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Potential Advantages Coming from the Synergy Between Products by Limb and Nadir Imaging Fourier Transform Spectrometers: 2D Data Fusion of CAIRT, IASI-NG (and Sentinel 5) Simulated Data

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Abstract: We study potential advantages coming from the exploitation of the synergy between limb and nadir measurements from Imaging Fourier Transform Spectrometers with the rigorous approach of the two-dimensional complete data fusion.

1. Introduction

An accurate knowledge of trace gas composition around the tropopause is particularly important to reduce significant uncertainties in projected future warming: changes in the surface air pollution and in the stratosphere-troposphere exchange may significantly affect it. Moreover quantifying the influence of stratospheric transport on near-surface tropospheric composition is important since it conditions attempts to derive emission fluxes from surface observations for important greenhouse gases.

The Changing-Atmosphere Infra-Red Tomography Explorer (CAIRT) is one of the four candidates for ESA's Earth Explorer 11, aimed to study the coupling between atmospheric composition, circulation and climate. By exploiting its imaging capabilities, CAIRT indeed can sound the atmosphere simultaneously from the middle troposphere to the lower thermosphere at 0.2 cm^{-1} spectral resolution and with horizontal sampling of 50 km along track, 50 km across track and vertical sampling of 1 km. Flying in loose formation with MetOp-SG mission allows to combine spatially resolved limb observations with horizontally resolved nadir measurements of IASI-NG and Sentinel-5 nadir spectrometers to extend limb observations down to the surface.

2. Main results

We evaluated advantages coming from the exploitation of the synergy between realistic simulations of CAIRT, IASI-NG and Sentinel 5 observations applying the rigorous approach of the complete data fusion [1] to the two-dimensional analysis, i.e. performed as a function of altitude and latitude (on satellite along track direction). Figure 1 reports the total error profile (left plot) and the diagonal elements of the Averaging Kernel matrix (right plot) of Ozone for all individuals measurements (CAIRT, IASI-NG, S5) and their combinations (CAIRT + IASI-NG, CAIRT + IASI-NG + S5). The total error includes both noise error and smoothing error. The McPeters and Labow [2] climatology was used for the a priori. The synergistic products demonstrate a better quality in sounding both the troposphere and the Lower Stratosphere region in terms of both spatial resolution and total error.

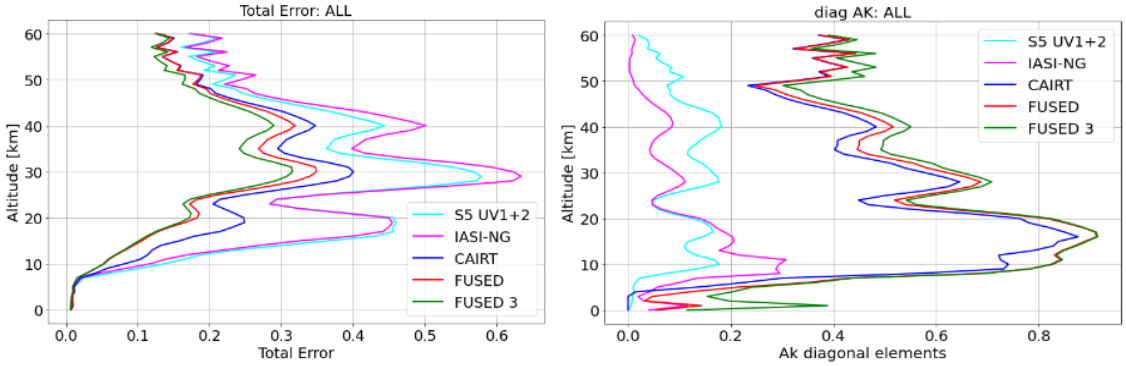

Fig. 1. Total error and diagonal elements of Averaging Kernel matrix for an Ozone profile retrieved on a grid of 1 km in the vertical direction and 50 km in the along-track direction assuming no binning in the across-track direction. The red curve, indicated as 'fused' in the legend, represents the combination of CAIRT and IASI-NG, the green one, indicated as 'fused 3', represents the combination of the three measurements CAIRT, IASI-NG and S5.

The synergistic products are characterised on one hand by a better quality in the troposphere than the one of nadir only measurements, thanks to the knowledge brought by limb measurement on the vertically resolved stratosphere, on the other hand also by a better quality in the Upper Troposphere - Lower Stratosphere than the one of limb observations only, thanks to the knowledge brought by nadir measurements on the horizontal variability of the atmosphere in the troposphere. This result is peculiar of the two dimensional analysis which is possible with limb and nadir measurements characterized by a high spatial resolution. When single profiles are combined (see results obtained with MIPAS and IASI real measurements [3], the combination gives an improvement in the lower troposphere only.

3. References

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