



Impacts of wildfire plumes from Northern America on atmospheric composition as observed by permanent observatories in Italy during June 2025

Paolo Cristofanelli¹, Francesca Barnaba², Alessandro Bracci¹, Claudia Roberta Calidonna³, Rita Cesari⁴, Daniele Contini⁴, Luca Diliberto², Francesco d'Amico³, Stefano Decesari¹, Adelaide Dinoi⁴, Leonardo Gori⁵, Angela Marinoni¹, Lucia Mona⁶, Davide Putero⁷, Isabella Zaccardo⁶, and Marco Zanatta¹

¹CNR, ISAC, Via Gobetti 101, I-40129 BOLOGNA, Italy (paolo.cristofanelli@cnr.it)

²CNR, ISAC, Via Fosso del Cavaliere 100, I- 00133 Roma, Italy

³CNR, ISAC, Zona Industriale-Comparto 15 - presso Fondazione Mediterranea Terina, I-88046 Lamezia Terme (CZ), Italy

⁴CNR, ISAC, Strada Prov.le Lecce-Monteroni Km 1,200, I-73100 Lecce, Italy

⁵Pisa University, Dipartimento di Scienze della Terra, Via Santa Maria 53, I - 56126 PISA, Italy

⁶CNR, IMAA, Zona Industriale Tito Scalo, Potenza, Italy

⁷CNR, ISAC, Corso Fiume 4, I-10133 Torino, Italy

In May and June 2025, wildfires in Canada produced atmospheric effects extending beyond North America. Large quantities of gases and aerosols emitted by biomass combustion were transported across the Atlantic and reached Europe. Here, our aim is to investigate how these events affect the variability of climate-altering species in Italy using observations from permanent observatories.

Clear evidences of this long-range transport were observed from 8th June 2025 at the GAW/WMO Global Station "O. Vittori" at Monte Cimone (2165 m a.s.l., northern Italy) and at the Potenza CIAO observatory (760 m a.s.l., southern Italy), two co-located sites for the Research Infrastructures ICOS and ACTRIS. It was also observed, albeit with weaker intensity, at the ACTRIS Environmental-Climate Observatory (ECO) in Lecce (37 m a.s.l., southern Italy). Atmospheric transport modelling (LAGRANTO and HYSPLIT back-trajectories) confirmed that the air masses affecting the sites originated in North America.

Average daily carbon monoxide (CO) values peaked to 207 ppb on 9th June at CMN and to 247 ppb at ECO, nearly doubling the levels measured during the preceding 7 days. Also, black carbon (BC) showed marked increases, with values more than doubling the average of the preceding days at both sites.

Additional confirmation of the plume's arrival and vertical evolution was provided by the ALICE-Net ceilometer at CMN: between 6th and 8th June, aerosol-rich layers were detected at high altitudes before gradually descending to the measurement site. At CIAO, the aerosol lidar observed smoke layers between 11 and 14 km from 5th to 10th June.

CO and ozone (O_3) remained high until 13th June at CMN (average values: 188 ppb and 70 ppb), and at ECO (average CO value of 232 ppb, O_3 data not available). Subsequently, intermediate values have been observed from 14th to 21st June. At CIAO, CO increased between 8th and 17th June, reaching up to 250 ppb.

No corresponding increases in carbon dioxide (CO_2) have been observed during the wildfire plume event. During the days characterized by the peaks in CO and O_3 (8th – 13th June), daily mean CO_2 values showed a – 6.4 ppm and – 3.4 ppm decrease with respect to the previous 7 days at CMN and ECO. The analysis of back-trajectories showed air masses travelling at pressure levels representative of the European PBL, where active ecosystems could take up CO_2 , in the 24 hours before the arrival at CMN.

The analysis of the day-to-day variability of nighttime/daytime N_2O , CO_2 and $\delta^{13}CO_2$, pointed to a significant influence of air masses from the regional PBL to CMN during the daytime on 9th – 14th and 18th – 19th June. This suggests that emissions occurring at regional scale could contribute to the observed atmospheric composition variability. Together with the role of air mass mixing and in-plume chemical processes along transport, this implies that attributing the observed enhancements to wildfire emissions requires careful and critical evaluation.

Acknowledgments: Observations/analyses are supported by the ITINERIS (PE0000021, NRRP – NextGenerationEU) and PRO-ICOS MED (PON 2014–2020) projects, funded by the Italian Ministry of University and Research and the European Union.