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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Anthropogenic, biomass burning, and volcanic emissions of black carbon, organic carbon, and SO_2 from 1980 to 2010 for hindcast model experiments" *by* T. Diehl et al.

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We thank both anonymous reviewers for their assessments and constructive comments on our submitted manuscript. Below we answer the non-technical issues raised. All noted typos and technical comments are also taken into account in the revised manuscript.

From Anonymous Referee #1

1. Improvement sufficient for publication will require addressing the following points, which are not exhaustive. The present presentation is a very mechanical description of the data construction. Both more nuance and detail are needed. It is not clear what is

the authors' own work and what was done by others, much clearer and complete referencing is needed. Much of the discussion appears to be a recapitulation of previous work (not all appropriately referenced). Much of this should be moved to a supplement. A table or two showing the sources for the different emissions (by time period as needed) for each of the data sets is needed.

Response: Besides the overall compilation into a single dataset, several of us were directly involved in creating individual parts of the emissions discussed in this paper: A) land-based anthropogenic emissions for A2-MAP (Streets), B) biomass burning for ACCMIP (Heil, Schultz), C) volcanic emissions (Diehl), D) yearly interpolated anthropogenic emissions in A2-ACCMIP (Heil) (which was also independently created by C. Granier under the name MACCity). While some of these individual emissions have been described elsewhere (references are given in the paper in these cases), our goal here was to provide a comprehensive description of a global time-resolved emission dataset from 1980-2010 for BC, OC, SO2, which is suitable for hindcast experiments of the global modeling community. We believe that moving some or all of these summaries to an appendix would be a disadvantage to a reader who would like to get an overall idea of the contents of the dataset. We will clarify the connections between some authors of this manuscript and already published papers.

We agree that an overview table showing the various sources for the individual sets will be very helpful, and will include such a table in the revised version.

2. The Gridding process needs to be more completely described. What regions were used, what assumptions for region/country boundary splitting, was gridding done by sector?

Response: For A2-MAP, the following paragraph is added to the supplement, including a table laying out the correspondence between countries and regions: "We derived this country map from the high-resolution land-cover and country boundaries vector map provided by the Interactive Data Language (IDL) software from Exelis Visual Informa-

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tion Solutions, which was adapted from the 1993 CIA World Database II map. Data points are approximately 1 km apart in this database. The correspondence between country and region names is given in Table S1. The country map was aggregated to a 0.5° spatial grid, assigning each cell to only one country (i.e. a sub-national split per grid cell was not taken into account). Each country was then unambiguously assigned to one region. The gridding of the regional emission trends was performed as follows. First, some overseas territories/islands without assigned region number were assigned to a region according to closest geographic proximity to one of the regions, rather than by political affiliation. Second, for each 1° grid cell of the 1996 base emissions, we compute the overlap with all 0.5° cells from the region map, excluding cells labeled as Antarctica or ocean. The 1996 base emissions per 0.5° box are calculated using the overlap fraction. Next, the denominator and the scaling factor Fr,y from equation 1 can be determined. Multiplying the scaling factors with the 0.5° base emissions yields the gridded version of the regional trends, which is aggregated back to 1° resolution."

Gridding was performed only for total emissions, not per sector; this statement is added to section 2.1.

In case of the anthropogenic A2-ACCMIP emissions, we did the time-interpolation separately for the individual sectors as provided by the original ACCMIP dataset. We have clarified this in the revised version of section 3.

3. Much more comparison with the literature is needed, particularly with the RCP inventory data from Lamarque et al., since this is used already by many models and comparison projects, and is also the source of some of the data here. The authors can start with the work on Granier et al. (2011), and extend that to discuss the data here. Since there are only two data sets presented, and only three emission species, a more extensive discussion of these as compared to Granier etal can be expected. This would allow the authors to discuss the reasons for some of the differences between the two data sets, and in some cases comment on which is likely to be closer to bing correct, instead of just noting where they are different as is done now.

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Response: The A2-ACCMIP data was derived from the ACCMIP (Lamarque et al. 2010) and the RCP8.5 scenario emissions, as described in section 3 of the paper, and the main part of our discussion focuses on comparing A2-MAP with A2-ACCMIP and therefore also with ACCMIP and RCP8.5, so this comparison is already included. We do not think that it is generally possible to infer correctness of emission data by simply comparing several emission inventories with each other, i.e. consistency does not imply accuracy (although comparing might provide a first motive for further analysis in special cases, like for the SO2 emissions over Eastern Europe in A2-MAP-v1). Such an attempt would require an assessment with extensive datasets and inverse modeling studies, which clearly goes beyond the scope of this paper. Even just identifying causes for the differences between emission databases is in most cases futile, since a vast number of data types and sources is typically used for creating them (inventory data, activity data, emission factors etc.), and the sources are not always described in sufficient detail in the corresponding references. It is also often subjective to judge the reliability of reported national data. Some of these issues are also discussed in section 4 of Granier et al. (2011).

We agree that it would be beneficial to extend the discussion to include more regions as well as individual sectors. For each of the 3 species, we will include time series of the 4 main sectors energy, residential, industry, and power, for each of the 17 regions shown in Fig.1. Most of these figures will be included in a supplement as a comprehensive reference, but we will include a small subset for the year 2000 in the main part of the paper, to discuss a) the fraction of each of the sectors with respect to total emissions, and b) differences between the datasets in global distributions for each of the 4 sectors.

Regarding a comparison with Granier et al., we have added a new paragraph to section 5.5:

“In their assessment of a number of emission inventories for BC, SO2, and other species (but excluding OC) Granier et al. (2011) discussed emission differences for the years 1980, 1990, 2000, and 2005, as summarized in their table 4. This includes

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data from ACCMIP, MACCity, and A2-MAP-v1 ("AEROCOM" in their notation). Generally, their findings show a larger variation of both BC and SO2, both globally and on a regional scale, as compared to our analysis above, with frequent deviations by more than 100%, which is partially caused by the larger number of inventories included in their study. However, their large SO2 differences over Central Europe, and also to a lesser degree over Western Europe, are influenced by the inclusion of the A2-MAP-v1 SO2 data in these regions, which we excluded in our discussion. Slightly different region definitions and using only 4 snapshots compared to all years in our study could also cause some deviations in the range of differences. Nevertheless, the findings agree on relative small differences of SO2 emissions in the USA, despite the larger number of years included in our study and the larger number of inventories in Granier et al. (2011), possibly indicating that most inventories use the same reported data from the EPA."

4. It is unclear why 5 or 10 year snapshots were used in some places when annually resolved data are available in the literature.

Response: The A2-MAP data is annually resolved (Streets et al., 2006, 2008, 2009). In A2-MAP-v2, the anthropogenic SO2 emissions were replaced with EDGAR4.1 data to more accurately reflect changes in Eastern Europe than in A2-MAP-v1. The SO2 data from EDGAR4.1 are indeed only available every 5 years prior to 2000. Since our SO2 data over Eastern Europe in A2-MAP-v1 had been derived from EDGAR 3.2, we decided to replace the data with the next version from EDGAR. On the other hand, although the ACCMIP data is only available in 10-year snapshots and the annual A2-ACCMIP anthropogenic emissions are merely a linear interpolation of ACCMIP emissions, we include them in this paper for their wide usage by large global modeling communities. We would also like to note that the biomass burning emissions in both A2-MAP and A2-ACCMIP are resolved monthly, not just as 10-year snapshots, and the volcanic emissions are resolved daily.

It is certainly true that there are other SO2 data with annual resolution available from

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1980 to 2005 (e.g. Smith et al, 2011), and we do not claim that our choice was based on the assumption that one dataset is more accurate than the other. Easy access to the data (the data was accessible via a website), and a history of collaboration with the database developers also played a role.

5. While BC and OC emissions are quite uncertain, SO2 emissions are known to much better accuracy, particularly in developed countries. There is no reason to believe, for example that emissions are grossly inaccurate in the USA and Western Europe country level inventories, for example. Some of the data here ,in contrast, appear to be outside of the estimated confidence range (e.g., smith et al. (2011). (Who also discuss some of the apparent biases in the Edgar 4.1 data used here.) Such issues need a much more through discussion.

Response: We agree with the reviewer that there is little disagreement about SO2 emissions for the USA and Western Europe, since most emission datasets rely on the same data sources for these regions (at least for the period considered in this study). However, we believe the uncertainty about SO2 emissions in Eastern Europe is larger for a number of reasons. After the major political upheavals in this region, there was a big push to clean up polluting facilities. Unfortunately, a lot of the action that took place was not widely publicized and was only known by in-country experts and groups like IIASA that had access to those experts. These actions consisted of either: closing polluting facilities, modernizing polluting facilities, switching fuels (including from high-sulfur fuels to low-sulfur fuels), and installing SO2 emission control devices. These actions, especially the last two, were often not well reported, but they had a big effect on SO2 emissions. This is why there was high uncertainty in SO2 emissions in Eastern Europe and steps were taken to improve the representation of that region in the emission datasets, which is for example reflected in the changes from EDGAR 3.2 (from which A2-MAP-v1 was derived) to EDGAR 4.1 (used in A2-MAP-v2). This issue might also have affected the emissions from OECD Europe, although to a smaller degree, since East Germany is included in this region throughout the whole period 1980-2010.

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Due to several country-boundary changes in this region around 1990, it is also possible that some accounting difficulties among old and new country designations in the energy data sets might have occurred, such as data omissions or double-counting. We will add a paragraph to section 4.1.1 outlining the points discussed above.

Although A2-MAP-v2 (EDGAR 4.1) most likely contains more accurate SO2 emissions from Europe as compared to A2-MAP-v1 (EDGAR 3.2), we agree that the A2-MAP-v2 SO2 data could be an overestimate (or underestimate) in other regions. We will discuss this aspect for the regions USA, former USSR, and East Asia in the revised paper.

6. The use of the term inventory for this data is, in my view, incorrect. These are not consistent estimates, and often contain what are likely inconsistent assumptions due to the combination of different datasets (and this should be discussed in more detail). The term data sets is more appropriate.

Response: We will replace “inventory” with “dataset” when referring to A2-MAP and A2-ACCMIP in this paper.

7. More detailed data needs to be supplied. At minimum, time series of emissions by a reasonable number of regions (for example the _30 regions used in the RCP data, see Table 2 Lamarque etal 2010) should be provided in a supplement. Emissions by sector would be even more useful. To be most useful, this should be the original country or region data, not data drawn from the gridded products, which can contain interpolation errors.

Response: We agree, and will provide additional data (see also our response to item #3 above).

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 24895, 2012.