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

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BACKGROUND

FARM was developed to assess the advantages of the synergistic inversion of coincident spectral radiance measurements such as those that will be acquired by forthcoming remote sensing satellite missions, like:

- the Far-infrared Outgoing Radiation Understanding and Monitoring (FORUM, [1]) and the Infrared Atmospheric Sounding Interferometer - New Generation (IASI-NG)
- and the Changing-Atmosphere InfraRed Tomography (CAIRT, [2]) and IASI-NG

THE RADIATIVE TRANSFER MODEL

For **F**(**x**), we use σ-IASI/F2N, a fast quasi-monochromatic radiative transfer model developed at UNIBAS and UNIBO (see [3] and references therein):

- Uses parametrized gas optical depths
- Chou / Tang scaling method to simulate the scattering from cloud ice-particles / water-droplets
- Computes analytical Jacobans wrt atmospheric and cloud params, surface temperature and emissivity, etc.
- So far can handle only nadir and zenith measurements, work is ongoing to build a new RTM based on σ-IASI/F2N principles, to handle also the limb-measurements of CAIRT.

ALGORITHM

FARM is a Bayesian inversion algorithm, using a priori and Tikhonov constraints. The cost function adopted is:

$$\zeta^2(\mathbf{x}) = (\mathbf{y}_1 - \mathbf{F}_1(\mathbf{x}))^T \mathbf{S}_{y1}^{-1} (\mathbf{y}_1 - \mathbf{F}_1(\mathbf{x})) + (\mathbf{y}_2 - \mathbf{F}_2(\mathbf{x}))^T \mathbf{S}_{y2}^{-1} (\mathbf{y}_2 - \mathbf{F}_2(\mathbf{x})) + (\mathbf{x}_a - \mathbf{x})^T (\mathbf{S}_a^{-1} + \mathbf{L}^T \mathbf{\Lambda} \mathbf{L}) (\mathbf{x}_a - \mathbf{x})$$

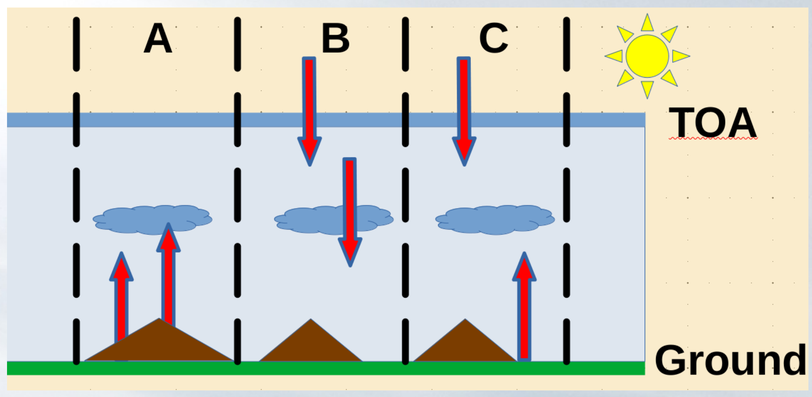
The minimum of the cost is found with the iterative Levemberg-Marquardt approach and a stopping criterion.

THE STATE VECTOR

$\mathbf{x} = (\mathbf{T}(p), Ts, \mathbf{VMR}_{i=1,...,N}, \mathbf{e}(\nu), \mathbf{CLD})$

$\mathbf{CLD} = (\mathbf{WC}(p), \mathbf{De}(p))_{i/w}$ or $(CTH, CBH, WC, De)_{i/w}$

MEASUREMENT CONFIGURATIONS HANDLED



Supported synergistic measurement configurations:

A) Zenith – Zenith
B) Nadir – Nadir
C) Nadir – Zenith

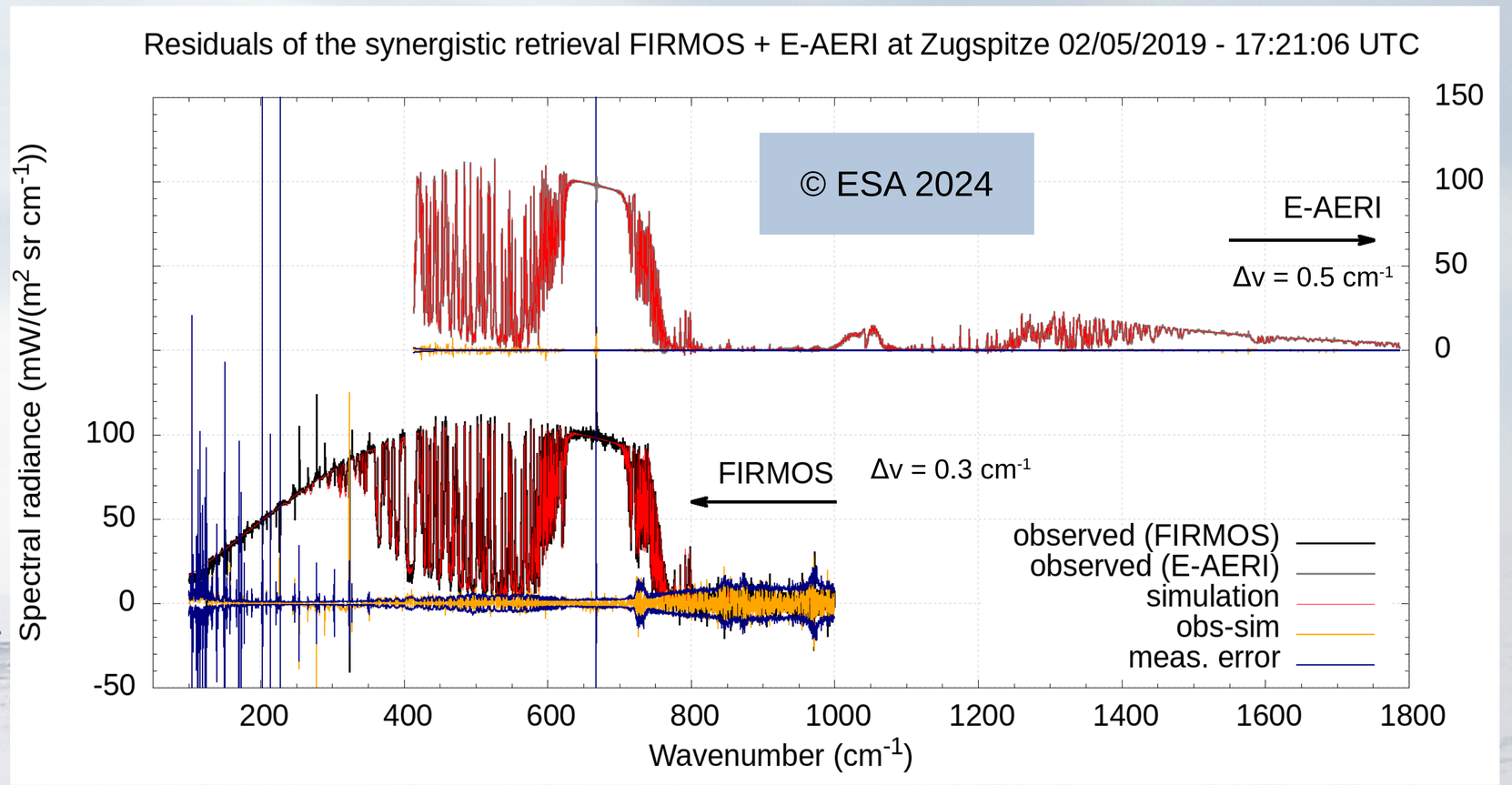
Slant views are supported, so far limb views are not supported.

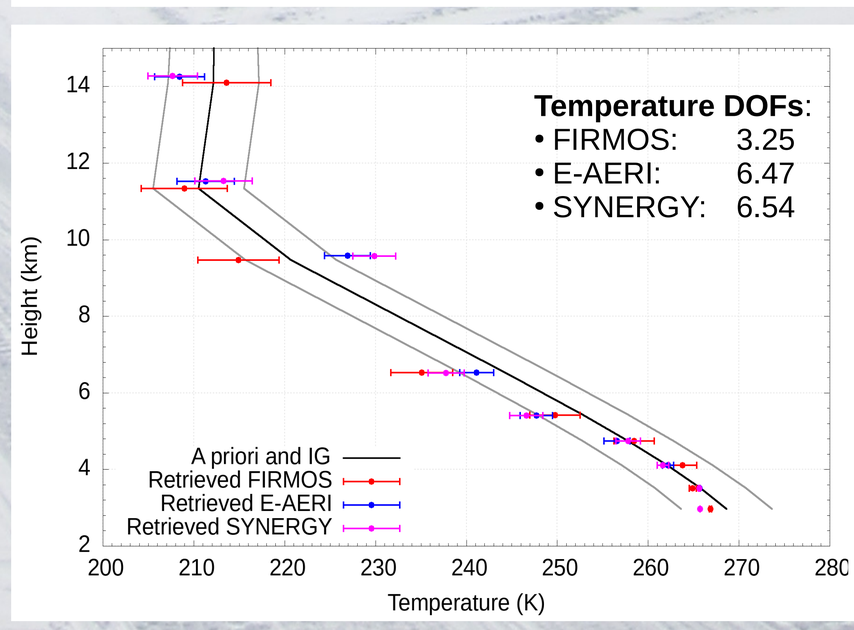
EXAMPLE OF APPLICATION

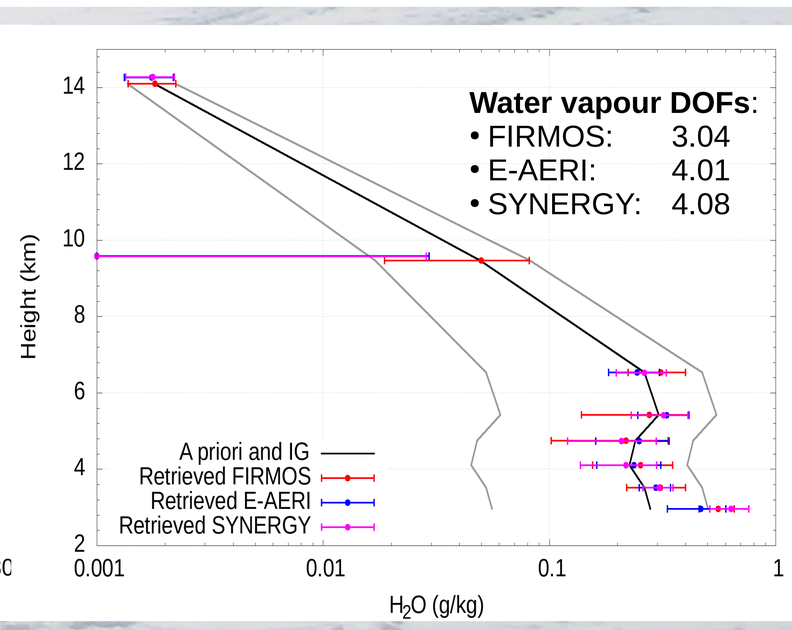
- Measurements from the Zugspitze (2962m AMSL) campaign by the European Space Agency (ESA), Jan – Feb 2019.
- FIRMOS (Far-InfraRed Mobile Observatory) and E-AERI (Extended-range Atmospheric Emitted Range Interferometer) measured simultaneously the downwelling spectral radiance.

FARM inversion in a clear-sky case

T and H_2O retrieval







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[1] FORUM web site: https://www.forum-ee9.eu/

[2] CAIRT web site: https://www.cairt.eu/

[3] Masiello G. et al., The new σ-IASI code for all sky radiative transfer calculations in the spectral range 10 to 2760 cm^{-1}: σ-IASI/F2N, J. of Quant. Spect.and Radiative Transfer, 312, 108814, 2024. https://doi.org/10.1016/j.jqsrt.2023.108814

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