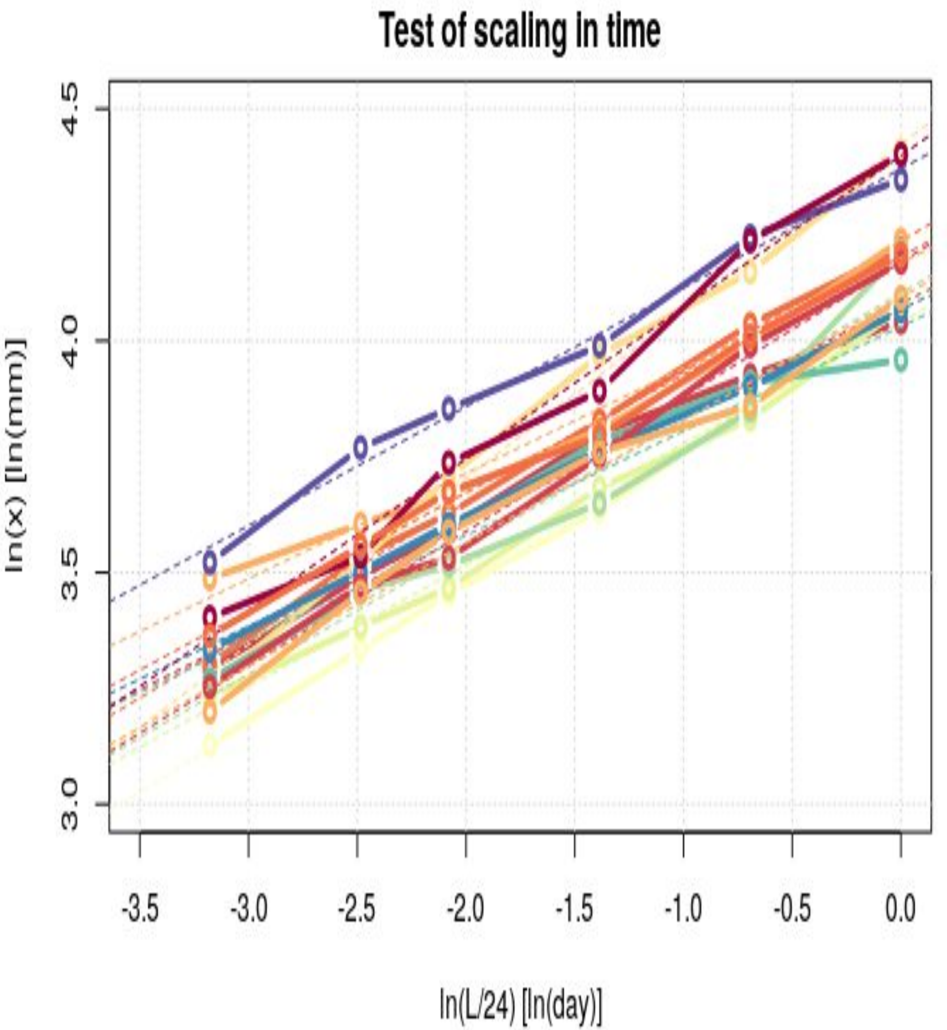
μ = *wet-day mean precipitation*; f_w = *wet-day frequency* (site-specific parameters);

ζ = *scaling dependency* (~0.4; **~universal? Fractal dimension**).

Benestad, R; Lutz, J; Dyrrdal, A; Haugen, JE; Parding, K; Dobler, A; "Testing a simple formula for calculating approximate intensity-duration-frequency curves", accepted, ERL, DOI: 10.1088/1748-9326/abd4ab

Calibrating the formula: Dependency factor ζ from the slopes of the curves

IDF-curves exhibit an almost linear log-log relationships. Approximation

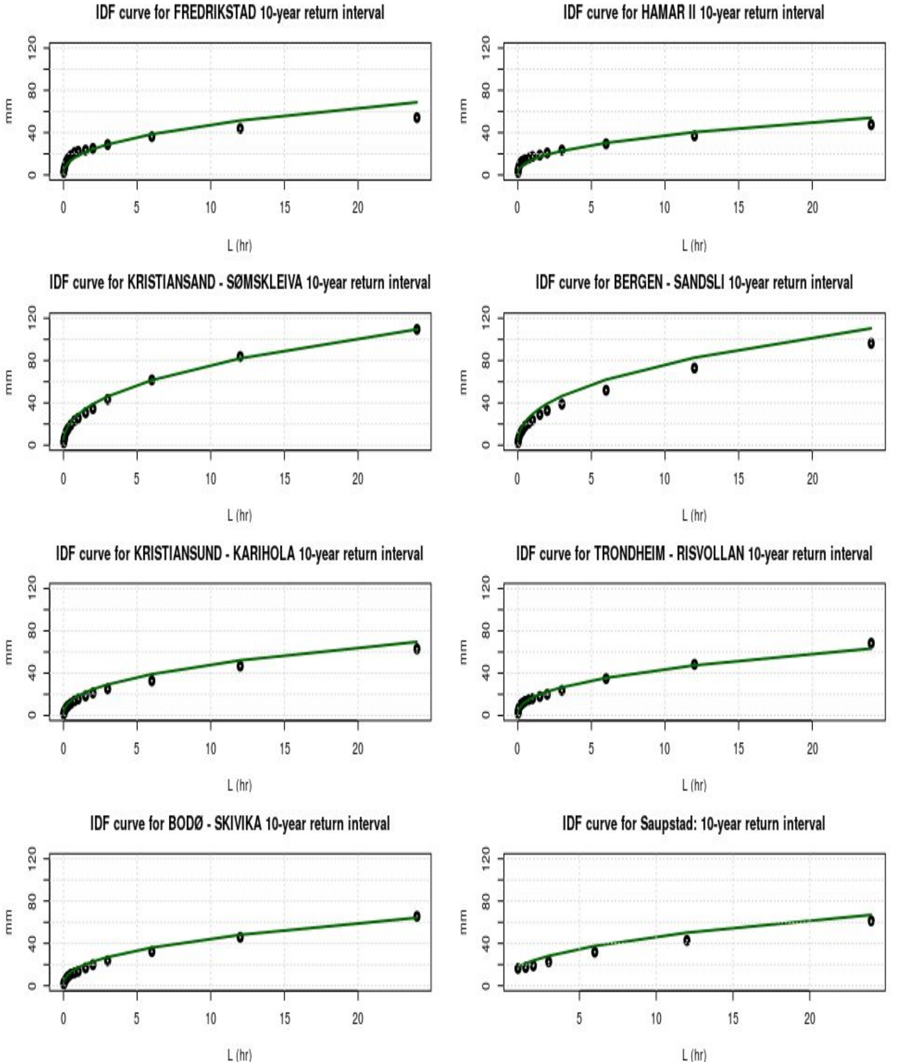


Rainfall: 10-yr return levels

Evaluation of the formula against independent data.

Is it a universally valid formula?

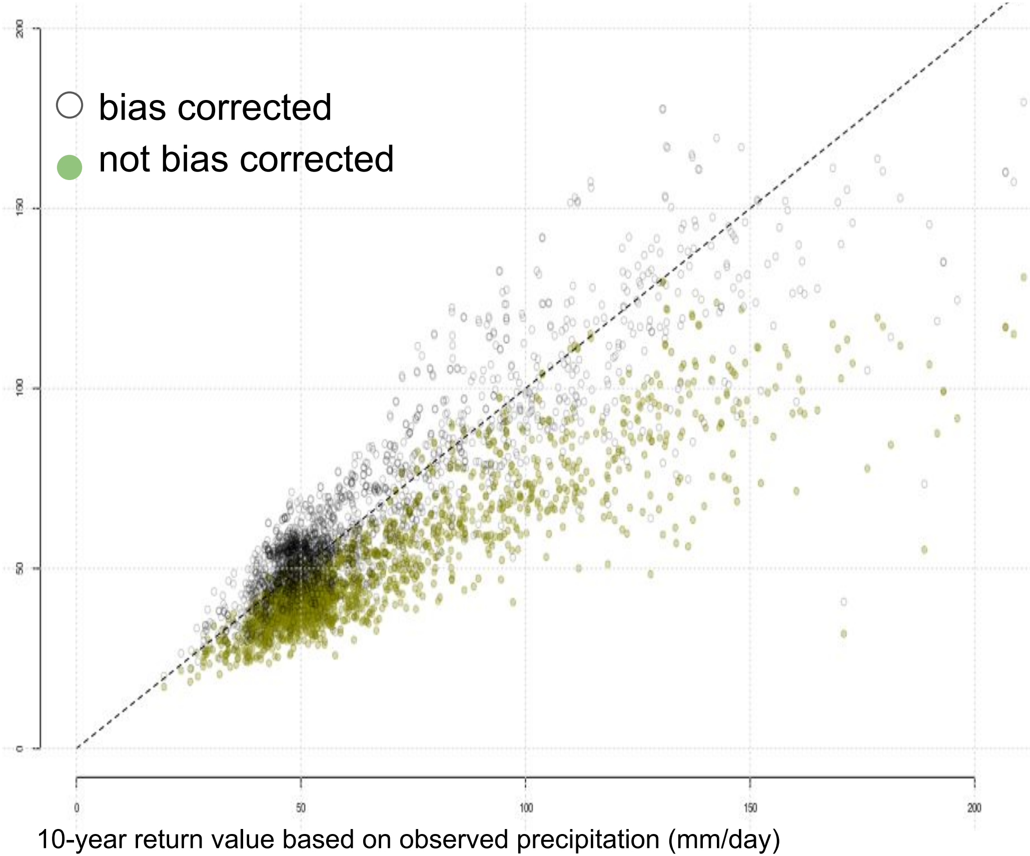
Is the scaling factor ζ (~0.4) universal or systematically affected by geographical factors in a predictable way?



Many sites: 24-hr rainfall

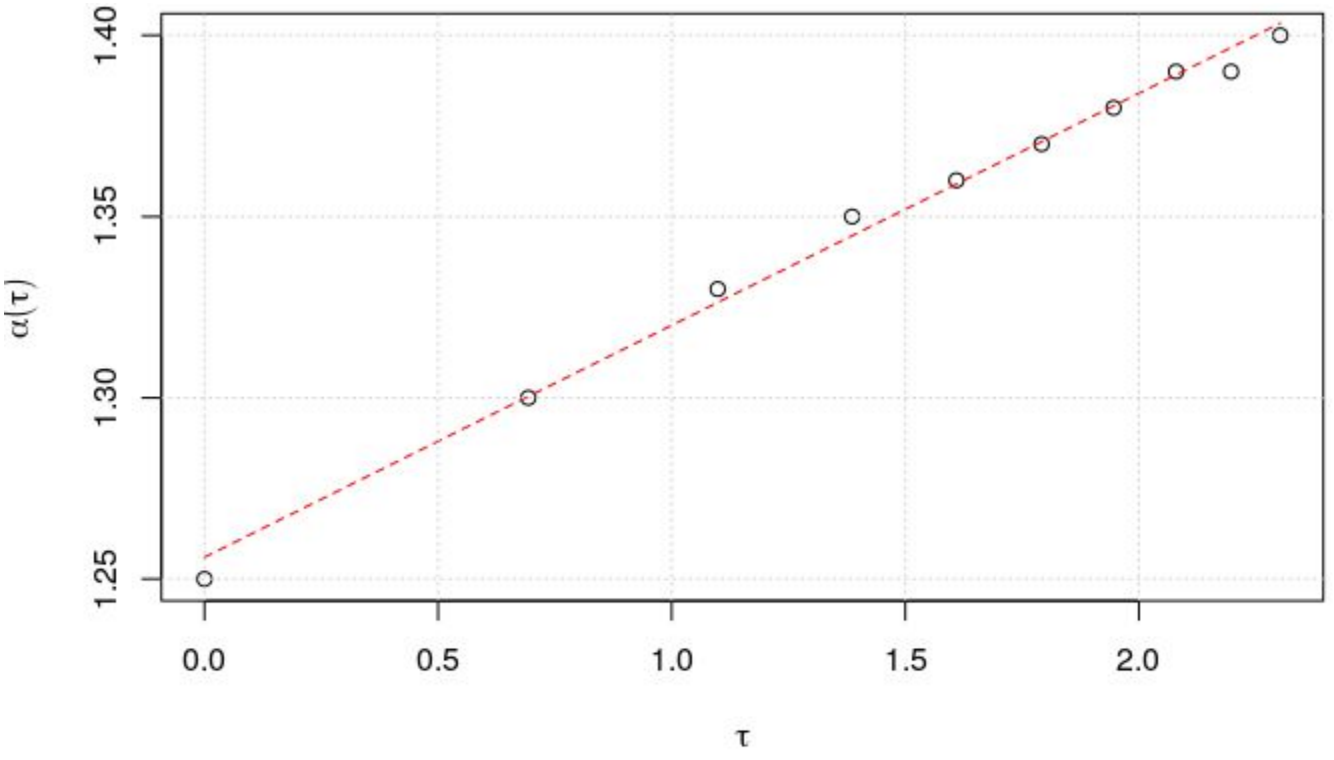
$$x_T = \alpha\ \mu\ \ln(\tau f_w)$$

Correction factor



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

The correction factor vs log(return period)

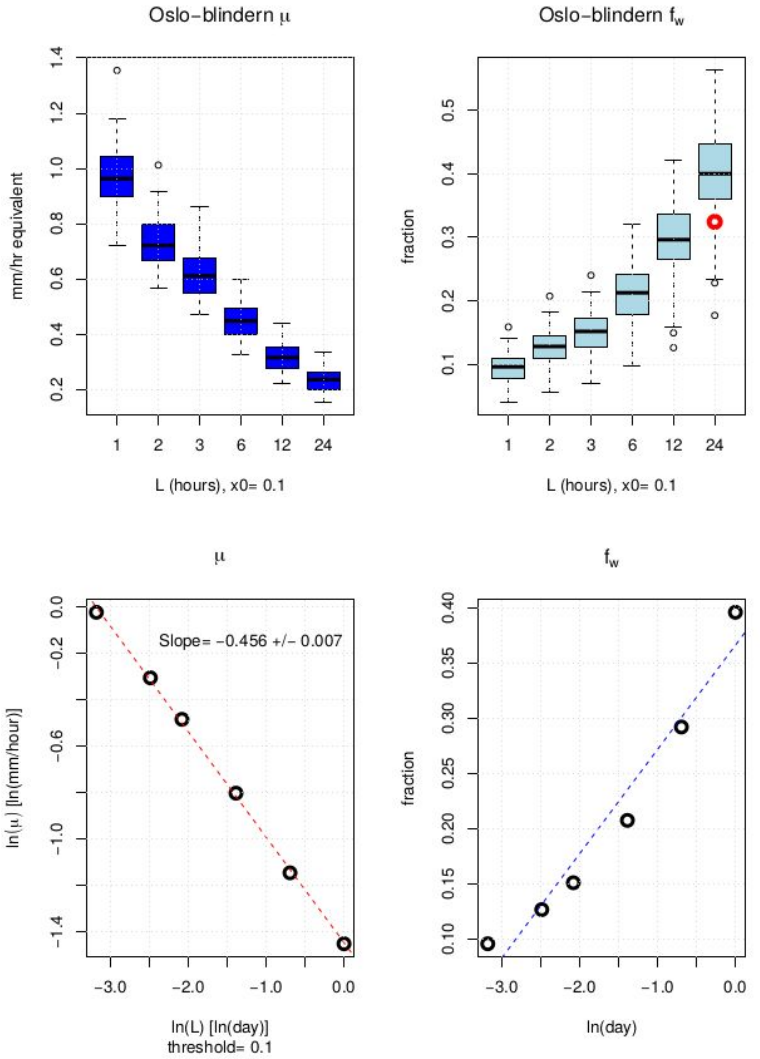


Examine scaling in μ and f_w.

Almost linear log-log relationship between μ and timescale L. Slope = β.

Almost linear log relationship between f_w and timescale L.

Both μ and f_w scaling dependencies are expected to influence the scaling dependency in x_L.



The inspiration behind the formula

$$x_L = \alpha\mu(L/24)^{\zeta} \ln[(f_w + \gamma \ln[L/24])\tau]$$

The scaling factor is a sum of scaling dependencies in μ and α: $\zeta = \beta + 1 + a_0$.

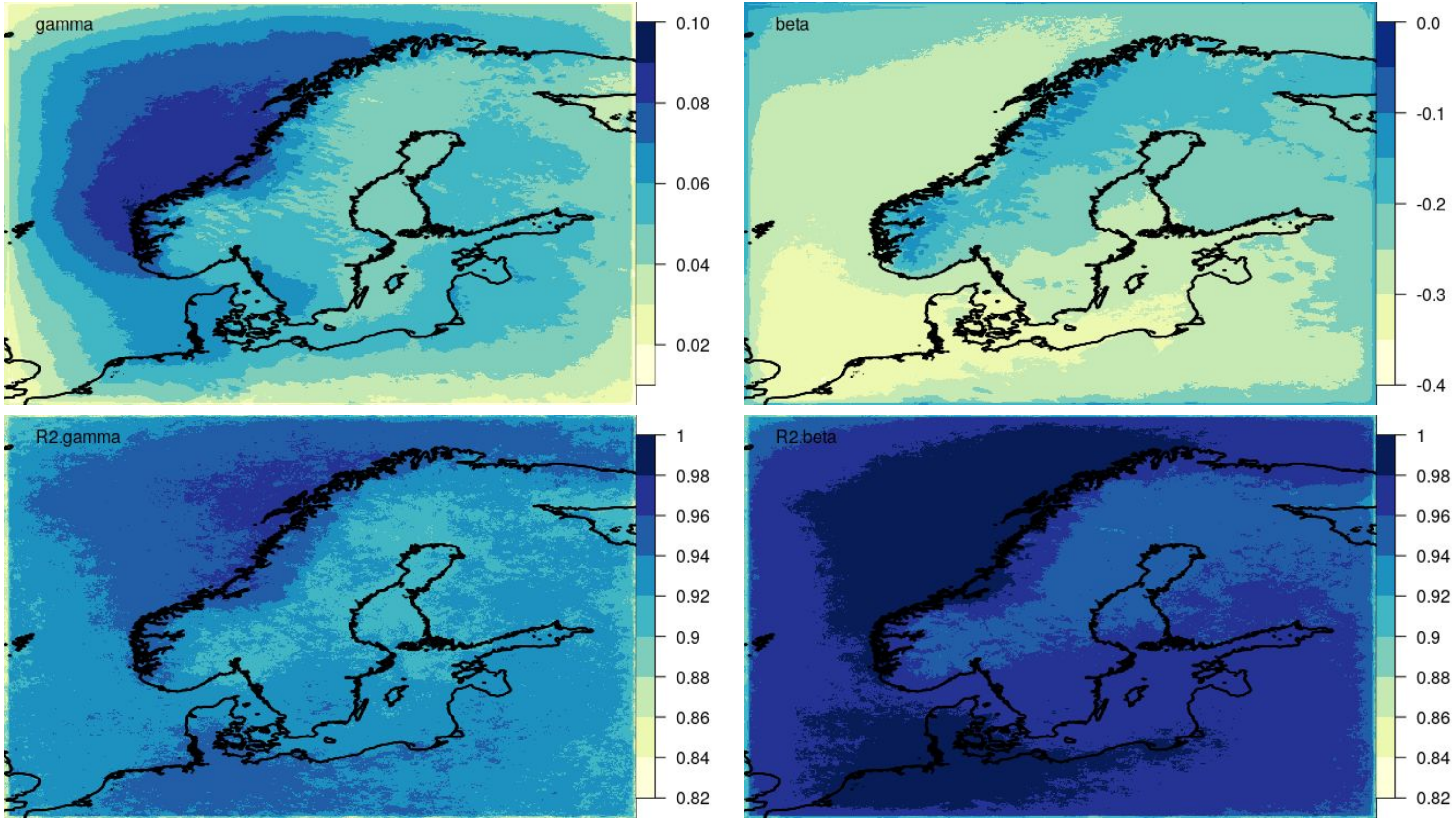
Empirical relationships:

$$\ln(\mu/L) = \beta \ln(L/24) + \mu_0$$

$$\ln(\alpha) = a_0 \ln(L/24) + \alpha_0$$

$$f_w = \gamma \ln(L/24) + f_0$$

Some results from Andreas Dobler (NorCP)



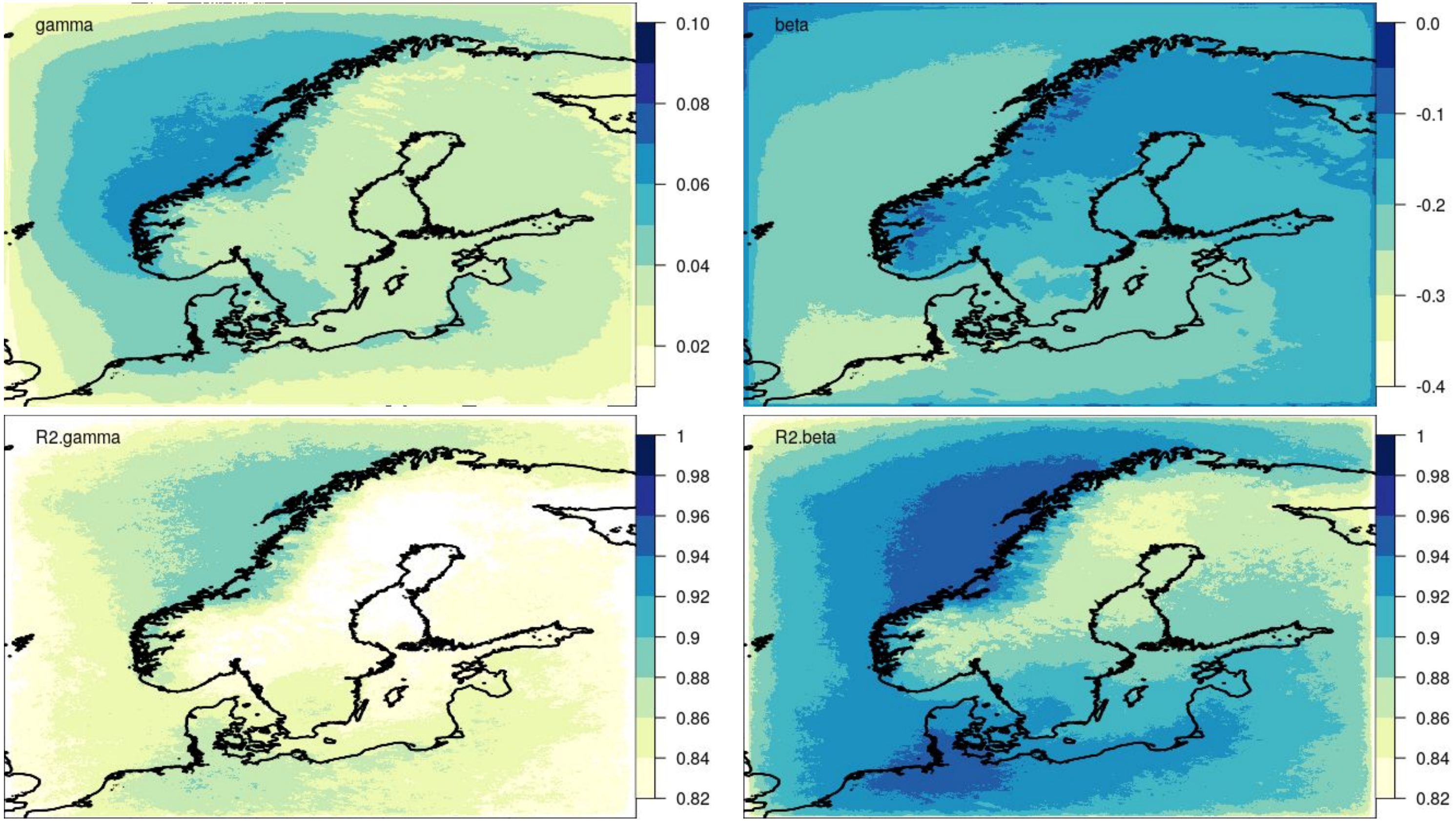
Timesteps [h]
1, 2, 3, 6, 12 & 24

1998 – 2018 (21 yr)

3km

Oslo - observed:
β ~ -0.12
γ ~ +0.6
(Benestad, et al, 2020, su to ERL)

Some results from Andreas Dobler (NorCP)



Timesteps [h]
¼, ½,
1, 2, 3, 6, 12 & 24

1998 – 2018 (21 yr)

3km

A change in return level can be expressed in terms of changes in μ and f_w:

$$\delta x_L = \alpha\left(\frac{L}{24}\right)^{\zeta} \ln(f_w \tau)\delta\mu + \alpha\mu\left(\frac{L}{24}\right)^{\zeta} \frac{\delta f_w}{f_w}$$

The first term dominates over the latter according to:

$$\ln(f_w \tau)\delta\mu > \mu \, \frac{\delta f_w}{f_w} \qquad \ln(f_w \tau)\frac{\delta\mu}{\mu} > \frac{\delta f_w}{f_w}$$

where

$$f_w \times \tau = (n_w/n) \times (n\tau_{yrs}) = n_w \tau_{yrs}$$

Typically, n_w ~ 100 for a year, and the return interval in years is τ_{yrs} ~1-200.