Interactive comment on “Multi-source SO_2 emissions retrievals and consistency of satellite and surface measurements with reported emissions” by Vitali Fioletov et al.

Anonymous Referee #1

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Comments on "Multi-source SO2 emissions retrievals and consistency of satellite and surface measurements with reported emissions" (acp-2017-485) by Fioletov et al.
This paper developed an algorithm to estimate multiple sources SO2 emissions from OMI SO2 VCD. The work is an extension of single SO2 source retrieval from the OMI satellite measurements by the same group. The identification of multiple SO2 emission sources from OMI retrievals has been a challenge. This study moved forward from single source retrieval and made an important contribution to the OMI data applications in a top-down approach to identify and verify the emission sources of criteria and precursor air pollutants. The paper is well-written and publishable in ACP

We would like to thank the reviewer for the evaluation and comments that helped us improve the manuscript.

I have only several minor questions and comments to the paper as outlined below.

1. pg.7, line 13-15. Does Gaussian point source model take into account atmospheric advection?

There is some confusion here. We did use a “pure” Gaussian point source model in our early work, but this study is based on a plume model that combines Gaussian and exponentially modified Gaussian functions as discussed in the Appendix. The latter is responsible for advection. We have added more information about the plume model to the main text.

2. pg. 7, line 17-18. "a well-developed quasi-steady planetary boundary layer", do you mean a neutral boundary-layer or Ekman layer?

We have not assumed any particular boundary-layer type. Depending upon geographic location and time of year, the local boundary layer could be unstable, neutral, or stable. But because the satellite overpass time is close to midday, we do assume that the boundary layer will have adjusted during the morning to any solar heating that occurred.

3. pg. 8. line 23. "This grid-based approach can be potentially used for area sources...", Gaussian point source model differs from the area source model. If SO2 emissions derived from Gaussian model, it might not be appropriate to apply Gaussian point source model (Eq. A1) in an area source problem

We assumed that an area source is a grid of emitting point sources, not just a single point source. Note that our model was developed for plumes as they are seen by the satellite instruments with relatively low spatial resolution.

4. pg 15, line 21, SO2 mass
is expressed as 'alpha' after the first equal sign and becomes 'a' after the 2nd equal sign

Corrected

5. pg 15, line 11-12, ' if the wind speed is zero, the distribution of SO2 near the source is governed by diffusion...'. Diffusion should also depend on the wind and be parameterized by wind. So diffusion should be zero if the wind speed is zero.

Molecular diffusion is always present at any wind speed, and the atmospheric turbulence driving turbulent diffusion can be generated both by mechanical processes and by convective heating, for which the near-midday satellite overpass time is favorable. Moreover, there is always some random error in the wind speed in direction that would also affect SO_2 distribution near the source. We changed the text to "…by diffusion or, more generally, random fluctuations..."

6. pg 18.,
line 9. " Polynomials up to the 6th degree were used for each one-year or one-season fit". Why use the 6th Legendre polynomial? What is difference of retrieved emissions between, say, 6th and 2nd polynomials

The problem is that we see some artificially biased SO_2 values over some regions. If the area is small, say a few hundred km by a few hundred km, we can simply assume a constant bias. However, for large areas, this assumption does not work and we instead add a function that changes relatively slow with latitude and longitude. The required polynomial degree depends on the area size and the gradients of that slowly changing bias.

This issue was discussed in the Supplement (Section S2):

"The correlation coefficient between OMI data with bias removed and VCDs calculated from the emission data is 0.75 for the actual OMI data, and 0.80, 0.83, 0.87, 0.89, 0.90, 0.909 for the bias removed by the 1st, 2d, 3d, 4th, 5th, and 6th degree polynomials respectively. The correlation noticeably improved if the polynomial bias removed, but the improvement is only marginal for the degrees above 3."

We have added three more figures to the supplement. They show the estimated bias for different polynomial degrees, the fitting results and the emission estimates for 2nd, 4th, and 6th polynomials. See also our response to the first comment from Reviewer #2.