**Atmospheric
Chemistry
and Physics
Discussions**

Interactive comment on "CO_2 column-averaged volume mixing ratio derived over Tsukuba from measurements by commercial airlines" *by* M. Araki et al.

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The authors thank Anonymous Referee #2 for his or her careful consideration of the manuscript and helpful comments. The authors have taken this opportunity to make several suggested improvements of the paper in response to these comments.

General comments

1. The major weakness of this paper is that the Xco2 calculated by the authors from the CONTRAIL measurements are not compared with or validated by any independent measurement. There are multiple references to the Tsukuba FTS which measures Xco2, and the authors even explain that ground-based FTS measurements of Xco2

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are important. However, we do not see any direct comparisons between the columns derived from the aircraft profiles and those from the FTS. A careful comparison of coincident FTS and CONTRAIL measurements under a variety of atmospheric conditions (T/P/H2O) would be invaluable for determining the accuracy and precision of the authors' method of calculating Xco2 from CONTRAIL, and would significantly strengthen the paper.

Response: We added a discussion of the comparison with XCO2 by FTS as section 3.5 and Fig. 2.

2. There are no references to the atmospheric water profile. According to Machida et al., the CONTRAIL CME profiles give a dry-air mole fraction of CO2 as a function of altitude. To compute a column-averaged dry-air mole fraction (i.e. Xco2), the total column of dry air needs to be computed. The authors obtain a number density of air from the rawinsondes or the CIRA-86 dataset, but do not mention whether these are dry-air densities or total densities. If they are total densities, they ought to be corrected for the water number density at each altitude. Do the CONTRAIL aircraft measure atmospheric pressure? This is another way of determining the total column of air without rawinsondes. In either case, NCEP or ECMWF global H2O profiles could be used to correct the pressure or number density, if the met data from Tsukuba do not include a water profile.

Response: Dry-air densities are used in the present analysis. We revised section 2, Analysis, as "Rawinsonde data were utilized for the number density profiles of dry-air in type I analyses." We added that "Observed total densities of air by the rawinsonde were corrected for the water number density using the relative humidity observed by the same rawinsonde."

Specific comments

Reviewer: Page 3403, Lines 4-7. There is a reference to "ground stations." Do you mean the in situ flask measurements?

Response: These "ground stations" are flask samplings and/or in-situ measurements using NDIR.

Reviewer: A short section on the data and models (grid size, time step, etc.) used in this work would be helpful and would make section 2 more readable.

Response: We added that "The current time data and the data predicted for 3 h later for the PBL heights were obtained for every 6 h at 00h00, 06h00, 12h00, and 18h00 UTC from the NCEP web site" and "CIRA-86 data having monthly mean values in a 5° latitude grid were employed." We mentioned the type of analyzer in the MRI tower, i.e., NDIR analyzer. We added the following explanation of the U.S. standard atmosphere: "...where the U.S. standard atmosphere, which is a model that defines values for atmospheric temperature, density, pressure, and other properties over a wide range of altitudes ..."

Reviewer: Page 3408, Lines 15-20. Why screen for clear sky profiles for an in situ measurement? If the FTS in Tsukuba can give you criteria for clear skies, why not use the X_{CO2} measurements from the FTS to compare the total columns?

Response: Since observable points of GOSAT are limited to clear-sky regions, we analyze data only from clear-sky days. We added a comparison with FTS in the revised manuscript.

Reviewer: Page 3408, Line 20. Why do you include the X'_{CO2} measurements? This extra complexity is justified later in the paper, but a one-sentence justification here seems appropriate.

Response: At the end of section 2, we added this justification: "Comparison between XCO_2 and $X'CO_2$ can demonstrate the effect of the low-altitude atmosphere on XCO_2."

Reviewer: Page 3411, Equation 4. Matsueda et al. have a 9-parameter equation. You only keep 7 parameters. Could you comment on this? What is the physical meaning of each parameter? Why is your a_5 the opposite sign to Matsueda et al.'s? Is that

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significant?

Response: Coefficient a_1 is a trend on the starting date. a_2 and a_3 are coefficients of the growth rate and its second order, respectively. a_4 and a_5 show the seasonal cycle and a_6 and a_7 describe its second harmonic. a_5 in the present fit has the opposite sign to that of Matsueda et al. To determine meaningful values of the first harmonic of the seasonal cycle, long-term data may be necessary. Although Matsueda et al. used the second harmonic of the seasonal cycle, the observational term of the present work is not sufficient to determine the second harmonic.

Reviewer: Page 3412, Lines 4 and 7. A seasonal amplitude of 4.63 ppm from the aircraft profiles and 8 ppm for the FTS X_{CO2} values is a big difference! What causes this difference? Can you plot the Tsukuba FTS columns in Figure 2 for comparison? Also, do you really believe you know the seasonal amplitude to two decimal places?

Response: First, the observational period in the present study is much shorter than that in Ohyama et al. Comparison of the amplitudes should be done after a long-period observation. For the observational period in the present study, we added a discussion of the comparison with XCO_2 of FTS. The FTS XCO_2 values from May to June 2007 are larger than the present values. The indication of two decimal places is meaningless in the comparison of the present amplitude with that of Ohyama et al. However, it is necessary when comparing XCO_2 with $X'CO_2$ in the present study.

Reviewer: In most places, errors are quoted for each CO_2 value. The exceptions are for the seasonal amplitude values in the abstract and section 3.5. What are the errors on those values?

Response: We added the errors in the abstract and section 3.4 as follows: The highest and lowest values of the fitted curve in 2007 were 386.4 +- 1.0 and 381.7 +- 1.0 ppm, respectively, for XCO_2 and 387.0 +- 0.8 and 381.1 +- 0.8 ppm for $X'CO_2$ in May and September, respectively, where the errors are 1 standard deviation of the residuals in the fit. The amplitude of the tentative seasonal variation, i.e., the peak-to-peak

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seasonal amplitude, by the present observation period for 1 year and 3 months was found to be 4.63 +- 0.15 and 5.91 +- 0.13 ppm by the fitted curves for XCO2 and X'CO2, respectively, where the errors are twice the standard error of a4 in the fitting.

Reviewer: It would be useful to see a figure comparing of the rawinsonde number densities and the CIRA-86 number densities.

Response: Because such comparison figures would require many pages, we briefly indicated the differences. We compared the rawinsonde number densities, CIRA-86 number densities, and those of the U.S. standard atmosphere. The profiles of the CIRA-86 number densities are similar to those of the rawinsonde, and differences (1–2%) of both in the altitude range of 0–10 km could be related to daily pressure variability.

Technical comments: All technical comments were applied to the revised manuscript.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 3401, 2010.
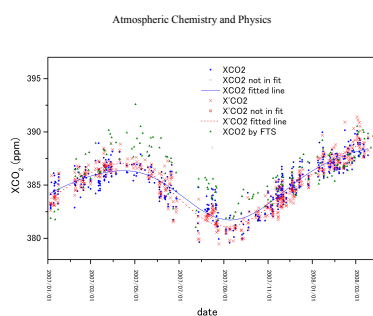
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Figure 2. Time series of X_{CO2} and X'_{CO2} from type I analysis over Narita using CONTRAIL data from January 2007 to May 2008. Data from 493 flights by five airliners were analyzed. X_{CO2} (blue marks and solid blue line) were numerically integrated to cover the entire altitudinal range, i.e., from the ground level to the lower thermosphere (85 km), and for X'_{CO2} (red marks and dotted red line) over the altitudinal range of 2–10 km. Data on 16 August 2007 were not included in the fit. Daily averaged X_{CO2} using the scaling retrieval algorithm by FTS are plotted by green marks.

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Fig. 1.

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