

Interactive comment on “Towards constraints on fossil fuel emissions from total column carbon dioxide” by G. Keppel-Aleks et al.

Anonymous Referee #1

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This study investigates the fossil fuel signal in total column CO₂. A method is proposed for detection and quantification of regional scale fossil fuel signals. This is very relevant in the context of current and planned satellite missions for space borne CO₂ monitoring. The manuscript reads very smooth. The authors do a nice job explaining the factors that are of relevance and may influence the results in a way that might limit the observational constraints on fossil fuel. It is not clear, however, how these complications work out for the current analysis and whether what is derived from GOSAT has really anything to do with fossil fuel CO₂ in the end. In my opinion further efforts in this direction are needed as explained below.

GENERAL COMMENTS

It is mentioned in the introduction that for emission monitoring a regional rather than a
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city-scale approach as needed to allow bridging the scale gap from the city scale to the national scale. Although this sounds quite reasonable, it introduces a very important complication. At the city scale one can be confident that the CO₂ contrast is due to fossil fuel, on the regional scale, however, this is much less clear. For example, the influence of biosphere emissions is mentioned several times, but the potential role of it in the analysis of the GOSAT data remains unclear. Some information can be derived comparing Table 2 (XCO_{2,fossil}) with Table 3 (XCO₂). For China I calculate a fossil contribution of 50%, but whether this is a lucky or unlucky shot is unclear. I recommend adding these percentages in Table 3 to get a better feeling. With biosphere contributions as high as 50%, and other factors complicating the comparison in this table, the agreement between model and GOSAT on sub ppm levels is actually amazing (bottom right part of the table). Is it right?

It is concluded that fossil fuel leaves a discernable signature in total column CO₂. However, the question is what is needed for emission monitoring. This should obviously only be a small fraction of the signature itself. It quickly bring the accuracy requirements down to something like a tenth of a ppm, which seems out of reach given influences of the biosphere, sampling biases, aerosols, etc. In the end the reader is left with the question if the method that is proposed in this study is really viable. It would be instructive to have a table providing an approximate error budget of the various influences that play a role.

I am surprised by the sign of the clear sky bias as discussed on page 29896 and shown in figure 6. Why would the fossil fuel contrast be systematically low under cloud free conditions. The subsidence / low wind speed conditions in high pressure systems rather tend to build up pollution in source regions. This would rather lead to a high bias when considering clear sky only. A low bias reminds rather of the biosphere sequestering carbon under sunny conditions, or the variability that is correlated with potential temperature. I conclude that the clear-sky bias in the XCO₂ contrast has little to do with the clear-sky bias in XCO_{2,fossil} contrast. Besides this, a related bias seems

to have been overlooked, which comes from the fact that if the fossil signature is easier detected outside the growing season, this coincides with the season when fossil fuel emissions are usually higher than average because, for example, of domestic heating during winter.

Looking at the noise in Figure 3, I'm wondering how sensitive the average is to the westward extension of the source region. The numbers in the caption should mention also the uncertainty of Table 3. It is only in comparison with the significance of the mean that the partial sentence 'although the individual retrievals are quite variable' makes sense. Looking at Figure 3 I find it actually hard to believe that the uncertainties of the GOSAT derived mean contrasts are really so low. Looking at the zero uncertainties listed for Australia I don't even understand how they were derived. Else, what is missing is a comparison of the size of the inferred fossil fuel signatures with what has been published by others in the past (Kort et al, for example).

MINOR COMMENTS

29891, L13: 'where available' between comma's 29894, L11: 0.2 instead of 0-2
29896, L14: It is not clear why aerosol should reduce the contrast. At the surface albedo of urban centers it seems more likely that aerosols cause overestimation of retrieved XCO₂, which would increase the XCO₂ contrast. 29899, L3: The point about bias correction is well taken, but the evidence may be circular in the case of ACOS since it is based on transport models.

Table 1: Why not use degrees West for the US? Figure 6: 'Fraction' instead of 'Fracion'

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