AQUACLEW case study progress report

Title of Case Study

Agricultural production in Central Denmark

Authors

Ernesto Pastén-Zapata, Hans Jørgen Henriksen, Torben O. Sonnenborg, Theresa Eberhart and Jens Christian Refsgaard,

Client Organisations

Central Region of Denmark
Aarhus University
SEGES
Danish Coastal Authority

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Water management issue

The challenges in this case study are to project the impact and uncertainty of climate change on the foundation for agricultural production. Climate change is expected to affect soil wetness during winter and spring, where more precipitation is foreseen, and dryness during spring, summer and early fall, where less precipitation is expected. More wetness/higher groundwater levels during winter and spring will adversely affect the field work in connection with sowing as well as crop growth on water logged fields leading to needs for increased drainage of fields, while dryer summers will adversely affect crop yield and lead to needs for increased irrigation. Hence, both flooding and drought will be examined with an integrated model with analysis of the resulting effect on the root zone moisture content, the groundwater level and the river discharge. Special focus is given to uncertainty of the projections of future conditions which is a function of both emission scenario, choice of climate model and agro-hydrological model uncertainty.

Use of Climate Data

Use of current climate services

The clients know about the national climate service (https://www.klimatilpasning.dk/). However, all clients perceive that this climate service is not updated, is not enough detailed and that adding of the most recent knowledge has been given less priority in the last years. Additionally, clients know about other national entities that provide climate change information, or focus on developing local models and climate services on a project level, which are not authoritative on the national scale.

The clients believe that the climate services should be useful at the local scale and the information provided by the current climate services does not fulfil that requirement.

Decisions based on climate data

As stated in the previous point, there is low confidence on the outputs from the current climate service, as it has not been updated in the last years. Therefore, it is not used in practice.

Nevertheless, the clients would like to have access to data in order to interpret it for the farmers, which are the end users and decision-makers. The clients think that the main information that could be obtained from the climate services are information about how much the farmers will achieve from irrigation in the future, how irrigation can influence on the discharge of streams and whether the farmers should invest in their land to obtain profits within the next 20-30 years.

Training received by the clients in using climate services

No training have been offered to the client

Preliminary Workflow Results

In Figure 1 the workflow of the project is shown.

Figure 1. Workflow outline of the project

The proposed workflow outline considers four main steps: climate change projections, hydrological impacts, risk assessment and adaptation measures. The preliminary results for each of the steps are described in the following lines.

Step 1: Climate change projections.

Along with staff from the Danish Meteorological Institute (DMI), GEUS selected climate model projections of precipitation and temperature from the Euro-CORDEX initiative. The selection intended to provide a wide representativeness of the available Global and Regional Climate Models.

The climate model simulations were bias-corrected using a direct method: distribution based scaling. The precipitation simulations were bias-corrected using a double Gamma distribution with a cut off threshold set at the 90th percentile and employing DMI's 10-km gridded observations a reference. Similarly, the temperature simulations were bias-corrected using the normal distribution and DMI's 20-km gridded observations as reference. Potential evapotranspiration was estimated using the temperature-based Oudin method at a 20-km grid.

As a result, we have bias-corrected simulations for precipitation, temperature and potential evapotranspiration for the entire of Denmark. These simulations cover the period from 1971 to 2100. Sixteen of the simulations are run under the Representative Concentration Pathway (RCP) 8.5 and five models are driven by RCP 4.5. A scientific peer-reviewed paper was the main output of this action.

A cross-validation analysis of the bias-correction method was developed for the region of the case study using precipitation simulations driven by RCP 8.5. The analysis covers different metrics related to the mean and extreme precipitation for the reference period and for the end of the century (Fig. 2). This work was presented during the General Assembly of the European Geosciences Unions in Vienna.

In addition, along with other partners, we are testing the bias-correction method. We mainly focus on determining if the method has a good performance under non-stationary conditions. Therefore, a new method is developed where we are setting a differential split sampling test for different bias correction methods using a set of climate models.

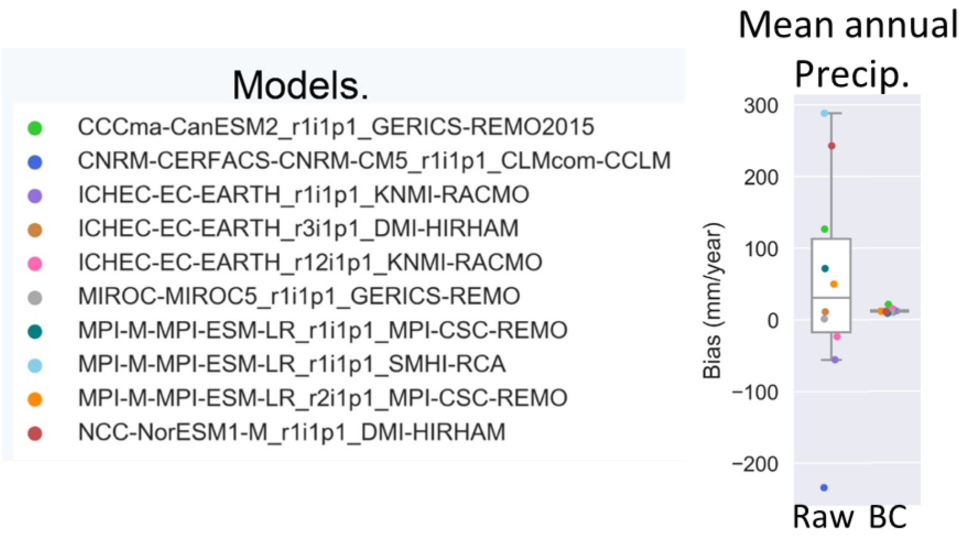

Figure 2. Cross-validation of the annual mean precipitation simulation for 16 RCMs driven under RCP 8.5 for the area 5 of the DK model. Results for both the climate models (raw data) and the bias-corrected data are illustrated.

Figure 3. Location of the Ahlergårde catchment, shown in blue

Furthermore, the uncertainty of the climate projections has been assessed for the Ahlergårde catchment (Fig. 3). This was done using the sixteen bias-corrected models driven by RCP 8.5. A new method is developed where the reduction of the uncertainty in the climate model projections focusing on discharge, groundwater head, soil moisture and evapotranspiration is evaluated. For instance, Figure 4 shows the reduction of uncertainty in the simulation of the 95th percentile of the discharge at the end of the century after removing climate models from the ensemble based on their simulation skill in the reference period. The analysis is part of a master thesis from a student enrolled at the University of Copenhagen and the University of Natural Resources and Life Sciences (BOKU) of Vienna, while carried out at GEUS. Highlights of this research will be presented during the Autumn Meeting of the American Geosciences Union in San Francisco.

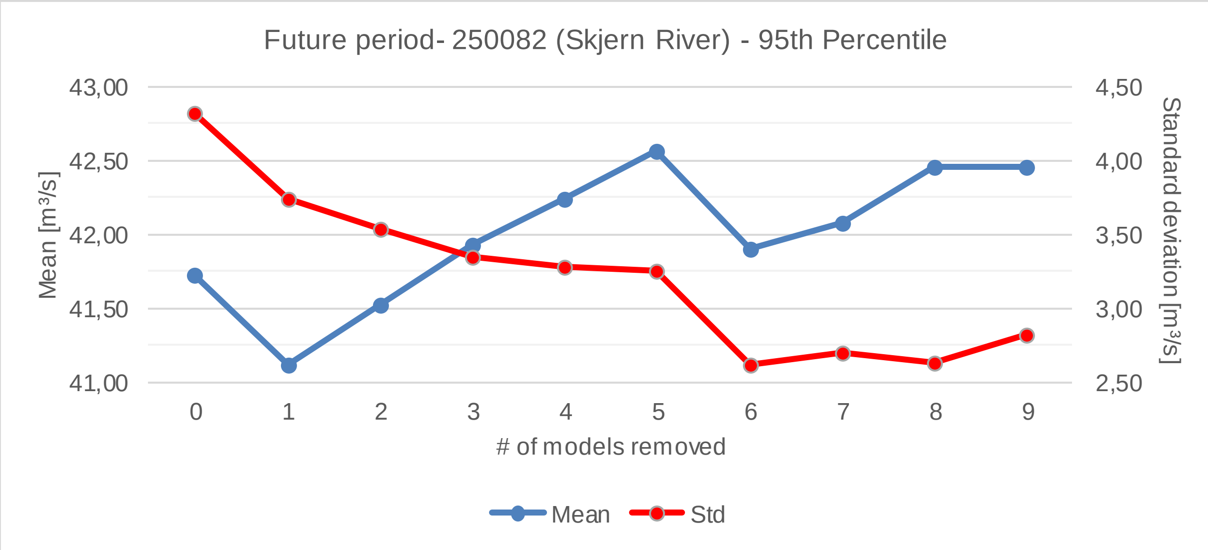

Figure 4. Reduction of uncertainty (standard deviation) for the 95th percentile of discharge in station 250082 of the Skjern River as a function of climate models removed

Step 2: Hydrological impacts (run hydrological models). Three alternative hydrological models are developed for the Storaa catchment (Fig. 5). All models are based on the MIKE-SHE model, but they have different conceptualization of the hydrological system, in specific the unsaturated zone. Some models have a relatively simple description, while others have more sophisticated descriptions. The simulation skill of each model is assessed using the observed discharge and groundwater head as reference. The aim of this approach is to discard models that could have low simulation skill for the variables of interest.

In addition, we are evaluating how good the models are to simulate the hydrology of a changing catchment. This is a new method and the main idea behind this approach is that the climate model projections indicate that precipitation will increase in the future. Therefore, we are testing whether our hydrological models are able to cope with such change and provide reliable simulations. Therefore, in practice, we calibrate the models within the three driest observed years and validate them for the three wettest observed years. We do this analysis for the three hydrological models described in the previous paragraph. The results from this step will be presented at the Autumn Meeting of the American Geosciences Union in San Francisco.

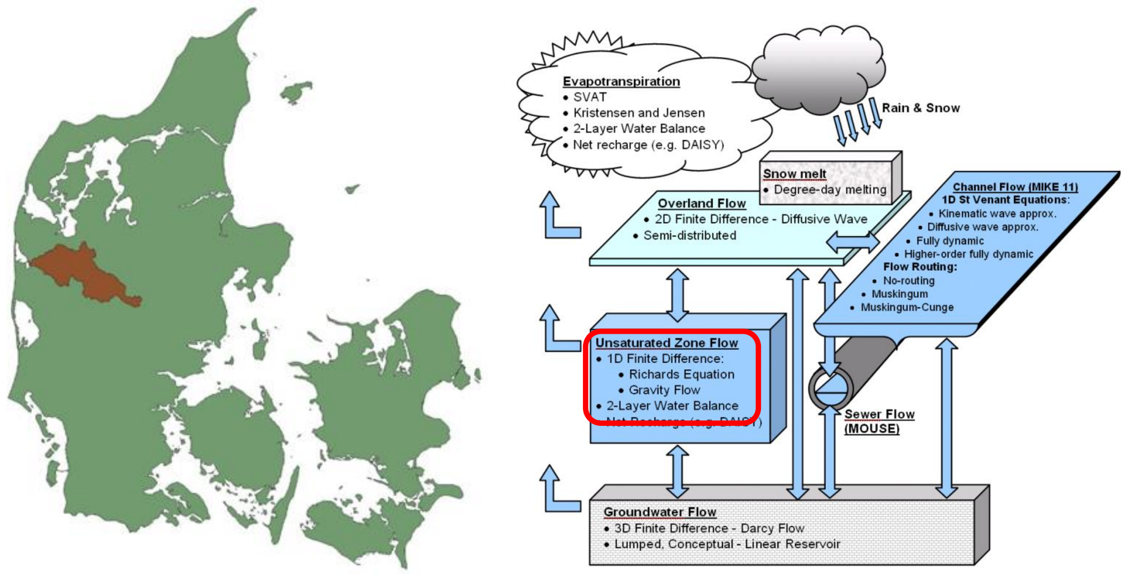

Figure 5. Location of the Storaa catchment (shown in brown) and the three different conceptualizations of the unsaturated zone that are assessed

Step 3: Assess risks of floods and droughts (indicators). Based on selected indicators the risk of fl oods and droughts will be assessed as a function of climate model, hydrological model and calibration methodology. A new method is developed where the results (indicators) characterized by different levels of uncertainty will be produced. This analysis is still pending as the data for the indexes is being produced (e.g. calibration of the hydrological models).

Step 4: Plan adaptation measures. This will include an evaluation of how uncertainty - and reduced uncertainty – affects the choice of adaptation measures. We already have some estimations of the climate model uncertainty and how it impacts on different variables that are relevant for the stakeholders. At the moment, we are working on the uncertainty that comes from the hydrological models as well as their ability to provide useful simulations in catchments with changing climate characteristics. Once the latter is finished, this new method will be able to provide a more clear insight of the uncertainty in order to plan adaptation measures.

In parallel, we are developing an expert elicitation to set probabilities on the confidence of the accuracy of climate and hydrological models. This method represents a subjective method to decrease the uncertainty of the projections in the impact change using knowledge expert. We plan to have an expert elicitation workshop in 2020, where we can test the suitability of the method.

Client perspective

Initially, our stakeholders would like to have the option of getting access to the whole uncertainty as well as to the reduced uncertainty. The main argument behind this is that there are different end users with different needs.

Additionally, for them it is important to get access to the projected changes in the mean conditions as well as the variability within the years. The mean is useful for planning and the variability to adapt to extreme conditions.

Finally, the stakeholders would like to have information that is useful at the local scale and for different periods, for instance the near future and the far future. The near future is important for investments, but this also depends in the type of end user. There might be other user that require the information for a longer time span.

Task list

What is remaining to be done?

a) Finish with the calibration of the hydrological model following the DSST procedure and run future climate scenarios.
b) Assess the risk of flood and droughts employing indexes and changes in the extreme conditions.
c) Expert elicitation

What is the time plan?

Point a) is expected to be done by January 2020. Point b) will have a significant advance by January 2020. Point c) will be finished when the expert elicitation workshop is due, in March 2020.