Earth Syst. Sci. Data Discuss.,
https://doi.org/10.5194/essd-2018-31-AC2, 2018

Interactive comment on "Gridded Emissions of Air Pollutants for the period 1970–2012 within EDGAR v4.3.2" *by* Monica Crippa et al.

Monica Crippa et al.

monica.crippa@jrc.ec.europa.eu

Received and published: 7 August 2018

The authors are grateful for the comments of Reviewer 2, which helped to improve the manuscript. We report below the answers point by point to the Reviewer's comments.

This manuscript presents updated gridded emissions of air pollutants from anthropogenic sources for the period of 1970 to 2012. This does not cover the emissions of GHGs, which is a separate publication. These emissions data are presented not only in the form of time series but also in the form of per capita and per GDP emissions. They also give high emitting areas over time and space known as hot spots at 0.1x0.1 grid cell level. The present version v4.3.2 is extended till 2012 and also has some updated information activity data and emission factors. This is a very good effort

and is essential for modelling work in this field. It is very well written article. I suggest that it may be approved for publication after the following comments/suggestions are taken care.

Major comments:

1. The emissions are calculated using emission factors mostly based on tests carried out possibly in US and Europe. What is the uncertainty of these emission factors for the Asian, African and south/central American regions? In particular a variety of fuels are used for cooking purpose in the developing countries (SE Asia, Africa, Central America etc). How these are taken care? Since these regions are contributing significantly to these emissions globally, such a question becomes important. The authors may clarify this aspect. We are grateful to the Reviewer for pointing out this very important aspect. While EF's were indeed determined mostly in North America and Europe, they pertain to a range of technologies. Emissions in developing countries are often higher than in industrialized countries, because the technologies they use now days were common in North America and Europe until some decades ago. The main uncertainty therefore is to know which technologies are used in developing countries, and to what extent older technologies are replaced by newer ones. In some cases, also installed equipment may not be properly operating or might be defective, which may also lead to higher emissions. In this study no uncertainty analysis evaluating the non-representativeness of emission factors from one region to another has been performed.

We added the following paragraph to address this issue in the manuscript:

"While EF's were indeed determined mostly in North America and Europe, they pertain to a range of technologies. Emissions in developing countries are often higher than in industrialized countries, because the technologies they use now days were common in North America and Europe until some decades ago. The main uncertainty therefore is to know which technologies are used in developing countries, and to what extent older technologies are replaced by newer ones. In some cases, also installed equipment may not be properly operating or might be defective, which may also lead to higher emissions. In this study no uncertainty analysis evaluating the non-representativeness of emission factors from one region to another has been performed. The emission factors used in EDGAR are mainly based on the EMEP/EEA (2013) guidebook and partly on the latest available scientific knowledge (EMEP/EEA (2016) guidebook). When information on EFs is missing or very uncertain (e.g. for African countries), default emission factors are considered to keep the consistency and comparability of the emissions among countries. For Latin America, a specific study has been performed to include region specific EFs for the road transport sector based on the work of D'Angiola et al. (2010) and Schifter et al. (2005). Such emission factors have been also applied in countries with emerging economy. More details on the road transport sector can be found in Crippa et al. (2016, b)."

2. There are various emission inventories available now, which are used in various chemical-transport models. Some of these are compared in Fig. 5a and 5b. There may be some feedback from these models based on the comparison with the observations. Do these updates in the calculation of the emissions take care of such comparison with observations?

The Reviewer correctly mentions the possibility of updating emission inventories using results from inverse modeling. Generally, in EDGAR a conservative approach is taken in using such information, as a mismatch of observed concentrations, and resulting 'updated' inverse modeling derived emissions may often be attributed to multiple sources of uncertainties in emissions, model and observations. If not based on solid and well-evaluated information, we risk correcting EDGAR emission data with incorrect or inconsistent information, and in general we prefer to present our best available information on activity data and EFs without correction. However, improvements using inverse modeling results of CH4, CO, NOx and SO2 have been done with EDGARv4.2 and with HTAPv2.2. The corrections are indeed difficult to allocate to a given source, but it is possible for point sources and shipping routes (e.g. NOx case of Ding et al.,

2017; SO2 case of Liu et al., 2018). In the case of CO (Hooghiemstra et al., 2011) no conclusion could be taken: both the emissions of v4.2 were the same factor 2 too low as those of GFED for the biomass burning. The improvement of the CH4 (location and emission factor) has been extensively discussed in the v4.3.2 GHG paper. Therefore, the updates implemented in the current version of the EDGAR air pollutant emission database (v4.3.2) do not include feedback coming from inverse modeling. Conversely, CH4 emission factors and locations of EDGARv4.3.2 have been improved based on the output of inverse modeling results, which for instance have consistently be indicating lower emissions from coal mining than was assumed in EDGAR. We are planning to further compare the EDGAR emissions using measurements (e.g. from satellite), however, several factors of uncertainty both in the measurements and inversion procedures should be taken into account. Therefore we will try to develop such comparisons and updates in future versions of EDGAR emissions. As discussed in the manuscript, the updates of EDGAR v4.3.2 are mainly based on more recent activity data compared to earlier versions, revised EF for some sectors and quality checks (e.g. mass balance for the aerosols). We added the following sentences to the manuscript to clarify which updates were performed in EDGARv4.3.2:

"Emission inventories can also be updated implementing results provided by inverse modeling. However, the current version of the EDGAR database takes a conservative approach in using such information for the air pollutants since a mismatch of observed concentrations, and resulting 'updated' inverse modeling derived emissions may often be attributed to multiple sources of uncertainties in emissions, model and observations. If not based on solid and well-evaluated information, emission data might be modified with incorrect or inconsistent information; therefore we prefer to present our best available information on activity data and EFs without correction. One example where compelling results from inverse modeling have been used is the update of CH4 emission factors of EDGARv4.32, which for instance have consistently be indicating lower emissions from coal mining than was assumed in EDGAR, as documented in Janssens-Maenhout et al. (2017)."

3. Why emissions of aerosols (all given components) are lower in this version than earlier ones and also with other inventories (Fig. 5b)? What factor (factors) has (have) contributed to this change? Aerosol emissions are lower in EDGARv4.3.2 compared to earlier versions mainly due to changes in the IEA biofuel consumption in the residential sector. To describe this information, we have updated the manuscript as following:

"The two most recent EDGAR releases, v4.3.1 and v4.3.2, are consistent, except for the biofuel consumption in the residential sector (which mainly explains the differences of aerosol emissions between the two versions and with the other emission inventories) for which the IEA activity data was known to have changed method (i.e. towards higher Tier) relying on comparable activity data." 4. Why OC has increased only by a factor of 1.2 from 1970 to 2012 while other components of aerosols (PM10, PM2.5 and BC) have increased by a factor of about 1.7 in the same time period? If this has been explained earlier, a reference may be given. We added the following explanation to the text: "Organic carbon emissions increased from 1970 to 2012 only by a factor 1.2 compared to the other aerosol components (PM10, PM2.5 and BC) which increased by a factor 1.7. The trend in OC emissions is mainly driven by the residential combustion of biomass and agricultural waste burning sectors for which we find OC emissions changing less rapidly than for the other sectors. We further note that EDGAR OC emission factors in certain sectors, such as chemical processes, iron and steel production, non-metallic mineral production, etc., are generally low, but highly uncertain due to a lack of observed emission factors."

Minor comments:

1. Changes from the earlier versions may be explained in more detail and also highlighted in the abstract as well as in the final summary. However, the present abstract is rather lengthy. General description may be cut as this is an update of the previous version v4.3.1. We agree with the Reviewer 2 that the abstract is rather lengthy, however, we tried to summarize there both the general description of the EDGAR database and the main results of this publication. Now we shortly mention in the abstract that some

updates in the EFs have been implemented compared to earlier version of EDGAR, but we mainly discuss it in the body of the manuscript as following: "The two most recent EDGAR releases, v4.3.1 and v4.3.2, are consistent for almost all sources, except for the biofuel consumption in the residential sector for which the IEA activity data was known to have changed method (towards higher Tier) relying on comparable activity data. A significant update has also been made for the ferroalloys production sector, production of chemicals, production of fuels, residential sector and solid waste, mainly affecting CO emissions. NMVOC emissions are higher in EDGAR v4.3.2 compared to earlier versions of the EDGAR estimates mainly due to updates of the emission factors for the NMVOC losses in the gas distribution sector. NMVOC EF for this sector have been revised checking the ratio of total NMVOC to methane. Based on the information about fugitive emissions in the gas distribution sector provided by Salway et al. (2002), in EDGARv4.3.2 we assume a ratio of 10.5% for 1990 and of 18.9% for 2000 between NMVOC and CH4 EF (note that CH4 emission factors have been also revised in EDGAR v4.3.2 compared to former versions as documented by Janssens-Maenhout et al. (2017)) as suggested by Höglund-Isaksson et al. (2017))."

2. Emission of NMVOC is much higher in this version (Fig. 5a) compared to your own earlier two versions as well as other inventories. It is mentioned that it includes the emissions from the gas distribution losses. This could be explained in more detail. We included the following sentences in the manuscript to explain the difference occurring for the NMVOC emissions between EDGARv4.3.2 and earlier versions: "NMVOC emissions are higher in EDGAR v4.3.2 compared to earlier versions of the EDGAR estimates mainly due to updates of the emission factors for the NMVOC losses in the gas distribution. NMVOC EF for this sector have been revised checking the ratio of total NMVOC to methane. Based on the information about fugitive emissions in the gas distribution sector provided by Salway et al. (2002), in EDGARv4.3.2 we assume a ratio of 10.5% for 1990 and of 18.9% for 2000 between NMVOC and CH4 EF (note that CH4 emission factors have been also revised in EDGAR v4.3.2 compared to former versions as documented by Janssens-Maenhout et al. (2017)) as suggested by

Höglund-Isaksson et al. (2017)).”

3. Figs. 1-4: The color codes for total emissions are not very clear in these diagrams. This may be taken care while making final diagrams.

We apologize for the technical issue occurred with Figs. 1-4. The resolution of these figures is in its original version high, but when producing the pdf file for the submission it significantly decreased. We will take care of this issue in the final stage of publication, checking with the editorial office the most appropriate resolution.

4. Fig. 9 is very small and not readable. Hope this will be taken care.

Figure 9 has been improved to make it readable.

5. Figs. S2a and S2b: Figure captions are not matching with the figures.

Figure captions of Figs S2a and S2b have been corrected.

6. Figs. S3a and S3b: Same color may be used for these sectors as in Figs. S2a &S2b

We changed the colors of Figs. S3a and S3b accordingly with the colors used in Figs. S2a and S2b.

References

Crippa, M., Janssens-Maenhout, G., Guizzardi, D., and and Galmarini, S.: EU Effect: Exporting Emission Regulations through Global Market Economy, Journal of Environmental Management, 183, 959-971, http://dx.doi.org/10.1016/j.jenvman.2016.09.068, 2016b.

D'Angiola, A., Dawidowski, L., D., Gómez, and Osses, M., 2010. On road traffic emissions in a megacity, Atmos. Environ. 44, (4), 483-493.

Ding, J., Miyazaki, K., van der A, R. J., Mijling, B., Kurokawa, J.-I., Cho, S., Janssens-Maenhout, G., Zhang, Q., Liu, F., and Levelt, P. F.: Intercomparison of NOx emission inventories over East Asia, Atmos. Chem. Phys., 17, 10125-10141,

https://doi.org/10.5194/acp-17-10125-2017, 2017.

EMEP/EEA, Emission Inventory guidebook, European Environment Agency. https://www.eea.europa.eu/publications/emep-eea-guidebook-2013, 2013.

EMEP/EEA: EMEP/EEA air pollutant emission inventory guidebook 2016, European Environment Agency, Copenhagen, 2016.

Höglund-Isaksson, L: Bottom-up simulations of methane and ethane emissions from global oil and gas systems 40 1980 to 2012, Environ. Res. Lett., Vol. 12 No.2, http://dx.doi.org/10.1088/1748-9326/aa583e, 2017.

Hooghiemstra, P. B., Krol, M. C., Meirink, J. F., Bergamaschi, P., van der Werf, G. R., Novelli, P. C., Aben, I., and Röckmann, T.: Optimizing global CO emission estimates using a four-dimensional variational data assimilation system and surface network observations, Atmos. Chem. Phys., 11, 4705-4723, https://doi.org/10.5194/acp-11-4705-2011, 2011.

Janssens-Maenhout, G., Crippa, M., Guizzardi, D., Muntean, M., Schaaf, E., Dentener, F., Bergamaschi, P., Pagliari, V., Olivier, J. G. J., Peters, J. A. H. W., van Aardenne, J. A., Monni, S., Doering, U., and Petrescu, A. M. R.: EDGAR v4.3.2 Global Atlas of the three major Greenhouse Gas Emissions for the period 1970–2012, Earth Syst. Sci. Data Discuss., https://doi.org/10.5194/essd-2017-79, in review, 2017.

Liu,F., Choi, S., Li,C., Fioletov, V.E., McLinden, C., Joiner, J., Krotkov, N.A., Bian, H., Janssens-Maenhout, G., Darmenov, A.S., da Silva, A.M.: A new global anthropogenic SO2 emission inventory for the last decade: A mosaic of satellite-derived and bottom-up emissions, Atm. Chem. Phys., 2018.

Salway, A. G., Murrells, T. P., Milne, R., and Ellis, S.: UK Greenhouse Gas Inventory,1990 to 2000 Annual Report for submission under the Framework Convention on Climate Change, AEAT/R/ENV/1000, naei00/ipcc/report/final/ghg_fccc1, Appendix 3, 2002.

Schifter, I., Díaz, L., Múgica, V., and López-Salinas, E., 2005. Fuel-based motor vehicle emission inventory for the metropolitan area of Mexico City, Atmos. Environ. 39(5), 931- 940.

Interactive comment on Earth Syst. Sci. Data Discuss., https://doi.org/10.5194/essd-2018-31, 2018.