Recent fluctuations and trends in streamflow across northern Canada: Insights from the IPY

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INTRODUCTION

- Rivers flowing to the Arctic Ocean and polar seas drain 82% of Canada’s landmass or 8.2 x 10⁶ km².
- This freshwater alters the physical, chemical and biological properties of the Arctic Ocean and polar seas, possibly affecting global ocean circulation.
- Here we use observational data spanning the IGY to the IPY from hydrometric gauges at 45 rivers of northern Canada to better understand freshwater fluxes to the Arctic Ocean. Specifically, we investigate:
  1) the temporal evolution of the hydrometric network across the Canadian pan-Arctic region;
  2) the impacts of anthropogenic developments (dams) on Hudson Bay streamflow seasonality;
  3) the reconstruction of natural runoff for the highly regulated La Grande Rivière, Québec;
  4) the intensification of the hydrological cycle in northern Canada based on observational evidence.

STUDY AREA

Key Points

1) There is a notable shift in the seasonality of Hudson Bay streamflow over time, with a detectable positive (negative) trend in winter (summer) streamflow from 1964 to 2005 caused mainly by seasonal water storage for hydropower production.
2) The larger shifts in annual hydrographs for regulated rivers compared to natural systems demonstrate the significant impact of water regulation on the timing of total Hudson Bay streamflow.
3) The naturally-flowing rivers show a marked decline in the variability of daily streamflow input to Hudson Bay in recent years while the opposite trend is found in the regulated systems.

EVOLUTION OF THE HYDROMETRIC NETWORK

Key Points

1) Total gauged area increases, levels off, then decreases for the Canadian pan-Arctic (CP-A).
2) The maximum gauged area in the Canadian pan-Arctic was 60% in 1990 before declining to 56% in 2005.
3) Mean data availability generally improves with watershed size.
4) The number of river systems with 30 years of continuous records peaks at 22 in 1998 and declines thereafter.

ANTHROPOGENIC IMPACTS

Key Points

1) Following Hirsch’s (1982) Maintenance Of Variance Extension (MOVE) technique, the 1960 to 2004 observed runoff for the Eastmain River (I) and Grande Rivière de la Baleine (III) are used to reconstruct naturalized monthly and annual runoff for the highly regulated La Grande Rivière (IV), Québec.

RECONSTRUCTING NATURAL RUNOFF

Key Points

1) Following Hirsch’s (1982) Maintenance Of Variance Extension (MOVE) technique, the 1960 to 2004 observed runoff for the Eastmain River (I) and Grande Rivière de la Baleine (III) are used to reconstruct naturalized monthly and annual runoff for the highly regulated La Grande Rivière (IV), Québec.

AN INTENSIFYING HYDROLOGICAL CYCLE IN NORTHERN CANADA

Key Points

1) The 1994-2007 total annual discharge for 45 rivers of northern Canada averages 1153 km³ yr⁻¹ with a coefficient of variation (CV) of 6.2%.
2) There is a recent (1989-2007, thin dashed line) 15.5% increase in the total annual flows owing to much above average values recorded in the last 10 years of study in response to higher precipitation amounts (Déry and Wood 2005).
3) Trends in CV computed from 11-year moving windows of annual streamflows exhibit spatially coherent signals with increasing variability (▲) across most of northern Canada, excluding some rivers with outlets to the Labrador Sea and eastern James Bay (▼).
4) For the period of interest, 46% and 30% of the available gauged area and river discharge, respectively, experienced detectable increases in variability.

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