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CLIMATE CHANGE RESEARCH

Exploring nearly one-in-a-millennium scenarios of extreme rainfall through dynamically downscaling palaeoclimatic simulations

Juan José Gómez-Navarro, Christoph Raible,
Sandro Blumer and Olivia Martius

September 1, 2015

- 1 Motivation and modelling framework
- 2 Downscaling results and bias correction
- 3 Caveats and outlook

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- Produce severe damages (relevant to insurance companies)
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- Produce severe damages (relevant to insurance companies)
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... but challenging

- Infrequent by definition
- Requires having long series we do not have
- **We try to do something in this respect (with models!)**

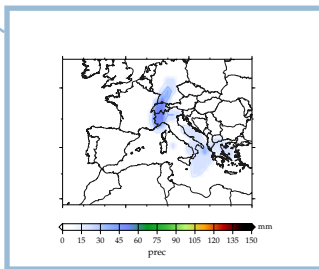
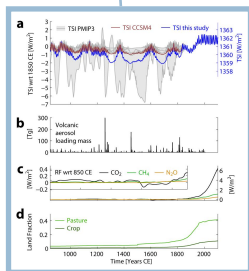
Model chain

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GCM
CESM

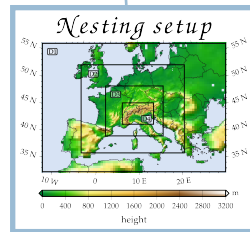
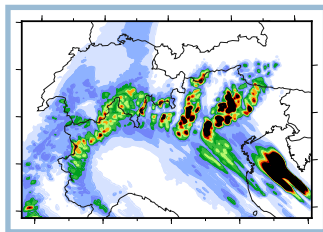


Model chain

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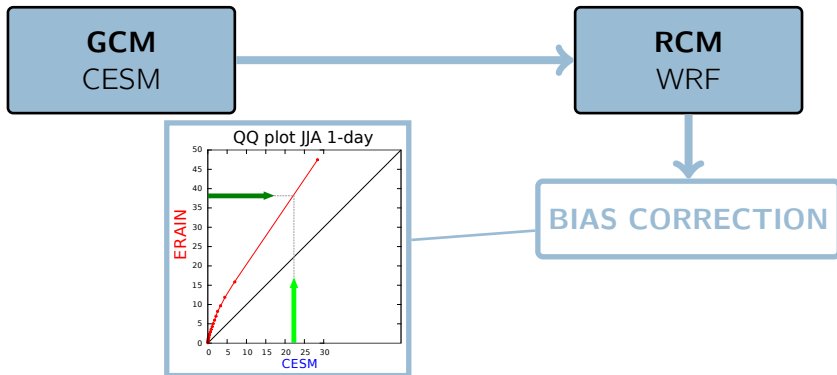


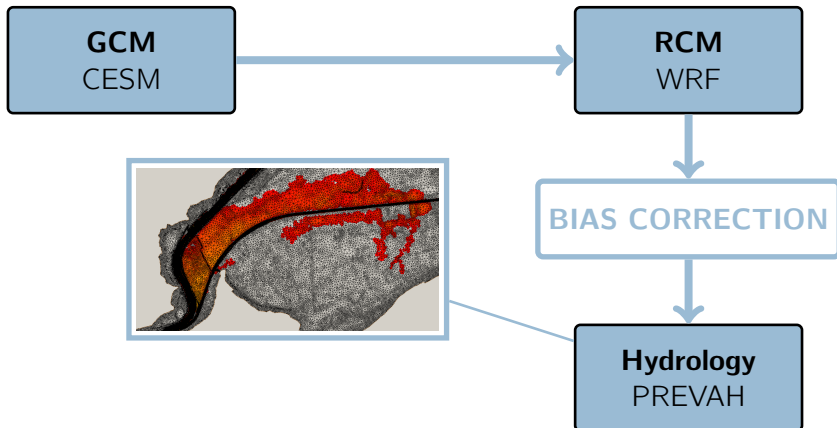
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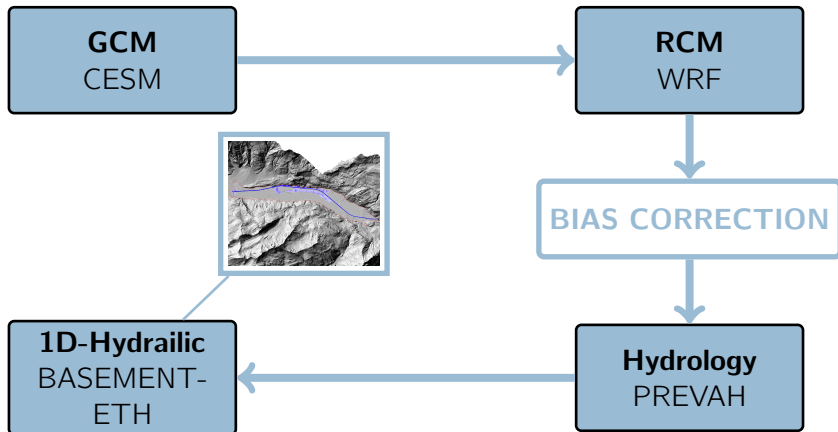


Model chain

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GCM

- CESM run in the University of Bern
- Transient simulation: fully coupled atmosphere & ocean driven by external forcings
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RCM

- Weather Research and Forecasting model (WRF)
- Four nested domains down to 2 km
- Convecting-resolving resolution: **no convection parameterization**

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The problem

- It is **NOT** possible to run 1000 years of 2 km-resolution simulation!
- Alternative: select "interesting dates" a priori within the GCM... **but how?**

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Solution #0

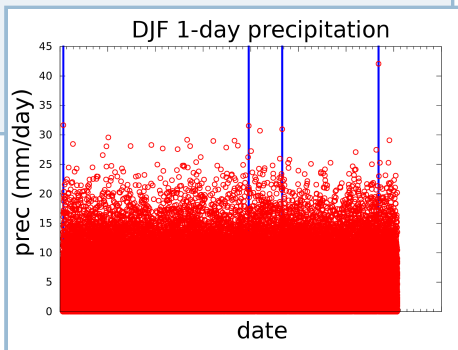
- A region over Switzerland is selected (12 grid points in the GCM)
- The precipitation over this region is used to select events
- Simple, but ignores the drivers of precipitation

Algorithm

- The 4 most rainy days are selected

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- Independently for each season (to minimise systematic errors arising from GCM biases)

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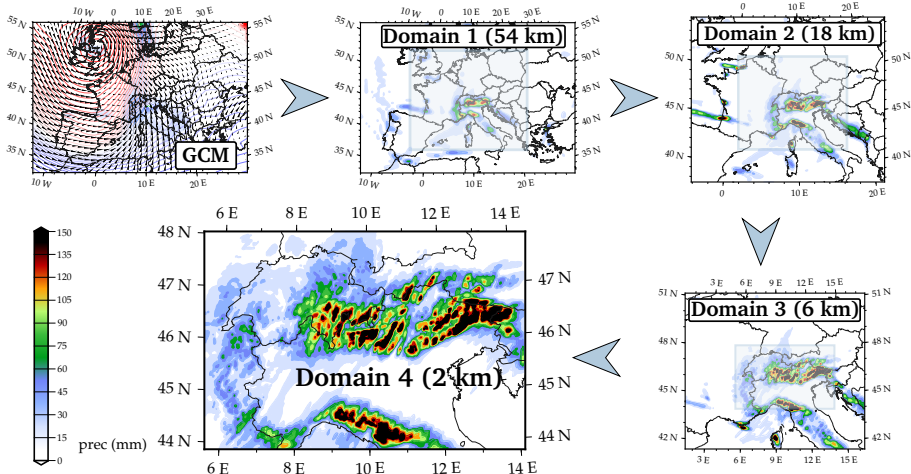
This results in $4 \times (1 + 2 + 3 + 5 + 10) \times 4 = \mathbf{336}$ simulated days, which is feasible

Downscaling Results

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Bias correction: generalities

In some applications, biases are not critical (e.g. delta approach),
BUT as part of the model chain, biases are crucial (non linear
processes)

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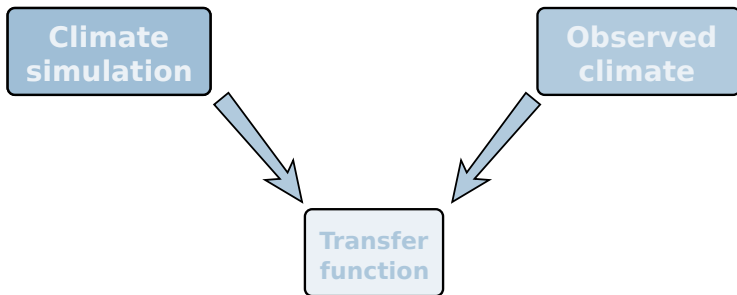
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**Climate
simulation**

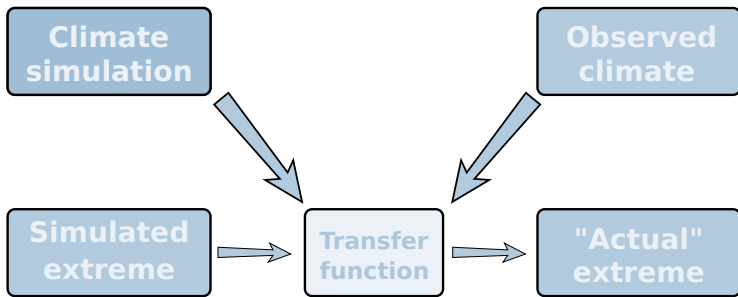
**Observed
climate**

Bias correction: generalities

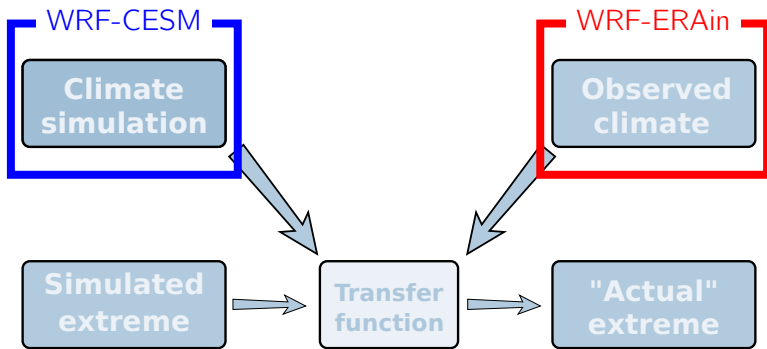
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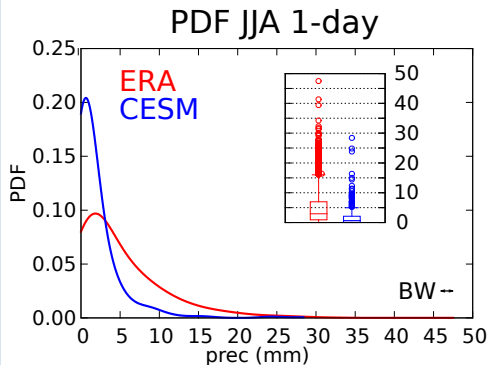
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Bias correction: examples



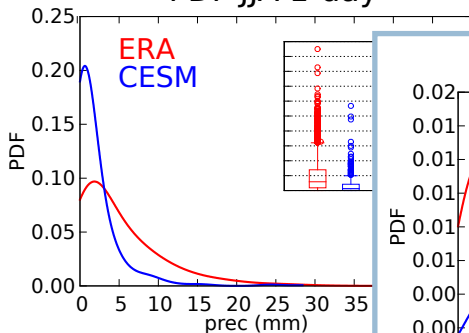
Bias correction: examples

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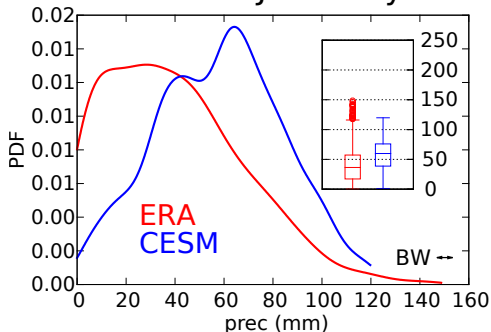
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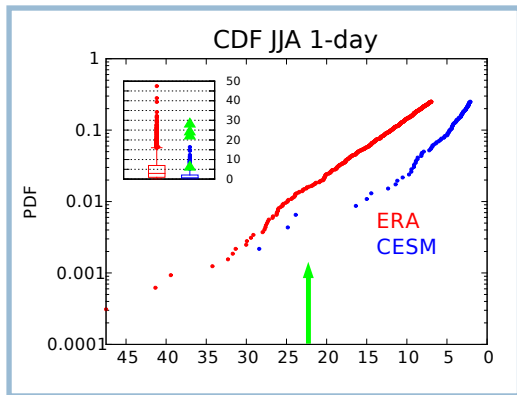
PDF JJA 1-day



PDF DJF 10-day



Bias correction: fitting the CDF

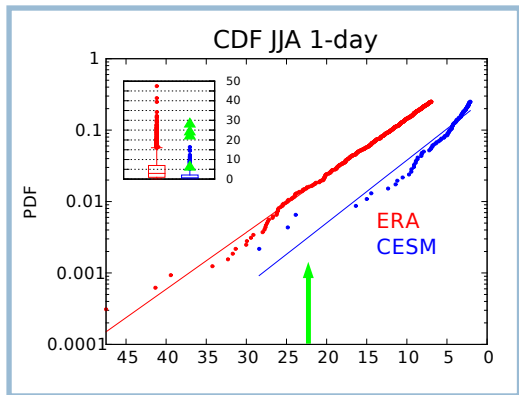


Bias correction: fitting the CDF

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$$\text{PDF} = Ae^{B \cdot \text{prec}}$$

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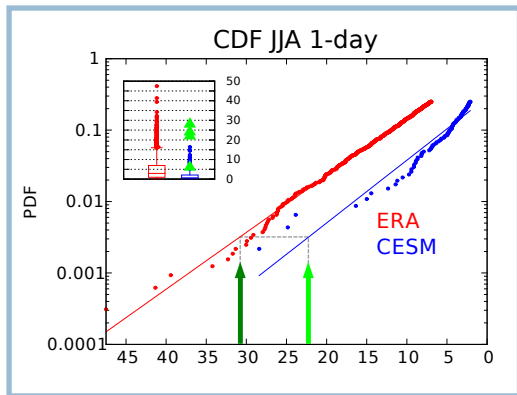
$$\overbrace{\ln(\text{PDF})}^y = \ln A + B \cdot \overbrace{\text{prec}}^x$$

Bias correction: fitting the CDF

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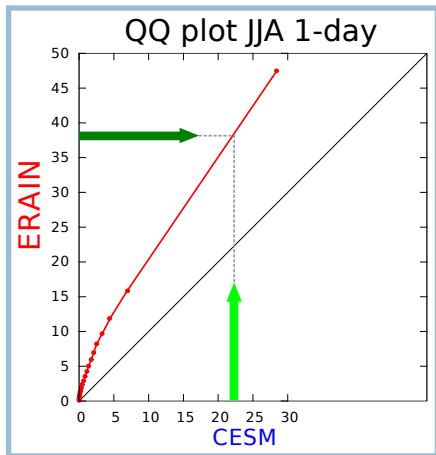
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Bias correction: Quantile mapping

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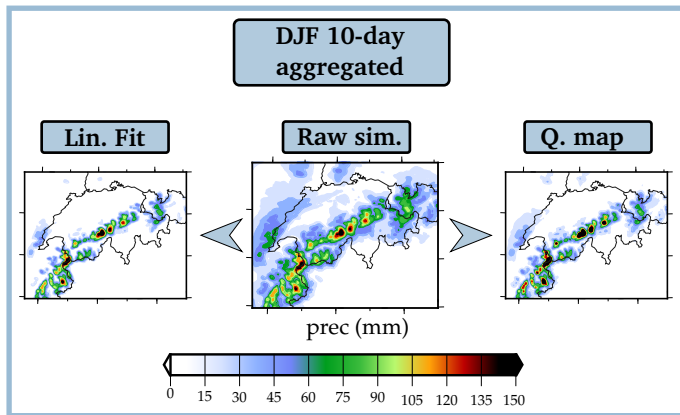


Bias correction: Results

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Limitations we are aware of

- The dataset used to remove biases is not itself unbiased \Rightarrow use observations instead of model data

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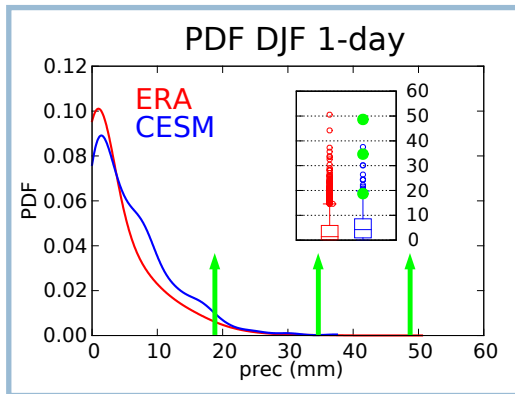
- The dataset used to remove biases is not itself unbiased \Rightarrow use observations instead of model data
- The number of cases is limited \Rightarrow downscale more cases
- Bias not systematic, but seasonal- and event-dependent \Rightarrow seasonal analysis
- We do not search for the physical mechanisms underlying events \Rightarrow split the analysis for each type of event (e.g Vb-events,...)???

How extreme are the "extremes" we pick?

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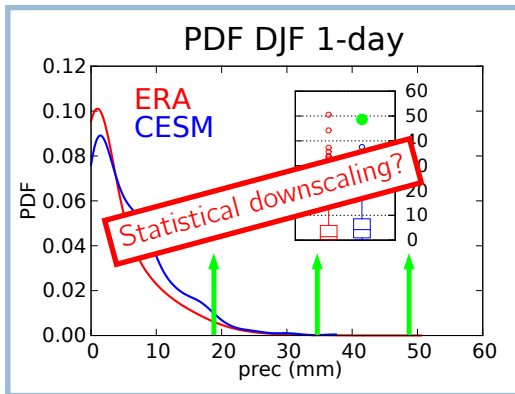
The "extremes" we previously selected within the GCM are not so extreme once downscaled

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The "extremes" we previously selected within the GCM are not so extreme once downscaled

- Novel methodology that allows to simulate unprecedented, yet physically based extreme situations
- Although model data, the climate information is bias-free
- Most technical challenges (in the climate models, but and also in the hydrological models) already addressed
- Further research is required to consistently remove biases of unprecedented events
- The selection of the dates needs to be considered more carefully, and more robust methodology should be developed

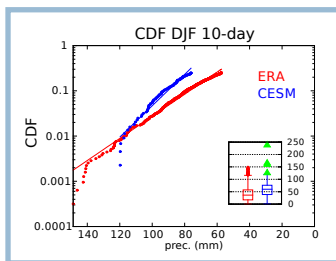
Methodological uncertainties to address

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- The CDFs not always line up



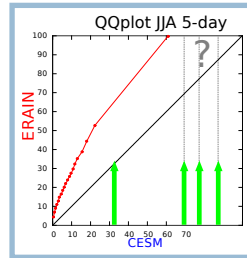
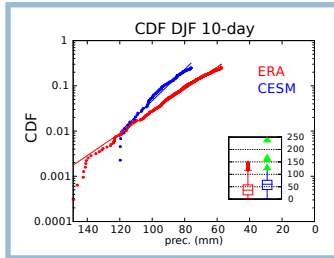
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Methodological uncertainties to address

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- The CDFs not always line up
- Quantile mapping is ill-defined for extremely infrequent events
- Should the transfer function be calibrated for each grid point? Separately for each region (regionalisation)?

