Review of "The measurement of atmospheric CO_2 at KMA/GAW regional stations, the characteristics, and comparisons with other East Asian sites" by Lee et al.

Summary of the manuscript

The authors have made CO_2 measurements using NDIR and CRDS instruments at the 3 Korean stations, AMY, JGS and ULD. They described the measurement system, overview of characteristics of CO_2 variations observed at these stations. Comparisons with variations at other stations in East Asia are also given.

General comment

Atmospheric measurement is a basis of top-down estimation of CO_2 emissions and uptakes. Given the increasing importance of East Asia in the global carbon budget, more number of high-quality measurements in the region helps carbon cycle studies. From this point of view, this work, which provides descriptions of hitherto unpublished CO_2 measurements and their characterization from Korea, is well acknowledged. This is a good contribution to the community and well within the scope of the ICDC10/GGMT-2017 special issue of ACP. My comments, which might be considered before acceptance of this manuscript, are detailed below.

1. I assume that "characteristics" and "comparisons" in the title are for variations observed at the different stations, and not for technical aspects of measurements. I would re-consider the title (in particular latter part) to make what is addressed in this manuscript clearer.
2. In the manuscript, the term "calibration" is used in different meanings. Sometimes the term is used to link instrument responses of an analyzer to known values of standards i.e. determination of the instrument response curves. In other places, the term is used to measure laboratory in-house cylinders for CO_2 mole fraction against standards at higher hierarchy levels i.e. propagation of CO_2 scale values from a standard to a standard. I would suggest to give definition of "calibration" at the beginning of section 2.3.1 and to use it exactly as same throughout the manuscript. It would improve readability of the section. In my understanding, "calibration" is in many cases used with the latter meaning in the WMO/GAW community.
3. In this respect, it is important to clearly describe KMA's standard scale system.

According to the text, “laboratory standards” provided from CCL (NOAA/ESRL) are positioned at the highest hierarchy (how many cylinders covering x ppm to y ppm?). Working standards routinely used at the stations are positioned at the 1 lower level and measured directly against “laboratory standards”. After this, sample air at the stations is measured against the working standards. These are fundamental information in maintaining the scale at KMA and in propagating the scale from CCL’s primary standard cylinders to sample data in Korea. I suggest the authors to re-structure section 2.3.1 and present such basic information systematically in the very first paragraph. In addition, determination of the response curve of the CRDS instrument and long-term surveillance of instrument condition are different topics, which could come after the description of the standards.

4. It would be a great help for readers if zoom-in maps of the 3 stations, which illustrate the surroundings of the stations as described in section 2.1, could be presented. The geographical scale of Figure 1 is still good in the context of relatively large-scale variations (e.g. Figs 8 and 9), but for smaller-scale phenomena that appear in Figs 4 to 7, information of surrounding geography play larger roles as discussed in the manuscript.
5. I think that the idea of “background” and “baseline” data (or CO_2 mole fraction) may not be consistent throughout the manuscript. In section 2.3.3, the authors define criterion for selecting “background” data. After that, in section 3.2, the authors define CO_{2BG} which is defined the curve fitting by Thoning et al. I do not think these two “backgrounds” are in agreement. The latter is composed of the long-term trend and seasonal cycle, which reflect global, hemispheric to regional variations. In contrast, the former contains synoptic scale variations, for instance elevated CO_2 events caused by tracking cyclones which transport signals from continental CO_2 emissions (e.g. Tohjima et al. 2010, 2014). The authors split “local” CO_2 elevations and “background/baseline” CO_2 level only, but discussions on such synoptic variations (intermediate scale) are missing. Such events are however important in the regional context of monitoring emissions from China, to which the authors mention in introduction and conclusion as value of the dataset. I hope to see, even briefly, discussions on synoptic variations, since it would help future data users who address CO_2 emissions from China using the data presented in this

study.

Specific comments

P3 L21: “can cool” to “can be cooled”

P3 L21: this sentence might be reformulated to read “…-80° C, which makes the real temperature of inner air flow to be -50° C.” The -80° C seems to be a set temperature. Where is the temperature sensor placed?

P3 L22: “drops it” and “cools it”—hard to get what “it” means. If I understand correctly, this sentence might be reformulated for instance, “The sample air is cooled to -20° C in the first trap, and then to -50° C in the second trap.”

P3 L25: “One of the dual traps is used to dry ambient air for 24 hr while…”

P3 L25: here “hr” is used instead of “hours” used at other places.

P4 L20: See my comment above. Here the calibration means anchoring the analyzers’ responses to the CO_2 scale guaranteed by the standards.

P4 L22: See my comments above. Here the calibration means to measure working standards against the CO_2 scale.

P4 L22: See my comments above. This sentence is very unclear. Should this be read like “working standards used at AMY are those directly provided by CCL?”

P4 L23: Insert “the” berfore “laboratory standards”

P4 L23: Is the “laboratory standards” primary standards that realize the WMO scale i.e. those at highest hierarchy at KMA? If this is the case, the term like “KMA primary standards” might better clarify the standard category at KMA. How large CO_2 mole fraction range is covered by the “laboratory standards”? And are these “laboratory standards” same as the “4 standard gases” appearing at the beginning of the paragraph? In summary, questions are how many “KMA primary standards” (that cover XX to YY ppm in CO_2 mole fraction) are prepared and how many “working standards” (that cover XXX to YYY ppm) are prepared for each station? Please describe these information systematically. Also, with what kind of instrument are the working standards measured against laboratory standards?

P4 L25: “When the scale is propagated” – this is normally called “calibration”. I understand that, firstly, working standards are calibrated against “laboratory standards” to assign them the WMO CO_2 scale values, and secondly, by analyzing these gases, the instrument responses are linked to the WMO CO_2 scale values.

P4 L26: Here “calibration” means to determine the instrument response curve.

P4 L27: Again “calibration” is used same as above.

P4 L30: Please exactly indicate the degree of agreement between KMA and CCL (+/-0.0X±0.0Y ppm) found from the Round Robin.

P5 L12: “500 ppm”. First, I would expect that some CO_2-elevated events (caused by “local” or “regional” sources) where CO_2 mole fraction exceeds 500 ppm can happen. This data treatment may perhaps lose data with scientific value. Second, since the atmospheric CO_2 mole fraction is increasing, I would use a value that well follows the atmospheric trend for instance XX ppm + the long-term trend. The constant value 500 ppm does not mean same as that in past or future years.

P6 L30: “calibrations”

P7 L24: “1.0±1.9 ppm at ULD”

P7 L25: As in my earlier comment, I need to question if the positive values in CO_{2XS} at the stations are simply ascribed to “local activities”.

P8 L5: “An automatic weather station…” This sentence might be moved to section 2.1.

P8 L15: What are the “tourist activities” specifically? Local transportation?

P8 L23: As in my earlier comment, the wording like signals of Chinese emissions in “baseline” data may be debatable. And “downwind of East Asia” – note that these two stations are also in East Asia.

P8 L32: “the degree and speed of atmospheric mixing” If the authors means dynamics of the PBL, they might mention to rectifier effect (e.g. Denning et al. 1999; Chan et al. 2008). The wording might be re-considered. Same comment as P11 L13.

P9 L7: Although I am not a non-native in English, I wonder if “plateau” can represents stabilization after decrease (not increase).

P9 L29: same comment as to P8 L23. AMY is also in East Asia.

P9 L10-15: Unfortunately, this paragraph does not try to explain possible causes of the diurnal variation observed in August. The up-valley and down-valley wind feature was already described in section 2.1. Here I hope to see discussions on how such a wind pattern or any possible sources/sinks upwind could affect variations in CO_2.

P9 L25: “4.8 to 5.8 ppm” and “-6.8 to -9.6 ppm” I guess these values are deviations from a certain value like an annual average from each station. Please explain.

P10 L15–23: All detailed technical information should be moved to section 2. In this section the authors should focus on how such technical events affected the

measurement data.

P11 L7: “using” to “relative to”

P11 L10: “regionally” to “locally”

P11 L11: What is “the long-transported CO_2 levels”? High wind speed does not explain the relatively low CO_2 level.

P11 L15: “Due to its location it is…” My understanding is that the latter “it” means “CO_2 mole fraction observed at ULD”. If this is the case, this sentence is strange. Mountain and valley breezes cannot change CO_2 mole fraction directly.

P11 L17: delete “added”

Table 3 caption: “abundances” to “mole fractions”.

Table 3: According to the caption, the uncertainties are simple standard deviations calculated from the all data collected during the respective years. It includes signals of the all components: the long-term, seasonal, synoptic-scale and diurnal variation, and results in too big estimates of uncertainties of the annual mean values. Indeed, the numbers tabulated in Table 3 apparently show that there are no significant differences in annual means between every successive years (i.e. no trend is detectable). The authors should calculate uncertainty that better represent an estimate of error of an average.

References:

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Denning et al. 1999, doi.org/10.3402/tellusb.v51i2.16277

Tohjima et al. 2010, doi.org/10.5194/acp-10-453-2010

Tohjima et al. 2014, doi.org/10.5194/acp-14-1663-2014