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Interactive comment on "Gridded uncertainty in fossil fuel carbon dioxide emission maps, a CDIAC example" *by* Robert J. Andres et al.

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Andres, Boden and Higdon "Gridded uncertainty in fossil fuel carbon dioxide emission maps, a CDIAC example" presents a new method to derive gridded uncertainty in CDIAC fossil fuel CO_2 emission maps. The scientific significance of this work is high, since it is useful and important work for carbon cycle science and perhaps also climate policy. The scientific quality is high with the present work pioneering new methods for this field. The presentation quality is good, but there is room for some improvement here.

Quantified uncertainty in fossil fuel CO_2 emission data is something that has been needed by the carbon cycle science community for some time. Andres et al. (2014) took a first step in deriving a global uncertainty value, but this manuscript goes much

further with actual gridded uncertainty maps that users of the gridded emission maps will soon be able to access. As CO_2 modellers use the gridded uncertainties, this manuscript will serve as a valuable reference to understand the details of how the uncertainties were derived and any limitations that they have. The manuscript also presents a revision to their gridded emission approach, specifically the implementation of time-varying population distributions for 1990-2011. One important issue that the author's did not address in enough detail was the reliability of population as a proxy for fossil fuel (and cement) CO_2 emissions. I have some suggestions for improvements to that discussion, but a more thorough analysis may perhaps be best addressed in a future paper. Overall, I would be supportive of publication of this manuscript in Atmospheric Chemistry and Physics, provided that some revisions are made according to the suggestions that follow.

Lines 42-50: The authors' discussion of the reduction in uncertainty for other components of the carbon cycle might leave the impression on a reader that the uncertainties on these components is smaller than it actually is. This is especially true for the terrestrial biospheric CO_2 flux, which is usually calculated as the residual of all other fluxes including fossil fuel (and cement) CO_2 emissions. This fact should be mentioned since in effect, good biospheric flux estimates (and knowledge of their uncertainties) depend on good FFCO2 estimates (and knowledge of their uncertainties). Secondly, I am surprised that the authors fail to mention in the introduction the fact that the uncertainty in FFCO2 may actually be growing for two reasons: 1) the overall magnitude of FFCO2 emissions has continued to grow (about 2.5 PgC/yr in 1960 to about 10 PgC/yr now) as shown in Figure 10 of Andres et al. (2014), so any fixed percent uncertainty would translate to a larger absolute value, and 2) the fact the growth has mainly occurred in countries with higher FFCO2 uncertainties, according to Table 2 in Andres et al. (2014). I would recommend adding these points to the introduction (in the authors' own words).

Lines 95-101: I find the wording "stock maps" to be odd, definitely not the standard in the field. If they mean maps of "atmospheric CO_2 concentrations", it would be better to

simply say that (or to be more exact "atmospheric CO_2 mixing ratios" or "atmospheric CO_2 column-averaged dry air mole fractions").

Lines 199-201: The authors should add once sentence to elaborate on what they mean by nighttime and daytime populations to assist readers. I suspected that I knew what they meant, but had to look up the terms to verify.

Lines 309-313. I do not think that a sub-national border is relevant here since the emission maps do not account for tabular data from individual sub-national units (states/provinces etc.). Is that the only example of this issue? This example may be relevant to mention with respect to lines 381-384.

Line 420: I recommend changing "Vulcan data product" to "Vulcan data product for the United States" to emphasize that this was not a global check.

Lines 458-460: For larger grid box sizes, it would be possible to test this by aggregating the gridded 1x1 data, for example to 2x2 or 5x5, and then repeating the comparison. They authors may want to try this. I would expect such a test to confirm that the population-FFCO2 emission relationship is more reliable for coarser spatial resolution. However, since the relationship is very likely non-linear, I would not expect this approach to be able to provide any quantitative information about the population-FFCO2 relationship at the finer spatial resolutions (0.25, 0.1 and 0.01 degrees).

Lines 497-506: I am a bit surprised by the conclusion that year of the population map did not matter much. Using the United States as an example, an old map might not have the correct East-West weighting since cities in the western part of the country have had more recent growth increases. In the developing world, there is a trend toward urbanization, with formal rural agriculturally-based populations resettling in cities. I would like to see at least one figure somehow quantifying the differences from using temporally-dependent population maps, so that the reader can judge the scale of the differences. Perhaps the difference were not large since the time period 1990-2012 was limited rather than spanning the whole data set period.

Line 552: "borders in water-dominated areas" should be "borders and in water-dominated areas"

There are multiple places in the manuscript (in addition to lines 458-460), where the issue of the population-FFCO2 emission relationship, the validity or per capita emissions, or the use of population as a proxy for FFCO2 emissions (versus other proxy data) is raised. The neglect of point sources in the current method was also mentioned with reference to the work of Singer et al. (2014). The spatial distributions from distributing emissions with population as a proxy and not accounting for large point sources could possibly be the largest uncertainty in the CDIAC 1x1 emission dataset, but this uncertainty is also the most difficult to address since the "true" FFCO2 emission values at fine spatial scales are simply not known. Nassar et al. (2013, JGR, 118, 917-933) compared the CDIAC 1x1 data (which uses a population-based proxy) and the ODIAC 1x1 data (which uses large point sources and a nighttime lights based proxy) over Canada against tabular reported activity-based FFCO2 at the provincial scale. The sum of the gridded data in each of 10 Canadian provinces and the combined northern territories was assigned a scale factor for each of dataset (CDIAC or ODIAC) that would give agreement with the tabular reported provincial total (see Figure 5 and Table 4). This test showed that less scaling was required (scale factors were usually closer to unity) when point sources and nightlights were used compared with using population. It is expected that this result would hold for other large countries (like the US or China) where there are regional differences in methods of energy generation including non-CO_2 emitting methods like nuclear or renewable energy (hydroelectricity, wind, solar, geothermal, tidal etc.) or there are large variations in climate, transportation systems or building style within a country (e.g. New York vs. Texas) resulting in large differences in per capita energy consumption. While the analysis in Nassar et al. (2013) is not a complete analysis or comparison of all proxy methods globally, a summary of the above finding and citation of the paper is surely warranted in this manuscript.

Figure 3. According to the text (line 267-270), the monthly uncertainty is a constant at

12.8

Figures 3,7,9, and 10. The color-bars all contain two very similar shades of blue that are very difficult to distinguish. The color-bar for Figure 11 nicely avoids this problem. Can the authors revise their colour-bars to avoid colours that are too similar as they have nicely done in Figure 11.

Figure 8. Units for FFCO2 should be given. Removing some zeros in the FFCO2 or populations would also enhance clarity.

Figure 12. The label “Urban – vertical extent?” is confusing and not discussed anywhere. Either explain or just replace with “Urban”.

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