Characterisation of Emitted Gaseous Species and Particle Concentrations Using HyperCam and Sampling System

H. Shariatmadar, M. Wooster

Department of Geography, Kings College London, London, United Kingdom

Introduction and Objective

Intro: Understanding the complex interactions between fire, ecosystems, atmospheric chemistry, and climate is crucial for developing effective strategies for fire management, conservation, and mitigating the impacts of wildfires on both local and global scales [1, 2].

Problem: The main problem regarding emissions from fires is the limited understanding of their long-term atmospheric interactions and implications for regional and global air quality, climate, and human health [3].

Objectives: The current objective is to quantify gas and particulate emissions from fires through various methods. These techniques aim to provide comprehensive data on the composition and characteristics of emissions, aiding in better understanding their impact on the atmosphere, climate, and human health.

Experimental Facilities

Telops HyperCam: The CH_4 HyperCam is a specialised tool designed for precise detection and quantification of methane in the atmosphere, focusing on measurements within the distinctive CH4 absorption feature (see Fig. 1).

Gas analyser: A gas analyser is used to measure the gas concentrations from oak combustion.

Sampling kit: In this experiment, a distinctive sampling system is employed to measure gas, PAHs, and particulate concentrations from fire emissions (see Fig. 1).

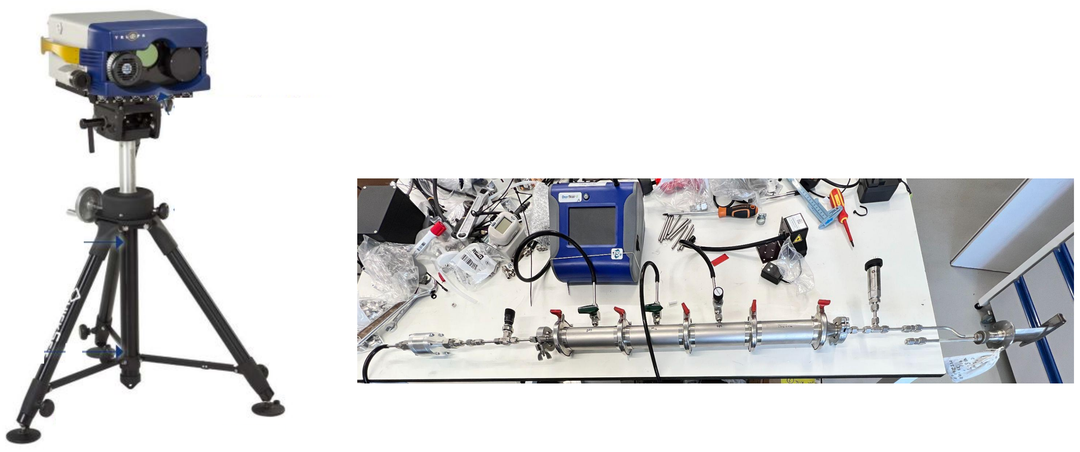

Figure 1: Left: Telops HyperCam; Right: Sampling kit.

Experimental results – Oak combustion

Objective: The CH4 HyperCam is utilised to detect methane and other species within the wavenumber range of 1200 to 1400 cm^{-1}. Additionally, a gas analyser is employed to extract gaseous species.

- The HyperCam exhibits strong signals for both brightness temperature and spectral radiance across the wavenumber range of 1200 to 1400 cm^{-1}, particularly in the oak combustion region. The peaks observed at a wavenumber of 1310 cm^{-1} can be indicative of methane signatures.
- Figure 3 illustrates the gaseous species' concentration resulting from oak combustion. The flame conditions indicated a sooty flame, and the CO2/CO ratio highlights the incomplete combustion process.

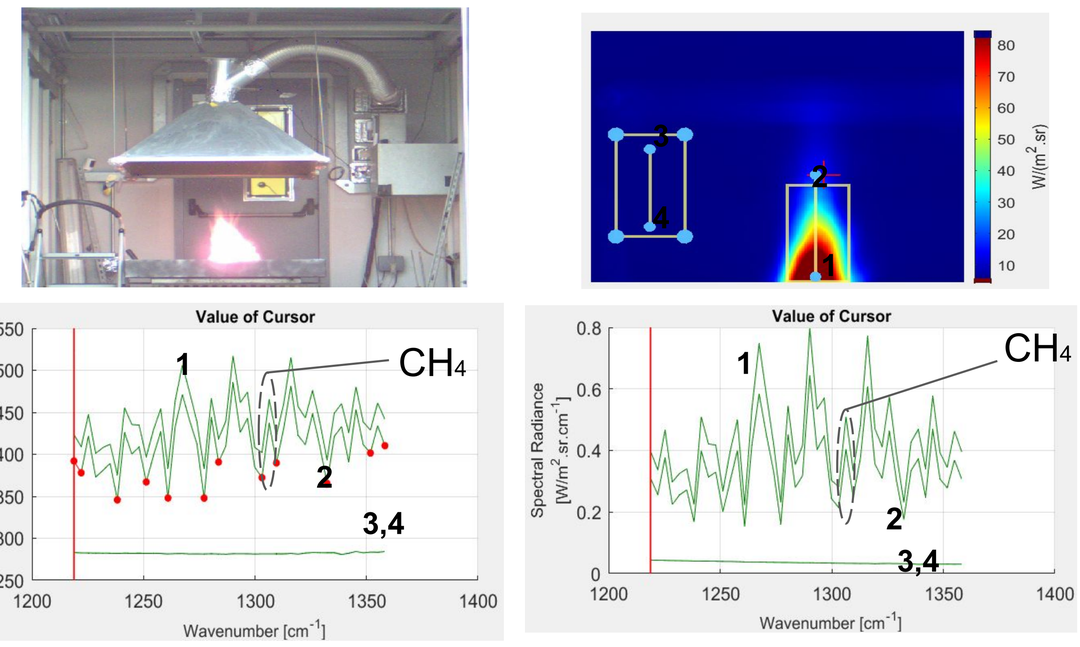

Figure 2: Top Left: sample photograph from oak combustion; Top Right: Image processeing considering four different regions; Bottom Left: Brightness temperature versus wavenumber for different regions; Bottom Right: Spectral radiance versus wavenumber for different regions.

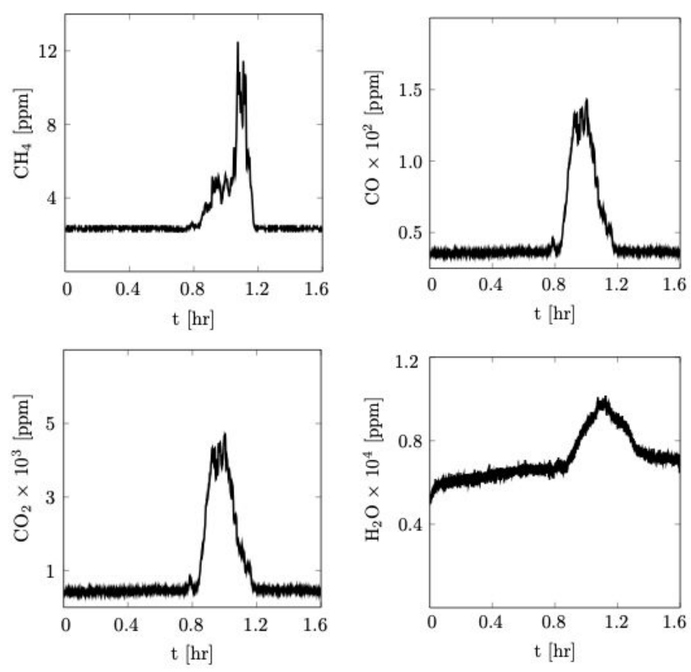

Figure 3: The concentration of gaseous species measuring via a gas analyser.

Experimental results - Candle

Objective: Our sampling system facilitates simultaneous measurements utilising various instruments such as MIRO, OPC, DRX, and a PAH sampling filter, enabling comprehensive analysis of the emitted components.

- The sampling time position was systematically altered during the experiment to evaluate how the distance from the candle affected the gaseous concentrations.
- The flame was laminar.
- The sampling flow rates were established and verified for various instruments using a flow meter and metering valves.
- Throughout the experiment, a pressure transducer is employed to continuously record the sampling pressure.
- Quartz wool and XAD–2 resin were used to capture PAHs/smoke.
- A GC/MS will be used to measure the PAH concentrations.

– Figure 4 presents the temporal variations in CH4, CO, CO2, and H_2O concentrations as measured by MIRO. The data will be used to validate our understanding of the underlying processes involved.

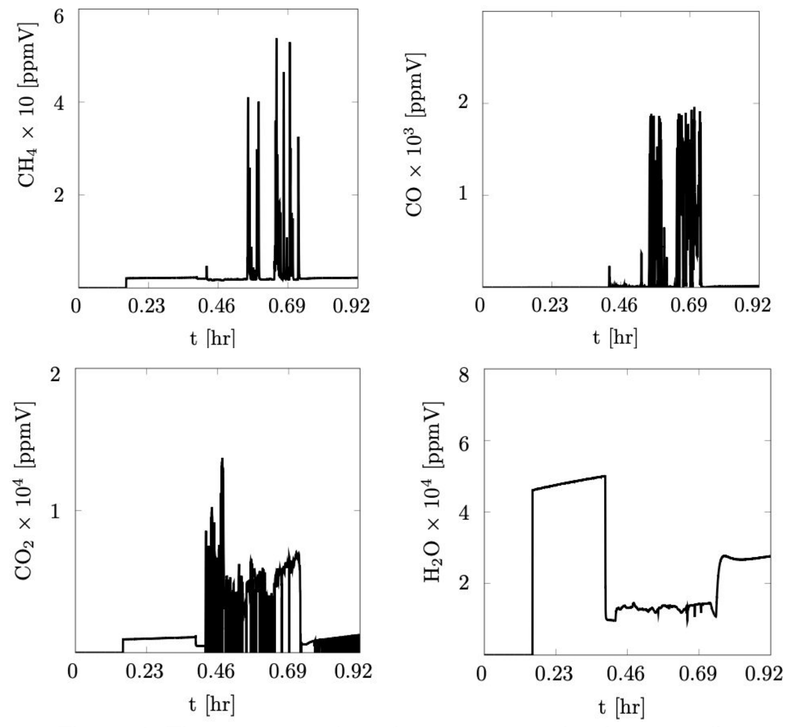

Figure 4: The concentration of gaseous species from candle.

– Figure 5 displays the changes in particulate matter (PM1, PM2.5, PM10) concentrations over time recorded by OPC–N3 with noticeable differences in their concentration trends.

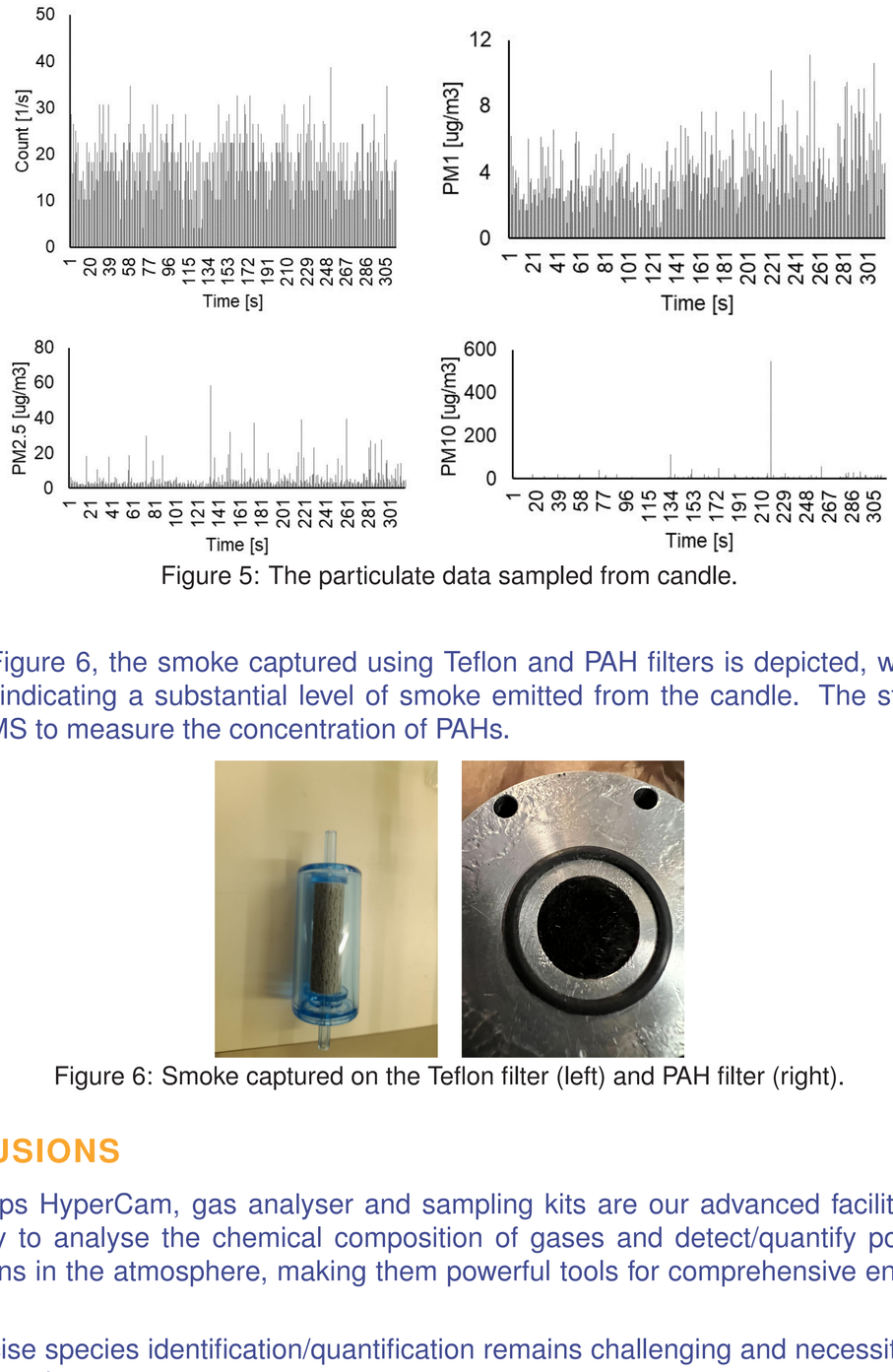

Figure 5: The particulate data sampled from candle.

– In Figure 6, the smoke captured using Teflon and PAH filters is depicted, with the dark color indicating a substantial level of smoke emitted from the candle. The study utilises GC–MS to measure the concentration of PAHs.

Figure 6: Smoke captured on the Teflon filter (left) and PAH filter (right).

Conclusions

- Our Telops HyperCam, gas analyser and sampling kits are our advanced facilities with the capability to analyse the chemical composition of gases and detect/quantify pollutant concentrations in the atmosphere, making them powerful tools for comprehensive environmental studies.
- The precise species identification/quantification remains challenging and necessitates further in-depth analyses.

References

[1] N. J. Abram, B. J. Henley, A. S. Gupta, T. J. R. Lippmann, H. Clarke, A. J. Dowdy, J. J. Sharples, R. H. Nolan, T. Zhang, M. J. Wooster, J. B. Wurtzel, K. J. Meissner, A. J. Pitman, A. M. Ukkola, B. P. Murphy, N. J. Tapper, M. M. Boer, Commun Earth Environ 2, 8 (2021).

[2] D. L. A. Gaveau, M. A. Salim, K. Hergoualc'h, B. Locatelli, S. Sloan, M. Wooster, M. E. Marlier, E. Molidena, H. Yaen, R. DeFries, L. Verchot, D. Murdiyarso, R. Nasi, P. Holmgren, D. Sheil, Sci Rep 4, 6112 (2014).

[3] M. J. Wooster, G. Roberts, G. L. W. Perry, Y. J. Kaufman, JOURNAL OF GEOPHYSICAL RESEARCH, 110 (2005).