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Impacts of forced and unforced climate variability on extreme floods using a large climate ensemble

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Frequency analysis has been widely used for the inference of flood magnitude and rainfall intensity required in engineering design. However, this inference is based on the concept of stationarity. How accurate is it when taking into account climate variability (i.e. both internal- and externally-forced variabilities)? Even in the absence of human-induced climate change, the short temporal horizon of the historical records renders this task extremely difficult to accomplish. To overcome this situation, large ensembles of simulations from a single climate model can be used to assess the impact of climate variability on precipitation and streamflow extremes. Thus, the objective of this project is to determine the reliability of return period estimates using the CanESM2 large ensemble. The spring flood annual maxima metric over snowmelt-dominated watersheds was selected to take into account the limits of global circulation models to properly simulate convective precipitation.

The GR4J hydrological model coupled with the CemaNeige snow model was selected and calibrated using gridded observation datasets on snowmelt-dominated watersheds in Quebec, Canada. Using the hydrological model, streamflows were simulated using bias corrected precipitation and temperature data from the 50 members of CanESM2. Flood frequency analyses on the spring flood annual maxima were then computed using the Gumbel distribution with a 90% confidence interval. The 20-year return period estimates were then compared to assess the impact of natural climate variability over the 1971-2000 return period. To assess the impact of global warming, this methodology was then repeated for three time slices: reference period (1971-2000), near future (2036-2065) and far future (2071-2100).

Over the reference period results indicate that the relative error between the return period estimates of two members can be up to 25%. Regarding the near future and far future periods, natural climate variability of extreme floods increases, irrespective of the direction of change for mean hydraulicity. Overall, these results suggest that using the historical record to estimate the return period of extreme events is not sufficient to cover natural climatic variability and can lead to significant errors in engineering design values.