Using climate services to evaluate projected changes in the management and planning of hydropower production

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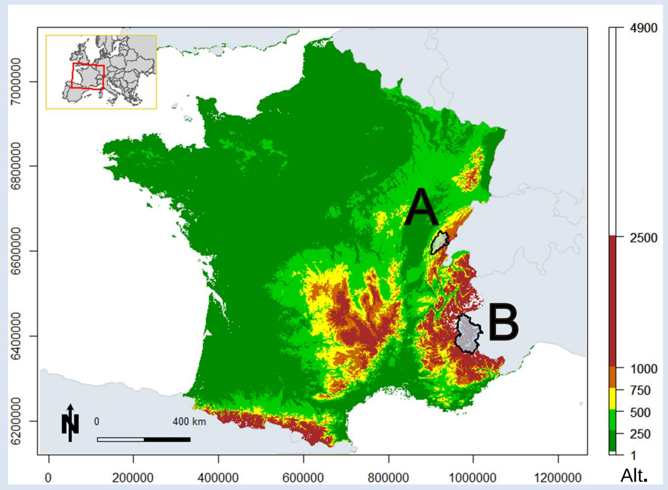
The hydropower sector is sensitive to climate variables as these affect energy generation and consumption. Climate services give key information to optimize reservoir operations and manage water storage. They provide guidelines for climate change adaptation and climate resilience strategies.

➢ With many climate services flourishing across Europe, the challenge today is to develop indicators for the energy sector based on these climate services in order to facilitate decision-making on energy production and planning at the regional and local levels in a context of climate change.

1. Data



- Two catchments: A: Ain at Vouglans; B: Durance at Serre-Ponçon.
- Two portals of climate services (EURO-CORDEX with RCP 8.5):
  - **Drias** (temperature and precipitation used in GR6J hydrological model to simulate riverflow) - 6 GCM/RCM.
  - **SWICCA** (riverflow) - 4 GCM/RCM.
- Flow observations from the French HYDRO database.

2. Methods

- **Flow ratios regime**

1) For each climate projection (GCM/RCM), calculation of the hydrological regime (interannual monthly riverflow $Q_P(m)$) and of the mean interannual flow rate ($\overline{Q_P}$) over three periods P (reference: 1976-2005, near future: 2021-2050, far future: 2061-2090).

2) Calculation of the monthly ratios for each period ($R_p(m)$) and each climate projection (i):

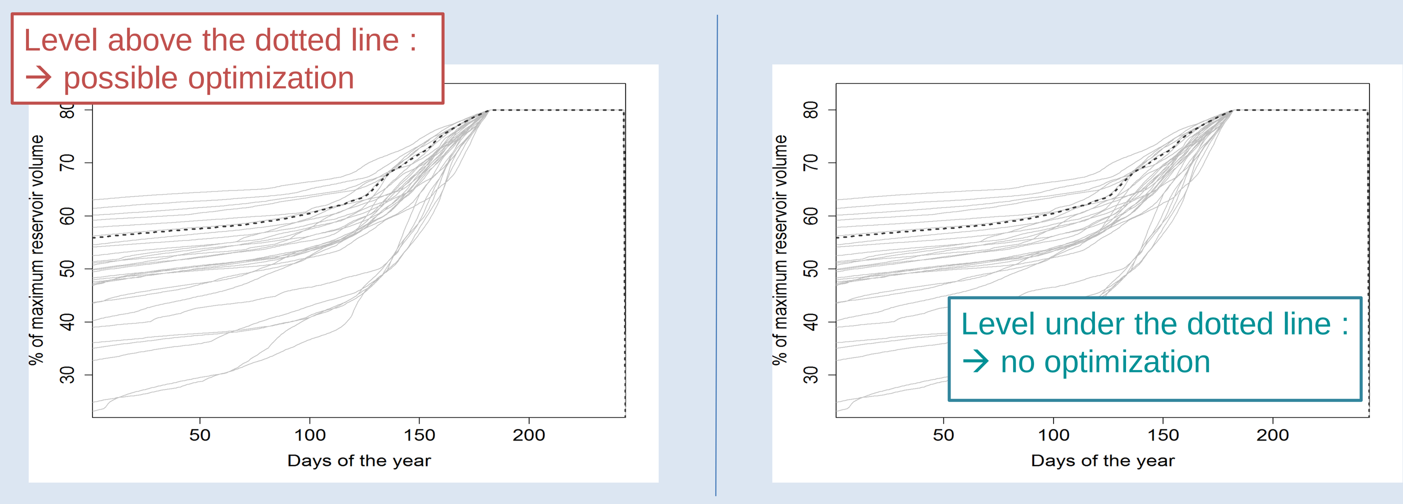
$$R_P^i(m) = \frac{Q_P^i(m)}{\overline{Q_P^i}} * 100$$

3) Calculation of the difference between ratios from future periods and the reference period:

$$\Delta R^i(m) = R_{Future}^i(m) - R_{Reference}^i(m)$$

- **Operating rule curves**

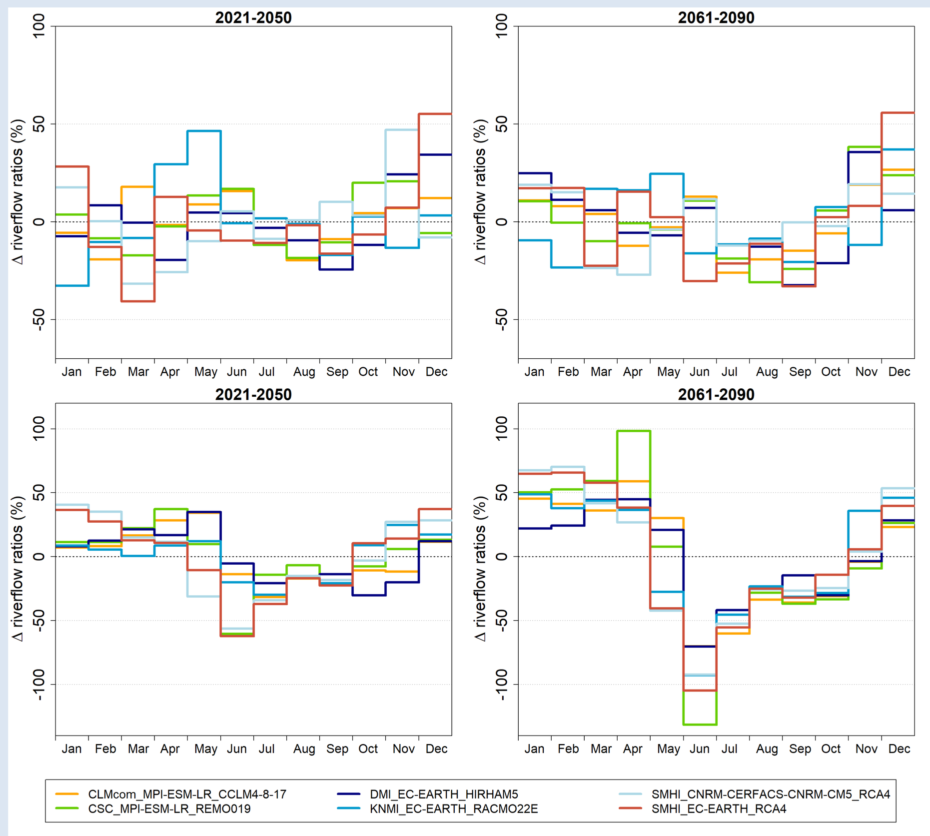
1) Represent how to manage the reservoir levels in order to reach the system's objective or constraint (here, the minimum volume in the reservoir during summer). Each gray line represents the rule curve for a given year, given its inflows and the minimum releases required. The dotted line shows the 80% guide curve. It indicates the minimum water level required at each day so that the constraint is achieved 8 years out of 10.



2) Use of conceptual reservoirs whose dimensions are defined as a function of the mean monthly flow over the reference period.

3. Results: riverflow ratios regime $\Delta R^i(m)$ (%)

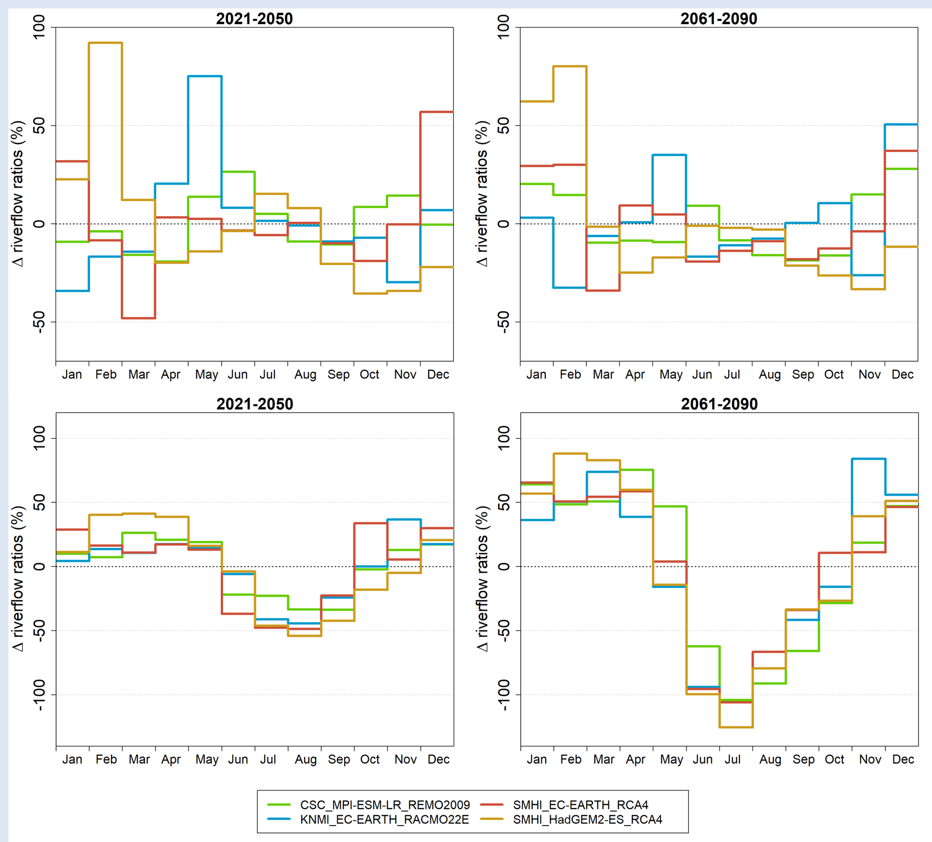
- **Drias: Vouglans (top) & Serre-Ponçon (bottom)**



- High dispersion of ratio values among GCM/RCM.
- Differences among GCM/RCM are more important during the winter season.
- Strong decrease of riverflows for the far future period.

- Differences among GCM/RCM more important in spring.
- For the two future periods, significant decrease of riverflows in spring and summer.

- **SWICCA: Vouglans (top) & Serre-Ponçon (bottom)**

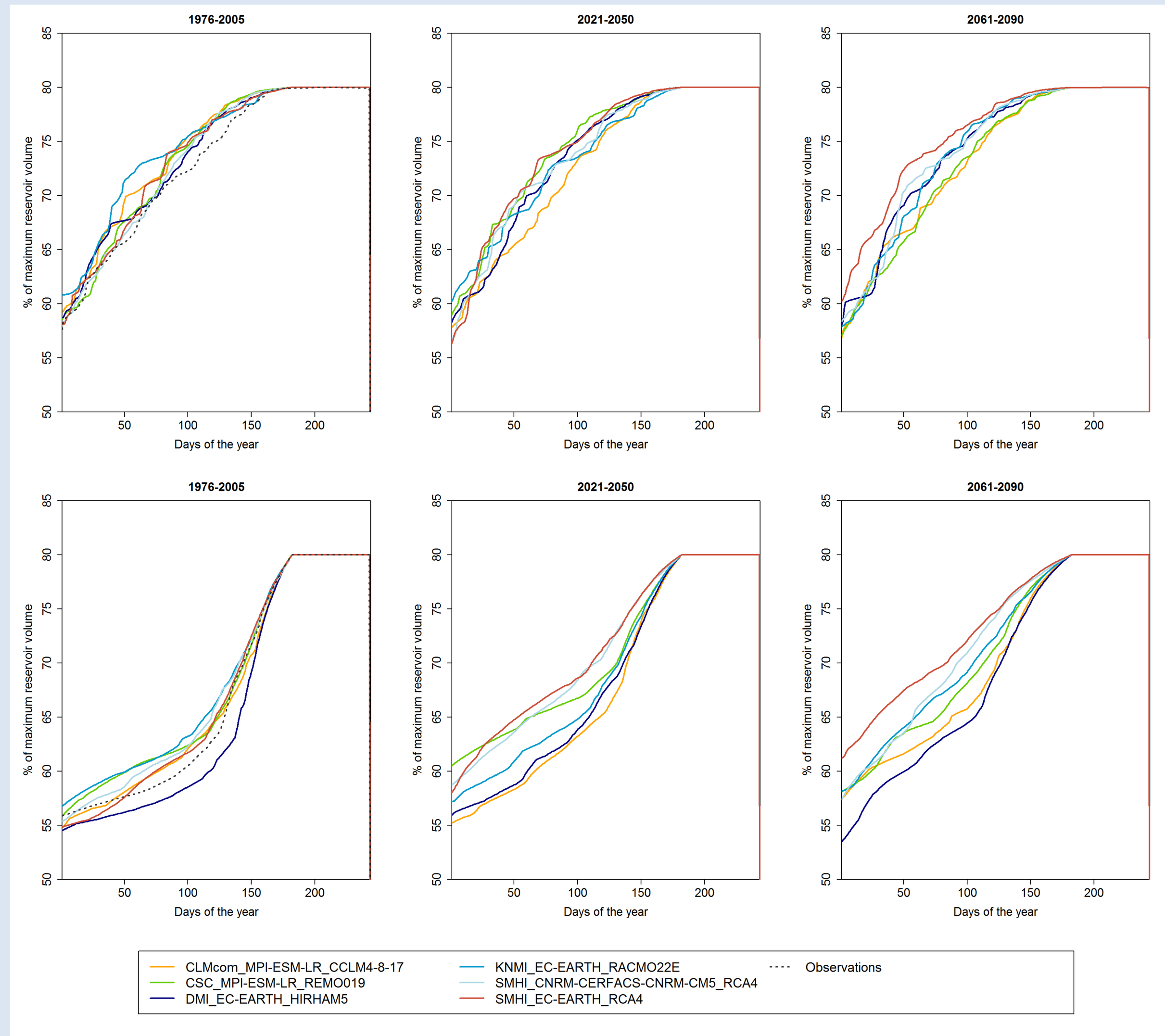


- Higher dispersion among the different GCM/RCM.
- Same trend observed as with the Drias climate service (convergence of GCM/RCM in summer).

- Trend of projected riverflows close to the one obtained with Drias data.
- Less dispersion among GCM/RCM in summer for the far period.

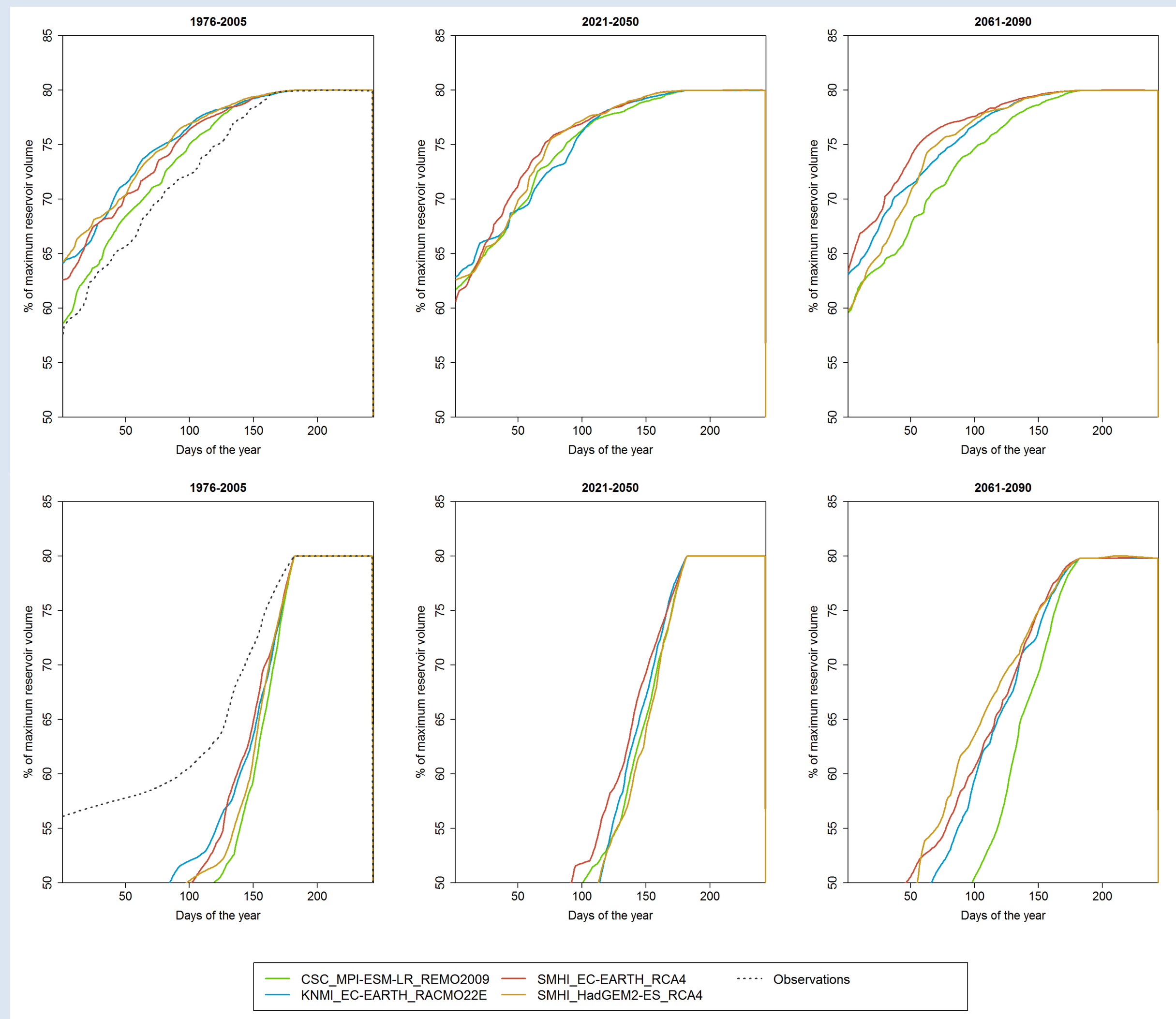
4. Results: operating rule curves

- **Drias: Vouglans (top) & Serre-Ponçon (bottom)**



- GCM/RCM-based guide curves close to observations-based guide curve for the historical period (left column).
- Small changes in the guide curves for the future for the Vouglans case (top, middle and right columns).
- Decrease of volume available for optimization (area over the curves) in the future for the Serre-Ponçon case (bottom, middle and right columns).

- **SWICCA: Vouglans (top) & Serre-Ponçon (bottom)**



- GCM/RCM-based guide curves more different to observations-based guide curve for the historical period (left column).
- SWICCA riverflows are higher in comparison with Drias-GR6J riverflows for the Serre-Ponçon case.
- Also decrease in volume available for optimization in the future (middle and left columns).

5. Conclusion

- Results may differ depending on the GCM/RCM set and on the portal used.
- Differences can have a direct impact on reservoir management indicators.
- It is important to take into account GCM/RCM projections of several climate services and to evaluate impacts on different hydrological regimes.
- Different data have different impacts on the operating rule curves and therefore on the flexibility of the hydropower system to adapt to a future climate context.
- Both portals indicate higher impact on the nival hydrological regime.

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