LEVERHULME WILDFIRES
SUMMER CONFERENCE

University of Reading

Imperial College London

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## Leverhulme Wildfires Summer Conference 2023

# Exploring Holocene changes in wildfires in China using a statistical modelling approach


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# Introduction

Observed fires →

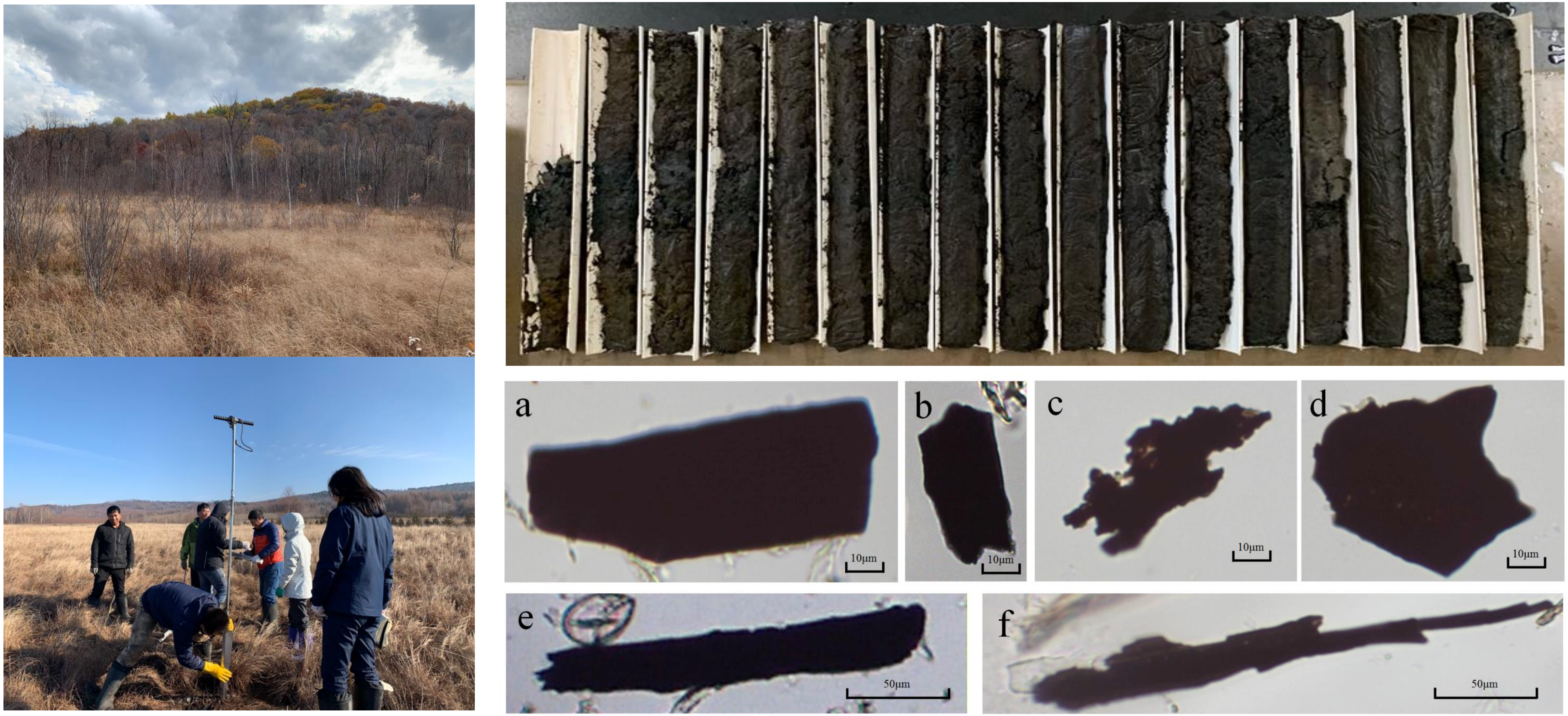
- Modern observations
- Sedimentary charcoal records

↓

provide fire information on timescales of hundreds to thousands of years

What is a sedimentary charcoal record?

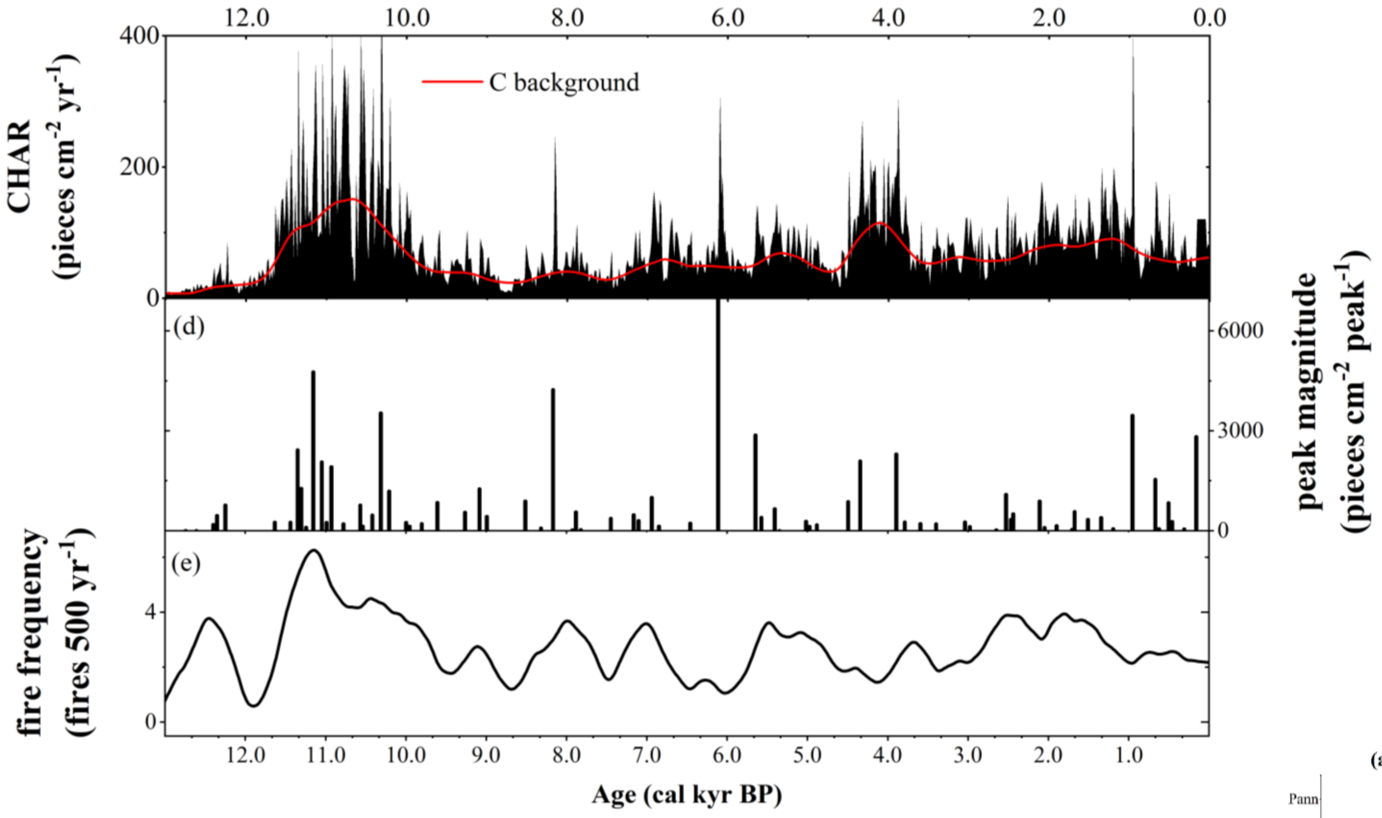
# Fire history based on sedimentary charcoal analysis: a case study in Changbai Mountains



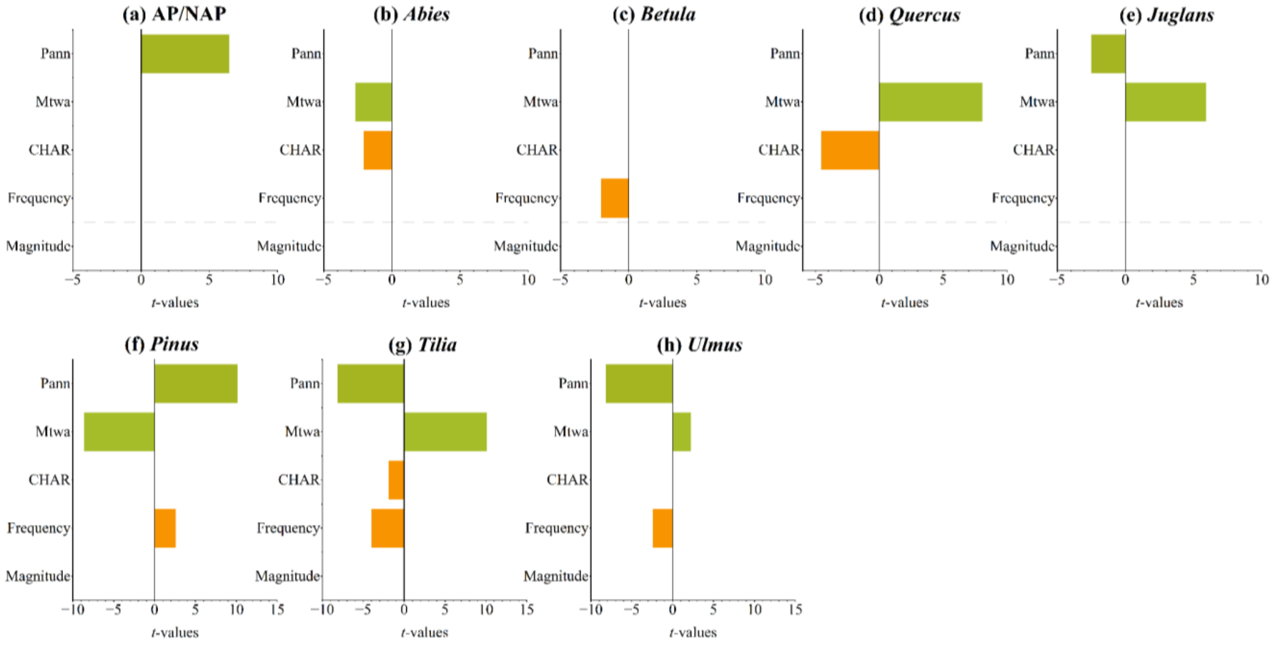

Field work photos and charcoal particles observed under microscope.

- **CharAnalysis 1.1** (designed by Higuera et al., 2009): quantitative reconstruct fire regimes

> - **CHAR- Background levels of fire**
> - **Fire magnitude**
> - **Fire frequency**



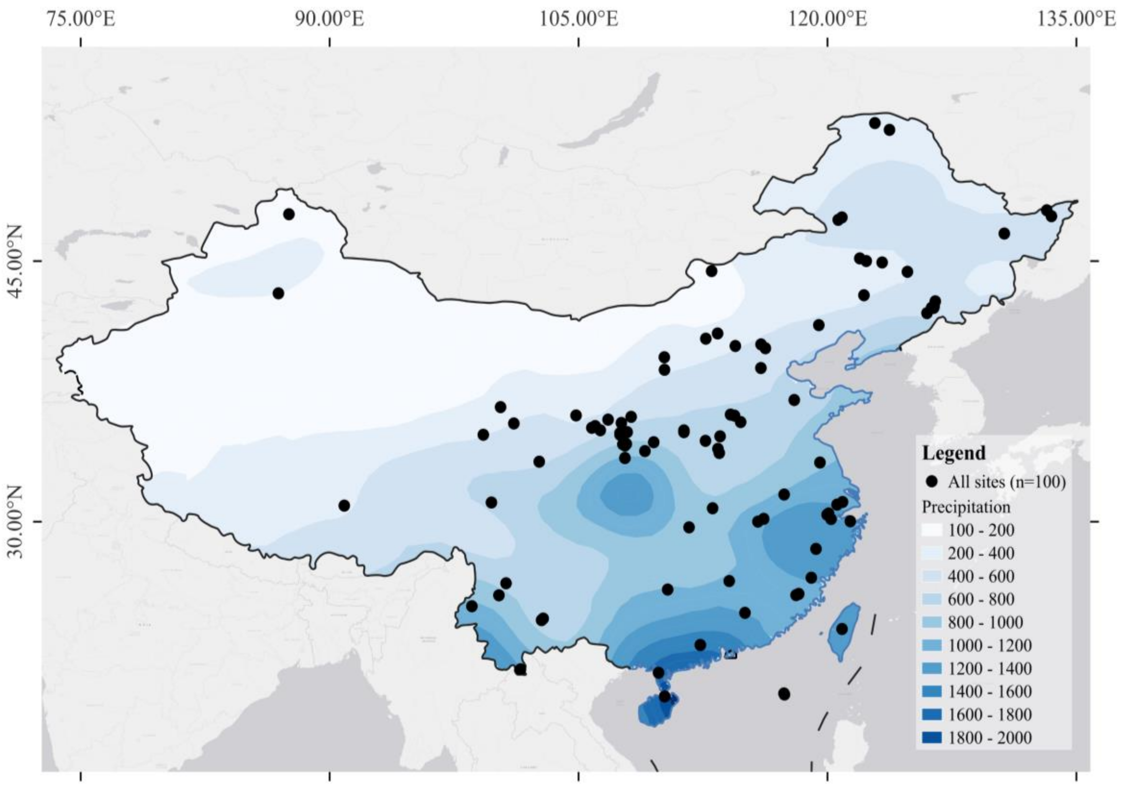

Reconstructed fire regimes for Gushantun (GST) peatland profile over the past 13,000 years. (Meng et al., 2023)



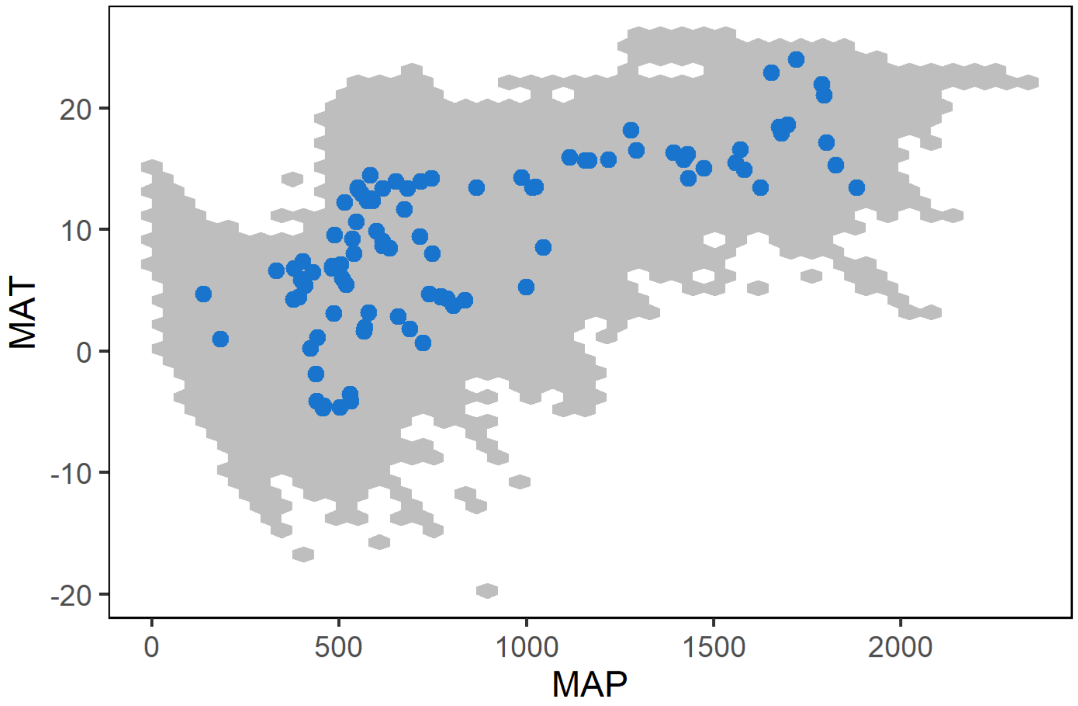

Relative importance of the climate and fire drivers to the forest composition and openness. (Meng et al., 2023)

# Observed fires

- Charcoal records-from the Reading Paleofire Database (RPD) (n=100)




Location of sites in China. The background color shows the modern precipitation.

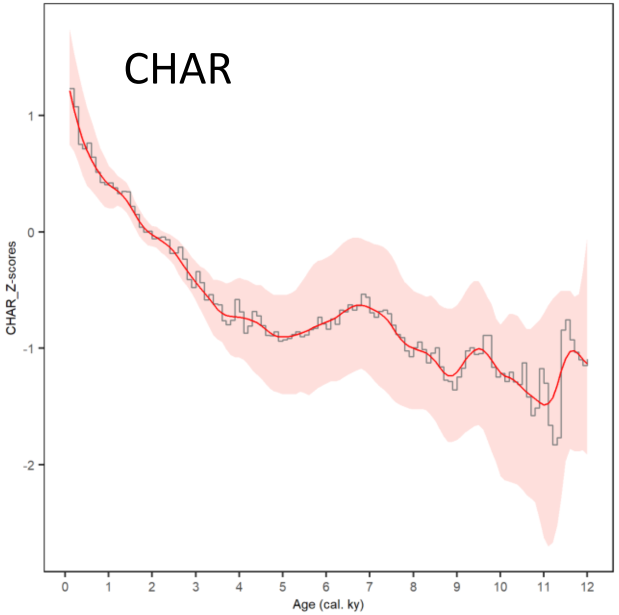


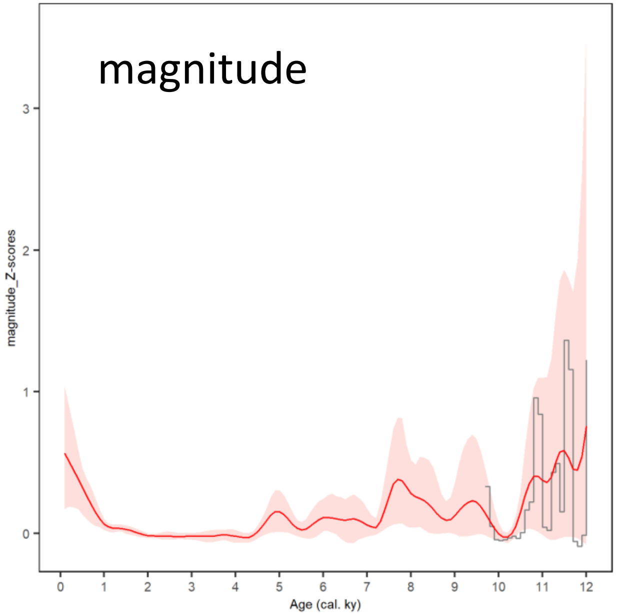

Site locations projected onto the climate space. The blue points show the distribution of sites.

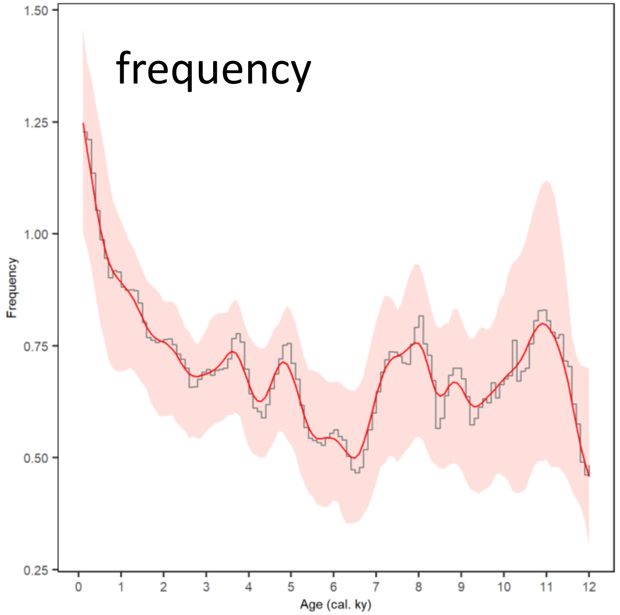
# Methods

1. **Charcoal analysis**: CHAR, frequency, magnitude (Different units for each records)
2. **Transformation and standardization**
   - Standardization techniques (Power et al., 2010)
     a) $c_i' = (c_i - c_{\min}) / (c_{\max} - c_{\min})$
     b) $c_i^* = \begin{cases} ((c_i' + \alpha)^\lambda - 1) / \lambda & \lambda \neq 0 \\ \log(c_i' + \alpha) & \lambda = 0 \end{cases}$
     c) $z_i = (c_i^* - \overline{c}^*_{(4ka)}) / s^*_{c(4ka)}$ (Replace 4ka with the base period chosen for this research)
   - Selection of base period
     - the interval 3000 to 1000 cal yr BP
     - exclude records which spans do not suitable for chosen base period
3. **Binning**
   - the Z-scores were binned using 200-year bins with a 100-year overlap

# Reconstructed fires: whole of China




**Background levels of fire**

- more fires: since 3ka
- peaks: 11.5, 9.5, 7 ka
- upward trend: since 5ka

**Fire magnitude**

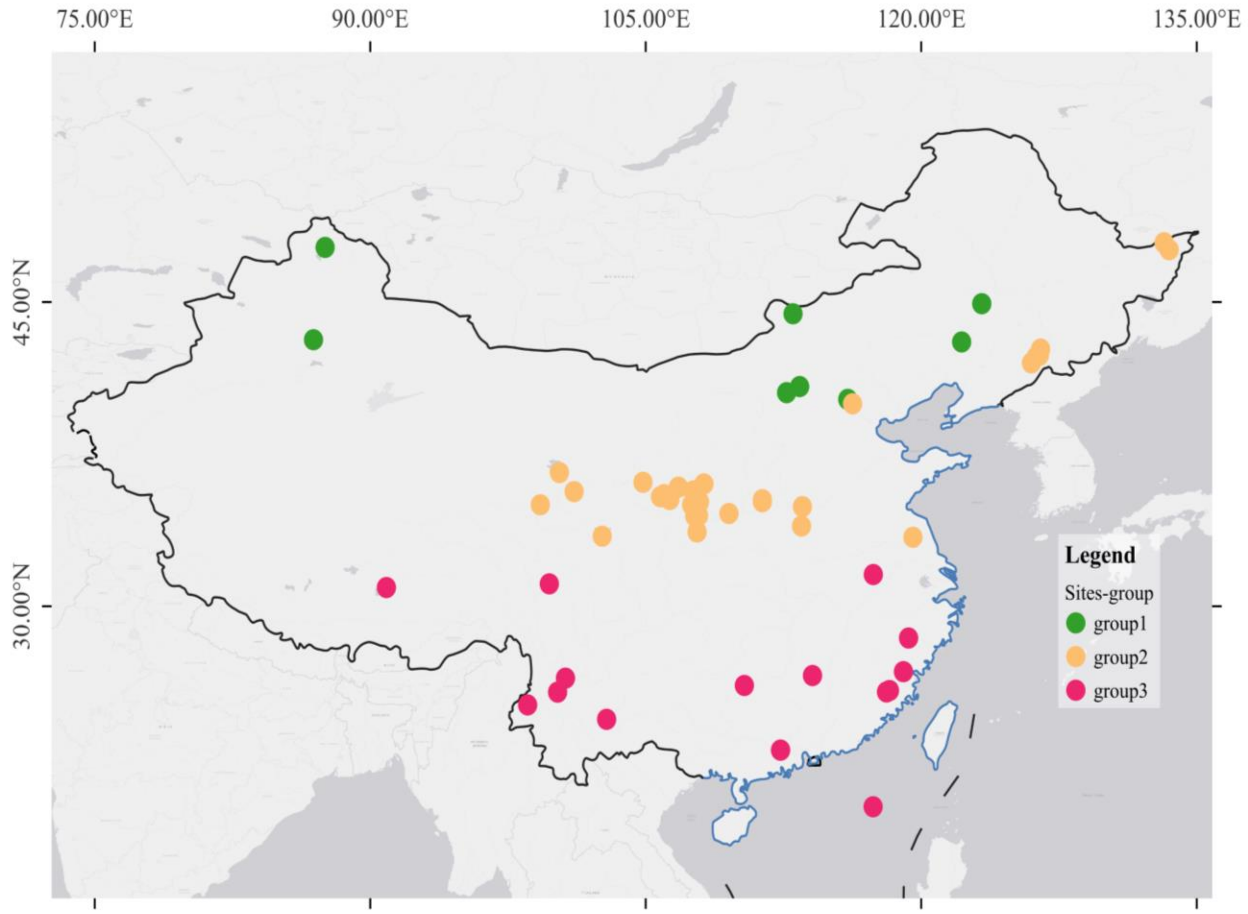
- more intense: late Holocene
- sharply rise: since 1ka

**Fire frequency**

- more frequent: since 1ka
- Peaks: 11, 8.8, 7.5, 4.5, 3.5 ka

dry

wet




Map of sites (n=57) retained after removing records which not include whole base period.

- Group 1 – northern China
- Group 2 – mid-China
- Group 3 – southern China

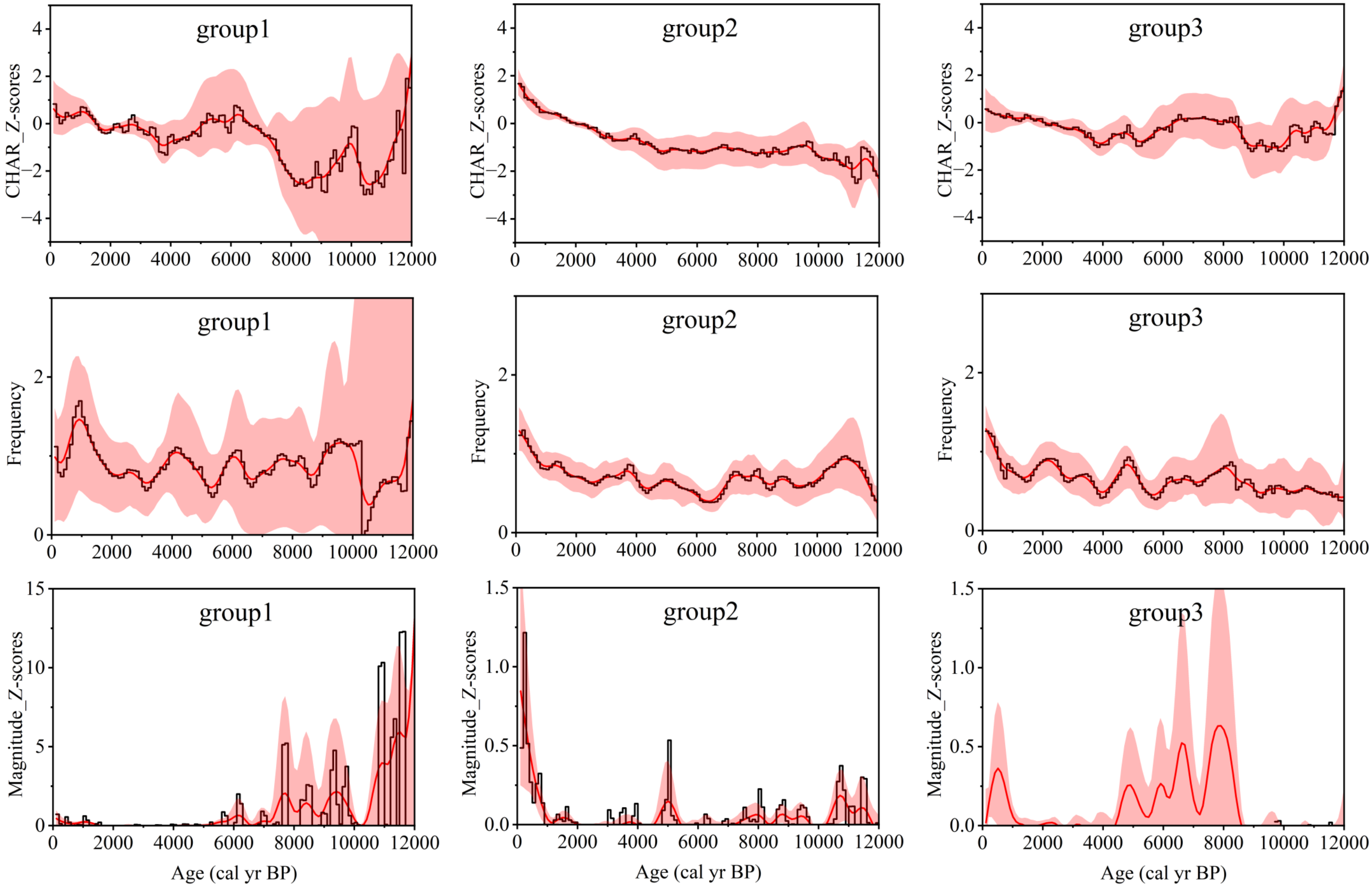
Represent three gradients of humidity in China

# Group

Background levels of fire

Fire frequency

Fire magnitude



# Simulated fires

- An existing statistically based global fire model (Hass et al., 2022)
- Input predictors (n=16)

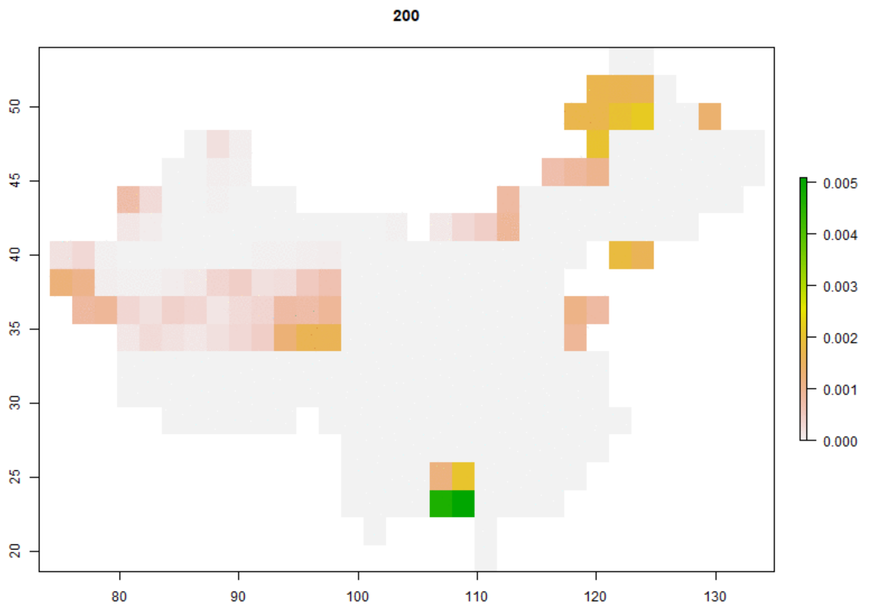
| Climate | |
|---|---|
| DD | MPI-ESM (Dallmeyer et al., 2020) |
| DD_seasonality | MPI-ESM (Dallmeyer et al., 2020) |
| VPD | MPI-ESM (Dallmeyer et al., 2020) |
| DTR | MPI-ESM (Dallmeyer et al., 2020) |
| Wind | MPI-ESM (Dallmeyer et al., 2020) |

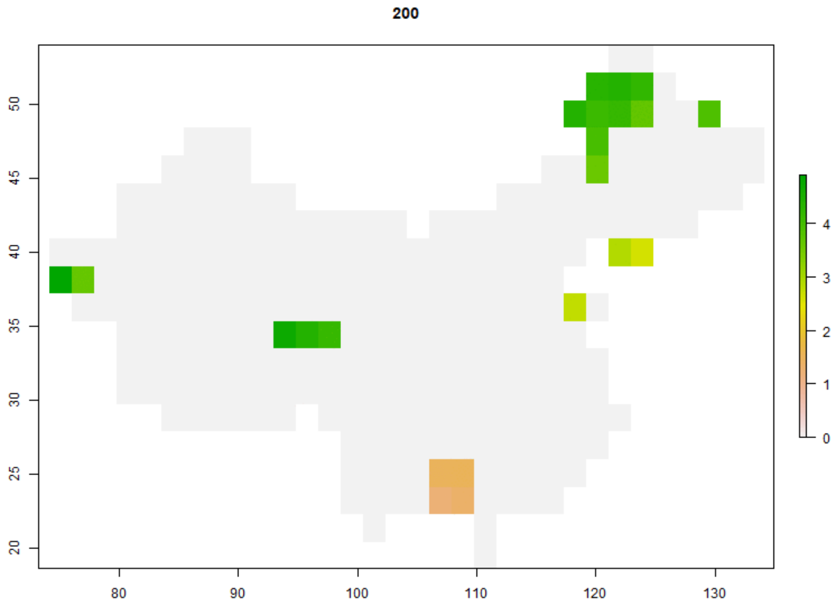
| Ignition sources | |
|---|---|
| Popd | HYDE 3.3 (Klein Goldewijk et al., unpublished) |
| Light | Without historical data, set same as modern WGLC WWLLN (Kaplan et al.,2021) |

| Vegetation, land cover and landscape fragmentation | |
|---|---|
| GPP | P-model (Stocker et al., 2020) |
| GPP_seasonality | P-model (Stocker et al., 2020) |
| Shrub | BIOME4 (Kaplan et al., 2003) |
| Grass | BIOME4 (Kaplan et al., 2003) |
| Tree | BIOME4 (Kaplan et al., 2003) |
| Roads | Without historical data, set to 0 |
| Crop | HYDE 3.3 (Klein Goldewijk et al., unpublished) |
| VRM | (Amatulli et al., 2018) |
| TPI | (Amatulli et al., 2018) |

- Simulated fire variables
  - Burnt area (BA), Fire size (FS), Fire intensity (FI)

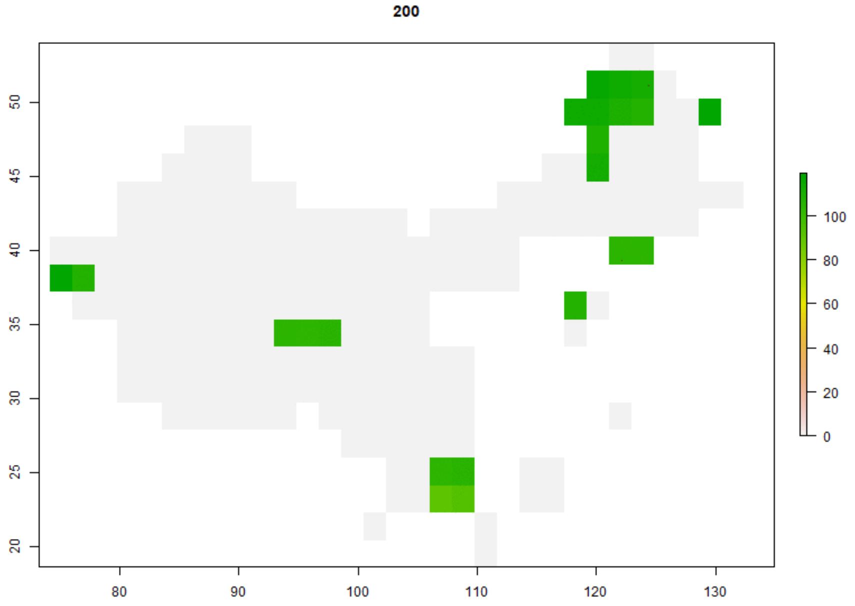
BA



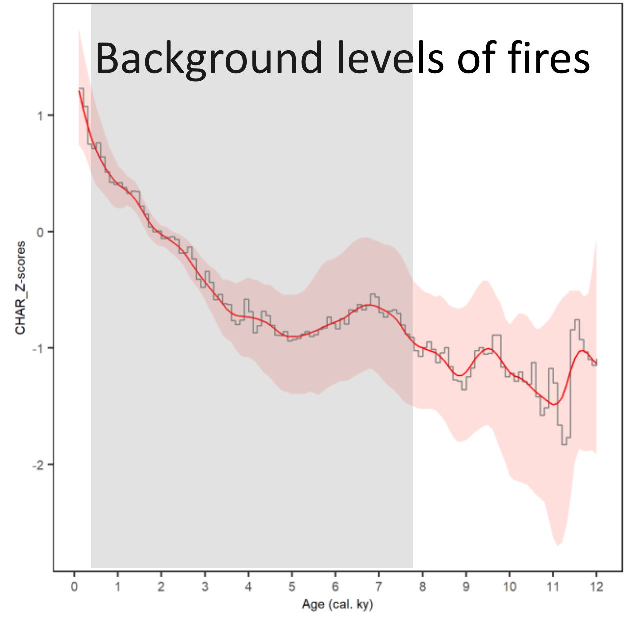

FS

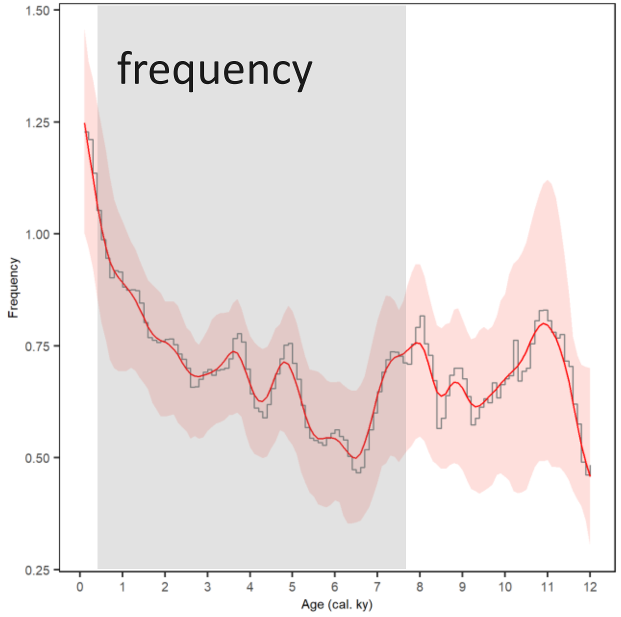
FI

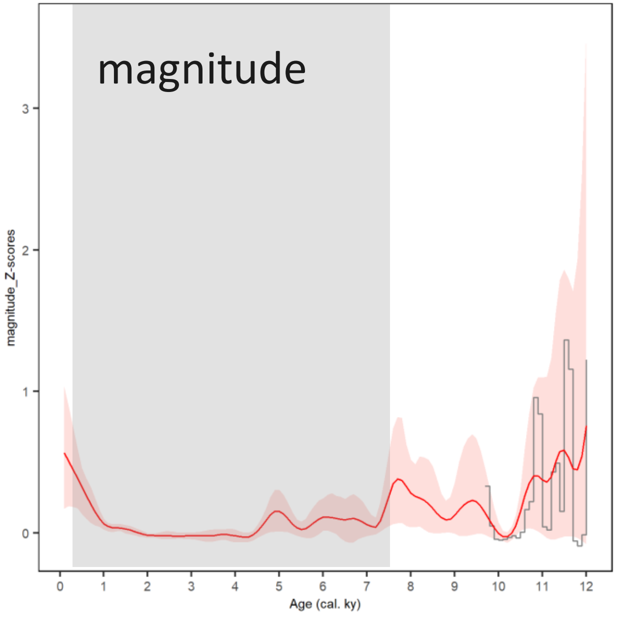


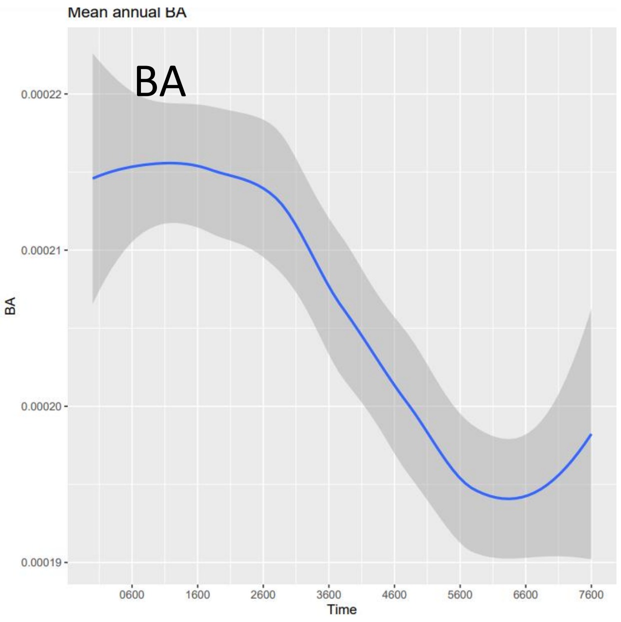

Results for MPI models

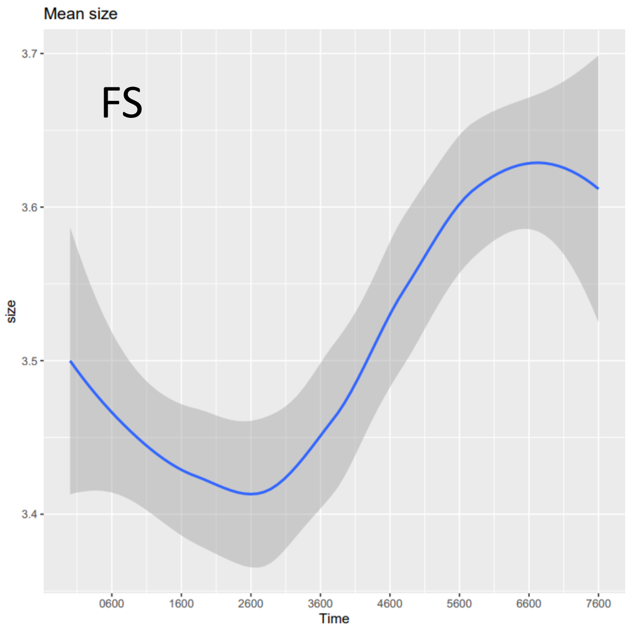
# Comparison

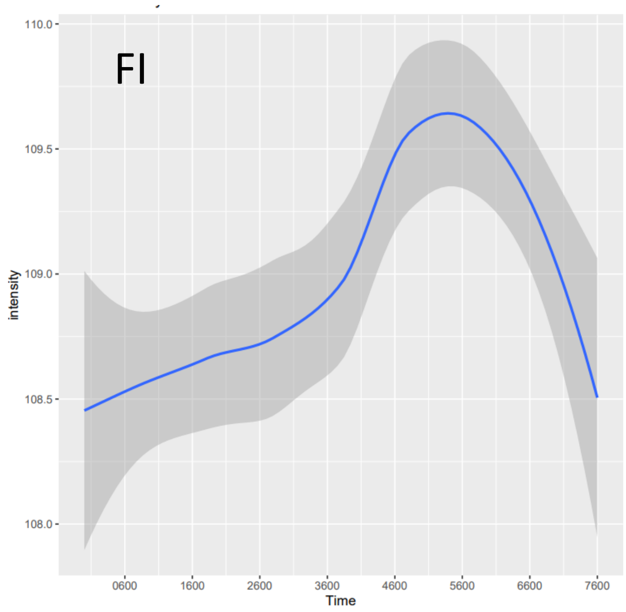


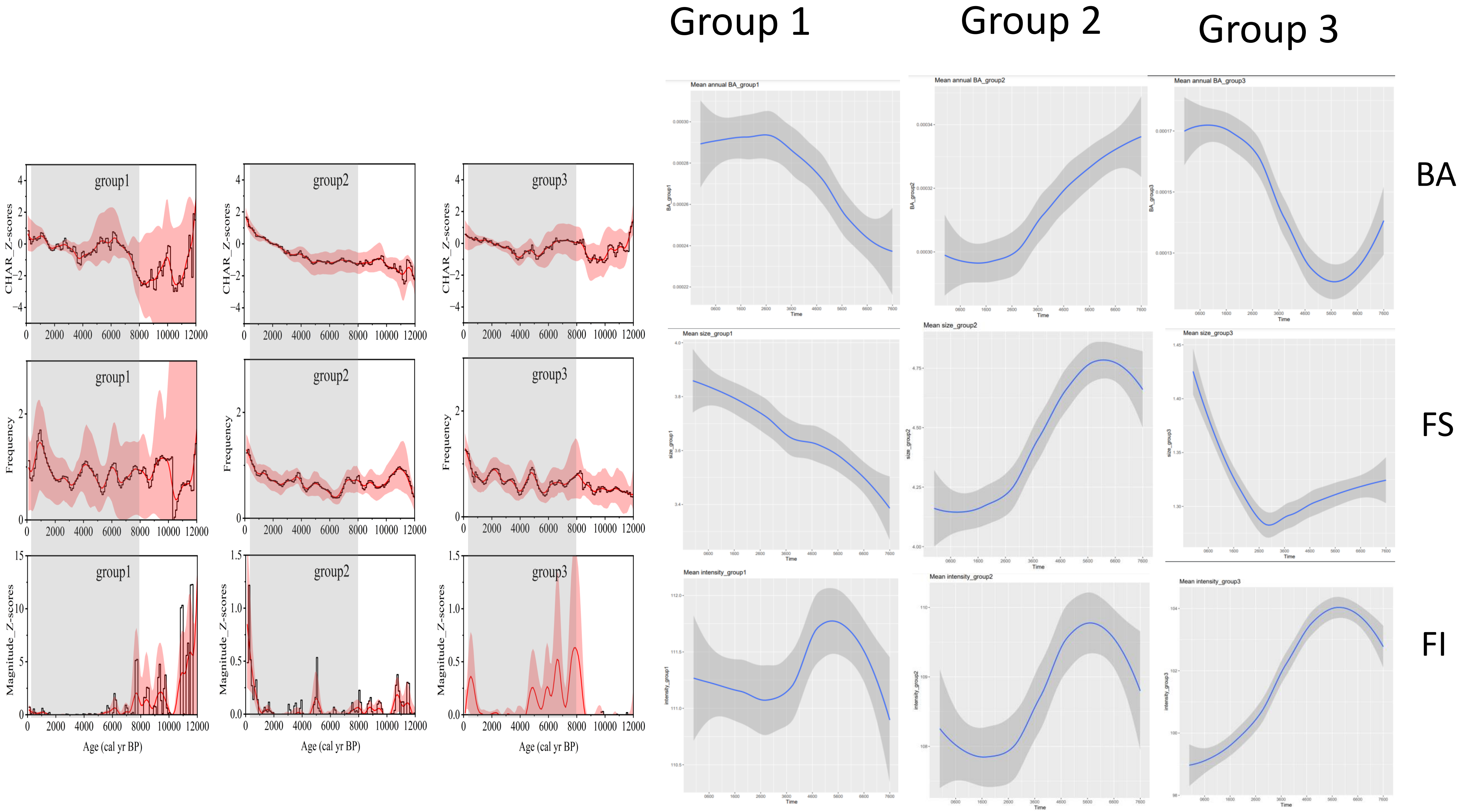




- **Background levels of fires- BA**
- **Frequency- BA**
- **Magnitude- FI**
- **FS**


Group 1
Group 2
Group 3
BA
FS
FI
group1
group2
group3
CHAR_Z-scores
Frequency
Magnitude_Z-scores
Age (cal yr BP)
Mean annual BA_group1
Mean annual BA_group2
Mean annual BA_group3
Mean size_group1
Mean size_group2
Mean size_group3
Mean intensity_group1
Mean intensity_group2
Mean intensity_group3
Time

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# Thank you!

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