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Impact of biomass burning on Arctic aerosol composition

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Why do we need to care about the impact of biomass burning emissions on Arctic aerosols?

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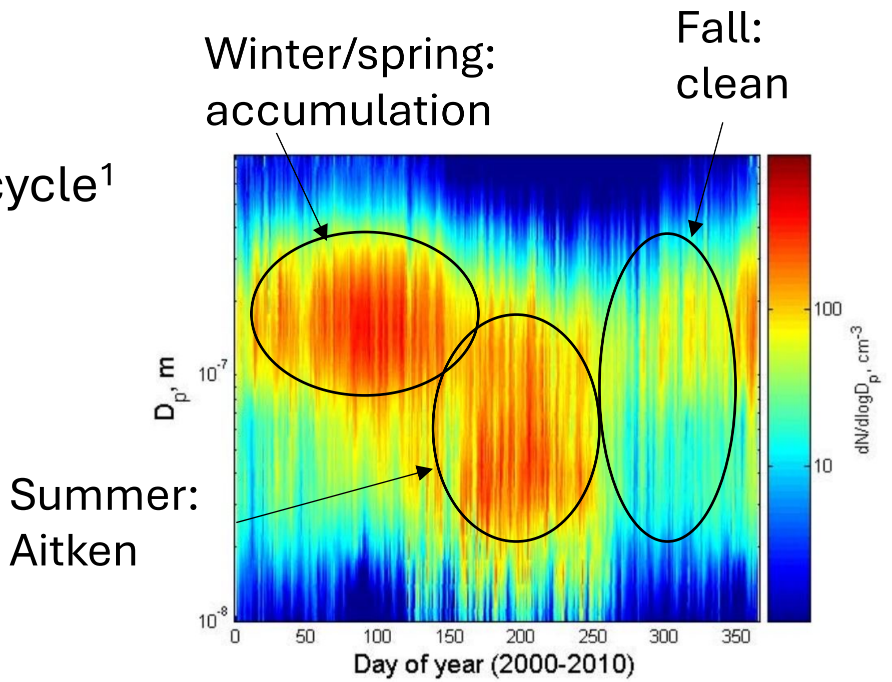
- Arctic: pristine environment, well defined aerosol annual cycle[1]

  → Sources and sinks related to transport (including BB) and local emissions   **Org** **BC**

- Increasing wildfire emissions during recent years (especially above 60°N)[2]

- Future: Arctic fires more likely (drier vegetation)[2]

- Past Arctic BB studies[3-6]: focus mainly on one event, chemical composition limited by coarse temporal resolution (day to weeks)



Daily average number size distributions on Svalbard, 2000-2010. Tunved et al., 2013

⟶ Need to better characterize chemical and physical characteristics of BB events to understand their climate impact

⟶ one entire year (2020), observations from Svalbard (NASCENT campaign)

[1]Tunved et al., 2013; [2]McCarty et al., 2021; [3]Zangrando et al., 2013; [4]Feltracco et al., 2020; [5]Stohl et al., 2014; [6]Yttri et al., 2024

BB: Biomass Burning

The measurement site: Zeppelin Observatory, Svalbard

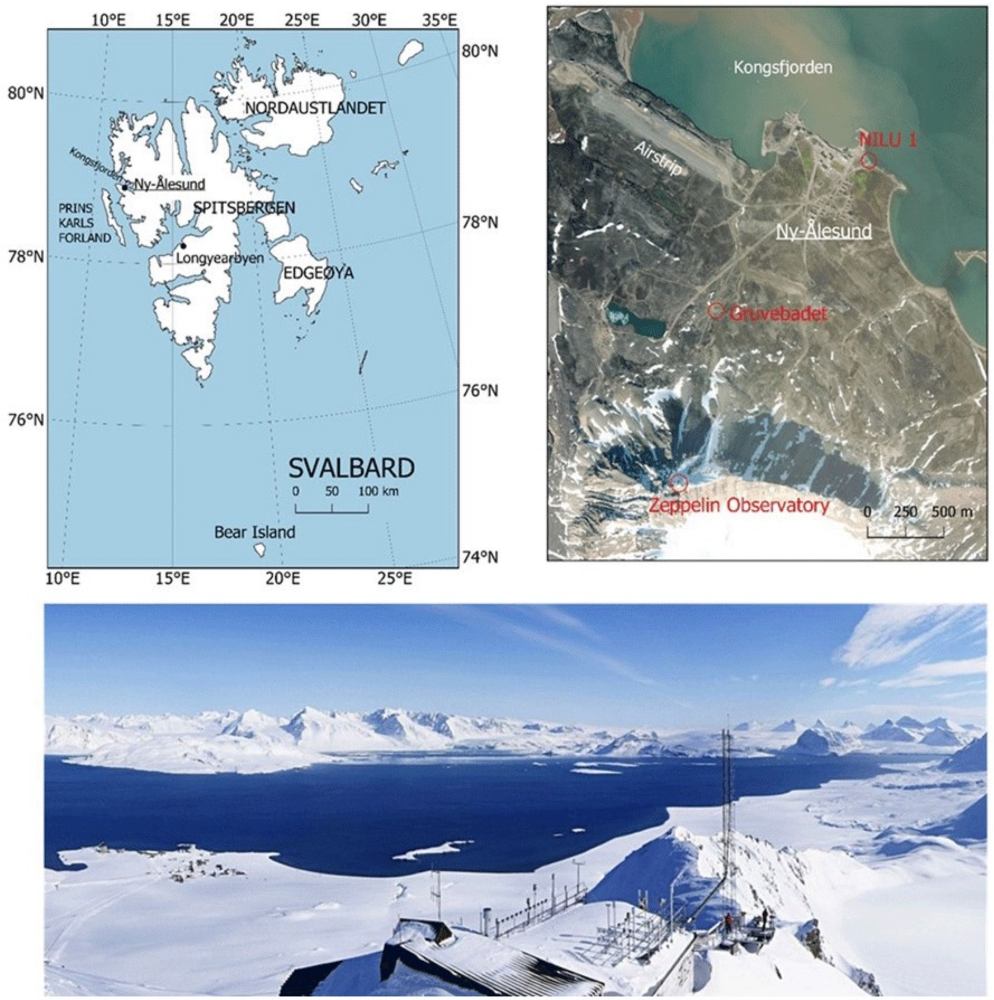


Figure taken from Platt et al., ACP, 2022.

Parameters of aerosol particles measured up at the Zeppelin Observatory (472 m a.s.l.):

Chemical properties:
- Bulk chemical composition (ACSM)
- Molecular-level chemical composition of organic aerosol (FIGAERO-CIMS)
- Black carbon (MAAP)

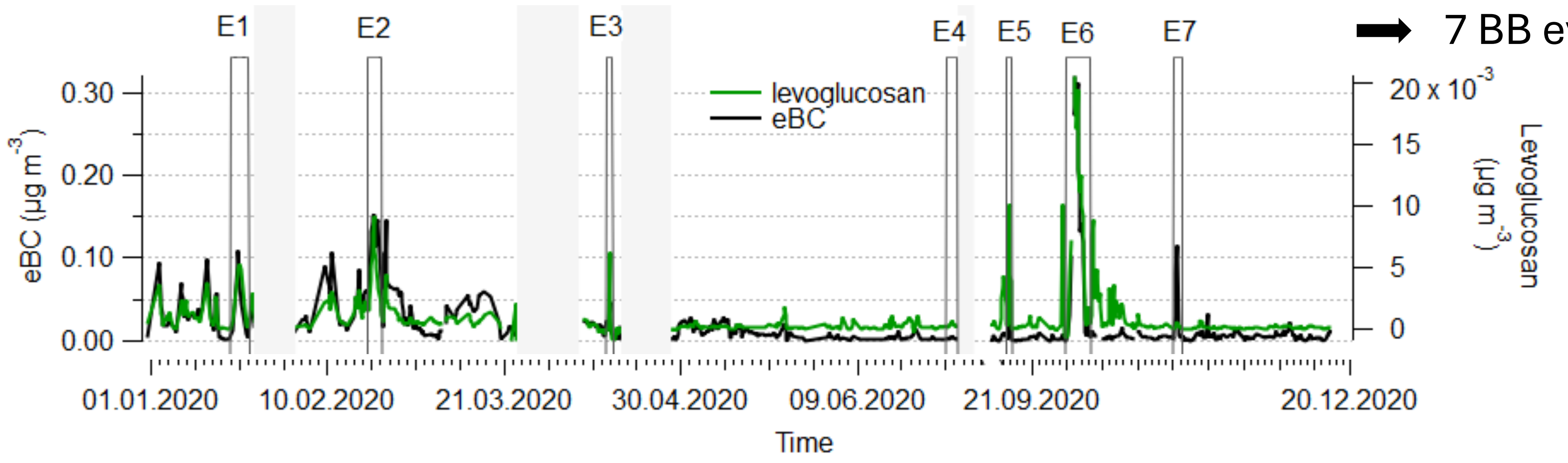
Physical properties:
- Number and size (DMPS)
- Mass concentration (FIDAS)

In addition:
- Probablilty of air mass origin (HYSPLIT back trajectories)

ACSM: Aerosol Chemical Speciation Monitor; FIGAERO-CIMS: Filter Inlet for Gases and Aerosols coupled to a Chemical Ionization Mass Spectrometer; MAAP: Multi Angle Absorption Photometer; DMPS: Differential Mobility Particle Analyzer; FIDAS: Fine Dust Aerosol Spectrometer; HYSPLIT: Hybrid Single Particle Lagrangian Integrated Trajectory model

Definition of biomass burning events

Based on eBC and levoglucosan ($C_6H_{10}O_5$):



➡ 7 BB events

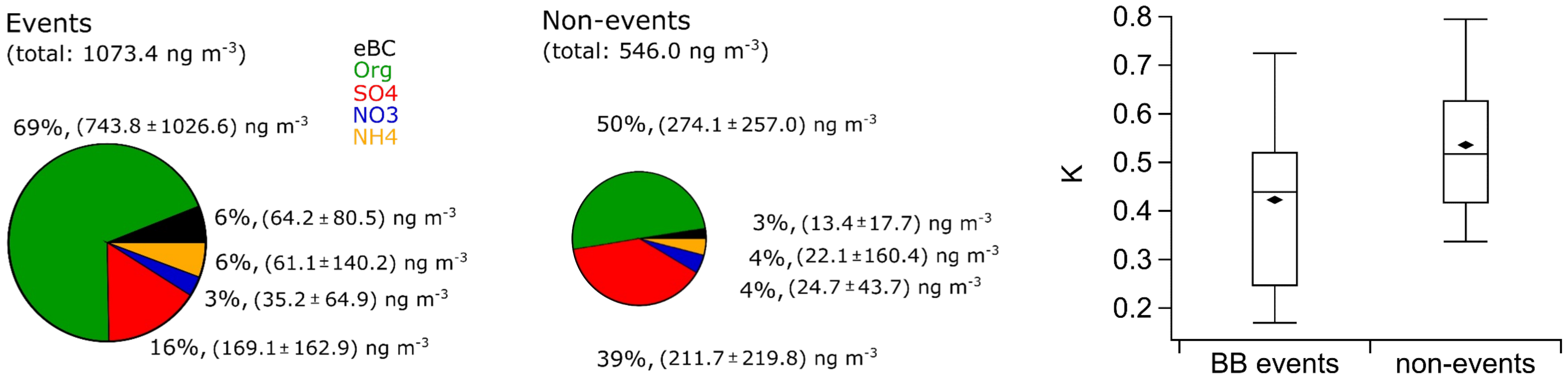
In the following:

Events: times of E1 to E7

Non-events: remaining episodes

Gramlich et al., 2024

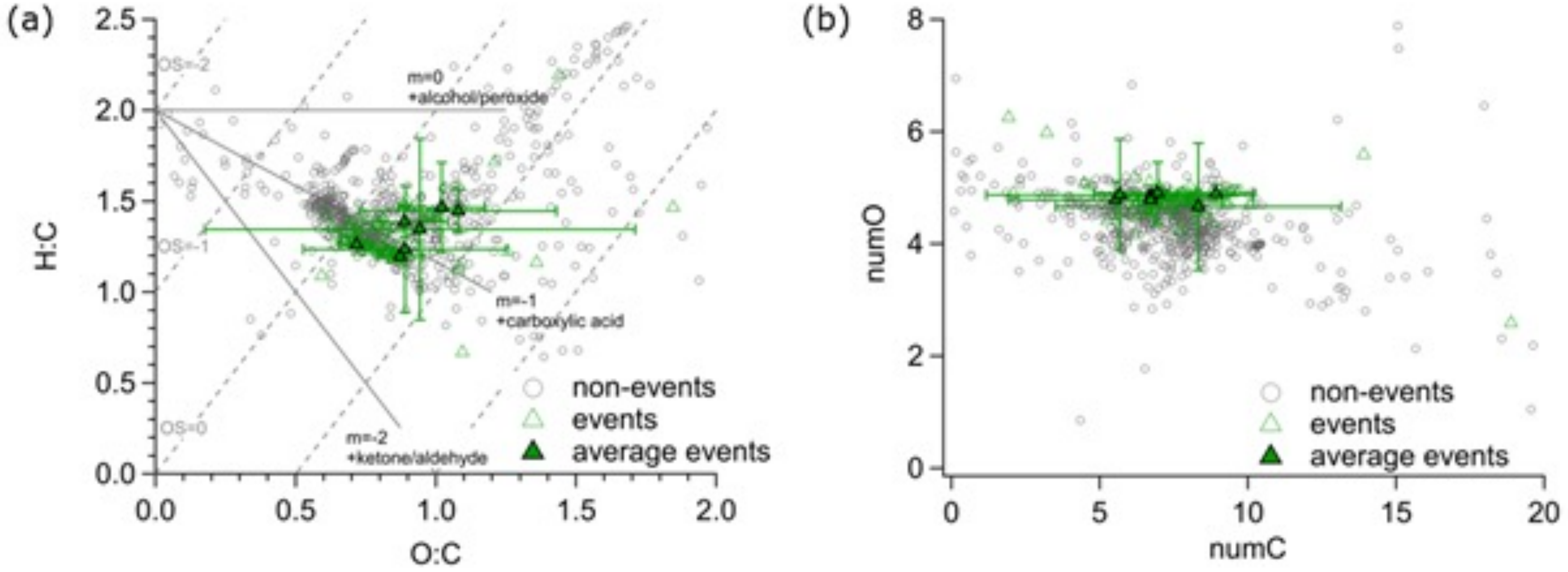
Bulk composition events vs. non-events and impact on hygroscopicity



- Significant higher absolute mass concentrations of Org and eBC during events
- Shift from organic- and sulfate dominated regime to organic dominated
- Less hygroscopic particles during BB events

Gramlich et al., 2024

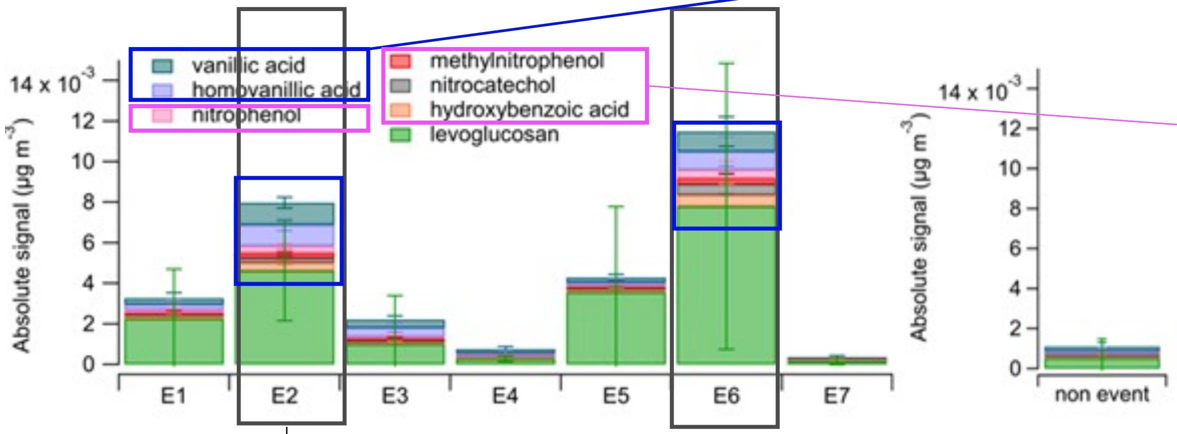
Molecular-level chemical properties of organic aerosol



Significant higher numO for BB events
-> more oxygenated during BB events

Gramlich et al., 2024

Biomass burning tracer compounds



indicative of conifers and deciduous wood burning[1,2]

indicative of grassland burning, wheat straws, rice, maize[3,4]

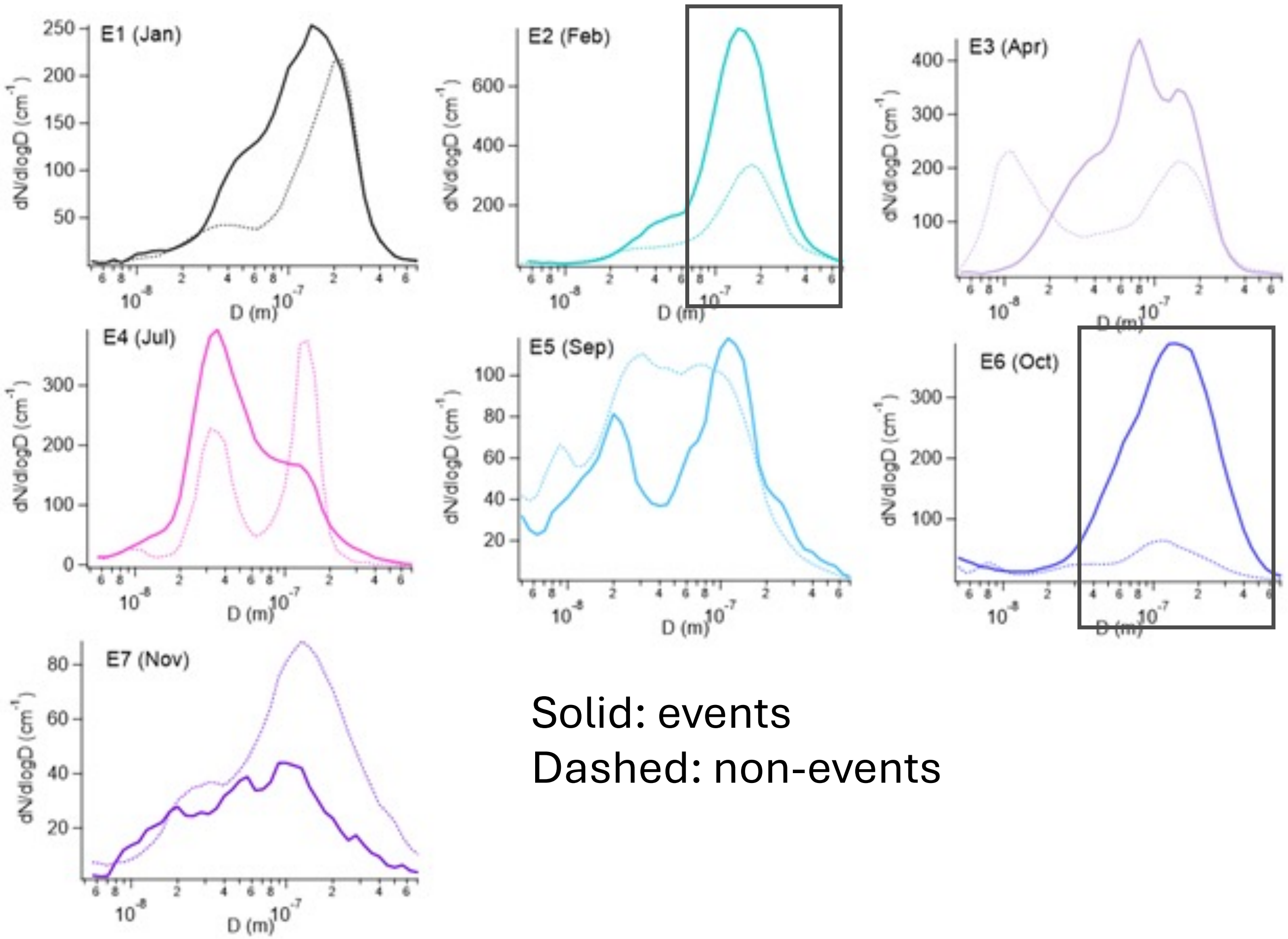
BB events 2 and 6 significantly higher than the non-events

Suggests agricultural fires mixed with forest fires and residential burning

[1]Kalogridis et al., 2018; [2]Oros and Simoneit, 2001; [3]Li et al., 2020; [4]Zuchowski et al., 2011

Gramlich et al., 2024

Number size distributions

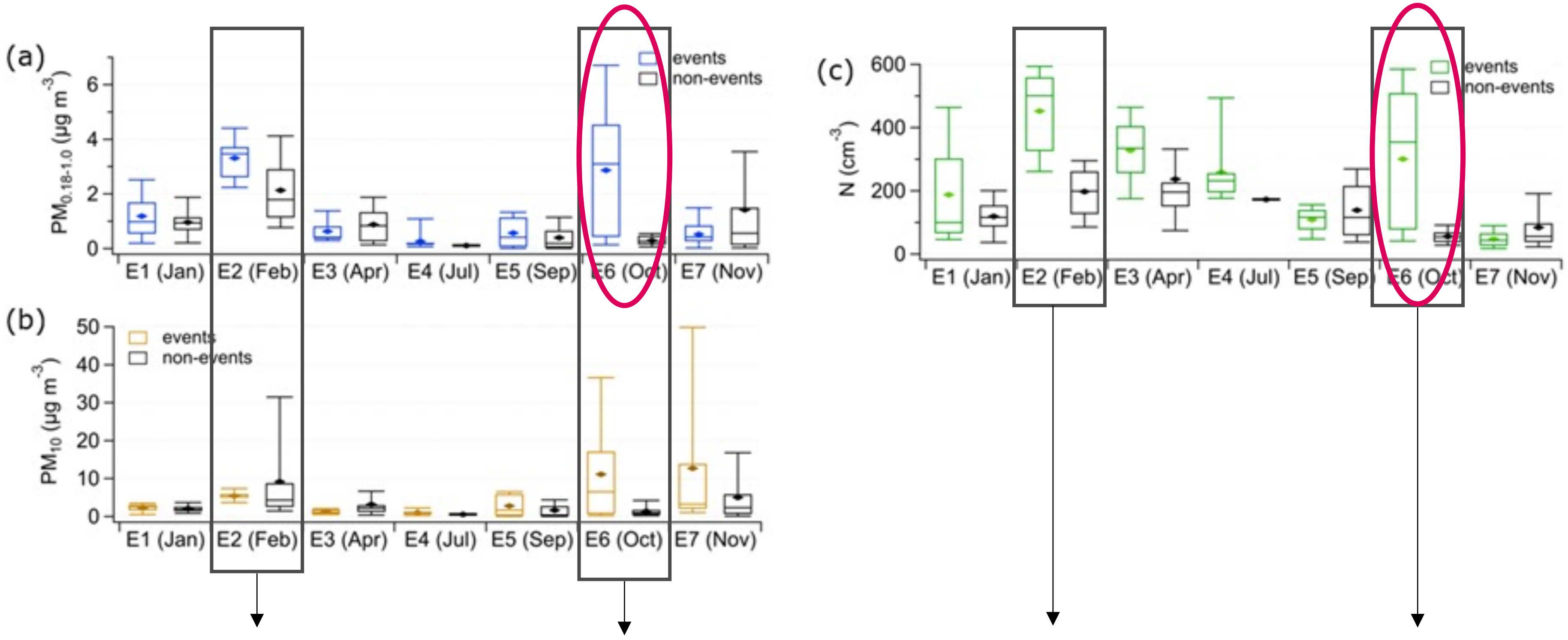


Solid: events
Dashed: non-events

- Accumulation mode particles present in all events (esp. E2, E6)
- in summer (E4, E5) additional Aitken mode -> mixture of long-range transported air with local emissions

Gramlich et al., 2024

Mass and number concentrations

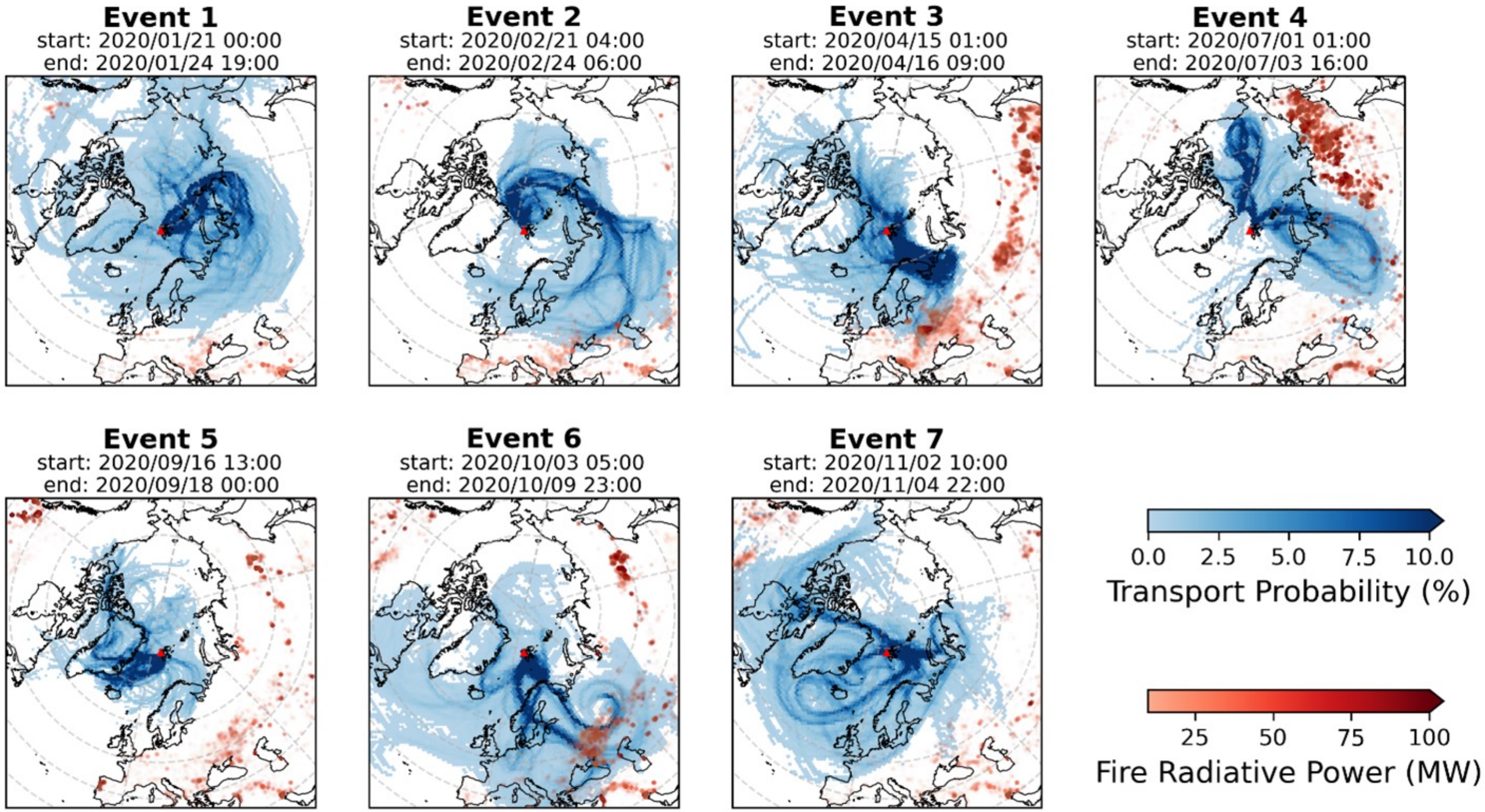


BB events 2 and 6 significantly higher concentrations than the non-events

Event 6: one order of magnitude higher PM1 and number compared to non-events

Gramlich et al., 2024

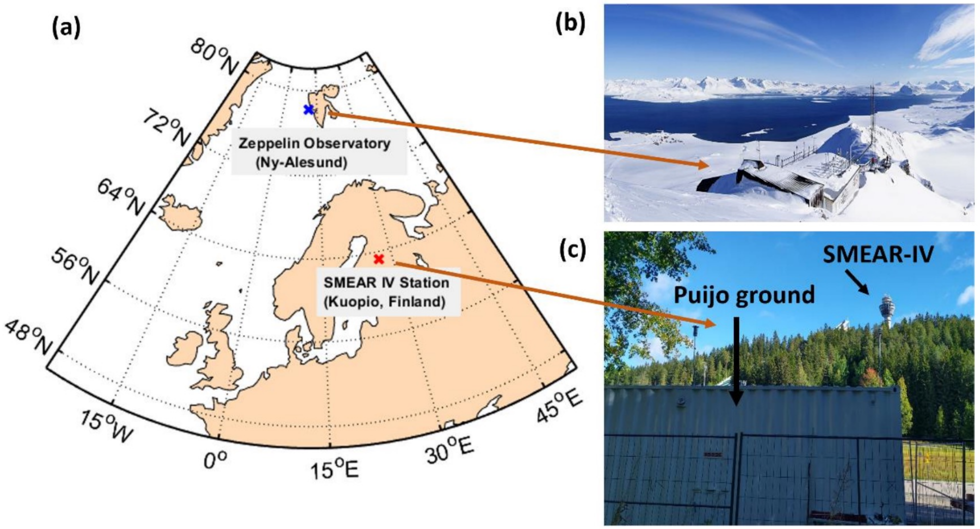
Air mass origin and fire regions during the individual events

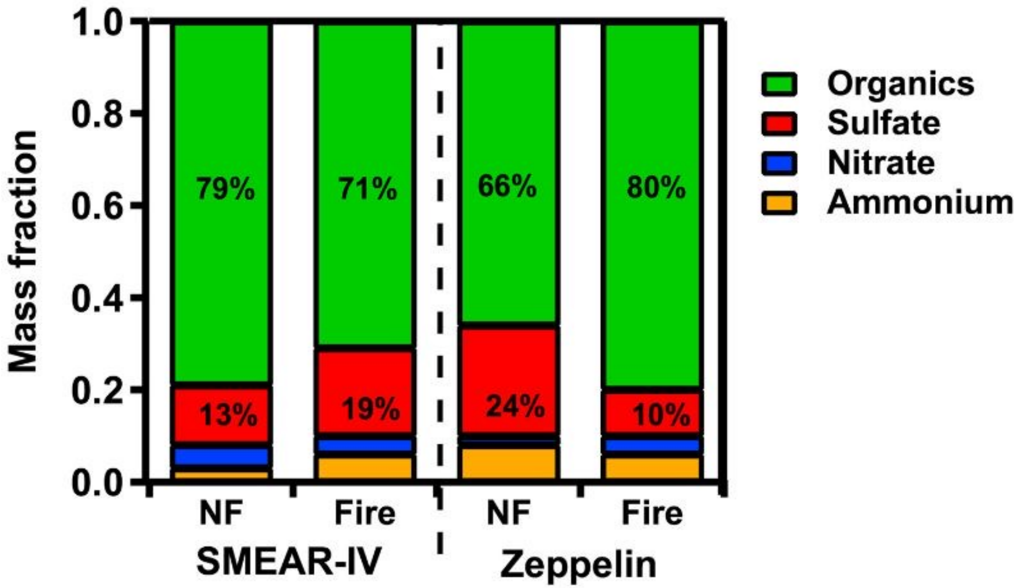


Origin for event 2 and 6 from Eastern Europe

Gramlich et al., 2024

A comparison of event 6 at two different sites





Opposite situation at the two sites

→ Properties of the plume and local background conditions matter

NF: no fire

Kommula et al., 2024

Summary and Conclusions

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- **Chemical properties:** significant higher organic signal -> reduction in hygroscopicity, more oxidized compounds; BB tracer compounds significantly higher during events 2 and 6
- **Physical properties:** mass concentration up to one order of magnitude higher during BB events; significantly higher number and mass concentration during events 2 and 6
- Fire source region with the largest impact: Eastern Europe

→ Impact of BB on the aerosol properties depends on the season and the local background conditions

Thank you!

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NATUR VÅRDS VERKET

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