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Swiss Confederation

Federal Department of Home Affairs FDHA
Federal Office of Meteorology and Climatology MeteoSwiss

From raw model output to probabilistic climate projections

Lessons learnt from a Bayesian analysis of regional climate projections in the Alps

23 March 2011

International Conference on the
Coordinated Regional Climate Downscaling Experiment – CORDEX
Trieste, Italy

A. Weigel, A. Fischer, C. Buser, H.R. Künsch, C. Schär,
M. Liniger, C. Appenzeller

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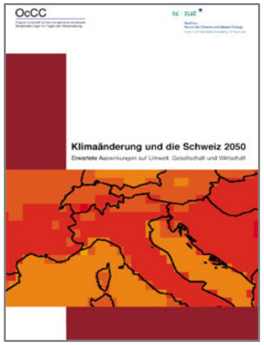
Swiss Climate Scenarios



CH2007 report (coordinated by OcCC)

PRUDENCE

CH2011

CH2011 report (coordinated by C2SM)

C2SM
Center for Climate Systems Modeling

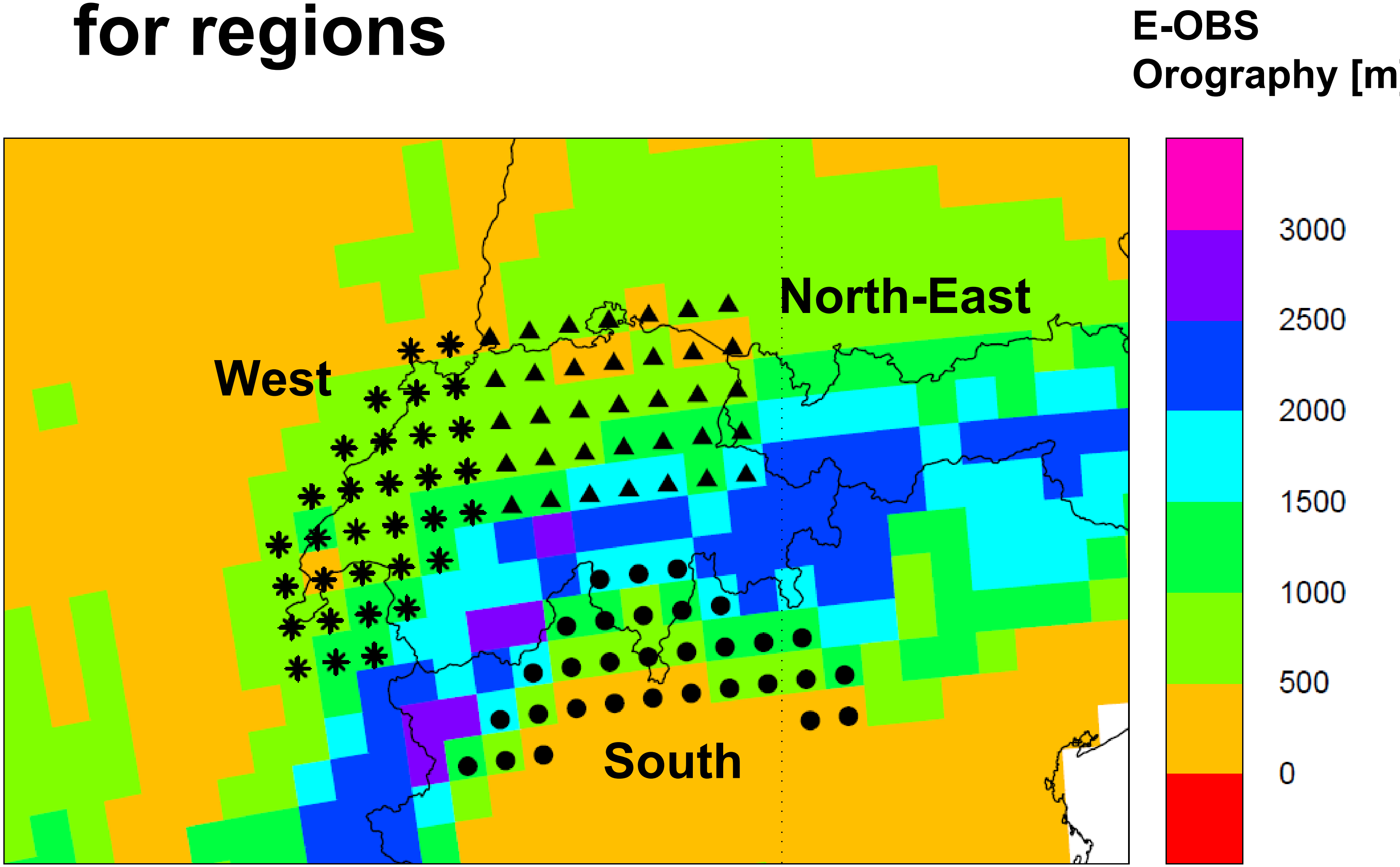
ENSEMBLES

~CH2016
or so

~CH2016 report

CORDEX

Seasonal mean change (T and P) for regions



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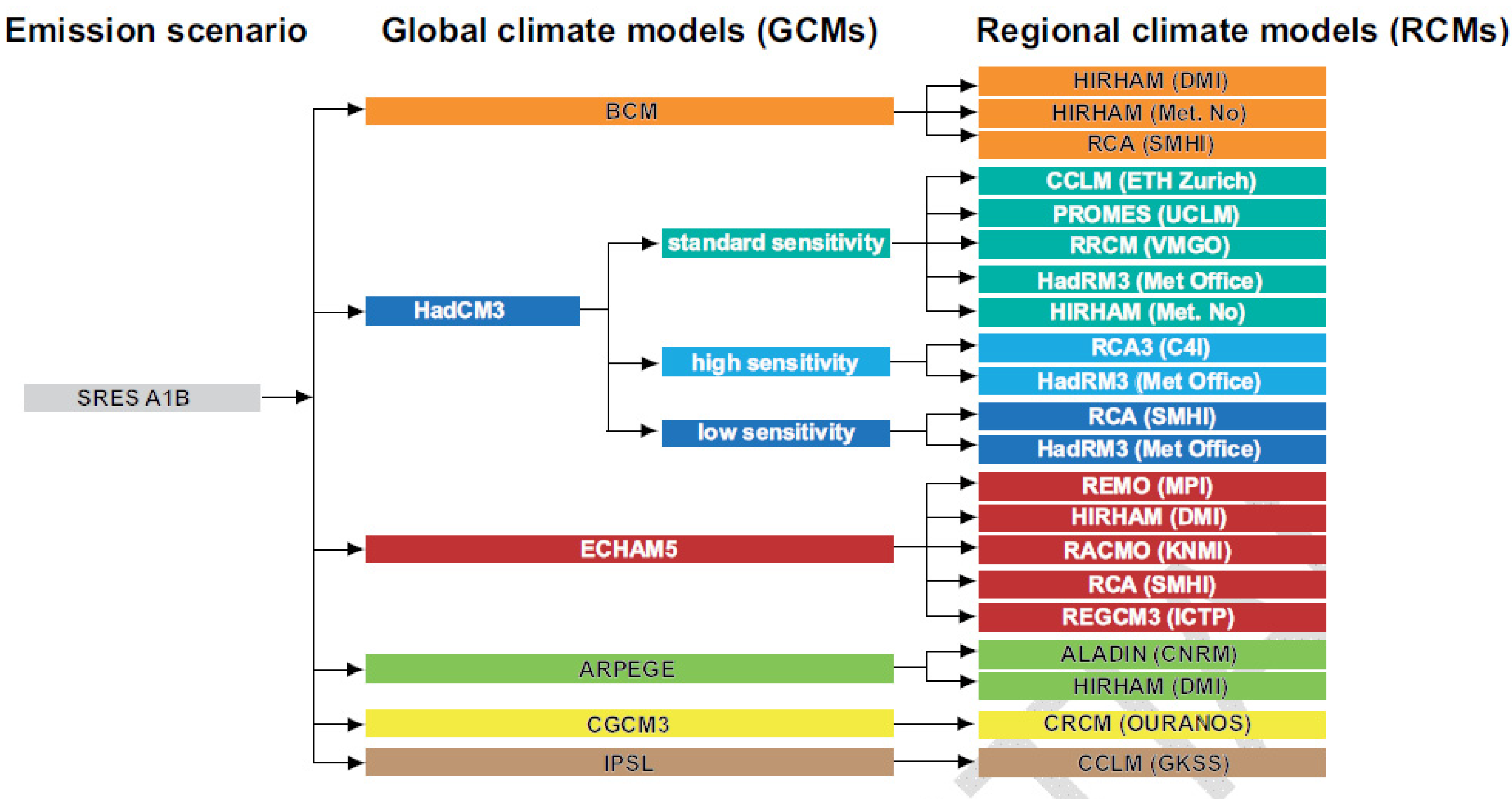
ENSEMBLES GCM-RCM chains



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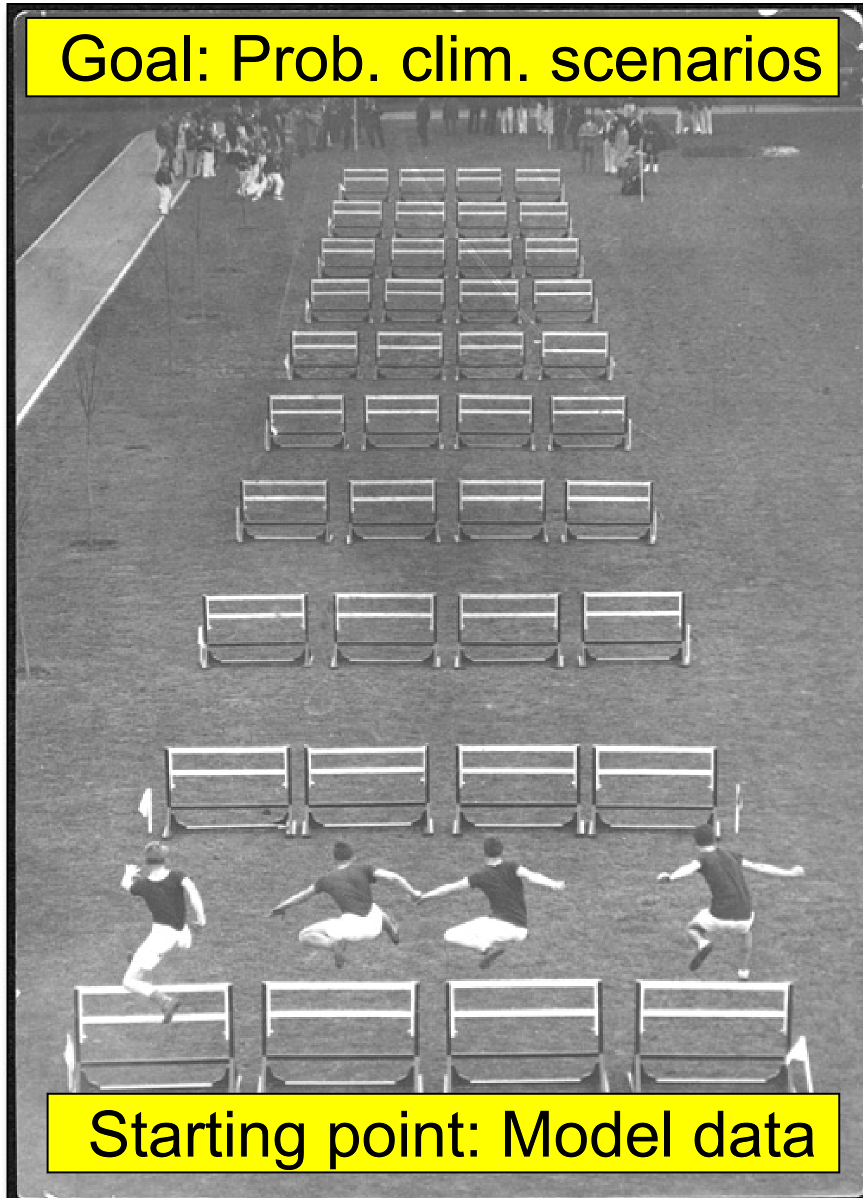

Bias

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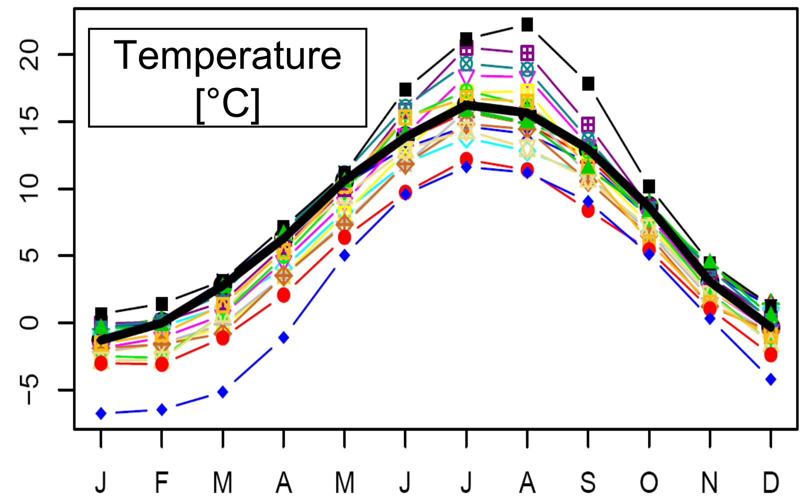
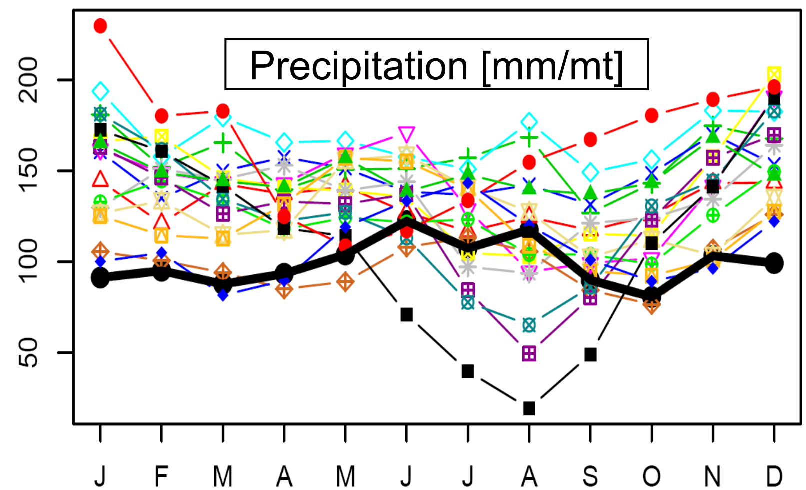
Climatology Northern Switzerland (1961-90)

Black: Observations (E-OBS)
Color: ENSEMBLES GCM-RCM chains





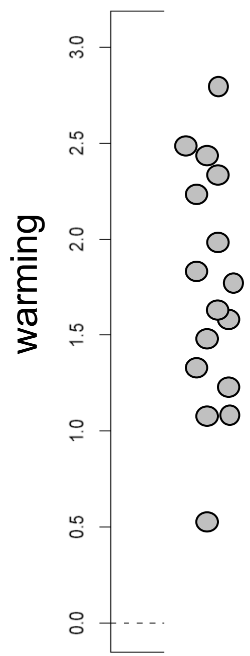
- Do systematic biases stay constant with time?
  -> assumed in most published climate projections (e.g. IPCC AR4)

- There is evidence that not! (Christensen et al. 2008, Buser et al. 2009)
  -> potentially large consequences

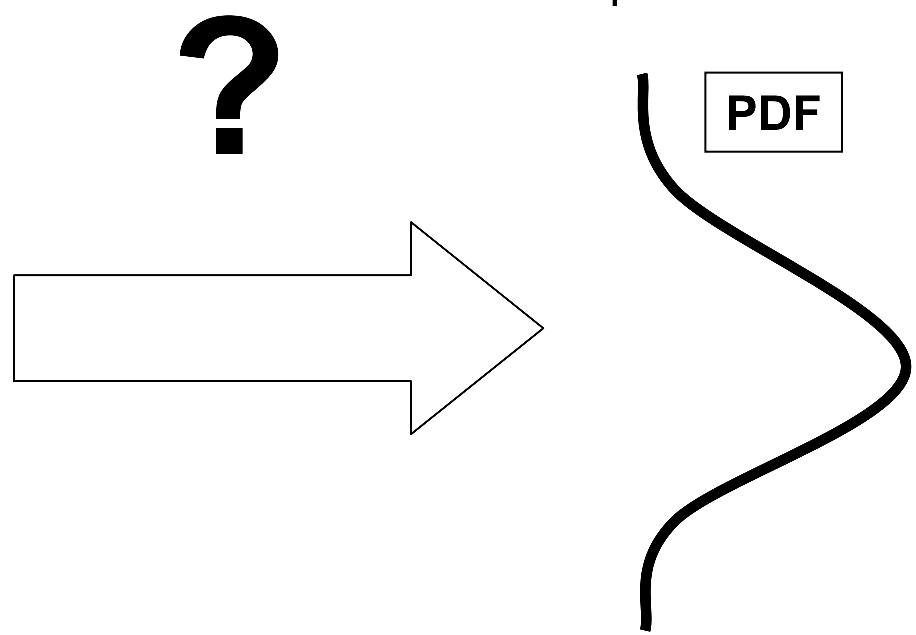
CH2011: Constant bias assumption

Multimodel projections

Model value
Switzerland



Quantifying
probabilities



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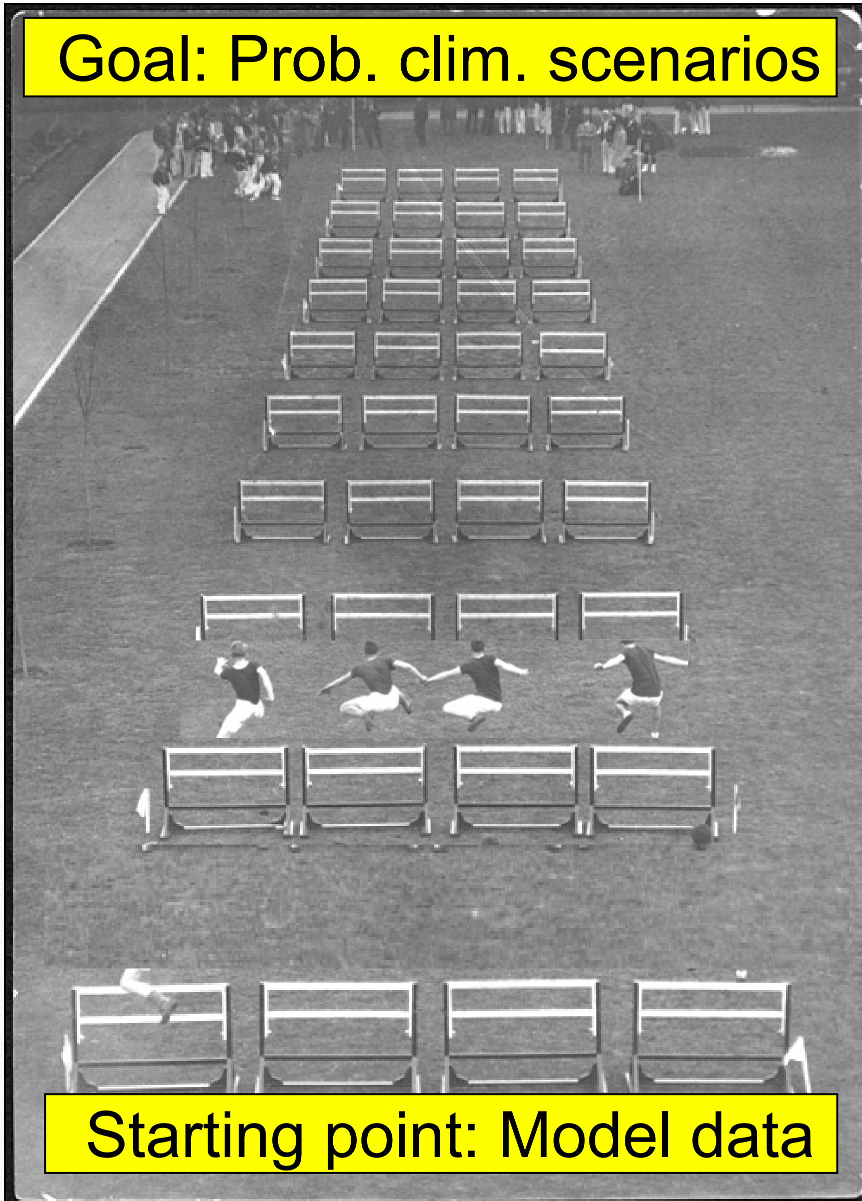

Correlations

Bias

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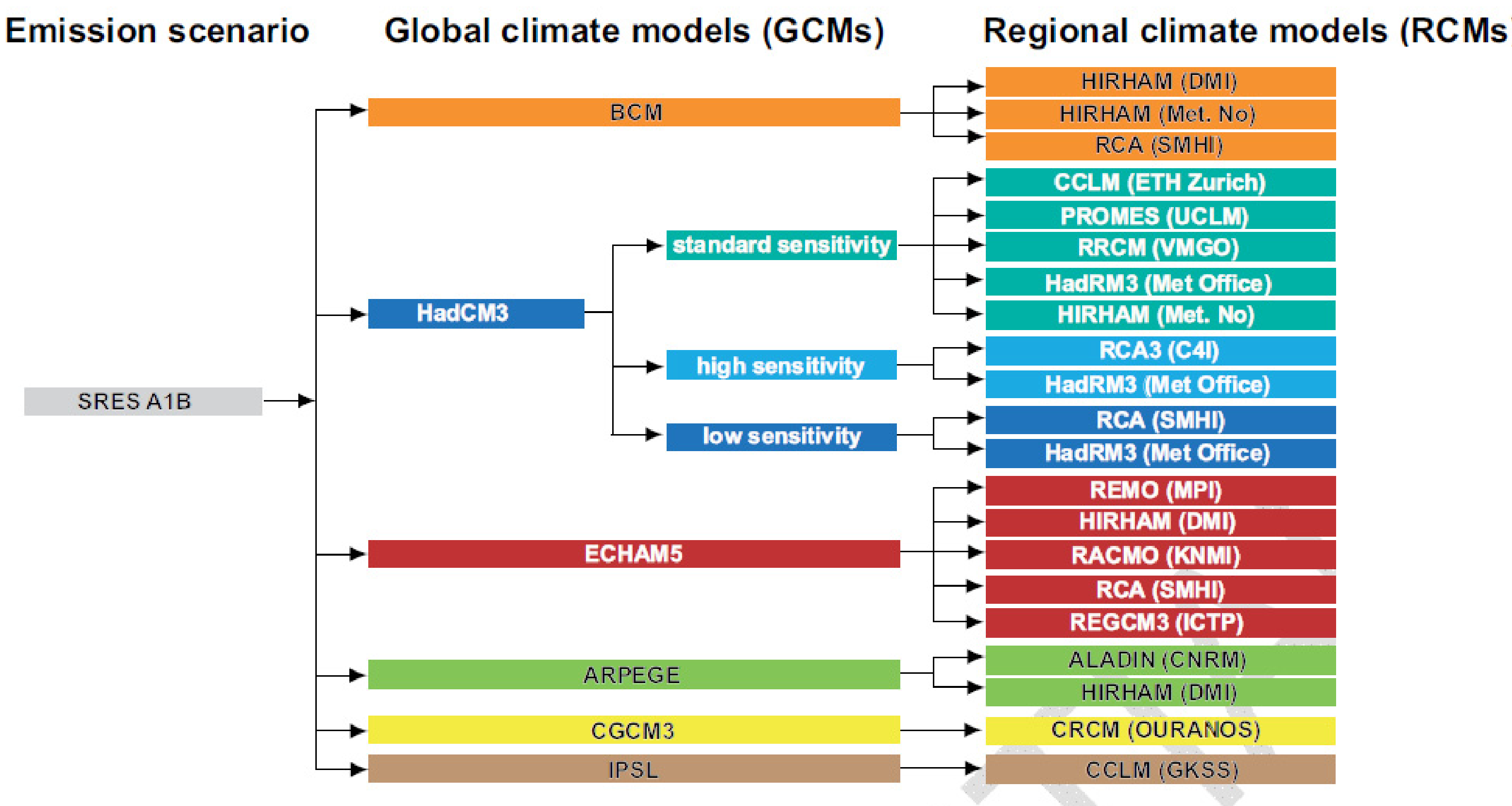
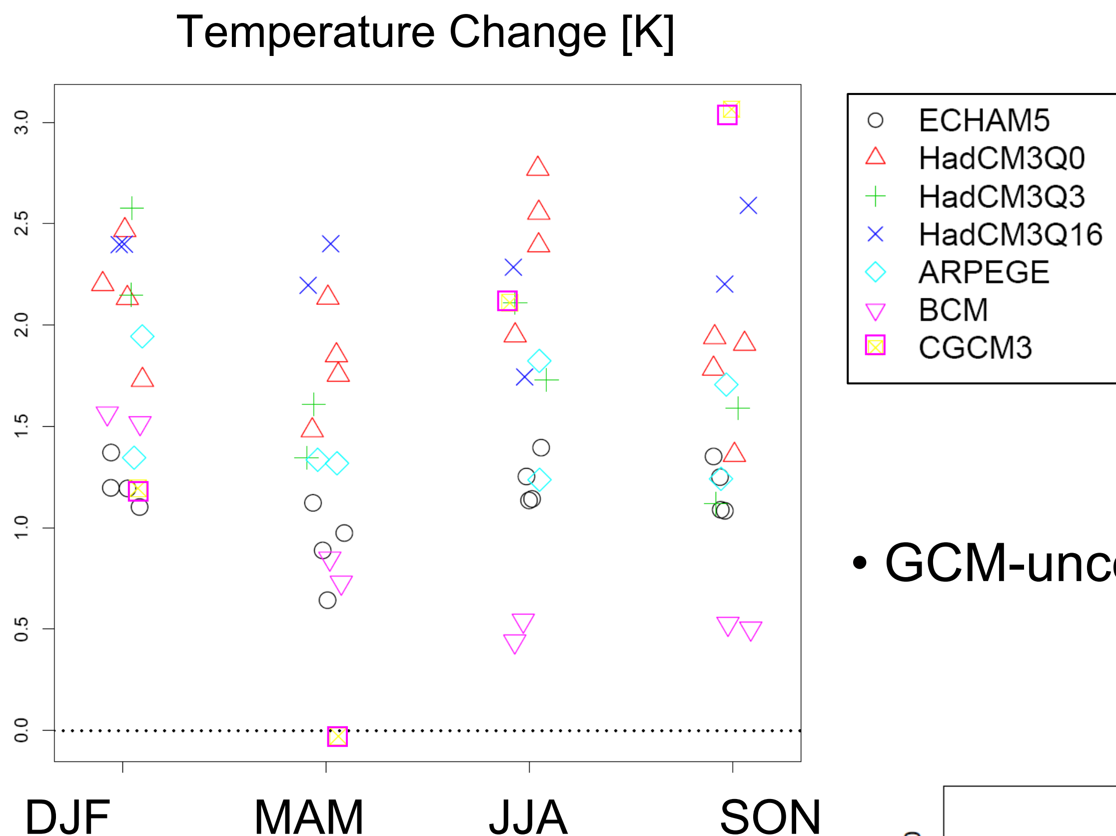
ENSEMBLES R2TB

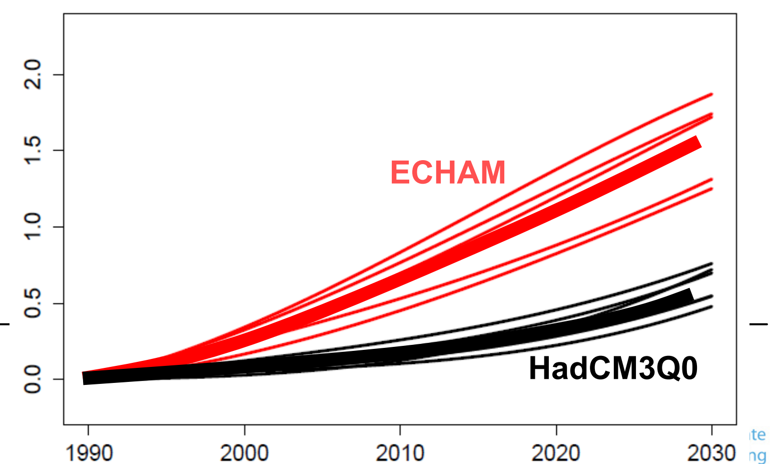


Correlation between GCM-RCM-chains



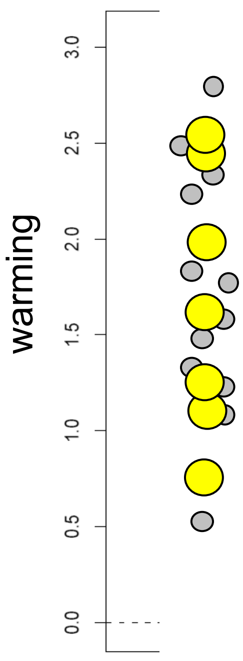
• GCM-uncertainty dominates

Average all RCMs driven by the same GCM

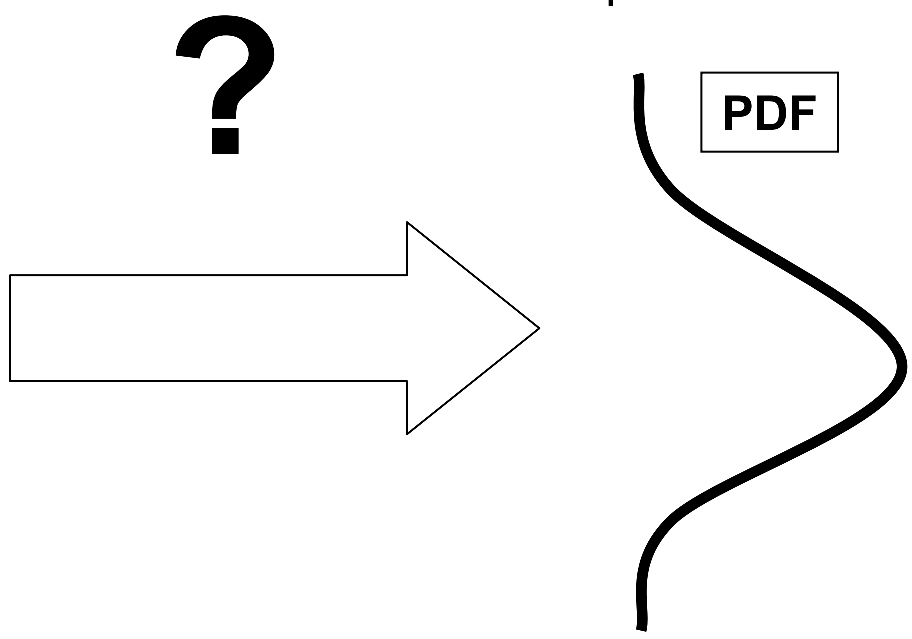


Multimodel projections

Model value
Switzerland



Quantifying
probabilities



CH2011: Assumption that RCM-averages are independent

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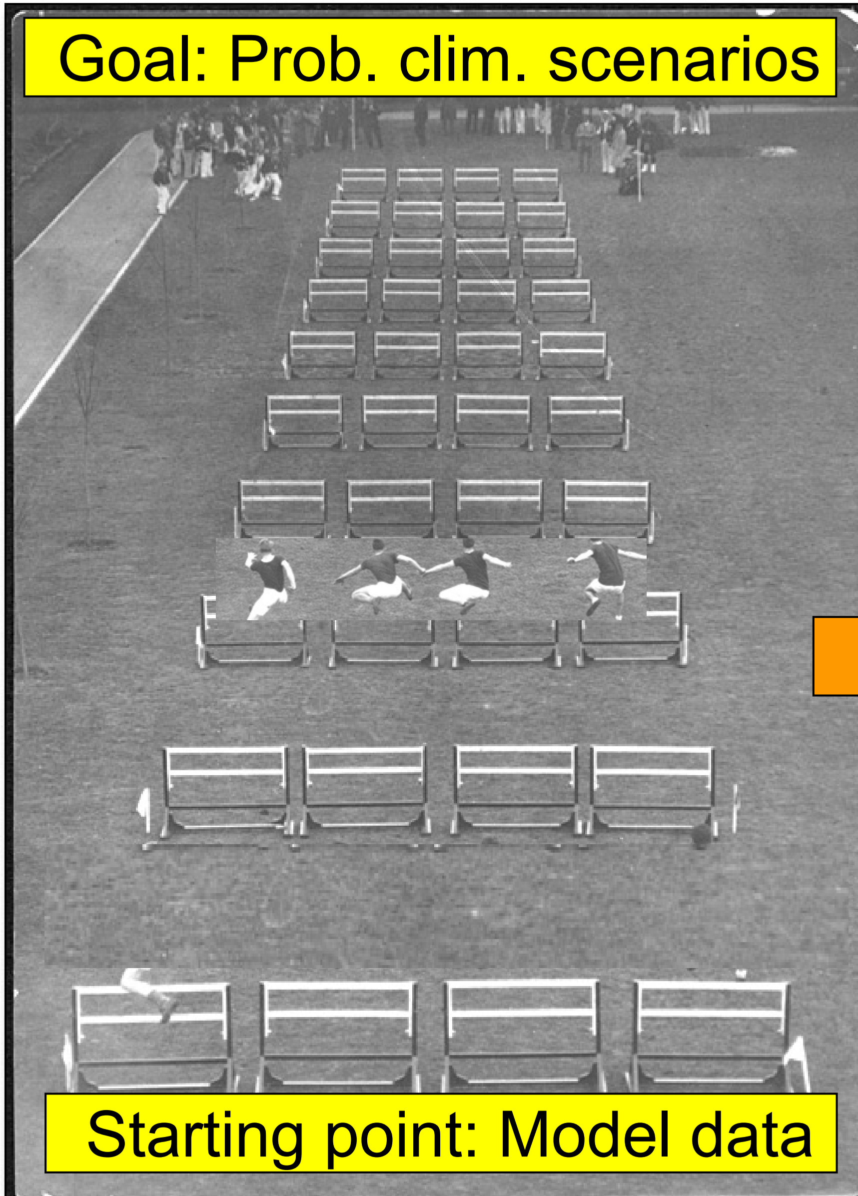


Weights

Correlations

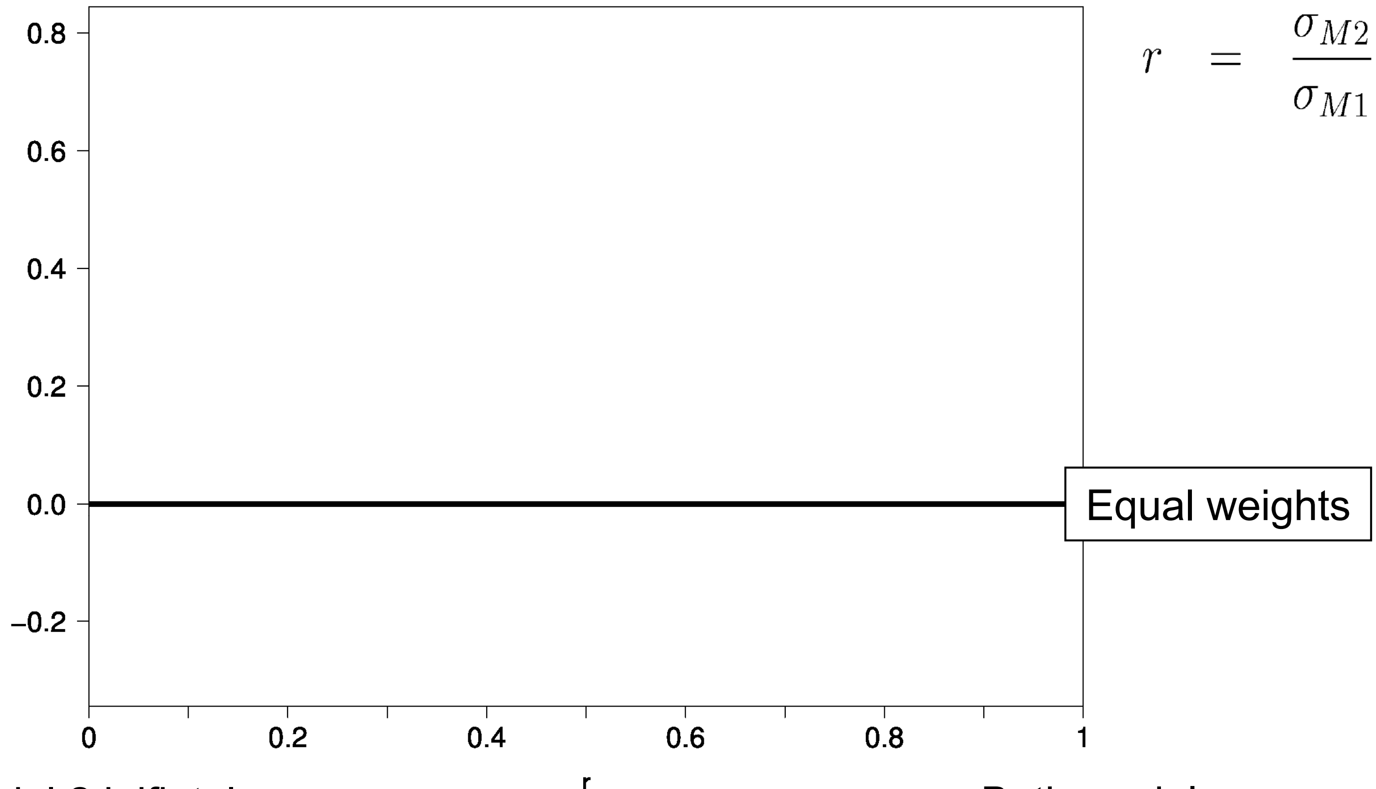
Bias

Effects of weighting

Increase of error (MSE)

Benchmark

Decrease of error (MSE)



$$r = \frac{\sigma_{M2}}{\sigma_{M1}}$$

Model 2 inifintely better than Model 1 → Both models have same skill

Weigel et al, 2010, J. Clim.

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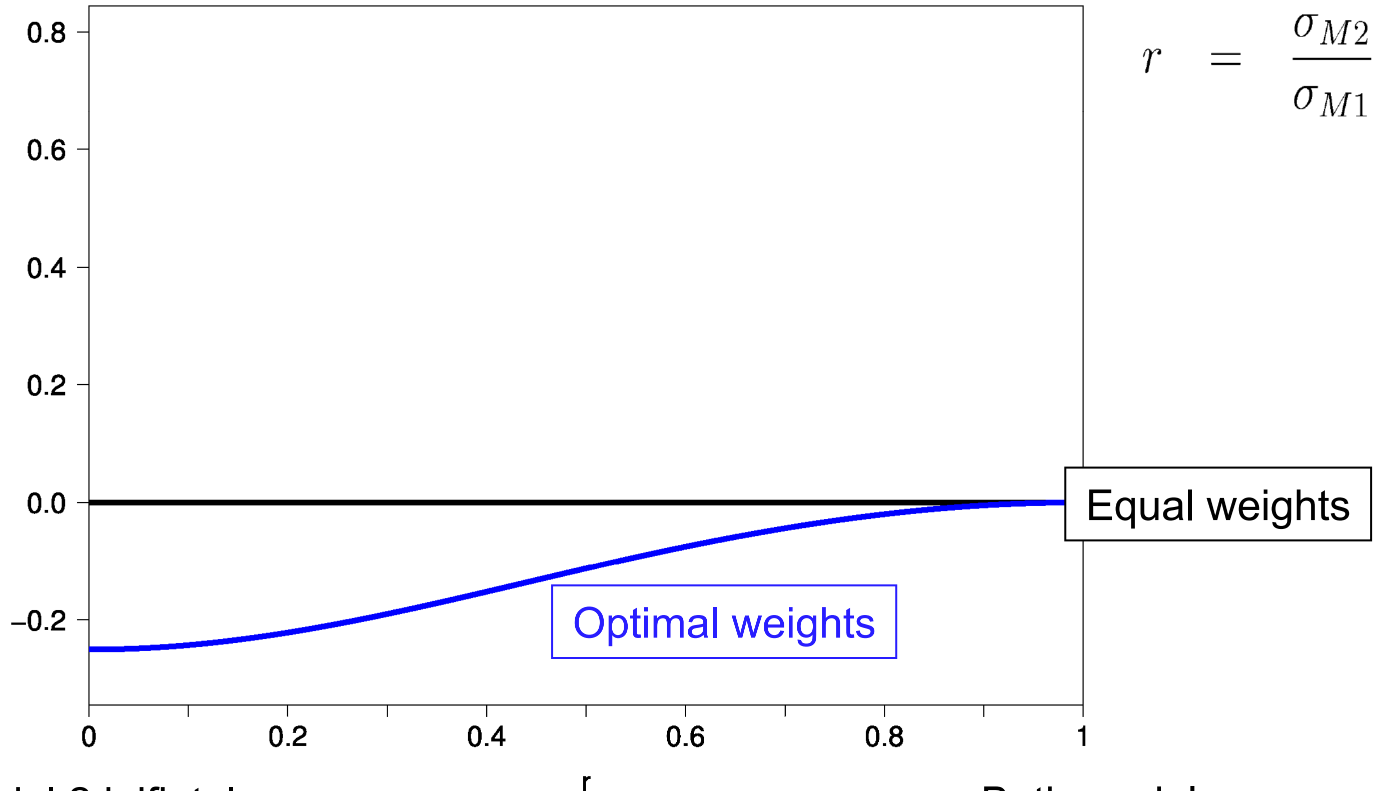
Effects of weighting

Increase of error (MSE)

Benchmark

Decrease of error (MSE)



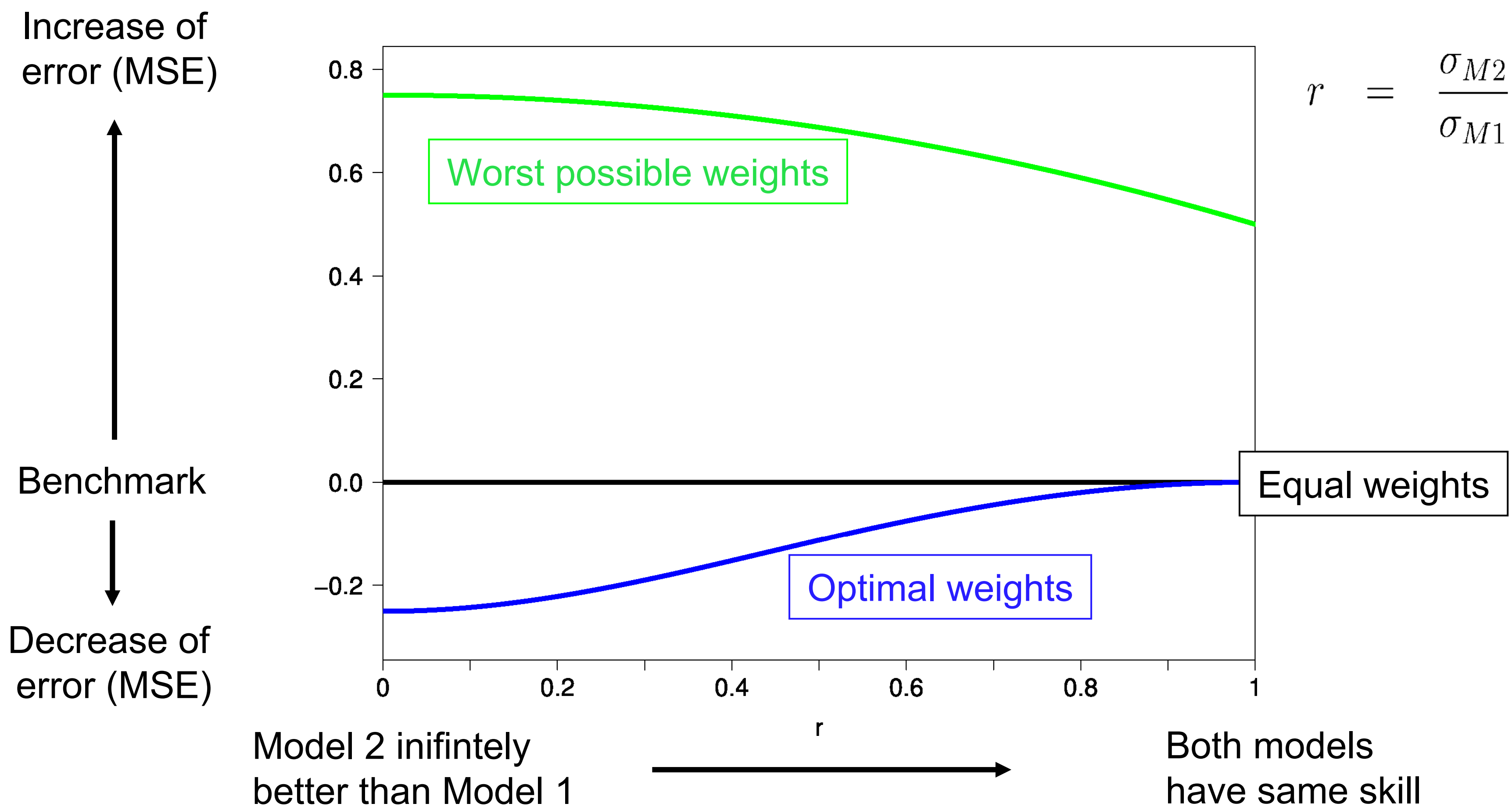
$$r = \frac{\sigma_{M2}}{\sigma_{M1}}$$

Model 2 inifintely better than Model 1

Both models have same skill

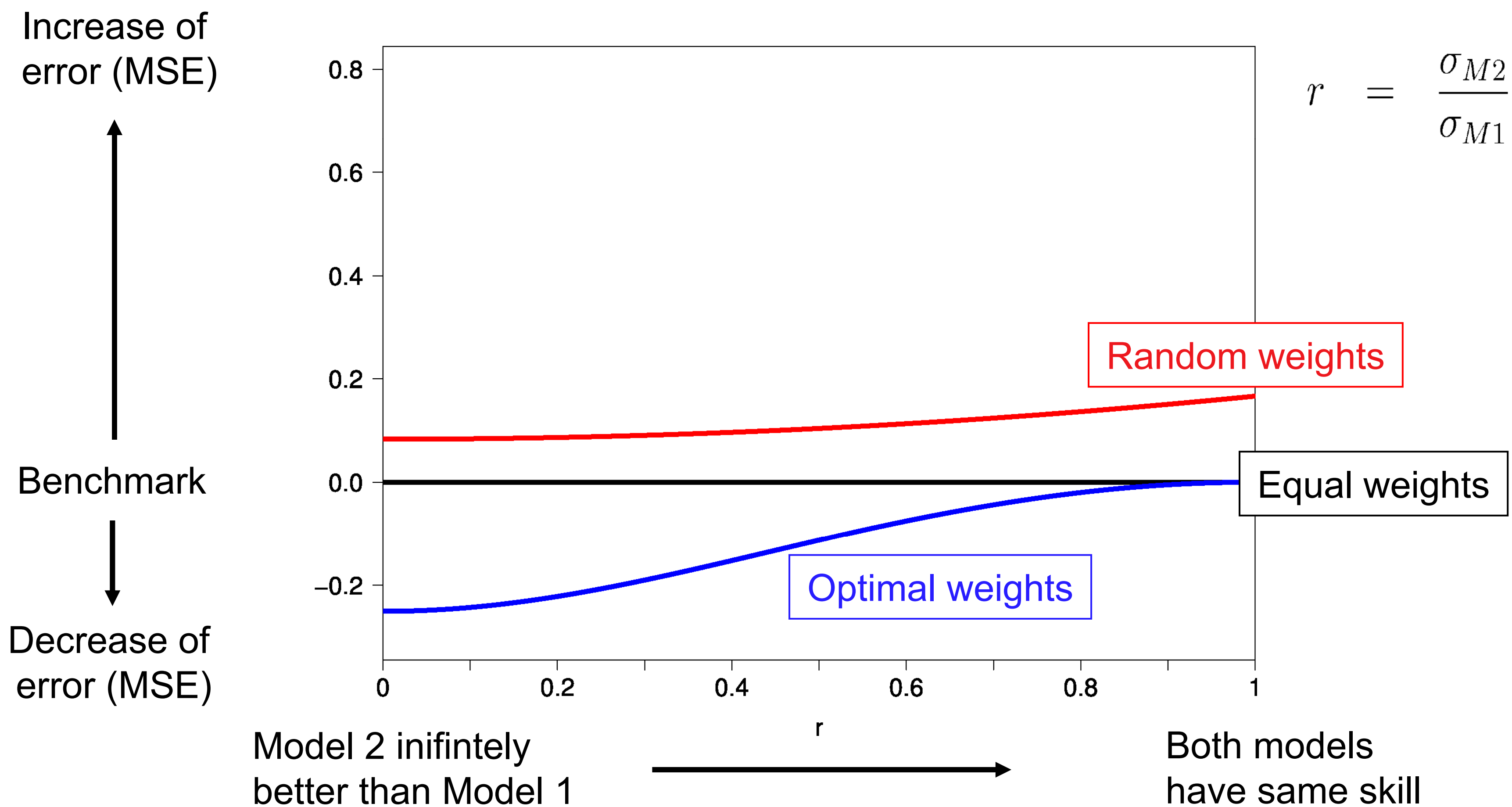
Weigel et al, 2010, J. Clim.

Effects of weighting



Weigel et al, 2010, J. Clim.

Effects of weighting



CH2011: No skill-based weights

Weigel et al, 2010, J. Clim.

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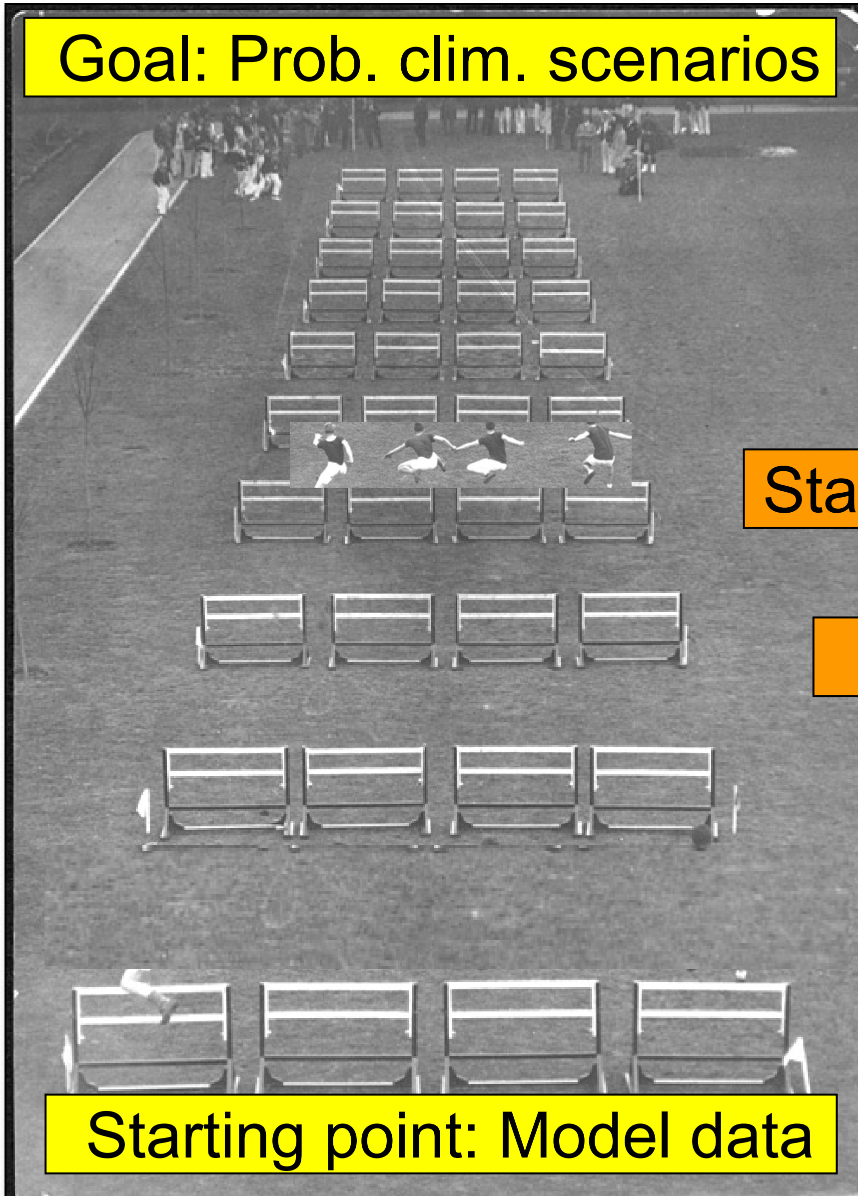

Statistical model

Weights

Correlations

Bias

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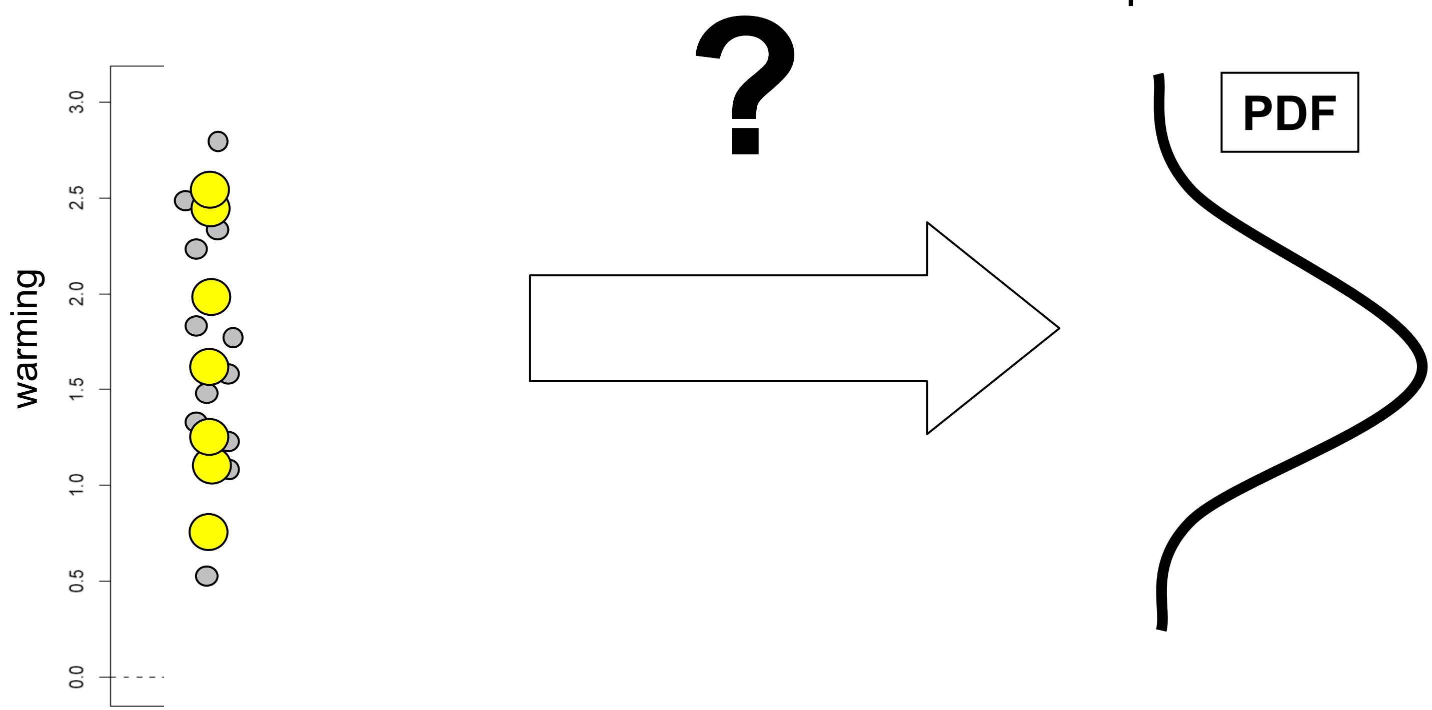
Multimodel projections

Model value Switzerland

Quantifying probabilities



CH2011: Bayesian algorithm of Buser et al. (2009)

Bayesian model of Buser et al. (2009)

Observations CONTROL $\sim N(\mu, \ldots)$

Models CONTROL $\sim N(\mu + \beta_i, \ldots)$

Observations FUTURE $\sim N(\mu + \Delta\mu, \ldots)$

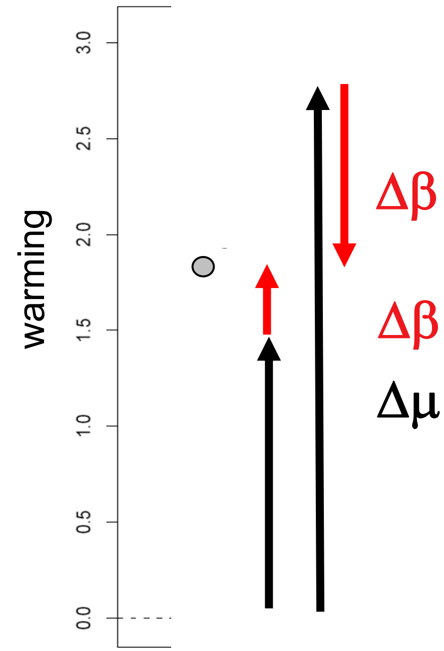
Models FUTURE $\sim N(\mu + \Delta\mu + \beta_i + \Delta\beta_i \ldots)$

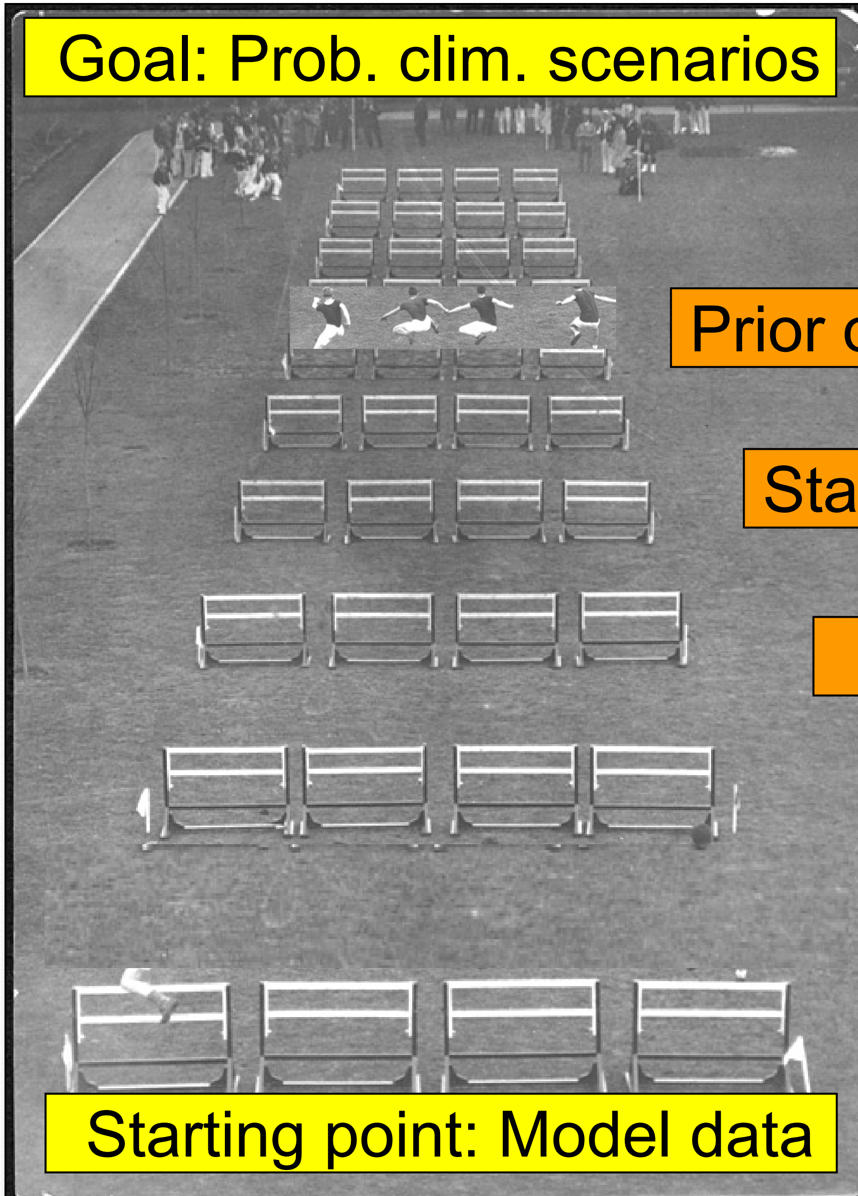
μ: Climate mean during control period

β_i: Systematic bias of model *i*

$\Delta\mu$: Climate change signal

$\Delta\beta_i$: Projection error of model *i*





Prior of model error

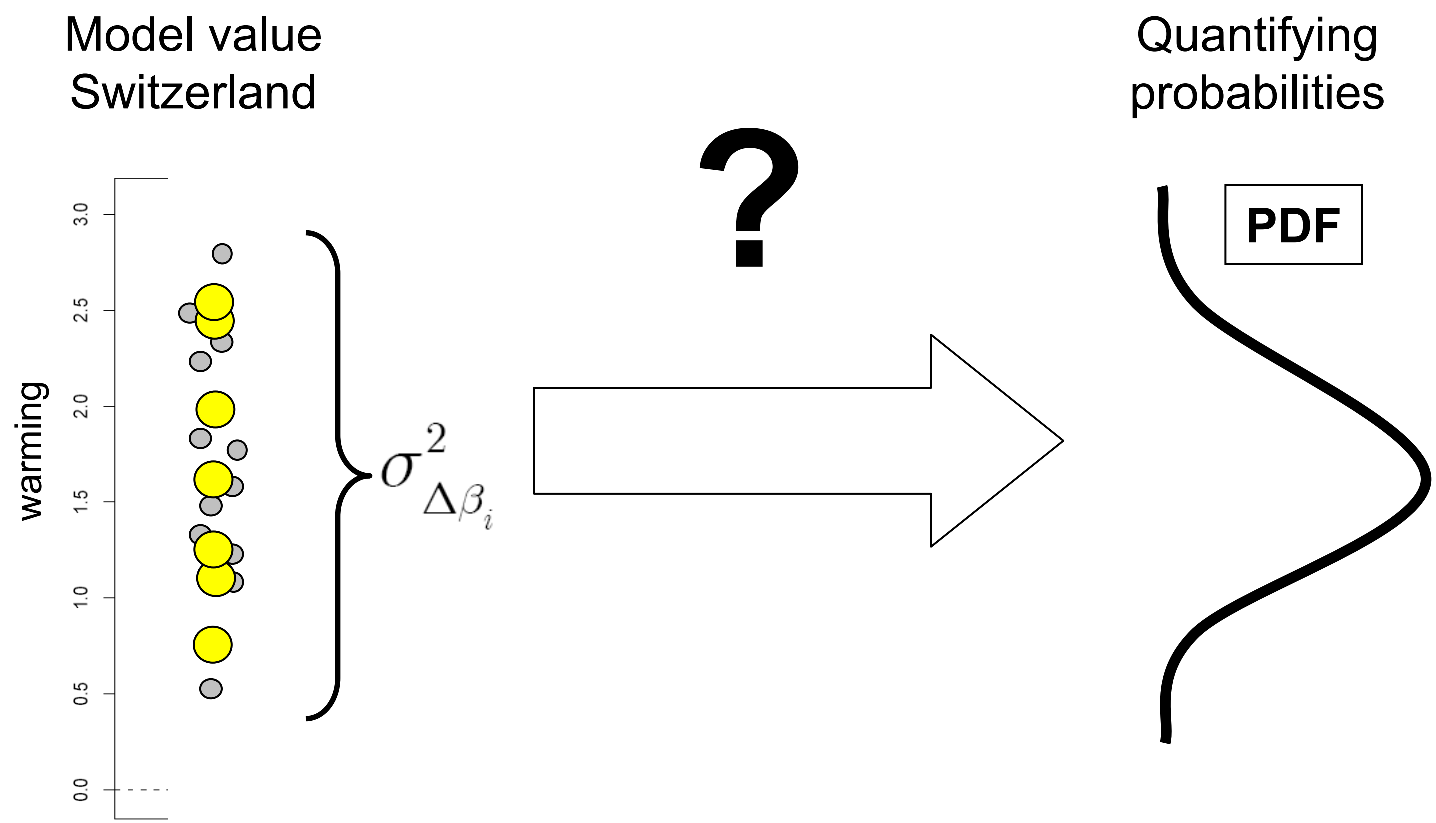
Statistical model

Weights

Correlations

Bias

Multimodel projections



CH2011: ENSEMBLES model chains fully sample model uncertainty

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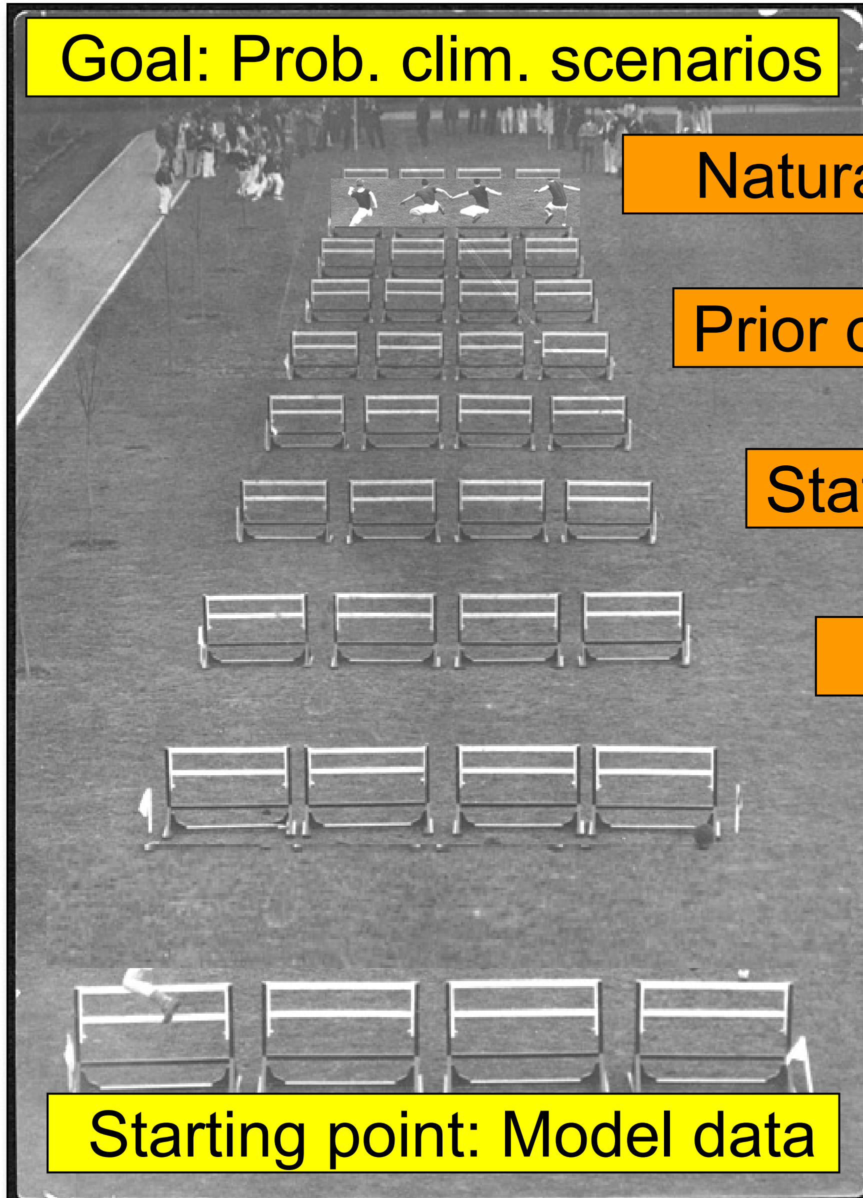


Natural variability

Prior of model error

Statistical model

Weights

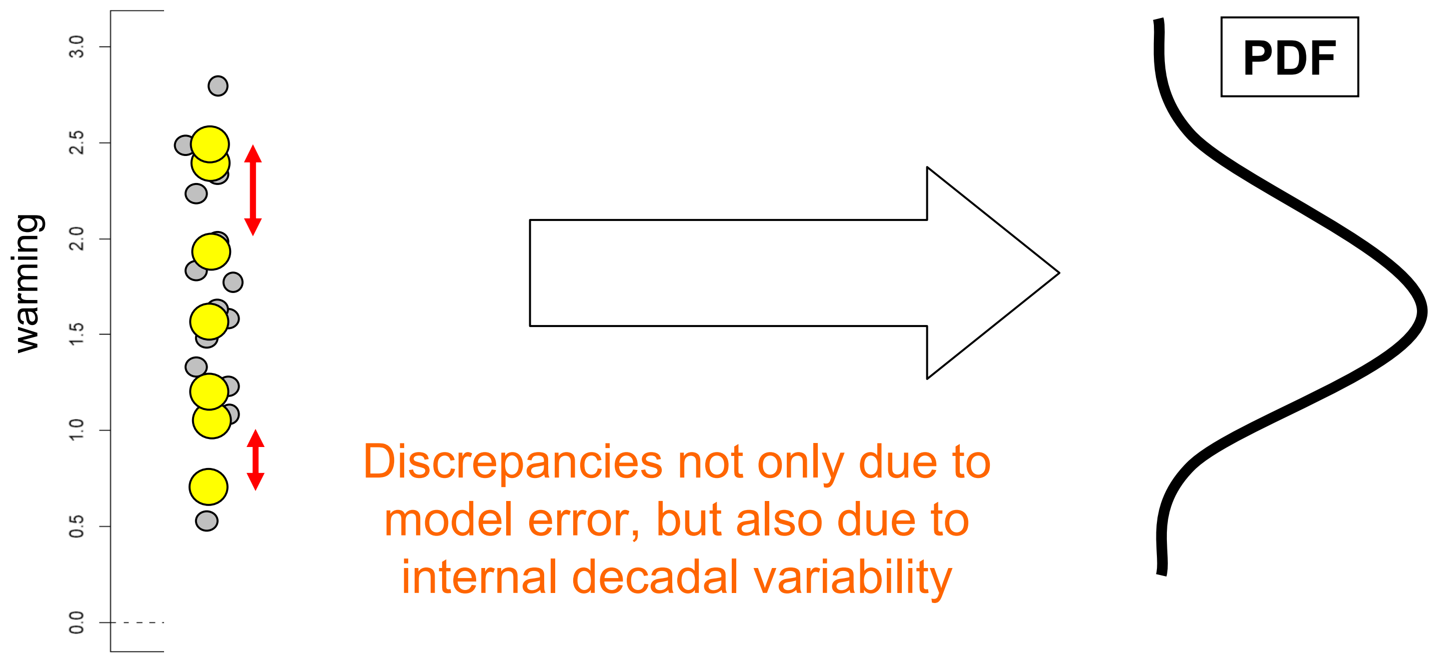
Correlations

Bias

Multimodel projections

Model value Switzerland

Quantifying probabilities



Discrepancies not only due to model error, but also due to internal decadal variability

Approach:	1. Filter out internal variability (Hawkins and Sutton 2009) 2. Bayesian model combination 3. Re-add internal variability

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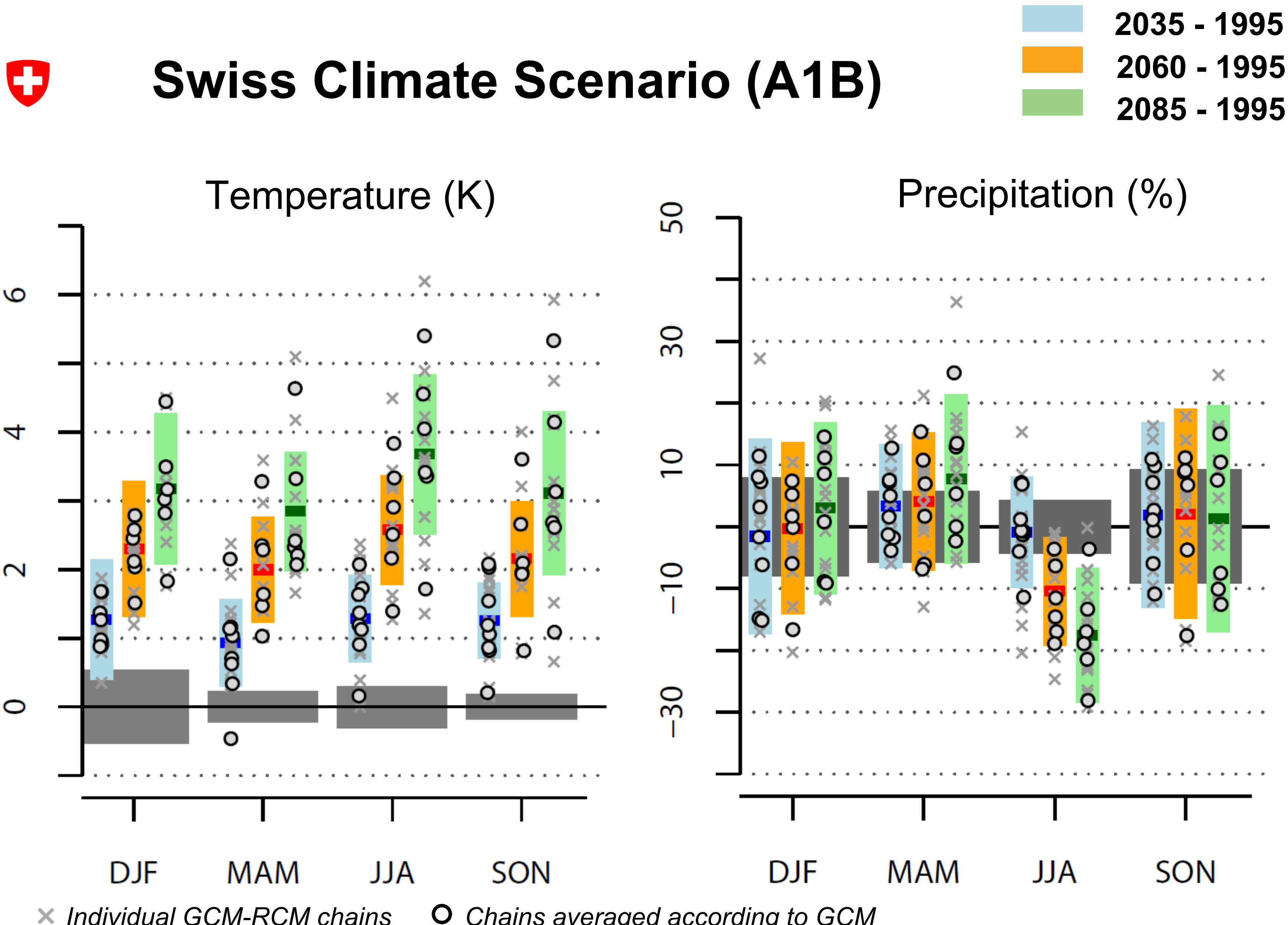
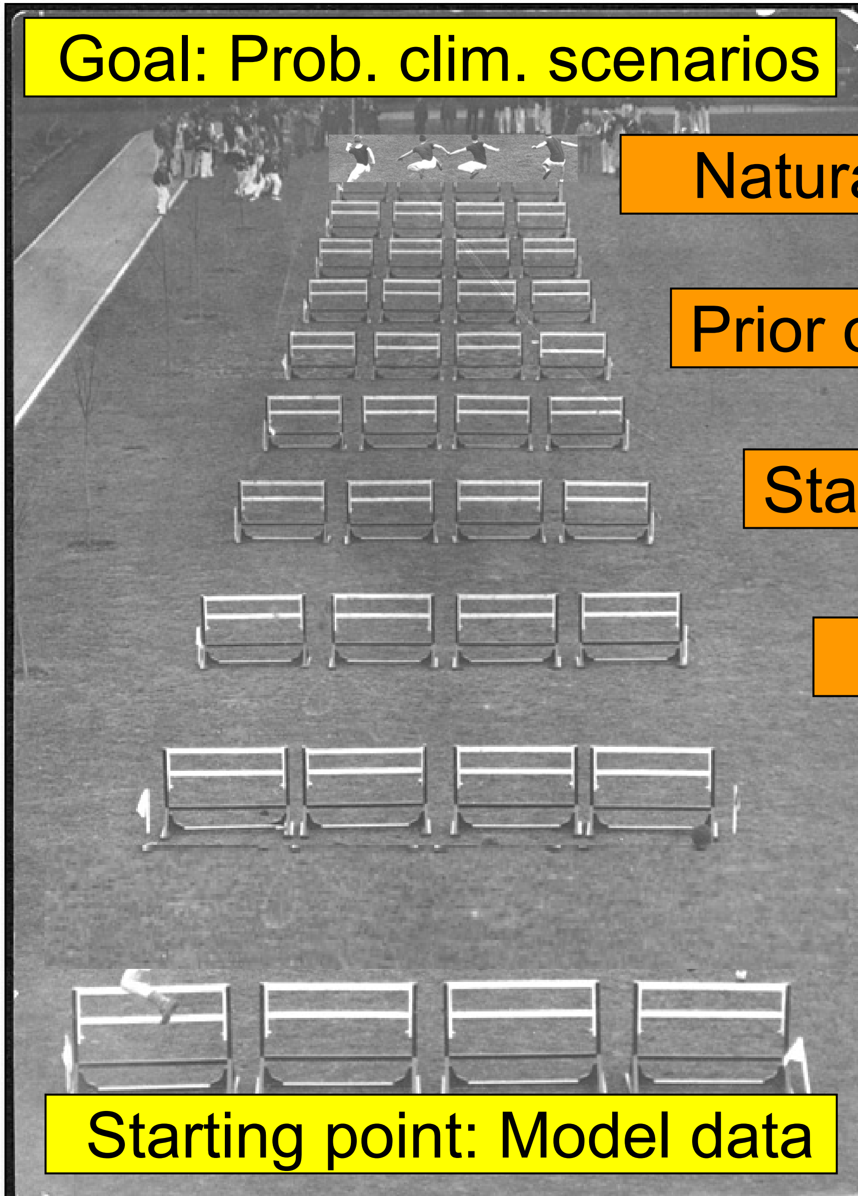
Swiss Climate Scenario (A1B)



A. Fischer et al, 2011, in prep.



Natural variability

Prior of model error

Statistical model

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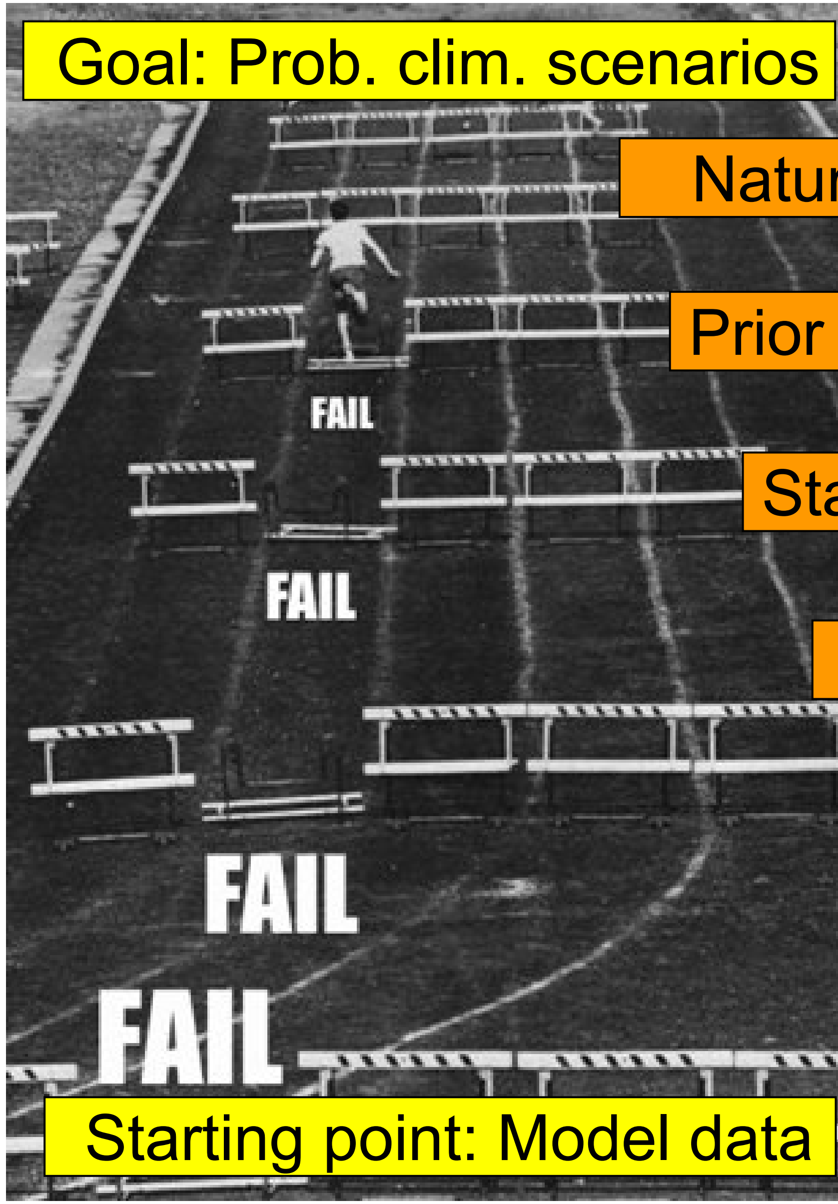
CH2011:

“Projection intervals should be interpreted as possible ranges of future climate evolution, which are consistent with the data at hand but may change as more information become available and more sources of uncertainty are included.“

Goal: Prob. clim. scenarios



Natural variability

Prior of model error

Statistical model

Weights

Correlations

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Starting point: Model data

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