2018 Headlines

Effects of persistent Arctic warming continue to mount

Continued warming of the Arctic atmosphere and ocean are driving broad change in the environmental system in predicted and, also, unexpected ways. New emerging threats are taking form and highlighting the level of uncertainty in the breadth of environmental change that is to come.

Video

Highlights

- **Surface air temperatures** in the Arctic continued to warm at twice the rate relative to the rest of the globe. Arctic air temperatures for the past five years (2014-18) have exceeded all previous records since 1900.
- In the **terrestrial system**, atmospheric warming continued to drive broad, long-term trends in declining terrestrial **snow cover**, melting of the **Greenland Ice Sheet** and **lake ice**, increasing summertime Arctic **river discharge**, and the expansion and greening of Arctic tundra **vegetation**.
- Despite increase of vegetation available for grazing, herd populations of **caribou and wild reindeer** across the Arctic tundra have declined by nearly 50% over the last two decades.
- In 2018 Arctic **sea ice** remained younger, thinner, and covered less area than in the past. The 12 lowest extents in the satellite record have occurred in the last 12 years.
- Pan-Arctic observations suggest a long-term decline in **coastal landfast sea ice** since measurements began in the 1970s, affecting this important platform for hunting, traveling, and coastal protection for local communities.
- Spatial patterns of late summer **sea surface temperatures** are linked to regional variability in sea-ice retreat, regional air temperature, and advection of waters from the Pacific and Atlantic oceans.
- In the Bering Sea region, **ocean primary productivity** levels in 2018 were sometimes 500% higher than normal levels and linked to a record low sea ice extent in the region for virtually the entire 2017/18 ice season.
- Warming Arctic Ocean conditions are also coinciding with an expansion of **harmful toxic algal blooms** in the Arctic Ocean and threatening food sources.
- **Microplastic contamination** is on the rise in the Arctic, posing a threat to seabirds and marine life that can ingest debris.

CAFF Conservation of Arctic Flora and Fauna
AMAP Arctic Monitoring and Assessment Programme
NOAA

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River Discharge

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Highlights

- In 2018, the combined daily discharge of the six largest Eurasian rivers peaked on June 4, five days earlier than the average over the 1980-89 reference period. The combined daily discharge of the Yukon and Mackenzie rivers peaked on May 29, four days earlier than the average during the reference period.
- In 2018, summer/autumn discharge (July 15-September 30) for the eight largest Arctic rivers was 20% greater than the 1980-89 reference period.
- Since last covered in the Arctic Report Card in 2015, Arctic river discharge has continued to increase, providing powerful evidence for the ongoing intensification of the Arctic hydrologic cycle.

The Arctic Ocean contains only about 1% of global ocean volume but receives greater than 10% of global river discharge (Aagaard and Carmack, 1989; McClelland et al., 2012). Consequently, terrestrial influences via river inputs are much stronger in the Arctic Ocean than in other ocean basins. Rapid change in the Arctic system is altering land-ocean linkages, impacting coastal and ocean physics, chemistry, and biology. Because rivers integrate processes occurring throughout watersheds, changes in the discharge and chemistry of large rivers can also signal widespread terrestrial change (Rawlins et al., 2010; Holmes et al., 2013).

Reported here are river discharge values for the eight largest Arctic rivers, updating the 2015 Arctic Report Card chapter (Holmes et al., 2015). Together, the watersheds of these eight rivers cover approximately two-thirds of pan-Arctic drainage area and account for over 60% of river water inputs to the Arctic Ocean (**Fig. 1**). Discharge measurements for the six Russian rivers began in 1936, whereas discharge measurements did not begin until 1973 for the Mackenzie River and 1976 for the Yukon River. Thus, we used 1980-89 as a reference period, the first decade with discharge measurements for all eight rivers.

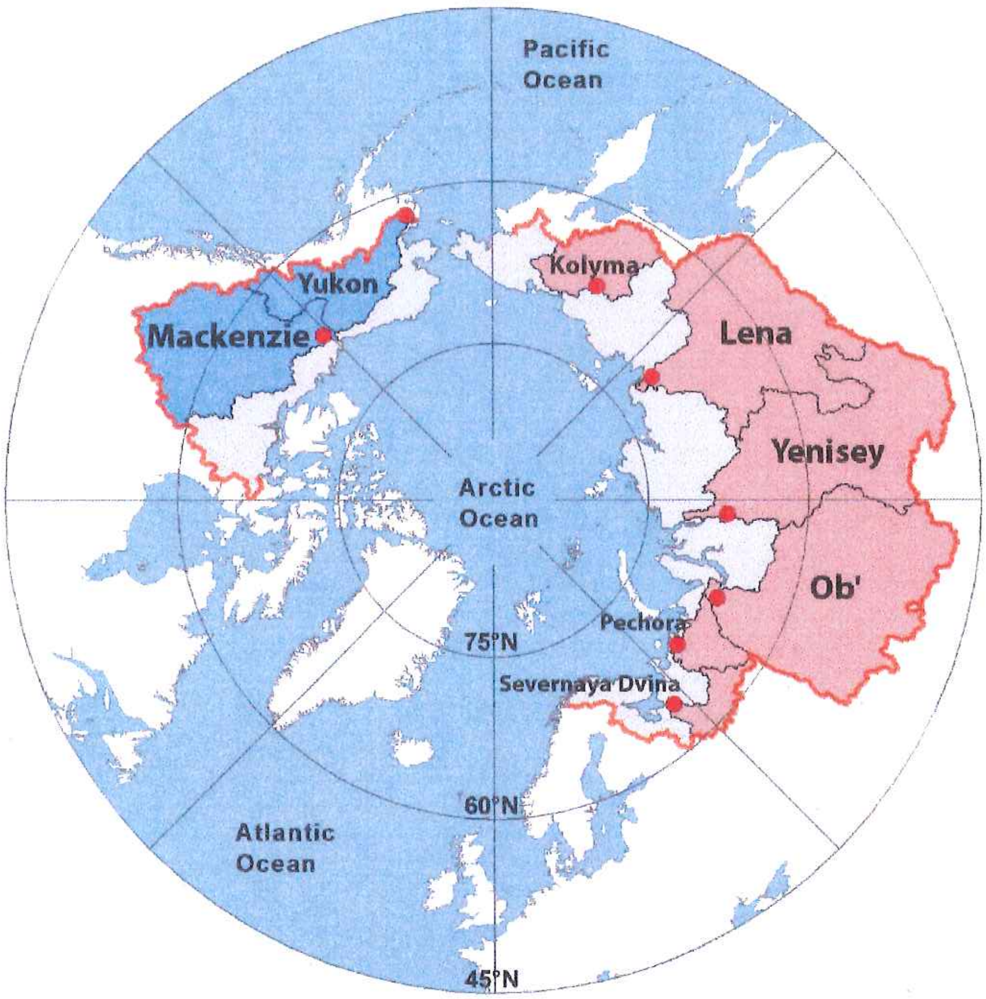

Fig. 1. Map showing the watersheds of the eight rivers featured in this report. Together they cover two-thirds of the 16.8 x 10^6 km^2 pan-Arctic watershed. The red dots show the location of the discharge monitoring stations and the red line shows the boundary of the pan-Arctic watershed.

A long-term increase in Arctic river discharge has been well documented (Peterson et al., 2002; McClelland et al., 2006). There is still some uncertainty about what is driving this trend, but documented increases in cold seasons precipitation provide a particularly compelling explanation (Shiklomanov and Lammers, 2009; Overeem and Syvitski, 2010; Rawlins et al., 2010; Déry et al., 2016; Rood et al., 2017). The long-term increasing discharge trend has been greatest for rivers of the Eurasian Arctic and constitutes the strongest evidence of intensification of the Arctic freshwater cycle (Rawlins et al., 2010).

In 2018, the combined daily discharge of the six Eurasian Arctic rivers peaked on June 4, five days earlier than the 1980-89 average (**Fig. 2a**). For the first nine months of 2018 (January 1-September 30), Eurasian river discharge was 7% greater than the 1980-89 average for the same period (**Table 1**). Discharge was particularly high in the Eurasian rivers during summer and autumn 2018, with their combined discharge over the period July 15-September 30 being 25% greater than the 1980-89 average for that same period (**Fig. 2**).

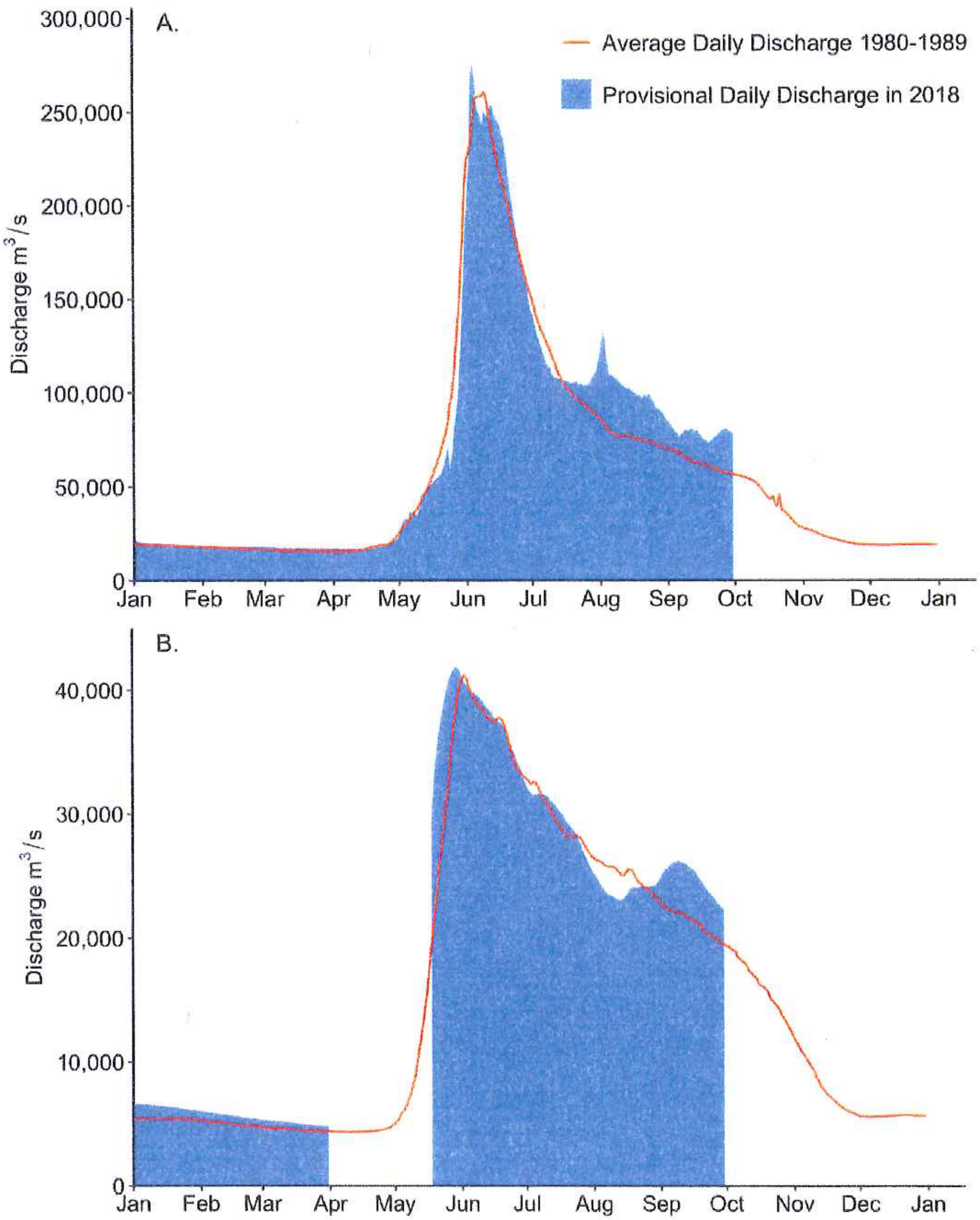

Fig. 2. Combined daily discharge (measured in cubic meters per second) for the first nine months of 2018 compared to the 1980-1989 average for the A) six Eurasian rivers, and B) two North American rivers. All 2018 data are provisional.

Table 1. Cumulative discharge for the first nine months of 2018 compared to the January-September average for 1980-89. Red values indicate provisional data and are subject to modification until official data are published. We

are not able to calculate Yukon River discharge for January-September 2018 because we are missing data for April 1-May 17.

	January - August Discharge (km³)							
	Pechora	S. Dvina	Ob'	Yenisey	Lena	Kolyma	Yukon	Mackenzie
2018	82	94	353	502	571	91	NA	241
1980-89 Average	94	83	318	503	490	65	169	227

The combined daily discharge of the Yukon and Mackenzie rivers peaked on May 29, 2018, four days earlier than the 1980-89 average (**Fig. 2b**). Discharge for the North American rivers from July 15-September 30 was 4% greater than the average over the 1980-89 reference period. When the Eurasian and North American rivers are considered together, their combined discharge in 2018 over the July 15-September 30 period was 20% greater than the average over the 1980-89 reference period.

In 2017, Eurasian Arctic river discharge was 12% greater than the average for the 1980-89 reference period (**Table 2**). In 2016 and 2015, river discharge was 5% and 15% greater than the 1980-89 average, respectively. In fact, over the past 15 years, Eurasian Arctic river discharge exceeded the long-term average in all but two years, 2003 and 2012 (**Fig. 3**). Taken together, these results indicate a continuing long-term trend of increasing Eurasian Arctic river discharge.

Table 2. Annual discharge for the eight largest Arctic rivers since 2015, compared to long-term and decadal averages back to the start of observations. Red values indicate provisional data.

	Discharge (km³/y)								
	Yukon	Mackenzie	Pechora	S. Dvina	Ob'	Yenisey	Lena	Kolyma	Sum
2017	192	290	109	127	446	608	590	108	2470
2016	242	281	87	97	431	530	652	66	2386
2015	213	265	137	80	527	649	585	64	2520
Average 2010-17	213	288	107	98	414	585	596	90	2391
Average 2000-09	206*	304	124	103	419	641	590	72	2459
Average 1990-99	216*	275*	117	111	405	613	532	68	2337
Average 1980-89	205	273	108	100	376	582	549	68	2261
Average 1970-79	183*	303*	108	94	441	591	529	65	2314
Average 1960-69	-	-	112	98	376	546	535	73	-
Average 1950-59	-	-	110	108	380	566	511	74	
Average 1940-49	-	-	102	100	424	578	498	72	-
Average for Period of Record	206	288	111	100	402	588	542	73	2310

*The first full year of Yukon discharge measurements at Pilot Station was 1976. Discharge measurements for the Yukon River at Pilot Station are missing for 1996-2001. The first full year of Mackenzie discharge measurements at

Arctic Red River was 1973. Discharge measurements for the Mackenzie River at Arctic Red River are missing for 1997 and 1998.

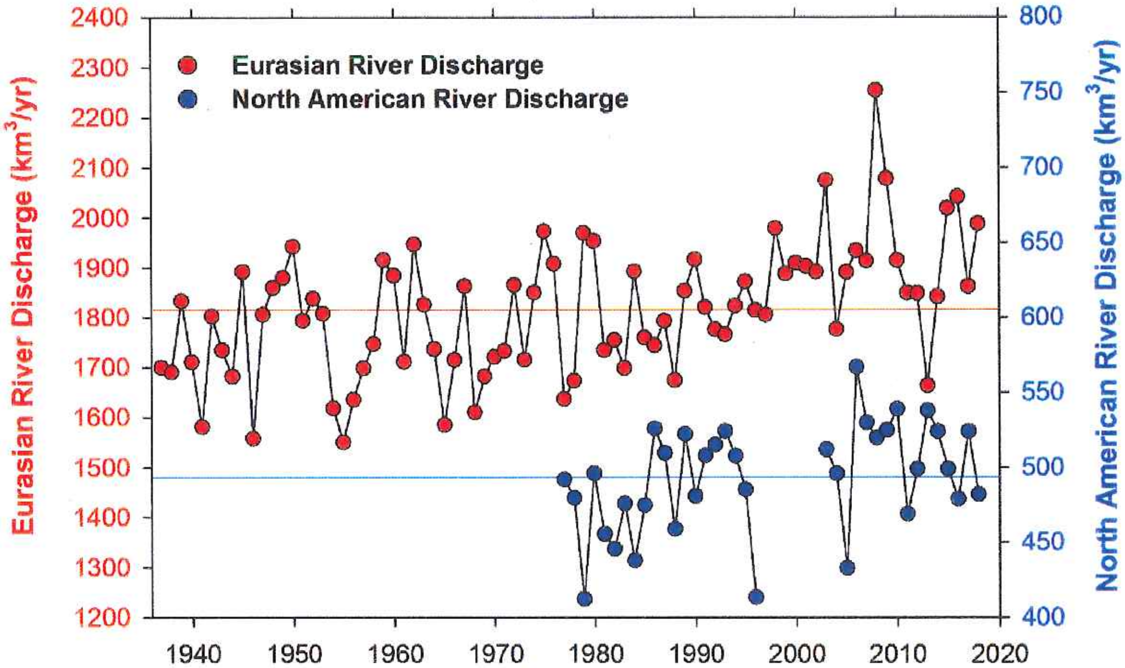

Fig. 3. Long-term trends in annual discharge for Eurasian (red) and North American (blue) Arctic rivers. Note the different scales for the Eurasian and North American river discharge; discharge from the former is 3-4 times greater than it is from the latter. Reference lines show long-term means for the Eurasian (1816 km^3/y, 1936-2017) and North American (493 km^3/y, 1976-2017) rivers.

In 2017, the combined discharge of the two largest North American Arctic rivers, the Yukon and Mackenzie, was 482 km^3, slightly above the 1980-89 reference period (**Table 2**). In 2016 the combined discharge of the Yukon and Mackenzie river was 9% greater than the 1980-89 reference period, whereas in 2015 the combined discharge of these two rivers was very similar to the reference period (**Table 2**). Since 1976, the increase in the combined river discharge has been 3.3±1.6% per decade for the Eurasian rivers and 2.0±1.8% per decade for the North American rivers (**Fig. 3**; Mann-Kendall trend analysis ±95% confidence interval).

Considering the eight Eurasian and North American Arctic rivers together, their combined discharge in 2017 (2470 km^3) was 9% greater than the average discharge for the period 1980-89 (**Table 2**). Values for 2016 (2387 km^3) and 2015 (2521 km^3) were 6% and 11% greater than the 1980-89 average, respectively. Overall these results indicate that Arctic river discharge continues to march upwards, providing powerful evidence for the intensification of the Arctic hydrologic cycle.

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