

Interactive
Comment

Interactive comment on “CO₂ and its correlation with CO at a rural site near Beijing: implications for combustion efficiency in China” by Y. Wang et al.

Y. Wang et al.

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We thank the reviewer for careful reading and thoughtful and constructive comments.

Reviewer 1:

This paper from Wang et al represents a very interesting study on atmospheric CO₂ monitoring and CO₂ emissions in China. The paper focuses on observed trends in CO₂ concentration between 2004 and 2008 in the region of Beijing and presents a CO₂/CO correlation study, inferring information on combustion efficiency in China. Information is also extracted from the data on CO₂ emission reduction during the Olympic Games in 2008. The topic is highly relevant and in the scope of the journal, and the method used

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are very interesting especially when the authors try to separate anthropogenic CO₂ from background CO₂. The title of the paper reflects the content of this latter. The abstract gives a concise summary. However, the authors do not compare their results to former studies. Also, the paper lacks information on the data precision, on station location and does not provide the CO time series used for the study. I strongly recommend the paper for publication in ACP after minor revisions detailed in the following, especially I underline the need for a map showing the station location and altitude, the need to show the CO timeseries, the need to give the data precision for CO₂ and CO, and the need to compare the results to previous studies. Response: As the reviewer suggested, we've added the site map, CO time series, data precision, and comparison with other studies. Please see our detailed response below.

SPECIFIC COMMENTS

p.12666 Line 6: Better precise what means binned by local time

Response: We clarified in the text as: "The CO₂-CO correlation analysis evaluated separately for each hour of the day."

Line 7: replace Seasons=> season

Response: Corrected.

Line 11: precise what upwind what

Response: We meant to say that the UUM site is upwind of Miyun during the prevailing northwesterly in winter/spring time. We revised the text as follows: "...at a Mongolian background station to the northwest."

Line 15-17: Also give information on CO₂ increase evolution year to year

Response: We added the text: "... with CO₂ increasing by 1.8 ppmv."

Line 24: replace levels=>level

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Response: Corrected.

Line 24 and 25 contain the word "increasing" twice, change one

Response: Corrected.

p.12667 Line 2: replace increases=> increase, are=>is

Response: Corrected.

Line 4: replace are=>is, remove the

Response: Corrected.

p.12668 Although a map of the stations has been published in another paper, readers get quickly lost when the authors describe the station locations. It seems to me mandatory to add a general map that will present all the stations cited in the paper (including Mauna Loa) and their altitude using a color palet for example. It would be useful to add geographical information, such as the Qinghai-Tibetan plateau location (cited p.12678) or any other specific geographical feature cited in the paper.

Response: We added a figure (new Figure 1) with the site map and the locations of other stations in Asia referenced in this paper. For other sites referenced in the paper but cannot be shown clearly in one figure, we give their lat/lon/alt information in the text.

p.12669 Line 16: Any more recent paper than Bishop et al. (1996)?

Response: We added the reference of Bishop and Stedman (2008) which reported a further increase of CO₂/CO ratio for US vehicles in the 2000s.

Line 25 and on p.12670 line 1-22: the paper sections are not very well presented and the text could be better organized: goals and information are too much mixed.

Response: We have rearranged and modified this section. Please see the revised manuscript.

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Line 24: Give the altitude of Miyun station, describe more in details Beijing (population, main activities, main pollution sources according to seasons).

Response: Altitude of the station (152m a.s.l.) is added. We added the following text about Beijing: “Beijing has a population of over 16 million and a vehicle fleet of more than 4 million at the end of 2009. Major pollution sources in Beijing are vehicle emissions, power plants, industry, residential boilers, and construction activities in the case of particulate emissions.”

p.12671 Line 4: replace county by country. Globally in this section it is mandatory to give the data precision for CO₂ and CO.

Response: We indeed mean ‘county’. The Beijing municipality is divided into 16 urban and suburban districts and two rural counties. Miyun is one of the rural counties. Response: We added data precision in section 2: “The analytical precision of the CO₂ measurements derived from 1-minute standard deviations of the calibration signals is 0.08 ppm (2-sigma).”

p.12674 Fig. 3b is not explained! This section is very interesting. The authors could go further by calculating the evolution of the rate from one year to the other ($18/8=2.45$ from Gregg et al, 2008 against $4/1.4=2.85$ from your observations, which is quite comparable). Compare your results to the references you gave (ex. the average rate of increase from your observations is 2.7ppm/year, and is thus similar to the one reported by Cho et al. 2007). You should mention that you use all the dataset here and will later on distinguish night and afternoon data.

Response: Fig. 3b is explained later in section 3.3 (background CO₂). In the revised manuscript we re-organized the figures and the original Fig 3a and 3b are two separate figures for clarity.

Based on the reviewer’s suggestion, we added the following clarification/discussion in the text: “All the data (i.e., 24-hour) are included in this figure and we will distin-

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guish nighttime and daytime data in subsequent discussions.” “Although the relative decrease in the growth rate of emissions appears comparable to that of Miyun CO₂ concentrations, the timing when the change had occurred does not exactly match (2006 for emissions versus 2007 for Miyun CO₂).”

Line 11: FTT study - explain better why point window 13 is selected rather than point 1.

Response: We applied FFT to smooth the weekly-mean time series, so the point window of 13 means 13 weeks, approximately the length of a season. This way we can see the underlying seasonal variations after smoothing. We've clarified this in the text.

p.12675 You need to show the CO timeseries!

Response: We added CO time series in new Figure 6 and Figure 9b.

Line 5-12: give references

Response: References added.

Line 11: replace "showing the data for 2007 and 2008" by 2007 and 2008 data

Response: Corrected.

Line 12: what are the uncertainty values?

Response: The uncertainties of CO and CO₂ observations are added in Section 2.

p.12676 Line 18: here you define the correlation coefficient as R, elsewhere it is R₂. Please correct this in the whole paper (text, figures and tables).

Response: Corrected. We now use R in the whole paper.

p.12678 Line 10: remove the comma after the point.

Response: Corrected.

p.12679 Lines 10-16: you can go further by computing ratios (8/3.2 and 2.7/1.6) and comparing them.

Response: We added the following discussion in the text: “This corresponds to a ratio of 2.5:1 (8/3.2) between China’s emission growth rate and the world’s in 2006, while Miyun data indicate a smaller ratio of 1.7: 1 (2.7/1.6) between regional CO₂ increases and global background. As this is a simple comparison, the discrepancy can be due to multiple factors such as the uncertainties in emission estimates, representativeness error of Miyun data for whole China, and the role of biosphere on regional and global CO₂.”

Line 27: give lifetime values

Response: The lifetime CO in winter is about 3 months and CO₂ about 100 yrs. We added this in the text.

p.12680 Line 4: the term "space heating" is not very clear to me (maybe should replace by indoor heating?)

Response: Replaced by domestic heating.

Line 14: explain what is p

Response: p is the probability value, which shows the significance of a statistical hypothesis. If the p value is smaller than the significance level, it implies that the null hypothesis (in our case the null hypotheses are that claim no increase in CO₂/CO with the years) is unlikely to be true.

Line 25: any comment on the fact that a larger dispersion is observed for higher CO concentrations?

Response: High CO concentrations are associated with pollution plumes from Beijing urban area (industry, vehicle, power plants) and local rural sources (biofuel combustion). The former tends to be efficient combustion compared with the latter. The contrast in CO₂/CO between them leads to the larger dispersion in the CO₂-CO scatter plot at higher CO.

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p.12681 Line 20: a reference is needed on the low combustion efficiency from local sources, otherwise the argumentation is not convincing.

Response: Local sources are mainly indoor combustion of biofuel for heating and cooking and rural vehicles, which has low efficiency compared with large industrial boilers and urban vehicles. Reference added.

p.12682 Line 14: precise what is Siberian High

Response: The Siberian High is a massive high pressure system with a collection of very cold air on the Eurasian terrain for most of the year. It reaches its greatest size and strength in winter. The contrast between the Siberian High pressure and low pressure systems over the Pacific Ocean provide the driving force for East Asian winter monsoon circulation. We clarified in the text.

Line 16: the differences between the wind sectors are not obvious, indeed.

Response: The back trajectories are grouped by similarity using the standard cluster analysis. The cluster analysis suggested four types of trajectories. The difference between them is a function of altitude, latitude and longitude of all the points along the trajectory, not just the end points. We explain each group in detail in the text. Having recognized some overlapping between the NWC and NCP group, we combined them into one 'North China' (NCN) group. The subsequent discussions are based on the NCN group.

p.12683 Line 1: what is the PBL height?

Response: The PBL height in winter is typically about 1 km in the afternoon but much less in the evening.

p.12684 Line 19 etc: remove [] and ()

Response: Done.

p.12685 Line 1: replace have by has Again, it is necessary to show the CO timeseries.

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Response: Corrected. CO time series shown in new Figure 6.

p.12689 Line 22: give distance between Miyun and UUM.

Response: It's about 640 km. Added in the text.

p.12690 Line 6: replace decreases by decrease. The sentence is confusing, please rewrite it.

Response: Corrected. The sentence now reads: "The increase in dCO_2/dCO was caused primarily by decrease in CO over the study period, offsetting the slowing down of CO₂ growth rate between 2007-2008."

Comment: $2.7/1.7=1.58$ ie 58% more, is this comparable to inventories? Quantify. Also, compare to references (and comment referring to the -20% target).

Response: We added the following discussion in the text: "Bottom-up studies of CO₂ emissions (Marland et al., 2007) suggested annual increase in Chinese fossil CO₂ emissions is a factor of 2.5 ($8/3.2 = 2.5$) larger than the global average in 2006. The Miyun data, however, suggests a much smaller difference of 1.6 ($2.7/1.7 = 1.6$). As this is a simple comparison, the discrepancy can be due to multiple factors such as the uncertainties in emission estimates, representativeness error of Miyun data for whole China, and the role of biosphere on regional and global CO₂."

Acknowledgements Acknowledgements, with a s at the end.

Response: Corrected.

Table 1: Column headers should be simpler (such as 2005, 2006, 2007 and 2008)

Response: Corrected.

Table 2: Better arrange column size versus title size

Response: Changed.

Figures Fig.1: -Replace system by set-up -Avoid unexplained acronyms such as MFC

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Response: Corrected. We added clarifications to the figure.

Fig.2: -Very nice figure indeed but y-axis is false, and a label for the x-axis is missing.

Response: Corrected.

Fig.3: Lack a map showing stations location, even if given in a former paper, especially for WLG, UUM and TAP. Altitudes of the stations should be given on the map (use a color palet for example). Estimated background comment could be clearer

Response: A new figure 1 is added to show the map of the Miyun site location and other background sites.

Fig. 4: Caption=> lines are FFT13 and FFT52 are "private cooking": use more general terms to explain your work

Response: Corrected.

Fig.5: Why did you use only one year to conduct this study? Make an insert easier to read for slope + R2 Here the correlation factor is R2 (some other times it is R., be more rigourous on this) Explain better the reduced axis method and refer to text

Response: Figure corrected. It is not appropriate to use several years' data to conduct this CO₂-CO plot, since background CO₂ has significant increases with time. The main purpose of this plot was to demonstrate the tight CO₂-CO correlation in non-summer seasons and the impact of active summertime biosphere on the correlation.

Fig.8: OK but indicate what the uncertainty bars represent

Response: The uncertainty bar is the uncertainty level of the slope calculated by RMA regression method.

Fig.10: Interesting approach, but hard to observe differences in the cluster area definition, it seems there is a lot of overlapping!

Response: See our response above.

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Interactive comment on Atmos. Chem. Phys. Discuss., 10, 12665, 2010.

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