ABoVE: River Ice Breakup and Freeze-up Stages, Yukon River Basin, Alaska, 1972-2016

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Documentation Revision Date: 2019-07-20

Dataset Version: 1

Summary

This dataset provides estimates of river ice breakup and freeze-up stages along selected reaches of the Yukon and Tanana Rivers in the Yukon River Basin in interior Alaska from 1972-2016. Time series of Landsat satellite images were visually interpreted to identify the day of year and characteristics of the different stages of river ice seasonality. The stages of breakup or freeze-up were distinguished from one another based on the spatial extent and patterns of open water and ice cover. Images were displayed as false color composites, with the shortwave infrared (SWIR), near infrared (NIR), and green bands represented by red, green, and blue.

This dataset includes 645 observations of river ice breakup or freeze-up stages on the Yukon and Tanana Rivers near the communities of Beaver, Grayling, and Tok, Alaska. Not all stages were observed each year, and in some years, multiple dates of the same stage were observed. Independent datasets of local observations were used to validate the remote sensing classifications. The purpose of this study was to determine how river ice seasonality has changed over time and how the changes impact people who depend on rivers for travel and access to subsistence resources (Brown et al. 2018).

There is one data file in comma-separated format (.csv) with this dataset.

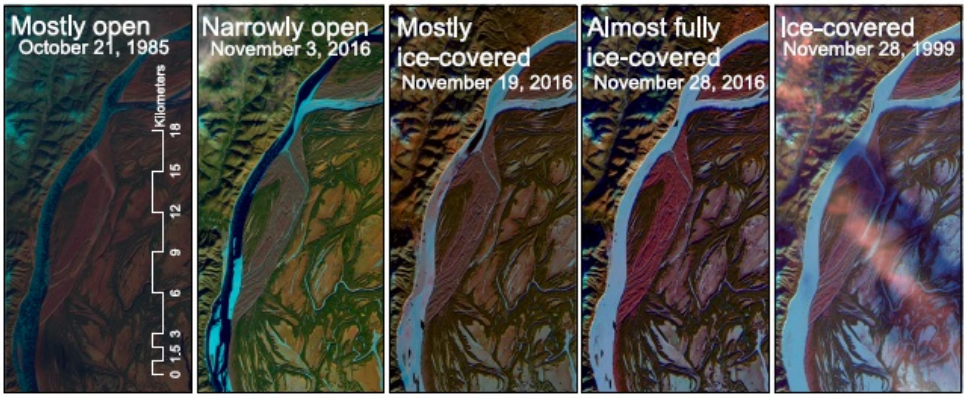

Figure 1. Examples of freeze-up stages in the Grayling study area. Landsat images are displayed as color composites (R: SWIR, G: NIR, B: green), where water appears dark blue and snow/ice appears light blue. From Brown et al. (2018).

Citation

Brown, D.R.N., T.J. Brinkman, and D. Verbyla. 2019. ABoVE: River Ice Breakup and Freeze-up Stages, Yukon River Basin, Alaska, 1972-2016. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1697

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1. Dataset Overview

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Project: Arctic-Boreal Vulnerability Experiment

The Arctic-Boreal Vulnerability Experiment (ABoVE) is a NASA Terrestrial Ecology Program field campaign based in Alaska and western Canada between 2016 and 2021. Research for ABoVE links field-based, process-level studies with geospatial data products derived from airborne and satellite sensors, providing a foundation for improving the analysis and modeling capabilities needed to understand and predict ecosystem responses and societal implications.

Related Publication:

Brown, D.R.N., T.J. Brinkman, D.L. Verbyla, C.L. Brown, H.S. Cold, and T.N. Hollingsworth. 2018. Changing River Ice Seasonality and Impacts on Interior Alaskan Communities. Journal of the American Meteorological Society, https://doi.org/10.1175/WCAS-D-17-0101.1

Acknowledgements:

This research was funded by the NASA ABoVE program, grant number NNX15AT72A.

2. Data Characteristics

Spatial Coverage: Alaska

ABoVE Reference Locations:

Domain: Core ABoVE

State/territory: Alaska

Grid cell(s): Ah0Av0Bh3Bv3Ch21Cv22, Ah1Av0Bh7Bv4Ch44Cv29, Ah1Av1Bh7Bv7Ch42Cv42

Spatial Resolution: Observations were derived from 30 m Landsat imagery along river reaches within a 65 km diameter buffer area around each community.

Temporal Coverage: 1972-11-04 to 2016-11-30

Temporal Resolution: Spring breakup and Fall freeze-up seasons

Study Areas (All latitude and longitude given in decimal degrees based on NAD83 datum.)

Region	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Yukon River Basin	-160.0647	-142.9856	66.3594	62.9036
Focal Communities*				
Beaver	-147.3964	-147.3964	66.3594	66.3594
Grayling	-160.0647	-160.0647	62.9036	62.9036
Tok	-142.9856	-142.9856	63.3367	63.3367

* Community locations: The study area for each community was a 65 km diameter circle centered on the community.

Data File Information

There is one data file in comma-separated format (.csv) with this dataset.

Table 1. Data file description

river_ice_stages_landsat.csv	This file provides the latitude, longitude, year and day for river ice breakup or freeze-up for three study areas in Alaska (Beaver, Grayling, and Tok) and descriptions regarding the breakup or freeze-up stages. The Landsat IDs used in the study are also provided.

Table 2. Variables in the data file.

Column Header	Units/format	Description
id		Unique record identifier (1-645 rows of observations)
study_area		Study area (Beaver, Grayling, Tok)
latitude	Decimal degrees	Latitude of center of study area (NAD83)
longitude	Decimal degrees	Longitude of center of study area (NAD83)
season		Season (break-up, freeze-up)

year	YYYY	Year
day_of_year	DDD	Day of year of imagery acquisition
river_ice_stage		Visually interpreted stage of river ice breakup or freeze-up. Refer to Table 3 for descriptions of the observations
landsat_id_1		ID of Landsat scene used for analysis
landsat_id_2		ID of additional Landsat scene used for analysis

Table 3. Description of Stages of Break-up/Freeze-up

River Ice Stages	Description
Break-up stages	
ice-covered	River is ice-covered except for isolated open water features
somewhat deteriorated	River is predominantly ice-covered but large open water leads are widespread
severely deteriorated	River has nearly contiguous expanse of ice but is severely deteriorated with large expanses of open water
partially open	Active breakup; river has open stretches but large expanses remain clogged with ice
mostly open	River is mostly open, but main channel still has floating ice; some sloughs may still have contiguous ice
open	River is clear of ice
Freeze-up stages	
open	River is clear of ice
mostly open	River is mostly open, but initial freezing has begun; some sloughs and tributaries may be ice-covered
narrowly open	Sides of main channel are ice-covered, leaving a narrow open channel; most sloughs and tributaries are ice-covered
mostly ice-covered	Some stretches of river are fully ice-covered and some stretches have open water
almost fully ice-covered	River is almost fully ice-covered but has widespread open water leads.
ice-covered	River is fully ice-covered except for isolated open water leads

3. Application and Derivation

This study could be useful to climate change policies considering the economics and human safety impacts from climate warming on communities in Alaska. Subsistence harvesters in high latitudes rely on frozen rivers for winter access to local resources. During recent decades, interior Alaskan residents have observed changes in river ice regimes that are significant hindrances to travel and subsistence practices. The duration of river ice cover for safe travel has declined over the last century and is expected to decline further as the climate continues to warm, thereby presenting new challenges to accessing subsistence resources and necessitating community adaptation (Brown et al., 2018).

4. Quality Assessment

The qualitative classifications of breakup stage were tested and validated by close associations with local observations and by normalized difference water index-based classifications showing consistent spatial cover of open water or deteriorated ice within each stage (Brown et al., 2018).

5. Data Acquisition, Materials, and Methods

The following sections are excerpts from Brown et al. (2018).

Study Area

The Yukon River, approximately 3,200 km in length, flows from northwestern Canada through interior Alaska and into the Bering Sea. The Tanana River is one of two major tributaries to the Yukon River that is glacier fed. Most streamflow occurs in summer from snowmelt, precipitation, and glacial melt. The Yukon River Basin encompasses diverse climatic and physiographic areas with varying permafrost extent, from sporadic to continuous. The basin covers a region that is predominantly composed of boreal forest vegetation and is generally characterized by a cold continental climate with low precipitation. Of the nine rural interior Alaskan communities in the Yukon River Basin associated with a larger study, three communities representing different regions were selected as the primary study sites: Beaver, Grayling, and Tok (Figure 2).

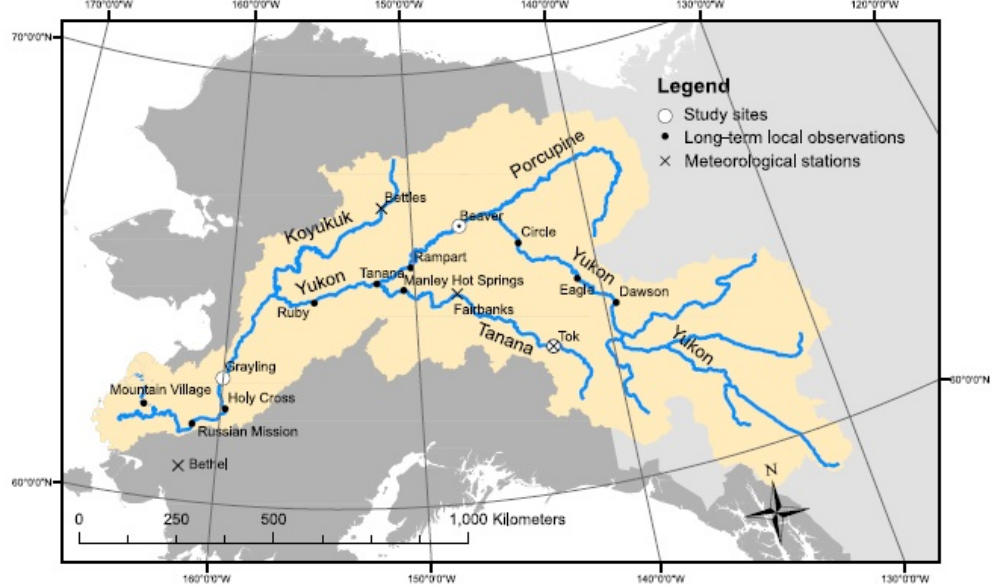

Figure 2. Map of Yukon River Basin (tan) in Alaska and western Canada showing the locations of major rivers, study sites, long-term local observations, meteorological stations (image is from Brown et al., 2018).

A 65-km diameter buffer was used to determine the study area around each community. The size of the study area was chosen to both represent core subsistence areas and maximize the sample size of remote sensing observations. Beaver (pop. 84) is located in the Yukon Flats region in the upper Yukon River. Contemporary Beaver is self-reported as 100% Alaska Native. Grayling (pop. 193) is a Holikachuk Athabascan community located along the lower–middle Yukon River. Tok (pop. 1258) is in eastern Alaska near the upper Tanana River. Of the three study communities, Tok has a much different ethnic profile, with only 16% of residents self-reporting as Alaska Native. Unlike Beaver and Grayling, Tok is located along the road network.

Satellite imagery

Satellite imagery from Landsat Multispectral Scanner (MSS), Thematic Mapper (TM), Enhanced Thematic Mapper Plus (ETM1), and Operational Land Imager (OLI) sensors were acquired from the United States Geological Survey (USGS; USGS 2017). Scenes during the shoulder seasons from each of the three study areas were used from 1972 to 2016. The full breakup season was captured using imagery from mid-March through May. Imagery from mid-October through November was used for the freeze-up season. Because of low sun elevation, imagery was generally not available beyond mid-November, limiting the ability to capture the end of the freeze-up season in many years. The repeat orbit cycle for each Landsat satellite is 16 days. However, at the high latitudes of our study areas, there was substantial overlap between passes, allowing for repeat coverage at less than a 16-day cycle. Historic imagery was used from 313 dates during the spring breakup period and 120 dates during the fall freeze-up period. The satellite imagery was visually interpreted to determine different stages of the breakup and freeze-up seasons and to determine their timing. Stages of breakup or freeze-up were distinguished from one another based on spatial extent and patterns of open water or ice cover. Images were displayed as false color composites, with the shortwave infrared (SWIR), near infrared (NIR), and green bands represented by red, green, and blue. High values in the thermal bands were also sometimes used to differentiate water from other dark surfaces during the freeze-up season.

Not all stages were observed each year, and in some years, multiple dates of the same stage were observed. To test whether the visual interpretations were conducted consistently and reliably, quantitative estimates were compared of the spatial extent of ice deterioration among the different breakup stages in the Beaver study area. This validation was limited to the breakup season because low sun angles and resulting shadows during the freeze-up season inhibited the use of band indices.

Local observations

Independent datasets of local observations were used to validate the remote sensing classifications. The Alaska–Pacific River Forecast Center (APRFC) of the National Weather Service maintains databases of local observations of breakup (APRFC 2017a) and freeze-up (APRFC 2017b) for locations throughout the state. These observations were made by ice observers for the National Weather Service who were either local residents or hydrologists.

6. Data Access

These data are available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

ABoVE: River Ice Breakup and Freeze-up Stages, Yukon River Basin, Alaska, 1972-2016

Contact for Data Center Access Information:

- E-mail: uso@daac.ornl.gov
- Telephone: +1 (865) 241-3952

7. References

APRFC, 2017a: Break up database. Alaska–Pacific River Forecast Center, National Weather Service, accessed 22 February 2017, https://www.weather.gov/aprfc/breakupDB

APRFC, 2017b: Freeze up data. Alaska–Pacific River Forecast Center, National Weather Service, accessed 4 April 2017, https://www.weather.gov/aprfc/freezeUp

Brown, D.R.N., T.J. Brinkman, D.L. Verbyla, C.L. Brown, H.S. Cold, and T.N. Hollingsworth. 2018. Changing River Ice Seasonality and Impacts on Interior Alaskan Communities. Journal of the American Meteorological Society, https://doi.org/10.1175/WCAS-D-17-0101.1