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Using empirical-statistical downscaling to quantify climate change impacts

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MISTRALS, Climate change impacts in the Mediterranean region

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Main message

Empirical-statistical downscaling (**ESD**) can be used to estimate change in *any* variable that is affected by large-scale conditions.

For climate change projections, downscale “climate” rather than “weather”.

ESD is suitable for probabilistic information and large multi-model ensembles.

What is “downscaling”?

Utilise inter-scale dependency to predict local outcomes.

Scales

Scales ≠ sample size.

E.g. the scale for **seasonal** statistics of **hourly** rainfall is ...

Why downscaling?

Models have a minimum skillful scale.

Use predictors that are **skillfully simulated by GCMs**.

A shift in statistics is due to changed physical conditions/phenomena

Different types of downscaling

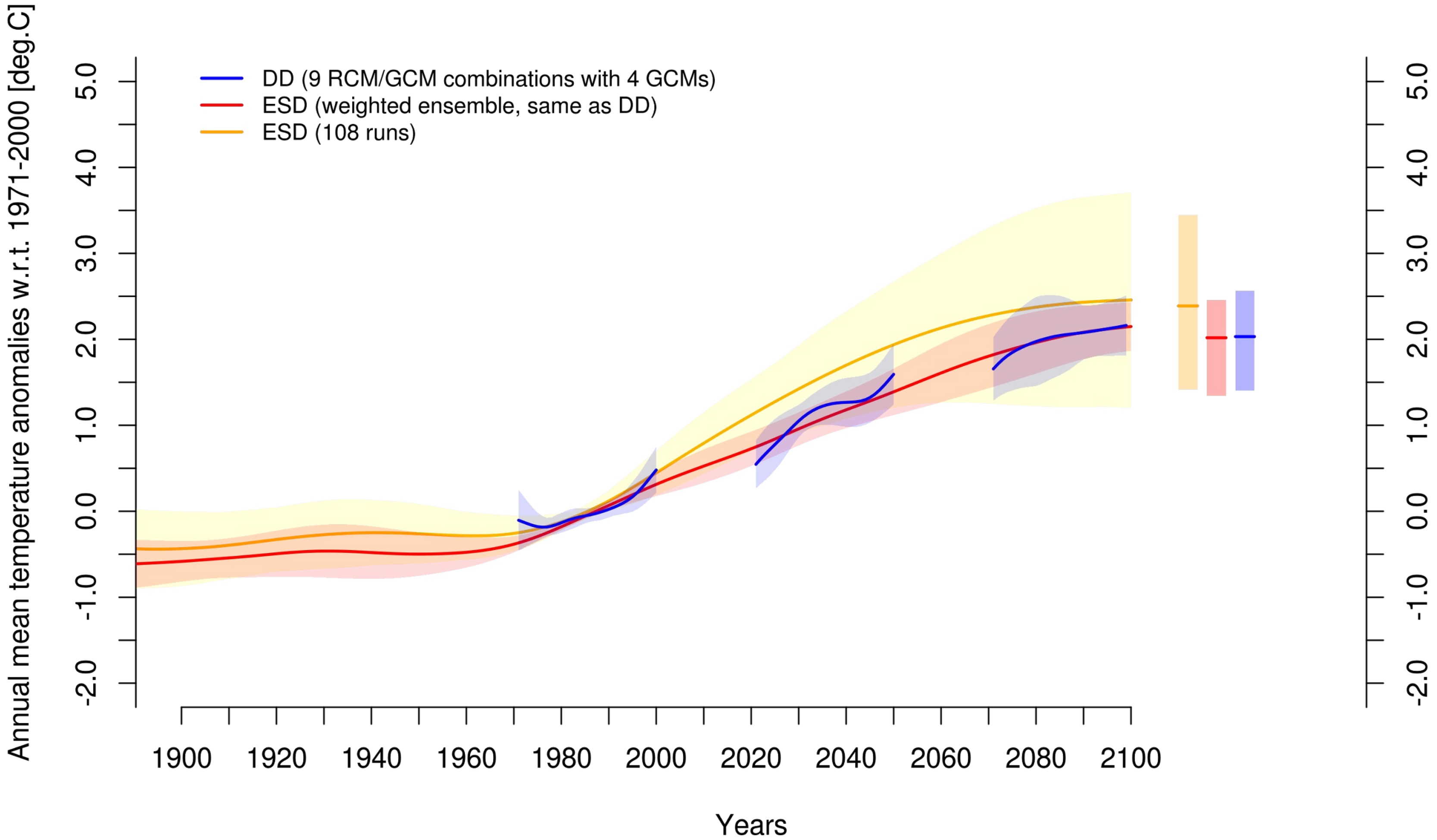
RCMs: source=primitive physical equations + parameterisation

ESD: source=empirical + statistical theory.

Robust downscaling

RCM & ESD make use of independent information

ESD can be used to downscale different information to RCMs.



Physical consistency?

Strictly **not** in either RCMs nor ESD.

RCMs: different energy and mass fluxes to GCM.

ESD: PCA-based predictands can conserve inter-variable covariance.

Statistical model in ESD

Make linear through transformations: **y = f(X)**

Multiple regression? Analog? Weather generator?

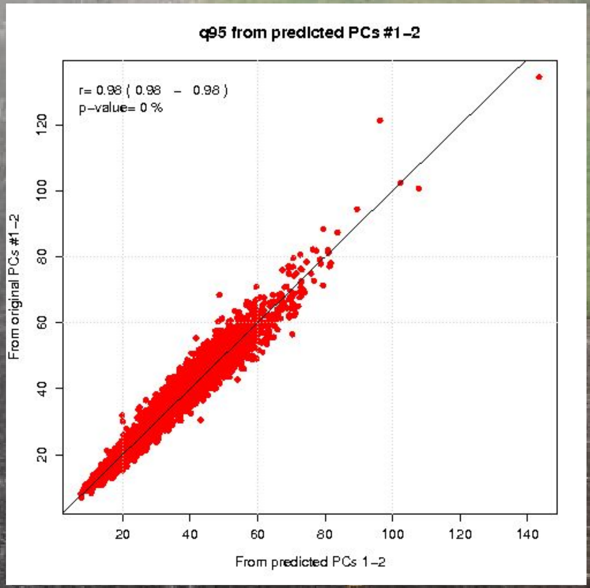
X =common EOFs (bias corrected)

Suitable for both **statistical parameters** and **LARGE ensembles**.

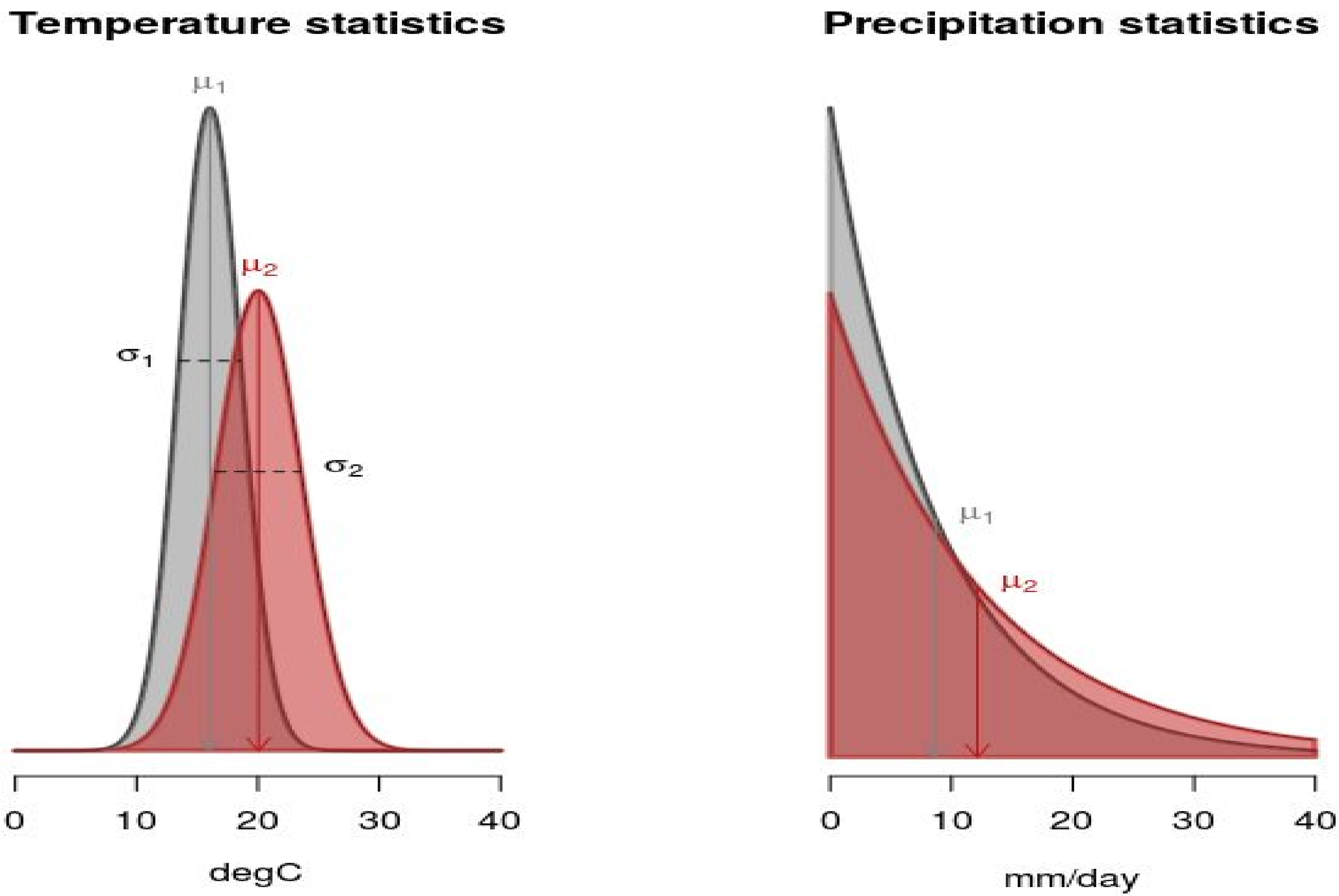
The “rain equation”

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

f_w = wet-day frequency
μ = wet-day mean

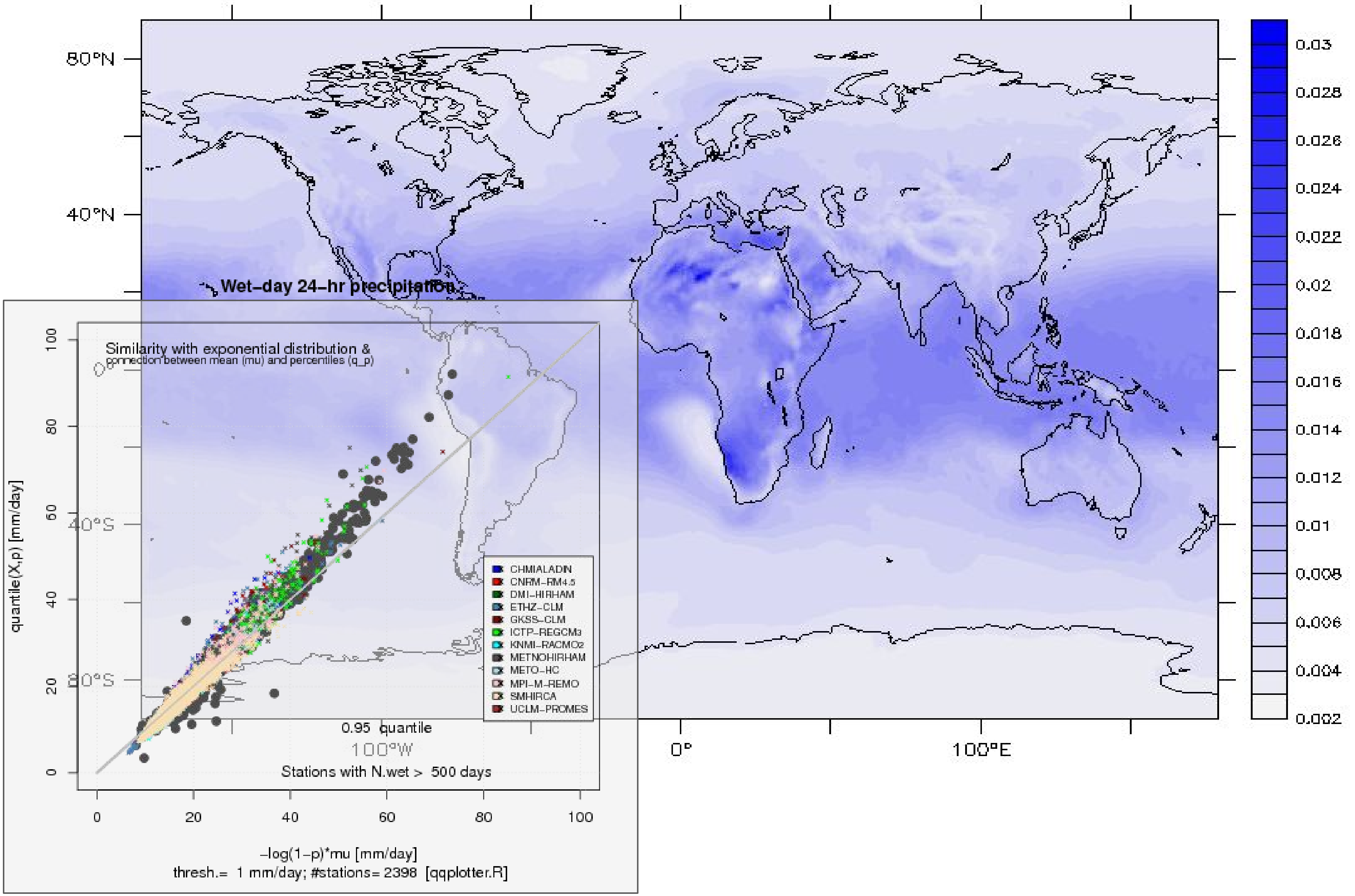


Statistics is remarkably predictable



“Climate” = weather statistics

"Climate" = "weather statistics"



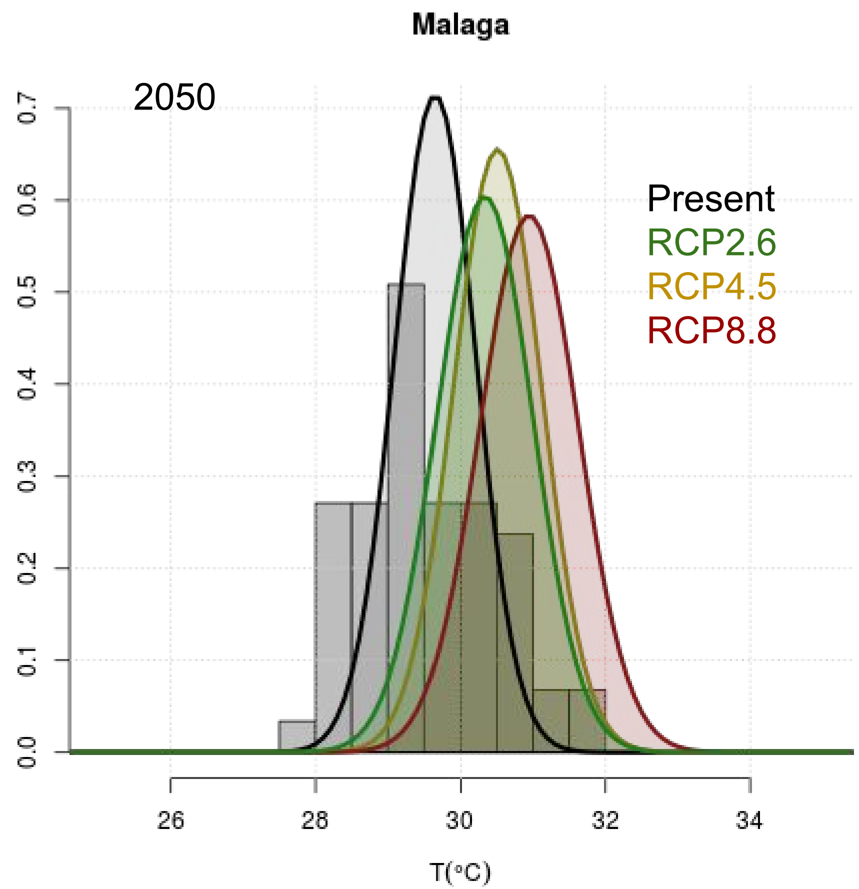
Downscaling statistical parameters

Parameters of pdf

[mean,sd, autocorrelation, …]

Influenced by physical conditions

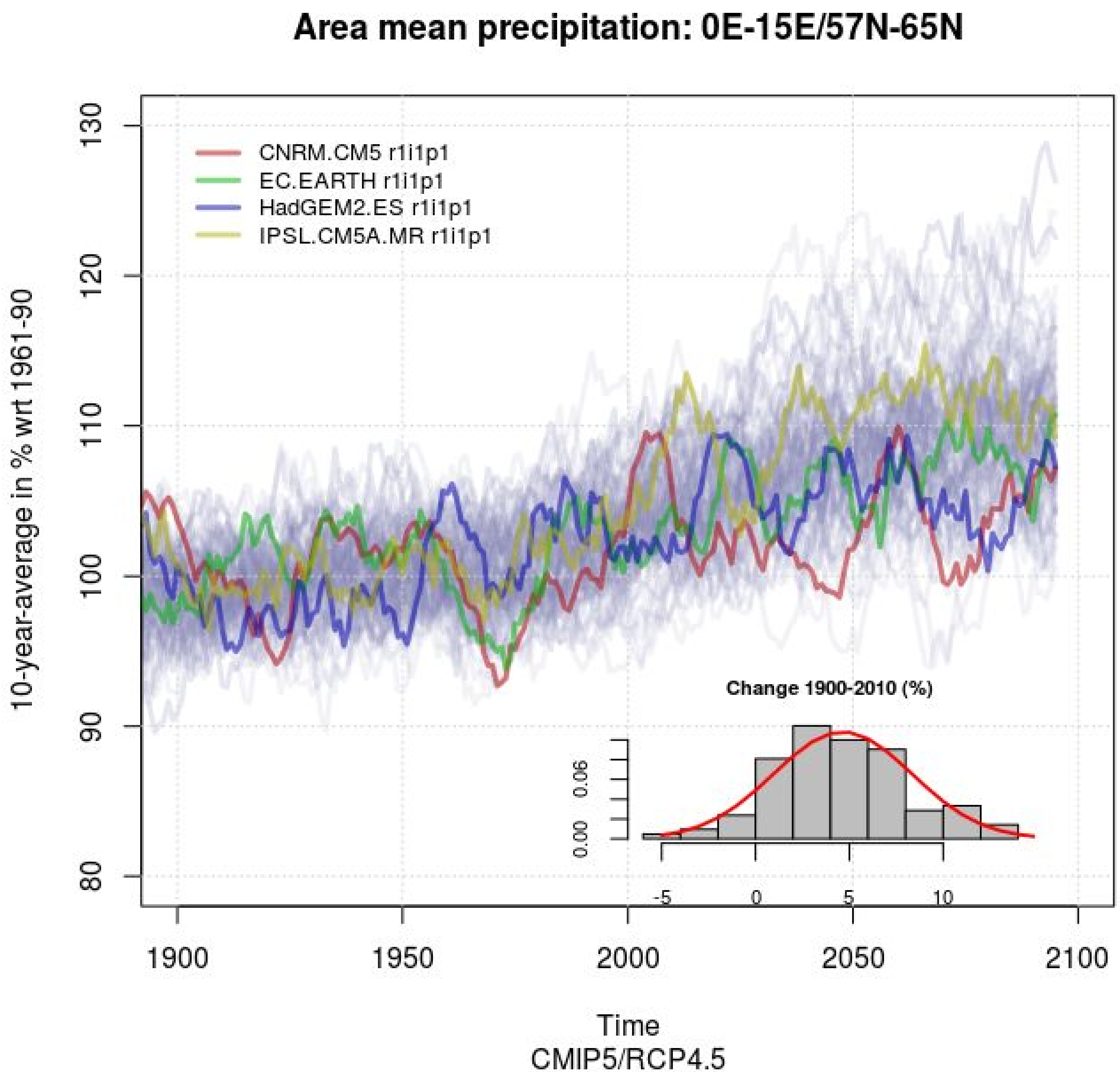
More predictable than individual outcome

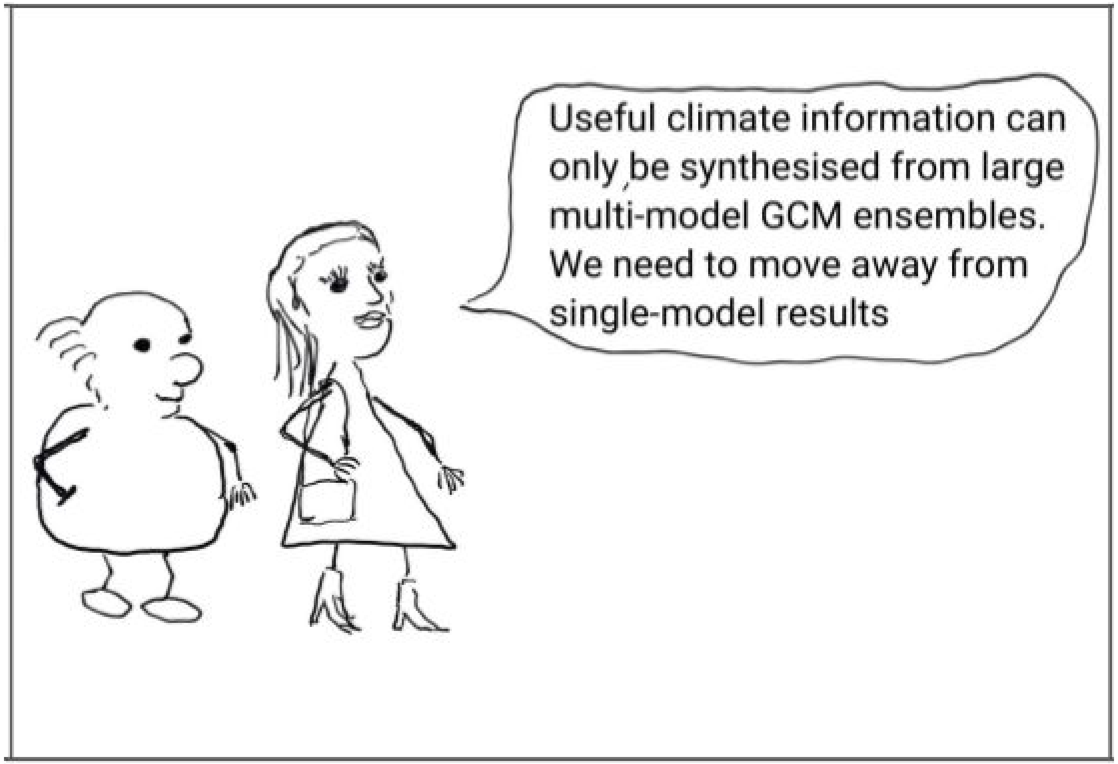


RCM ~ “weather-approach” - ESD ~ ”climate-approach”

Non-deterministic natural variations

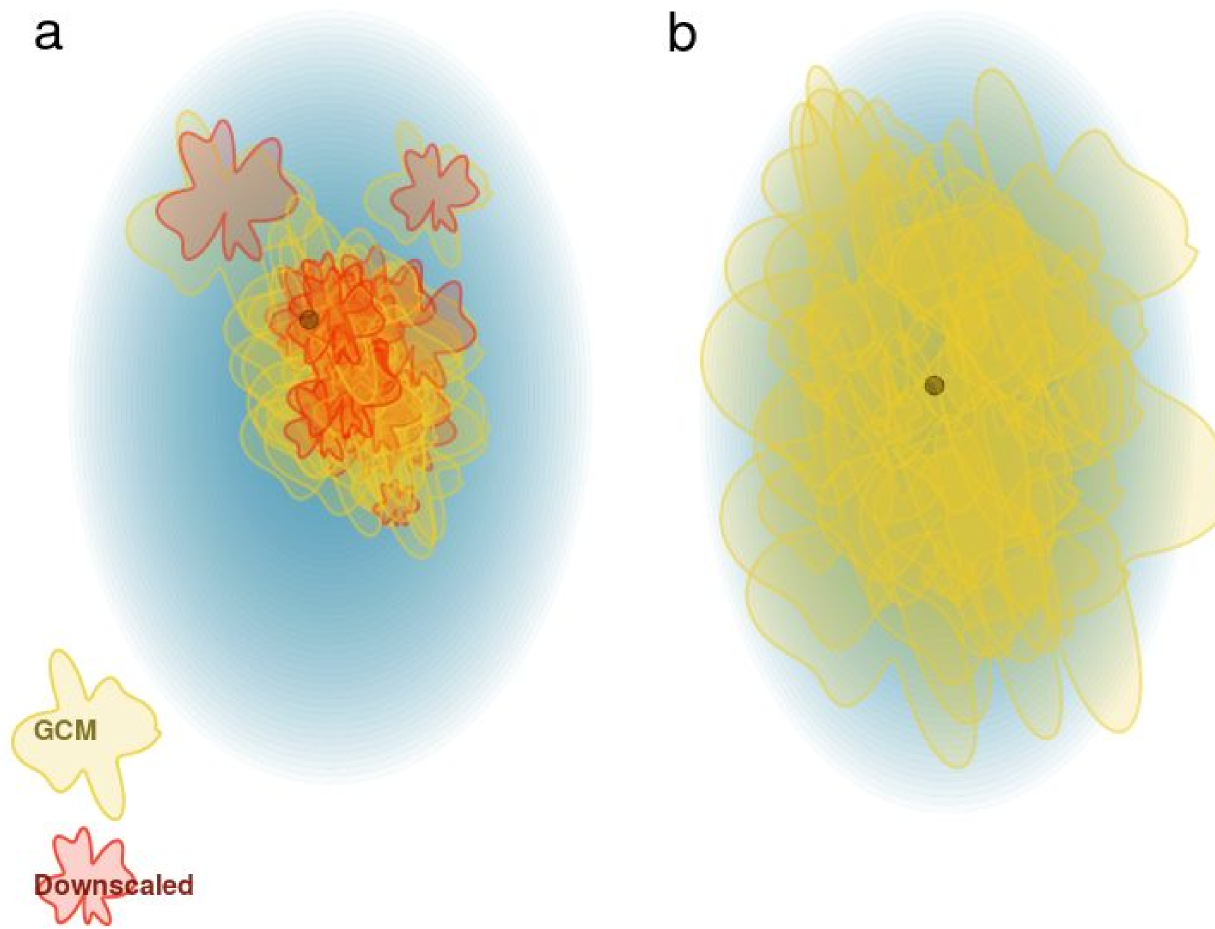
Ensembles!




Useful climate information can only be synthesised from large multi-model GCM ensembles. We need to move away from single-model results

Multi-model ensembles

Problem: not a statistical sample

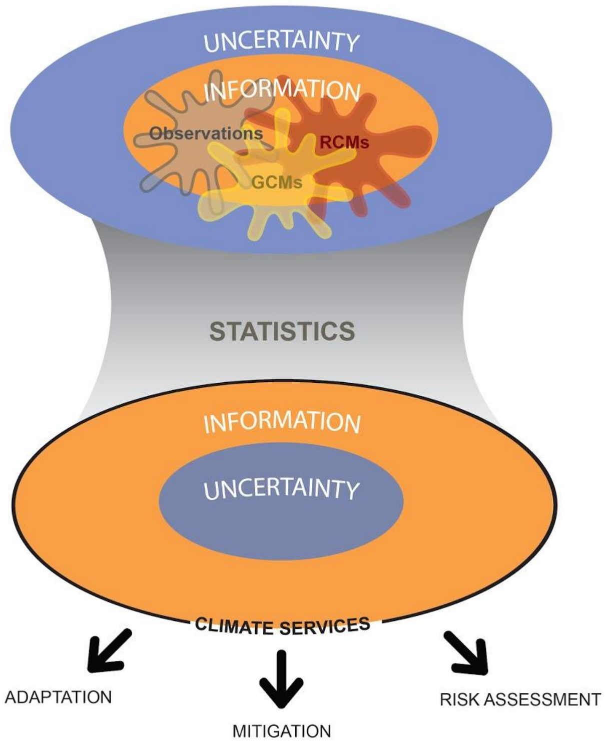


Distillation of robust information

Multiple independent sources of information.

ESD & Statistics apply constraints and makes use of redundancies.

The range of uncertainty is also useful information about sensitivities.

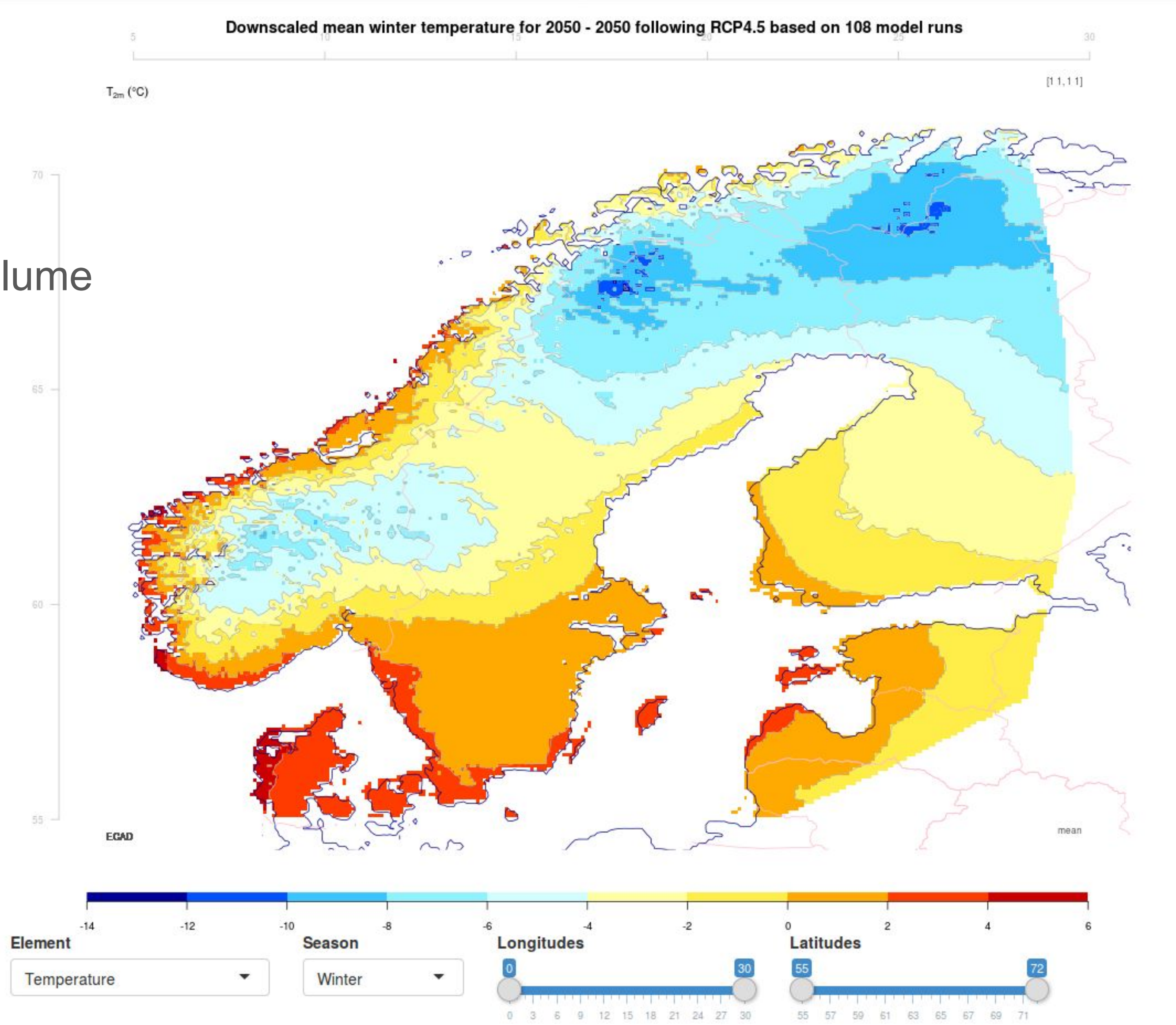


Observations + model results

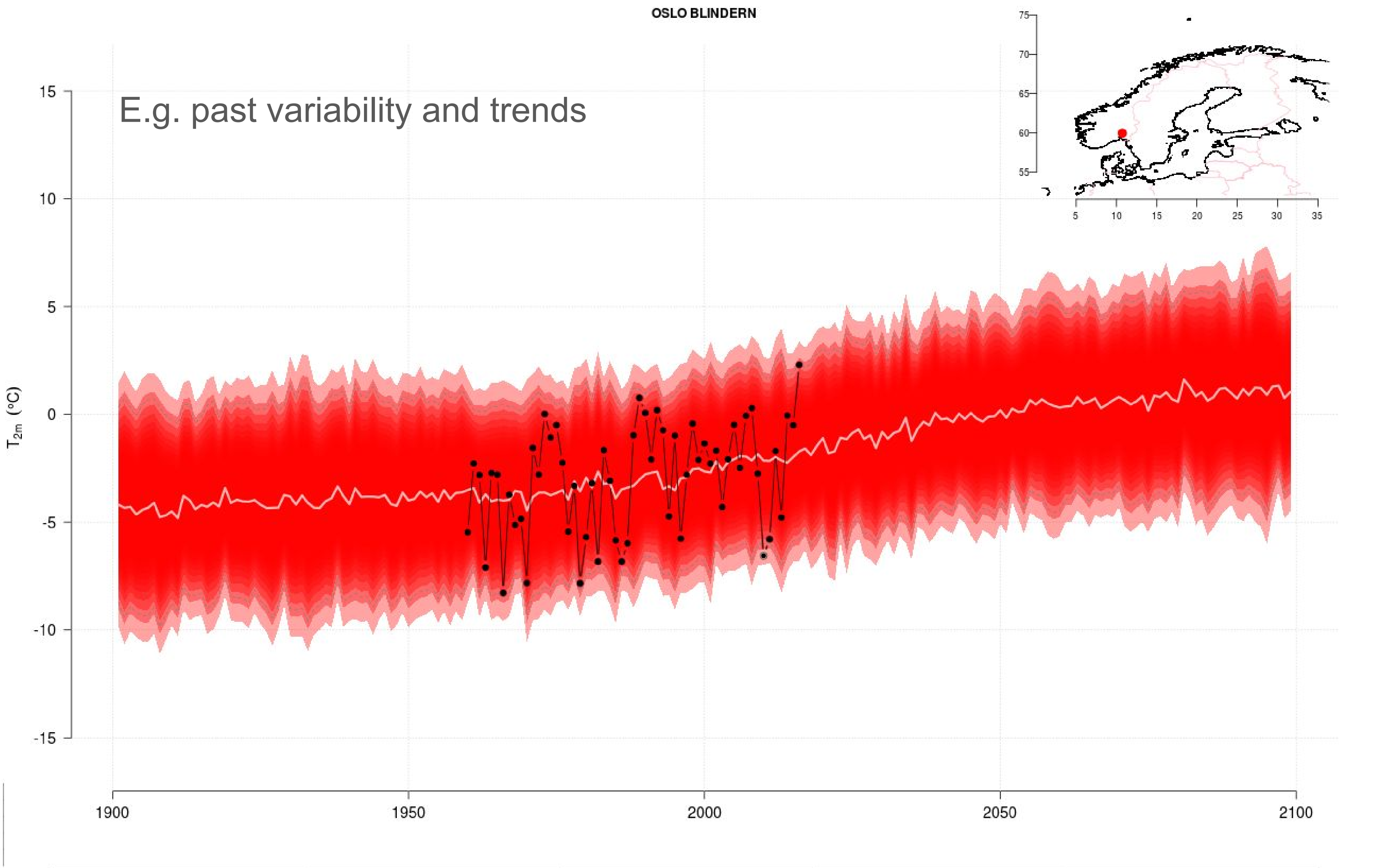
Gridded results

Complicated objects

Compression of data volume

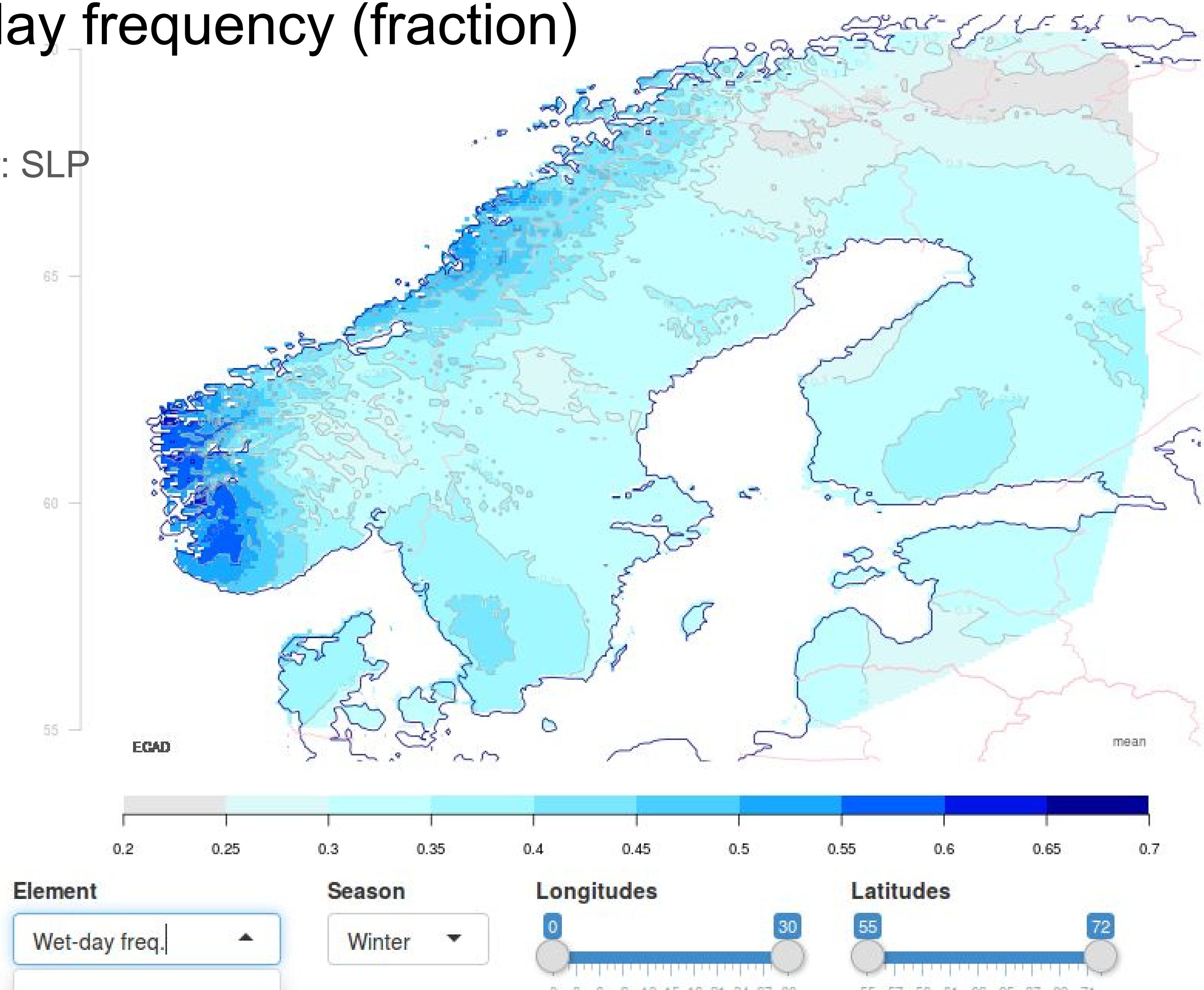


Validation of multi-model ensemble projections

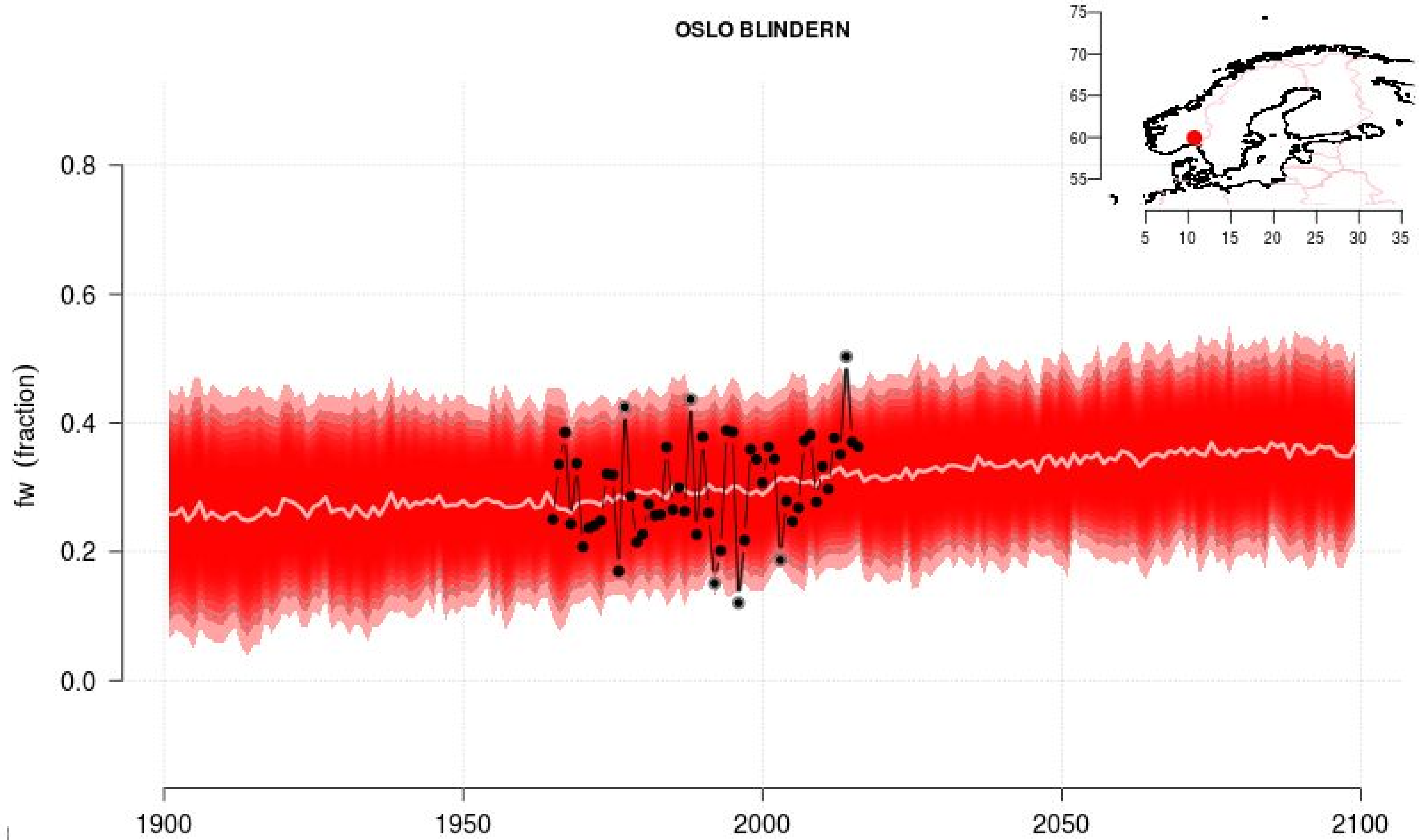


Wet-day frequency (fraction)

Predictor: SLP



Wet-day frequency



Location

OSLO BLINDERN

Element

Wet-day freq.

Season

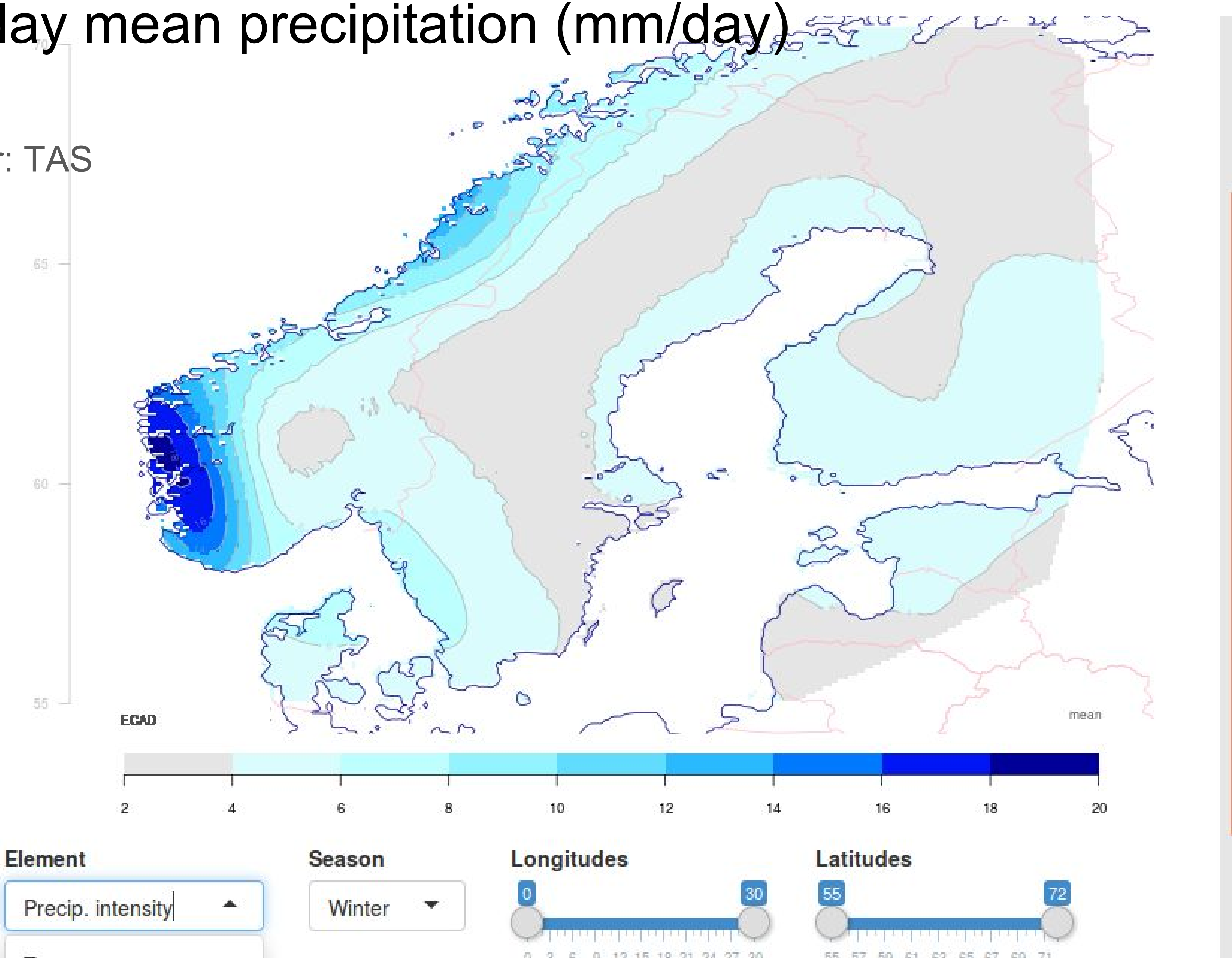
Winter

Scenario

RCP4.5

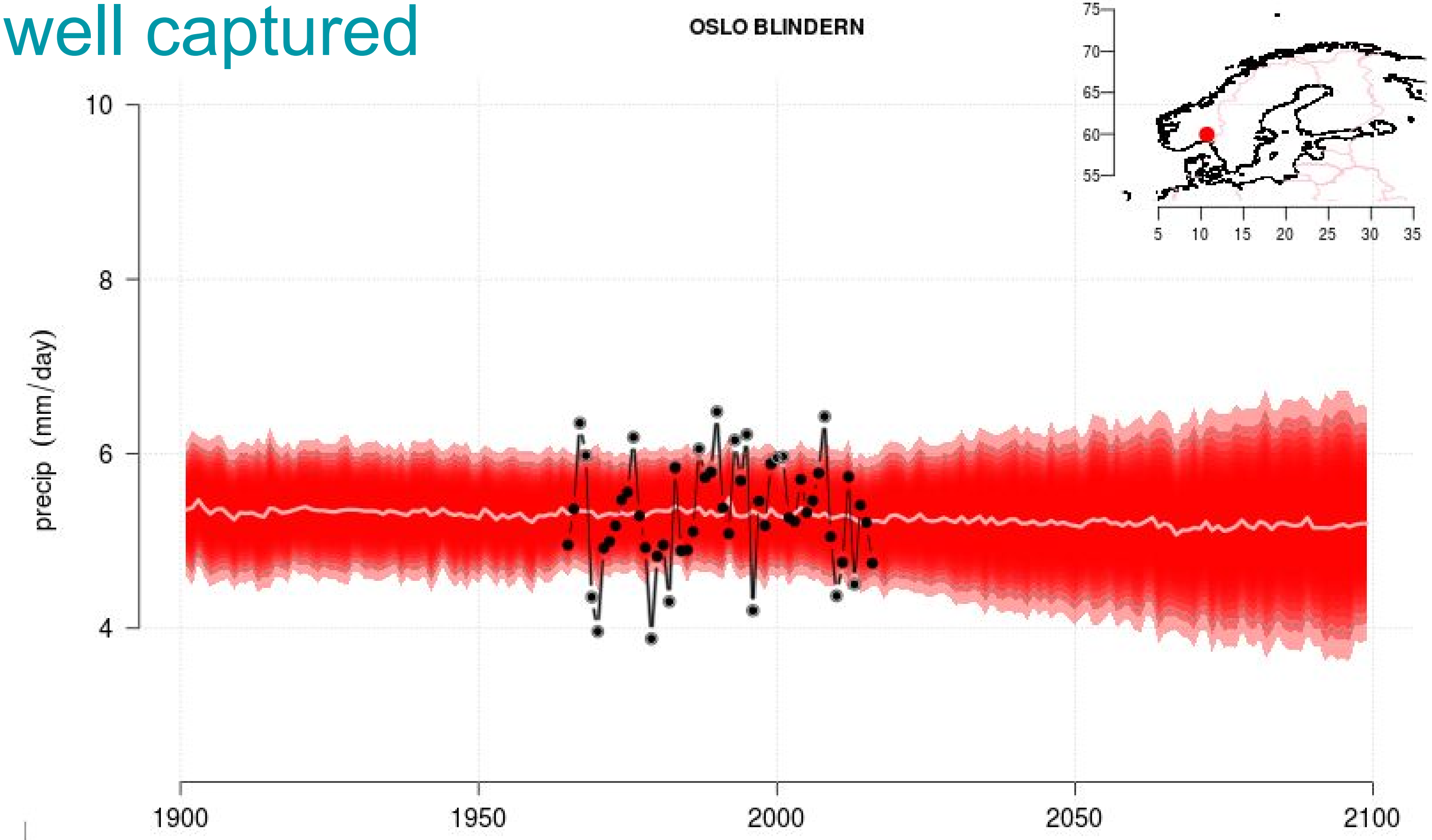
Wet-day mean precipitation (mm/day)

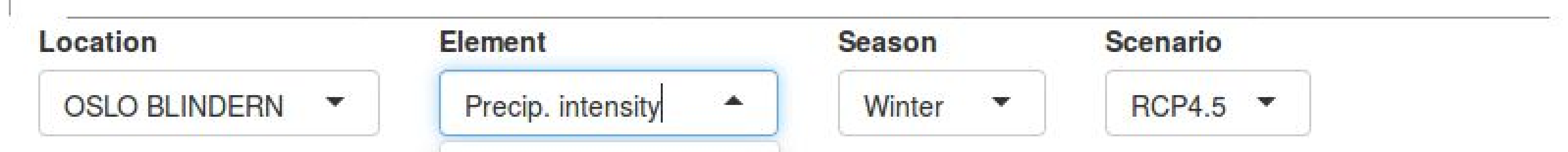
Predictor: TAS



Wet-day mean precipitation

Not well captured

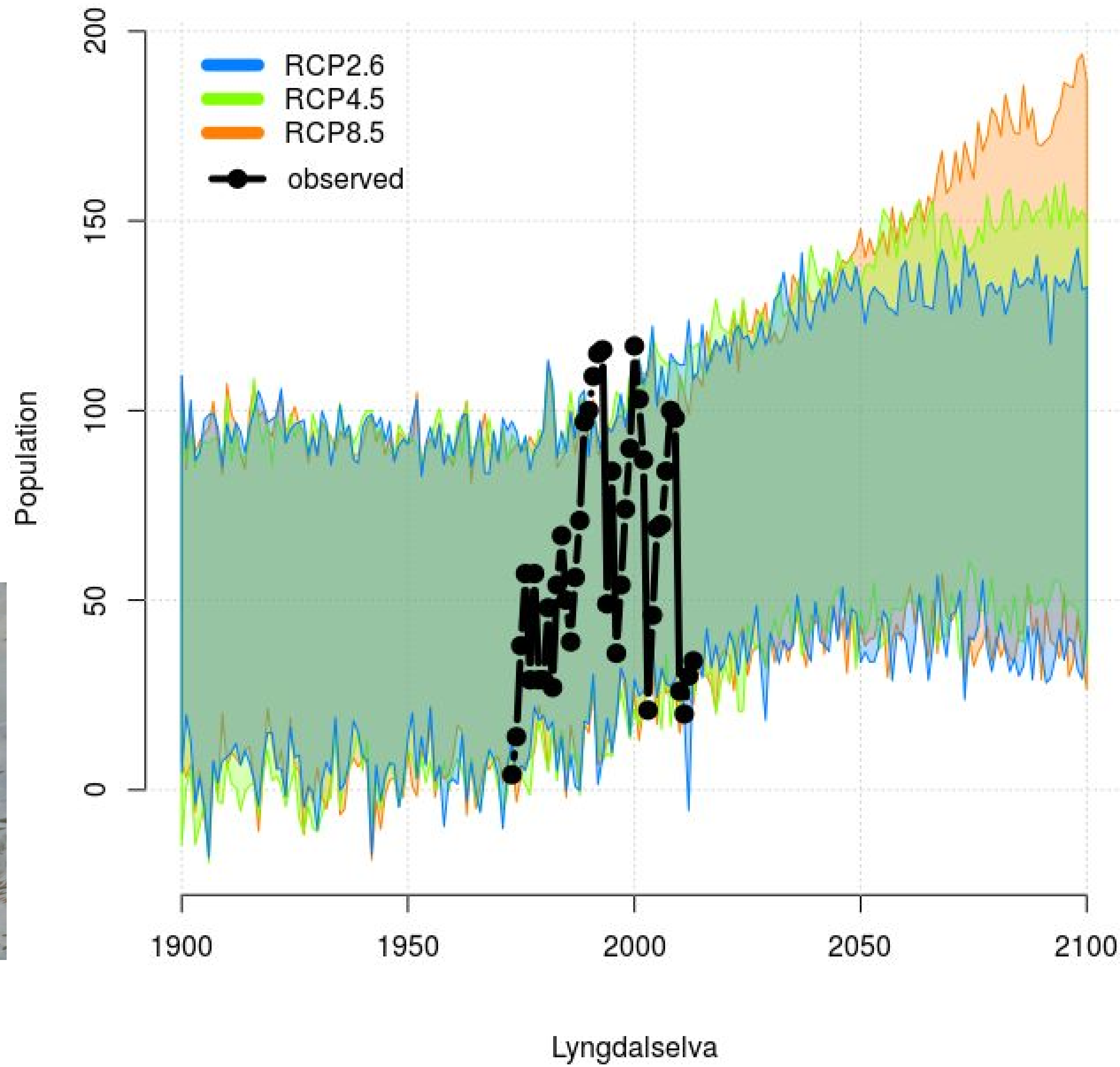




Dipper population

Affected by winter temperature.

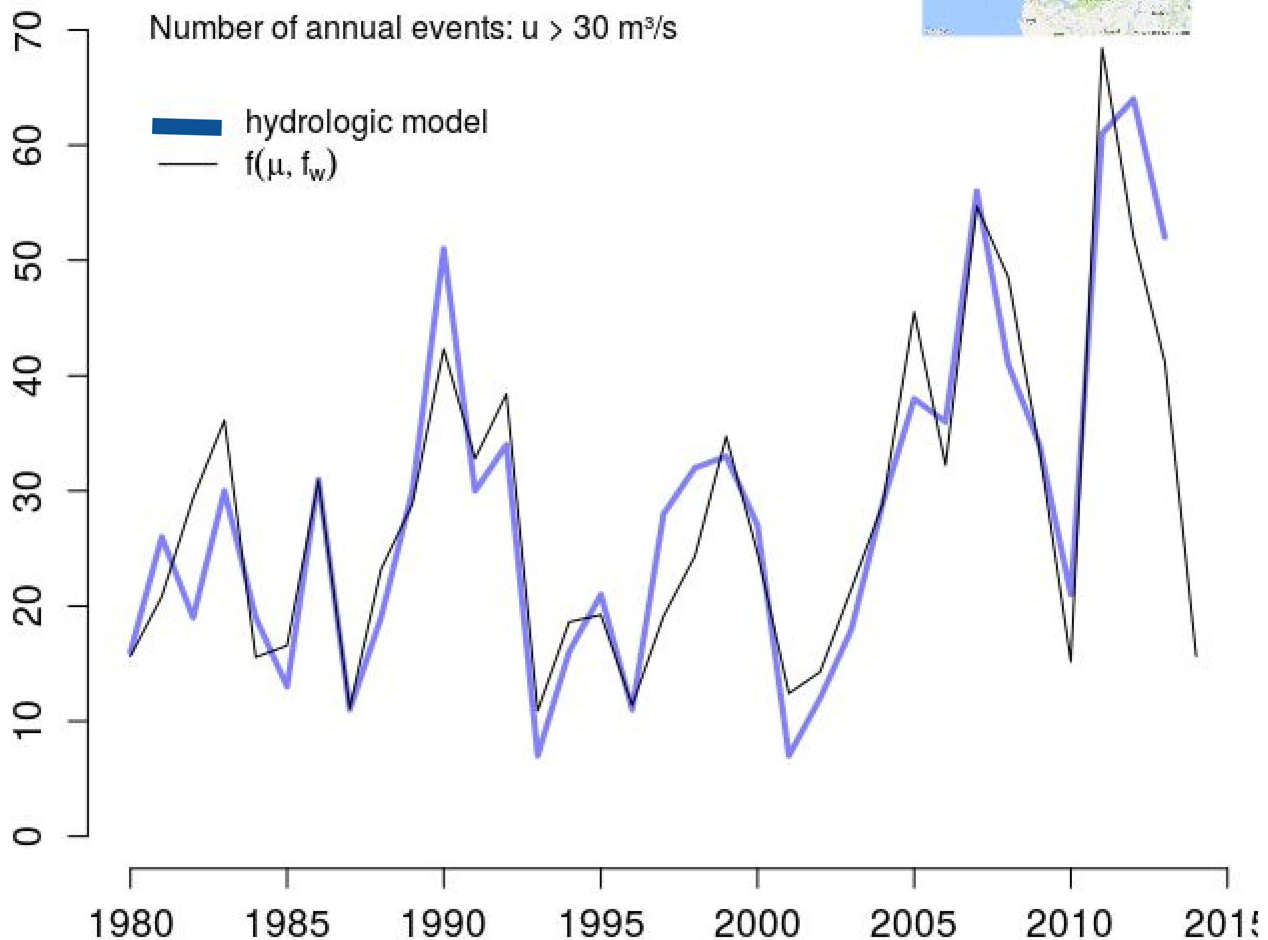
Poisson distribusjon



River run-off

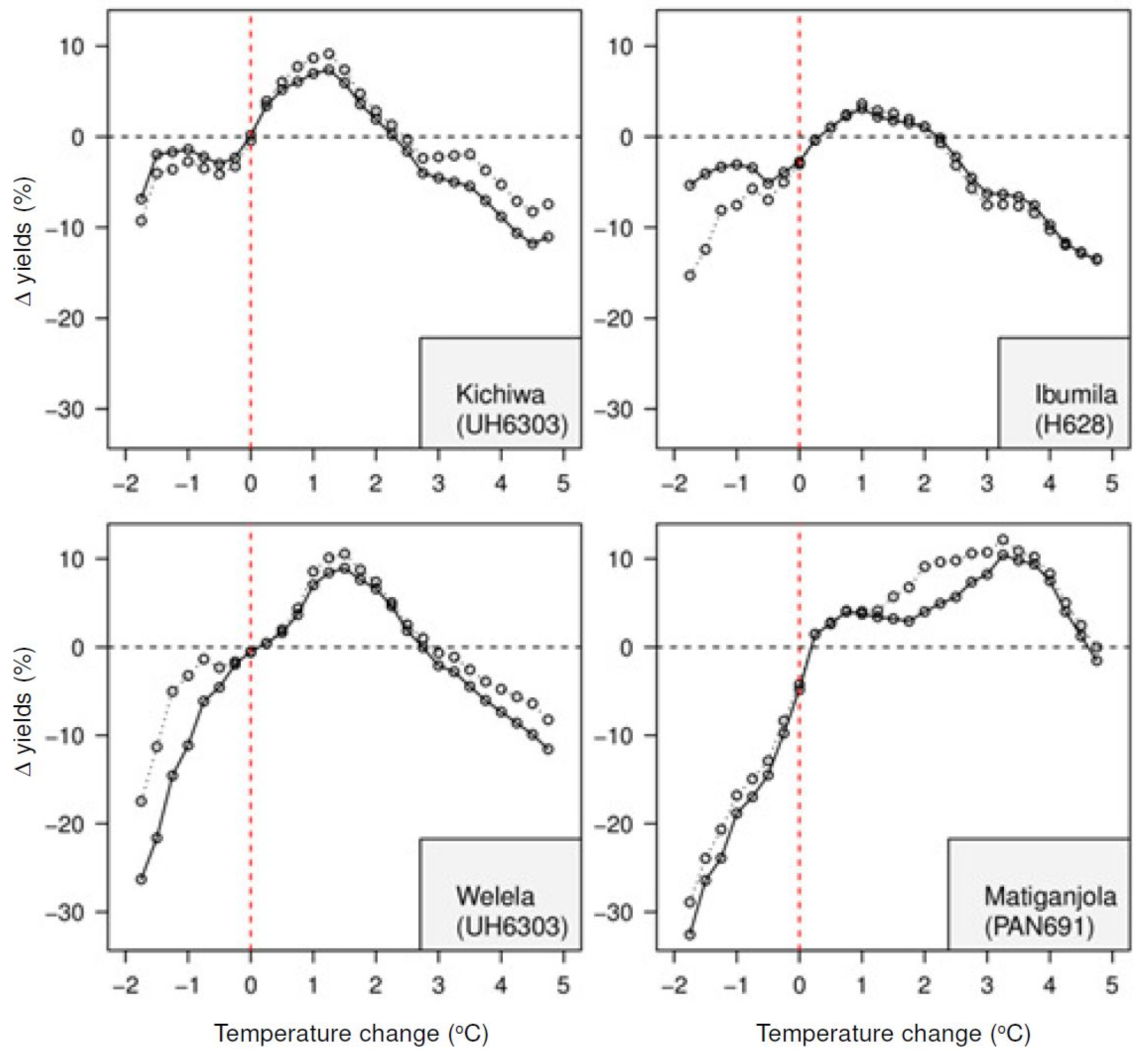
Small catchment.

Responds to number of wet days and the rain intensity.



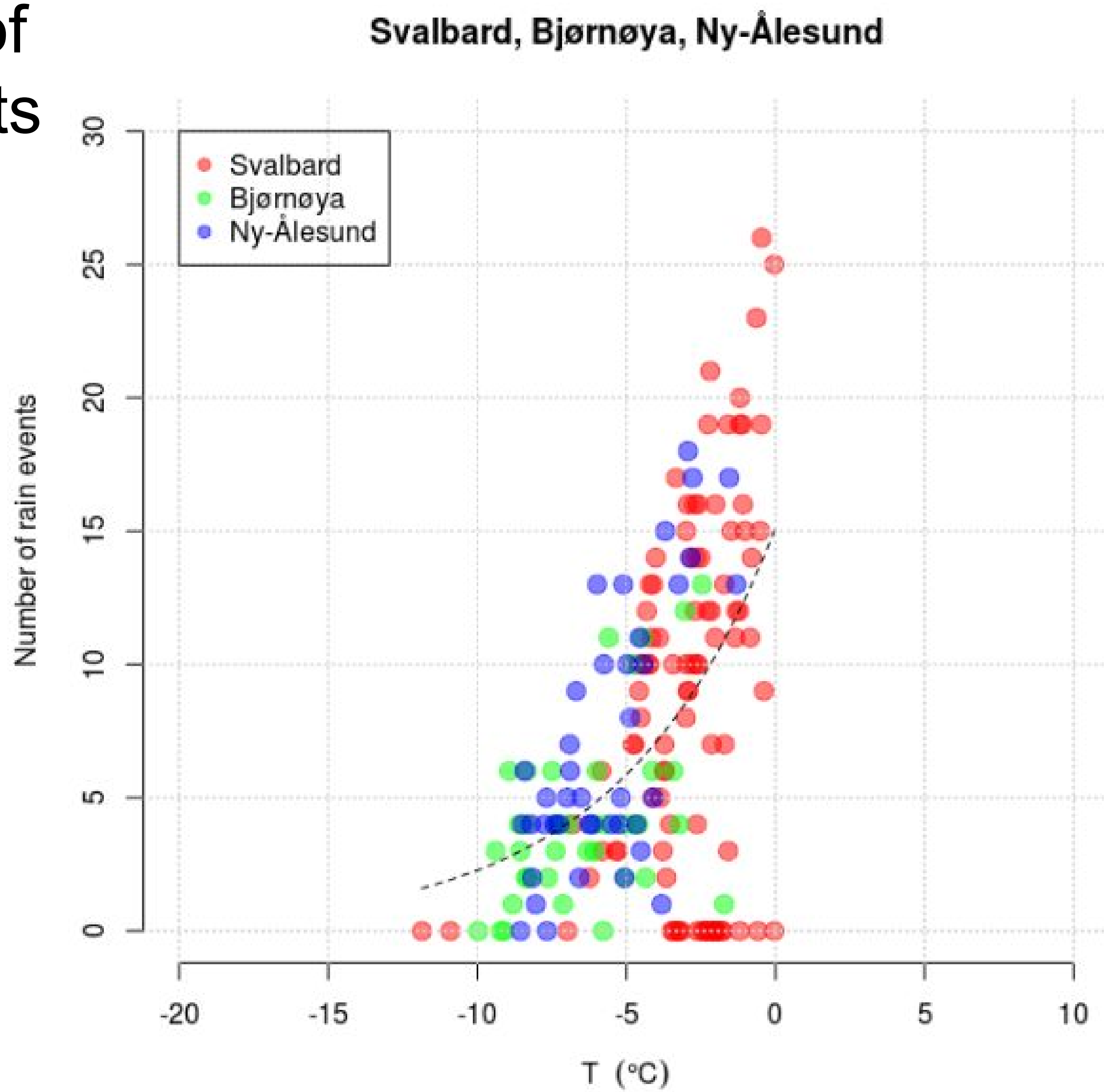
Maize crops have an optimum temperature

Monte-Carlo type experiment with a crop model for Maize crops in Tanzania

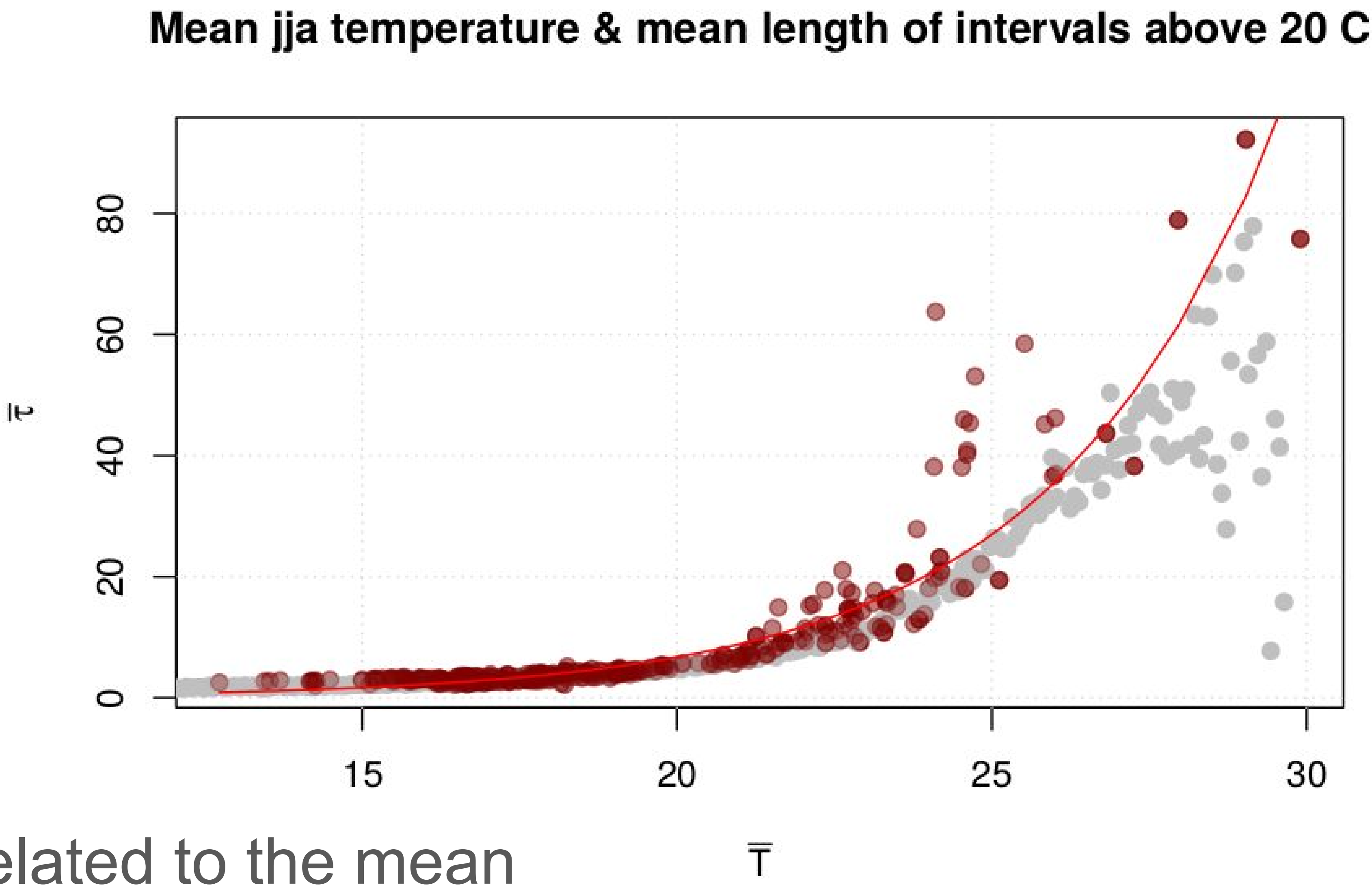


Mtongori, et al. (2015), African Crop Science Journal 23 (4), 399-417, http://dx.doi.org/10.4314/acsj.v23i4.9

Number of rain events in winter



Duration of heat waves

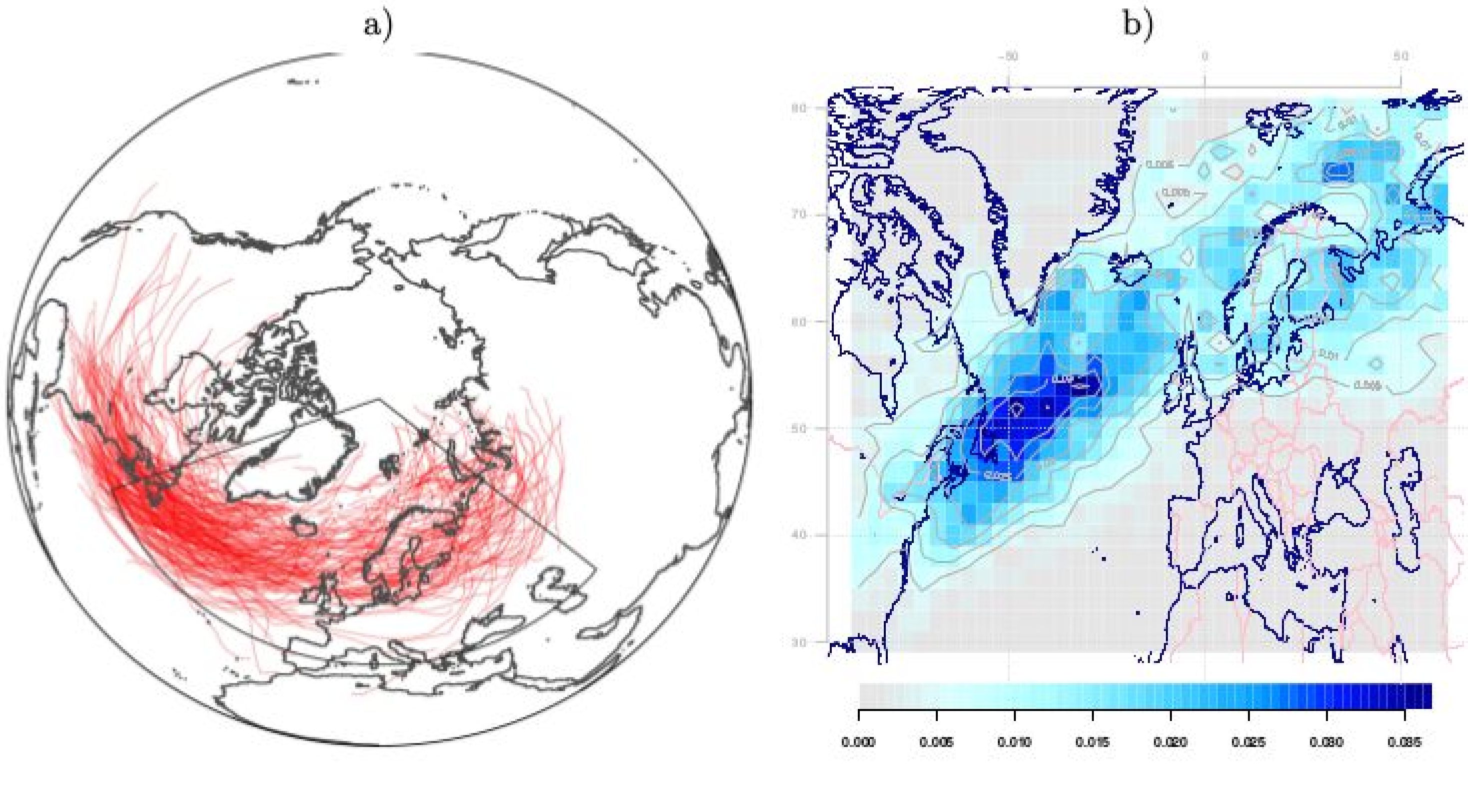


Related to the mean

source: ECA&D

Storm tracks

Storm climate is sensitive to large-scale environment



Type of information

Traditional: temperature, precipitation, indices.

Storm tracks, parameters describing curves

Events: number, duration.

Objective

Provide answers concerning local climate

Risk picture

Analysis for improved understanding - why are there changes?

Main message

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