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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Evaluating High-Resolution Forecasts of Atmospheric CO and CO_2 from a Global Prediction System during KORUS-AQ Field Campaign" *by* Wenfu Tang et al.

Anonymous Referee #2

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This manuscript presents a comparison between three modelling products of the Copernicus Atmosphere Monitoring Service (CAMS) and in situ measurements from the KORUS-AQ (and KORUS-OC) campaign in the vicinity of the Korean peninsula during May/June 2016. Airborne, surface, ship-based, and satellite measurements of CO and CO2 are compared to the CAMS analysis and two forecast products at different spatial resolutions. The statistical analysis is relatively straightforward and clearly laid out, and some patterns of over- and underestimation are found for the two tracers under different conditions. The importance of vertical transport in the understanding of these differences could be further explored, as outlined below. While I understand the other reviewer's comment that this manuscript might be a better fit for GMD, as it

is assessing the capabilities of a specific modelling system, the general conclusions about the potential underestimation of CO emissions from China make it relevant for a broader audience as well. This is ultimately an editorial decision. However the quality of the manuscript, datasets and analysis is good, and appropriate for publication. Below are some suggestions, some major, some minor, on how the analysis might be slightly extended in order to better understand the processes driving the model-data mismatch.

Section 3.3: In the discussion about the relative agreement in the profile for CO2 vs. the disagreement between the lower atmosphere values between the observations and the model, a discussion of the relevance of the mixing height and/or planetary boundary layer was somewhat lacking. A difference in profile shape can be attributed to incorrect fluxes, incorrect mixing, or a combination of the two. By having two tracers with differing results, it should be possible to deepen this analysis a bit. There is further discussion about the vertical gradients of the tracers, but no attempt is made to diagnose the PBL height. Given the model data and the meteorological information from the aircraft profiles, this should be possible. Could you at least comment on this, and why such an approach was not undertaken? It is even suggested that there might be a "possible weaker boundary layer mixing in CAMS". Here diagnosing the PBL height (as a function of time) from both the model fields and the profiles might be enlightening.

Another interesting point might be the representation of urban effects for Seoul in particular. Here it would be interesting to compare the PBL height as modelled vs. measured in the vicinity of Seoul compared to other less rural sites. However this may be beyond the scope of this study.

For the special case of Seoul, the low altitude measurements were taken during missed approaches at the airport. Given all the air traffic in the region, might it be that the CO in this area is locally very much enhanced, and as such not representative of even the relatively small spatial footprint of the CAMS model? Here perhaps a referral to a

relevant paper by Boschetti et al. (Tellus B, 2015) looking at enhancements of CO in the boundary layer from commercial airline measurements might be relevant.

Regarding the assessment of the outflow over the West Sea, I was confused by the phrase: "Hence, the wind speeds dominate the transport flux variations in CO2." I'm not sure what is meant here. Is this because the outflow pattern wasn't as strong as for CO? But aren't both flux variations (more or less) linearly dependent on wind speed anyhow? Please clarify.

The discussion about the correlation of CO and CO2 over the West Sea is quite interesting, and invites further inquiry. The suggestion that the difference in time factors for anthropogenic CO and CO2 (with the former having constant monthly values and the latter having diurnal variability) should effect the correlation over Korea as well. Could it be explained by the differences in transport times, e.g. diurnal CO2 emissions peak in daytime while measurements are being made over Korea, whereas daytime measurements over the West Sea represent nighttime emissions from China, where the difference in time factors is at a maximum? In terms of just the correlation in the fluxes, it should be easy to test if EDGAR has a higher spatial correlation between CO2 and CO in Korea vs. China.

The analysis of the satellite data is not particularly illuminating, with the exception of the separation of MOPITT data into those influence by outflow. Regarding the use of the OCO-2 data, most of the data references are pre-launch, and should be updated. Wunch et al. 2017 would be a better up to date reference than those from 2011, and an updated estimate of the OCO-2 precision, even if it is coming from grey literature (such as the ACOS OCO-2 User's Guide) would be preferable to a largely theoretical assessment from Boesch et al., 2011. It is unclear what is meant by the "recommended quality control" in section 2.2.4. Does this mean the standard quality flag? Was the bias correction applied? Was a certain warn-level threshold used? Please elaborate.

If the Taylor skill score is being used for the assessment of the forecasting skill as in

section 3.1, the equation should be in the main paper, and not just in the suppplement. Please include it here as well.

P4, L18-20: The text here states that the CO analysis runs at "approximately 40 km horizontal resolution", but in Figure 1 it is shown to be 80 km horizontal resolution. Later on page 5 80 km is given again, and the text on P4 refers to that fact that the CO2 analysis is at a higher spatial resolution (in both the horizontal and vertical). Please ensure that the information is consistent and correct.

Minor/typographical comments:

P2, L11: show -> shows

P2, L12: "over Seoul metropolitan" -> either "over the Seoul metropolitan area" or "over Seoul"

P3, L6: near-real time -> near-real-time

P3, L16: field -> field campaign

P4, L20: Perhaps this should be one sentence?

P4, L25: 4-days shouldn't be hyphenated (four days)

P4, L26: 16km -> 16 km

P5, L26: The -> the

P6, L1, L2, and often afterwards: South Korean peninsula -> the South Korean peninsula

P6, L8-10: The third scientific question needs to be restated. It doesn't make sense as it is written here.

P6, L27: data is -> data are

P6, L30-31: Wouldn't UTC be one day behind local time?

P7, L7: combustion signatureS (plural needed to match grammar)

P7, L10-12: Not sure which preposition should be used to describe the jetway flights, I would suggest "in", but consistency is more important. Also check the grammar: "Flights in the Seoul-Busan jetway were designed to capture... Flight in the Seoul-Jeju jetway, on the other hand, sampled air over..."

P7, L17: Baengnyeong site is located in less populated Baengnyeong Island, Incheon which is northwest of Seoul. -> The Baengnyeong site is located on the sparsely populated Baengnyeong Island, Incheon, northwest of Seoul.

P7, L19: "on remote" -> "on the remote"

P8, L21: resolutions -> the resolutions

P9, L2: Here is the first of many instances of referring to the in situ measurements collected from the DC-8 aircraft as simply "DC-8". As a reader I found this jarring. Perhaps instead refer to the dataset as the "DC-8 in situ data" or the "aircraft data" or "the airborne measurements"?

P9, L8: inconsistent description of correlation range (to vs. -)

P9, L12: CAMS have -> CAMS has

P9, L15: those for -> that of

P10, L14: tale -> tail (Please change later instances as well.)

P10, L25: West Sea -> the West Sea

P11, L28: than in Korea -> as in Korea

P12, L1: West Sea -> the West Sea

P13, L27: West Sea -> the West Sea

P14, L11: Baengnyeong -> the Baengnyeong

P15, L10 (and other locations): Olympic Park should always be capitalized (both words)

P15, L13: exhibit -> exhibits

P15, L23: shop tracks -> ship tracks

P17, L7-9: There are a few disjointed short sentences here. (e.g. "Because the size of CO data () is much larger than that of CO2 ().") Perhaps they could be joined together to make more sense?

P17, L24-25: near Korean coast -> near the Korean coast

P18, L15: "(by -2 to -4 ppmv for CO2 and -86 to -88 ppbv)" -> "(by -2 to -4 ppmv for CO2 and -86 to -88 ppbv for CO)"

P27, caption label: I would suggest using "bright" instead of "luminous" to describe the colours. Also add some articles when describing the sites, i.e. "The Olympic Park and Yonsei sites are located in an urban region (Seoul) while the Baengnyeong and Fukue sites are located in remote regions. The Taehwa site is located in a forest near Seoul."

P34, Figure 9: The figure label includes DC-8 still, but I believe this is in fact surface-based in situ data. If so, please remove these confusing labels.

P40, Table 3: The label refers to satellite measurements, but it should be in situ measurements.

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