Integrating Climate Change Considerations into Environmental Assessments of Hydro-electric Power Projects in Eastern and Northern Canada

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Climate Change/EA

- Climate change has been recognized internationally and by the federal, provincial and territorial governments in Canada as an important environmental issue.
- EA has the potential to link project planning to the broader management of climate change issues in Canada.
- Members of the public and government agencies have raised questions and expressed interest in how climate change is, and should be considered in project reviews.

Climate Change/EA

- Jurisdictions expect that the consideration of climate change in project EAs will be consistent with broader climate change policy
- Increase attention to, and awareness of, GHG emissions from projects subject to EA
- Stimulate consideration of less emission-intensive ways to design and operate projects
- Help proponents manage or reduce the potential risks associated with climate change impacts on projects
- Assure the public that climate change considerations are being taken into account.

Climate Change/EA

- Incorporating climate change considerations in EA can help to determine whether projects are consistent with jurisdictional actions and initiatives to manage GHG emissions
- It can also assist proponents in using best practices that adapt to possible climate change impacts, such as changes in the frequency or intensity of extreme weather events, increases in mean temperatures or altered precipitation patterns and amounts.

Climate Change/EA

- Jurisdictions recognize that our understanding of climate change and its implications is still developing (CEAA, 2003)
- Furthermore, there are currently no legal requirements or clearly sanctioned benchmarks for GHG emission reductions
- Similarly, the assessment of potential climate change impacts and the identification of effective adaptation responses are new and evolving fields in which more research is required.

Climate Change/EA

- While our understandings and policies are advancing, it is still useful that project proponents and government EA practitioners and decision makers be aware of any important climate change implications related to proposed projects
- Potential risks to the project, providing they do not affect the public, public resources, the environment, other businesses or individuals, may be borne by the project proponent and are not generally a concern for jurisdictions.

Climate Change/EA

- Normally, projects are designed with some assumption about the climate in which it will function
- The conventional way is to assume that the climate of the past is a reliable guide to the future
- Given the possibility of climate change and variability in the future, this assumption may no longer hold
- Thus design criteria must be based on probable future environmental conditions, including climate change, over the life of the project.

Climate Change/EA

- Environmental Impact Assessments of projects and activities should consider not only the effects of the project on the environment, but also the impacts of impending climate-related changes on the project or activity, namely the impacts of the environment on the project
- Potential risks can be identified for each of these sectors
- To determine the risks to which sectors are exposed it is necessary to examine their vulnerability to specific hazards
- Potential hazards expected from climate variability and climate change include: increased near-surface temperatures, increased/decreased precipitation and its variability, more frequent and intense storms, changing weather patterns and sea level rise.

Climate Change/EA

- In general, two practical approaches for incorporating climate change considerations in EA:
- Greenhouse Gas (GHG) Considerations: where a proposed project may contribute to GHG emissions.
- Impacts Considerations: where climate change may affect a proposed project.

Climate Change/EA

- In view of the fact that certain projects have life cycles that extend well into the future and that climate, including its variability, is expected to change in the foreseeable future, EAI practitioners are now being asked to integrate climate change considerations into EAs, where applicable.

Objectives

- The focus of this paper is on the second issue, namely the extent to which large hydro-electric power projects may be influenced by climate change over their life cycle
- Furthermore, in the light of our data analyses, whether there is sufficient justification for the inclusion of climate change considerations in EAs of such projects.

Objectives

- The main objectives of the proposed research project are to develop appropriate methodologies and guidelines, based on the results of the proposed research, to facilitate the integration in climate change considerations into environmental assessments of hydropower and similar projects.

Objectives

- A further objective would be to assess the impacts of greenhouse gas climate change on the climate and hydrology of drainage basins that are exploited for hydro-electric power generation in Eastern and Northern Canada and to demonstrate that large-scale climate change need to be integrated in the engineering design and environmental assessments of projects such as the erection of hydropower dams.

Project/context

- Although, not a typical EIA project, the study did integrate a number of the essential elements of a generic EIA namely project description and screening, project scoping and identification of potential impacts, identification of project alternatives, evaluation of significant impacts and public input
- However, the focus of the study was to evaluate and report significant findings relating to the potential impacts of the environment, namely climate change and variability, on the project, in this case hydro-electric power plants.

Methodology

- The methodology of the research project basically involves coupling climate change scenarios with two different hydrological models, namely the SSARR (Streamflow Synthesis and Reservoir Regulation) and the Thornthwaite Water Budget (WATBUG) models, so as to assess future changes in such basin hydrology responses as net basin supply, river discharge and likely maximum flood events.

Methodology

- Scenarios of climate change are derived from two A-OGCMs, namely the Canadian (CGCM2) and the British (HadCM3)
- Two scenarios/time slices of climate, each spanning 30 years are considered: one current (1961-1990) and a future time slice (2040-2069)
- Because of scaling problems, the required diagnostics of the coarse A-OGCM's, namely surface level maximum and minimum air temperature and precipitation are downscaled, for the three Quebec drainage basins using the Statistical DownScaling Method (SDSM)

Methodology

- The study covers three drainage basins in Québec, spanning from south (Vermillon: 47°39’ N, 72°56’ W; Sainte-Marguerite : 50°09’ N, 66°36’ W), to north (Grande Baleine: 55°16’ N, 77°47’ W) that are used/targeted for hydropower
- Two other drainage basins in northern Manitoba (Grass River), Newfoundland- and-Labrador (Eagle River) are also studied

Methodology

- For the Québec drainage basins, the downscaled climate parameters are then be coupled to the SSARR hydrological model, so as to determine current (1961-1990) and future (2040-2069) hydrological characteristics of the selected drainage basins, including mean daily and monthly net basin supply, reservoir levels, discharge and likely maximum floods.

Methodology

- Similarly, scenarios of climate change are derived from two the A-OGCMs, namely the Canadian CGCM2 and the British HadCM3, each spanning 30 years, one current (1961-1990) and one future (2040-2069) are coupled to the WATBUG model for estimating river basin discharge
- However, in this case, no downscaling of the GCM data is done
- Instead the nearest grid point of each GCM with respect to the drainage basins is used
- This approach seems appropriate for the larger drainage basins in Northern Manitoba and in Churchill-Labrador.

Methodology

- In the case of WATBUG, for each drainage basin, water surplus is distributed over the entire year, using the methodology suggested by Black, so as to capture the monthly evolution of river discharge, depending on temperature and precipitation
- The calibration is done for the current (1961-1990) period and these same tuning parameters are retained when applied to the future (2040-2069) climate.

Methodology

- It is apparent from the previous section that the results on the changes in river basin discharge between the current (1961-1990) and the future (2040-2069) would seem to vary and be inconsistent, depending on the river basin in question and the climate scenario and the hydrological used

Results

- When coupling the SSARR hydrological model with the CGCM1 scenario future (2040-2069) peak spring discharge increases for the Vermillon River basin, but decreases for the Sainte-marguerite and Grande-Baleine River basins

Results

- On the other hand, by coupling the WATBUG hydrological model with both the CGCM and HadCM3 climate scenarios and applying them to the Grande-Baleine River basin, we obtain somewhat conflicting results.

Results

- As opposed to the SSARR hydrological model, the WATBUG model coupled to the CGCM1 climate scenario gave increasing, instead of decreasing discharge for the future (2040-2069), as opposed to the current (1961-1990) climate.

Results

- Furthermore, when WATBUG is coupled to both the CGCM1 and HadCM3 climate scenarios and applied to the Grande-Baleine River basin, the differences in monthly discharge and peak spring discharge are greater for the future (2040-2069), as opposed to the current (1961-1990) climate when using the HadCM3 scenario.

Results

- It must be noted though that the Had CM3 simulations for the current climate underestimates relative to observed data
- Similarly for the Eagle River drainage basin, using the coupling to the WATBUG hydrological model, the CGCM1 climate scenario gave an increase in peak discharge whereas the HadCM3 model gave a decrease in peak spring for the future (2040-2069) climate relate to the current (1961-1990) climate.

Results

- What seems to be consistent, across different climate scenarios, hydrological models and drainage basins, is the fact that the onset of spring peak discharge is advanced by about two weeks and, in general, peak spring discharge is greater under the future (2040-2069) climate as opposed to the current (1961-1990) climate.

Results

- These results have to be considered in the light of the spatial and temporal scales of the two approaches used to couple hydrological models to A-OGCM diagnostics
- For the SSARR model downscaled daily data is used
- In the case of the WATBUG model nearest-point large-scale A-OGCM monthly data is used.

Panel

- These results and arguments were presented in a workshop to a panel of experts consisting of research (Universities, Ouranos), government officials (Federal and Provincial) and private (Hydro-Quebec) representatives

Panel

- They were asked that given the cascade of uncertainties inherent in A-OGCM climate models and scenarios and the results obtained
- Whether it is justifiable to incorporate climate change considerations into the EA process and methodology relating to hydro-power projects.

Panel

- The conclusions derived was that given the uncertainties in climate change scenarios and the results presented, it may be premature to consider integrating climate change considerations into the environmental assessments of hydro-power projects
- For the time being climate change issues should be looked at in the context of regional and strategic environmental assessment procedures

Panel

- The panel also concluded that the research did address a number of issues pertinent to the EA process and the implications of climate change, especially in regards to hydro-power projects in Northern Canada.

Table 1 :

Drainage Basin	Location	Area
Vermillon	47°39’N, 72°56’W	2 630 km^2
Sainte-Marguerite	50°09’N, 66°36’W	6 177 km^2
Grande-Baleine	55°16’N, 77°47’W	36 300 km^2
Grass River	55°74’N, 97°00’W	15 400 km^2
Eagle River	55°53’N, 57°49’W	10 900 km^2

Table 2 : Mean Seasonal Discharge (m3/s) for the Vermillon River Basin (1961-1990)

	Observed Mean Discharge (m3/s)	Simulated Mean Discharge (m3/s)
Spring	75.8	58.3
Summer	41.3	31.2
Autumn	31.6	23.1
Winter	20.7	14.2

Table 3 : Characteristics of the simulated discharge (m3/s) for the Vermillon River basin

	1961-1990	2040-2069	Difference (%)
Mean (m3/s)	31.8	34.2	+ 7.5
Standard Deviation(m3/s)	36.9	44.9	+ 21.8
Minimum (m3/s)	9.3	9.8	+ 5.4
Maximum (m3/s)	367.0	478.0	+ 30.2

Table 4 : Simulated seasonal discharge (m3/s) for the Vermillon River basin

	1961-1990 (m3/s)	2040-2069 (m3/s)	Difference (%)
Spring	58.3	68.9	+ 18.2
Summer	31.2	29.3	- 6.1
Autumn	23.1	23.5	+1.7
Winter	14.2	14.6	+ 2.8

Table 5 : Characteristics of the simulated discharge (m3/s) for the Sainte-Marguerite River basin

	1961-1990	2040-2069	Difference (%)
Mean (m3/s)	154.2	141.0	-8.5
Standard Deviation (m3/s)	233.0	203.4	-12.7
Minimum (m3/s)	27.0	25.4	-5.9
Maximum (m3/s)	1760.0	1800.0	2.3

Table 6 : Simulated seasonal discharge (m3/s) for the Sainte-Marguerite River basin

	1961-1990 (m3/s)	2040-2069 (m3/s)	Différence (%)
Spring	72.7	109.0	+ 49.9
Summer	377.8	289.1	- 23.5
Autumn	122.2	123.3	+ 0.9
Winter	41.4	37.0	- 9.7

Table 7 : Characteristics of the simulated discharge (m3/s) for the Grande-Baleine River basin

	1961-1990	2040-2069	Différence (%)
Mean (m3/s)	640.2	584.1	- 8.8
Standard Deviation (m3/s)	523.9	419.4	-19.9
Minimum (m3/s)	121.0	121.0	0.0
Maximum (m3/s)	2910.0	2310.0	-20.6

Table 8 : Simulated seasonal discharge (m3/s) for the Grande-Baleine River basin

	1961-1990 (m3/s)	2040-2069 (m3/s)	Différence (%)
Spring	167.9	222.5	+ 32.5
Summer	1285.6	1091.0	- 15.1
Autumn	767.1	692.4	- 9.7
Winter	304.9	326.0	+ 6.9

Table 9 : Statistics on the variability of mean monthly discharge (m^3s^{-1}) for Grande Baleinefor the 1961-90 and 2040-69 time periods (CGCM10)

	N	Minimum	Maximum	Mean	Standard Deviation
CGCM1 (1961-90)	360	196	2210	558	420
CGCM1 (2040-69)	360	178	2123	582	435

Table 10 : Statistics on the variability of mean monthly discharge (m^3s^{-1}) for Grande-Baleine for the 1961-90 and 2040-69 time periods (HadCM3).

	N	Minimum	Maximum	Mean	Standard Deviation
HadCM3 (1961-90)	360	83	1344	279	174
HadCM3 (2040-69)	360	29	1484	323	244

Table 11 : Statistics on the variability of mean monthly discharge (m^3s^{-1}) for GraS River for the 1961-90 and 2040-69 time periods (CGCM1)

	N	Minimum	Maximum	Mean	Standard Deviation
CGCM1 (1961-90)	360	16	337	80	52
CGCM1 (2040-69)	360	20	324	81	53

Table 12 : Statistics on the variability of mean monthly discharge (m^3s^{-1}) for Grass River for the 1961-90 and 2040-69 time periods (HadCM3)

	N	Minimum	Maximum	Mean	Standard Deviation
HadCM3 (1961-90)	360	14	760	126	118
HadCM3 (2040-69)	360	34	880	149	135

Table 13 : Statistics on the variability of mean monthly discharge (m^3s^{-1}) for Eagle River for the 1961-90 and 2040-69 time periods (CGCM1)

	N	Minimum	Maximum	Mean	Standard Deviation
CGCM1 (1961-90)	360	42	826	214	194
CGCM1 (2040-69)	360	42	1130	274	257

Table 14 : Statistics on the variability of mean monthly discharge (m^3s^{-1}) for Eagle River for the 1961-90 and 2040-69 time periods (HadCM3)

	N	Minimum	Maximum	Mean	Standard Deviation
HadCM3 (1961-90)	360	42	993	199	193
HadCM3 (2040-69)	360	42	891	204	188

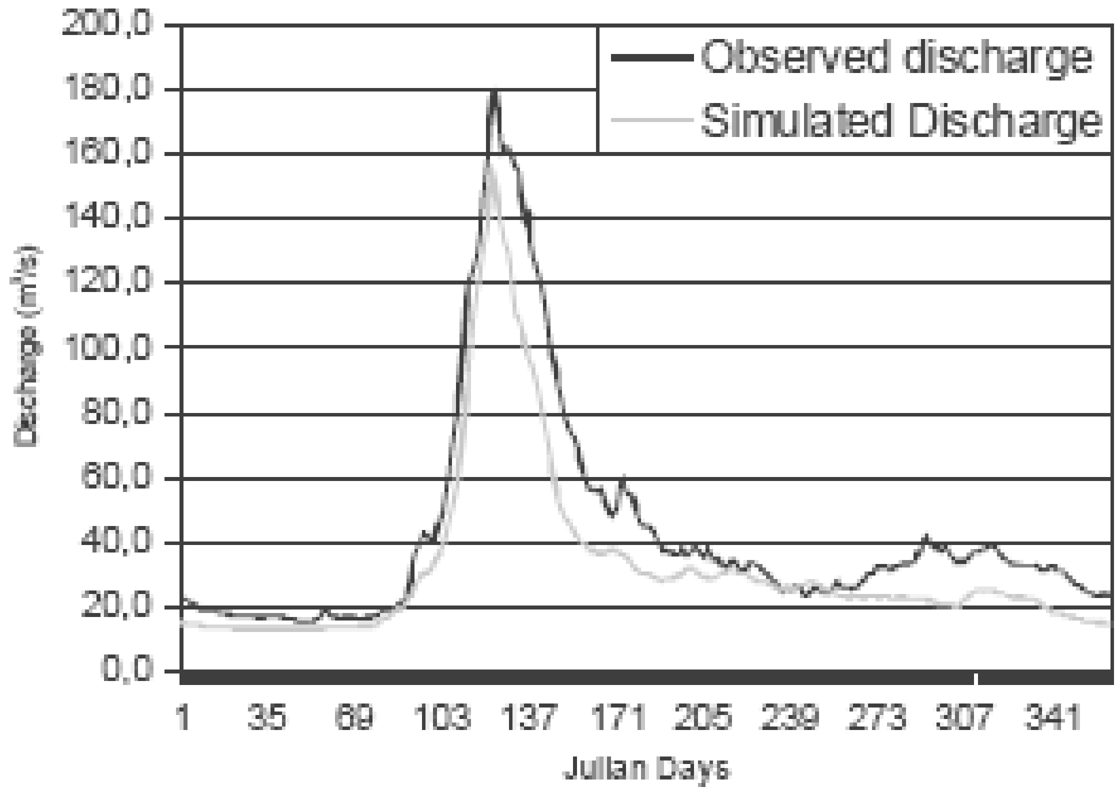

Figure 2: Flood Hydrograph for the Vermillon River basin (1961-1990)

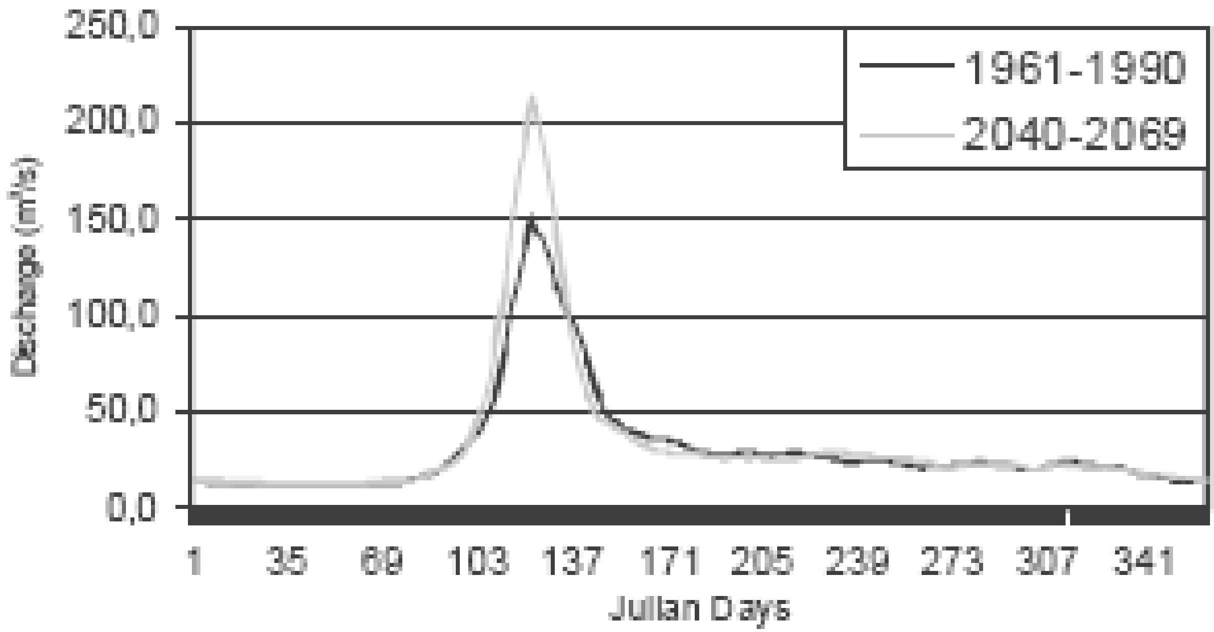

Figure 3: Comparison between current and future discharge for the Vermillon River basin

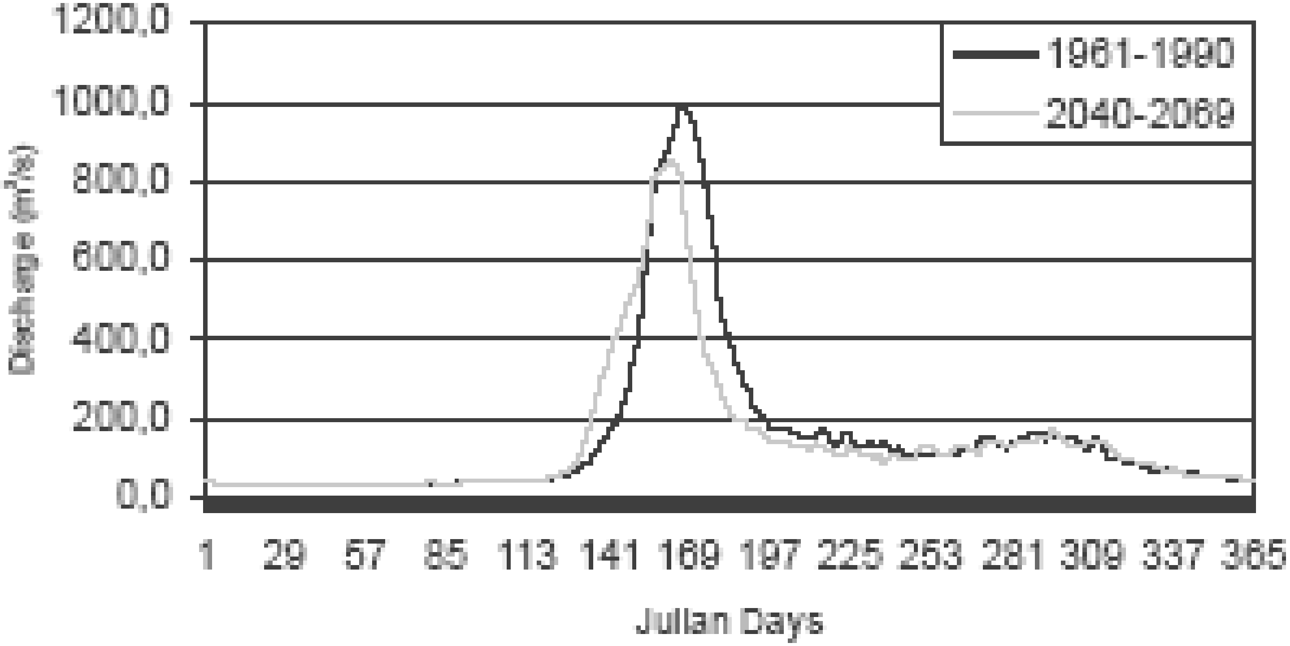

Figure 4: Comparison between current and future discharge for the Sainte-Marguerite River basin

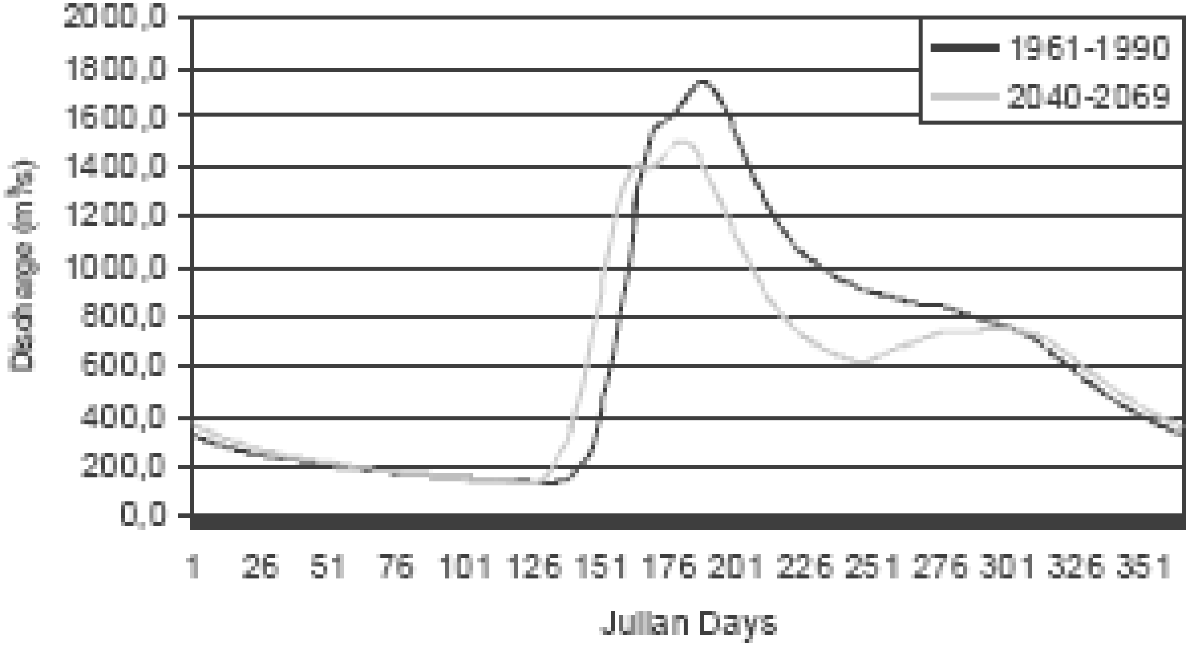

Figure 5: Comparison between current and future discharge for the Grande-Baleine River basin

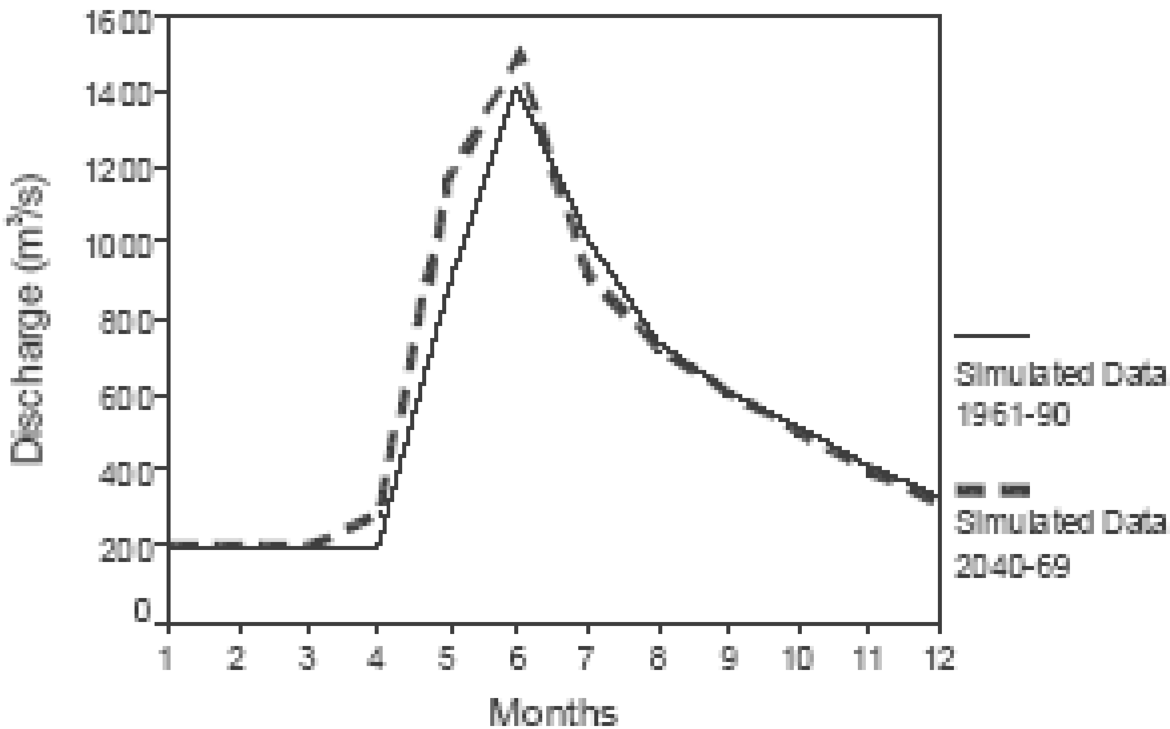

Figure 6. Variations of mean monthly discharge (m^3/s) of the Grande-Baleine river basin for the periods 1961-90 and 2040-69 according to CGCM1.

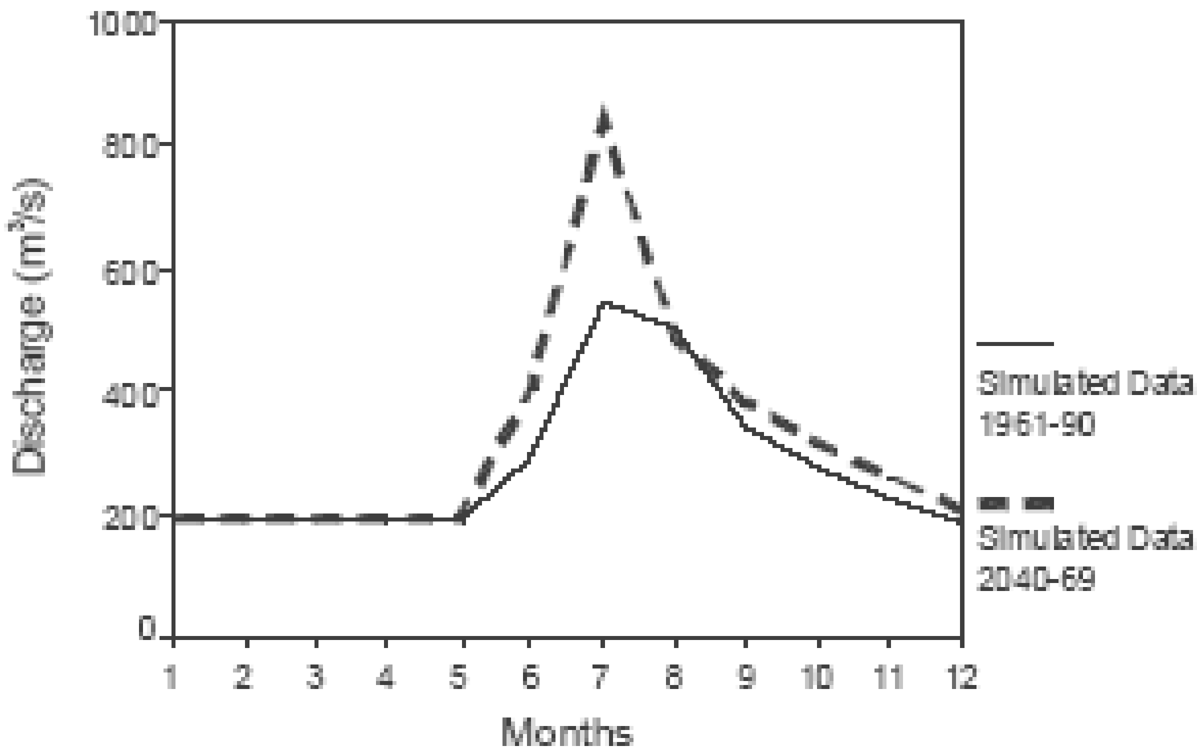

Figure 7. Variations of mean monthly discharge (m^3/s) of the Grande-Baleine river basin for the periods 1961-90 and 2040-69 according to HadCM3.

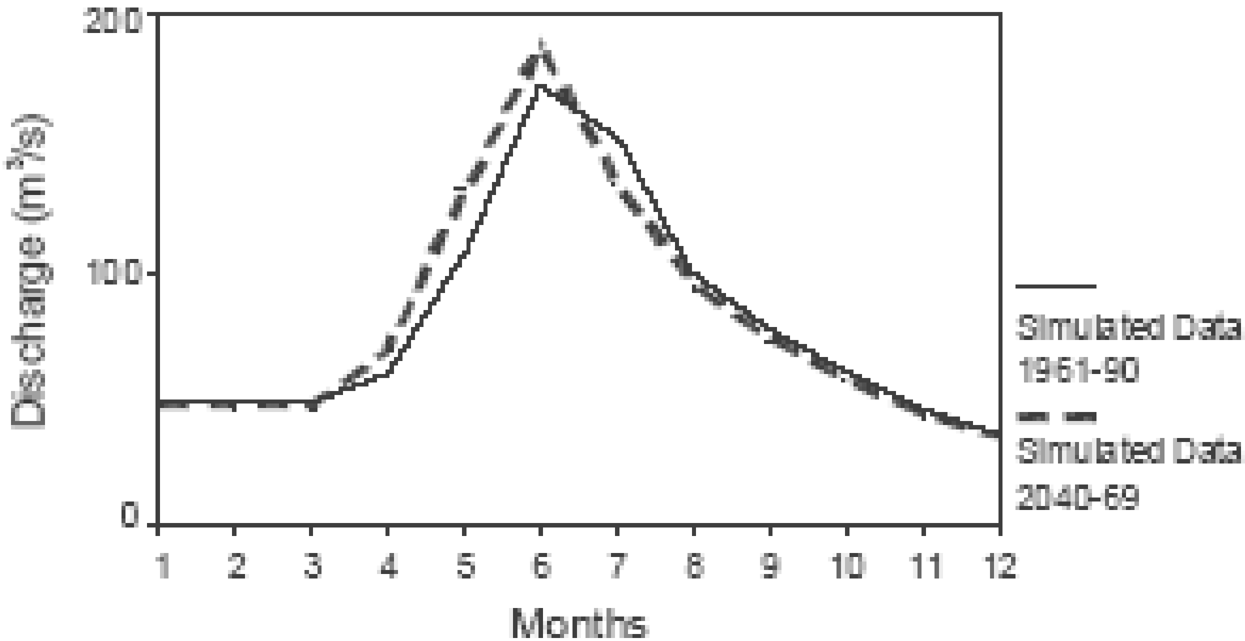

Figure 8. Variations of mean monthly discharge (m^3/s) of the Grass River basin for the periods 1961-90 and 2040-69 according to CGCM1.

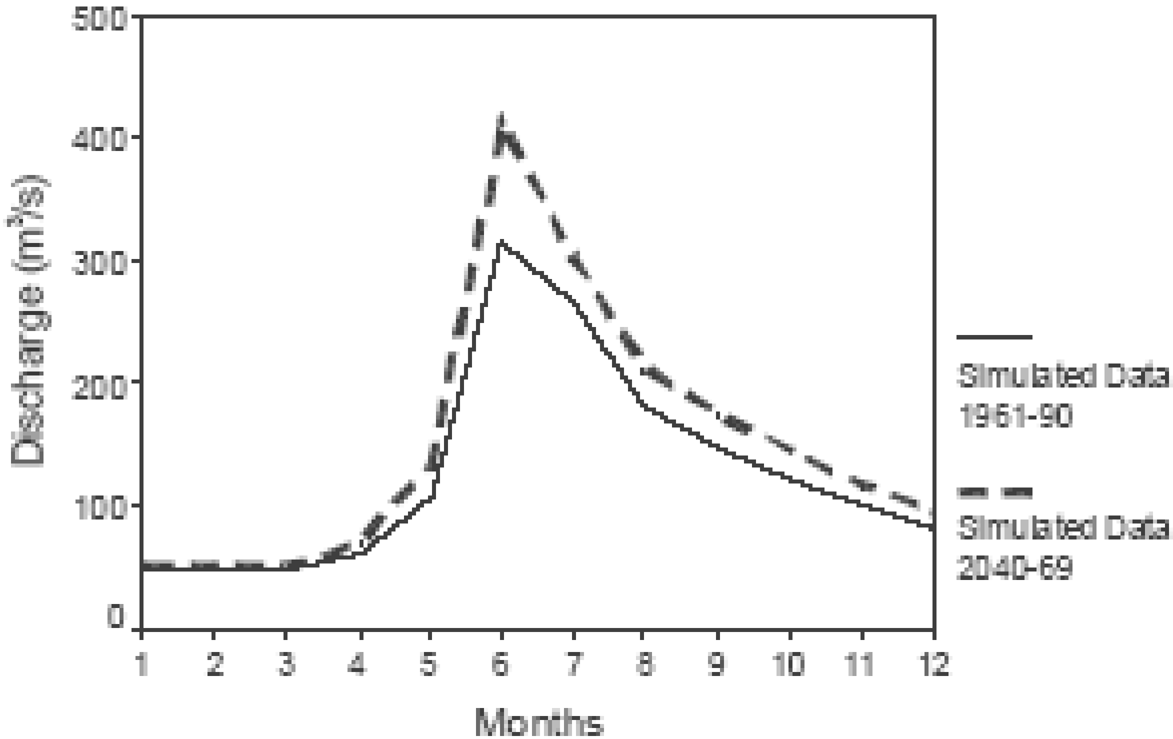

Figure 9. Variations of mean monthly discharge (m^3/s) of the Grass River basin for the periods 1961-90 and 2040-69 according to HadCM3.

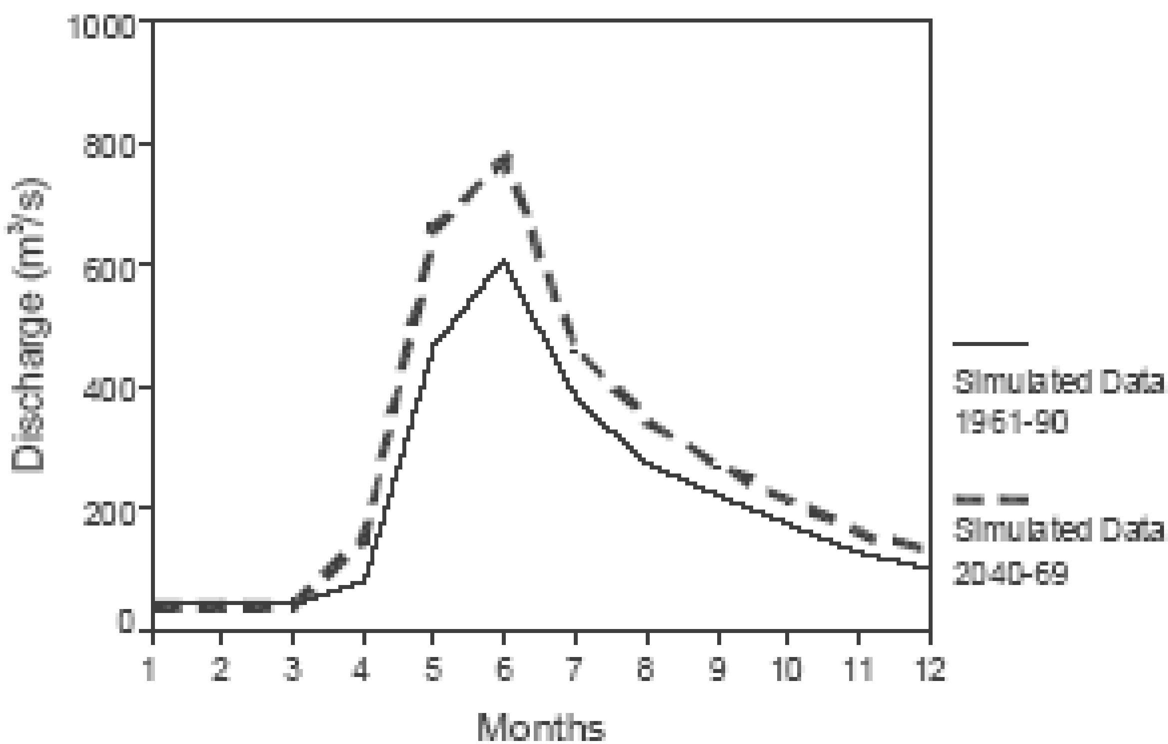

Figure 10. Variations of mean monthly discharge (m^3/s) of the Eagle River basin for the periods 1961-90 and 2040-69 according to CGCM1

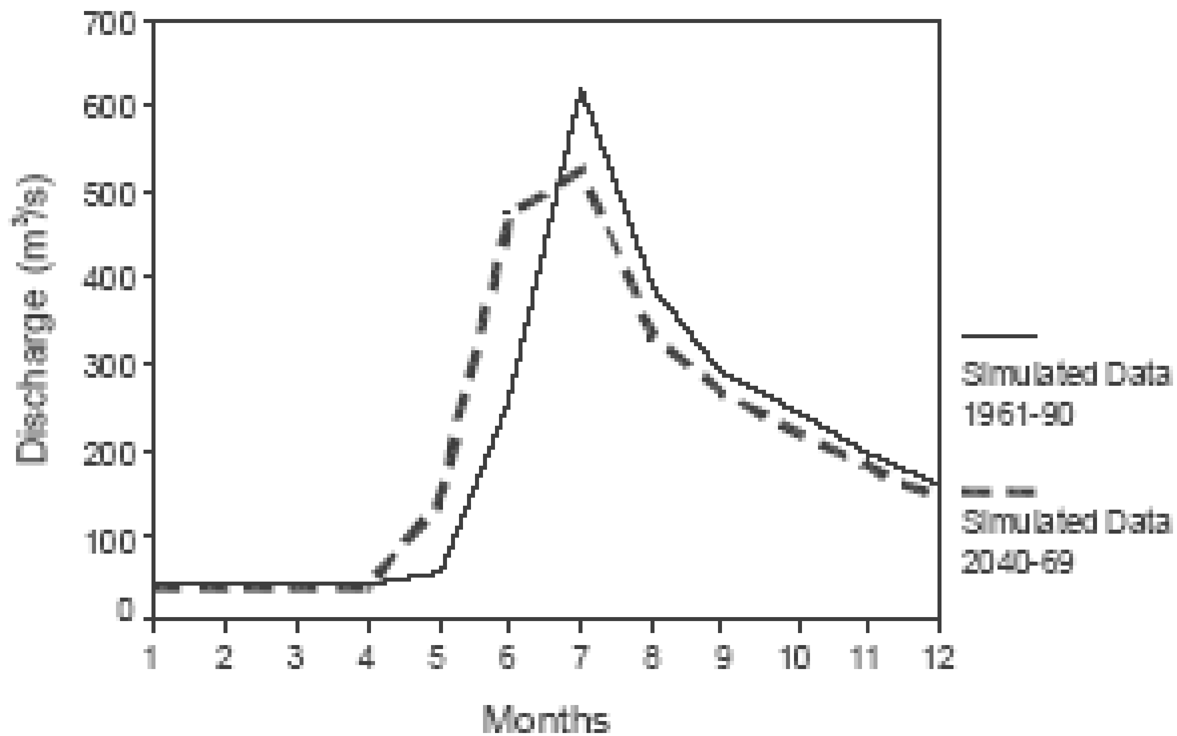

Figure 11. Variations of mean monthly discharge (m^3/s) of the Eagle River basin for the periods 1961-90 and 2040-69 according to HadCM3

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