Supplementary materials for

A harmonized 2000–2024 dataset of daily river ice concentration and annual phenology for major Arctic rivers

Jiahui Qiu¹, Kari Luojus², Harri Kaartinen³, Yubao Qiu⁴, Jari Silander⁵, Epari Ritesh Patro¹, Björn Klöve¹, and Ali Torabi Haghighi¹

¹Water, Energy and Environmental Engineering Research Unit, University of Oulu, Oulu 90014, Finland

²Space and Earth Observation Centre, Finnish Meteorological Institute, Helsinki 00101, Finland

³Department of Remote Sensing and Photogrammetry, Finnish Geospatial Research Institute, National Land Survey of Finland, Espoo 02150, Finland

⁴Aerospace Information Research Institute, Chinese Academy of Sciences, Beijing 100094, China

⁵Quality of Information, Finnish Environment Institute, Helsinki 00790, Finland

Correspondence to: Jiahui Qiu (Jiahui.Qiu@oulu.fi)

This file includes:

15 Tables S1-S2

Figures S1-S10

Table S1: Comparison of mean cloud cover over six major rivers based on different satellite strategies. Mean cloud fractions over the six major river basins were compared for the entire hydrological year and the winter season (October 1 to April 30), using both the single-sensor approach (Terra or Aqua) and the final dual-sensor strategy adopted in this study.

	Terra annual	Terra winter	Aqua annual	Aqua winter	Combined annual	Combined winter
Mackenzie	0.624	0.648	0.612	0.621	0.439	0.383
Yukon	0.625	0.624	0.614	0.602	0.465	0.407
Kolyma	0.532	0.515	0.516	0.488	0.350	0.314
Lena	0.588	0.593	0.571	0.559	0.442	0.395
Yenisey	0.703	0.762	0.688	0.743	0.561	0.607
Ob	0.709	0.754	0.698	0.729	0.568	0.589
Average	0.630	0.649	0.617	0.624	0.471	0.449

Table S2: Mean phenology records (freeze-up date, breakup date, and ice duration) of six major rivers over 24-year period.

	Mean freeze-up date	Mean breakup date	Mean ice duration (day)
Mackenzie	October 20	April 24	187.45
Yukon	October 6	May 6	212.71
Kolyma	October 1	May 23	234.36
Lena	October 13	April 28	198.09
Yenisey	November 3	April 8	156.97
Ob	October 27	April 10	166.72
Average	October 20	April 22	184.97

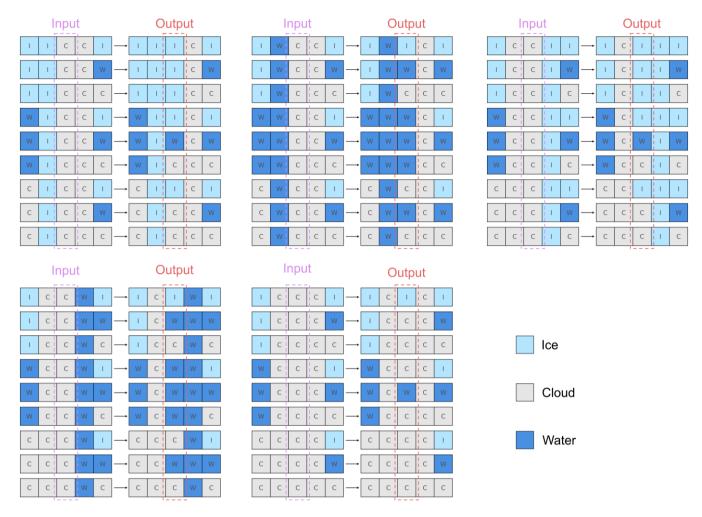


Figure S1: Logic flow for reclassifying central-day cloud pixels using a 5-day window. Of the 45 possible combinations, 13 lead to reclassification as river ice, 13 as water, and 19 remain as cloud.

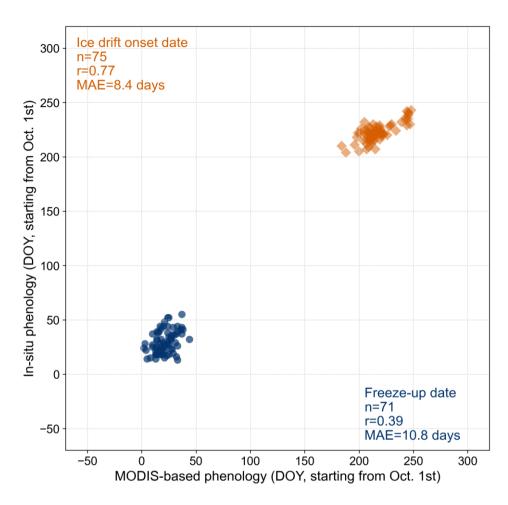


Figure S2: Comparison of MODIS-derived river ice phenology (freeze-up and breakup dates) with long-term gauge records. Satellite-based breakup events were compared with the in situ ice drift onset date.

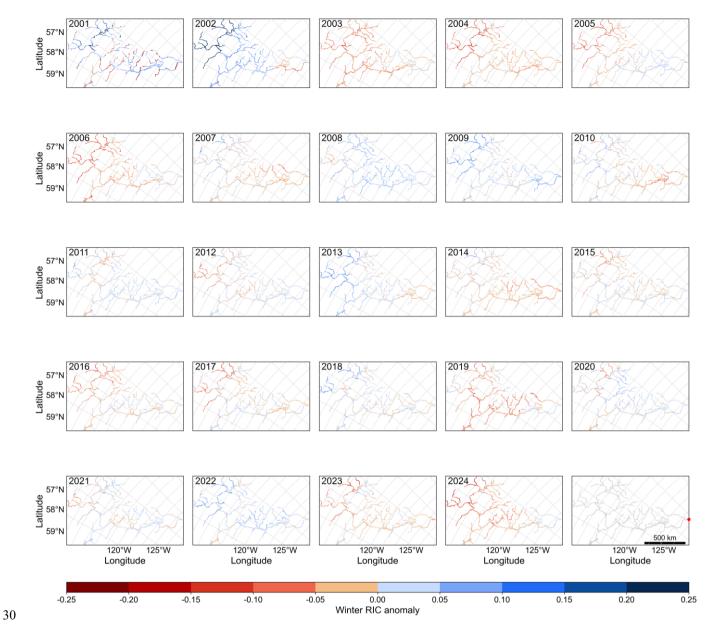


Figure S3: Maps show hydrological year winter (October-April) anomalies in MODIS-derived RIC across the Mackenzie River basin. Anomaly is defined as the winter-mean RIC for a given hydrological year minus the 24-year climatological winter mean (2001–2024) computed at each pixel. All maps are presented in the EPSG:3995 coordinate reference system.

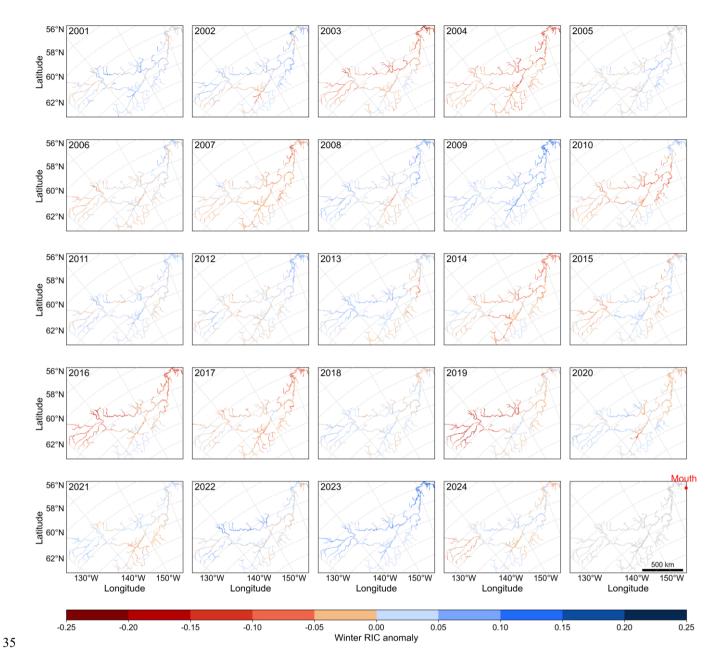


Figure S4: Maps show hydrological year winter (October-April) anomalies in MODIS-derived RIC across the Yukon River basin. Anomaly is defined as the winter-mean RIC for a given hydrological year minus the 24-year climatological winter mean (2001–2024) computed at each pixel. All maps are presented in the EPSG:3995 coordinate reference system.

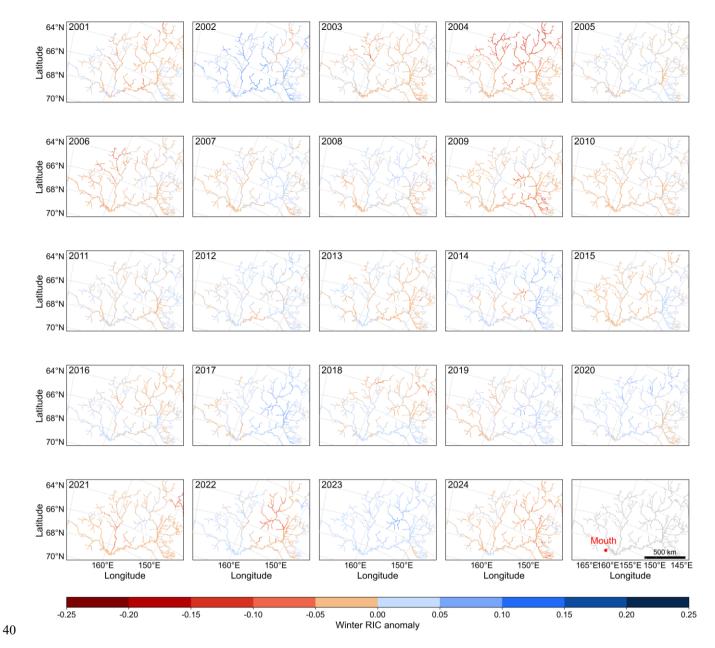


Figure S5: Maps show hydrological year winter (October-April) anomalies in MODIS-derived RIC across the Kolyma River basin. Anomaly is defined as the winter-mean RIC for a given hydrological year minus the 24-year climatological winter mean (2001–2024) computed at each pixel. All maps are presented in the EPSG:3995 coordinate reference system.

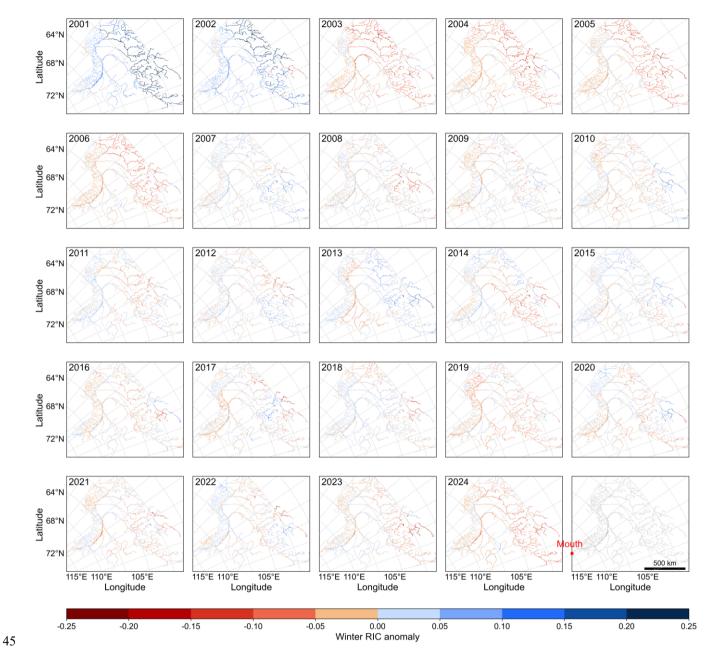


Figure S6: Maps show hydrological year winter (October-April) anomalies in MODIS-derived RIC across the Lena River basin. Anomaly is defined as the winter-mean RIC for a given hydrological year minus the 24-year climatological winter mean (2001–2024) computed at each pixel. All maps are presented in the EPSG:3995 coordinate reference system.

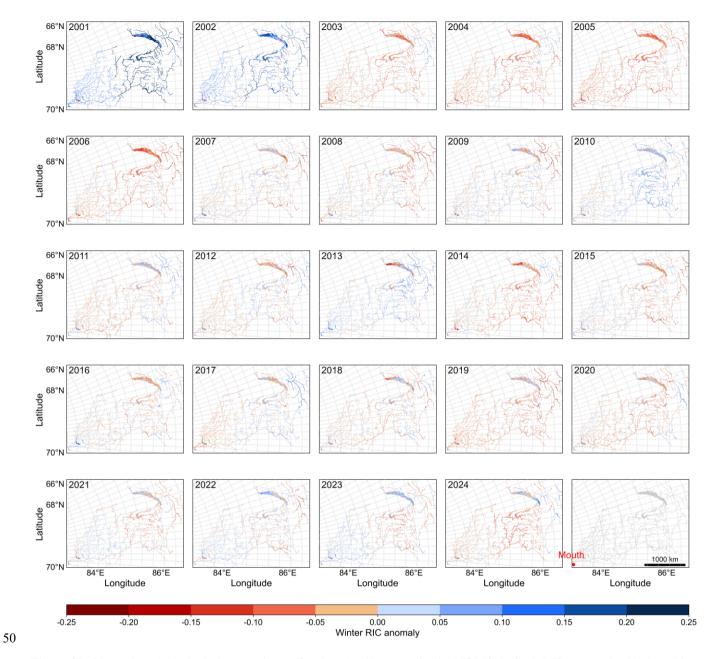


Figure S7: Maps show hydrological year winter (October-April) anomalies in MODIS-derived RIC across the Yenisey River basin. Anomaly is defined as the winter-mean RIC for a given hydrological year minus the 24-year climatological winter mean (2001–2024) computed at each pixel. All maps are presented in the EPSG:3995 coordinate reference system.

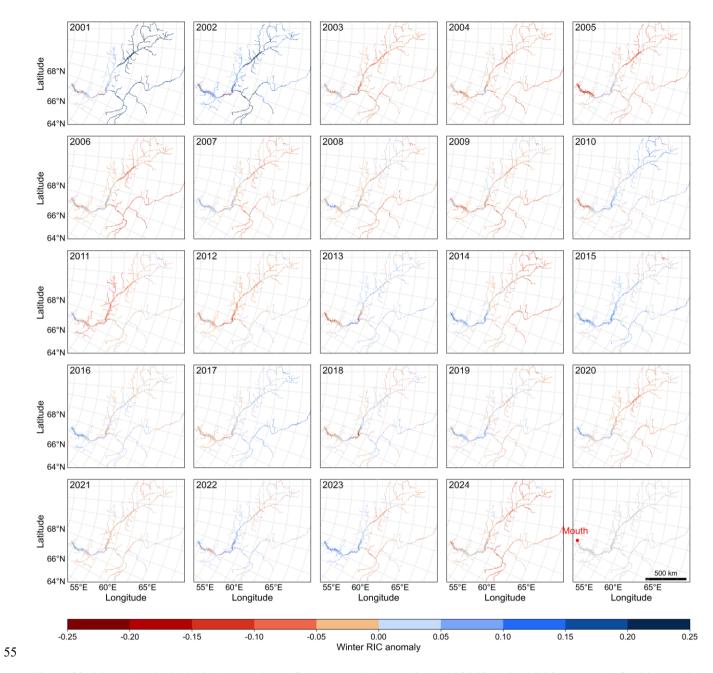


Figure S8: Maps show hydrological year winter (October-April) anomalies in MODIS-derived RIC across the Ob River basin. Anomaly is defined as the winter-mean RIC for a given hydrological year minus the 24-year climatological winter mean (2001–2024) computed at each pixel. All maps are presented in the EPSG:3995 coordinate reference system.

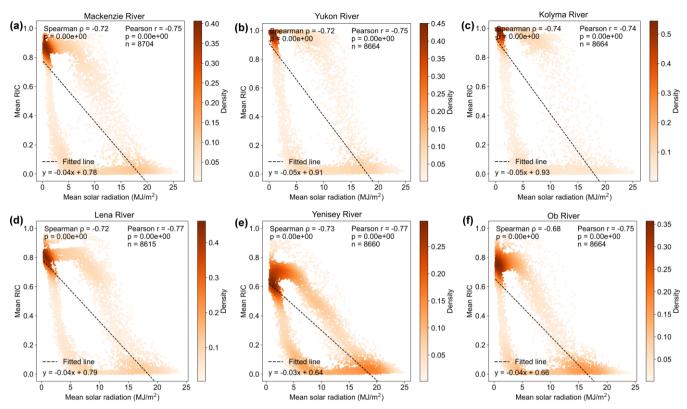


Figure S9: Correlation between MODIS-derived winter RIC and net solar radiation across six major Arctic rivers. Each point denotes the basin-mean RIC and contemporaneous net solar radiation for a given date.

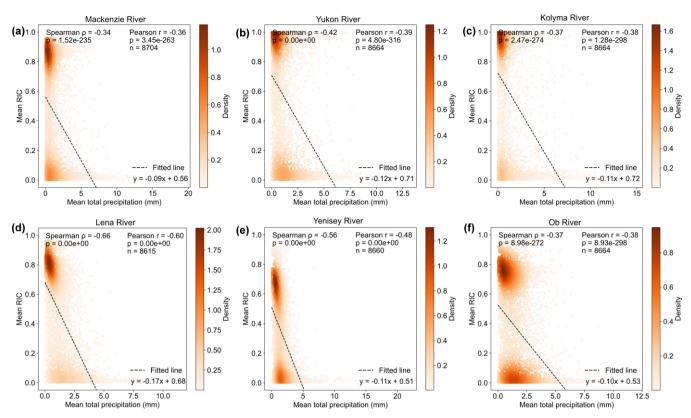


Figure S10: Correlation between MODIS-derived winter RIC and total precipitation across six major Arctic rivers. Each point denotes the basin-mean RIC and contemporaneous total precipitation for a given date.