Observed Changes in Arctic River Discharge: An Annotated Bibliography
A Contribution to the NSF FWI Changes and Attribution Working Group
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This bibliography briefly summarizes selected papers addressing observed changes in arctic river discharge. The intent is to provide a quick introduction to the relevant literature for those not extremely familiar with it. Selected papers tend to address changes occurring over large spatial scales. Suggestions for additional papers to include are encouraged.

A companion document (~2 pages, yet to be written) will attempt to “synthesize” these and other papers, including model studies, into a single coherent summary of recent (1900 to present) changes in river discharge at the pan-arctic scale.


Berozovskaya et al. examine long-term annual precipitation and discharge trends for the Yenisey, Lena, and Ob’ river watersheds. If both data sets were reliable, one would expect concordance in precipitation and discharge trends. However, observed increases in Yenisey River discharge are apparently accompanied by decreases in precipitation, while precipitation increases over the Ob’ River watershed are insufficient to explain the larger discharge increases. The authors acknowledge that the accuracy of river discharge measurements is much higher than precipitation measurements, but conclude that the inconsistency of trends casts doubt on both data sets. They end by asking whether the available discharge and precipitation data are of sufficient quality to support robust conclusions about the changing arctic system.


Déry et al. investigate discharge trends of 42 rivers flowing into Hudson, James, and Ungava bays for the 1964-2000 period. They document a 13% decrease (96 km³/y) in combined annual discharge over the 37 year period. They also demonstrate that the onset of peak flow has generally gotten several days later and that peak discharge has significantly decreased. The decrease in river discharge into these bays correlates with
increasing salinity at an oceanographic monitoring station on the inner Newfoundland Shelf.


Lammers et al. summarize contemporary hydrography of the pan-arctic watershed based on data from more than 3700 discharge monitoring stations in Russia, Canada, the U.S., and Europe. This paper contains a wealth of statistics describing the hydrography of the pan-arctic watershed. The primary objective was not change detection, but increases in winter runoff in Siberia and Alaska were noted. The authors speculate that the trends were caused by warming, which shifted more of the snowmelt signal to winter (which they define as December through March).


This volume contains a wealth of information on the arctic hydrologic cycle. Chapters discussing trends in arctic river discharge include those by Grabs et al., Shiklomanov et al., Semiletov et al, and Stewart.

Very briefly, Grabs et al. discuss periodicities, jumps, and trends in discharge for the major arctic rivers. They note significant increases in discharge during the winter months, and an overall annual positive trend for Siberian rivers. Causality of trends is not considered.

Shiklomanov et al. note that annual discharge from rivers in the European part of Russia has increased since the 1980's, but that at the pan-arctic scale river discharge to the Arctic Ocean has not significantly changed. They also consider human water use, particularly in the Yenisey River basin.

Semiletov et al. identify a positive long-term trend in annual discharge from Siberian arctic rivers and consider the how changing atmospheric circulation patterns may be the driving factor. A large amount of additional climatological data (including precipitation and air temperature trends) is also included.

The chapter by Stewart addresses the hydrologic cycle of the Mackenzie River basin. Over the 1973-1995 period, a slight decrease in annual river discharge is noted.

McClelland, J. W., R. M. Holmes, B. J. Peterson, and M. Stieglitz (2004), Drivers of increasing river discharge in the Eurasian Arctic: consideration of dams,
McClelland et al. consider three potential causes of observed increases in discharge from the six largest Eurasian arctic rivers: dams, permafrost thaw, and fires. The authors conclude that none of these explanations are likely major contributors to the observed discharge increases. Instead, they suggest that increased precipitation – caused by global warming driven increases in atmospheric moisture transport from the tropics to the poles – is the likely explanation.


Peterson et al. investigate changes in the combined discharge from the six largest Eurasian arctic rivers (Yenisey, Lena, Ob', Kolyma, Pechora, Severnaya Dvina) over the period of record (1936-1999). They document a 7% increase (128 km³/y) over that time period and show that it correlates to global surface air temperatures and the NAO. They suggest that if river discharge remains linked to global warming and the earth warms as projected by the IPCC, increasing arctic river discharge over the coming century may be of sufficient magnitude to influence Atlantic thermohaline circulation.


Savelieva et al. investigate the relationships between atmospheric circulation patterns and hydrologic parameters in Siberia. They note that total annual river discharge in Siberia has increased over the period of record, with the post 1970s increase being about 4.5%. Large seasonal changes are documented, including increasing winter discharge. This paper primarily investigates atmospheric circulation drivers of these changes (changes in the location and intensity of the Siberian High and Aleutian Low after 1970), but also notes that increasing groundwater inputs related to the thickening permafrost active layer may be in part responsible for the discharge increase.


Serreze et al. examine hydroclimatological characteristics of the Yenisey, Lena, Ob', and Mackenzie rivers from 1960 onwards. This paper contains a great deal of information on precipitation and evapotranspiration, which will not be detailed here. Concerning observed changes in river discharge, the authors present data indicating that cold season discharge has increased in the Yenisey and Lena watersheds. They speculate that these changes may be a function of warming induced increases in active layer thickness and
permafrost thaw. They also present data indicating that Yenisey discharge has increased in spring, decreased in summer, and increased annually.


Yang et al. investigate long-term (1935-1999) monthly trends in discharge, air temperature, precipitation, river ice thickness, and active layer depth for the Lena River watershed. They identify substantial hydrologic changes, including 25-90% increases in cold season discharge (October through April). Annual discharge increases of 6% were also identified, whereas there was a slight decrease in discharge in September. The authors speculate that the large increases in cold season discharge are related to changing permafrost conditions caused by climate warming.


Yang et al. examine long-term (1935-1999) discharge trends in the Yenisey River watershed. They conclude that annual discharge has increased about 3% at the outlet, but that much larger changes have occurred in the seasonality of discharge. For example, at Igarka (the downstream most discharge monitoring station), November-April flow abruptly increased 40-70% in the mid 1970's, whereas flows in May decreased greatly. These changes in seasonality are primarily attributed to dam construction and operation. An effort is made to reconstruct what discharge would have been in the absence of dams. The authors note that several studies have identified winter discharge increases in other large arctic rivers such as the Lena and Ob', but not in the Yukon and Mackenzie rivers which are less developed.

Yang, D., B. Ye, and A. Shiklomanov (2004b), Discharge characteristics and changes over the Ob River watershed in Siberia, Journal of Hydrometeorology, 5, 595-610.

Yang et al. investigate long-term (1936-1990) discharge trends in the Ob’ River watershed, including major subbasins. In the upper Ob’ watershed, winter discharge increases whereas summer discharge decreased over the period of record. Summer discharge decreases were explained as responses to water loss to agriculture and to dam effects, whereas winter increases were attributed to winter releases from dam for hydroelectric production. In the lower Ob’ watershed, discharge increases were noted in summer and winter, with minor declines in autumn. Winter discharge increases were attributed to dam regulation and summer discharge increases were attributed to increasing summer precipitation. The authors note that it is difficult to separate direct human
impacts on discharge (dam operation, irrigation losses) from climate change without additional information.