Selecting regional climate scenarios for impact modelling studies

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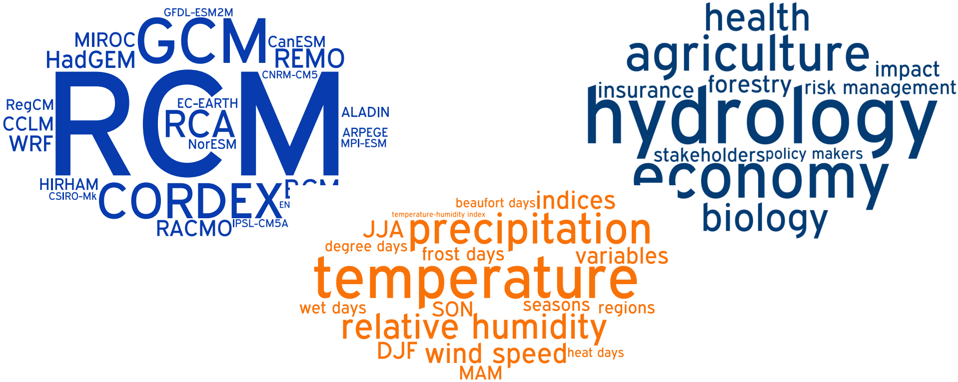
Motivation

Climate model output data are applied within climate impact studies



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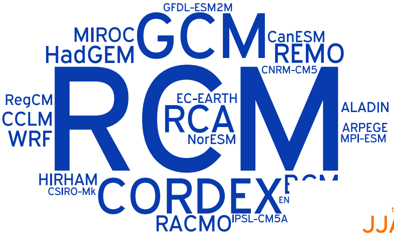
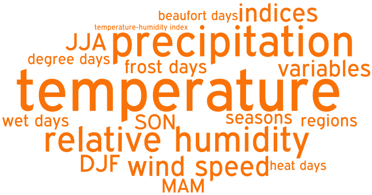




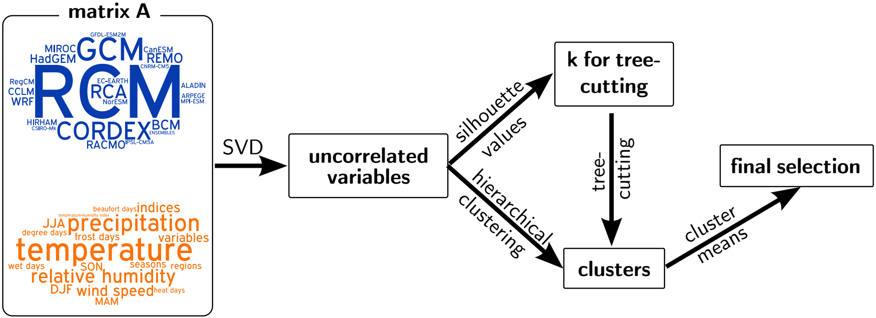
Common issue: Climate model ensemble is bigger than what can/want/will be used by impact modellers

Idea

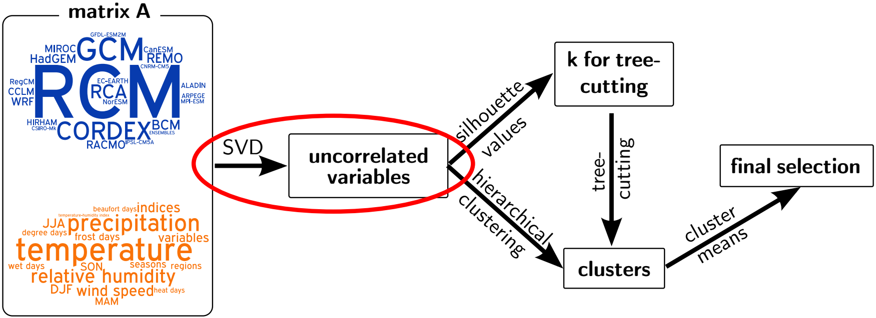
See also poster of **Thomas Mendlik: Wednesday Y85, 17.30-19.00, Session CL5.5**
Ensemble reduction in five steps.

1. Identify user requirements (variables, seasons, regions).
2. Transform variables into uncorrelated (orthogonal) variables.
3. Calculate the optimum number of clusters.
4. Use hierarchical clustering to group the simulations.
5. Select the simulation closest to the group's mean as representative.

Selection process – sketch



Selection process – SVD



SVD

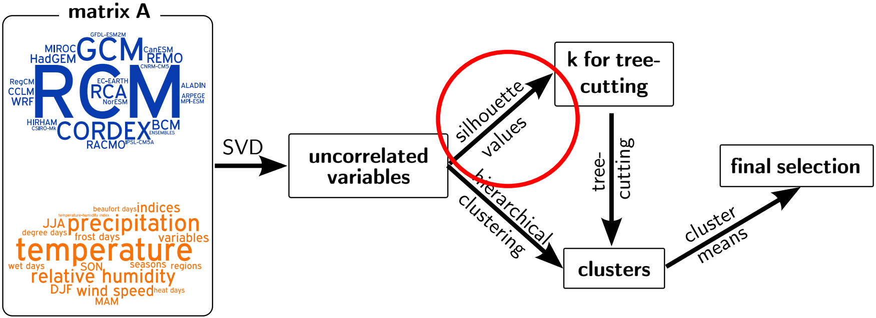
- Uncorrelate and reduce variables without loosing information.
- Transform to orthogonal vector space.

- Standardized data matrix $\mathrm{A} = \{a_{ij}\}$ with m models and n variables.

$$a_{ij} = \mathrm{ccs}\left(\langle sim_i(\phi_j)\rangle\right), i \in [1, m], j \in [1, n]$$

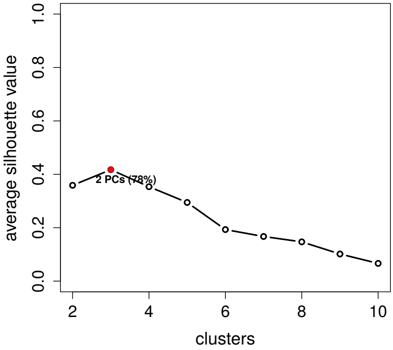
E.g. a_{ij} can be the CCS of temperature from one simulation averaged over Austria and averaged over summer months.

Selection process – How many simulations to select?



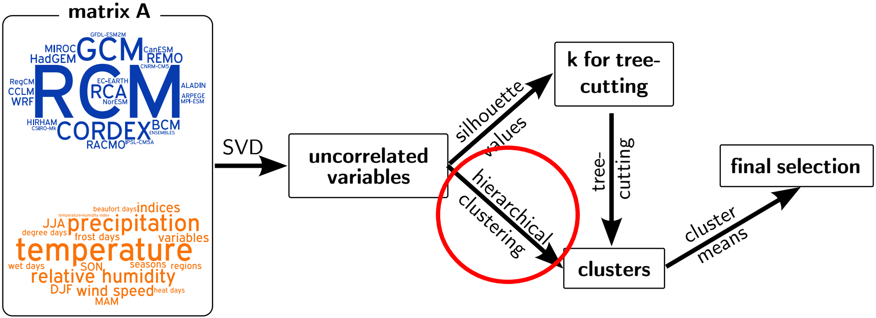
Optimum size of subset

- Silhouettes (Rousseeuw, 1987): distance measure (point to all other points in different clusters).
- Testing for different number of clusters
- Quantity of interest: highest average silhouette value



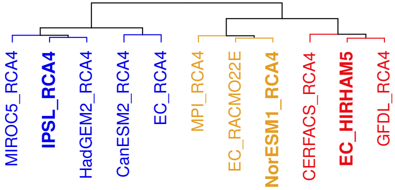
Rousseeuw, P. J. (1987). Silhouettes: A graphical aid to the interpretation and validation of cluster analysis. *J. Comput. Appl. Math.*, 20(0):53–65.

Selection process – Hierarchical clustering

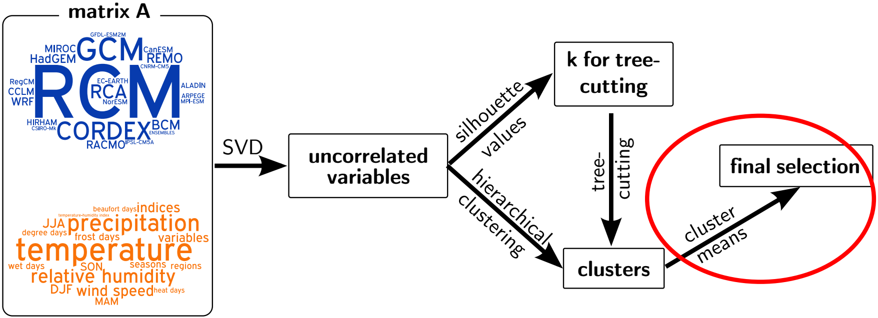


Hierarchical clustering

- Applied to euclidean distances between PCs
- Bottom-up, starting with m clusters
- Clusters built by minimizing distances
- Distance representing similarity

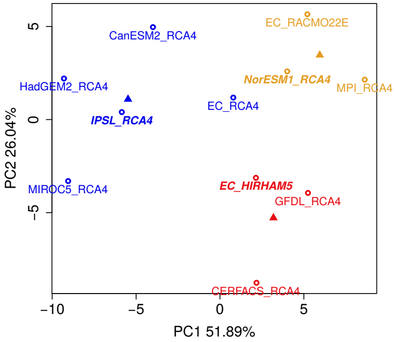


Selection process – Selection



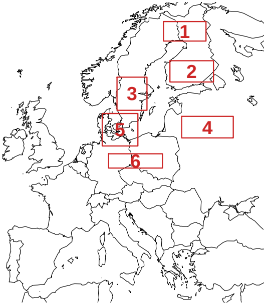
Selection from clusters

- Cluster represents group distinct from the others
- Multidimensional **means** represent clusters
- Selection: Simulations closest to cluster means
- Clusters with only 2 members: arbitrary choise



Ingredients for variables

ϕ	*seasons*	*regions*
mean temperature	winter	region 1
min temperature	spring	region 2
max temperature	summer	region 3
precipitation	autumn	region 4
rel. humidity	annual	region 5
wind speed		region 6
beetle degree day		
exceeding threshold		
frost days		
wet day frequency		
Beaufort day		



Example study

- CCS: 2069–2098 vs. 1971–2000,
- 6 regions Northern Europe,
- 4 seasons

Example 1:

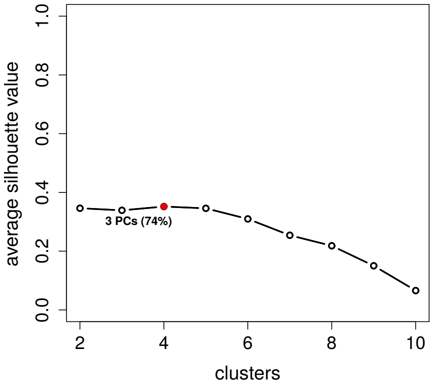
- temperature (tas) & 2 indices,
- precipitation (pr) & 1 index

Example 2:

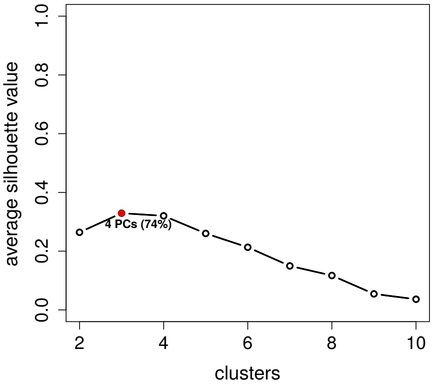
- relative humidity (hurs),
- precipitation (pr) & 1 index

Example study

Example 1 (tas,pr,ind)



Example 2 (hurs,pr,ind)



Example study

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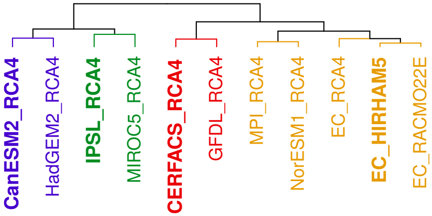

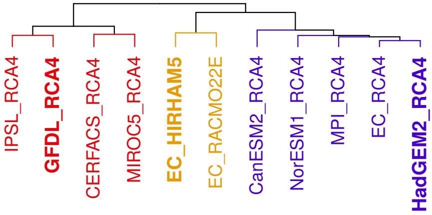

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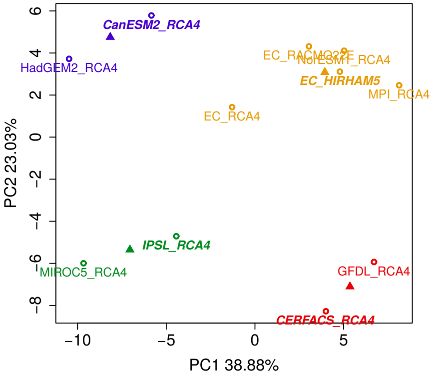
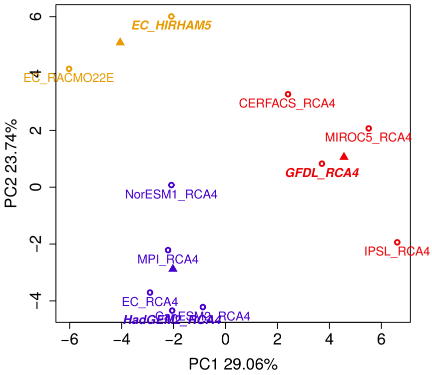


Example 2 (hurs,pr,ind)

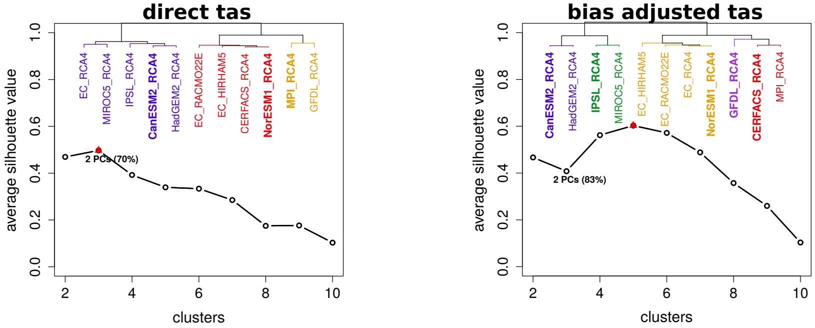


Results

- Many combinations of variables analysed.
- 3 CCS periods analysed (separately).

- High sensitivity to choice of variable.
- CCS of temperature is dominating clustering.
- Temperature dominates NOT final selection.
- Experiments without temperature sensitive to indices.
- Influence of CCS of clim. indices stronger at end of century.
- Sensitivity to choice of period.

Effect of bias adjustment – outlook



- bias adjusted mean temperature (quantile mapping)
- 6 temperature threshold indices (degree days)
- Rockel boxes, CCS: 2069–2098

Summary

- Sensitivity to input information (variables, region, ...).
- Importance for application.
- Sensitivity to bias adjustment $\rightarrow$ relate to impact study?
- Method reduces an ensemble if needed.
- No statement about the quality of the simulations.

Outlook

- Ongoing: evaluation and application within different climate impact studies with bias adjusted data.
- Information about single periods (non CCS) will be included.
- Inter-variable relation: Use of multi-variate indices.

Set-up – simulations

Table : 11 GCM-RCM combinations from EURO-CORDEX RCP8.5 on 0.44° grid.

GCM	RCM
CanESM2	SMHI-RCA4
CERFACS CNRM CM5	SMHI-RCA4
IPSL CM5A MR	SMHI-RCA4
MIROC5	SMHI-RCA4
HadGEM2-ES	SMHI-RCA4
M-MPI-ESM-LR	SMHI-RCA4
NorESM1-M	SMHI-RCA4
GFDL-GFDL ESM2M	SMHI-RCA4
EC-EARTH	SMHI-RCA4
EC-EARTH	DMI HIRHAM5
EC-EARTH	KNMI RACMO22E