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Interactive comment on "PMIF v1.0: an inversion system to estimate the potential of satellite observations to monitor fossil fuel CO_2 emissions over the globe" *by* Yilong Wang et al.

Anonymous Referee #2

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This study assesses the potential of satellite imagery of a future mission CO2M XCO_2 to constrain the emissions from cities and power plants over the whole globe for one year. To reduce the computational cost of the traditionally used 3-D full transport models, this study simplified the observation operator with a few idealized hypotheses: (a) a Gaussian plume model, no model errors, (b) no overlapping effects from nearby hotspots, (c) no impact of natural carbon cycle fluxes. It is useful to get a global-scale estimate for the potential of emission uncertainty reductions for the proposed mission – even though the results are not very positive in terms of CO_2 measurements' potential in constraining fossil fuel CO_2 emissions alone given those idealized setups.

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Discussion paper

General comments:

The authors highlight the global scope of this study, but no global distribution is shown. Fig. 6 shows information about US and China, why only these two regions? The global results are aggregated with emission density bins (Fig 2 - 5), which I assume is not the only determining factor. With simple statistics of median spread, a lot of information is lost. It does not really provide a "global" view. Fig. 1 highlighted the impacts of wind speed, which may create spatial patterns that overlay with emission density maps. Such information may reveal a better global overview.

Also, a posterior uncertainty of 20% has been used as a benchmark throughout the paper (given a 30% prior uncertainty). However, only a few cases/days can meet such a requirement. Thus, it may be more helpful to show what posterior uncertainty can be achieved for a given length of days across typical regions (e.g., using a 2-D matrix?)

A few technical points:

-L35: "more than 10 times within one year" is a low number. As stated above, if this is the case, is using 20% as the only threshold discussed in the paper a reasonable choice?

-L58-59: other studies worth mentioning, for instance:

Kort, E. A., Frankenberg, C., Miller, C. E. and Oda, T.: Space-based observations of megacity carbon dioxide, Geophys. Res. Lett., 39(17), n/a-n/a, doi:10.1029/2012GL052738, 2012.

Nassar, R., Hill, T. G., McLinden, C. A., Wunch, D., Jones, D. B. A. and Crisp, D.: Quantifying CO_2 Emissions From Individual Power Plants From Space, Geophys. Res. Lett., 44(19), 10,045-10,053, doi:10.1002/2017GL074702, 2017.

Schwandner, F. M., Gunson, M. R., Miller, C. E., Carn, S. A., Eldering, A., Krings, T., Verhulst, K. R., Schimel, D. S., Nguyen, H. M., Crisp, D., O'Dell, C. W., Osterman, G. B., Iraci, L. T. and Podolske, J. R.: Spaceborne detection of localized carbon dioxide

sources., Science, 358(6360), eaam5782, doi:10.1126/science.aam5782, 2017.

-L102: "for the first time" - It is important to talk about the bright side, however, it is equally important to define the underlying assumptions clearly. The discussion came later, but I believe a higher level of clarification here will be helpful.

-L105: How about observations near the edge of the swath? The resolution would change accordingly.

-L137: y_{fixed} is not explained.

-L144, 148: "In this study" is used quite a lot. Not all necessary.

-L152: not accounting for diffuse CO_2 fluxes is an important distinction. It is an important assumption that needs to be emphasized as the natural carbon cycle will have a strong imprint in many areas.

-L225: a simple description of the sigma parameter (e.g., what determines it) will help the reader without having to refer to Ars et al. (2017).

-L369: why not just use Fig. S3 for side by side comparison?

-L404: "N20". There are quite some acronyms already that need checking back and forth. Will improve the reading removing some that do not have intuitive meanings.

-L501: How about the optimized state? Curious how well will the Gaussian Plum model do if it assimilates the psuedo observations generated using the full 3-D models in this case. It will be a strong demonstration if it can get the emission order general variations right!

-L519: Quite a few studies explore the interfering effect of natural CO_2 fluxes.

Wu, K., Lauvaux, T., Davis, K. J., Deng, A., Lopez Coto, I., Gurney, K. R. and Patarasuk, R.: Joint inverse estimation of fossil fuel and biogenic CO2 fluxes in an urban environment: An observing system simulation experiment to assess the impact of mul-

tiple uncertainties, Elem Sci Anth, 6(1), 17, doi:10.1525/elementa.138, 2018.

Yin, Y., Bowman, K., Bloom, A., Worden, J.: Detection of fossil fuel emission trends in the presence of natural carbon cycle variability, Environmental Research Letter, 14(8):084050, doi:10.1088/1748- 9326/ab2dd7, 2019.

-L538: Again, I understand that 20% posterior uncertainty is a desirable goal, but it did not provide a full picture if the values for the high emission densities are only at the order of 10 days for a year. Other references will help define the landscape.

-Figure 3: the number of clamps is repeated in every plot from Fig. 3-5. Reductant to repeat so many times. Maybe indicate clearly that (a) and (b) are the same just for different experiments.

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