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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Spatial and temporal variation of CO over Alberta using measurements from satellite, aircrafts, and ground stations" *by* H. S. Marey et al.

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Author's response letter Thank you for your careful reviews and comments to improve the quality of the manuscript. We have provided point to point responses to all comments and questions.

Anonymous Referee #1 In section 2.1.1 the authors comment on the use of TIR+NIR MOPITT data and the restriction of the data used to daylight only. They comment that the daylight data "has better information content". However the NIR channels operate by reïňĆected sunlight and so at night the TIR+NIR product is identical to the

TIR product that has no sensitivity near the surface. This should be mentioned as a stronger driver for working only with daylight data. Thank you for your suggestion. The paper was revised based on the reviewer comment, as shown in lines 141-144.

In section 3.1 with reference to Figure 2 the winter variation DJF seems comparable with the MAM and JJA with SON showing the ïňĆattest distribution. It is hard to see the author's assertion that the spatial variations are less prominent in winter. It would be very useful to have the topography as well since the column amount is inïňĆuenced by the topography – less atmosphere = less CO at constant average mixing ratio. The authors mention topography on p 31776 but only in the context of fewer sources – which is also true. We agree and this was corrected, as shown in line 196. Regarding topography effect on total column CO values, we created a SRTM 90 DEM map over Alberta (Figure 1) and it demonstrates mountain peaks along the western border, to lowland areas in northeastern Alberta as mentioned in line 223 of the revised manuscript. Then we converted the CO total column to volume mixing ratio (vmr) to find out the influence of topography on CO spatial variations as shown in Figure 2. It is obvious that total CO vmr has the same spatial pattern as CO total column which implies that the topography does not have a significant influence on CO spatial variations. Accordingly we decided to not include the effect of topography in this part of discussion.

In Figure 3 the SON season is said to be similar to JJA but it does not show the same maximum in the North East as JJA – it seems distinctly ïňĆatter. Corrected, as shown in line 207.

The main difference between ïňĄgures 2 and 3 seems to be that in DJF the CO is generally concentrated nearer the ground (possible inïňĆuenced by subsidence). In fact, to figure out if CO is concentrated near to the ground, CO profile should be analyzed and this is shown in Fig 5, however the main difference between ïňĄgures 2 and 3 is that, the spatial variations in spring are less than total column variations (Fig. 2) as mentioned in line 208.

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On p 31776 line 12 it should be noted that CO is a product of incomplete combustion processes and so although CO increases with increasing combustion, it decreases with increasing regulation of the combustion: forest ïňĄres produce a lot of CO, power stations comparatively little. We agree; that is why we analyzed MODIS fire counts as well to help in the interpretation of CO variations. The manuscript was revised based on the above comment, as shown in line 231.

On P 31778 the authors say that “Calgary is expected to experience Chinook winds more frequently than Edmonton” I would assume that the data exist to verify this speculation. The referee wonders whether the fact that the Edmonton winter/spring proïňĄle seems less well mixed than Calgary or Fort McMurray is signiïňĄcant. The fact that Edmonton winter/spring proïňĄle seems less well mixed than Fort McMurray is signiïňĄcant as it is verified by positive Omega averages at 700hPa from 2002 to 2013 especially from Dec-Mar.

On p 31780 The text talks about a “rate” but the speciïňĄes a unit of “%” whereas a rate should have a time unit as well. This is also true for P 31783. It is changed accordingly to "decreasing percent for the whole period" as shown in lines 336 and 402.

Figure 8 and its explanation is somewhat confusing. If the annual average value is subtracted from each month, then the trend over years should be zero, but there is a trend which implies perhaps that the series annual average is being subtracted. This should be clariïňĄed. We are sorry for the typo; actually the whole series average is being subtracted. The manscuript is revised accordingly, as shown in line 332.

The rates of decline of CO over the cities is clearly visible in Figure 10. More intriguing to the referee is the suppression of the seasonal cycle in all three regions which seems very pronounced. The authors attribute this to the improvement in vehicles and if so, this is remarkable. Yes the rates of decline of CO over the cities are clearly visible in Figure 10. However there is no suppression of the seasonal cycle in Fig 10, just the y axis scale is large (up to 1000 ppb) enough to show the seasonality of MOPITT data

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as it is more suitable to plot ground data. The MOPITT seasonality is clearer in Fig 8 where the scale fits the data very well.

There is almost always a problem with relating satellite measurements of pollutants to speciïňĄc surface sites, since the surface sites are often chosen to be where the signal is highest, not where it is “typical”. Perhaps some comment on the location of the sites as typical of the region or to monitor speciïňĄc hot spots could be made.

Actually the stations in Edmonton and Calgary are part of the monitoring network in typical urban centers, however Fort McMurray station represents industrial region and this is clarified in line 167.

In section 3.5 – neither dry conditions nor sinking air “cause” ïňĄres – an ignition source is needed – but they do set conditions for ïňĄres to spread and persist. Corrected as shown in line 451.

Figure 13 c,d shows the MOPITT CO distribution during the ïňĄre of 2012. It would be useful to compare that distribution to another year without ïňĄres – even at the expense of deleting one of c,d to make room. Technical Details. This topic warrants further details, that can be more appropriately addressed in a separate paper. We are writing now a paper about the impact of biomass burning on air quality including a comparison with another year without ïňĄres. Hence we prefer to leave this part as is.

P 31768 Lines 18 and 22 - it may be just my pdf reader, but the “s” on “sites” and “ex-acerabates” is detached from the word itself. P 31768 Line 24 “..the declining trend...” Done as shown in lines 26, and 30.

P 31769 Line 18 “..used to decrease the bitumen’s....” Done as shown in line 51.

P 31769 Line 20 “Large amounts of natural gas....” Done as shown in line 53.

P 31770 Line 18 “.. there has been no research published using them....” (is that the intent?) Done as shown in line 76.

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P 31770 Line 27 428692.5 is surely stated far beyond the accuracy of the assessment. Done as shown in line 85.

P 31771 Line 7 “CO can also be produced....”. Done as shown in line 93.

P31772 Line 3 “analysed using MODIS ïňĄre counts.” changed as shown in line 116.

P 31772 Line 9 “..represents an industrial...” . Done as shown in line 122.

P31773 Line 15 “..cloud edges and coastlines.” Done as shown in line 157.

P 31773 Line 20 “The CASA Data...” Done as shown in line 162. P 31774 Line 5 (and several ïňĄgure legends) “The symbols F,... represent the cities of Fort....Calgary respectively.” Done as shown in line 193.

P 31775 Line 12 “...seasons display minimum...”. Done as shown in line 200.

P 31775 Line 17 “The summer season demonstrates...” . Done as shown in line 204.

P 31775 Line 19 “..fall season illustrates a similar....” . Done as shown in line 205.

P31775 Line 20 “...spring and summer indicate a...” . Done as shown in line 208.

P 31776 Line 7 “..are less than 1.5 x 10ËĘ?? molecular cm-2..” Needs an exponent, surely? Done as shown in line 221.

P 31777 Line 5 “...temporal climatologies...”. Done as shown in line 245.

P 31777 Line 17 “Calgary, the vertical...”. Done as shown in line 256.

P 31778 Line 12 “..contribute to pollution....”. Done as shown in line 276.

P 31778 Line 17 “...and declines rapidly.” Done as shown in line 282.

P 31778 Line 26 “...attributed to other sporadic....ïňĄres. The forest ïňĄre...” . Done as shown in line 289.

P 31779 Line 16 “..above the planetary...”. Done as shown in line 307.

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P 31783 Line 1 “..maximum rates of decline of 4.7...” . Done as shown in line 402.

P 31786 Line 1 “..affected by the ïňĄre emissions...” . Done as shown in line 482.

Figure 1: Personally I would have chosen a different colour than blue for the oil sand regions. My ïňĄrst thought was “what are those lakes doing in Alberta?” The map is changed to another one as shown in line 812.

Figures 2,3 Legend “The symbols F,... represent the cities of Fort....Calgary respectively.” Done as shown in lines 819 and 828.

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 31767, 2014.

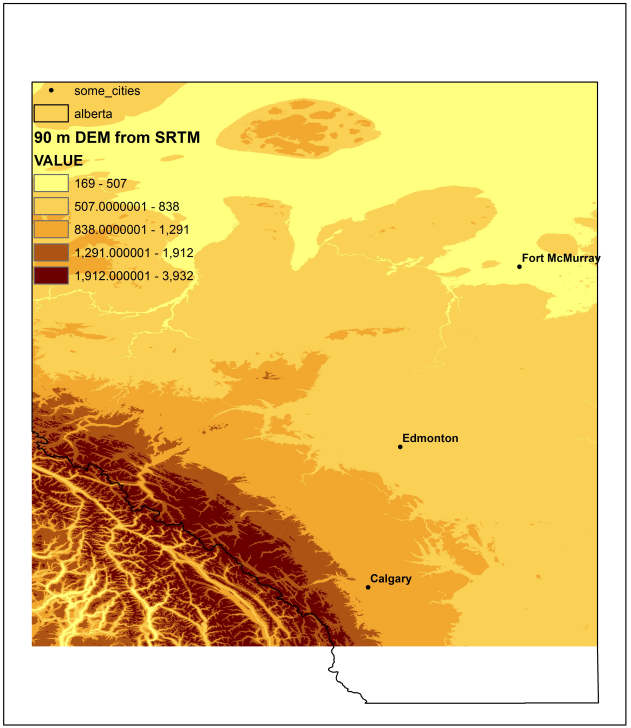

Fig. 1. SRTM 90 DEM over Alberta

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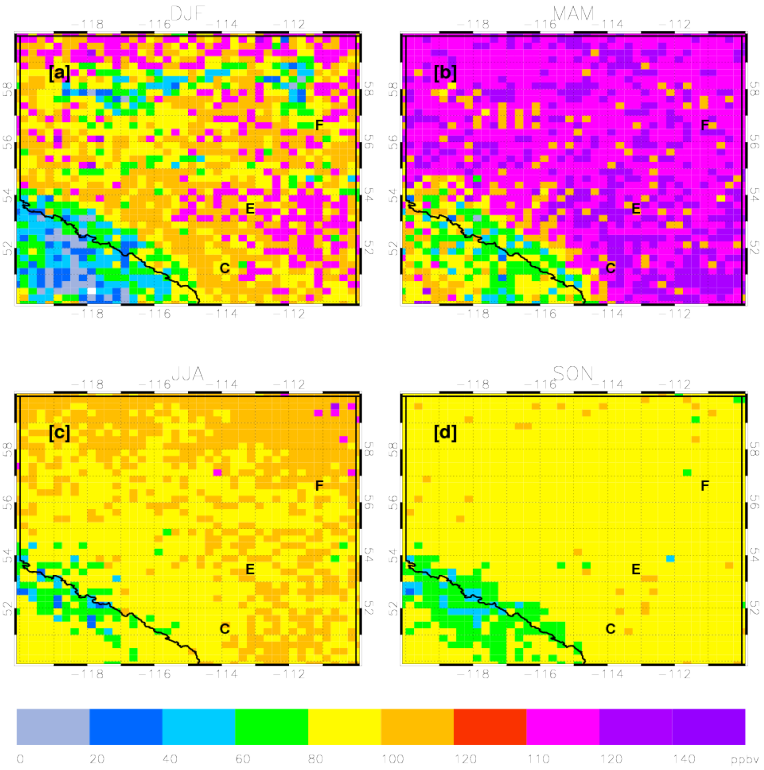

Fig. 2. MOPITT CO total column in vmr

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