Reconstruction of Fire History of the Yukon-Kuskokwim Delta, Alaska

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Highlights

Wildfire is an important disturbance in Arctic ecosystems that can abruptly perturb global carbon cycling and atmospheric chemistry.

We investigate a **lake sediment core** from the Yukon-Kuskokwim (YK) Delta, Alaska to observe **how climate and ecosystem properties influence wildfires in Arctic Tundra.**

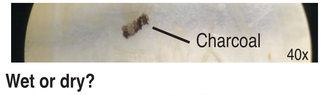
Questions

1. How do **fire properties** (frequency—intensity) change over time?
2. What are **fire—climate** relationships in the YK Delta?
3. How does **ecosystem properties** (soil pH—lake productivity) affect wildfires?

Methods

Preparation — Extruded **the 51.5-cm core** at 0.5 cm increment, and measured weight, and bulk density for all samples

Fire record — **Counted charcoal particles** (>250 um) under a microscope from a cc of each sample, and calculated for charcoal/cc of bulk sediment



Climate data — **Wet or dry?**
X-ray Fluorescence (XRF) to analyze the amount of Fe and Ti in each sample

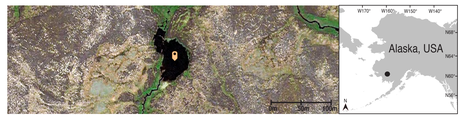
Warm or cold?
GDGTs to analyze the temperature along the core

Ecosystem — **Ecosystem properties**
XRF to analyze the amount of Si and Ti in each sample (lake productivity) and GDGTs to analyze soil pH

Chronology — Submitted samples to WHOI for **14C dating** (Accelerator Mass Spectrometry)

Study Site

Lake Lin (61.28721, -163.26052)

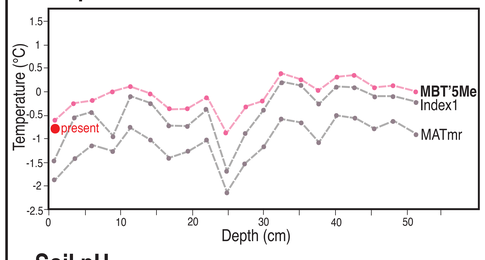


Surface size	= 2955.6 sq.m
Water depth	= 1 m
Elevation	= 2.43 m above sea level
Known fires	= 2015, 1972
Climate	= Warm, low-shrub tundra
Average annual temperature	= -0.75 °C
Average annual total precipitation	= 472 mm

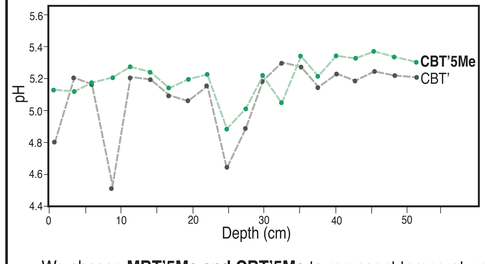
GDGTs

We plotted temperature and soil pH using 3 different indices based on De Jonge (2014) as shown below.

Temperature

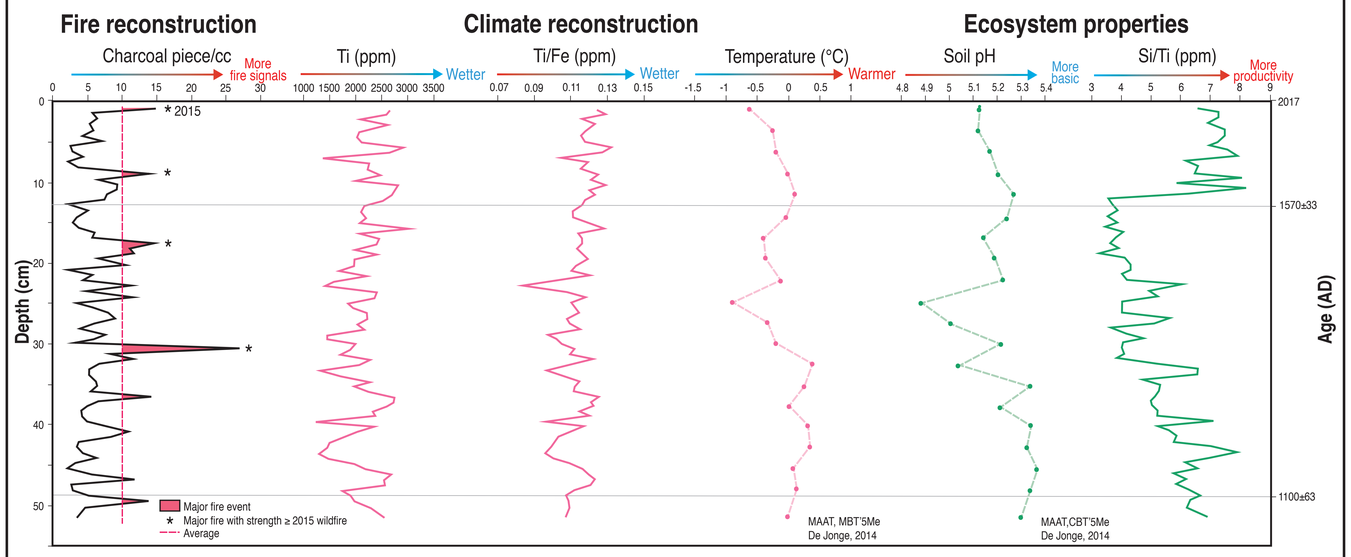


Soil pH



We choose **MBT'5Me and CBT'5Me** to represent temperature and soil pH for this region respectively because at the topmost core, MBT'5Me shows the closest temperature (-0.61°C) to the modern average annual temperature (-0.75°C), and CBT'5Me is the pH index that corresponds with MBT'5Me.

Preliminary correlations



Wildfires

- Charcoal piece/cc is very variable.
- 12 peaks are identified as major fires that rise above the average charcoal concentration.
- The 1st peak corresponds to the 2015 wildfire.
- 3 peaks show equal or greater charcoal abundance as the 2015 peak.
- Fire recurrence interval between major fires is shorter after 17.5 cm (≤1510 AD).

Wetness

- Ti/Fe increases slightly over time, indicating wetter.
- Ti is constant over time.
- Ti/Fe is influenced by Ti (R^2 = 0.74), and Fe (R^2 = 0.46) respectively.

Temperature

- Temperature shows little variability.
- Temperature slightly decreases over time (colder).
- There is a positive correlation between the temperature and soil pH (R^2 = 0.49).

Soil pH

- Soil pH is very fluctuated at 20-45 cm (1140-1470 AD); the rest of the core shows little variability.
- Soil pH slightly decreases over time (more acidic)

Lake productivity

- Si/Ti decreases over time, indicating less productivity.
- At 11-12 cm (1600-1650 AD), Si/Ti increases significantly from 3.26 to 8.21 ppm.
- It is independent to the fire record.

Preliminary conclusion

Fire properties

- **Fire recurrence interval of the YK Delta is longer after 1510 AD.** (from 60 years/fire to 250 years/fire)
- Major fires with an intensity equivalent to the 2015 wildfire first appeared at 30.5 cm (1340 AD), and reoccur every 225 years.

Fire—climate

- **Fire recurrence interval is longer and fire intensity increases when climate is wetter and colder.**

Fire—ecosystem

- There is no relationship between wildfires and lake productivity as indicated by Si/Ti (diatoms).
- Soil pH is more acidic when temperature decreases.
- **Fire recurrence interval is longer when pH is lower.**

Reference

Chipman et.al. (2015) "Spatiotemporal patterns of tundra fires: late-Quaternary charcoal records from Alaska".
De Jonge et.al. (2014) "Occurrence and abundance of 6-methyl branched glycerol dialkyl glycerol tetraethers in soils: Implications for palaeoclimate reconstruction".
Finsinger et.al. (2014) "A guide to screening charcoal peaks in macrocharcoal-area records for fire-episode reconstructions".
Kylander et.al. (2010) "High-resolution X-ray fluorescence core scanning analysis of Les Echets (France) sedimentary sequence: new insights from chemical proxies".

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