University of Applied Sciences and Arts Northwestern Switzerland
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Towards Stand-Alone Monitoring of Carbonaceous Aerosol:
FATCAT Measurements and Thermogram-Based Interpretation

Why carbonaceous aerosol monitoring needs improvement

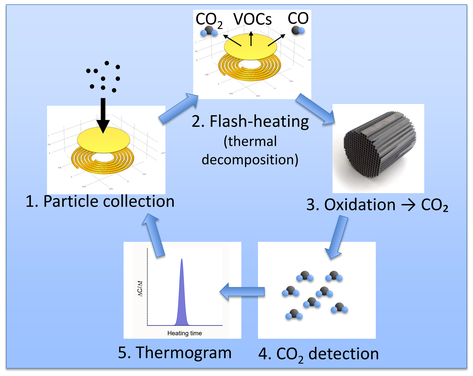
- Carbonaceous aerosol plays a major role in climate and health impact
- Existing metrics (PM, EC/OC, eBC) have limitations
- Limited time resolution and/or compositional insight
- Need for autonomous, interpretable measurements

What FATCAT adds

- High-time-resolution **particle-bound total carbon (TC)** thermograms (~20 min to 2 h, depending on monitoring conditions)
- Autonomous, low-maintenance operation
- Direct insight into volatility/refractivity and aerosol mixing state
- Robust metallic filter (no leakage)
- Compatible with GAW monitoring sites (e.g. Jungfraujoch)
- Field-proven performance in real ambient conditions (TRL 7)

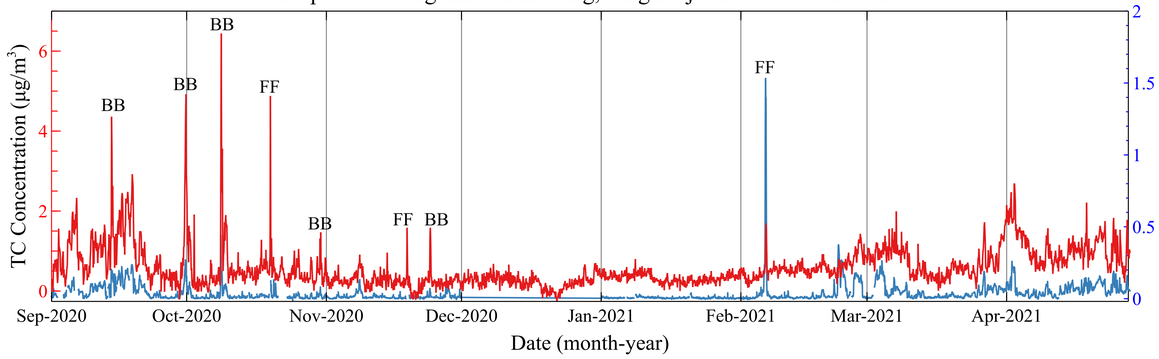
A FATCAT prototype was deployed at the Jungfraujoch research station, where long-term unattended measurement campaigns were conducted with minimal user intervention as part of the GAW-CH Plus research projects (2018–2021). The Jungfraujoch Global GAW station (3580 m a.s.l.) provides a unique site to observe free-tropospheric background as well as episodic influence from local sources and long-range transport.

FATCAT measurement principle

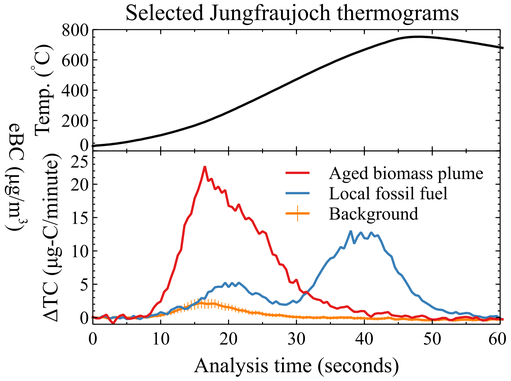


FATCAT measures TC with high time resolution, enabling insight into aerosol composition and mixing state. Aerosol particles are collected on a robust metallic filter, rapidly heated by induction, oxidized to CO_2, and quantified to produce a thermogram representing carbon release over time.

Unsupervised long-time monitoring, Jungfraujoch Global-GAW station

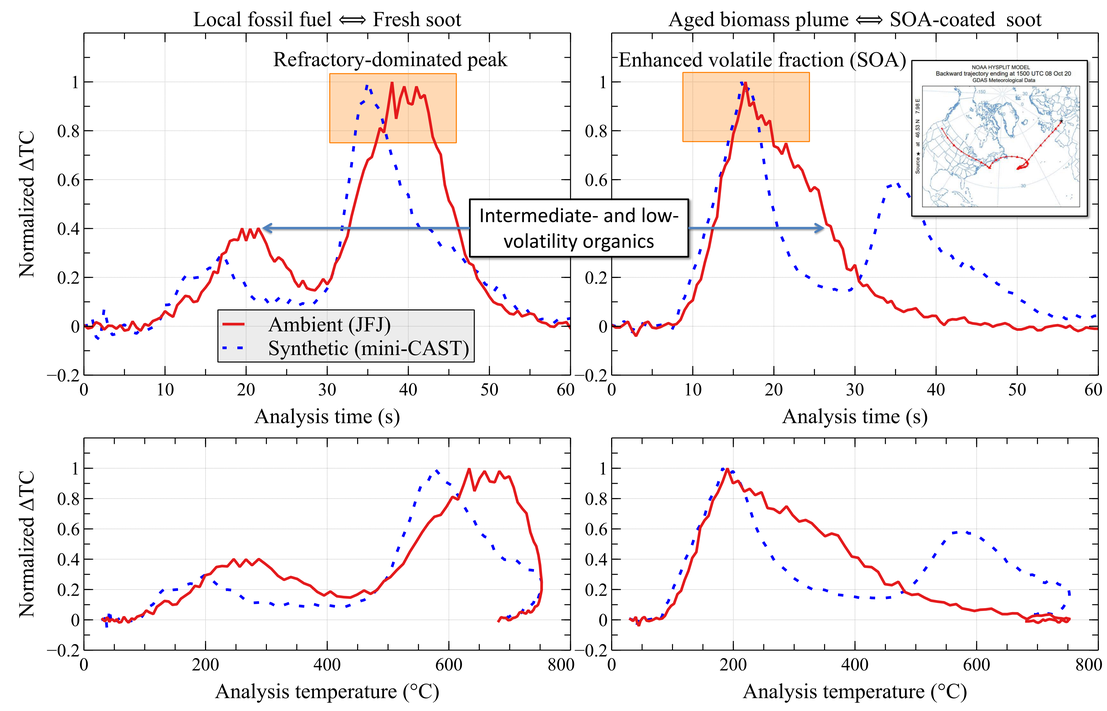


Selected Jungfraujoch thermograms



Left: Long-term unattended FATCAT measurements at Jungfraujoch show variability in total carbon under different atmospheric conditions. Selected events are marked as fossil-fuel (FF) or aged biomass-burning plumes (BB) influenced periods. Equivalent black carbon (eBC) from a MAAP instrument is shown for comparison (data courtesy of PSI). **Right:** Representative thermograms for selected events illustrate differences between FF influence, aged BB plumes, and clean free-tropospheric background.

Jungfraujoch thermograms compared to thermograms from selected sythetic aerosol samples



Thermograms measured at Jungfraujoch are compared with selected synthetic aerosol samples representing key source types and mixing states. Local fossil-fuel influence aligns with fresh soot, whereas aged biomass-burning plumes—including cases attributed to wildfires in California—show an enhanced volatile fraction that is better represented by SOA-coated soot. Synthetic aerosol experiments provide controlled reference cases that enable interpretation of ambient thermograms in terms of source and mixing state. Temperature representation supports interpretation in terms of volatility and refractory behaviour. Synthetic aerosol data: METAS measurement campaign, EURAMET 22NRM02 STANBC project.

What can be inferred from FATCAT thermograms?

In contrast to bulk EC/OC or eBC measurements, thermograms provide information on volatility distribution of carbonaceous aerosol.

Thermogram structure is reproducible under controlled conditions, enabling comparison across samples.

- Early signal → high-volatility organic material
- Late signal → refractory carbon (soot-like)
- Intermediate features → intermediate- and low-volatility organics (e.g. biomass burning and primary emissions)
- Peak shift and broadening → ageing and internal mixing (e.g. SOA coating)
- Synthetic aerosols support interpretation

Take-home messages

- Stand-alone ambient monitoring of carbonaceous aerosol
- Thermograms reveal composition and mixing state
- Thermograms link ambient observations to aerosol sources and ageing
- Field-proven system suitable for long-term monitoring networks
- Supports next-generation aerosol monitoring

Performance

- Measurement principle: thermal decomposition of aerosol carbon with CO_2 detection
- Time resolution: Concentration dependent; 20 min (City) to 2 hours (Jungfraujoch) per thermogram
- Detection limit: 0.16 µg C m^{-3} (Jungfraujoch)
- Autonomous operation over multi-month campaigns
- FATCAT enables interpretation of ambient carbon measurements in terms of volatility-resolved composition and aerosol ageing processes.

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