Response to comments on "A global map of emission clumps for future monitoring of fossil fuel CO_2 emissions from space" by Y. Wang et al.

We thank the referee for reviewing our manuscript. Please find attached a point-by point reply to each of the comments raised by the referee with legible text and figures organized along the text. Please find below the point-to-point responses (in black) to all referee comments (in blue). For your convenience, changes in the revised manuscript are highlighted with dark red. All the pages and line numbers correspond to the original version of text.

This paper presents an algorithm for generating distributions of CO2 emission hotspots based on a high-resolution proxy. It applies this algorithm to generate such a distribution for 2016. It assesses the sensitivity of the distribution to parameters in the algorithm.
The paper is probably in scope for ESSD. My only concern is that it adds value to an existing data product rather than generating significant new data itself. Its main contribution is likely to be the clumping algorithm it uses and I urge the authors to make the algorithm as well as the data available. The paper is also clearly written and presented.

Response:

We would like to thank the referee for the valuable comments and suggestions for improving our manuscript.

Indeed, the algorithm presented in this paper is one of the major assets of this paper. The algorithm can be applied to other high-resolution emission maps (Sect. 3.2). Apart from the algorithm itself, Sect. 3.2 showed some consistencies between the results derived from ODIAC and those based on other emission maps. Given such consistencies algorithm, the complexity and the value of the algorithm, we think that this paper is in scope for ESSD: "Articles on methods describe nontrivial statistical and other methods employed (e.g. to filter, normalize, or convert raw data to primary published data) as well as nontrivial instrumentation or operational methods." (https://www.earth-system-science-data.net/about/aims_and_scope.html).

We have published the dataset at https://doi.org/10.6084/m9.figshare.7217726.v1. And we provide the code in the supporting information.

I believe the paper makes a significant contribution. My main concern is some unexamined assumptions. Most crucially the underlying data set is not a true map of emissions but of emission proxies, mainly nighttime lights plus off-line estimates of emissions from power-stations. The spatial distribution of the proxy might well differ systematically from that of real emissions. In particular, there is a good chance that onroad emissions have greater spatial extent around emission cores than nighttime lights and may serve to amalgamate proximal clumps. This is testable now since the recent VULCAN product is available at the same resolution and includes these emissions. I recommend running the algorithm over VULCAN and ODIAC within the contiguous U.S. for the same year and comparing results.

Response:

We appreciate that the reviewer confirm the contribution of this study to the community.

The suggestion by the reviewer is indeed an important one. We are aware that we can't assume an emission field from a single emission dataset as perfect. As pointed out by the reviewer, ODIAC might miss some of the on-road emissions in the emission distribution due to the use of nightlight emission proxy. Following the reviewer's suggestion, we run the algorithm over the new version of the VULCAN emission data product (VULCANv3.0) provided by Prof. Gurney, one of the co-authors of this manuscript, and compare the results with the one based on ODIAC. The VULCANv3.0 use detailed primary data sets across the US. In the new version of VULCAN, they are in principal the same collection of datasets as described in Gurney et al. (2009), but with improvements in the data quality. The VULCANv3.0 also improves the spatial and temporal resolution compared to VULCANv2.2 (Gurney et al., 2009).

Fig. R1 shows the clump results based on ODIAC (a-f) and VULCANv3.0 (g-l) in the vicinity of three mega cities in US. The emission field in ODIAC are much smoother than that in VULCANv3.0. In VULCANv3.0, there are a large amount of small clumps around the large cities. Some of these small clumps correspond to the on-road emissions (e.g. long and narrow lines), and some correspond to small cities. For the on-road emissions, the algorithm sometimes split the road into several segments (e.g. the Pacific Coast Highway, Fig. R1h). In total, the ODIAC clumps covers 58% of the emissions in VULCANv3.0, while the emissions from on-road transportation and small cities that are missed by ODIAC clumps account for 27% of the total emissions in VULCANv3.0. This result is similar to that discussed in the manuscript Sect. 3.2, indicating some consistencies between the clump results derived from different emission products.

We would like to note that VULCANv3.0 is not yet publicly available, and that ESSD does not recommend to include such data (see Carlson and Oda, 2018 ESSD). Following the recommendation by the editor, we have not included this comparison in the manuscript. However, we discuss the limitation of the single use of the ODIAC product, which used nighttime light as a proxy for emissions in Sect. 4.2.

"**4.2 Impact of using ODIAC on the identification of emission clumps**

ODIAC used nighttime light as a proxy for the spatial distribution of emissions. The accuracy of the proxy in representing the distribution of actual emissions largely impacts the extent of the clumps. For example, compared with other emission products, ODIAC does not capture line source emissions such as on-road transportation (Oda et al., 2018; Gurney et al., 2019). The satellite observations of CO indicated significant CO enhancement over major roads (Borsdorff et al., 2019). Since our clump map is derived from ODIAC emission product, some of the roads that generate significant XCO_2 plumes may be missed by the clumps defined in this study. As the ODIAC team is planning to include transportation network data in their emission product (Oda et al., 2018), our clump map could be updated with a new version of ODIAC,

~~The emission clumps is a valuable concept relevant for the monitoring of fossil fuel CO_2 emissions from satellites.~~ Fig. 8 shows that… "

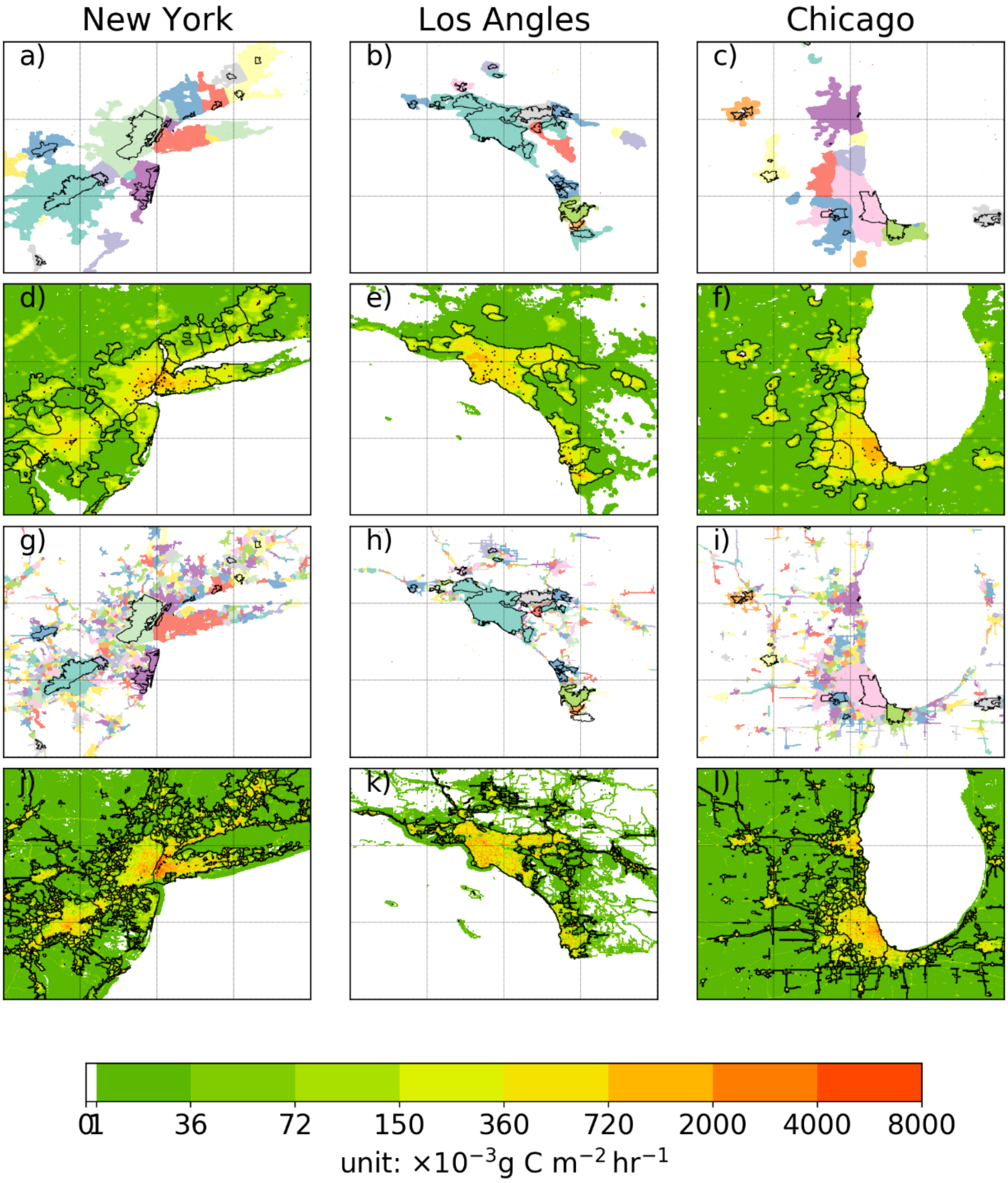

Figure R1 Emission clumps near New York (a, d, g and j), Los Angles (b, e, h and k) and Chicago (c, f, i and l) based on ODIAC product (a-f) and VULCANv3.0 (g-l). In a-c and g-i, solid lines depict the urban areas from ESRI product. Colored patches depict the clump area. In d-f and j-l, solid lines depict the boundaries of final clumps (boundary of colored patches in a-c and g-i). Colored fields in d-f show the emissions from ODIAC product. Colored fields in j-l show the emissions from VULCANv3.0. Light dashed lines indicate 1 °×1 °grids.

Some specific comments

1) L140 I did not think the DMSP lights were available for 2016 but that ODIAC had switched to VIIRS.

Response:

The ODIAC model employs the DMSP radiance calibrated nighttime light products (https://www.ngdc.noaa.gov/eog/dmsp/download_radcal.html) for estimating emission spatial distributions of non-point emissions (see Oda et al. 2018). As the reviewer pointed out, the DMPS data are not available for the year 2016 (the latest radiance calibrated data is for year 2010). The current ODIAC model uses the 2010 DMSP nighttime light product for the period 2010-2017. As mentioned in Oda et al. (2018), the research team plans to use the VIIRS nightlight for future versions of the ODIAC emission product development. But the version of the ODIAC data product used in this study (ODIAC2017) is still based on the DMSP nighttime light data.

2) L240 Probably there is no need to mention the python version though pointing out the package used is good. Note my firm suggestion above that the algorithm be made available.

Response:

To maintain the traceability and reproducibility, we provide all the computer codes that is used to produce the emission clumps presented in this study, with detailed comments.

References:

Carlson, D. and Oda, T.: Editorial: Data publication – ESSD goals, practices and recommendations, Earth System Science Data, 10(4), 2275–2278, doi:https://doi.org/10.5194/essd-10-2275-2018, 2018.

Gurney, K. R., Mendoza, D. L., Zhou, Y., Fischer, M. L., Miller, C. C., Geethakumar, S. and Can, S. de la R. du: High Resolution Fossil Fuel Combustion CO2 Emission Fluxes for the United States, Environmental Science & Technology, 43(14), 5535–5541, 2009.