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2000 years of fire history documented in SW Yakutia, Russia

Preliminary data from a unique high-resolution macroscopic charcoal record

1) Background

- **Fires** are one of the most **important natural disturbances** in the boreal zone, impacting vegetation composition, carbon balance and human activity
- **Sedimentary charcoal** is widely used to reconstruct fire history
- In Siberia, data on fire history is **very sparse**, with a distinct lack of highly resolved charcoal records [1]

Key messages

- First **continuous, high-resolution** (c. 7 yrs / sample) macroscopic charcoal record from the region for the past c. 2000 years
- Mean fire return interval **(FRI)** of c. **70 – 80 years**
- After a peak around 750 CE **decreasing fire activity** until c. 1850 CE
- Recent charcoal accumulation rate **(CHAR)** among the **lowest** of the record → potential sign of anthropogenic fire suppression?

2) Location

- **Lake Khamra** (SW Yakutia, N 59.99°, E 112.98°)
- Transition zone of **evergreen** to **summergreen**, larch-dominated boreal forest
- Discontinuous/sporadic **permafrost**
- **Lake sediment coring** during an AWI expedition in 2018, recovering 242 cm long core EN18232-3

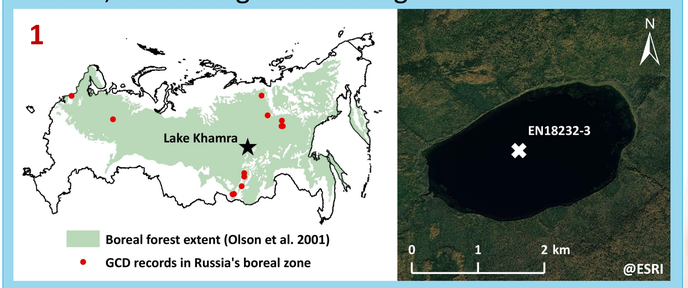


Fig. 1: Location of Lake Khamra in Russia and sediment core EN18232-3. GCD = Global Charcoal Database, all records in East Siberia being non-continuous or of lower temporal resolution. Sources of data used: [1,2]

3) Methods

- For 306 continuous **macroscopic charcoal samples:** Sieving (150 µm), bleaching (NaClO), counting size classes & morphotypes [3]
- For 24 samples: **Microscopic charcoal**, **pollen and non-pollen palynomorph** counts; additional **µXRF** data
- Statistical approach including **CharAnalysis** [4,5], signal-to-noise index (**SNI**) [6] and superposed epoch analysis (**SEA**)

4) Chronology

- **^{210}Pb/^{137}Cs** [7] and **^{14}C bulk** age dating
- Evidence for influence of **old organic carbon** on ^{14}C → Assuming a constant dead carbon effect with time
- Residual ^{14}C fit well with Pb/Cs ages and uniform appearance of the core

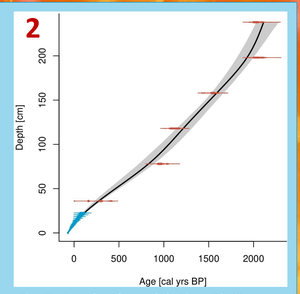
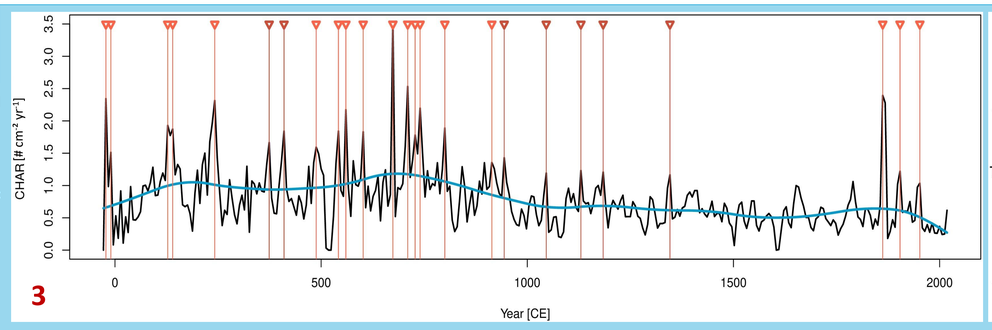


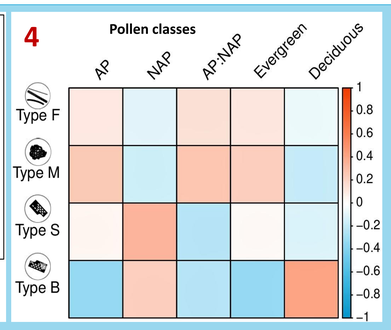
Fig. 2: Age-depth model. Blue: Pb/Cs; Red: ^{14}C; computed with CLAM ver. 2.3.2 [8]

5) Results

Left (Fig. 3): Macroscopic charcoal record with reconstructed fire events. Black line: CHAR (Charcoal accumulation rate); Blue line: Mean CHAR; Light red lines: Fire events with SNI > 3; Dark red lines: Fire events with SNI < 3
Right (Fig. 4): Correlations (Kendall's τ) of most prevalent charcoal **morphotypes** (shapes from [3]) with **pollen classes**. Centered log-ratio transformed percentages. **(N)AP = (Non-) arboreal pollen**

Bottom: Identified fire events and fire return intervals (FRIs) per size class. Min FRI equals interpolated resolution of 6 yrs. Reduced version of charcoal sum only allows for 1 fire event per CHAR peak distribution





- **Peak fire activity** around 750 CE, then decreasing towards a **low-fire period** around 1600 CE. Despite **more frequent** fire events since 1850 CE, recent CHAR is among the **lowest** of the record

Particle class	Fire events (#)	Mean FRI (yrs)	Max FRI (yrs)
> 150 µm	70	28.6	174
300 – 500 µm	56	35.8	162
> 500 µm	14	145.4	966
Sum (reduced)	30 (25)	68.1 (82.3)	516 (516)

- Large particles record **fewer fire events** than smaller ones, likely originating closer to the lake
- Low correlations hint at **potential associations** between reconstructed vegetation and various charcoal morphotypes/appearances
- Unlike previous research [9], SEA of fire events and µXRF elements does not reveal a strong association between **soil geochemistry and fires**

6) Outlook

- Examining possibility of **calibrating** charcoal records with other proxies (e.g. tree fire scars) and incorporation of **uncertainties** to make reconstructions more robust
- Approximation of **fire intensity** using fire biomarkers (see [4] and display by Dietze et al., D594, EGU 2020)
- Diving deeper into connections between **fire, vegetation and soils** and see what could be improved in future studies
- **Human perspective:** What can be learned from fire history regarding fire management and risk assessment?

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