

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

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We thank the reviewer for her/his careful reading of and suggestions for our manuscript. We respond point-by-point to the reviewer's comments below:

The manuscript “Towards constraints on fossil fuel emissions from total column carbon dioxide” from Keppel-Aleks et al. submitted for publication in ACP covers an interesting topic relevant for ACP, is well written and contains new material not published before. I therefore recommend publication after the items listed below have been carefully considered by the authors.

The authors missed to cite other relevant publications discussing total column carbon
C12884

dioxide observations to derive information on anthropogenic/fossil CO₂ emissions. This is a serious shortcoming of the manuscript. Among these publications are at least the following (see References): Schneising et al., 2008, discussed the use of real SCIAMACHY satellite data to obtain information on anthropogenic CO₂ emissions for central Europe. The potential of future satellites (focusing on finer scales than in this manuscript, primarily power plants) is discussed in Bovensmann et al., 2010, and Velazco et al., 2011. These and possibly other related publications need to be cited. This is a major comment. Please make sure that all relevant publications are cited. It is also recommended for the revised version to cite publications which appeared after submission of this manuscript, e.g., Schneising et al., 2012.

We have added citations to Bovensmann and Velazco to the introduction: “Recently, progress has been made in bottom-up monitoring for fossil fuel CO₂ emission attribution from point sources such as power plants (e.g., Bovensmann et al., 2010 and Velazco et al., 2011) and from urban areas (e.g., Turnbull et al., 2011 and Newman et al., 2012).”

Page 29892, line 9 following: The approach of selecting the north-south boundaries based on potential temperature is explained, but no assessment is presented on the impact of this approach on the quality of the results. Please provide an assessment of the impact of the assumptions made on the derived XCO₂ contrast presented later.

We have added text to the methods section to address the impact of defining north-south boundaries based on potential temperature on the results: “In AM2 simulations, the seasonal cycle in the biospheric contrast between source and upwind regions is reduced by up to 1 ppm when using averaging regions defined by potential temperature rather than fixed geographic coordinates, while the magnitude of the simulated fossil contrast is not affected.”

This supports text in the results section: “Although the regional biospheric contrast is minimized by the use of the semi-Lagrangian averaging regions, growing season

contrasts are of order 1 ppm for Europe and China, suggesting that the fossil fuel signal may be more clear in satellite data acquired outside the growing season."

Page 29893, line 7-9: Is "prediction" the right term or is "method" more appropriate?

We think that "prediction" is the right term, since the model is being used to simulate the XCO₂ contrasts given prescribed surface fluxes as boundary conditions and any error in these boundary conditions can impact the comparison between the simulations and the observations.

Page 29893, line 15 following: Is the same filtering as applied to GOSAT data also applied to the AM2 model data?

We present two results for the AM2 model data in table 3: data sampled only where/when GOSAT data were obtained, which implicitly filters the data, and data obtained everywhere within the defined averaging regions. We think it is informative to present both sets of results, as it illustrates the potential magnitude of the sampling bias induced by filtering some of the GOSAT data.

Page 29894, line 9 following: Discussion of Table 2 and content of table caption: Please add a more detailed explanation on Table 2. Is my understanding correct that the table shows, for example, the contrast between a European source region and an upwind region in India? If yes, does this really make sense? But maybe I misunderstood the table.

We have added additional text to the table caption to clarify what is being presented:

"X_{CO₂,fossil} contrast [ppm] calculated for six paired source-upwind regions (columns) during October – November resulting from emissions from tagged source regions

C12886

(rows) and from global emissions. We use dynamically adaptive emission and upwind regions to calculate the contrasts, except for India where we defined stationary averaging boxes. The regional contrast for each source-upwind pair is dominated by its own emissions."

Page 29898, line 28: The statement on geostationary observations seems to be quite optimistic and not justified by a reference. GEO observations of XCO₂ and XCH₄ at high spatial resolution in combination with high SNR will be much more challenging and there are clear limitations: likely compromises on the spatial resolution have to be made, the large amounts of "slant observation conditions" from GEO will likely yield larger systematic errors for XCO₂ and it will not be possible to get globally comparable data from one GEO satellite only. If the better temporal sampling will outperform the above deficiencies needs to be shown. Either remove or at least tone down the statement on GEO or include a reference where the advantages of GEO for the envisaged application are justified.

We have modified the discussion of geostationary data to simply state, "Both the sampling bias in AM2 (Table 3) and the cloud bias (Fig. 6) point toward footprint size as a key design factor in the utility of satellite observations for fossil fuel emissions monitoring at policy relevant accuracy. OCO-2 or CarbonSat, whose footprints are 40 and 20 times smaller than that of GOSAT, may be an easier data set from which to diagnose fossil emission trends as the likelihood of cloud-free scenes will be greater and the spatial coverage will therefore be more complete. Geostationary observations may also reduce the cloud bias by providing multiple retrievals of a given scene each day (Duren and Miller 2012)."

Page 29899, line 6 and following: Concerning future missions: The published CarbonSat (Bovensmann et al. 2010) and CarbonSat constellations concepts (Velazco et al., 2011) also aim at contributing to quantify fossil fuel contributions to the overall carbon

C12887

budget, with similar spatial resolution as OCO-2, but much improved spatial coverage (one order of magnitude better than OCO-2). This also needs to be mentioned and cited adequately in the conclusions section.

We regret omitting CarbonSat from future mission concepts, and have added it to the discussion section in two paragraphs:

“Both the sampling bias in AM2 (Table 3) and the cloud bias (Fig. 6) point toward footprint size as a key design factor in the utility of satellite observations for fossil fuel emissions monitoring at policy relevant accuracy. OCO-2 or CarbonSat, whose footprints are 40 and 20 times smaller than that of GOSAT, may be an easier data set from which to diagnose fossil emission trends as the likelihood of cloud-free scenes will be greater and the spatial coverage will therefore be more complete.”

“The launch of OCO-2 and other satellites will provide more, and potentially better, datasets with which to work. For example, OCO-2 requires single-sounding precision of 1 ppm (Miller et al., 2007; Wunch et al., 2011a), slightly better than the single-sounding precision of 1.0–1.5 ppm for ACOS-GOSAT data (O’Dell et al., 2012). Additionally, the upcoming CarbonSat will provide coincident methane retrievals that may elucidate the processes contributing to regional variations in X_{CO_2} (Bovensmann et al., 2010). ”

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C12888