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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 #2

Received and published: 18 January 2015

GENERAL REMARKS

Analyzing the content and the context of the manuscript, I would say the study described in the manuscript has fulfilled 3 objectives : 1) Introduction of the models which are used in POLMIP ; 2) Showing a comparison of the models with observations in the Arctic, and make conclusions about how good the models reproduce the observations; and 3) Conclusions about the emission data set.

I think the manuscript does a valuable job in comparing the results of model simulations with observations in the Arctic. It is important to estimate the reliability of CTMs in this

remote but vulnerable region, which is impacted by pollution from different origins. Therefore, it is very nice that the study uses for this the extensive data set obtained during the International Polar year 2008. The manuscript is well written and agreeable to read.

However, the paper lacks analysis to attribute the differences between model results and observations to specific model components. It does it for some model components (complexity of the chemistry scheme to some degree, photolysis rates and cloud fields), but other possible contributing factors are only mentioned but have not been investigated (impact of dry/wet deposition, tracer transport scheme, convection and boundary layer parameterisations, vertical resolution in lowest 5 km, reduced grid near the poles, inclusion of stratospheric chemistry, ...). In the abstract is mentioned : "to quantify the differences in model chemistry and transport schemes." I read this as a focus of POLMIP (broader than this manuscript), and not only of this study. However, it gives the suggestion that it might all be investigated in this study. The abstract continues : "Differences in a number of model parameters are identified as contributing to differences in the modeled chemical species, including cloud fields and photolysis rates." But this makes arise the question : which others have been identified? Also, the analysis of cloud fields and photolysis rates feels a bit limited to an illustration. Further, in the conclusions is written : "However, numerous differences occurred among the model outputs due to the different chemical schemes ans physical parameterizations such as convection, boundary layer mixing and ventilation, wet and dry deposition." However, at the end I have the impression that the contribution of these different parameterisations to the actual model differences is not quantified. Finally, in the first paragraph of the conclusions is already written : "Additional model diagnostics are required to completely understand the differences among models." I think such suggestions should be made at the end of the conclusions.

I write this because, at the moment, as a reader one gets the impression that certain things will be investigated or analyzed, but in the end they are not. It would therefore be

ACPD
14, C11302–C11337, 2015

nice if the analysis could be improved and extended. What type of model components play a large role in the modeling of the chemical composition of the Arctic atmosphere? If this extension is not possible, then it should be explained why only the clouds and photolysis rates are explicitly illustrated. In that case also, make the text more clean and sober: focus only on the aspects you really investigate in the study. Just mention the ones you don't investigate (and possibly estimate their relevance based on other studies for the Arctic), but state from the beginning that they are not the focus of the study. Therefore the abstract, Section 4, and the Conclusions (Section 7) should be thoroughfully rewritten.

There are valuable conclusions about the emissions data set. However, these conclusions only have a value if this is a publicly available dataset, and which is intended to be used by others, or which at least can be investigated. Although the webpage http://bio.cgrer.uiowa.edu/arctas/emission.html was accessible, further links which would guide to the data did not work. The links on that webpage which did not work were : (i) "This inventory is available for download", and (ii) "Gridded emissions can be accessed at the University of Iowa ACESS website http://www.cgrer.uiowa.edu/EMISSION_DATA/index_16.htm, under the direction of Gregory Carmichael, Principal Investigator of this project."

Further, I think the manuscript contains too many figures.

The structure of the paper could be improved. Now the Sections 4, 5, and 6 all contain results, so they might be brought together (as Sections 4 and 6 are short). Section 3 should have a more general title.

Below you can find : (i) a list of smaller general remarks, (ii) a list of detailed comments on the manuscript text, (iii) a list of detailed comments on the tables, and (iv) a list of detailed comments on the figures

SMALLER GENERAL REMARKS

ACPD
14, C11302–C11337, 2015

1. Figures There are too many figures. In some figures, too small fonts are used. Some plots are too small. The layout of some of the figures should be improved.

2. For MOZART, 2 things are unclear : (i) which photolysis rate calculation is actually used for the principal simulations? (ii) how are the clouds and the humidity calculated? Is CAM (nudged to GEOS-5) also used?

3. Maybe mention a bit more explicitly which papers are companioning papers within POLMIP. I presume that Monks et al. [2014] and Arnold et al. [2014] are, but this is not explicitly said. Are there others?

4. I would consequently use "wildfire" instead of "fire".

5. Abbreviations Be consequent in how abbreviations are defined : first the long expression, followed by the abbreviation between brackets. It is probably not possible to always follow this rule, but try to be as consequent as possible. What strategy is followed for the first letter in the full expression : CTM (small letter in full expression), GCM (big letters in full expression), SLCP (small letters in full expression)?

6. Homogenize the description of the different models (see DETAILED COMMENTS on TEXT)

7. LMDZ-INCA, LMDZ both are used in the text. Try to just choose one.

DETAILED COMMENTS on TEXT

Please find below a list of detailed comments. Among these, there are quite some comments and suggestions about language use. Feel free not to follow these suggestions on language, but please give a good reason why you do not do so.

p 29332 : Norrkoping -> Norrk\"oping (\" on the o)

p 29332 : University Innsbruck -> University of Innsbruck

p 29333, l 2-3 : "atmospheric chemistry observations" : this is a bit vague.

ACPD

14, C11302–C11337, 2015

p 29333, l 5-11 : 5 times "differences" on only a few lines

p 29333, l 15-23 : the order of these last three sentences is a bit strange. First, a sentence about usefulness of aircraft observations without conclusions. Second, a sentence about satellite observations with conclusions. Third, a sentence about aircraft observations (although) with conclusions. Maybe sentence one and three can be put together.

p 29334, l 3-5 : Two aspects are mentioned ((i) heat transport from lower latitudes, (ii) local radiative forcing). The second one is really about climate change, while the first one is even true without climate change. Try to formulate more precisely.

p 29334, l 8 : aerosol -> aerosols (as on line 5)

p 29334, l 27-28 : twice "significant" in the same sentence

p 29335, l 4 : "it" refers to "Arctic" I presume. It would be clearer to explicitly write it.

p 29335, l 12-16 : maybe add "only" before "in close proximity", and "mainly" before "retaining only". Otherwise the last 3 parts of the sentence do not fit together well.

p 29335, l 21 : "slow" before "mixing"?

p 29335, l 22 : and more -> or more

p 29335, l 25 : "Climate" -> "of Climate" in the definition of POLARCAT

p 29336, l 5 : "focused" -> "focuses"

p 29336, l 5 : "this comparison" : does this refer to the whole POLMIP, or just to this paper? Is POLMIP limited to gas phase chemistry evaluation?

p 29336, l 9-10 : "evaluate ... with ... observations" : is this correct language use?

p 29336, l 13-14 : "by methyl chloroform observations and emissions" : maybe "by methyl chloroform observations and its emission estimates"

ACPD
14, C11302–C11337, 2015

p 29336, l 17 : "than transport does" -> "than differences in transport"

p 29336, l 23 : "efficiency in" -> "efficiency of"

p 29336, l 24 - p 29337, l 2 : I would suggest to add section numbers in this paragraph

p 29336, l 26 : "of all of the models to observations" -> "of model results with observations"

p 29336, l 26-28 : This sentence is a bit strange as an ozonesondes is more an instrument, wile "NMHC" and "compounds" are species. I would suggest to homogenize the sentence.

p 29336, l 28 : "emissions" -> "the emissions"

p 29337, l 4 : "collaboration of experiments" : is this the correct description?

p 29337, l 12-13 : "of each mission" -> "for each mission"

p 29337, l 13-14 : "transported to the Arctic" : shouldn't it be after "wildfire plumes" (if the measured wildfire plumes are not the ones going to the Arctic, than the sentence is correct I think)

p 29337, l 17-18 : abbreviation precedes the full name, while different for ARCTAS

p 29337, l 20 : is the word "sources" needed?

p 29337, l 21 : fire plumes -> wild fire plumes

p 29337, l 24 : "Spring" -> "spring", maybe cancel "in spring" as the dates make this clear (between 30 March and 11 April).

p 29338, l 1 : shouldn't GRACE be explained : Greenland Aerosol and Chemistry Experiment?

p 29338, l 2 : "Greenland" maybe not needed as already mentioned on page 29337, l 25. On the other hand, it is maybe good to repeat it.

ACPD

14, C11302–C11337, 2015

p 29338, l 5 : here again the explanation follows the abbreviation. Maybe it is unavoidable due to the YAK-part.

p 29338, l 10 : the section "3 Models" seems to be more general than just about models. Another title might be more appropriate.

p 29338, l 12 : twice "output" -> maybe change the second one into "monthly mean species distributions and diagnostics"

p 29338, l 14-15 : there is some tension between "All the models" and "with a few exceptions". Maybe change in "Most of the models"

p 29338, l 16 : "global" - except WRF?

p 29338, l 16 : "meteorology" is vague; maybe "meteorological forcing". In addition to differences in "chemistry scheme", "meteorology", and "deposition schemes", the models probably also differ in vertical distribution of BB emission distribution, tracer transport schemes, detrainment/entrainment rates in convection, etc.

p 29338, l 17-18 : twice "output", and "a number" should be avoided. Maybe : "... included monthly mean distributions of mixing ratios and some other diagnostics"

p 29338, l 18 : "evaluation" -> "an evaluation"

p 39338, l 20 : "a smaller number" -> "a limited number"

p 29339, l 2 : www.ceip.at -> http://www.ceip.at as on p29335, l 28

p 29339, l 3-5 : maybe the sentence can be rewritten to have "speciation" only once

p 29339, l 4 : is in this paper VOCs used to describe the same set as NMHC (defined on p 29336, l 27)?

p 29339, l 6-8 : "provided daily" : maybe also mention that they are given to/used in the models on daily basis too.

p 29339, l 7 : INventory to agree with FINN (maybe put N as a capital letter)

ACPD

14, C11302–C11337, 2015

p 29339, l 10 : "these" -> "the ARCTAS", because "these" is confusing as different emission datasets are mentioned just above

p 29339, l 11 : "showed" -> "showed that"

p 29339, l 17 : "usual" -> "standard"

p 29339, l 19 : "intercomparison" -> "POLMIP intercomparison" to make clear that it is not just about this paper

p 29339, l 19 : "dynamics" -> "tracer transport"

p 29339, l 26 : "far removed" -> far away

p 29339, l 28 : "This offset in location produces differences in atmospheric composition" : I think I understand what is meant, but it should be expressed more clearly

p 29340, l 4 : "March through August" -> looking at Fig. 1, I would rather say "March through July"

p 29340, l 10-11 : meteorology -> "origin of meteorological data"

p 29340, l 12 : Table 1 -> Table 2

p 29340, l 27 : "integrated forecasting system" -> "Integrated Forecasting System"

p 29340, l 27-28 : I would add "(ECMWF)" after "European Centre for Medium Range Weather Forecasting" (it is later used, e.g., on p 29342, l 20)

p 29341, l 4-5 : is it necessary to mention "and applies the emission and dry deposition fluxes as part of the vertical diffusion scheme"?

p 29341, l 5-6 : is this the best way to describe this?

p 29341, l 2 : CTM is defined here while "chemical transport model" is already used earlier (e.g. p 29334, l 27). The definition should be given there.

p 29341, l 7 : "model convective precipitation" -> "convective precipitation"

ACPD

14, C11302–C11337, 2015

p 29341, l 7 : "the C-shaped profile" -> "a C-shaped profile"

p 29341, l 10 : 3-D is defined later (page 29343, l 26)

p 29341, l 19 : "includes an" -> "includes "

p 29341, l 24 : GMI : abbreviation first

p 29341, l 25 : I would replace "chemical transport model" by "CTM"

p 29341, l 27-28 : is it necessary to mention "with all the emissions from the specified inventory". I would rather only mention the exceptions to this rule.

p 29342, l 1 : "several" : are there more than these 2? If so add "e.g.," at the beginning, or ", ..." at the end.

p 29342, l 5 : "but" -> "and"

p 29342, l 9 : LMDz should be after the full expression

p 29342, l 9 : the definition of GCM, should not use capital letters to be in agreement with the definition of CTM : so general circulation model

p 29342, l 11 : ORCHIDEE should be after the full expression

p 29342, l 16 : "gasphase" versus "gas-phase" (both used in the text)

p 29342, l 18-19 : I would write "sulfate" instead of "sulfates"

p 29342, l 20 : "6h" too cryptic -> "6-hourly"

p 29342, l 23 : "global annual total" -> "global annual total emission"

p 29342, l 24 : abbreviation before long expression

p 29342, l 25 : use the abbreviation CTM (because it is introduced earlier on p 29341, l2)

p 29342, l 26-28 : should it be mentioned that the specified emissions have been used?

ACPD

14, C11302–C11337, 2015

p 29342, l 28-29 : which one is actually used for the analysis here? In Fig. 4, they are presented both: but what with the rest of the analysis?

p 29343, l 3-5 : this sentence is identical to the one for GMI, except for the list of oxygenated hydrocarbons. Maybe try a slightly different formulation.

p 29343, l 5 : "is the same"; but the CAM-chem explication mentions stratospheric chemistry"? Are the aerosols identical?

p 29343, l 9 : abbreviation before definition

p 29343, l 16 : "It includes ..." -> "In total, the TM5 chemical mechanism ..."

p 29343, l 18-19 : is it worth mentioning this specificity, as other models might also do it (but just don't mention it in their description)?

p 29343, l 22 : "as" -> "than"

p 29343, l 23 : "by a fourth-order polynomial function" -> "as a function of"

p 29343, l 20-25 : is the lightning parameterization of TM5 the same as the one of C-IFS? But apparently different aspects are stressed.

p 29343, l 25 : has TOMCAT a name definition? 3-D should be defined earlier.

p 29344, l 1 : "Extended Tropospheric chemistry" : shouldn't chemistry start with a capital letter?

p 29344, l 3 : aerosol -> aerosols

p 29344, l 5 : the ";" between the references -> "and"

p 29344, l 9 : full expression for MATCH?

p 29344, l 9 : chemistry transport model -> CTM

p 29344, l 16: "in (Andersson et al. 2007)" -> "in Andersson et al. (2007)"

ACPD

14, C11302–C11337, 2015

p 29344, l 16 : "evaluation" -> an "evaluation"

p 29344, l 17 : this should not be "we" as it does not refer to all authors

p 29344, l 20 : I would add "only" after "but"

p 29344, l 20 : "reaching about 16 km" -> "reaching about 16 km high"

p 29344, l 21 : I would skip "In addition to the standard daily POLMIP emissions"

p 29344, l 23 : "annual global total" -> "annual global total emission"

p 29344, l 23-25 : why specifically mentioning the DMS emissions?

p 29344, l 25 : Maybe something can be mentioned about the boundary conditions for tracer concentrations at the 20N boundary?

p 29344, l 26 : has WRF a full name?

p 29345, l 5 : fire -> wildfire

p 29345, l 5 : 1 -> 1 x 1

p 29345, l 13 : GOCART (definition after abbreviation)

p 29345, l 17 : N. America -> North America

p 29345, l 24 : "meteorology fields -> "meteorological fields"

p 29345, l 25-27 : shouldn't it be LMDz instead of LMDZ?

p 29346, l 3-4 : How can you calculate water vapour only based on surface water fluxes? Is there a cloud parameterization in MOZART? Is there CAM behind?

p 29346, l 15 : "that are" -> "which are" ; "source of" -> "source for"

p 29346, l 21 : "agree on in the location" -> "agree on the location" or "agree in the location"

ACPD

14, C11302–C11337, 2015

p 29346, l 26 - p 29347, l 2 : by mentioning explicitly dry deposition, one can give the impression that dry deposition is determining for the tropospheric ozone differences. Especially the April differences in the NH will only by slightly impacted by the deposition scheme, I presume. Isn't the influx from the stratosphere determining: is there a difference in performance among models which prescribe O3 at the top of the model, and those using explicit stratospheric chemistry?

p 29346, l 28 : "surface layer" : or is it meant "boundary layer"? The surface layer is often just a fraction (1 tenth) of the boundary layer.

p 29347, l 4 : magnitude -> should be little bit more specific like "concentration/mixing ratio/value"

p 29347, l 5-6 : I would think that the other models possibly also show a maximum in the tropical mid- to upper-troposphere. But when that maximum is lower than 2x10-6 it will not be visible in this type of plots. Maybe change : "maximum" -> "a maximum higher than 2x10e-6".

p 29347, l 7 : "have" -> "reach OH concentrations of"

p 29347, l 11 : "a number of compounds" -> I would suggest to be more specific

p 29347, l 14 : CO was already used on page 29334, so the definition should come earlier

p 29347, l 17 : C2H6 already mentioned earlier, so should be defined earlier

p 29347, l 17-19 : can differences in transport contribute to these differences?

p 29347, l 19 : Table 1 -> Table 2?

p 29347, l 21-22 : inverse order of H2O2 and hydrogen peroxide

p 29348, l 2-3 : strange sentence, improve it.

p 29348, l 15 : "The hourly model output" -> "Hourly model output"

ACPD
14, C11302–C11337, 2015

p 29248, l 21 : can one learn something from showing additionally RMSE-profiles?

p 29248, l 24-25 : what type of upper boundary conditions have been used in SMATCH? Maybe also refer to Figs. 5 and 7 where the different behavior of SMATCH was noticeable.

p 29248, l 25 - p 29349, l 1 : GEOS-chem : can this be linked to the different emissions? Is there a reason for this?

p 29349, l 10 : provide -> provides

p 29349, l 12 : "over a range of latitudes" : "over a range of mid- to high latitude stations"

p 29349, l 15 : "altitude" : has for some of the stations a model level different from the lowest level been chosen?

p 29350, l 1-3 : While the former sentence indicates an advantage of using averaging kernels, this sentence mentions a possible disadvantage. Therefore I would replace "also" by something like "on the other hand", or start with "however".

p 29350, l 4-5 : I think this introductory sentence should be improved.

p 29350, l 10 : "fires" -> "wild fires"

p 29350, l 14-16 : can this be more specific?

p 29350, l 17 : "median", while the figure 13 caption says "mean"

p 29350, l 19 : I think this "while"-construction is not so lucky; "regions" : I'd rather use the word "pixel" again, or "grid point"

p 29350, l 21-22 : "Figure 13a and c" -> "Figures 13a and c"

p 29350, l 23 : median

p 29350, l 24-26 : "Northwest" , while "north east" on line 9

ACPD
14, C11302–C11337, 2015

p 29350, l 29 : "East-China", while "East China" on line 13 (but here it is more an adjective)

p 29350, l 29 : "indicating a large uncertainty introduced by the models" : this looks like models introduce uncertainty. I'd rather say that our knowledge is uncertain.

p 29351, l 5 : "for forests" -> "for forest fires"

p 29351, l 6 : "the hourly output" -> "hourly output"

p 29351, l 11 : I would put (A1, A2) immediately behind ARCTAS-A

p 29351, l 19 : GRACE -> to "-GRACE"

p 29351, l 20 : fire -> wild fire

p 29351, l 22 : "with" -> "and"

p 29351, l 24-25 : the same -> in the same way

p 29351, l 25 : "were" -> "was"

p 29351, l 26 : "measurement uncertainty" : is this the measurement uncertainty on one single observation? Or is it a reduced uncertainty as the observations shown are already the mean/median over a large number of individual observations?

p 29351, l 22 - p29352, l 2 : In this short paragraph of text, three large figures are introduced. In the following sentence "To make a more quantitative ...", one temporarily gets the impression that these profiles as such will not be discussed anymore further. However, in the next 2 pages, one refers several times to the profiles. To avoid this initial misconception, I would start the sentence "To make a more ..." by something like "in addition".

p 29352, l 12 : "indicating" -> "indicating that"

p 29352, l 14 : 100% -> 90 %

ACPD

14, C11302–C11337, 2015

p 29352, l 17 : (Fig. 14) -> (Fig 18.)

p 29352, l 18 : hugely : I would use another word

p 29353, l 2 : "of too fine a scale" -> "of a too fine scale"?

p 29353, l 7-8 : I would replace the first "with" by "and"

p 29353, l 8 : ethanol is not shown in figure 19?

p 29353, l 9 : a poor job of : can you express this differently?

p 29353, l 10 : much closer is true for CARB, but not for B

p 29353, l 16 : refer to Figs. 16 and 18, after "For ARCTAS"

p 29353, l 16-18 : however if the conditions are homogeneous, it should not have a large impact. And if the flight legs are long, part of the observations will be in/below/above clouds, and averages can than still make sense.

p 29353, l 18 : These average biases -> "The average biases"

p 29353, l 20 : I would add "(see Fig. 18)" after "In summer"

p 29254, l 4 : fires -> wild fires

p 29354, l 7-8 : is the "," before "back trajectories" correct?

p 29354, l 15 : "make" -> "makes"

p 29354, l 21 : express 252-258 E as 92-98 W, etc ...

p 29354, l 21 : between the surface and 850 hPa (to avoid confusion)

p 29355, l 1 : 252-258E : express as ... W

p 29355, l 19-20 : maybe you can add "POLMIP"

p 29355, l 23 : "driven to at least some degree by observed ..." -> "driven by, to some

ACPD

14, C11302–C11337, 2015

degree at least, observed ..."

p 29355, l 23-24 : meteorology -> meteorological data/fields

p 29355, l 25 : "occurred among the model outputs" -> "occurred in the model results"

p 29356, l 3 : I would not write "completely", as that is probably a too high expectation

p 29356, l 1-6 : this is a very weak conclusion : just illustrating differences, and requiring for "additional model diagnostics in the future". This contradicts with the suggestion in the abstract (line 5-6) "to quantify the differences in model chemistry and transport schemes". Do we learn something about transport schemes? Suggestions for new/other research should be stated at the end of the conclusions.

p 29356, l 7-9 : Why is this a reason?

p 29356, l 14 : indicate -> indicate that

p 29356. l 19 : "dynamics" : this contradicts a bit the sentence on p 29355, l 23-25, where it was suggested that all model represent the "dynamics of the study year".

p 29356, l 29 : OVOCs should be defined. Or is VOC meant?

DETAILED COMMENTS on the TABLES :

Table 1 : The abbreviation "bb" should be defined in the caption or in the text. BIGALK, BIGENE, ... should be defined (or referenced).

Table 2 : Try to use the same naming for acetone and methanol as in Table 1.

Table 3 : For WRF-Chem, the number of levels is not indicated. In the chemistry description for WRF-Chem is written "MOZART" : is this "MOZART-4"?

DETAILED COMMENTS on the FIGURES :

Figure 2 : The colours for CAM4-chem and CAM5-chem are very similar (as in other figures). Can this be changed? Units for pressure should be mentioned [hPa]. Is the

ACPD

14, C11302–C11337, 2015

unit mmol/mol for water vapour correct (as often water vapour mixing ratio is expressed in kg/kg or g/kg)? If possible, it would be nice if some extra values where given on the y-axis (e.g. 200, 500, 700 hPa).

Figures 3-4 : These plots are too small.

Figures 3-6 : Units for Pressure should be mentioned (on the y-axis or in the caption), and if possible extra values should be indicated on the y-axis.

Figure 7 : It would increase the readability of the figure when the names of the species are mentioned on the top of every individual plot (instead of on the y-axis). Only having on the y-axis "mixing ratio [ppbv]" would be ok. The common title "50-70N ZA 700 hPa" is not nicely integrated in the figure. The text in the caption is possibly enough to make this clear.

Figure 9 and 10 : It would be nice to have the station latitude (and possibly the longitude) in the top of every individual plot. If possible, it would be nice to have some more pressure values on the y-axis. It would be nice to have the number of sondes indicated in the plots. It is mentioned in the text that there were daily launches during April, but it seems that for some stations there were much less than 30 profiles available.

Figure 11 : Try to use for the longitude the "... W" notation if the longitude is between 180 E and 359 E.

Figure 12 : I don't know if the general title for this figure is needed - I would rather use the figure caption for this. Possibly add "upper left panel" after "OMI tropospheric column NO2". The figure is in general too small to read the values and units on the colourbar.

Figure 13 : The text in this figure is too small. It would be nice to indicate the boxes also in the bias figures (although it is true that the reason for their definitions comes from the OMI plot). The actual link between the individual boxes in Fig. 13 and individual descriptive names used in Fig. 14 and in the text (NW-Europe, NE-US., E-China,

ACPD
14, C11302–C11337, 2015

Japan, S. Korea, W. Asia, E. Asia, Canada, East. Sib.) are never explicitly made. Maybe one should, or (i) indicate the names in the figures next to the boxes, or (ii) make a table giving the coordinates of the boundaries/corners of the areas.

Figure 14 : A too small font is used in this figure. The word "model" is difficult to read in the upper right blue box. Somewhere should be mentioned that one looks at column values. I would replace "whiskers to" -> "whiskers show" or "GENERAL REMARKS

Analyzing the content and the context of the manuscript, I would say the study described in the manuscript has fulfilled 3 objectives : 1) Introduction of the models which are used in POLMIP ; 2) Showing a comparison of the models with observations in the Arctic, and make conclusions about how good the models reproduce the observations; and 3) Conclusions about the emission data set.

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However, the paper lacks analysis to attribute the differences between model results and observations to specific model components. It does it for some model components (complexity of the chemistry scheme to some degree, photolysis rates and cloud fields), but other possible contributing factors are only mentioned but have not been investigated (impact of dry/wet deposition, tracer transport scheme, convection and boundary layer parameterisations, vertical resolution in lowest 5 km, reduced grid near the poles, inclusion of stratospheric chemistry, ...). In the abstract is mentioned : "to quantify the differences in model chemistry and transport schemes." I read this as a focus of POLMIP (broader than this manuscript), and not only of this study. However, it gives the suggestion that it might all be investigated in this study. The abstract con-

ACPD
14, C11302–C11337, 2015

tinues : "Differences in a number of model parameters are identified as contributing to differences in the modeled chemical species, including cloud fields and photolysis rates." But this makes arise the question : which others have been identified? Also, the analysis of cloud fields and photolysis rates feels a bit limited to an illustration. Further, in the conclusions is written : "However, numerous differences occurred among the model outputs due to the different chemical schemes ans physical parameterizations such as convection, boundary layer mixing and ventilation, wet and dry deposition." However, at the end I have the impression that the contribution of these different parameterisations to the actual model differences is not quantified. Finally, in the first paragraph of the conclusions is already written : "Additional model diagnostics are required to completely understand the differences among models." I think such suggestions should be made at the end of the conclusions.

I write this because, at the moment, as a reader one gets the impression that certain things will be investigated or analyzed, but in the end they are not. It would therefore be nice if the analysis could be improved and extended. What type of model components play a large role in the modeling of the chemical composition of the Arctic atmosphere? If this extension is not possible, then it should be explained why only the clouds and photolysis rates are explicitly illustrated. In that case also, make the text more clean and sober: focus only on the aspects you really investigate in the study. Just mention the ones you don't investigate (and possibly estimate their relevance based on other studies for the Arctic), but state from the beginning that they are not the focus of the study. Therefore the abstract, Section 4, and the Conclusions (Section 7) should be thoroughfully rewritten.

There are valuable conclusions about the emissions data set. However, these conclusions only have a value if this is a publicly available dataset, and which is intended to be used by others, or which at least can be investigated. Although the webpage http://bio.cgrer.uiowa.edu/arctas/emission.html was accessible, further links which would guide to the data did not work. The links on that web-

ACPD
14, C11302–C11337, 2015

page which did not work were : (i) "This inventory is available for download", and (ii) "Gridded emissions can be accessed at the University of Iowa ACESS website http://www.cgrer.uiowa.edu/EMISSION_DATA/index_16.htm, under the direction of Gregory Carmichael, Principal Investigator of this project."

Further, I think the manuscript contains too many figures.

The structure of the paper could be improved. Now the Sections 4, 5, and 6 all contain results, so they might be brought together (as Sections 4 and 6 are short). Section 3 should have a more general title.

Below you can find : (i) a list of smaller general remarks, (ii) a list of detailed comments on the manuscript text, (iii) a list of detailed comments on the tables, and (iv) a list of detailed comments on the figures

SMALLER GENERAL REMARKS

1. Figures There are too many figures. In some figures, too small fonts are used. Some plots are too small. The layout of some of the figures should be improved.

2. For MOZART, 2 things are unclear : (i) which photolysis rate calculation is actually used for the principal simulations? (ii) how are the clouds and the humidity calculated? Is CAM (nudged to GEOS-5) also used?

3. Maybe mention a bit more explicitly which papers are companioning papers within POLMIP. I presume that Monks et al. [2014] and Arnold et al. [2014] are, but this is not explicitly said. Are there others?

4. I would consequently use "wildfire" instead of "fire".

5. Abbreviations Be consequent in how abbreviations are defined : first the long expression, followed by the abbreviation between brackets. It is probably not possible to always follow this rule, but try to be as consequent as possible. What strategy is followed for the first letter in the full expression : CTM (small letter in full expression),

ACPD
14, C11302–C11337, 2015

GCM (big letters in full expression), SLCP (small letters in full expression)?

6. Homogenize the description of the different models (see DETAILED COMMENTS on TEXT)

7. LMDZ-INCA, LMDZ both are used in the text. Try to just choose one.

DETAILED COMMENTS on TEXT

Please find below a list of detailed comments. Among these, there are quite some comments and suggestions about language use. Feel free not to follow these suggestions on language, but please give a good reason why you do not do so.

p 29332 : Norrkoping -> Norrk\"oping (\" on the o)

p 29332 : University Innsbruck -> University of Innsbruck

p 29333, l 2-3 : "atmospheric chemistry observations" : this is a bit vague.

p 29333, l 5-11 : 5 times "differences" on only a few lines

p 29333, l 15-23 : the order of these last three sentences is a bit strange. First, a sentence about usefulness of aircraft observations without conclusions. Second, a sentence about satellite observations with conclusions. Third, a sentence about aircraft observations (although) with conclusions. Maybe sentence one and three can be put together.

p 29334, l 3-5 : Two aspects are mentioned ((i) heat transport from lower latitudes, (ii) local radiative forcing). The second one is really about climate change, while the first one is even true without climate change. Try to formulate more precisely.

p 29334, l 8 : aerosol -> aerosols (as on line 5)

p 29334, l 27-28 : twice "significant" in the same sentence

p 29335, l 4 : "it" refers to "Arctic" I presume. It would be clearer to explicitly write it.

ACPD
14, C11302–C11337, 2015

p 29335, l 12-16 : maybe add "only" before "in close proximity", and "mainly" before "retaining only". Otherwise the last 3 parts of the sentence do not fit together well.

p 29335, l 21 : "slow" before "mixing"?

p 29335, l 22 : and more -> or more

p 29335, l 25 : "Climate" -> "of Climate" in the definition of POLARCAT

p 29336, l 5 : "focused" -> "focuses"

p 29336, l 5 : "this comparison" : does this refer to the whole POLMIP, or just to this paper? Is POLMIP limited to gas phase chemistry evaluation?

p 29336, l 9-10 : "evaluate ... with ... observations" : is this correct language use?

p 29336, l 13-14 : "by methyl chloroform observations and emissions" : maybe "by methyl chloroform observations and its emission estimates"

p 29336, l 17 : "than transport does" -> "than differences in transport"

p 29336, l 23 : "efficiency in" -> "efficiency of"

p 29336, l 24 - p 29337, l 2 : I would suggest to add section numbers in this paragraph

p 29336, l 26 : "of all of the models to observations" -> "of model results with observations"

p 29336, l 26-28 : This sentence is a bit strange as an ozonesondes is more an instrument, wile "NMHC" and "compounds" are species. I would suggest to homogenize the sentence.

p 29336, l 28 : "emissions" -> "the emissions"

p 29337, l 4 : "collaboration of experiments" : is this the correct description?

p 29337, l 12-13 : "of each mission" -> "for each mission"

ACPD
14, C11302–C11337, 2015

p 29337, l 13-14 : "transported to the Arctic" : shouldn't it be after "wildfire plumes" (if the measured wildfire plumes are not the ones going to the Arctic, than the sentence is correct I think)

p 29337, l 17-18 : abbreviation precedes the full name, while different for ARCTAS

p 29337, l 20 : is the word "sources" needed?

p 29337, l 21 : fire plumes -> wild fire plumes

p 29337, l 24 : "Spring" -> "spring", maybe cancel "in spring" as the dates make this clear (between 30 March and 11 April).

p 29338, l 1 : shouldn't GRACE be explained : Greenland Aerosol and Chemistry Experiment?

p 29338, l 2 : "Greenland" maybe not needed as already mentioned on page 29337, l 25. On the other hand, it is maybe good to repeat it.

p 29338, l 5 : here again the explanation follows the abbreviation. Maybe it is unavoidable due to the YAK-part.

p 29338, l 10 : the section "3 Models" seems to be more general than just about models. Another title might be more appropriate.

p 29338, l 12 : twice "output" -> maybe change the second one into "monthly mean species distributions and diagnostics"

p 29338, l 14-15 : there is some tension between "All the models" and "with a few exceptions". Maybe change in "Most of the models"

p 29338, l 16 : "global" - except WRF?

p 29338, l 16 : "meteorology" is vague; maybe "meteorological forcing". In addition to differences in "chemistry scheme", "meteorology", and "deposition schemes", the models probably also differ in vertical distribution of BB emission distribution, tracer

ACPD
14, C11302–C11337, 2015

transport schemes, detrainment/entrainment rates in convection, etc.

p 29338, l 17-18 : twice "output", and "a number" should be avoided. Maybe : "... included monthly mean distributions of mixing ratios and some other diagnostics"

p 29338, l 18 : "evaluation" -> "an evaluation"

p 39338, l 20 : "a smaller number" -> "a limited number"

p 29339, l 2 : www.ceip.at -> http://www.ceip.at as on p29335, l 28

p 29339, l 3-5 : maybe the sentence can be rewritten to have "speciation" only once

p 29339, l 4 : is in this paper VOCs used to describe the same set as NMHC (defined on p 29336, l 27)?

p 29339, l 6-8 : "provided daily" : maybe also mention that they are given to/used in the models on daily basis too.

p 29339, l 7 : INventory to agree with FINN (maybe put N as a capital letter)

p 29339, l 10 : "these" -> "the ARCTAS", because "these" is confusing as different emission datasets are mentioned just above

p 29339, l 11 : "showed" -> "showed that"

p 29339, l 17 : "usual" -> "standard"

p 29339, l 19 : "intercomparison" -> "POLMIP intercomparison" to make clear that it is not just about this paper

p 29339, l 19 : "dynamics" -> "tracer transport"

p 29339, l 26 : "far removed" -> far away

p 29339, l 28 : "This offset in location produces differences in atmospheric composition" : I think I understand what is meant, but it should be expressed more clearly

ACPD
14, C11302–C11337, 2015

p 29340, l 4 : "March through August" -> looking at Fig. 1, I would rather say "March through July"

p 29340, l 10-11 : meteorology -> "origin of meteorological data"

p 29340, l 12 : Table 1 -> Table 2

p 29340, l 27 : "integrated forecasting system" -> "Integrated Forecasting System"

p 29340, l 27-28 : I would add "(ECMWF)" after "European Centre for Medium Range Weather Forecasting" (it is later used, e.g., on p 29342, l 20)

p 29341, l 4-5 : is it necessary to mention "and applies the emission and dry deposition fluxes as part of the vertical diffusion scheme"?

p 29341, l 5-6 : is this the best way to describe this?

p 29341, l 2 : CTM is defined here while "chemical transport model" is already used earlier (e.g. p 29334, l 27). The definition should be given there.

p 29341, l 7 : "model convective precipitation" -> "convective precipitation"

p 29341, l 7 : "the C-shaped profile" -> "a C-shaped profile"

p 29341, l 10 : 3-D is defined later (page 29343, l 26)

p 29341, l 19 : "includes an" -> "includes "

p 29341, l 24 : GMI : abbreviation first

p 29341, l 25 : I would replace "chemical transport model" by "CTM"

p 29341, l 27-28 : is it necessary to mention "with all the emissions from the specified inventory". I would rather only mention the exceptions to this rule.

p 29342, l 1 : "several" : are there more than these 2? If so add "e.g.," at the beginning, or ", ..." at the end.

ACPD

14, C11302–C11337, 2015

p 29342, l 5 : "but" -> "and"

p 29342, l 9 : LMDz should be after the full expression

p 29342, l 9 : the definition of GCM, should not use capital letters to be in agreement with the definition of CTM : so general circulation model

p 29342, l 11 : ORCHIDEE should be after the full expression

p 29342, l 16 : "gasphase" versus "gas-phase" (both used in the text)

p 29342, l 18-19 : I would write "sulfate" instead of "sulfates"

p 29342, l 20 : "6h" too cryptic -> "6-hourly"

p 29342, l 23 : "global annual total" -> "global annual total emission"

p 29342, l 24 : abbreviation before long expression

p 29342, l 25 : use the abbreviation CTM (because it is introduced earlier on p 29341, l2)

p 29342, l 26-28 : should it be mentioned that the specified emissions have been used?

p 29342, l 28-29 : which one is actually used for the analysis here? In Fig. 4, they are presented both: but what with the rest of the analysis?

p 29343, l 3-5 : this sentence is identical to the one for GMI, except for the list of oxygenated hydrocarbons. Maybe try a slightly different formulation.

p 29343, l 5 : "is the same"; but the CAM-chem explication mentions stratospheric chemistry"? Are the aerosols identical?

p 29343, l 9 : abbreviation before definition

p 29343, l 16 : "It includes ..." -> "In total, the TM5 chemical mechanism ..."

p 29343, l 18-19 : is it worth mentioning this specificity, as other models might also do

ACPD
14, C11302–C11337, 2015

it (but just don't mention it in their description)?

p 29343, l 22 : "as" -> "than"

p 29343, l 23 : "by a fourth-order polynomial function" -> "as a function of"

p 29343, l 20-25 : is the lightning parameterization of TM5 the same as the one of C-IFS? But apparently different aspects are stressed.

p 29343, l 25 : has TOMCAT a name definition? 3-D should be defined earlier.

p 29344, l 1 : "Extended Tropospheric chemistry" : shouldn't chemistry start with a capital letter?

p 29344, l 3 : aerosol -> aerosols

p 29344, l 5 : the ";" between the references -> "and"

p 29344, l 9 : full expression for MATCH?

p 29344, l 9 : chemistry transport model -> CTM

p 29344, l 16: "in (Andersson et al. 2007)" -> "in Andersson et al. (2007)"

p 29344, l 16 : "evaluation" -> an "evaluation"

p 29344, l 17 : this should not be "we" as it does not refer to all authors

p 29344, l 20 : I would add "only" after "but"

p 29344, l 20 : "reaching about 16 km" -> "reaching about 16 km high"

p 29344, l 21 : I would skip "In addition to the standard daily POLMIP emissions"

p 29344, l 23 : "annual global total" -> "annual global total emission"

p 29344, l 23-25 : why specifically mentioning the DMS emissions?

p 29344, l 25 : Maybe something can be mentioned about the boundary conditions for

ACPD

14, C11302–C11337, 2015

tracer concentrations at the 20N boundary?

p 29344, l 26 : has WRF a full name?

p 29345, l 5 : fire -> wildfire

p 29345, l 5 : 1 -> 1 x 1

p 29345, l 13 : GOCART (definition after abbreviation)

p 29345, l 17 : N. America -> North America

p 29345, l 24 : "meteorology fields -> "meteorological fields"

p 29345, l 25-27 : shouldn't it be LMDz instead of LMDZ?

p 29346, l 3-4 : How can you calculate water vapour only based on surface water fluxes? Is there a cloud parameterization in MOZART? Is there CAM behind?

p 29346, l 15 : "that are" -> "which are" ; "source of" -> "source for"

p 29346, l 21 : "agree on in the location" -> "agree on the location" or "agree in the location"

p 29346, l 26 - p 29347, l 2 : by mentioning explicitly dry deposition, one can give the impression that dry deposition is determining for the tropospheric ozone differences. Especially the April differences in the NH will only by slightly impacted by the deposition scheme, I presume. Isn't the influx from the stratosphere determining: is there a difference in performance among models which prescribe O3 at the top of the model, and those using explicit stratospheric chemistry?

p 29346, l 28 : "surface layer" : or is it meant "boundary layer"? The surface layer is often just a fraction (1 tenth) of the boundary layer.

p 29347, l 4 : magnitude -> should be little bit more specific like "concentration/mixing ratio/value"

ACPD
14, C11302–C11337, 2015

p 29347, l 5-6 : I would think that the other models possibly also show a maximum in the tropical mid- to upper-troposphere. But when that maximum is lower than 2x10-6 it will not be visible in this type of plots. Maybe change : "maximum" -> "a maximum higher than 2x10e-6".

p 29347, l 7 : "have" -> "reach OH concentrations of"

p 29347, l 11 : "a number of compounds" -> I would suggest to be more specific

p 29347, l 14 : CO was already used on page 29334, so the definition should come earlier

p 29347, l 17 : C2H6 already mentioned earlier, so should be defined earlier

p 29347, l 17-19 : can differences in transport contribute to these differences?

p 29347, l 19 : Table 1 -> Table 2?

p 29347, l 21-22 : inverse order of H2O2 and hydrogen peroxide

p 29348, l 2-3 : strange sentence, improve it.

p 29348, l 15 : "The hourly model output" -> "Hourly model output"

p 29248, l 21 : can one learn something from showing additionally RMSE-profiles?

p 29248, l 24-25 : what type of upper boundary conditions have been used in SMATCH? Maybe also refer to Figs. 5 and 7 where the different behavior of SMATCH was noticeable.

p 29248, l 25 - p 29349, l 1 : GEOS-chem : can this be linked to the different emissions? Is there a reason for this?

p 29349, l 10 : provide -> provides

p 29349, l 12 : "over a range of latitudes" : "over a range of mid- to high latitude stations"

ACPD
14, C11302–C11337, 2015

p 29349, l 15 : "altitude" : has for some of the stations a model level different from the lowest level been chosen?

p 29350, l 1-3 : While the former sentence indicates an advantage of using averaging kernels, this sentence mentions a possible disadvantage. Therefore I would replace "also" by something like "on the other hand", or start with "however".

p 29350, l 4-5 : I think this introductory sentence should be improved.

p 29350, l 10 : "fires" -> "wild fires"

p 29350, l 14-16 : can this be more specific?

p 29350, l 17 : "median", while the figure 13 caption says "mean"

p 29350, l 19 : I think this "while"-construction is not so lucky; "regions" : I'd rather use the word "pixel" again, or "grid point"

p 29350, l 21-22 : "Figure 13a and c" -> "Figures 13a and c"

p 29350, l 23 : median

p 29350, l 24-26 : "Northwest" , while "north east" on line 9

p 29350, l 29 : "East-China", while "East China" on line 13 (but here it is more an adjective)

p 29350, l 29 : "indicating a large uncertainty introduced by the models" : this looks like models introduce uncertainty. I'd rather say that our knowledge is uncertain.

p 29351, l 5 : "for forests" -> "for forest fires"

p 29351, l 6 : "the hourly output" -> "hourly output"

p 29351, l 11 : I would put (A1, A2) immediately behind ARCTAS-A

p 29351, l 19 : GRACE -> to "-GRACE"

ACPD

14, C11302–C11337, 2015

p 29351, l 20 : fire -> wild fire

p 29351, l 22 : "with" -> "and"

p 29351, l 24-25 : the same -> in the same way

p 29351, l 25 : "were" -> "was"

p 29351, l 26 : "measurement uncertainty" : is this the measurement uncertainty on one single observation? Or is it a reduced uncertainty as the observations shown are already the mean/median over a large number of individual observations?

p 29351, l 22 - p29352, l 2 : In this short paragraph of text, three large figures are introduced. In the following sentence "To make a more quantitative ...", one temporarily gets the impression that these profiles as such will not be discussed anymore further. However, in the next 2 pages, one refers several times to the profiles. To avoid this initial misconception, I would start the sentence "To make a more ..." by something like "in addition".

p 29352, l 12 : "indicating" -> "indicating that"

p 29352, l 14 : 100% -> 90 %

p 29352, l 17 : (Fig. 14) -> (Fig 18.)

p 29352, l 18 : hugely : I would use another word

p 29353, l 2 : "of too fine a scale" -> "of a too fine scale"?

p 29353, l 7-8 : I would replace the first "with" by "and"

p 29353, l 8 : ethanol is not shown in figure 19?

p 29353, l 9 : a poor job of : can you express this differently?

p 29353, l 10 : much closer is true for CARB, but not for B

p 29353, l 16 : refer to Figs. 16 and 18, after "For ARCTAS"

ACPD

14, C11302–C11337, 2015

p 29353, l 16-18 : however if the conditions are homogeneous, it should not have a large impact. And if the flight legs are long, part of the observations will be in/below/above clouds, and averages can than still make sense.

p 29353, l 18 : These average biases -> "The average biases"

p 29353, l 20 : I would add "(see Fig. 18)" after "In summer"

p 29254, l 4 : fires -> wild fires

p 29354, l 7-8 : is the "," before "back trajectories" correct?

p 29354, l 15 : "make" -> "makes"

p 29354, l 21 : express 252-258 E as 92-98 W, etc ...

p 29354, l 21 : between the surface and 850 hPa (to avoid confusion)

p 29355, l 1 : 252-258E : express as ... W

p 29355, l 19-20 : maybe you can add "POLMIP"

p 29355, l 23 : "driven to at least some degree by observed ..." -> "driven by, to some degree at least, observed ..."

p 29355, l 23-24 : meteorology -> meteorological data/fields

p 29355, l 25 : "occurred among the model outputs" -> "occurred in the model results"

p 29356, l 3 : I would not write "completely", as that is probably a too high expectation

p 29356, l 1-6 : this is a very weak conclusion : just illustrating differences, and requiring for "additional model diagnostics in the future". This contradicts with the suggestion in the abstract (line 5-6) "to quantify the differences in model chemistry and transport schemes". Do we learn something about transport schemes? Suggestions for new/other research should be stated at the end of the conclusions.

p 29356, l 7-9 : Why is this a reason?

ACPD

14, C11302–C11337, 2015

p 29356, l 14 : indicate -> indicate that

p 29356. l 19 : "dynamics" : this contradicts a bit the sentence on p 29355, l 23-25, where it was suggested that all model represent the "dynamics of the study year".

p 29356, l 29 : OVOCs should be defined. Or is VOC meant?

DETAILED COMMENTS on the TABLES :

Table 1 : The abbreviation "bb" should be defined in the caption or in the text. BIGALK, BIGENE, ... should be defined (or referenced).

Table 2 : Try to use the same naming for acetone and methanol as in Table 1.

Table 3 : For WRF-Chem, the number of levels is not indicated. In the chemistry description for WRF-Chem is written "MOZART" : is this "MOZART-4"?

DETAILED COMMENTS on the FIGURES :

Figure 2 : The colours for CAM4-chem and CAM5-chem are very similar (as in other figures). Can this be changed? Units for pressure should be mentioned [hPa]. Is the unit mmol/mol for water vapour correct (as often water vapour mixing ratio is expressed in kg/kg or g/kg)? If possible, it would be nice if some extra values where given on the y-axis (e.g. 200, 500, 700 hPa).

Figures 3-4 : These plots are too small.

Figures 3-6 : Units for Pressure should be mentioned (on the y-axis or in the caption), and if possible extra values should be indicated on the y-axis.

Figure 7 : It would increase the readability of the figure when the names of the species are mentioned on the top of every individual plot (instead of on the y-axis). Only having on the y-axis "mixing ratio [ppbv]" would be ok. The common title "50-70N ZA 700 hPa" is not nicely integrated in the figure. The text in the caption is possibly enough to make this clear.

ACPD
14, C11302–C11337, 2015

Figure 9 and 10 : It would be nice to have the station latitude (and possibly the longitude) in the top of every individual plot. If possible, it would be nice to have some more pressure values on the y-axis. It would be nice to have the number of sondes indicated in the plots. It is mentioned in the text that there were daily launches during April, but it seems that for some stations there were much less than 30 profiles available.

Figure 11 : Try to use for the longitude the "... W" notation if the longitude is between 180 E and 359 E.

Figure 12 : I don't know if the general title for this figure is needed - I would rather use the figure caption for this. Possibly add "upper left panel" after "OMI tropospheric column NO2". The figure is in general too small to read the values and units on the colourbar.

Figure 13 : The text in this figure is too small. It would be nice to indicate the boxes also in the bias figures (although it is true that the reason for their definitions comes from the OMI plot). The actual link between the individual boxes in Fig. 13 and individual descriptive names used in Fig. 14 and in the text (NW-Europe, NE-US., E-China, Japan, S. Korea, W. Asia, E. Asia, Canada, East. Sib.) are never explicitly made. Maybe one should, or (i) indicate the names in the figures next to the boxes, or (ii) make a table giving the coordinates of the boundaries/corners of the areas.

Figure 14 : A too small font is used in this figure. The word "model" is difficult to read in the upper right blue box. Somewhere should be mentioned that one looks at column values. I would replace "whiskers to" -> "whiskers show" or "and whiskers".

Figure 15 : Within the figure I would also write "ARCTAS-CARB instead" of "ARCTAS-C" to limit ambiguity.

Figure 16 : Species names should be shown at the top of the figures. There are also x-axis labels winch overlap. One should try to improve the writing of "j o3 o1d" into "j(o3->o1d)" and "j no2" into "j(no2)".

ACPD
14, C11302–C11337, 2015

Figure 17 : The mentioning of "ARCPAC P3 April 11-21" is not very elegant with respect to the rest of the figure (same comment as for Fig. 7). It would also be more practical for the reader if the names of the species should be mentioned at the top of the individual plots instead of below the x-axis.

Figure 18 : There are overlapping or too close values on the x-axis for some of the plots. Name of the species should be mentioned on the top of each individual plot, instead of on the x-axis. The x-axis should contain "mixing ration [ppbv]" or just "[ppbv]".

Figure 19 : The way "Campaign" (horizontal) and "Model Bias (%)" (vertical) are added in the figure should be improved. Eventually change the caption to contain the information, e.g. : "Mean bias" -> "Mean bias (%)" and "A1 : ARCTAS ..." -> "The campaigns are ..." . I would also write "ARCTAS-A1" and "ARCTAS-A2" instead of "ARCTAS-A" twice.

Figure 20 : In the caption, I think Enhancement Ratio can be written with small letters. Does it make sense to also plot the uncertainty on the estimate from the models? Or does that give no interesting information? and whiskers".

Figure 15 : Within the figure I would also write "ARCTAS-CARB instead" of "ARCTAS-C" to limit ambiguity.

Figure 16 : Species names should be shown at the top of the figures. There are also x-axis labels winch overlap. One should try to improve the writing of "j o3 o1d" into "j(o3->o1d)" and "j no2" into "j(no2)".

Figure 17 : The mentioning of "ARCPAC P3 April 11-21" is not very elegant with respect to the rest of the figure (same comment as for Fig. 7). It would also be more practical for the reader if the names of the species should be mentioned at the top of the individual plots instead of below the x-axis.

Figure 18 : There are overlapping or too close values on the x-axis for some of the plots. Name of the species should be mentioned on the top of each individual plot, instead of

ACPD

14, C11302–C11337, 2015

on the x-axis. The x-axis should contain "mixing ration [ppbv]" or just "[ppbv]".

Figure 19 : The way "Campaign" (horizontal) and "Model Bias (%)" (vertical) are added in the figure should be improved. Eventually change the caption to contain the information, e.g. : "Mean bias" -> "Mean bias (%)" and "A1 : ARCTAS ..." -> "The campaigns are ..." . I would also write "ARCTAS-A1" and "ARCTAS-A2" instead of "ARCTAS-A" twice.

Figure 20 : In the caption, I think Enhancement Ratio can be written with small letters. Does it make sense to also plot the uncertainty on the estimate from the models? Or does that give no interesting information?

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 29331, 2014.