Anonymous Referee #1

This manuscript developed a new global SO_2 emission inventory by integration of bottom-up inventory and satellite observations. Satellite-based observations have been widely used in providing top-down constraints on surface emissions; however, top-down inventories are difficult to be used in due to lack of bottom-up information such as sectoral contribution. This work developed a harmonization approach that integrated OMI-inferred emission information into HTAP global emission inventory, and the new inventory has been proved to improve the model agreement with observations. The new method developed from this work has large potential in improving and timely updating bottom-up inventories. This is a very timely work for the emission inventory community. It's novel, and relevant to ACP readership. This manuscript is clearly structured and generally well written. It could be published in ACP after addressing the following minor issues.

Response: We thank Referee #1 for the encouraging comments. All comments and suggestions have been considered carefully and well addressed below.

1. A direct comparison (scatter plots) between OMI-based estimates and bottom-up inventory should be provided over the locations where OMI estimates are available.

Response: We thank you for the suggestions. We have added the illustration for differences between OMI-based estimates and bottom-up inventory in Figure 2b. We have also added a scatter plot (Figure S1) comparing the satellite-derived and the HTAP emissions estimates for year 2010 in the supplement.

2. Uncertainties of OMI-based estimates should be discussed comprehensively and compared with bottom-up inventories.

Response: We thank you for the suggestions. We have added the discussion about uncertainties of OMI-based emissions estimates and compared it with bottom-up inventories in Section 2.3, as follows:

"Uncertainties in the OMI-based estimates may contribute to the differences. These uncertainties can be grouped into three categories: in the retrieval of the OMI SO_2 vertical column density (VCD); those that come from the fit of the OMI-detected SO_2 downwind plume; and those related to the wind information. The overall uncertainty in annual emissions is estimated to be around 50% (Fioletov et al., 2016), with the primary contributors of the air mass factor

calculation when determining VCD (27%) and the wind height (20%). On the other hand, uncertainties inherent in the total magnitude of bottom-up emissions may also contribute to the differences such as when bottom-up emissions are not routinely updated. The uncertainties of emissions from the industry sector are estimated to range from 15% to 70% over countries depending on how well the statistical infrastructure is maintained by individual countries (Janssens-Maenhout et al., 2015 and references in there). In addition, the uncertainties of spatial distribution may cause the differences. In fact, emissions from some emitting sectors in bottom-up inventories are not tracked with individual point sources but spread out over larger areas instead. The country-specific emissions in HTAP are allocated where possible to the locations of point sources (e.g. public electricity plants), but a large fraction (e.g. some smelters of which the location are not available) remains distributed over the countries with spatial proxies (e.g., urban population) of which the representativeness is only qualitatively known."

3. It would be nice if the authors could provide some insights of using this approach for other pollutants such as NO_x.

Response: We thank you for the suggestions. We have added the discussion about the insights of the approach in conclusion, as follows:

"Finally, the merging inventory methodology proposed in this study is potentially applicable for other air pollutants. It has good potential for application to NO_x, as NO_x emissions from power plants and cities can be quantified by similar CTM-independent approaches as well [Beirle et al., 2011; Liu et al., 2016]. However, merging satellite-derived urban NO_x estimates with bottom-up inventories is more challenging than point source emissions. Urban emissions are distributed over a larger number of sectors, including large contributions from areal sources such as road transport. An alternative method needs to be explored to reconcile bottom-up and top-down satellite-derived urban emissions."