Spatiotemporal Trends in Aufeis in Northern Alaska using Google Earth Engine

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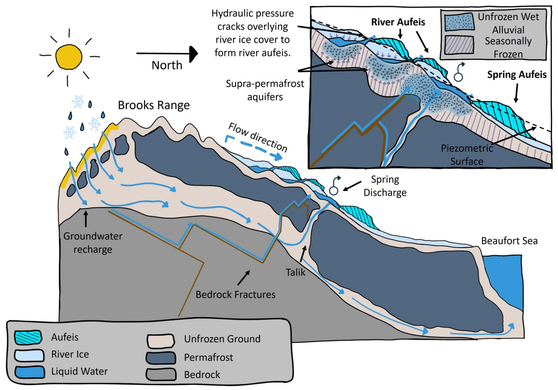
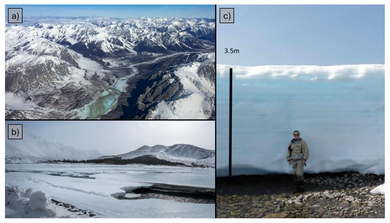
What is AUFEIS??

Aufeis, is commonly referred to as river icings, overflow, or naled, and translates in German as “on top of ice”.



Aufeis is an ice feature created by successive flows of groundwater or river water rising to the surface and freezing in sheet-like layers.



IMPORTANCE: The Role of Aufeis

- Critical water storage mechanism of the cryosphere, especially in unglaciated basins.
- Liquid water habitat for overwintering fish populations and supports fish migration as it melts.
- Indicators of changing subsurface hydrologic pathways through thawing permafrost environments.
- Costly geohazard to infrastructure, including bridges, roads, and culverts.

Example Impact: 2015 Sagavanirktok River

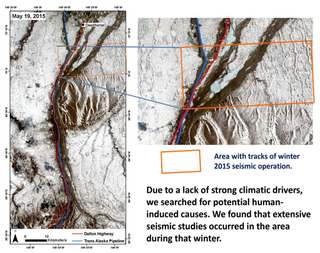


Figure: Shur 2016 ICOP

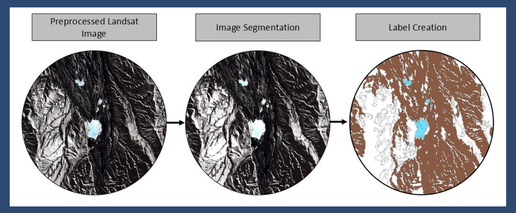
Image: FairbanksFodar/ M. Nolan

An extreme icing event and the resulting flooding caused $15.5 million in damages and forced an 18-day closure of the Dalton Highway and adjacent pipeline infrastructure.

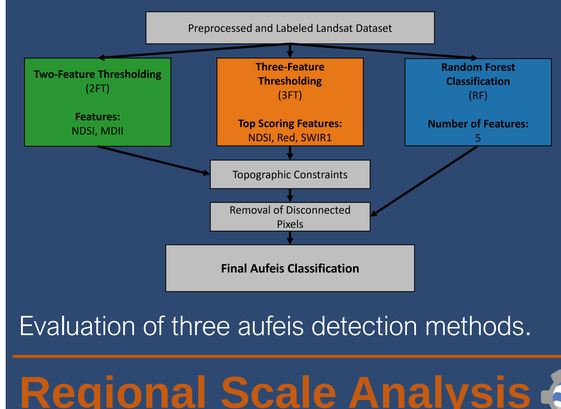
How has the distribution of aufeis changed over the satellite record?

Development of an Aufeis Detection Method

To train and compare aufeis detection methods, we created validation data for four sites on the North Slope of Alaska.

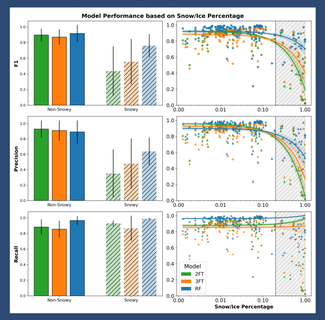


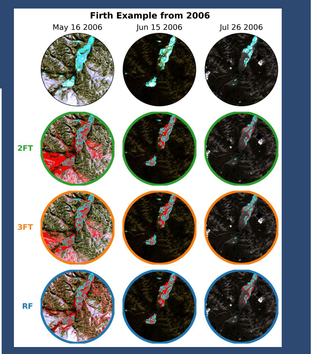
Of the 525 images downloaded for the four sites, ~42% (N=217) were chosen for the creation of training data in ArcGIS Pro.



Evaluation of three aufeis detection methods.

Model performance on snowy imagery.





Firth River Aufeis Example from 2006.

Dann, J., Zwieback, S., Leonard, P., & Bolton, W. R. (2025). Evaluating Aufeis Detection Methods Using Landsat Imagery: Comparative Assessment and Recommendations. *Science of Remote Sensing*, 100230.

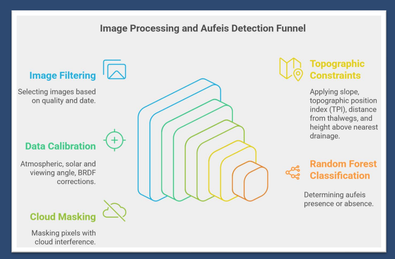
Highlights:

- First intercomparison study of aufeis detection methods for Landsat imagery
- Aufeis detections using random forests outperform decision tree-based techniques
- The near-infrared improves aufeis classification accuracy in snow-covered scenes.

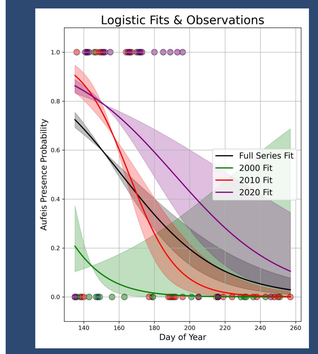
Regional Scale Analysis

Research Questions:

1. Where and to what extent is aufeis forming?
2. How has the distribution and timing of aufeis changed over the optical satellite record?



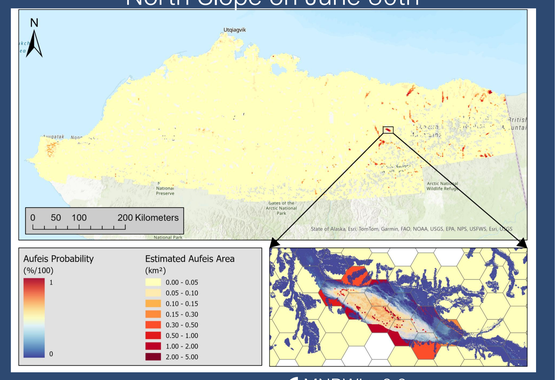
The RF method has been applied over the entirety of the North Slope Borough based on Landsat and Sentinel-2 Imagery between 1984 – 2024.



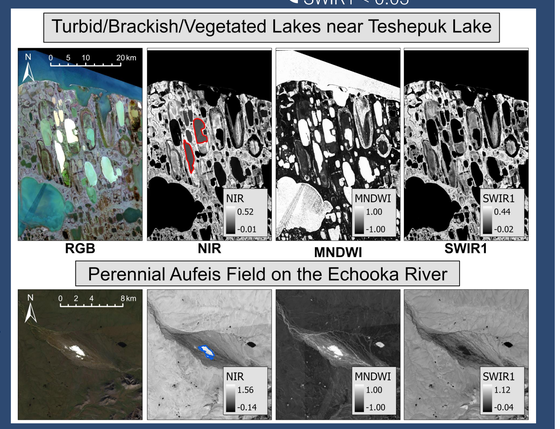
A **pixel-based** logistic regression approach to monitoring aufeis that can be applied at scale.

$$p(DOY) = \frac{1}{1 + e^{(\beta_0 + \beta_1 * DOY)}}$$

Predicted Distribution of Aufeis Across the North Slope on June 30th

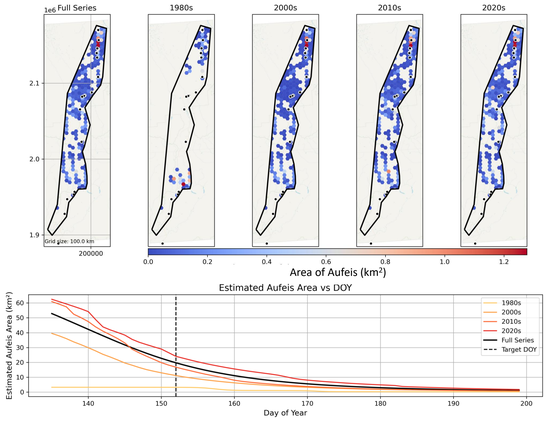


Water Mask = { MNDWI > 0.0; NIR < 0.15; SWIR1 < 0.03

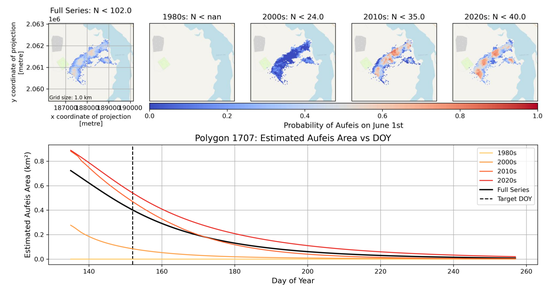


Case Study: The EvoME Project

The Evolving Meta-Ecosystems project investigates the ecological impacts of climate-driven habitat change. To support their research on fish and bird habitat along the Dalton Highway, I provided figures illustrating decadal changes in aufeis near key study sites.



Aufeis along Galbraith Lake appears to be increasing in the 21st century.



Anticipated Trends

Other studies have observed that perennial aufeis fields are smaller, seasonal fields disappear earlier in the summer, and that small aufeis fields may be becoming more prevalent [Koch et al., 2024; Makarieva et al., 2022; Pavelsky and Zarnetske, 2017].

Implications of Future Work

Monitoring and understanding aufeis dynamics at regional to pan-Arctic scales is essential for:

- Assessing climate-driven hydrological shifts for their impact on water availability and human infrastructure.
- Informing ecological studies of freshwater systems and habitats

StoryMap: Aufeis in the Arctic Refuge

Master’s Thesis

International Arctic Research Center
UNIVERSITY OF ALASKA FAIRBANKS
Alaska Climate Adaptation Science Center

Ask me a question!

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