AQUACLEW case study progress report

Title of Case Study

Water Resource Allocation for Tourism, Agriculture and Energy

Authors

Rafael Pimentel, María José Pérez-Palazón, María José Polo

Client Organisations

Endesa Hydropower Generation, Unit Sur

Water Planning Office Andalusian Department of Environment.

Tropical Coast of Granada, Municipalities Community

Date

04/09/2019

Water management issue

Semiarid areas are characterised by a large climatic variability (i.e. alternancy of wet and very dry years, torrential episodes of heavy precipitation during late winter and early autumn). Consequently, the hydrological regime is also extremely changeable. Water has been one of the main motos for these areas development. Therefore, water allocation and management constitute a current issue over these areas, where the main productive sectors are traditionally agriculture and tourism.

In this context, this study case is carried out in the Guadalfeo River Basin (Figure 1). A mountainous Mediterranean watershed in Sierra Mountain (Southern Spain), where the highest summits of the Iberian Peninsula are located. Hence, snow constitutes a factor that needs to be considered in water management. Urban supply and its seasonal fluctuations conditioned by tourism, agriculture, together with hydropower generation in small power plants at the mountainous headwaters, are the main sectors competing for water and its allocation. Therefore, It is crucial to establish management strategies not only in the present context but also in the context of global warming, which poses a risk for the current supply system and water resource availability on a long term basis.

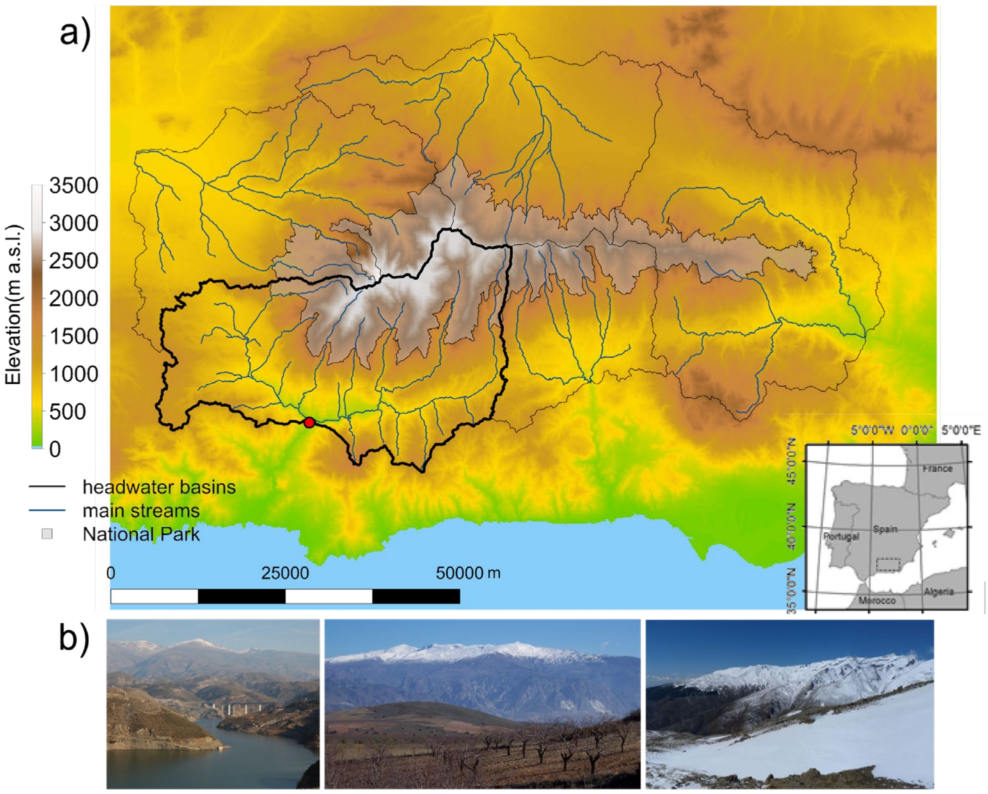

Figure 1. (a) Location of the Guadalfeo river basin within Sierra Nevada Mountain Range; (b) Examples of different landscapes on the catchment, from left to rigth: Rules dam, almod trees orchard, highest submits.

In general CS provides an open framework to assess the seasonality shifts associated with changes in the hydrological regime, with specific emphasis on the snow regime, and to estimate their impact on the decision making process. Also, they allow developing operational strategies both in the medium and long term.

Three clients were selected to cover all sectors in the study area (Table 1). Each client possesses different management issues, which are applied over a specific area (Figure 2).

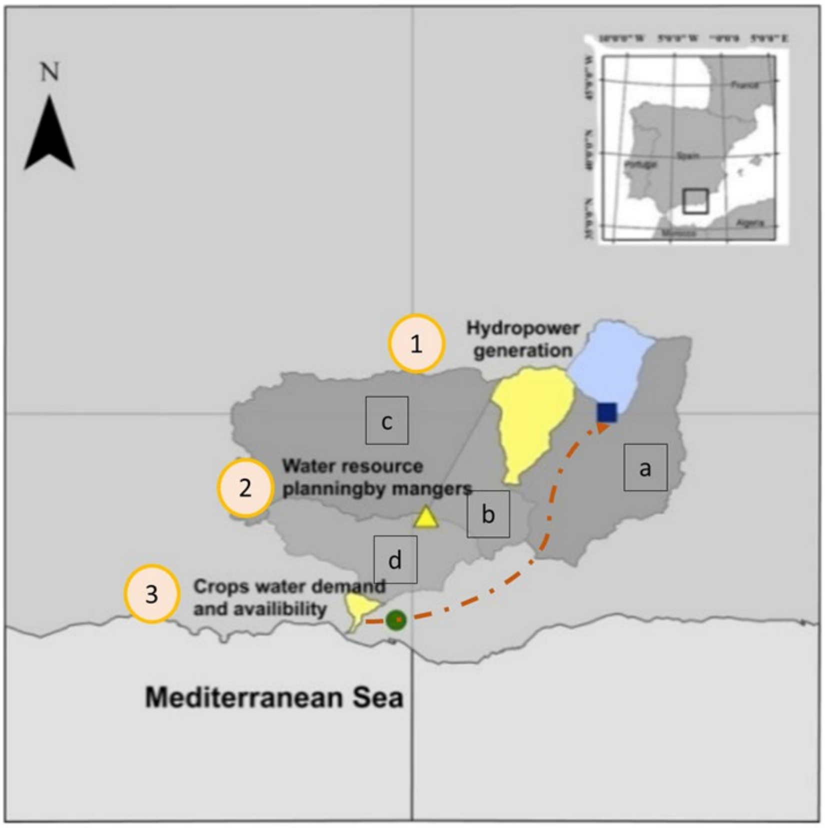

Figure 2. Catchment delineation provided by SWICCA (four catchment in the area a-d); location of the different catchments clients are interested in: (client 1) Poqueira Catchment (yellow area); (client 2) Guadalfeo Catchment Upstream Rules dam (dark gray area); (client 3) Trevelez Catchment (light blue area);

Table 1. Summary of client, needs and management issues to be solved

Client	Character	Sector	Management issue
1. ENDESA Hydropower	Private company	Energy	Energy production capacity. Planning for future needs in terms of infrastructures and machineries.
2. Water Planning Office (Andalusian Department of Environment.)	Public entity	Agriculture Tourism	Water resources management plan.
3. Tropical Coast Municipality Community	Regional association	Agriculture Tourism	Water supply strategies.

Use of Climate Data

The level of specialization of the client is different, therefore, the use of climate data they do and the ones they are willing to use is conditioned by this level of expertise.

Client 1 (Endesa Hydropower) is a private company which main aim is to produce energy to be competitive in the energy market. They have experience working with a) meteorological data, mainly precipitation and temperature provided by AEMET and SAHI; and, b) streamflow, they have their own gauging station network with stations in some of the stream where their small hydropower plants are located and also are familiar with the information the regional water authority provided with. However, they have very little experience in climatic aspects and terminology (i.e. climate scenarios, climate projections, model ensemble, etc.). In spite of that, they are interested in including climate scenario assessment in their management. They think this information could be very useful to take decisions regarding the planning of future needs (i.e. is going to be worthwhile to buy new machinery for energy production or maintain the buildings?, how is going to evolve the delay between snowmelt and peak flow, which conditions the main part of their profits?). This client was involved in previous projects related to climate service and thus, they are familiar with some of the terminology. Moreover, during the meetings held during the duration of the projects all their doubts have been solved.

Client 2 (Water Planning Office (Andalusian Department of Environment) is a public entity responsible for the water management of the reservoir system Béznar-Rules. They have experience using meteorological data (REDIAM and AEMET), water demands, population statistics, land use change information. They need climate information mainly to develop, revisit and implement the water resources management plans of the system. The training about CS is limited, they are aware of the terminology used in these services. However, they are a bit skeptical regarding the quality and use of this information. During the meetings held during the duration of the projects all their doubts have been solved.

Client 3 (Tropical Coast Municipality Community) is a regional association deal with the water supplies in the mouth of the river. They need to satisfy the agricultural demands not forgetting the urban water needs, especially during the summer. They are only familiar with basic meteorological information (AEMET) and some hydrological information related with water levels in the ponds that provide the water. Their training in CS related issues is minimum. During the meetings held we have explain basic concepts and how CS could be used for developing their strategies.

Preliminary Workflow

The case study is structured in seven steps going from more technical aspects (downloading information, manipulating data, and producing corrected time series according to clients' needs) to assessments and suggestions to develop adaptation and management strategies (Figure 2.)

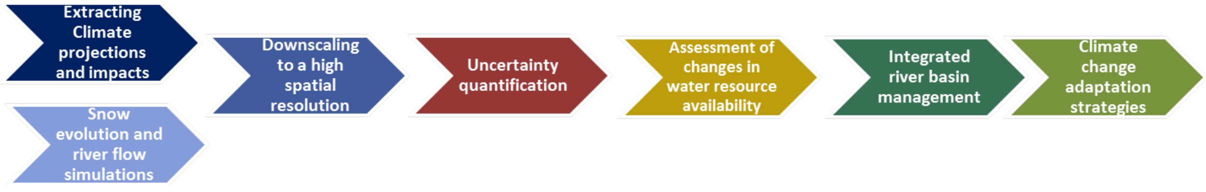

Figure 2. Case study workflow

1 Extracting Climate projections and impacts

Procedures

The Climate Service SWICCA (www.swicca.eu) has been used as the provider of climatic information. Within the climate impact indicator (CII) available on the platform. Table 2 shows those selected for each client. Based on previous works, within the different combination of global models-regional models-bias adjustment techniques,

Table 2. Climate Impact Indicators extracted from SWICCA

CIIs	Clients	Spatial Resolution	Temporal Resolution	Period (reference/future)	Scenarios
Precipitation (seasonality)	Clients 1,2 & 3	SWICCA Catchments	Seasonality	1970-2000/ 2010-2100	rpc 2.6, 4.5 and 8.5
Temperature (seasonality)	Clients 1,2 & 3	SWICCA Catchments	Seasonality	1970-2000/ 2010-2100	rpc 2.6, 4.5 and 8.5
River Flow	Clients 1,2 & 3	SWICCA Catchments	Daily Seasonality	1970-2000/ 2010-2100	rpc 2.6, 4.5 and 8.5
Snow Water Equivalent	Client 1	SWICCA Catchment	Seasonality	1970-2000/ 2010-2100	rpc 2.6, 4.5 and 8.5

Preliminary results

Information has been downloaded from the service, aggregated to different temporal (i.e. monthly, seasonal, yearly, decadal), combined to cover the spatial area required (i.e. river discharge from all catchment flowing to the Rules-Beznar reservoir system has been sum) in each of the study case.

2 Snow evolution and river flow simulations

Procedures

The distributed and physically based hydrological model WiMMed (Watershed Integrated Model for Mediterranean areas; Polo et al, 2010) has been used as local hydrological model. WiMMed has been calibrated locally and their results are used as reference truth in our analysis. The model is used not only for hydrological simulation (streamflow and snow water equivalent), but also, as interpolation tool to distributed the point meteorological information (precipitation and temperature in this case).

Preliminary results

Variables simulated in this step are summarized in Table 2

Table 3. Variables simulated with the local model WiMMed.

Variable simulated	Clients	Spatial Resolution	Temporal Resolution	Period (reference/future)
Precipitation (seasonality)	Client 1 Client 2 Client 3	Poqueira Guadalfeo (Rules) Trevelez	Daily	1970-2000

Temperature (seasonality)	Client 1 Client 2 Client 3	Poqueira Guadalfeo (Rules) Trevelez	Daily	1970-2000
River Flow	Client 1 Client 2 Client 3	Poqueira Guadalfeo (Rules) Trevelez	Daily	1970-2000
Snow Water Equivalent	Client 1	Poqueira	Daily	1970-2000

3 Downscaling to a high spatial resolution

Procedures

To solve the clear scale issues due to both: a) different spatial resolutions between catchments where the users need the information and the catchments delineated by the CS; and, b) more than biases in climatic variables reproduced by climate models; downscaling techniques are used. Within the different techniques (i.e. linear scaling, quantile mapping, distribution based scaling) here, we have used transfer functions. These are functions that for a given temporal resolution, relate local and CS simulations.

Preliminary results

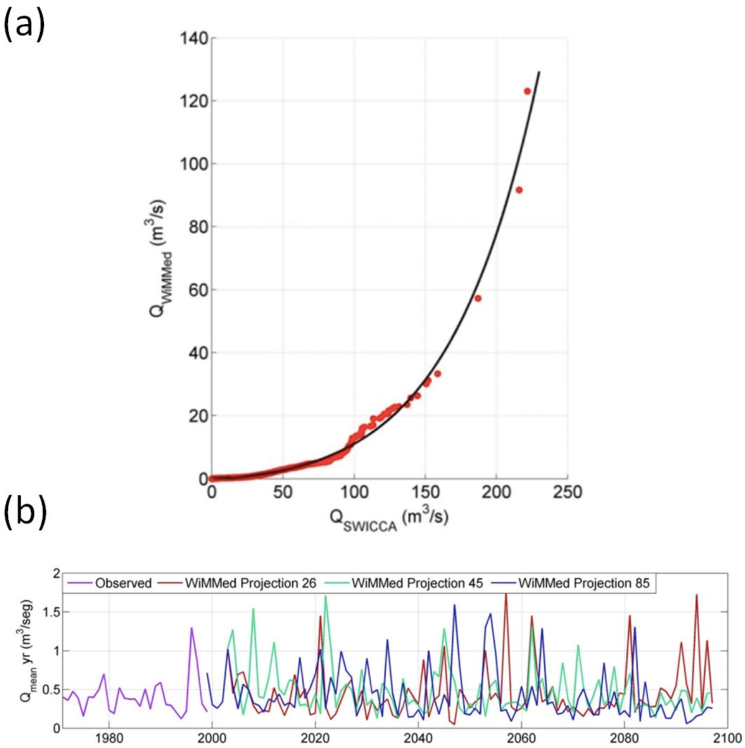

Figure 3 (a) Transfer function for Client 1; (b) reconstruction of the three future scenarios analyzed

Four different transfer functions (see example in FIgure 3 a), three for streamflow and one for SWE, are defined. Catchments compared and the temporal scale in which each of them is defined are summarized in Table 4. These functions are defined in the reference period (1970-2000) assuming the local model results as reference dataset. Then, they are applied in the future period (2010-2100) to correct the different scenario projections (Figure 3 b) trying to build more realistic time series.

Table 4. Variables simulated with the local model WiMMed.

Client	Variable	Spatial resolution SWICCA CS	Spatial resolution Local Model	Temporal scale
Client 1	Streamflow SWE	Catchment (a)	Poqueira	Daily Monthly
Client 2	Streamflow	Catchments (a), (b) and (c)	Guadalfeo - Rules	Daily
Client 3	Streamflow	Catchment (a)	Trevelez	Daily

4 Uncertainty quantification

Procedures

In the climate community, uncertainty is usually calculated as the spread of different simulations, which result of the combination of global models - regional models - bias adjustments techniques. The mean of this ensemble is selected as a representative value of the simulations. However, another part of the community starts to argue on the problems that could imply using model which performances in the reference period (where observations are available) are disastrous. Following this second path and taking into account that climate models in our study area give very bad results, we have chosen only the model (SMHI_RCA4_EC-EARTH) that better represent climatic variables, precipitation and temperature, in the reference period and calculated actual uncertainty. For that, errors between the chosen climate model and the local simulation are calculated. Normal distribution is adjusted to characterize these errors and Monte Carlo simulations are performed to generate the uncertainty bands (Figure 4).

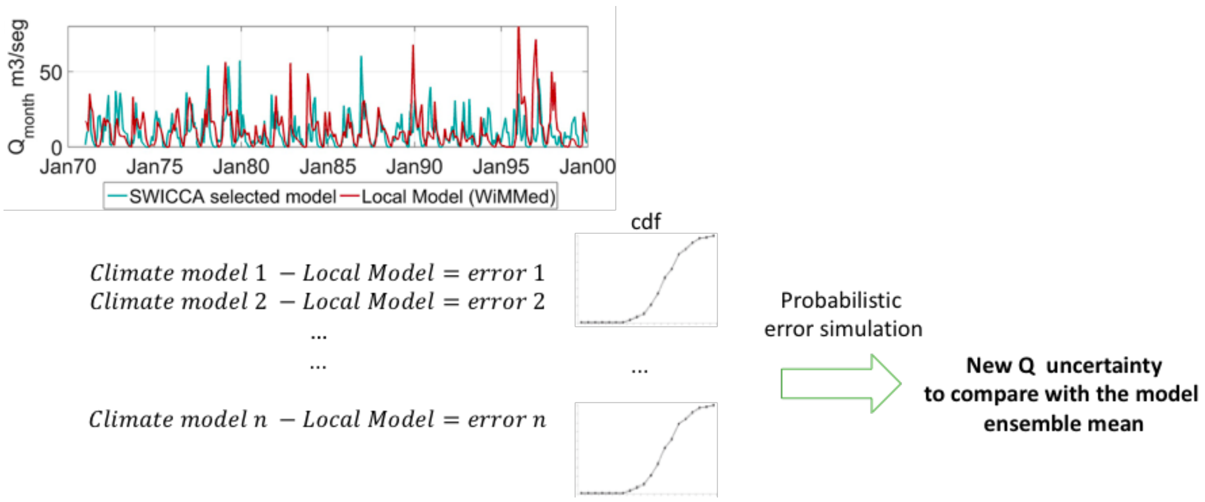

Figure 4. Scheme of uncertainty generation

5 Assessment of changes

On going work.

6 Integrated river basin management

On going work.

7 Adaptation strategies

On going work.

Client perspective

The main question could be summarized in how CS can be useful in their management strategies? It is difficult, at least for our clients, to see the value of information with such a long time horizon. They are more familiar using weather forecast or real time flooding alert systems. Therefore, an effort was done to persuade them to think in possible management issues they would have in a longer time horizon (see Table 1). Moreover, not all of them know the terminology used in CS and therefore how to use this information. A lot of time during the meeting has been used to explain the terminology, the climate production chance, the model performances, etc…

The clients with this new mindset, were also concerned about spatial scales, usually their problems take place in a scale more local than the one offered by pan-European CS; and, uncertainty, how they are going to trust the results of a model, whose simulation in the reference period are not correct?.

Hence, our work is planned to show the use of CS as a tool to solve the main management issue each client proposed, emphasising on the spatial scale and the uncertainty problems. The clients do not expect a complete fulfill until the end of the project and at this stage we think we will cover the request we were compromised.

Task list

Four steps are already completed (1-4), three of them will be finished during autumn. Below the time planning. We have added outside the workflow, the time needed for the final meeting with the clients and the writing of the final report

1 Climate Change Impact Indicators → COMPLETED
2 Simulations → COMPLETED
3 Downscaling → COMPLETED
4 Uncertainty quantification → COMPLETED
5 Assessment of changes → ON GOING

- Revisite the main question to be assessed in each case.
- Define metrics to evaluate the changes.
- Calculation of these metrics.

- Due date: end of October

6 Integrated river basin management → ON GOING

- Assessment of metric calculated in 5
- Answer the question related to the main management issues of each client

- Due date: 30 Nov 2019

7 Adaptation strategies → ON GOING

- Suggestion of possible strategies to follow for each client

- Due date: 20 Dec 2019

· Final meeting with each client to show final results (our plan is doing in during January)
· Final report (31 Jan 2020)