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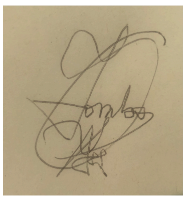
Dear Editor,

Attached herewith, please find the revised version of our manuscript entitled ”Ground-based MAX-DOAS observations of NO_2 and H_2CO at Kinshasa and comparisons with TROPOMI observations”. On behalf of all my co-authors, we wish to thank the reviewers for their invaluable feedback, which has greatly helped to improve the revised version of our manuscript.

In response to the reviewers’ comments, we have undertaken substantial revisions to the manuscript. We have introduced a significant modification pertaining to the H_2CO product, which is described in the subsequent pages. This change leads to more robust retrievals, in particular during the dry season, and to a better correspondence with TROPOMI observations. We have meticulously incorporated the reviewers’ criticism and suggestions, which have enriched our analysis.

Should further elucidation or clarification be required, we remain available to provide additional information. We hope that the revised version of our manuscript will be accepted for publication in your journal.

Yours sincerely,



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Explanatory Letter for H_2CO Product Change

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1 Problem overview

Checking on the quality of the H_2CO fitting results, we noticed that fitting residuals systematically degraded for low elevation angles. This problem was prominently observed in the UV spectral range where H_2CO is retrieved, but was essentially absent in the visible part of the spectrum used for NO_2 retrieval. The Figure 1 below, panel (a) illustrates the observed dependency. After further inspection, we noticed that the increased residual structure was systematic in nature (i.e. always of the same shape) which points to an instrumental issue. The exact reason for it could not be identified, but it might be related to an angular dependence of the spectral reflectivity of the mirror used to collect the sky light on the fiber optic (possibly connected to polarization effects). In any case we attempted to design an empirical correction to reduce the impact of these spectral features on H_2CO and O_4 retrievals. The approach adopted is described below

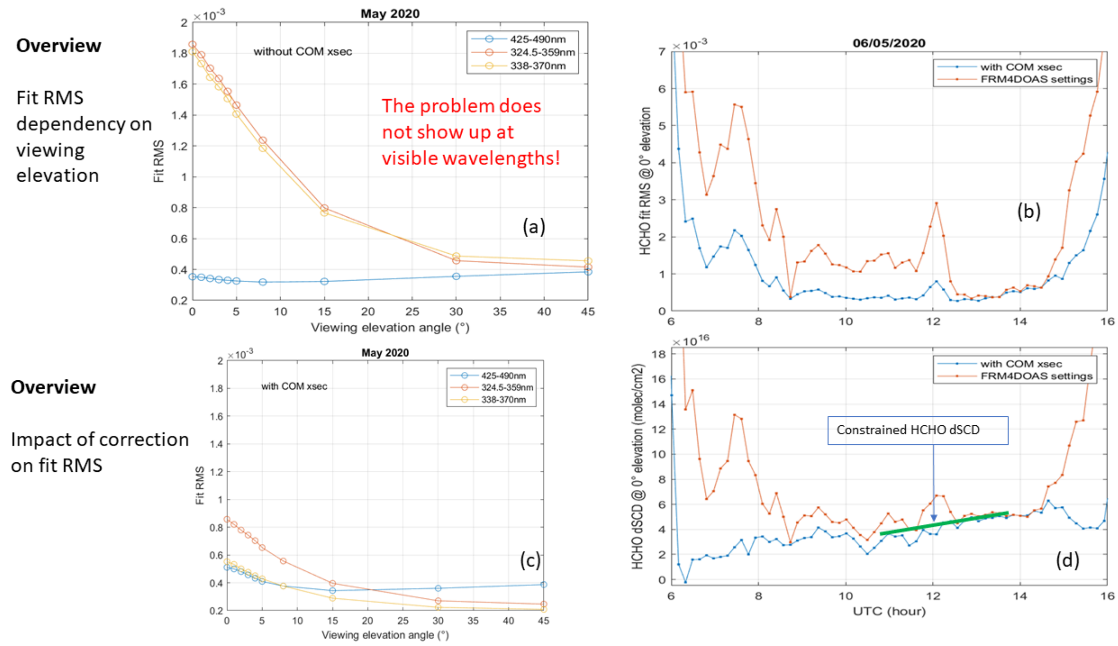

Figure 1: Eliminating H_2CO contamination in COM Cross-section.

2 Empirical correction

The idea of the correction is to introduce an additional vector in the DOAS fit, that effectively accounts for the systematic spectral features. This new effective cross-section was empirically constructed from measured residuals (see Figure 2) on a day showing a large variability in the effect (see Figure 1, panel b). To minimize the risk of introducing a systematic bias on the retrieved H_2CO, we constrained the H_2CO differential slant column (dSCD) in the DOAS fit applied to construct the COM residual cross-section using values extracted from surrounding measurements less affected by the artefact (see Figure 1 panels c and d). The resulting COM cross-section was then introduced in the fit for all other measurements resulting in (1) a large improvement of the fit residuals (see Figure 1, panel b), (2) a much smoother diurnal variation of the H_2CO dSCD (see Figure 1 panel d), and (3) the elimination of the correlation between H_2CO dSCDs and fit residuals (see Figure 2, panels c and d). The same procedure was applied in the spectral range used for O_4 retrieval. The impact of the correction on retrieved H_2CO and O_4 dSCDs is illustrated in Figure 4 and Figure 3. The use of these corrected dSCDs in the profiling algorithm MMF resulted in a significant improvement of the stability of the inversion (i.e. the number of rejected profiles was largely reduced), which further validates the approach.

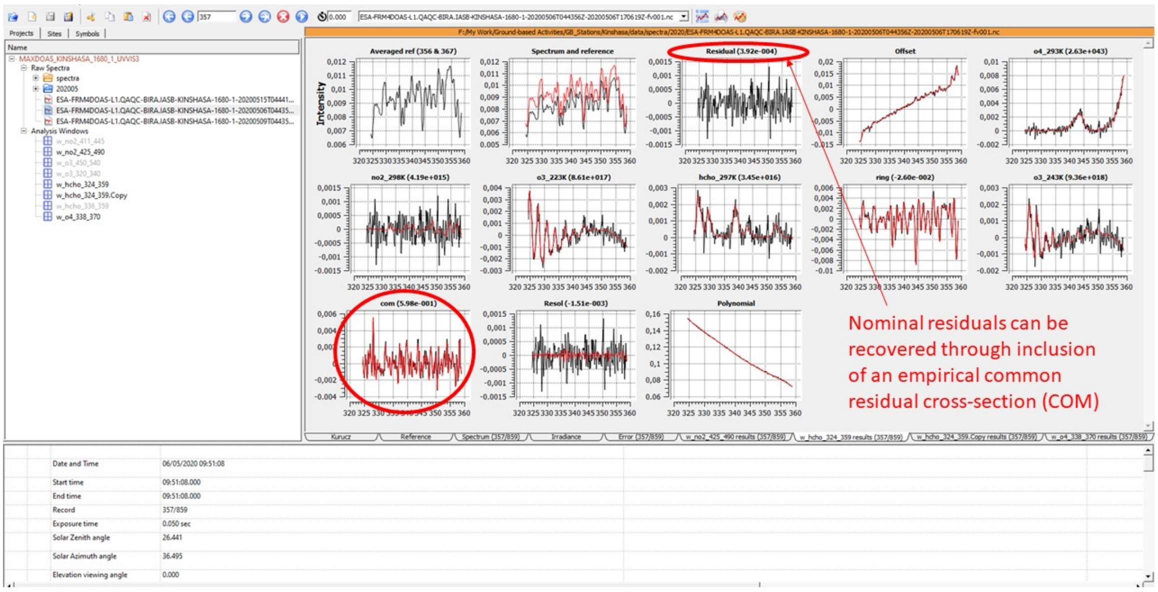

Figure 2: Recovery of Nominal Residuals via empirical Inclusion of a Common Residual Cross-section (COM).

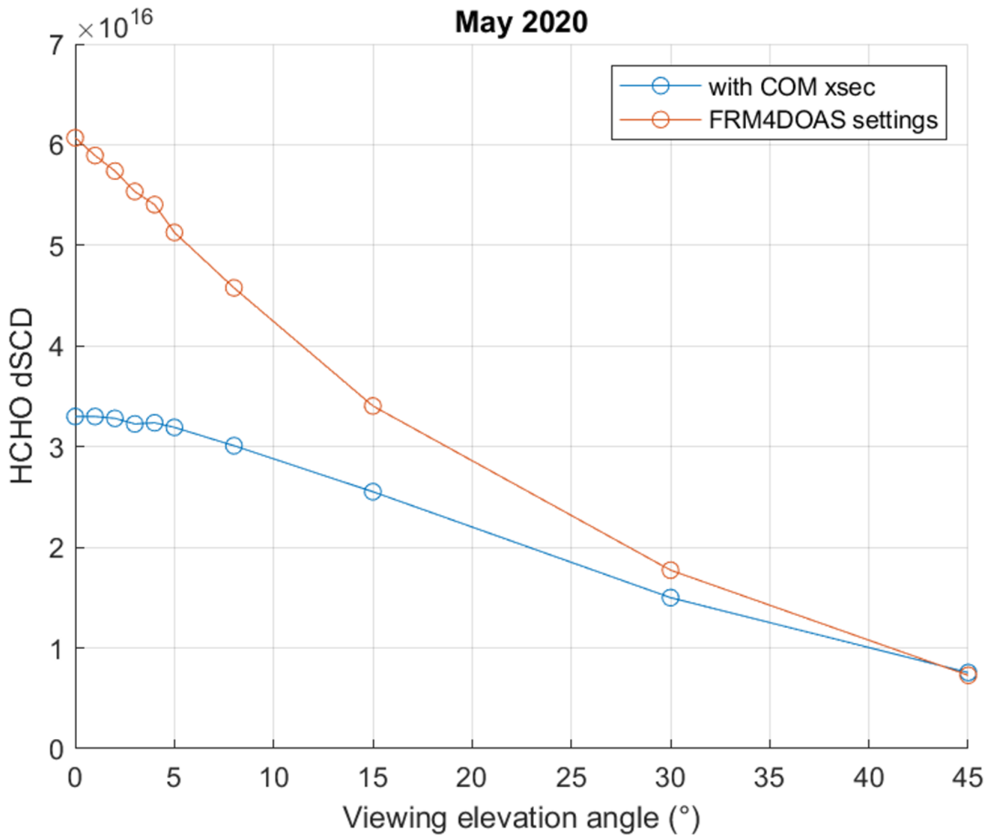

Figure 3: Impact of correction on H_2CO dSCDs. dSCDs reduced by approx. 45% at lowest elevation angles.

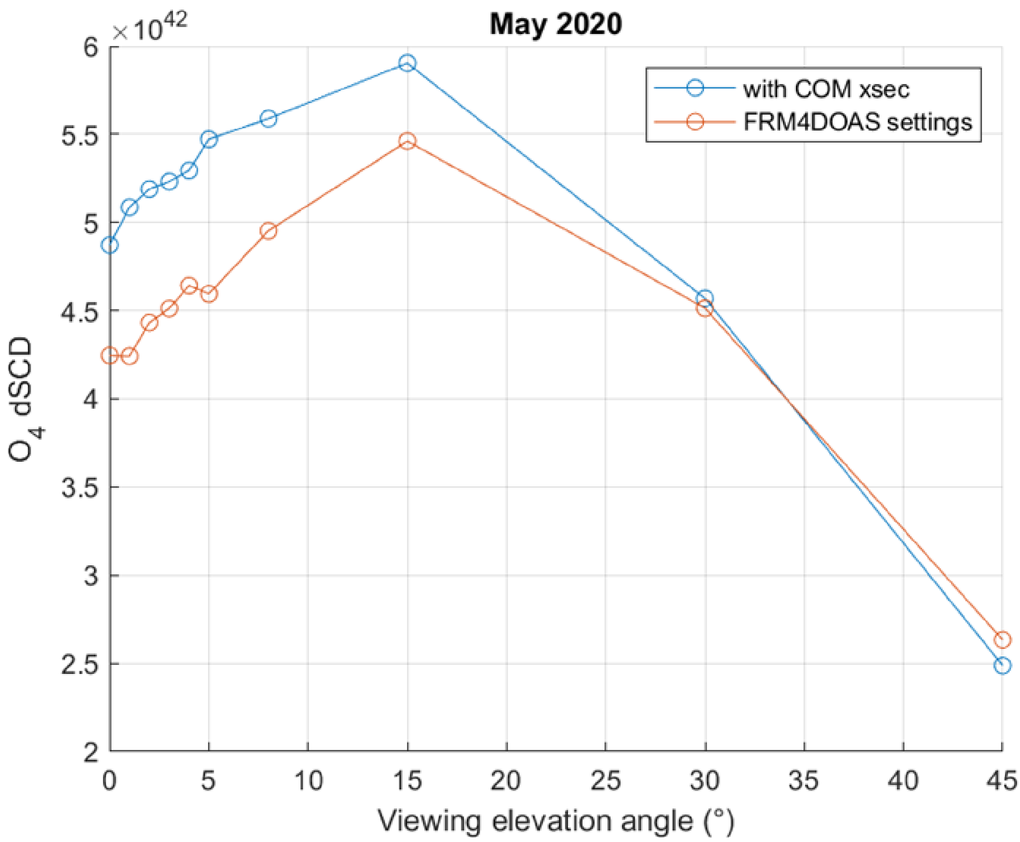

Figure 4: Impact of correction on O_4 dSCDs. Effect opposite to H_2CO, and of reduced amplitude (approx. 20% at lowest elevations)