

FARM: FAsT Retrieval Model for the Simultaneous Inversion of Co-located Spectral Radiance Measurements

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ABSTRACT

FORUM (Far-infrared Outgoing Radiation Understanding and Monitoring) will be the 9th Earth Explorer mission of the European Space Agency (ESA). The core instrument of the FORUM experiment will be a Fourier Transform Spectrometer, covering the spectral range 100 - 1600 cm⁻¹. This broad interval includes most of the Earth's outgoing longwave radiation spectrum, including the Far-InfraRed (FIR) region. Planned for launch in 2027, FORUM will fly in loose formation with the MetOp-SG-A satellite, hosting the Infrared Atmospheric Sounding Interferometer - New Generation (IASI-NG). The Mid InfraRed (MIR) range (645 to 2760 cm⁻¹) of the upwelling atmospheric spectrum measured by IASI-NG will effectively complement the FORUM measurement. Altogether, the two missions will provide co-located spectral radiance measurements with unprecedented spectral coverage, from 100 to 2760 cm⁻¹. While the FIR part of the spectrum (100 -667 cm⁻¹) measured by FORUM is more sensitive to the water vapour content in the Upper Troposphere Lower Stratosphere, the MIR region will be measured by IASI-NG with a higher signal-to-noise ratio, thus supplying very precise information on the surface temperature and on the atmospheric temperature profile, that may be exploited to effectively constrain FORUM retrievals.

In view of the exploitation of the synergy between FORUM and IASI-NG measurements, within the FIT-FORUM project (Forward and Inverse Tool for FORUM) funded by the Italian Space Agency (ASI), we developed a new Bayesian retrieval algorithm with the capability to perform the simultaneous inversion of two co-located spectral radiance measurements. The tool, named FAsT Retrieval Model (FARM), is based on a fast pseudo-monochromatic and parametrized radiative transfer model (σ -IASI). FARM includes the capability to simultaneously retrieve atmospheric and cloud parameters and can handle both air/space-borne nadir measurements and ground-based zenith measurements. Regarding clouds, the initial baseline of FARM was to retrieve full vertical profiles of cloud liquid- and ice- content and of particle dimensions. To better constrain the inversions, however, the FARM code has recently been extended with the functionality to represent liquid- and ice- clouds with only a few scalar parameters: cloud top- and bottom- heights, liquid- and ice- water paths, and droplets- ice crystals- effective dimensions.

In this work, we illustrate the functionalities of the developed algorithm and present some examples of its application based both on simulated measurements and on measurements acquired in ground-based and stratospheric balloon campaigns. Particularly interesting is the application of the FARM algorithm to the simultaneous inversion of coinciding measurements acquired by the current IASI satellite instruments and the REFIR-PAD FIR spectroradiometer operated by CNR-INO from the Concordia base in Antarctica.