River Ice Breakup on Major Alaskan Rivers: Insights into Predictability, and a new Degree-Day Based Model

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Photo credit: *Tanana River near Salcha, May 2023, contributed to Fresh Eyes on Ice (Tori Brannan)*

Objective: To enhance breakup guidance for the Alaska-Pacific River Forecast Center (APRFC)

NOAA / NWS funding through CICOES

Generate daily updated predictions of breakup date

Start in early April for 37 river locations on priority list (2024)

Based on degree days (DD ⩾ 25°F)

Run operationally starting April 2024

Better understand breakup process

Objective, scientific model choices

Investigation of predictors and factors affecting predictability

Provide user-friendly products

Probabilities of breakup next days/weeks ← APRFC feedback

Code distributed via GitHub &run by APRFC (starting 2025)

Extend work to the future

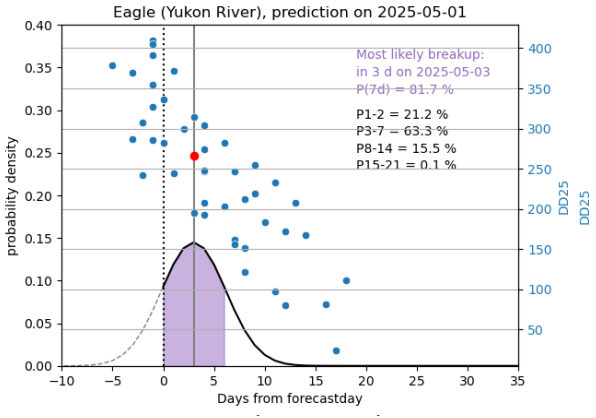
- dynamical forecasts
- "early indicators"
- solar radiation
- ice conditions
- breakup sequence along a river
- breakup severity

Icons: https://thenounproject.com/

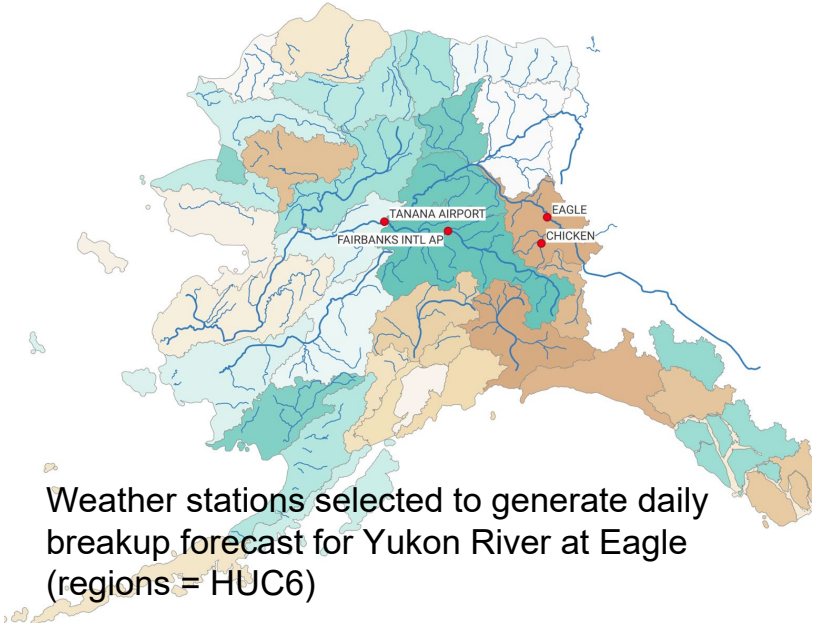
Example: Yukon River at Eagle

median breakup date: May 5
trend: 1 day earlier per 15 years

Evaluation of DD25-based model		
	forecast on April 20	actual breakup
2024	2024-05-05	2024-05-03
2025	2025-05-02	2025-05-01



breakup forecast visualization product
blue dots: historical time to breakup vs DD25



Weather stations selected to generate daily breakup forecast for Yukon River at Eagle (regions = HUC6)

Selection based on correlation between forecast date and DD25 anomaly throughout the breakup season

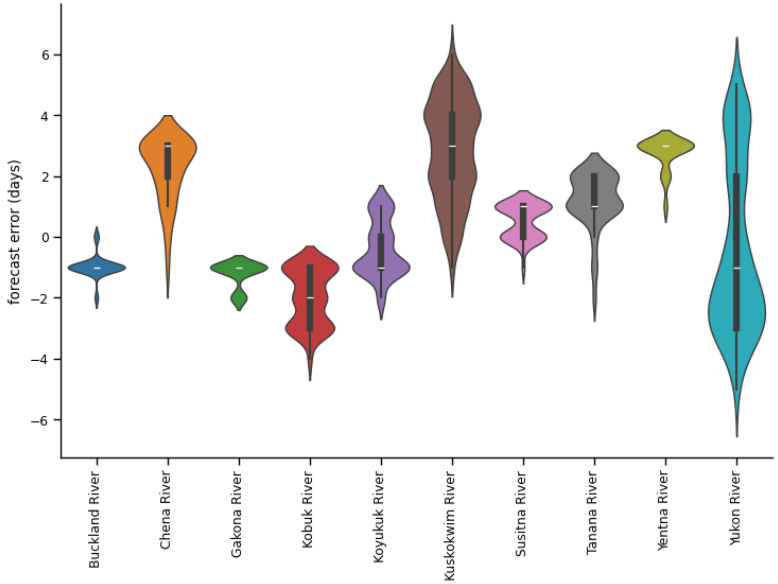
How well did the model perform?

2024 - first operational run:

- Maximum error: 6 days late to 5 days early (April 1 to end of breakup)
- Most forecasts within target ± 3 day window

2025 - operational runs by APRFC:

- Added 9 locations
- Errors similar to 2024 (based on Yukon and Kuskokwim Rivers)



2024: forecast errors by river

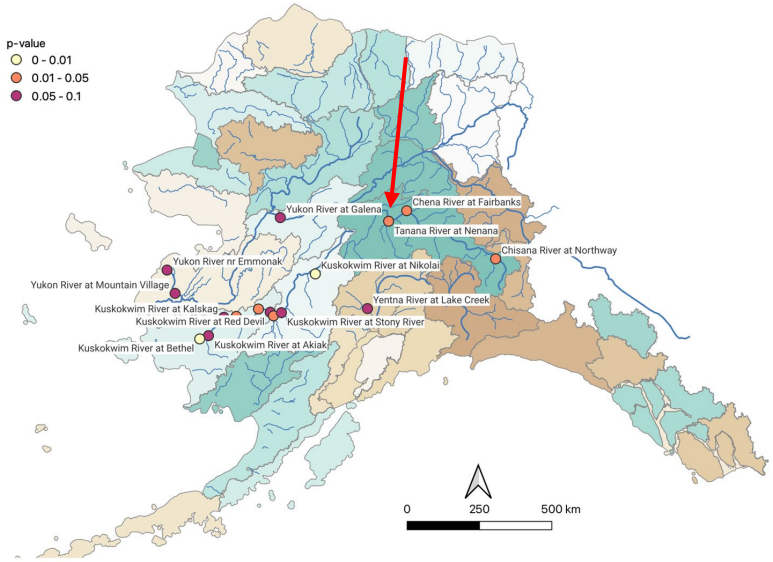
What else did we learn?

Pre-season predictor analysis (ML):

- Works better on Interior locations than along the coast
- **Greater variability** in model error than DD25 model, typically underpredicted
- Important predictors: ENSO, EA, EP NP, AO and Ice Thickness
- **Ice thickness at Nenana** correlates well with breakup date along Kuskokwim river

2025 season:

- **Rain-on-snow events** during late winter may have accelerated ice melting on the Kuskokwim River



Correlation of ice thickness measured on the Tanana River at Nenana (arrow) with breakup date

Future work:
characterize ice conditions
enhance predictors
refine model

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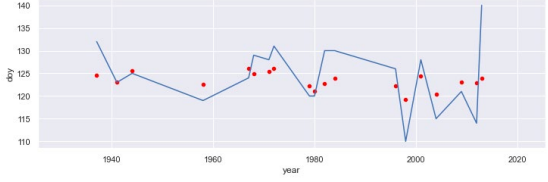
Extra slides

Nenana Ice Classic: Alaskans like to place bets on the breakup date

- 2022 Nenana Ice Classic forecasting by Uma Bhatt's Climate Journal Club
- Machine learning based on pre-season predictors.
- Accuracy score of $\leq$ than 2 days

Training set

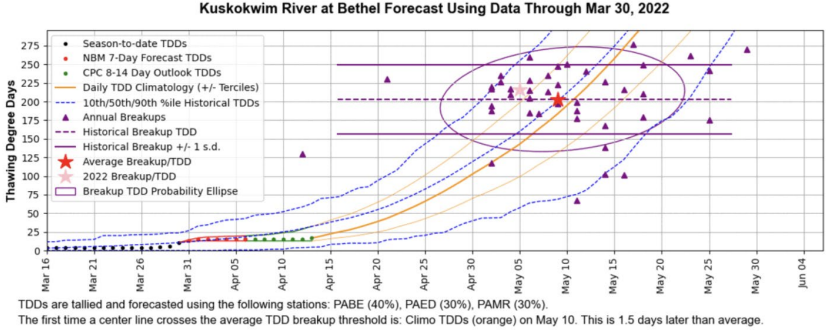
Test set



Betting slips

The Alaska -Pacific River Forecast Center: breakup guidance

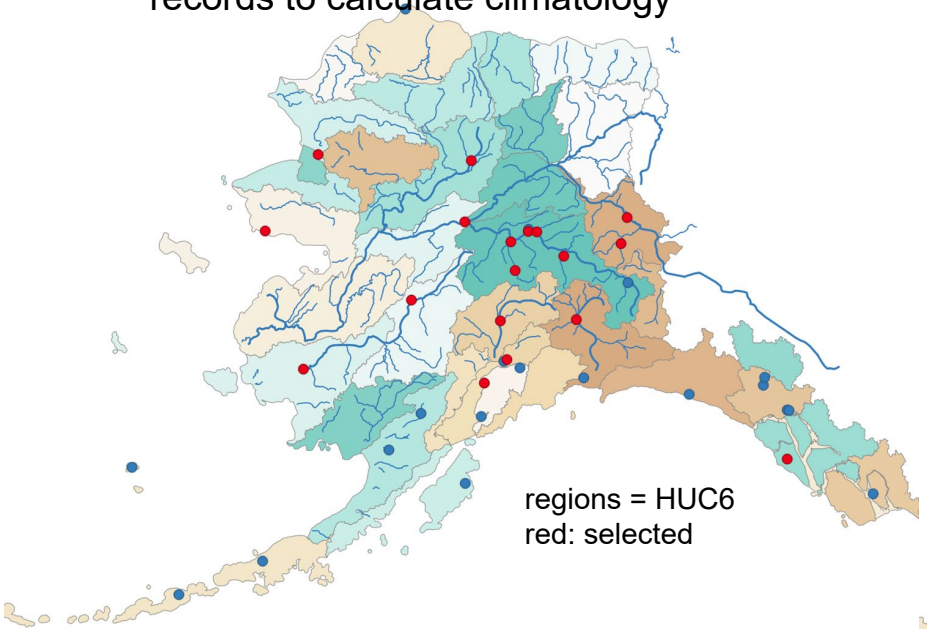
- "Modified Ted Moran model". Run by Brian Brettschneider (image credit)
- Based on thawing degree days (TDD) measured at custom-selected weather stations
- Assumption: breakup happens when a certain amount of TDD has been accumulated



Goal: Enhance APRFC breakup guidance
Predict date of river breakup at key locations, improving on existing degree -days based model

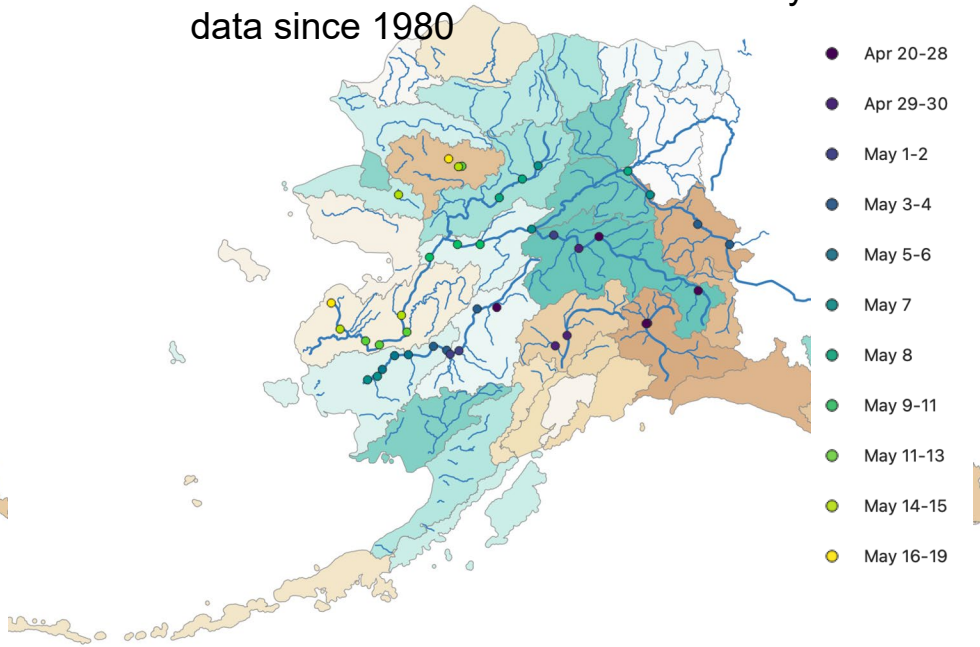
Weather stations (37)

Requirement: long-term temperature records to calculate climatology



Breakup locations (41)

Priority: Yukon, Tanana, Kuskokwim, Koyukuk & Buckland Rivers. Should have 30 years of data since 1980



How to select stations for each location?

Weather stations were selected based on the correlation between breakup date at the location and **25 °F degree-day** anomaly at the station throughout the breakup season (Apr/May)