# Tracing Carbon in the Sky: CO₂ and CH₄ Isotope Signatures under Dust and Fire Events at the POT Station, Part of the CIAO Observatory (CNR-IMAA)

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A new atmospheric station dedicated to the observation of greenhouse gases has recently been implemented at the CNR-IMAA Atmospheric Observatory (CIAO). The station, called POT, is part of the Integrated Carbon Observation System (ICOS) Research Infrastructure and provides continuous measurements of carbon dioxide (CO₂) and methane (CH₄) atmospheric concentrations.

Thanks to the ITINERIS project, its observation capability has recently been enhanced with the acquisition of a high-resolution and high-precision Picarro G2201 continuous analyser for the investigation of the behaviour of stable carbon isotopes in CO₂ and CH₄ and this contribution has been essential to the development of a high-resolution isotopic dataset.

Isotopic analysis represents a powerful tool for source attribution, enabling the identification of emission origins through the isotopic signature left by various physical and chemical processes occurring in the atmosphere.Located in a strategic position at the heart of the Mediterranean Basin, CIAO provides optimal conditions for the monitoring and investigation of the frequent Saharan dust intrusions affecting the Mediterranean region. Continuous air sampling from the 100-meter tower of the POT station enabled the detection of isotopic shifts following multiple dust events observed in March 2025. These in-situ observations represent the first field evidence in Mediterranean area suggesting a potential link between mineral dust and methane oxidation, possibly driven by fractionation mechanisms that favour the atmospheric removal of lighter ¹²CH₄, resulting in an enrichment of ¹³CH₄. Such findings could support the hypothesis that mineral aerosol can influence methane isotopic signatures through heterogeneous processes, offering new insights into the interactions between dust and greenhouse gases in the free troposphere.

In addition to the POT station demonstrated also sensitivity to long-range fire events. Infact a distinct increase in CO concentrations was observed following the intense Canadian wildfires occurred in June 2025, in agreement with signals reported across multiple European stations. Therefore, based on this observation, our research focused on the characterization of local fire events through the stable carbon isotope analysis. The application of the Keeling plot methodology enabled the identification of combustion-related isotopic signatures, highlighting the potential of isotopic tracers for distinguishing fire-derived contributions to regional greenhouse gas variability.

**Keywords: carbon isotopes, methane oxidation, Keeling plot**