ACS> Vol.2 No.4, October 2012

OPEN ACCESS

Possible Impacts of Climate Change on Daily Streamflow and Extremes at Local Scale in Ontario, Canada. Part II: Future Projection

PDF (Size:674KB) PP. 427-440 DOI: 10.4236/acs.2012.24037

Author(s)

Chad Shouquan Cheng, Qian Li, Guilong Li, Heather Auld

ABSTRACT

The paper forms the second part of an introduction to possible impacts of climate change on daily streamflow and extremes in the Province of Ontario, Canada. Daily streamflow simulation models developed in the companion paper (Part I) were used to project changes in frequency of future daily streamflow events. To achieve this goal, future climate information (including rainfall) at a local scale is needed. A regression-based downscaling method was employed to downscale eight global climate model (GCM) simulations (scenarios A2 and B1) to selected weather stations for various meteorological variables (except rainfall). Future daily rainfall quantities were projected using daily rainfall simulation models with downscaled future climate information. Following these projections, future daily streamflow volumes can be projected by applying daily streamflow simulation models. The frequency of future daily high-streamflow events in the warm season (May–November) was projected to increase by about 45%-55% late this century from the current condition, on average of eight-GCM A2 projections and four selected river basins. The corresponding increases for future daily low-streamflow events and future daily mean streamflow volume could be about 25%-90% and 10%-20%, respectively. In addition, the return values of annual one-day maximum streamflow volume for various return periods were projected to increase by 20%-40%, 20%-50%, and 30%-80%, respectively for the periods 2001-50, 2026-75, and 2051-2100. Inter-GCM and interscenario uncertainties of future streamflow projections were quantitatively assessed. On average, the projected percentage increases in frequency of future daily high-streamflow events are about 1.4-2.2 times greater than inter-GCM and interscenario uncertainties.

KEYWORDS

Rainfall-Related Streamflow; Future Projection; Downscaling; Statistic Methods; Ontario; Canada

Cite this paper

C. Shouquan Cheng, Q. Li, G. Li and H. Auld, "Possible Impacts of Climate Change on Daily Streamflow and Extremes at Local Scale in Ontario, Canada. Part II: Future Projection," *Atmospheric and Climate Sciences*, Vol. 2 No. 4, 2012, pp. 427-440. doi: 10.4236/acs.2012.24037.

References

[1] F. Bultot, A. Coppens, G. L. Dupriez, D. Gellens and F. Meulenberghs, "Repercussions of a CO2 Doubling on the Water Cycle and on the Water Balance—A Case Study for Belgium," Journal of Hydrology, Vol. 99, No. 3-4, 1988, pp. 319-347. doi:10.1016/0022-1694(88)90057-1

[2] D. Panagoulia and G. Dimou, "Sensitivity of Flood Events to Global Climate Change," Journal of Hydrology, Vol. 191, No. 1-4, 1997, pp. 208-222. doi:10.1016/S0022-1694(96)03056-9

[3] G. Drogue, L. Pfister, T. Leviandier, A. El Idrissi, J-F. Iffly, P. Matgen, J. Humbert and L. Hoffmann, "Simulating the Spatio-Temporal Variability of Streamflow Response to Climate Change Scenarios in a Mesoscale Basin," Journal of Hydrology, Vol. 293, No. 1-4, 2004, pp. 255-269. doi:10.1016/j.jhydrol.2004.02.009

[4] D. Cameron, "An Application of the UKCIP02 Climate Change Scenarios to Flood Estimation by Continuous Simulation for a Gauged Catchment in the Northeast of Scotland, UK (with Uncertainty),"

- Open Special Issues
- Published Special Issues
- Special Issues Guideline

ACS Subscription

Most popular papers in ACS

About ACS News

Frequently Asked Questions

Recommend to Peers

Recommend to Library

Contact Us

Journal of Hydrology, Vol. 328, No. 1-2, 2006, pp. 212-226. doi:10.1016/j.jhydrol.2005.12.024

[5] K. A. Forbes, S. W. Kienzle, C. A. Coburn, J. M. Byrne and J. Rasmussen, "Simulating the Hydrological Response to Predicted Climate Change on a Watershed in Southern Alberta, Canada," Climatic Change, Vol. 105, No. 3-4, 2011, pp. 555-576. doi:10.1007/s10584-010-9890-x

[6] A. L. Kay, R. G. Jones and N. S. Reynard, "RCM Rainfall for UK Flood Frequency Estimation. II. Climate Change Results," Journal of Hydrology, Vol. 318, No. 1-4, 2006, pp. 163-172. doi:10.1016/j.jhydrol.2005.06.013

[7] D. Panagoulia and G. Dimou, "Linking Space—Time Scale in Hydrological Modelling with Respect to Global Climate Change: Part 2. Hydrological Response for Alternative Climates," Journal of Hydrology, Vol. 194, No. 1-4, 1997, pp. 38-63. doi:10.1016/S0022-1694(96)03221-0

[8] T. Jiang, Y. D. Chen, C. Y. Xu, X. H. Chen, X. Chen and V. P. Singh, "Comparison of Hydrological Impacts of Climate Change Simulated by Six Hydrological Models in the Dongjiang Basin, South China," Journal of Hydrology, Vol. 336, 2007, pp. 316-333.

[9] A. W. Wood, D. P. Lettenmaier and R. N. Palmer, "Assessing Climate Change Implications for Water Resources Planning," Climatic Change, Vol. 37, No. 1, 1997, pp. 203-228. doi:10.1023/A:1005380706253

[10] L. E. Hay, R. L. Wilby and G. H. Leavesley, "A Comparison of Delta Change and Downscaled GCM Scenarios for Three Mountainous Basins in the United States," Journal of American Water Resources Association, Vol. 36, No. 2, 2000, pp. 387-397. doi:10.1111/j.1752-1688.2000.tb04276.x

[11] L. Sushama, R. Laprise, D. Caya, A. Frigonb and M. Slivitzkyb, "Canadian RCM Projected Climate-Change Signal and Its Sensitivity to Model Errors," International Journal of Climatology, Vol. 26, No. 15, 2006, pp. 2141-2159. doi:10.1002/joc.1362

[12] R. L. Wilby and T. M. L. Wigley, "Downscaling General Circulation Model Output: A Review of Methods and Limitations," Progress in Physical Geography, Vol. 21, No. 4, 1997, pp. 530-548. doi:10.1177/030913339702100403

[13] R. G. Najjar, "The Water Balance of the Susquehanna River Basin and Its Response to Climate Change," Journal of Hydrology, Vol. 219, No. 1-2, 1999, pp. 7-19. doi:10.1016/S0022-1694(99)00041-4

[14] P. H. Whitfield, J. Y. Wang and A. J. Cannon, "Modelling Future Streamflow Extremes—Floods and Low Flows in Georgia Basin, British Columbia," Canadian Water Resources Journal, Vol. 28, No. 4, 2003, pp. 633-656. doi:10.4296/cwrj2804633

[15] M. D. Dettinger, D. R. Cayan, M. K. Meyer and A. E. Jeton, "Simulated Hydrologic Responses to Climate Variations and Change in the Merced, Carson, and American River Basins, Sierra Nevada, California, 1900-2099," Climatic Change, Vol. 62, No. 1-3, 2004, pp. 283-317. doi:10.1023/B:CLIM.0000013683.13346.4f

[16] K. Jasper, P. Calanca, D. Gyalistras and J. Fuhrer, "Differential Impacts of Climate Change on the Hydrology of Two Alpine River Basins," Climatic Research, Vol. 26, No. 2, 2004, pp. 113-129. doi:10.3354/cr026113

[17] Y. B. Dibike and P. Coulibaly, "Hydrologic Impact of Climate Change in the Saguenay Watershed: Comparison of Downscaling Methods and Hydrologic Models," Journal of Hydrology, Vol. 307, No. 1-4, 2005, pp. 145-163. doi:10.1016/j.jhydrol.2004.10.012

[18] W. S. Merritt, Y. Alisa, M. Barton, B. Taylor, S. Cohen and D. Neilsen, "Hydrologic Response to Scenarios of Climate Change in Sub-Watersheds of the Okanagan Basin, British Columbia," Journal of Hydrology, Vol. 326, 2006, No. 1-4, pp. 79-108. doi:10.1016/j.jhydrol.2005.10.025

[19] C. S. Cheng, G. Li, Q. Li and H. Auld, "Statistical Downscaling of Hourly and Daily Climate Scenarios for Various Meteorological Variables in South-Central Canada," Theoretical and Applied Climatology, Vol. 91, No. 1-4, 2008, pp. 129-147. doi:10.1007/s00704-007-0302-8

[20] C. S. Cheng, G. Li, Q. Li and H. Auld, "A Synoptic Weather Typing Approach to Simulate Daily Rainfall and Extremes in Ontario, Canada: Potential for Climate Change Projections," Journal of Applied Meteorology and Climatology, Vol. 49, No. 5, 2010, pp. 845-866. doi:10.1175/2010JAMC2016.1

[21] C. S. Cheng, G. Li, Q. Li and H. Auld, "A Synoptic Weather-Typing Approach to Project Future Daily Rainfall and Extremes at Local Scale in Ontario, Canada," Journal of Climate, Vol. 24, No. 14, 2011, pp. 3667-3685. doi:10.1175/2011JCLI3764.1

[22] C. S. Cheng, Q. Li, G. Li and H. Auld, "Possible Impacts of Climate Change on Daily Streamflow and Extremes at Local Scale in Ontario, Canada," Part I: historical simulation. Atmospheric and Climate Sciences, Vol. 2, No. 4, 2012, pp. 416-426.

[23] PCMDI, "WCRP CMIP3 Multi-Model Dataset," 2008. http://www-pcmdi.llnl.gov/ipcc/about_ipcc.php

[24] Environment Canada, "DATA," 2006. http://www.cccma.bc.ec.gc.ca/data/data.shtml

[25] J. G. Galway, "The Lifted Index as a Predictor of Latent Instability," Bulletin of the American Meteorological Society, Vol. 37, 1956, pp. 528-529.

[26] J. J. George, "Weather Forecasting for Aeronautics," Academic Press, Waltham, 1960.

[27] R. C. Miller, "Notes on Analysis and Severe Storm Forecasting Procedures of the Air Force Global Weather Central," Technical Report 200(R), Headquarters US Air Weather Service, Omaha, 1972.

[28] R. W. Katz, "Techniques for Estimating Uncertainty in Climate Change Scenarios and Impact Studies," Climatic Research, Vol. 20, No. 2, 2002, pp. 167-185. doi:10.3354/cr020167

[29] IPCC, "Summary for Policymakers," In: S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor and H. L. Miller, Eds., Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge and New York, 2007, 18 pp.

[30] Ontario Management Act: Legislative Assembly of Ontario. "Bill 148 2002: An Act to Provide for Declarations of Death in Certain Circumstances and to Amend the Emergency Plans Act," 2006. http://www.ontla.on.ca/documents/Bills/37_Parliament/Session3/b148ra_e.htm

[31] H. Auld, D. MacIver, J. Klaassen, N. Comer and B. Tugwood, "Atmospheric Hazards in Ontario," ACSD Science Assessment Series No. 3 Meteorological Service of Canada, Environment Canada, Toronto, 2004.

[32] C. E. M. Sefton and D. B. Boorman, "A Regional Investigation of Climate Change Impacts on UK Streamflows," Journal of Hydrology, Vol. 195, No. 1-4, 1997, pp. 26-44. doi:10.1016/S0022-1694(96)03257-X

[33] D. Gellens and E. Roulin, "Streamflow Response of Belgian Catchments to IPCC Climate Change Scenarios," Journal of Hydrology, Vol. 210, No. 1-4, 1998, pp. 242-258. doi:10.1016/S0022-1694(98)00192-9

[34] N. W. Arnell, "Relative Effects of Multi-Decadal Climatic Variability and Changes in the Mean and Variability of Climate due to Global Warming: Future Streamflows in Britain," Journal of Hydrology, Vol. 270, No. 3-4, 2003, pp. 195-213. doi:10.1016/S0022-1694(02)00288-3

[35] K. Eckhardt and U. Ulbrich, "Potential Impacts of Climate Change on Groundwater Recharge and Streamflow in a Central European Low Mountain Range," Journal of Hydrology, Vol. 284, No. 1-4, 2003, pp. 244-252. doi:10.1016/j.jhydrol.2003.08.005

[36] N. W. Arnell and N. S. Reynard, "The Effects of Climate Change due to Global Warming on River Flows in Great Britain," Journal of Hydrology, Vol. 183, No. 3-4, 1996, pp. 397-424. doi:10.1016/0022-1694(95)02950-8