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Enhancing total carbon quantification using fast-thermograms

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Carbonaceous aerosols (CA) are an important component of the atmosphere impacting climate and health. They comprise a wide range of substances with a continuum of properties (thermal, optical, etc.) and various degrees of toxicity. This has created the desire to split the totality of CA into fractions to better understand their impact and the dynamic of atmospheric processes, including the formation of secondary organic aerosols. Traditional methods like thermal-optical analysis (TOA) separate particle-bound total carbon (TC) into organic (OC) and elemental carbon (EC), while optical techniques focus on diverse black carbon fractions (eBC and rBC). Despite the important data generated by these methods, a major challenge persists: the operational definition of fractions based on sample behaviour during analysis, rather than on a clearly defined material composition. This leads to potential artifacts in mass quantification and an unclear equivalence among different fractions.

Our study introduces a novel approach utilizing total carbon (TC) measurement, a reliable and robust parameter, enhanced with fast thermograms produced by our FATCAT measurement system [1]. The new measuring device allows autonomous, continuous operation over several months in, for example, air hygiene measuring stations and has a detection limit of 0.2 μg/m^3 TC. Unlike traditional thermograms produced by, e.g., TOA, fast thermograms provide insights into volatility and refractoriness without imposing an artificial separation into fractions or a thermal protocol. Laboratory tests demonstrate identifiable patterns for different primary and secondary organic matters or different soot types. Additionally, ambient measurements from diverse locations using FATCAT highlight the influence of various sources on thermogram patterns. This method offers a straightforward yet robust tool for carbonaceous aerosol analysis, which can be used for source apportionment and understanding fundamental sample properties.

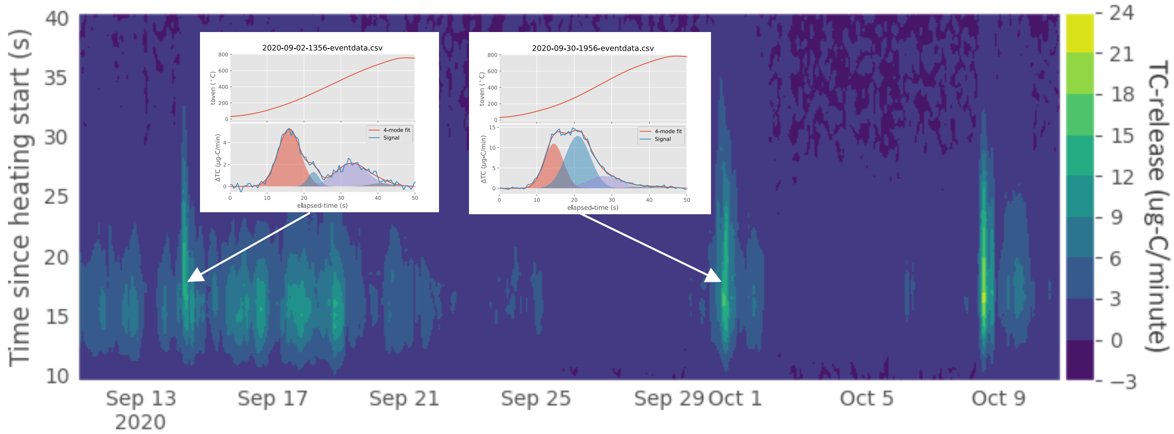

Figure: Contour plot of thermograms from one month of unattended FATCAT measurement at the Jungfraujoch GAW Global monitoring site. The color scale represents the rate of release of carbon from the sample during analysis. The insets show the detail of thermograms corresponding to local fossil fuel emissions (left) and intercontinental transport of biomass burning emissions (right) events.

[1] A. Keller, P. Specht, P. Steigmeier, E. Weingartner, *Aerosol Research*, **2023**, 1, 65–79.