

Aerosols and Greenhouse Gases: A Coupled Retrieval Strategy for Future Targeted Greenhouse-Gas Missions

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Accurate remote sensing of greenhouse gases requires precise characterization of atmospheric aerosol loading, and exploiting this coupling is the focus of this contribution. Following the success of missions such as JAXA's GOSAT, NASA's OCO-2, and Copernicus' TROPOMI/Sentinel-5P, space-based monitoring of CO₂ and CH₄ emissions is now established, driving the need for accurate total-column observations of these trace gases. Building on this heritage, the European Copernicus CO2M mission aims to measure the dry-air column-averaged mixing ratio of CO₂ to an accuracy of 0.5 ppm ($\approx 0.1\%$), at 2×2 km² resolution, with near-global coverage every few days. Achieving this accuracy depends critically on precise knowledge of the light path and thus on an accurate description of atmospheric aerosol properties. This requirement motivates a payload combining a multi-angle polarimeter (MAP) and a spectrometer, whose co-located measurements enable joint aerosol and greenhouse-gas retrievals.

This concept is general and extends naturally to smaller, targeted greenhouse-gas sources. Targeted missions such as TANGO (launch 2028, spatial resolution better than 300 m) are designed to observe individual emission plumes, opening a distinct retrieval regime. From a greenhouse-gas perspective, elevated aerosol layers perturb the light path more strongly than near-surface aerosols, yet — because such layers vary less in space and time than boundary-layer aerosols — the requirements on temporal and spatial co-registration between aerosol and gas observations can be relaxed. This enables a retrieval concept for TANGO supported by global aerosol measurements from instruments such as 3MI (MetOp-SG) and MAP. In this work, we demonstrate a sequential retrieval framework in which aerosol microphysical properties are retrieved first and then used as input to a dedicated full-physics retrieval of CO₂ and CH₄ from TANGO observations in the 1.6 μ m region. Conceived as an exploratory data-processing approach for TANGO, this synergistic strategy can sharpen the interpretation of complex greenhouse-gas patterns — in particular the separation and quantification of mixed CO₂ and CH₄ emissions from incomplete combustion during oil-and-gas flaring, and from urban-scale sources.