Hydro-Quebec Case Study

Climate Change Impacts on Hydro-Quebec's Annual Water Inflow, Evolution of the Mean and Variability

By: Guillaume Jean Tarel[1], Catherine Guay[2], Marie Mainville[2]

Context

In a 2015 article, Guay et al. used the CMIP3 set to show, among other things, a probable future increase in mean annual streamflow in Quebec (Guay et al., 2015). To complete these results and assess the impact of climate change on the hydropower fleet, it is also important to characterize the probable evolution of the variability of inflows (HQD, 2019). This analysis is made using the simulations from the cQ2 project based on the CMIP5 climate set.

Objective

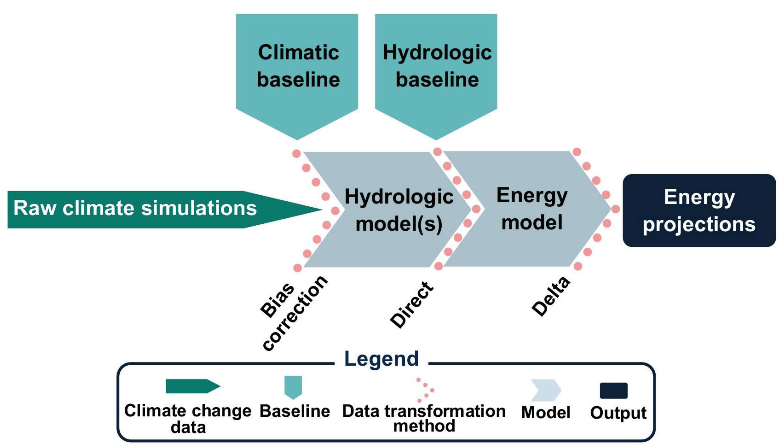
- Compare results obtained with CMIP5 to the previous simulations derived from CMIP3.
- Analyze the evolution of variability by 2050.
- Evaluate whether the available hydrological simulations accurately represent the sequences of years characterized by low runoff.

Approach

As part of the cQ2 project, CMIP5 climate simulations were used as inputs to a hydrological model (HSAMI) to produce simulations of future flows for several dozen sites in the HQP system. Two radiative forcing trajectory scenarios were taken into account (RCP 4.5 and 8.5). The initial step, adequacy analysis, validates whether the available data adequately reproduce the observed history (control period 1971–2000). The analysis showed that:

- the annual means and inter-annual variability, represented by the standard deviation, are suitable variables.
- the cumulative variables over several years (for example the sequences of years of low water levels) are not adequately represented by the available data.

In the light of these findings, the changes in annual means and inter-annual variability were therefore calculated using a delta approach, comparing the variables between the future period and the reference period. Changes in the sequences of years of low water levels have not been studied.

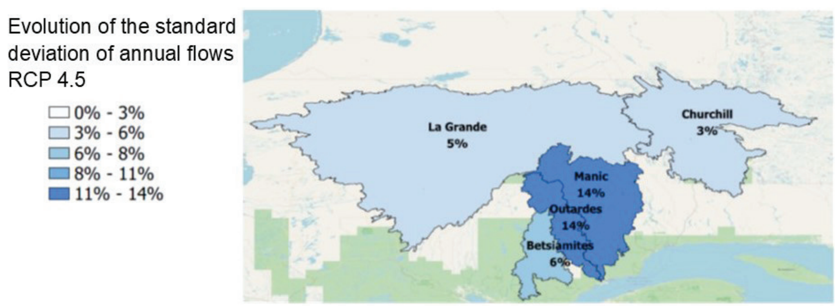


[1] Hydro-Québec Production, [2] Centre de recherche d'Hydro-Québec

Results

Note: The results below are presented in terms of the probable future change in annual mean flows. As the conversion efficiencies of the flows into energy are vary between different facilities, it is not possible to directly transpose the evolution of the flows into an energy evolution. Moreover (see above), the evolution of the sequences during years of low water levels has not been studied.

In terms of flows, the annual means show an increase between the control period (1971–2000) and the future period (2036–2065). The figure below provides more detail about the most important basins (for the RCP 4.5 scenario). The changes are of the same order of magnitude as obtained in Guay et al. (2015). As the mean increases, so do the standard deviations in the case of RCP 4.5. Even in the case of RCP 8.5, the standard deviations increase considerably more than the means. This results in an increase in the variability of flows from year to year.



Lessons learned

- This type of assessment is not trivial and there is a relatively high risk of making faulty conclusions using inappropriate data (Fournier et al., 2020)
- Conducting an adequacy analysis of simulations, comparing the simulations with available history, is essential and should be recommended to all users. Relying on external expertise or the Ouranos Guidebook on Valuation of Hydropower Assets and Climate Change Physical Impacts (Fournier et al., 2020) is also recommended.
- For Hydro-Quebec Production, the analysis of the available simulations showed that it is necessary to further study the sequences of years of low water levels.

Reference

This case study was developped as part of the Guidebook: Fournier, E., Lamy, A., Pineault, K., Braschi, L., Kornelsen, K., Hannart, A., Chartier, I., Tarel, G., Minville, M. et Merleau, J. (2020). Valuation of Hydropower Assets and Climate Change Physical Impacts A Guidebook to Integrate Climate Data in Energy Production for Value Modelling, Ouranos, Montréal, 208 pages.

Guay, C., Minville, M., and Braun, M. (2015). A global portrait of hydrological changes at the 2050 horizon for the province of Québec. Canadian Water Resources Journal, 40(3), 285–302. https://doi.org/10.1080/07011784.2015.1043583

Hydro Québec Distribution. (2019, Novembre 1). Complément d'information du plan d'approvisionnement 2020-2029. http://publicsde.regie-energie.qc.ca/projets/529/DocPrj/R-4110-2019-B-0009-Demande-Piece-2019_11_01.pdf