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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Quantifying burning efficiency in Megacities using NO_2 / CO ratio from the Tropospheric Monitoring Instrument (TROPOMI)" *by* Srijana Lama et al.

Anonymous Referee #1

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General Comments

This manuscript presents a novel application of satellite measurements of CO and NO2 to estimate regional-average burning efficiency for a number of large cities. The method is enabled by the capabilities of a relatively new satellite sensor and will likely interest many readers of ACP. With one major exception, the presented methods seem sound and the paper is generally well written. The following issues should be addressed before publication of this manuscript in ACP.

The one significant problem with the manuscript is the discussion of how the differing vertical sensitivities (column averaging kernels) of TROPOMI CO and NO2 retrievals

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Discussion paper

are handled. To quantify the impact of this effect on Delta(XNO2)/Delta(XCO) ratios, the authors introduce the variable A_influence in Eq. 6. It is unclear how this factor was derived or how it is calculated in practice; no derivation appears either in the main text or Appendices. Presumably, it somehow depends on the TROPOMI CO and NO2 averaging kernels, but these dependences are not presented. There is a paragraph on the effects of the differing averaging kernels at the bottom of p. 11 (lines 282-290), but this paragraph only adds to the confusion since nowhere does it actually refer to the variable A_influence.

In the same paragraph, the authors report that "The CAMS simulated city enhancements averaged over June to August, 2018 did not compare well with TROPOMI for CO, possibly due to the coarse resolution of CAMS. Therefore, to calculate the averaging kernel impact, a few days were selected when CAMs CO and NO2 enhancements did compare relatively well with TROPOMI." This gives the impression that the authors' method of analyzing the effects of the averaging kernel differences for CO and NO2 was based on a small number of 'cherry-picked' cases where the higher resolution of TROPOMI (compared to CAMS) was not an issue. Thus, it appears that the authors are probably underestimating the uncertainty of the averaging kernel-related error. I believe this entire issue requires more discussion and perhaps more analysis.

Specific Comments

1. The actual lifetimes of CO and NO2 should be discussed somewhere, perhaps in the paragraph that begins on p. 3, l. 75.

2. p. 4, l. 103. Rodgers (2000) does not specifically discuss this type of retrieval algorithm and is not really an appropriate reference. Mathematically, averaging kernels play a different role in optimal estimation-based methods (as described by Rodgers) and Tikhonov regularization.

3. The chosen QA threshold values (0.75 for NO2 and 0.7 for CO) would seem to allow low-clouds for CO retrievals but not for NO2 retrievals. Are scenes with clouds

excluded from this study because of the stricter QA threshold value for NO2? Clouds could have a significant impact on the TROPOMI CO column averaging kernels.

4. Conceptually, the Upwind Background and Plume Rotation methods seem to have much in common. The text in Sections 2.4.1 and 2.4.2 should somewhere discuss expected differences in the outcomes from these two methods. Are there any obvious pros and cons to each method?

5. For the Plume Rotation method, why use the first quartile upwind and fourth quartile downwind concentrations (instead of simple averages for upwind and downwind regions)?

Technical Corrections (partial list)

The numeral 2 should be subscripted in 'NO2' (in Abstract and elsewhere).

Throughout the paper, 'mega cities' and 'mega-cities' should be replaced by 'megacities.'

p. 2, l. 48. 'depends' should be 'depend'

p. 2, l. 55. 'in respect' should be 'with respect'

p. 2, l. 66. 'precursor' should be capitalized

p. 3, l. 76. 'source' should be 'sources'

p. 8, l. 229. 'over passes' should be 'overpasses'

p. 8, l., 232. 'life time' should be 'lifetime'

p. 9, l. 244. missing Delta symbols before XNO2 and XCO

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