Analysis of the robustness of climate change results with respect to the ensemble size

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Statements about possible future climate change are usually based on ensembles of model simulations. But, the question rises how many simulations are adequate to derive a robust assessment of the bandwidth of a climate change signal?
Let's assume that an available large ensemble of simulations represents the "knowledge" of climate changes bandwidth. The goal of the introduced method is to **determine the minimum ensemble size of a drawn random sample, which still obtain a reliable bandwidth of the full ensemble**.

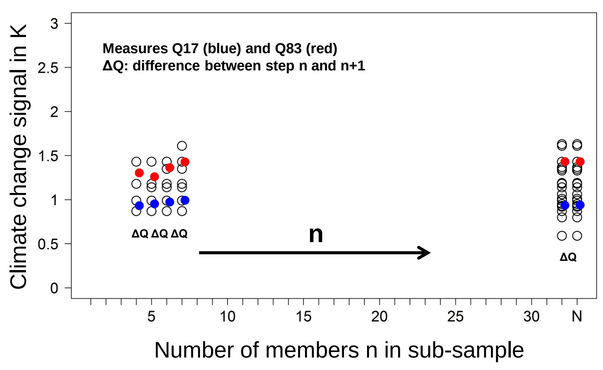
Method

Method: Testing the convergence of the range of climate change, while the size of the drawn sample is enlarged successively

First, a measure has to defined, representing the bandwidth of climate change of a special quantity. Here the quantiles Q17 and Q83 are used to represent the characteristic of the full ensemble according to the "likely"-range of 66% in the IPCC report.
Results analyzing a trial ensemble of 33 simulations (mixed RCP and SRES scenarios) of 2m-temperature 50 year climate change signals over Germany are shown here.

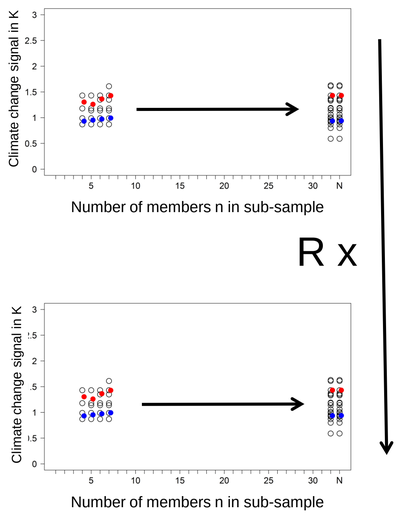
1. Procedure

- A sample of n elements (starting with 4) is drawn randomly with replacement from the full ensemble
- Enlarge successively the drawn sample by 1 element up to the total number N
- Compute the measures Q17 and Q83 for all n=4,…,N
- Compute the difference ΔQ of Q17 and Q83 between all steps n and n+1
- For all steps n → n+1: test, whether ΔQ exceeds a criterion ε (e.g. 5% of median). If ΔQ < ε, the range of the full ensemble is sufficient reproduced .



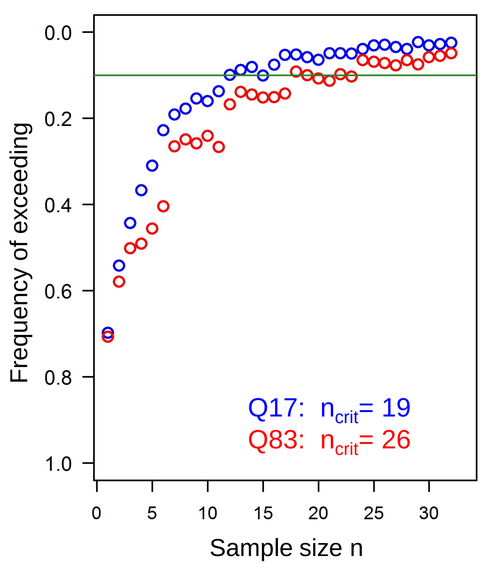
2. Resampling

- The procedure is repeated R-times
- Count the number of exceedances U_n for each step



3. Test

- Test, if the frequency of exceeding U_n is smaller than a value allowed (e.g. V_{crit} = 10%) for each step
- The smallest step $n=n_{crit}$ where the condition $U_n < V_{crit}$ is fulfilled for this and all following steps is the minimum ensemble size which represents the full ensembles bandwidth.

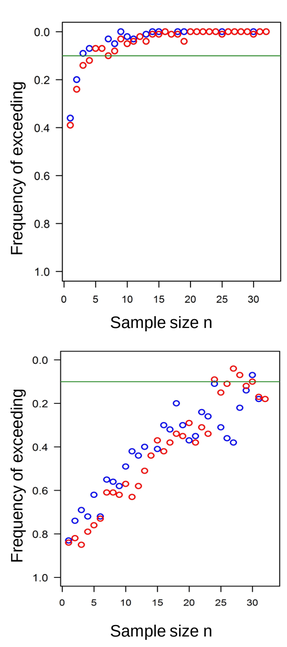


Dependency on parameters

The minimum ensemble size n_{crit} depends on parameters, which have to be defined:
Measure: range of climate change, e.g. quantiles Q17 and Q83
criterion ε: for the difference between step n and n+1, e.g. 5% of median
frequency of exceeding allowed: e.g. V=10%

The figures on the right side show results for two artificial examples with different width of the distribution function.

If a higher accuracy of the reproduced range is required, the parameters ε and V have to set to smaller values. So, the range converges later (or never) and more simulations are need.



Outlook

Up to now just climate 30-year means are used as input data. A further resampling step will included to introduce the effect of internal variability in to the consideration. For this, the 30-year means will computed by drawing (with replacement) 30 single annual means out of the original data.

ReKliEs-De project: investigate a large ensemble RCP8.5-driven simulations from EURO-CORDEX framework and additional simulations conducted in the ReKliEs-De project.

ReKliEs-De
Regionale Klimaprojektionen Ensemble für Deutschland

GEFÖRDERT VOM
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