



Canadian wildfire smoke plume altitudes in 2025

– a comparative study using EarthCARE, Sentinel-5P observations and GFAS-driven FLEXPART simulations

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EUROPEAN SPACE AGENCY

Wildfire seasons and emissions

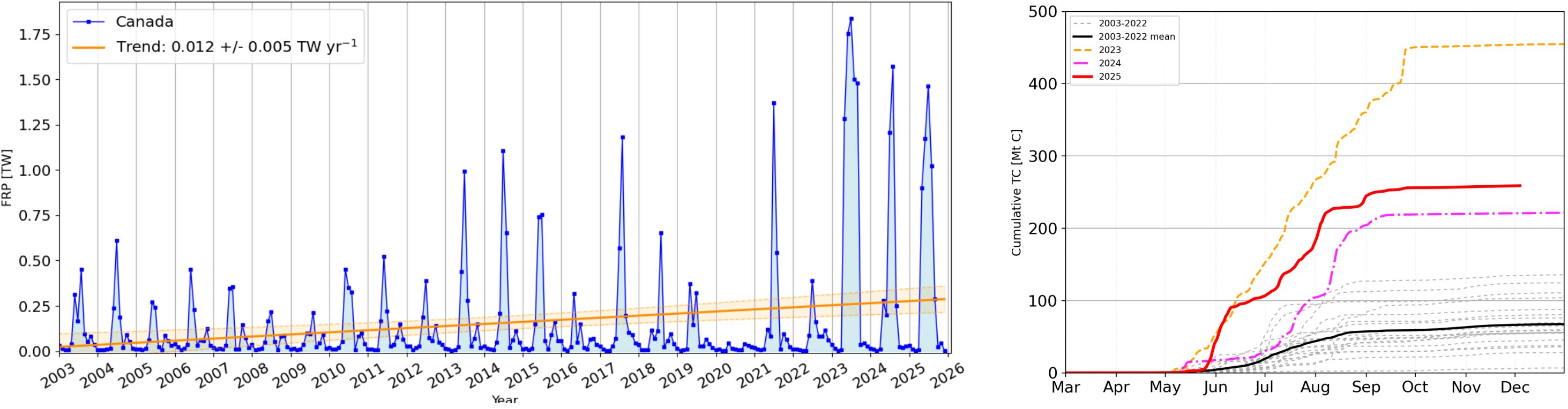


Fig. 1 Monthly FRP over Canada from 2003 to November 2025, based on CAMS GFASv1.2 MODIS data, showing an increasing trend.
Fig. 2 Cumulative GFAS carbon emissions from Canadian wildfires in 2025 compared with 2003–2025.

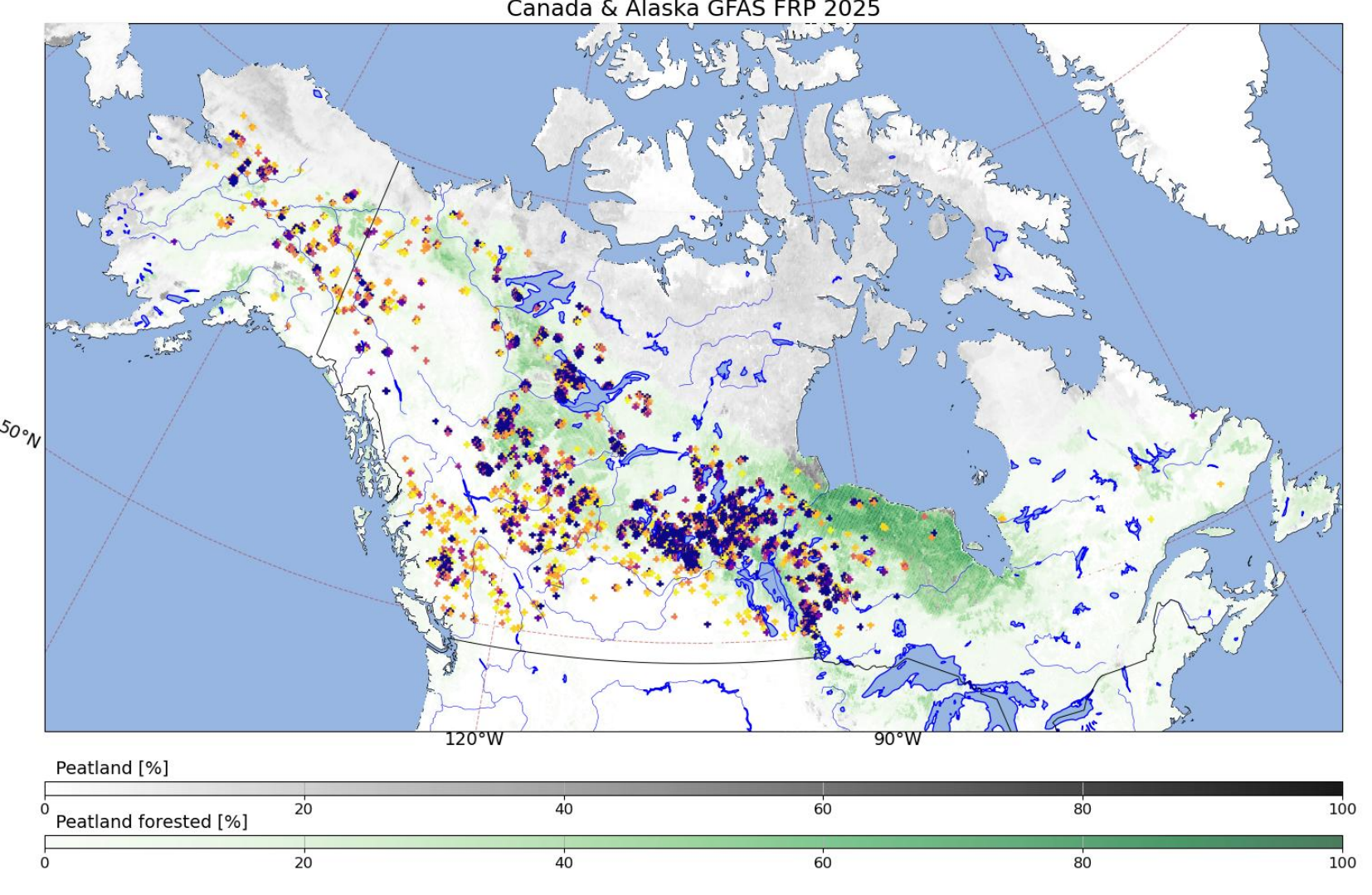


Fig. 3 2025 fire locations and intensity overlaid on peatland and forested peatland distributions.

Plume altitude estimates

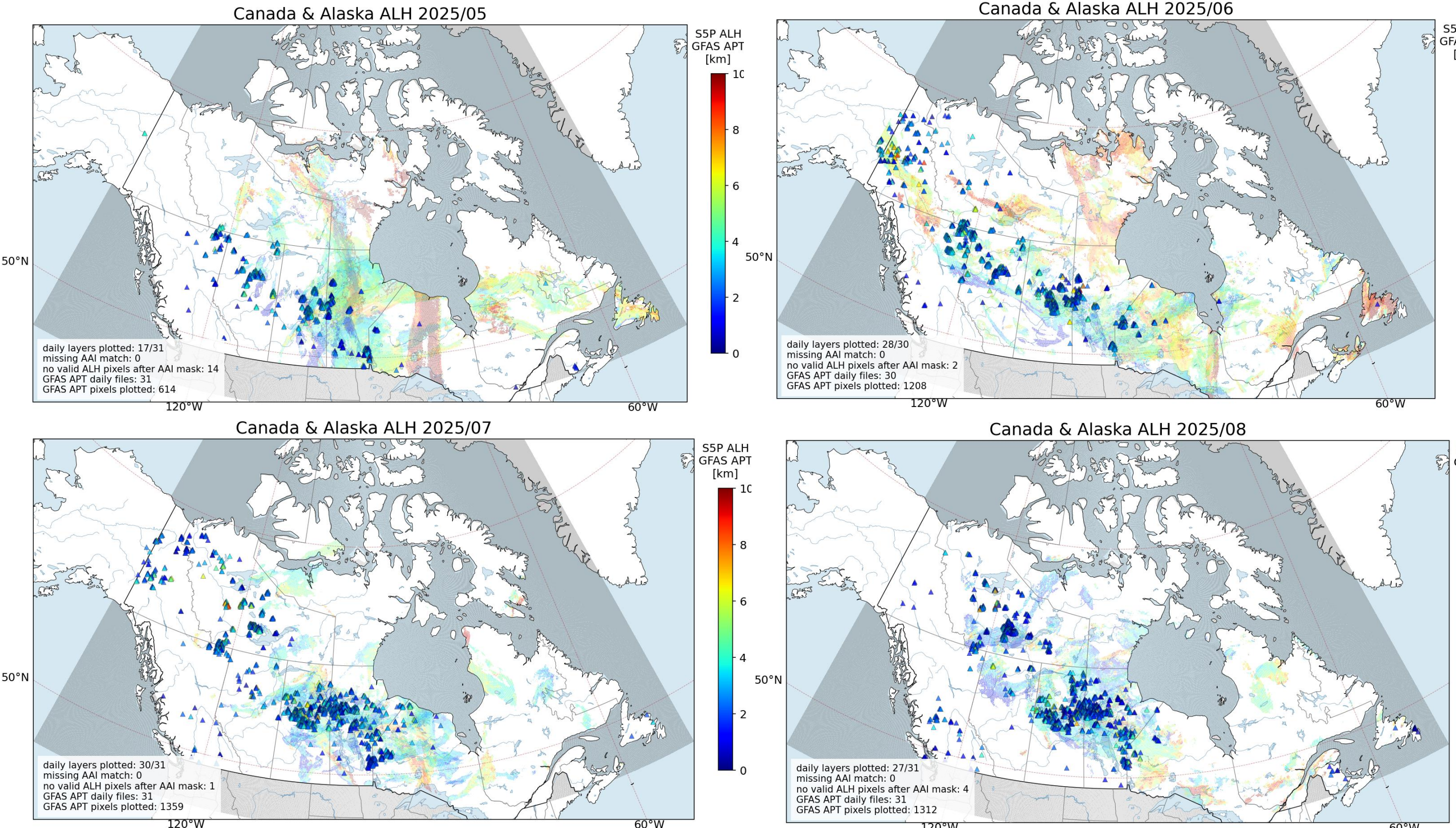


Fig. 4 May–August 2025 GFAS maximum plume height, shown as triangles, overlaid on daily S5P/TROPOMI aerosol layer height for absorbing wildfire plumes (AAI > 2)

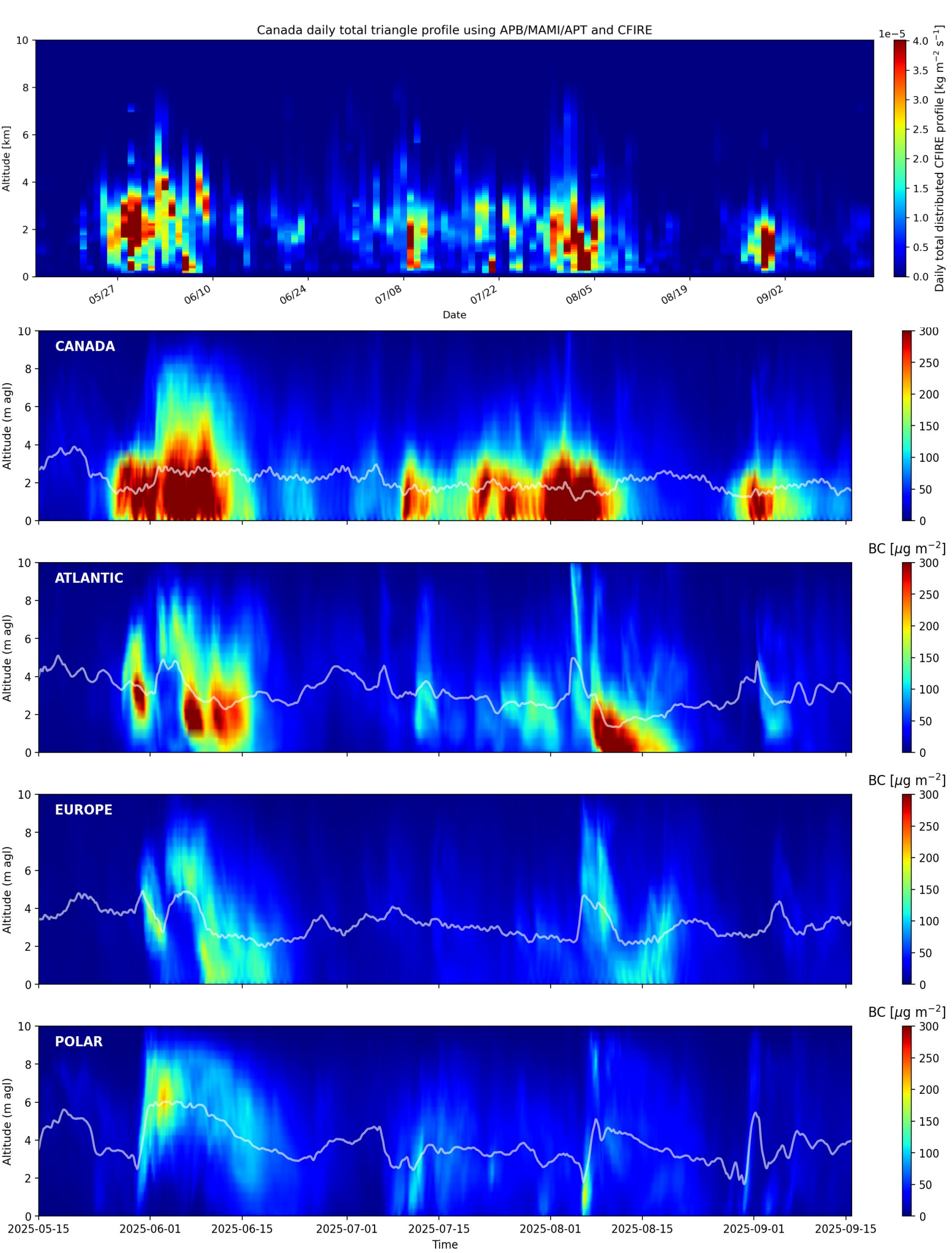


Fig. 5 Daily mean GFAS carbon-emission profiles for Canada in 2025, distributed between plume bottom, mean injection height, and plume top.
Fig. 6 FLEXPART black carbon vertical distribution for four regions from 15 May to 15 September 2025. Emissions are initially distributed uniformly from the surface to the GFAS plume top; future simulations will test alternative injection profiles.

EarthCARE observations & model validation

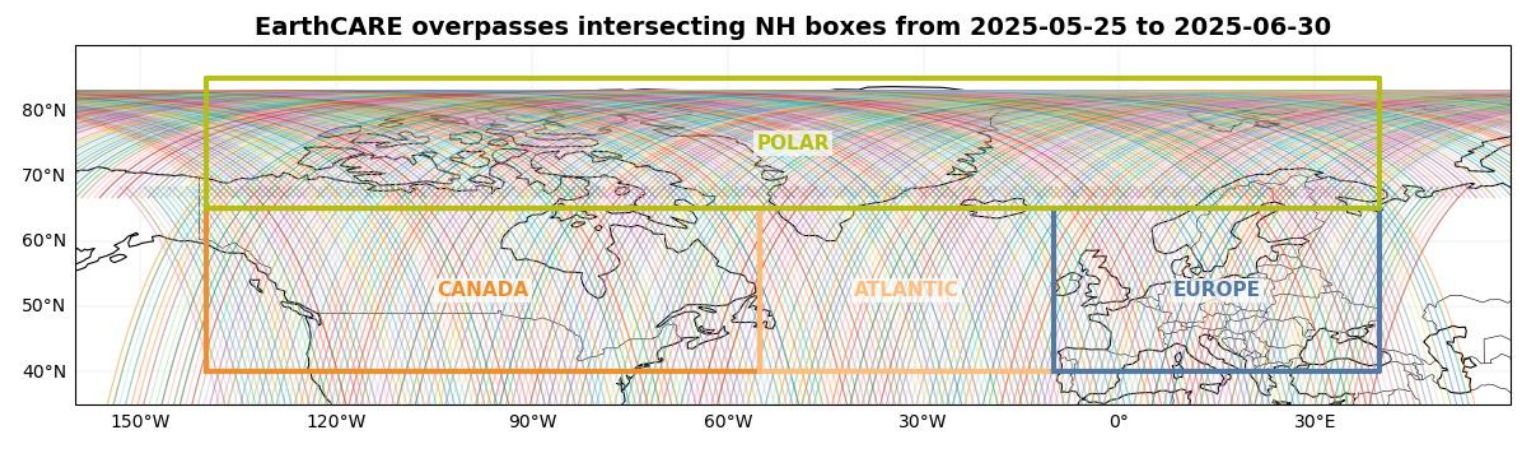
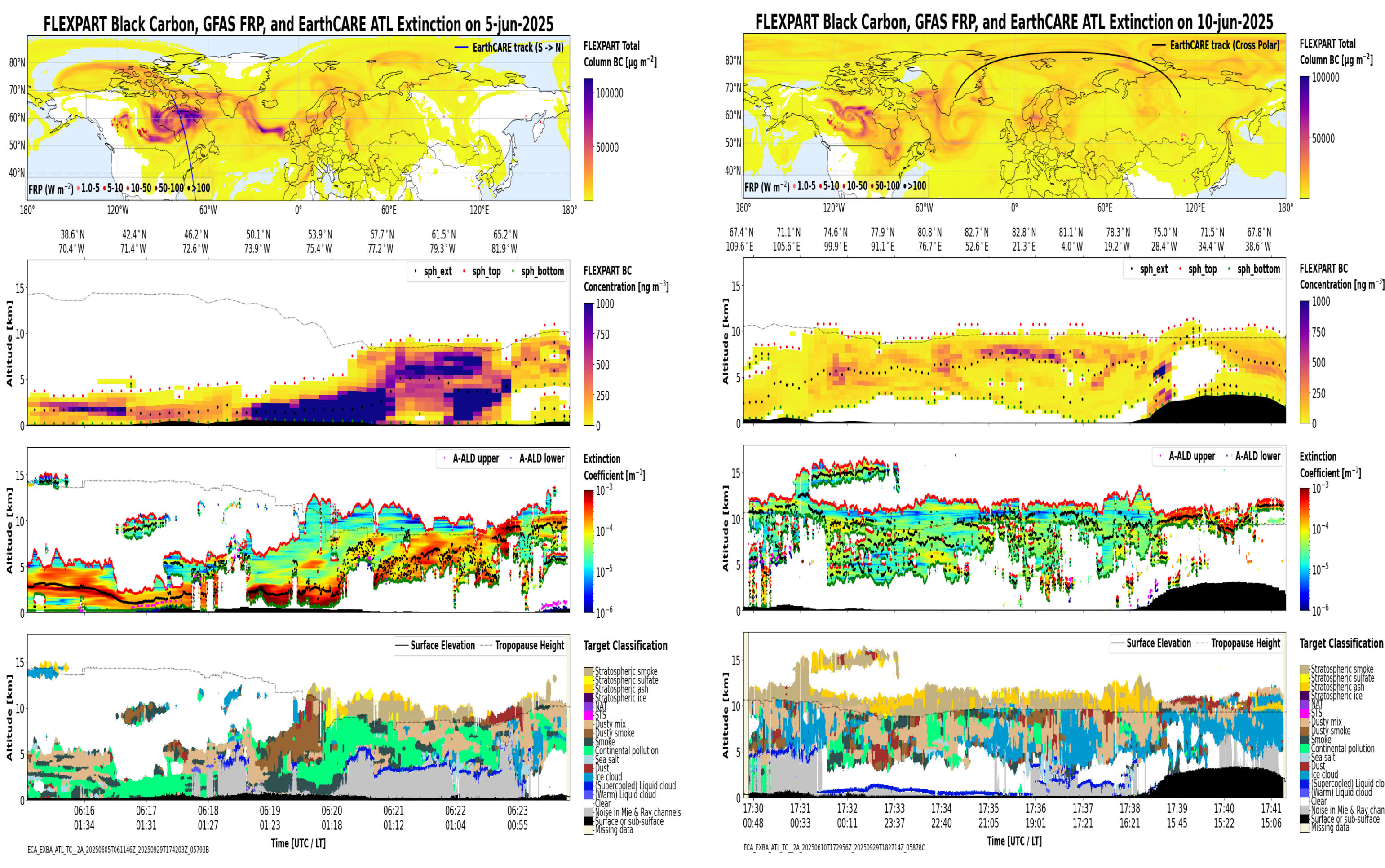


Fig. 7 EarthCARE overpasses across the Canada, Atlantic, Europe, and Polar analysis regions, 25 May–30 June 2025.



Figs. 8–9 FLEXPART black carbon and EarthCARE ATLID extinction/target classification along 5 and 10 June 2025 overpasses. FLEXPART captures most plume structures and altitudes but misses the highest UTLS smoke layers.

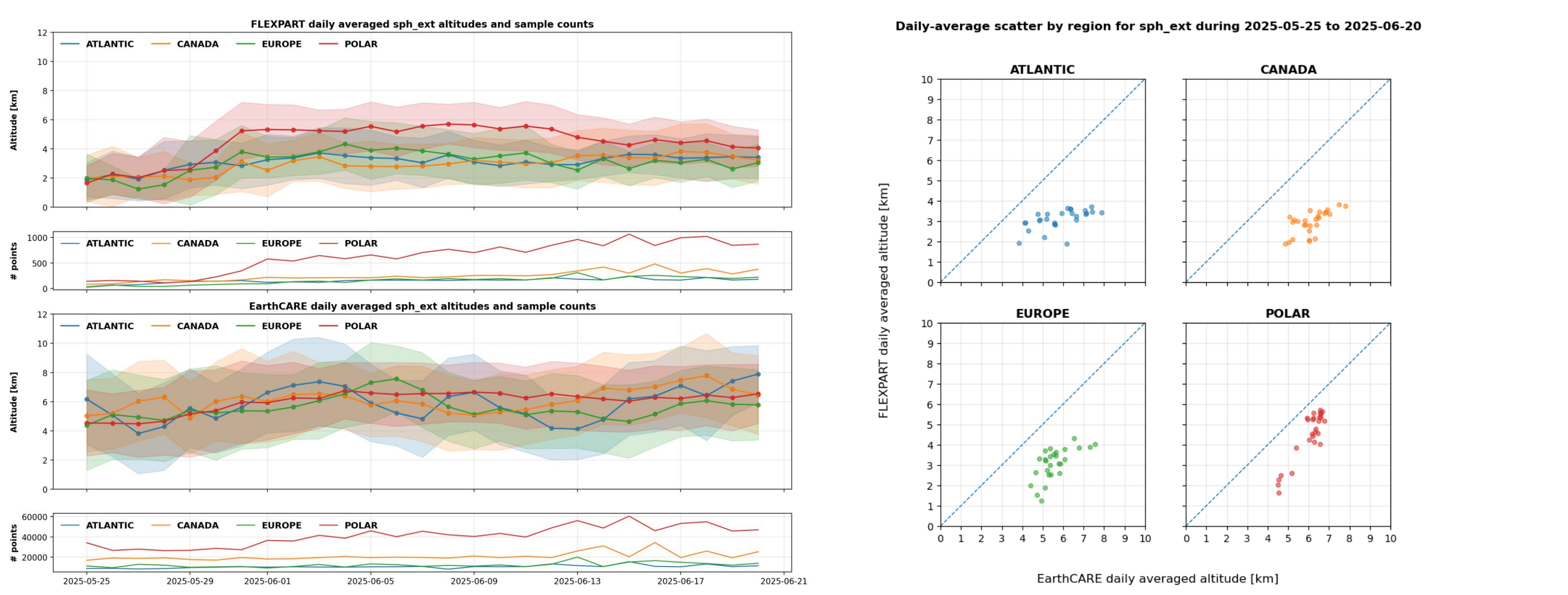


Fig. 10 Preliminary FLEXPART–EarthCARE comparison of daily extinction-weighted plume heights and sample counts, 25 May–20 June 2025.

Key findings:

- 2025 showed strong early Canadian wildfire emissions.
- FLEXPART captures the main smoke transport and plume-height patterns seen by Sentinel-5P/TROPOMI and EarthCARE.
- The highest UTLS smoke layers are underestimated, likely due to missing extreme GFAS injection heights.

Next steps:

- Expand the statistical analysis of the 2025 Canadian wildfires, focusing on their vertical evolution and transport pathways, assumptions regarding emission profiles, the effects of cloud screening, and the characterization of aerosol layers.

Data and tools. GFASv1.2 fire emissions and injection heights; FLEXPART black carbon simulations; Sentinel-5P/TROPOMI absorbing aerosol layer height; EarthCARE ATLID extinction and target classification.

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