Atmos. Chem. Phys. Discuss., 13, C8147–C8169, 2013
www.atmos-chem-phys-discuss.net/13/C8147/2013/

Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Climatology of pure Tropospheric profiles and column contents of ozone and carbon monoxide using MOZAIC in the mid-northern latitudes (24 N to 50 N) from 1994 to 2009" *by* R. M. Zbinden et al.

R. M. Zbinden et al.

regina.zbinden@aero.obs-mip.fr

Received and published: 17 October 2013

Reply to Anonymous Referee 1

We are very grateful to the Anonymous Referee for his insightful review, useful comments, valuable suggestions and detailed corrections which help to improve the quality of the manuscript. We have followed your suggestions.

Minor Comments and Suggestions:

- By using the ozone and CO datasets from MOZAIC, the authors are able to use the correlation between ozone and CO to diagnose the impact of different processes or air mass origin. However, to my knowledge, the NO_x data has also been available since 2001. The ability to pin down upper tropospheric enhancements of NO_x comes to mind as potentially useful additional information in the interpretation.

Reply : *The NO_y measurements have been performed on only one MOZAIC aircraft, starting in 2001 for four years, and among them only very few NO_x measurements are available. For example, the data base includes over Germany, the best documented site, 16,041 O_3 profiles, almost 500 NO_y profiles, and less than 20 NO_x profiles. Therefore, due to this NO_x sampling, NO_x cannot be included in our climatology.*

- While there are over 40,000 aircraft profiles used in the climatology presented in the paper, some of the sites are severely undersampled as the authors point out. In particular, I wonder about the statistical significance of the seasonal cycle and the danger of overinterpretation at Los Angeles and think the discussion about this site could be scaled back greatly.

Reply : *Yes, some sites are poorly sampled as pointed out in the text. Nevertheless, the MOZAIC documentation at Los Angeles is a reference to complement other results from research aircraft campaigns which are also sparse in space and in time. No measurement regularly documents the whole troposphere in these area, if we except remote sensing data. Moreover, we have tested the seasonal variability of PTP(O_3, z, t) when the data set over Germany is under sampled consistently with the Los Angeles sampling (300 profiles) in 24h time-coincidence. We found the O_3 dichotomy can still be clearly observed on the seasonally-averaged tropospheric profiles (Figure S1), with more fine structures seen on the undersampled profiles. We agree with your argument on the poor sampling and have revised the text accordingly.*

Below, modifications as suggested

⇒ Regarding the O_3 seasonal cycle, we have replaced Page 14707 Line 29 - Page 14708 Line 4 by *In summer, the secondary peak appears rather small, despite a high z_{DT}, probably under a strong influence of subtropical Pacific air masses that Oltmans et al. (2008) have already shown. From the 24 hours backward trajectories (provided on MOZAIC web site), 50% of the 1994-2006 profiles in summer reveal a subtropical Pacific air mass origin (36% in May, not shown). In addition, during wintertime, the O_3 exceeds 27 DU in Los Angeles and is in the range of the Asian sites. This site is included in the study in spite of its poorest sampling, considered to be the lowest limit acceptable.*

⇒ Regarding the CO seasonal cycle, we have replaced Page 14710 Line 20-24 by *The Los Angeles amplitude is 50% greater than in the other US cycles. The winter-spring maximum is almost equivalent to that of the northern US sites while the deep narrow low minimum in late summer suggests probably an impact of the depleted polluted air from Asia or clean air from southern Pacific. Despite the poorest MOZAIC CO sampling, the seasonal cycle appears to be captured as well.*

⇒ Regarding the North American profiles, we have replaced Page 14713, Line 10-22 by *Considering now Los Angeles, the typical autumn/winter and spring/summer seasonal dichotomy is not found. The profiles exhibit fine structures along the vertical, probably accentuated by the low MOZAIC monthly sampling rate. However, the spring O_3 spikes of +0.03 DU between 2 and 7 km could be indications of long-range transport from Asia as shown by Jaffe et al. (2003), Parrish et al. (2004), Cooper et al. (2005) and Neuman et al. (2012). The summer O_3 profile, above 1 km, is unusually close to the autumn-winter one (less than 0.02 DU difference) while CO is extremely low, that might be related to air coming from the southern Pacific as already studied by Oltmans et al. (2008) and Neuman et al. (2012). In contrast, below 1 km, the highest summer maximum of all the sites studied (0.28 DU) seems more in agreement with the lack*

of deep convection studied by Cooper et al. (2006). The winter CO is higher than elsewhere in the US. Thus, to summarize from what MOZAIC has measured under this poor sampling, the secondary peak of the $PTC_m(O_3)$ cycle, in summer, depends on a high z_{DT} and on heavy local pollution as O_3 in the BL reaches 0.28 DU (maximum of the overall study) with high CO up to 3 x *10^{16} mol/cm^2.*

⇒ Regarding the conclusion, we have replaced Page 14723, Line 3-4, by : *In addition, Los Angeles is almost in the range of Asian pollution, excepted in summer when incoming air from the Pacific probably strongly interplays. We found that, to be included in a climatological study, Los Angeles is at the lowest sampling rate acceptable.*

- Page 14700, Line 18: How sensitive are the results to the choice of a 2 PVU cutoff for the tropopause and how easily would it be to offer an alternate dataset with say a change in the lapse rate instead? From a model comparison perspective, it may be difficult to compare with a pure tropospheric climatology from MOZAIC if there are differences in how the tropopause is defined.

Reply 1: *Regarding your question on the choice of a 2 PVU cutoff for the tropopause, and the sensitivity of the results, we refer to Thouret et al. (2006) who have already discussed this criterion with the MOZAIC data set when selecting only the cruise part of flights to document the upper-troposphere/lower-stratosphere. These authors have defined the tropopause layer as a layer between z_{DT} + 15 hpa and z_{DT} - 15 hpa. In the present paper, we selected the 2 pvu surface to fix the z_{DT} and by using the same definition, our results, excluding the stratospheric air-mass for each individual profile, are consistent with their results. Thus, we did not discuss again this topic.*

Reply 2: *Regarding your question to offer an alternate dataset with say a change in the lapse rate instead of a 2 pvu cutoff, technical reasons will be the most important limitation to decline. In fact, the lapse rate criterion could be fixed only at an altitude (z_{lr}) below z_{top}-1 km , and more tropospheric profiles would remain uncompleted without* *perspective to be included in the study. When z_{lr} is above z_{top}-1 km it seems unrealistic to use temperatures from an external data set that satisfy the MOZAIC vertical resolution (50 m) in order to fix z_{lr}. We have the feeling it would not benefit to the tropopause positioning accuracy and to further scientific objectives. For that reason, the MOZAIC data base provides, along all the flight tracks and for each measurement (i.e. during ascent, cruise and descent phases), the PV value and the pressure of iso-PV surfaces (1.5, 2, 3 and 4 pvu). Moreover, the dynamical tropopause has been already used in satellite/ground truth comparison (de Laat et al., 2009; Clerbaux et al., 2008; Bak et al., 2013).*

Below, modifications as suggested

⇒ Add accordingly to the Osman review Page 14701, before Line 20: *The Table S1 provides the percentage of profiles corresponding to the 3 cases encountered at the 11 sites.*

⇒ Replace Page 14700, Line 17-18 by : *To set up z_{DT} at time t, . . .the potential vorticity pressure of 2-PVU is used, referring to the study by Thouret et al. (2006) with MOZAIC data when selecting only the cruise part of flights to document the upper-troposphere / lower-stratosphere.*

⇒ Add Page 14699 Line 27, before "However. . ." : *The dynamical tropopause criterion is more adapted than the lapse rate to capture the tropospheric ozone trends (on sites where statistics are significant) and to distinguish the contribution of the stratospheric exchanges from the strict troposphere mostly due to anthropogenic activities, in further studies. Additionally, the dynamical tropopause has been already used in satellite/in-situ comparison (Clerbaux et al., 2008; Hegglin et al. 2008; de Laat et al., 2009; Bak et al., 2013). Furthermore, some technical reasons reinforce the choice of using a dynamical tropopause instead of the lapse rate criterion as explained in section 3.1.*

⇒ Add the reference : *Bak J., Liu X., Wei J. C., Pan L. L.,Chance K. and Kim J.*

Table S1. Percentage of MP profiles for the 3 cases where $z_{DT} < z_{top}$, $z_{top} < z_{DT} < z_s$, $z_{top} < z_s < z_{DT}$.

	Percentage of MP with		
Sites	$z_{DT} < z_{top}$	$z_{top} < z_{DT} < z_s$	$z_{top} < z_s < z_{DT}$
Los Angeles	24.3	31.3	44.3
USeast	41.9	31.9	26.2
USlake	43.5	34.3	22.1
USsouth	10.5	26.6	62.8
Paris	46.0	46.0	8.0
Germany	49.5	44.4	6.1
Vienna	58.4	36.3	5.3
Eastmed	34.8	16.3	48.9
Uaemi	4.5	5.1	90.4
Beijing	48.2	36.0	15.8
Japan	31.4	29.3	39.2

H., Improvement of OMI ozone profile retrievals in the upper troposphere and lower stratosphere by the use of a tropopause-based ozone profile climatology, Atmos. Meas. Tech., 6, 2239–2254, doi:10.5194/amt-6-2239-2013, 2013.

⇒ Add Page 14701 Line 2: *If the lapse rate criterion was selected instead of a dynamical criterion, the thermal tropopause could have been fixed only at an altitude (z_{lr}) below z_{top} -1 km. The different z_{top}, z_{lr} and z_{DT} are shown for case (a) of Fig. 1. Consequently, using z_{lr} instead of z_{DT}, more profiles would be turned into uncompleted tropospheric profiles, without any perspective to be completed.*

⇒ Replace Fig. 1 to show the position of z_{lr} in case (a).

- Page 14703, Line 4: Please list the number of coincident profiles and for what subset of the years the MOZAIC/WOUDC comparison is made.

Reply : *It has been done.*

Below, modifications as suggested

⇒ Replace Page 14703 Line 2 and 3 after "…available for neighbouring areas :" by *Wallops Island for USeast (936 sondes from 1994-08-22 to 2009-03-27 with 640 MOZAIC profiles in time-coincidence) Hohenpeissenberg for Germany (1823 sondes from 1994-08-01 to 2009-03-30 with 5127 MOZAIC profiles in time-coincidence) and Tateno for Japan (798 sondes from 1994-08-10 to 2009-03-26 with 402 MOZAIC profiles in time-coincidence).*

- Page 14703, Line 4: What is the precision of the WOUDC measurement?

Reply : *Smit and Team ASOPOS (2013) have discussed in details the quality of ozonesonde measurements. They mentioned "the effective height resolution of the vertical profile of an ozonesonde is 100-150 m" which is comparable or slightly less than MOZAIC. They specify "in the absence of significant concentrations of interfering gases, ECC ozonesondes have a precision of 3-5% and an absolute accuracy of about 10% in the troposphere, since differences in sonde manufacture and preparation introduce tropospheric biases of* $\pm$*5%". Their Table 3.3 provides bias, precision and accuracy of the most common ozonesondes (with Electrochemical Concentration Cell (ECC sondes, at Wallops Island), Brewer-Mast (BM sondes, at Hohenpeissenberg) and Carbon Iodine cell (KC sondes at Tateno)). Between the surface and 15 km, the bias is from 0 to – 7%, the precision is from 3 to 10% and the accuracy from 4 to 13%.*

Below, modifications as suggested

⇒ Add Page 14703 at the end of line 3: *The effective height resolution of the vertical profile of an ozonesondes is 100-150 m and the bias, the precision and the accuracy differ with ozonesonde types: Electrochemical Concentration Cell (ECC sondes, at Wallops Island), Brewer-Mast (BM sondes, at Hohenpeissenberg) and Carbon Iodine*

(KC sondes at Tateno), as discussed in details by Smit and Team ASOPOS (2013). They indicate, between the surface and 15 km, the bias varies from 0 to – 7%, the precision from 3 to 10% and the accuracy from 4 to 13%. Thus, ozonesonde quality results depend on instrument type, launch conditions and altitude, while MOZAIC does not.

⇒ Add the following reference: *Smit, H. G. J., and Team ASOPOS. Quality assurance and quality control for ozonesonde measurements in GAW. WMO/GAW Rep 201 (2013).*

- Page 14703, Line 4: Is there no coincident measurement that you could use to also validate the impact of Mfit on CO?

Reply : *No, for CO, as far as we know, there is nothing equivalent to the WOUDC ozonesondes we could use to validate the impact of Mfit on CO. The World Data Centre for Greenhouse Gases (WDCGG) collects only data from sites at the ground surface.*

- Page 14709, Line 21: Please list the satellite retrieval versions used in the studies. For example, the instrumental drift for MOPITT has been corrected in the latest version of the retrieval (Deeter et al., 2013).

Reply : *This has been done, it was missing, thank you.*

Below, modifications as suggested

⇒ Replace Page 14709, Line 21-22 : *SCIAMACHY error range estimate of CO total columns (version 6.3) is 0.05-0.1* x*10*^{18}*mol/cm*^{2} *(de Laat et al., 2007);*

⇒ Add the reference: *Laat, A.T.J. de, A.M.S. Gloudemans, I. Aben, J.F. Meirink, M. KROL, G. van der Werf and H. Schrijver, SCIAMACHY carbon monoxide total columns: Statistical evaluation and comparison with CTM results. J. Geophys. Res., 112, 2007, doi:10.1029/2006JD008256, 2007.*

⇒ Replace Page 14709, Line 22-23: *ACE-FTS (version 2.2) has a 16% positive bias maximum on 108 MOZAIC coincidences (Clerbaux et al., 2008) between 5 and 12 km, where interfering species and temperature uncertainties have the strongest impact.*

⇒ Replace Page 14709, Line 23-24: *ACE-FTS (version 2.2) compared to SPURT aircraft data result in relative differences in the mean of ±9% and ±12% in the upper troposphere and lower stratosphere, respectively (Hegglin et al., 2008) with an estimated 1 km vertical resolution;*

⇒ Replace Page 14709, Line 24-26: *From MOPITT and the HIAPER Pole to Pole Observations (HIPPO) validation campaign, the MOPITT bias, standard deviations, correlation coefficients and temporal drifts for the version 4, version 5-TIR, version 5-NIR have been estimated on total column to be 0.04 x10^{18}mol/cm^2, 0.06 x10^{18}mol/cm^2 and 0.08 x10^{18}mol/cm^2, respectively, with a noticeable temporal instrumental drift (Deeter et al., 2013).*

⇒ Add the reference : *Deeter, M. N., S. Martínez-Alonso, D. P. Edwards, L. K. Emmons, J. C. Gille, H. M. Worden, J. V. Pittman, B. C. Daube, and S. C. Wofsy, Validation of MOPITT Version 5 thermal-infrared, near-infrared, and multispectral carbon monoxide profile retrievals for 2000–2011, J. Geophys. Res. Atmos., 118, doi:10.1002/jgrd.50272, 2013.*

- Page 14710, Line 13: If the July bump is from a particularly intense biomass burning year in North America, why is there no interannual variability (as reflected by the box and whiskers) for July in Figure 6 for USeast?

Reply : *The July bump observed on $\mathrm{PTC}_m(\mathrm{CO})$ seasonal cycle over the USeast is associated to a small interannual variability, on the contrary to USlake. For these two sites, the interannual variability (IAV) on tropospheric CO column results from only 5 years (2002-2006) and not from intramonthly statistics (i.e. from all the July profiles of*

the period). Nevertheless, such small IAV is intriguing as within the 2002-2006 period, the Canadian fires were the most important fire events in 2004. Furthermore, from a MOZAIC case study on 18 July 2004 over Dallas, Morris et al. (2006) have pointed out the extension of Alaskan fires down to Texas. These fires from Alaska and Yukon territories had probably an extension also to the west coast of US. Here, the goal is to show the small IAV is due to compensatory effects between the internal tropospheric layers and/or the tropospheric column depth of the $\mathrm{PTC}_m(\mathrm{CO})$. Thus, Fig. S2 shows the vertical profile of the July anomaly 2004 (i.e. the average of (2002, 2003, 2005, 2006) minus 2004) for USeast and USlake. It results in a 2.5-10 km USlake positive anomaly, up to 0.8 x 10^{15} mol/cm^2 and a negative USeast anomaly extending 2-5.5 km with a maximum at 3 km up to -1.6 x 10^{15} mol/cm^2. Thus, it suggests USeast has been more on the CO plume pathway (or branch of pathway) than USlake, or that MOZAIC has sampled more frequently on his pathway, which explains the difference between USeast and USlake in July . The Figure S2 also shows how negative and positive anomalies on profiles may be counterbalanced, leading to lack of anomaly on $\mathrm{PTC}_m(\mathrm{CO})$ in 2004. Thus, to better document the tropospheric climatology and understand the origin of variability, the paper provides an insight into the seasonal tropospheric profiles, in section 4.2.

Below, modifications as suggested

⇒ Replace Page 14710, Line 13-15 by : *The July bump observed on $\mathrm{PTC}_m(\mathrm{CO})$ seasonal cycle over the USeast is associated to a small interannual variability, on the contrary to USlake. The interannual variability on tropospheric CO column results from only 5 years (2002-2006) for both northern US sites and, within this shorter period, the Canadian fires in 2004 were the most important fire events. On 18 July 2004, the extension of Alaskan fires down to Texas has been pointed out by Morris et al. (2006) on a MOZAIC case study. These fires from Alaska and Yukon territories had probably also an extension to the west coast of US. The profiles of the CO 2004 anomaly (i.e. the average of (2002, 2003, 2005, 2006) minus 2004) in July at*

USeast and USlake are given in Figure S2. It results, at USlake, in a 2.5-10 km positive anomaly, up to 0.8 x*10*^{15} *mol/cm*^{2} *and a negative anomaly, at USeast, extending 2-5.5 km with a maximum at 3 km up to -1.6* x*10*^{15} *mol/cm*^{2}*. Thus, it suggests the USeast has been more on the CO plume pathway (or branch of pathway) than the USlake. This finding and difference appear in agreement with what MOPITT has captured (http://www.ucar.edu/news/releases/2005/wildfires.shtml). The Figure S2 also shows how negative and positive anomalies on profiles may be counterbalanced leading to a lack of anomaly on* $\mathrm{PTC}_m(\mathrm{CO})$ *in 2004. Thus, the IAV of the* $\mathrm{PTC}_m(\mathrm{CO})$ *seasonal cycle does not reveal details comparable to IAV of the* $\mathrm{PTP}_m(\mathrm{CO})$ *due to compensatory effects between internal layers.*

⇒ Add the Figure S2.

⇒ Add the reference : *Morris G. A., Hersey S., Thompson A. M., Pawson S., Nielsen J. E., Colarco P. R., Wallace McMillan W., Stohl A., Turquety S., Warner J., Johnson B. J., Kucsera T. L., Larko D. E., Oltmans S. J., and Witte J. C., Alaskan and Canadian forest fires exacerbate ozone pollution over Houston, Texas, on 19 and 20 July 2004. J. Geophys. Res., 111, D24S03, doi:10.1029/2006JD007090, 2006.*

- Page 14711, Line 28: Why is there a March minimum in Beijing when a spring peak is seen at Japan? Note that 'exceeding the Japanese one' at the top of Page 14712 is imprecise as I read it to imply that there was also a March minimum at Japan when I think you mean that it exceeds the Japanese minimum when it occurs in August.

Reply : *Thank you for this comment, the text was undoubtedly unclear and confusing.*

Below, modifications as suggested

⇒ Replace Page 14711, Line 28-29, by : *The Beijing CO cycle in Figure 6 has a very specific 2.5-9.0* x*10*^{18} *mol/cm*^{2} *vertical scale. In fact, the minimum of its cycle is 3.35* x*10*^{18} *mol/cm*^{2} *in November, and this minimum is exceeding the maximum of all the*

cycles of the 10 other sites studied (i.e. 3.05 x*10*^{18} *mol/cm*^{2} *in March in Japan).*

- Page 14713, Line 7: Could this higher ozone in the BL be associated with the large biogenic emissions in the southern US during August-September?

Reply : *Thank you for this very interesting comment. The higher ozone in the BL may result from such biogenic emissions in the southern US during this period. Furthermore, at that time in the BL, the CO is the lowest of all the studied sites due probably to the influence of oceanic air masses. Thus, it suggests this BL high ozone results from very local production, in which biogenic emissions might interplay. Note that airborne measurements over the South United States during the field Campaigns TexAQS2000, ICARTT2004, and TexAQS2006 have allowed to quantify the biogenic emissions, have shown great interannual variability (by a factor of 2) within 2002-2006, and have found out the emission inventories were overestimated by a factor of 2 (Warneke et al., 2010).*

Below, modification as suggested

⇒ To add Page 14713, Line 9 after "modified." : *Furthermore, at that time in the BL, the CO is the lowest of all the studied sites due probably to the influence of oceanic air masses. Thus, it suggests this BL high ozone results from very local production, in which biogenic emissions might interplay. Note that airborne measurements over the South United States during the field Campaigns TexAQS2000, ICARTT2004, and TexAQS2006 have allowed to quantify the biogenic emissions, have shown great interannual variability (by a factor of 2) within 2002-2006, and have found out the emission inventories were overestimated by a factor of 2 (Warneke et al., 2010). The biogenic emissions contribution is an hypothesis to explain such higher ozone in the BL .*

⇒ Add the Reference : *Warneke C., de Gouw J. A., Del Negro L., Brioude J., McKeen S., Stark H., Kuster W. C., Goldan P. D., Trainer M., Fehsenfeld F. C., Wiedinmyer C., Guenther A. B., Hansel A., Wisthaler A., Atlas E., Holloway J. S., B. Ryerson T., Peischl J., Huey L. G., and Case Hanks A. T., Biogenic emission measurement and* *inventories determination of biogenic emissions in the eastern United States and Texas and comparison with biogenic emission inventories. J. Geophys. Res., 115, D00F18, doi:10.1029/2009JD012445, 2010.*

- Page 14719, Line 8: Please note the version of the satellite retrievals in the description. Explain how the correspondence criterion is chosen between the satellite and MOZAIC data. As the authors later note, these comparisons are not truly one-to-one.

Reply : This has been done

Below, modification as suggested *and the footnotes remains unchanged*

⇒ To replace Page 14719, Line 8-15 by : *The seasonal cycle comparison between the spaceborne and MOZAIC data is performed using the TES Level-3 Version 2 (2.0° x 4.0° gridded data) and AIRS Level-3 Version 5 (1.0° x 1.0° gridded data). Our PTC(O_3) will be compared to the tropospheric O_3 columns from TES*[7] *(Beer et al., 2001, Worden et al., 2007) by selecting the periods 2006-2007 or 2007. Our PTC(CO) will be compared to the CO columns from AIRS*[8] *(Susskind et al., 2003; 2010) by selecting the 2002-2009 period. The geographical coordinates of the data extraction are [47-52°N, 6-10°E] for Germany, [134-136°E, 33-35°N] for Osaka, [135.8-137.8°E, 34.1-36.1°N] for Nagoya and [138.7-140.7°E, 35.6-37.6°N] for Tokyo to check also the consistency of the individual sites. Our comparison is indeed not a validation. Validation has to be strictly a truly one-to-one. Nevertheless, this simple comparison is interesting by itself because it results from two independent data sets, with their own limit and performance.*

- Page 14720, Line 4: TES does not truly provide vertically-resolved information – note the degrees of freedom for signal (DOFS) is usually 2. If you are using TES for ozone, why not also use CO? This is outside of the scope of this paper, but it would be interesting to see if the satellite retrievals are able to capture the MOZAIC ozone-CO

correlations (see Zhang et al. (2006) and Voulgarakis et al. (2011)).

Reply : Only two years from TES were available (2006-2007) and seven years from AIRS (2003-2009). We have preferred to consider the longer period coverage of AIRS for CO than using the same instrument for both chemical species within a shorter period.

- Page 14738: Could you explain in the text what you mean by the grey shaded rectangle in Figure 2 and the definition of Mclim and Wclim. Change 'underlined' to 'shown.'

Reply : This has been done.

Below, modification as suggested

⇒ Add Page 14073 Line 15 : *Note the grey shaded rectangles of the Figure 2c highlights the layer unvisited by MOZAIC within the month and period and thus the greatest impact of Mfit on the monthly-averaged profile climatology.*

- Page 14739: In Figure 3, please show the fit statistics inset.

Reply : This has been done.

Below, modification as suggested

⇒ The Fig. 3 has been replaced.

- Page 14741: With mean in Figure 5, do you mean median?

Reply : No, both are provided. The intersection between the ETC line and the box is the mean while the median is the horizontal line. This difference is clear, for example, at UAEMI in February and December where the median is less than the mean and conversely at Beijing and Vienna in May.

Below, modification as suggested

⇒ On the Figure 5 and 6, we have replaced the caption to clarify and added the legend in one of the subfigure as suggested by M. Osman.

All your suggestions for fixing grammar have been taken into account, indeed thank you for your very constructive review.

- References added accordingly to your request :

Deeter, M. N., S. Martínez-Alonso, D. P. Edwards, L. K. Emmons, J. C. Gille, H. M. Worden, J. V. Pittman, B. C. Daube, and S. C. Wofsy (2013), Validation of MOPITT Version 5 thermal-infrared, near-infrared, and multispectral carbon monoxide profile retrievals for 2000–2011, J. Geophys. Res. Atmos., 118, doi:10.1002/jgrd.50272.

McMillan, W. W., Evans, K. D., Barnet, C. D., Maddy, E., Sachse, G. W., and Disken, G. S.: Validating the AIRS Version 5 CO retrieval with DACOM in situ measurements during INTEX-A and –B, IEEE T. Geosci. Remote, 49(7), 2802-2813, doi:10.1109/TGRS.2011.2106505, 2011.

Voulgarakis, A., Telford, P. J., Aghedo, A. M., Braesicke, P., Faluvegi, G., Abraham, N. L., Bowman, K.W., Pyle, J. A., and Shindell, D. T.: Global multu-year O3-CO correlation patterns from models and TES satellite observations, Atmos. Chem. Phys., 11, 5819-5838, doi:10.5194/acp-10-2491-2010, 2010.

Zhang, L., Jacob, D. J., Bowman, K. W., Logan, J. A., Turquety, S., Hudman, R. C., Li, Q., Beer, R., Worden, H. M., Worden, J. R., Rinsland, C. P., Kulawik, S. S., Lampel, M. C., Shephard, M. W., Fisher, B. M., Eldering, A., and Avery, M. A.: Ozone-CO correlations determined by the TES satellite instrument in continental outflow regions, Geophys. Res. Lett., 33, L18804, doi:10.1029/2006GL026399, 2006.

Figure S1 : Seasonal mean tropospheric O_3 profiles for Germany as sampled by MOZAIC (16,041 profiles, plain lines) and under sampled consistently with the Los Angeles (300 profiles, dotted lines) in 24h time-coincidence.

Figure 1 : Pure tropospheric profiles up to z_{DT}, PTP(O_3, z, t) (red), from three typical individual MOZAIC profiles, MP(O_3, z, t) (black), using the preliminary seasonal tropospheric profile, $\overline{TP}(O_3, z, s)$ (blue). For **(a)** $z_{DT} < z_{top}$; **(b)** $z_{top} < z_{DT} < z_s$; and **(c)** $z_{top} < z_s < z_{DT}$. Δ_s and Δ_f will be the layer filled using $\overline{TP}(O_3, z, s)$ (blue) and $Mfit_s$ (green), respectively. See the text for more explanations on z_{DT}, z_{lr}, z_s and z_{top}, the horizontal lines in red, purple, blue and black, respectively.

Figure S2 : Monthly mean tropospheric profiles of the CO July 2004 anomaly (i.e. the average of (2002, 2003, 2005, 2006) minus 2004) at USeast (red line) and USlake (dotted blue line) in mol/cm^2.

Figure 3 : Comparison of MOZAIC $\overline{\text{MPTP}}(\text{O}_3, z, m')$ and WOUDC $\overline{\text{WPTP}}(\text{O}_3, z, m')$, with z between 2 and 8 km in time coincidence, over USeast (left), Germany (middle) and Japan (right). Measurement altitudes refer to colour scale, from black (2 km) to yellow (8 km). The slope (s), the intercept (i) and the correlation coefficient (r) of the linear fit (black line) are given for each site with the bisector (grey line). All values are in DU.

Figure 5 : Cycles of $\text{TC}_m(\text{O}_3)$, in blue, and $\text{PTC}_m(\text{O}_3)$ box and whisker, in red, expressed in DU by referring to left vertical axis for USeast, USlake, USsouth, Los Angeles, Germany, Paris, Vienna, Japan, Beijing, Uaemi and Eastmed. z_{DT} is the thick green line and z_{top} the thin green line, both referring to the right vertical axis in km. Monthly sampling frequency of each site is provided above the X axis. Box uses the quartiles [Q25, Q50, Q75]. The end of box whiskers are the $\geq$Q25-1.5IQR or $\leq$Q75+1.5IQR.

Figure 6 : Same as Fig. 5 but for CO, expressed in x10^{18}mol/cm^2. Note that only

Beijing is plotted with a specific scale.

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/13/C8147/2013/acpd-13-C8147-2013-supplement.pdf

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 14695, 2013.

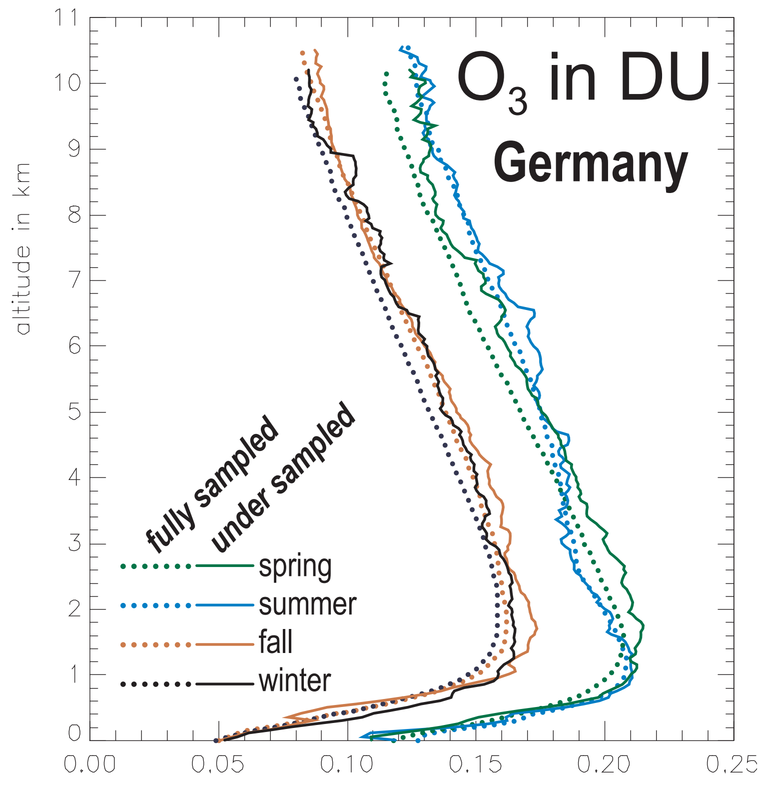

Fig. 1. Additionnal Fig. S1

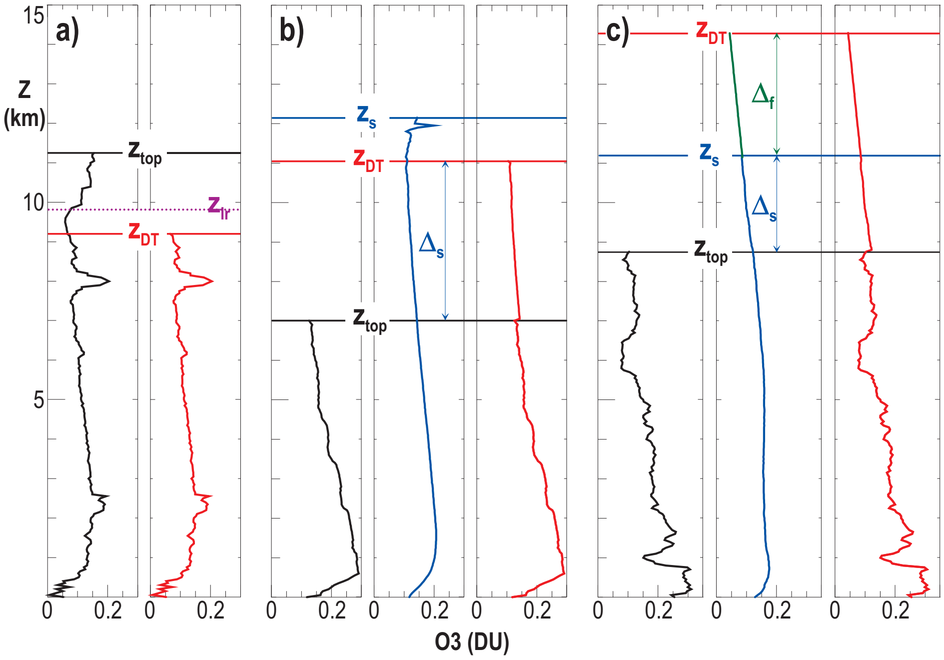

Fig. 2. to replace - Fig. 1 :

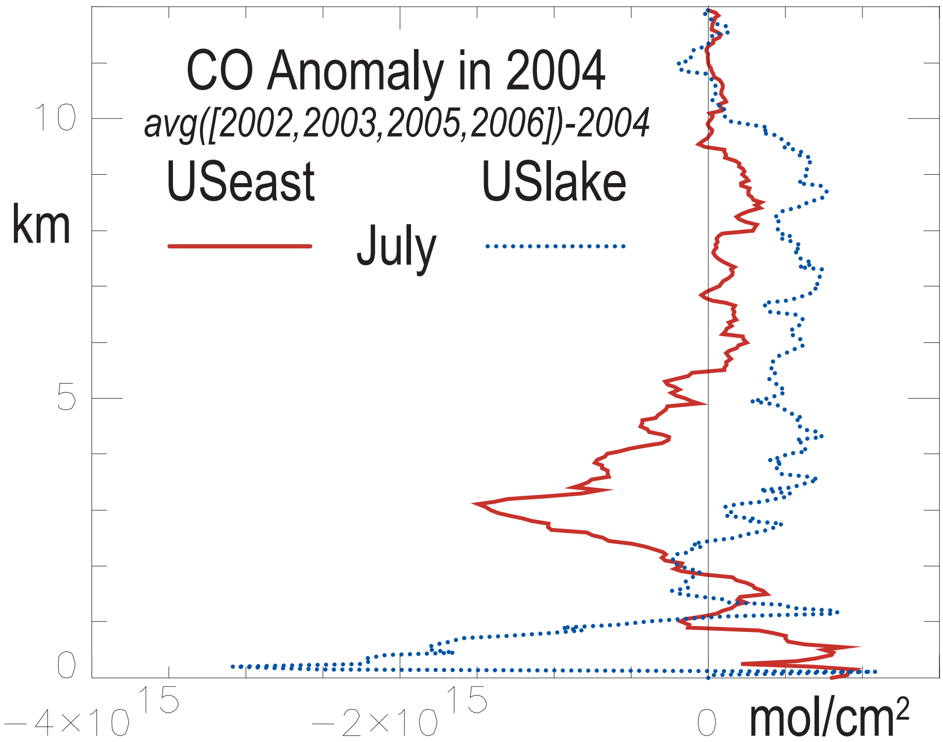

Fig. 3. Additionnal Fig. S2 :

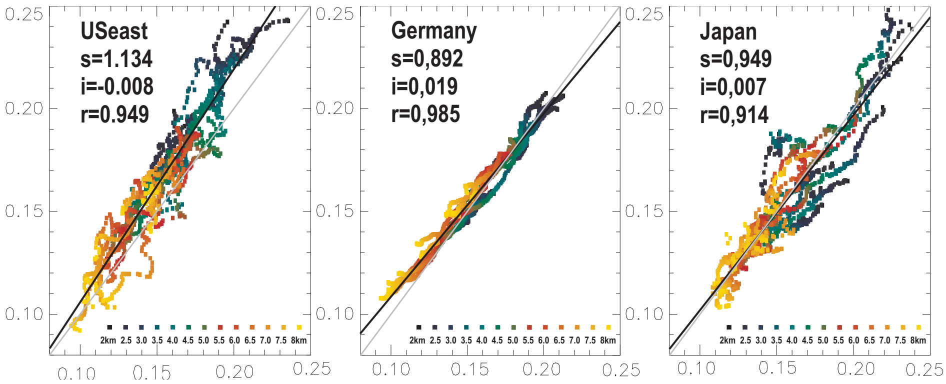

Fig. 4. to replace - Fig. 3 :

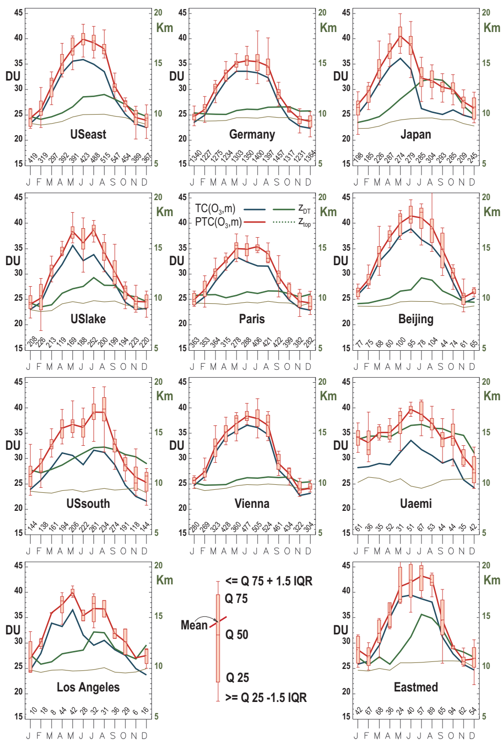

Fig. 5. to replace - Fig. 5 :

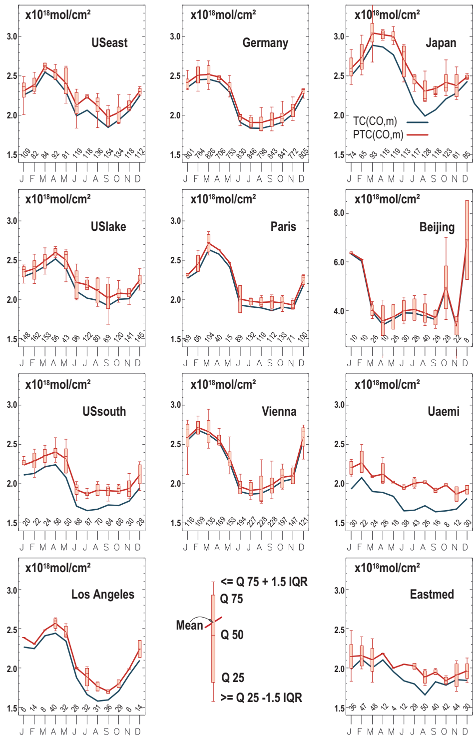

Fig. 6. to replace - Fig 6: