

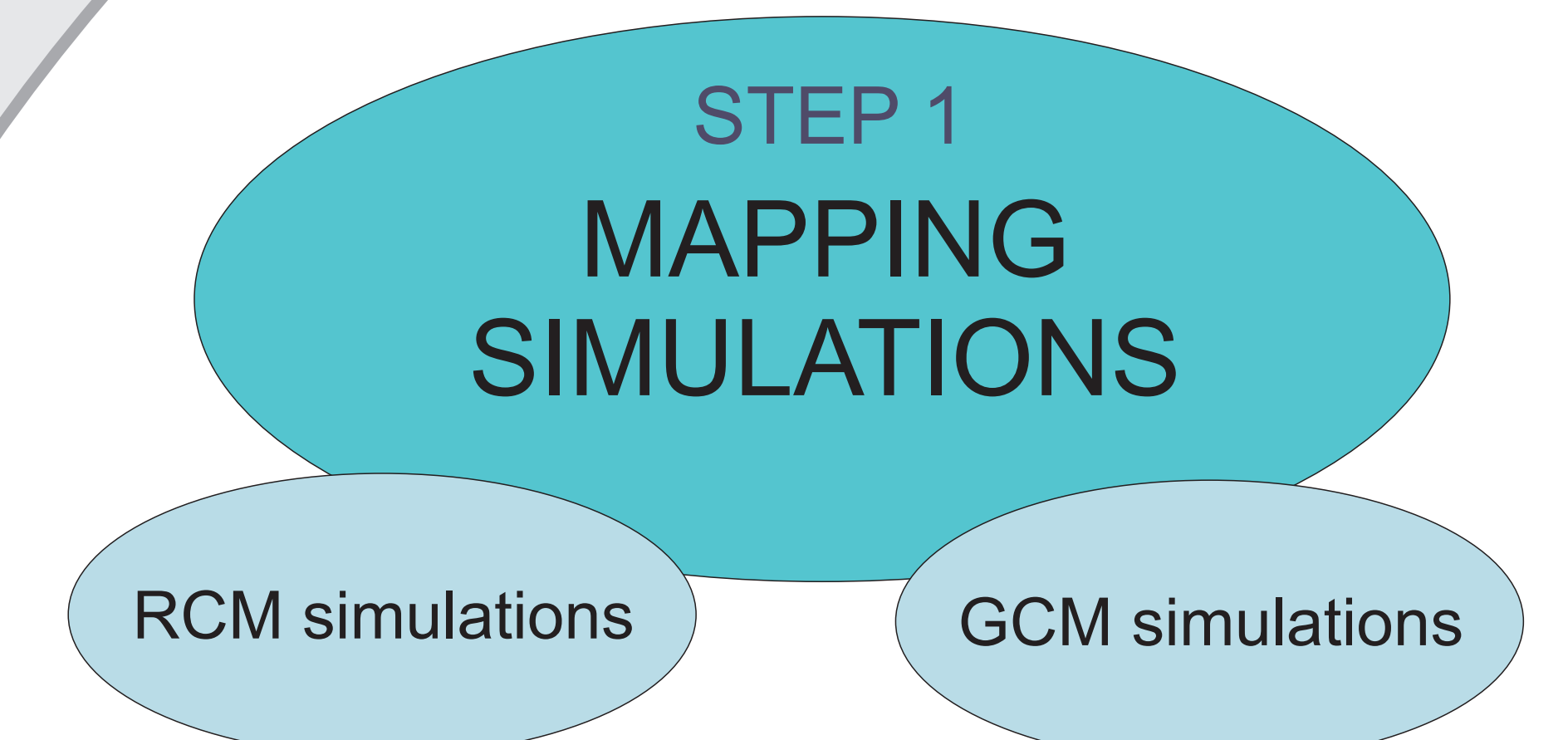
On procedures for model selection in providing climate scenario data for impact studies - A challenge to both communities



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INTRODUCTION
 Most impact studies require climate change information provided from climate simulations. To give the most useful information, the climate model data need to fulfill various requirements related to the respective impact studies. In many cases there is a discrepancy between what climate models can provide and what the impact models need. Thus, compromises have to be made. Here we highlight some of the important considerations to make when shaping climate model output to fit impacts models based on examples from projects in which DMI participates, with a particular focus on the FP7 projects MODEXTREME and IMPRESSIONS.
 MODEXTREME is an agricultural project, with the main purpose of improving agro-meteorological crop models. Climate data will be used for making estimates of future crop yields.
 IMPRESSIONS is a cross-sectoral project, which focuses on impacts and risks from high-end scenarios on global, regional and local scale. A wide spectrum of impacts are explored to supply decision-makers with consistent knowledge about consequences of high-end scenarios.



STEP 2: EVALUATING THE AVAILABLE SIMULATIONS
 Second step is to evaluate the available simulations. If any of the simulations display outlier behaviour, it can be wise to exclude them from the study. In addition it should be assessed if the output is of sufficient accuracy for the impacts study in question or if bias correction is necessary. Evaluation requires observations, which in many cases only are available for a limited number of parameters, for limited areas or for limited timeperiods.

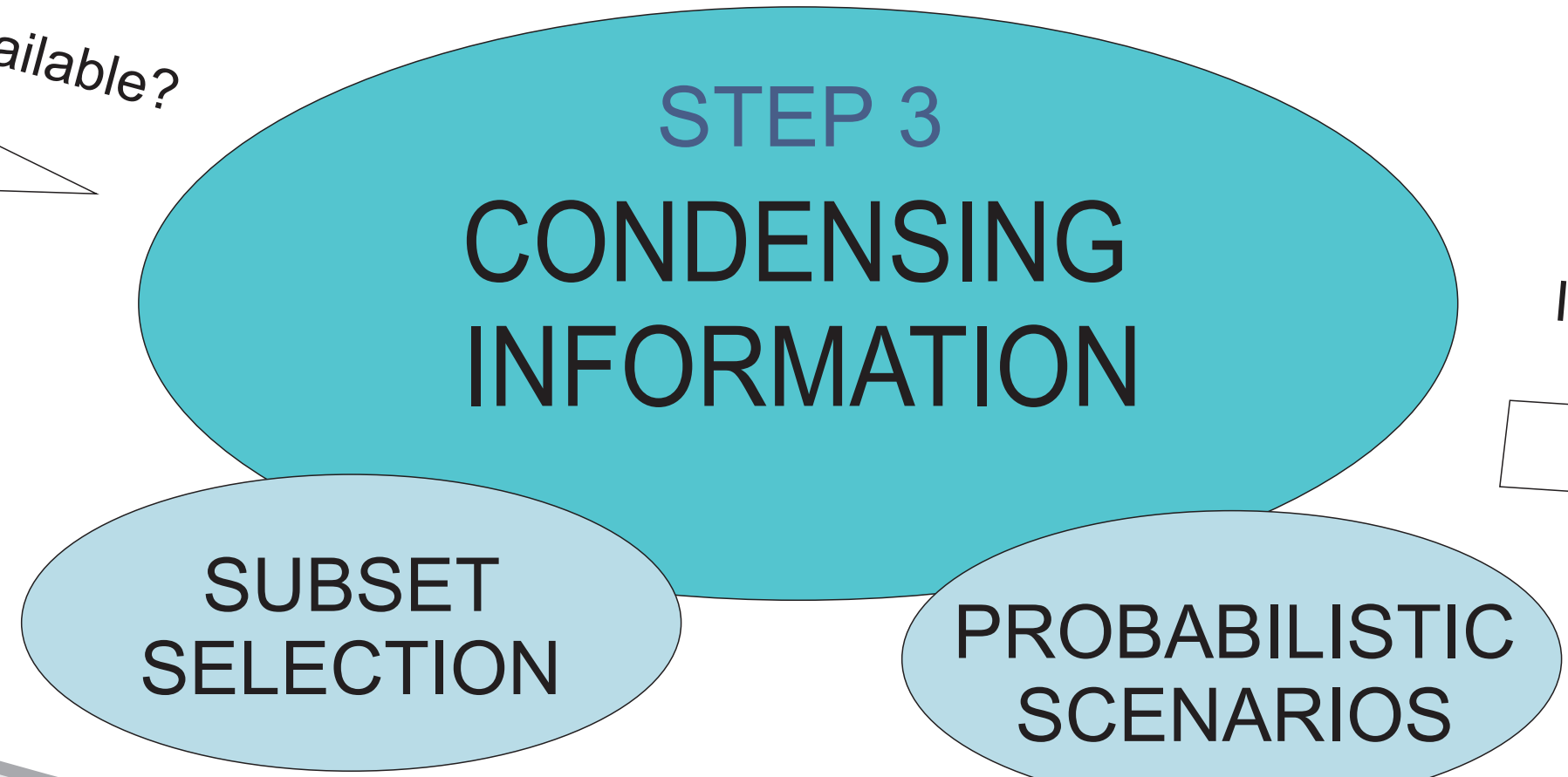
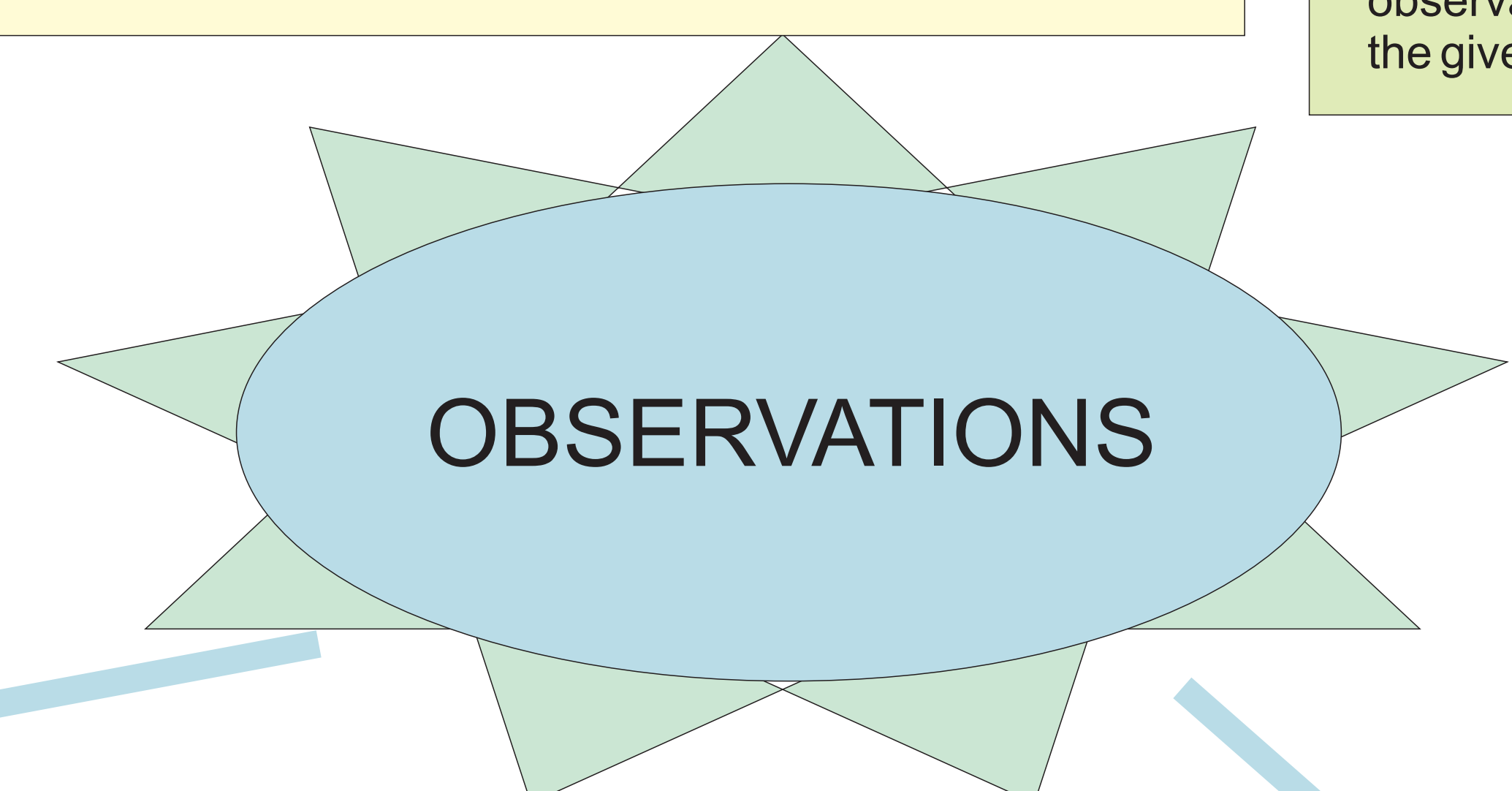
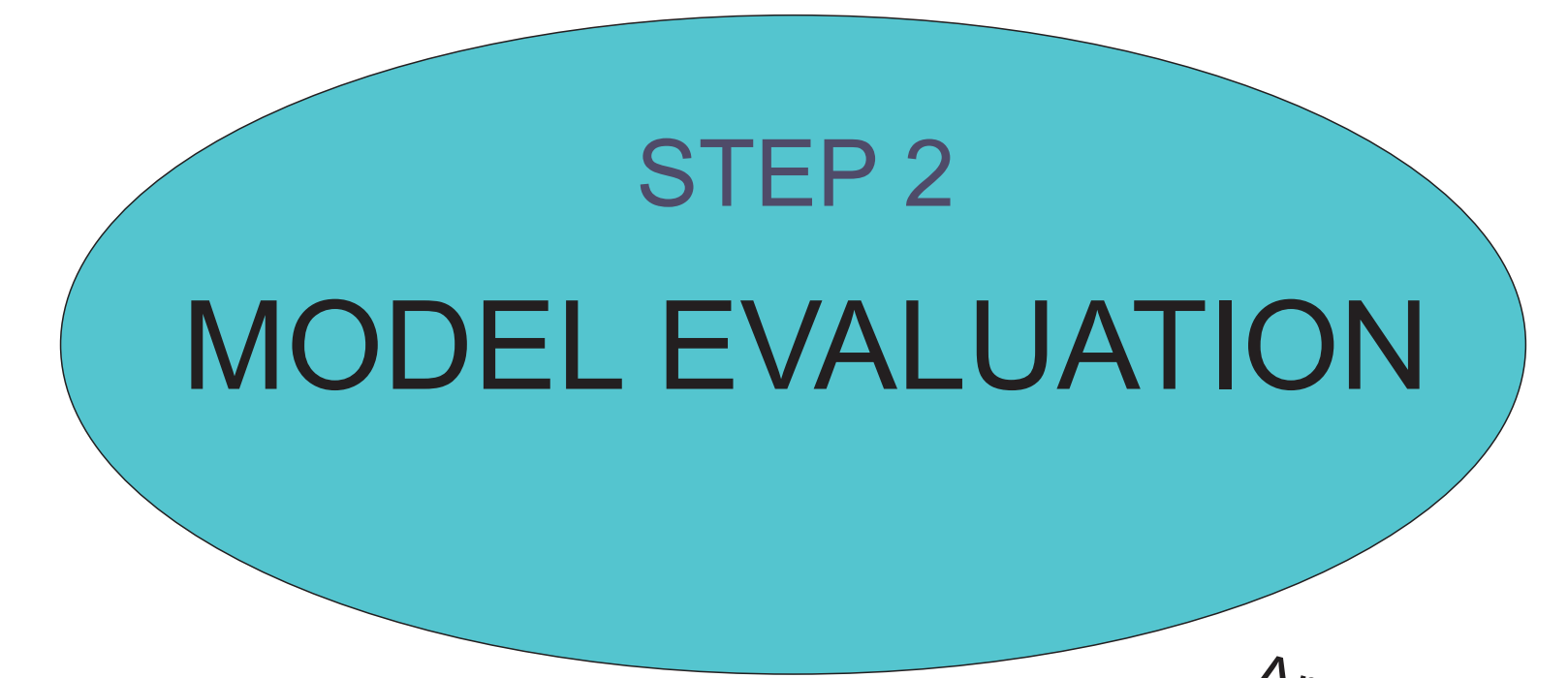
EXAMPLES
 - In MODEXTREME it was decided to exclude two of the 11 CORDEX-EUR11 simulations from the study due to missing data at the time of analysis and (too) extreme behaviour.
 - In both MODEXTREME and IMPRESSIONS bias correction of basic atmospheric variables is made to provide suitable data for highly calibrated impact models.

STEP 4: CORRECTING MODEL BIAS
 Many impact models are highly calibrated and depend on input which has considerable smaller bias than climate models output. This issue is most often addressed by using either bias correction, in which the climate model output is corrected, or by the delta change approach, in which only the climate change signals from the climate models are used. However, bias correction is not always necessary: Recent experiences from CRES have show that correction of the climate model output is not always necessary to obtain reasonable climate change signal from hydrological models.
 Most often some sort of bias adjustment is made, and at this step a decision has to be made on which method to use. Using bias correction has the potential of breaking the inter-variable dependency of the climate model output, which may be a problem for some impact models, so this issue also needs to be addressed. An evaluation of different bias adjustment methods can be found in Rätty et al., [2014].
 Both delta change and bias correction rely heavily on high quality observations which are not always available, of the necessary variables at the given locations. This is a strong limiting factor of bias adjustment.

EXAMPLES
 - In MODEXTREME an empirical statistical error correction using quantile mapping is applied to daily temperature and precipitation values, but obtaining observations to bias correct with has been a challenge in South America and Africa; here project partners running the impact models have supplied their own station observations to make bias correction feasible.
 - In MODEXTREME both minimum and maximum temperature are bias-corrected leading to cases where the minimum temperature of a day are higher than the maximum temperature. This is corrected for posterior to provide a consistent data set.
 - In IMPRESSIONS, a delta change approach is applied for changes in monthly means, whereas daily data are bias corrected.

STEP 1: MAPPING AVAILABLE CLIMATE MODEL OUTPUTS
 In many cases impact modellers require climate model output of very high horizontal and temporal resolution of many variables of high accuracy. Thus reconciling expectations with actual possibilities is often a lengthy process at the beginning of projects.
 First step is to get an overview of which simulations are available, and whether to use GCM or RCM data. GCM data have the advantage of global coverage and the availability of a large ensemble, but the disadvantage of a relatively coarse resolution of 100-200 km. The RCMs have an advantage of higher resolution of 12-50km, but only cover limited regions and are (almost) unavailable in some regions. RCMs often offer data of a higher temporal resolution than GCM data.

EXAMPLES
 • In MODEXTREME climate change information is only needed at local scale, and the interest is on weather extremes which are best represented by RCM data at high spatial resolution, so RCM data are used for several different continents using CORDEX simulations. One challenge here has been to get hold of a sufficient number of RCM simulations for e.g. South America and East Asia.
 • In IMPRESSIONS both global, regional and local impact models are involved and it is important that the chosen scenarios are consistent across scales. Global scenarios are based on GCM output, whereas RCM data is used for Europe.



STEP 3: CONDENSING INFORMATION
 In many impact studies only output from 3-5 climate models can be applied. In cases where more climate models than this are available a decision has to be made regarding which simulations to use, and how to portray the spread and uncertainty of the ensemble. One widely used method is to make a subset selection, which can be done in several ways, e.g.:
 • By visual inspection
 • Principal Component Analysis and cluster analysis
 • By favouring certain properties e.g. high climate sensitivity
 Another approach altogether is to use probabilistic scenarios where statistical information about the full ensemble is condensed into a few probabilistic scenarios. In this case the impact model would need to be designed for probabilistic information.

EXAMPLES
 - In MODEXTREME 4 of the 9 EUR-11 CORDEX simulations were chosen using a PCA analysis, and by prioritizing the use of different driving GCMs, to find a subset that represents the spread of the full ensemble in the best possible way. Only precipitation was considered for the subset selection.
 - In IMPRESSIONS the focus is on high-end climate change and GCMs were selected to include models of high and low sensitivity. A second criteria was that RCM downscaling experiments should be available in the Euro-CORDEX archive.
 - In addition in IMPRESSIONS probabilistic scenarios are being generated.

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DMI as climate data provider
 During the past years DMI has been involved in several projects providing climate model data for impact studies including

- ENSEMBLES (EU-FP7)
- WATCH (EU-FP7)
- EMTOX (EU-FP7)
- CRES (DSF)
- HYACINTS (DSF)
- IMPRESSIONS (EU-FP7)
- IMPACT2C (EU-FP7)
- MODEXTREME (EU-FP7)