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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The POLARCAT Model Intercomparison Project (POLMIP): overview and evaluation with observations" *by* L. K. Emmons et al.

Anonymous Referee #1

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This paper provides an overview of the POLARCAT Model Intercomparison Project (POLMIP) and presents the results concerning ozone and its precursors. The paper is accompanied by two additional manuscripts by Monks et al. and Arnold et al. that contain complementary analysis. The paper addresses the very important question of model comparison focusing on ozone and its precursors in the Arctic region. 9 global and 2 regional models with similar emissions are included in the comparison. Consistent differences exist between different models as well as between models and observations (aircraft observations from POLARCAT mission, ozonesondes, OMI NO2 columns, C2H6 and C3H8 surface measurements). As demonstrated nicely with trac-

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ers in the accompanying paper by Monks et al., the differences between models in CO in the Arctic are due mostly to differences in chemistry (OH fields are different) rather than differences in transport from source regions. The paper by Emmons et al. contains an analyses of some of the reasons for the different OH concentrations: different cloud coverage leading to different photolysis rates, differences in H2O mixing ratios. Other possible reasons, such as differences in ozone deposition velocities, are identified but not analysed. The comparisons with observations allow identifying some consistent model biases and lead to suggestions for possible improvements, e.g. emission inventories.

General Comments This is a well-written article presenting an important intercomparison of models in the context of a measurement campaign (POLARCAT). Important and interesting insights on the reasons of the inter-model differences are provided.

1) What is not entirely clear is that even though it is stated that the same emission inventories are used in all models, some differences are present. This is due to differences in the chemical mechanisms (some species are not explicitly modelled), but it is not clear if these are the only differences (e.g. the differences in GEOS-CHEM emissions). 2) Some of the figures (epically related to the comparison with OMI NO2 columns) are somewhat hard to analyse. 3) It could be also helpful if the objectives of this paper with respect to the accompanying papers (especially Monks et al) could be somewhat more detailed in section 1.

Some additional suggestions for improving the clarity of the text are provided in the specific comments below.

Specific Comments

Page 29335, line 13: change “slow mixing” to “slow vertical mixing”? Page 29335, line 18: add that the rapid advection follows isentropic surfaces, which can explain the layering Page 29336, line 17: to be more clear, change “than transport does” to “ than differences due to different transport in the models”. Page 29336, line 26: rephrase

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"following these". It would be also nice to give the corresponding section numbers. Page 29342, lines 28-29: Only one version of MOZART-4 results is shown starting with figure 7. Which of these versions is used? Page 29345, line 20: I would suggest to change the title of section 4, for example: Overview of model characteristics and of the main model differences.

Page 29346: line 21: remove "in" after "agree on"

Page 29347, line 19: should be Table 2?

Page 29347, line 19: It is not clear why different emissions were used in GEOS-Chem. This is not explained in the model description section.

Page 29348: line 18-19: the means were compared?

Page 29348: lines 23-25- Please indicate how the too strong transport from the stratosphere is consistent with the values lower than observations above 300 mb. And also is the strong negative bias present for some models above 300mb real? Or is this due to the binning of levels across the tropopause (and the exact location of model levels in this zone of high vertical gradients)?

Page 29349: section 5.2 : why is the difference between GEOS-Chem and other models so large for ethane? According to table 2, the differences in total fluxes are small.

Page 29349: section 5.3, first paragraph: Please specify if total NO2 columns are considered or rather mostly tropospheric columns.

Page 29349: line 25: please explain further the sentence starting with: The averaging kernels of the . . .

Page 29349: section 5.3, first paragraph : it would be very helpful to have some more information on the relative values of the averaging kernels at different levels. How much weight is on average given to the boundary layer as compared to the free troposphere and/or upper troposphere?

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Page 29350: line 6: replace “model bias” by “mean model bias”

Page 29350: lines 17-20. Split the sentence by ending the first sentence after respectively. Please explain how it was decided whether 90% of NOx emissions originate from anthropogenic or biomass burning emissions. This is based on model inventories used? Also should a threshold be used to filter the data in the plot? The ship emissions do not bring much information to these plots.

Page 29350, lines 23-25 – why not restrict the zone over NW Europe so that it does not include the North Sea? The strong emissions are only over land.

Page 29350, lines 25-29: a conclusion seems to be missing. Is my understanding correct: model NO2 columns are underestimated over pollution hotspots, but the spread in model results does not allow to draw conclusions on the quality of the NOx emissions used. Also it would be helpful to understand what weight is given to the boundary layer NOx (see also comment above).

Page 29351: lines 9-10: Split the sentence: Figure 15 shows . . . of the campaign. The flight tracks have . . .

Page 29351: line 25: add that data were binned in 1 km bins.

Page 29351: line 26: how was the measurement uncertainty calculated for the binned median values?

Page 29352: line 6-7: the sentence starting with ‘In the cases. . .’ should probably be moved to the end of the previous paragraph. In Fig 19, only one measurement is considered. Also it might be helpful to add, that “more than one measurement” indicates measurements with different instrument/technique.

Page 29352, lines 10-11: I would not put the sentence ‘consistent with’ between parentheses: this is an important statement.

Page 29352, lines 16 : after ‘boundary layer’ could add ‘(ARCTAS-B, fig. 18).

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Page 29352, line 20 : missing ‘some’ before cases.

Page 29353: lines 16-18: the fine structure in OH is due mostly to what sub-grid processes? Cloud distribution and resulting photolysis? Fine scale plumes?

Page 29354: line 17: the exact location and strength of model sources could be also added to the list of reasons why the modelled and observed plumes do not overlap in space and time.

Page 29354: lines 19-22: were all pixels in the selected zones affected by fires? If not, why not take only pixels inside the plumes from fires? Will taking pixels not in the plumes affect the calculated slopes?

Page 29355: line 9: “fire emissions” or should it be “fire emission factors”? Not having compared CO in these airmasses (observations vs plumes), it seems that one cannot extend the conclusions to emissions but should talk only about emission factors.

Page 29355: line 17: as in the previous comment. Should it be emission factors rather than emissions?

Page 29356: line 26: replace “ozonesondes” by “ozone”

Figure 8: The station Narragansett seems not to be used in later figures (9 and 10)

Figure 9-10: Comments on these figures: showing both: the individual measured profiles and mean biases on the same figures does not really facilitate the analysis of these figures. Can they be split to show the mean profiles (observations + models) and biases separately? This would also allow zooming in on the biases. It would also be nice to have in these figures some information on the standard deviations. It is understood that it would be hard to include this information for these plots for all models at the same time. But it could be presented at least for the observed data instead of showing the individual ozonesonde profiles. Showing individual observed profiles probably does not bring much useful information compared to mean + standard deviation. Showing mean + standard deviation would however simplify the figures.

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Figure 13: indicate in the legend that left column for April and right for June-July.

Figure 14: indicate in the legend that the box plots show model results! They include data from all models?

Figure 15: It seems that Grace and POLARCAT France measurements are not used in this paper. Is there a reason for this? This could be mentioned in the legend Please add also AP next to ARCPAC

Figures 16-18 : not easy to distinguish between thick and thin error bars? Use error bars with vertical lines? Also replace ARCTAS-A by ARCTAS A1? WRF can be removed from the legend in figure 16?

Figure 17: nomenclature: “P3” not used in figure 15, for clarity might be helpful to remove it.

Figure 19: why OH was not included?

Table 2: Change title from Emissions to Global emissions. Indicate in the legend that the regional models were not listed, as the global values cannot be provided.

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