

Interactive comment on “Variation of CO₂ mole fraction in the lower free troposphere, in the boundary layer and at the surface” by L. Haszpra et al.

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The manuscript describes the relation between tower based CO₂ mole fraction measurements and airborne profile measurements for a period of several years. Both data sets represent an important source of information for inverse models that derive regional scale source/sink estimates. The paper is well written, and I recommend publication after my comments and questions below have been addressed (which I regard as minor changes).

General comments:

- 1) It remains unclear why the authors used PBL heights from ECMWF, although tem-
C4070

perature and moisture data were available for each flight. As the authors calculated PBL heights from these data for validation of the ECMWF PBL heights, I would recommend using these rather than model derived PBL heights. A bias of about 100m and 32% unexplained variance (r^2 of 0.68) seems significant and likely has an impact on the calculated mean CO₂ mole fraction within the PBL, especially given that there are often strong vertical gradients in CO₂ near the top of the PBL. This could also have an effect on the seasonal behaviour, as the bias might change throughout the year. It would also be interesting to know the standard deviation of the differences between aircraft data derived and ECMWF diagnosed PBL heights in addition to the bias.

- 2) Traceability of profile data and tower data: when assessing the small difference between tall tower measurements and the mixed-layer mean derived from aircraft measurements, the accuracy of those measurements seem to be a crucial limitation. It needs to be made very clear, to what level each of the measurements are traceable to the WMO CCL scale, especially given the observed differences between co-located flask sample analysis and airborne profile data. In this regard, a plot comparing the lowest altitude of the profile measurements with those made at the top level of the tower should be presented.

Detailed comments:

P 11544 L 6: When filling cylinders with calibration gas from a larger tank, there can be an impact on the CO₂ mole fraction. Also, the mole fraction can change during time in the small tanks, for example through diffusion within pressure regulators. It should be described in detail how where the tanks, and if the mole fraction of the calibration gas in the small cylinders was compared to the original tank containing WMO CCL certified standard gases before and after use of the small cylinders for calibration of the airborne instrument. Note that any differences in the calibration of the aircraft instrument and the calibration of the instrument used for the tower measurements will result biased results for the assessment of differences of tower measurement and mean boundary layer mole fraction.

P11544 L 15: It is unclear how the comparison of the ascending and descending profiles can provide information on both, the changes in the atmosphere and on the performance of the instrument. The authors should explain how they distinguished the influence of these two on differences in the profiles.

P11544 L 22: It should be explained how the meteorological information was used to evaluate if the measured mole fraction profiles were realistic. In order to exclude erroneous data usually additional information on instrument parameters such as pressures and temperatures are used, otherwise a sampling bias might result when specifically assessing “unrealistic” data.

P11546 L25: Regarding the non-linearity: Was a multi-point calibration performed repeatedly at least on ground? Was the non-linear component of the calibration curve changing over time? When using a linear correction to the “raw in situ airborne measurements”, is there a problem with not capturing the non-linear component? As the linear correction is based on the comparison with flask data, does this mean the information from the in-flight calibrations was not used at all in the reported mole fraction data? This should be clarified. I would expect that e.g. the offset of the signal changes significantly during the time between flask samples, so that at least the information from “zero” checks contain valuable information. Also a scatter plot showing the comparison of in situ and flask CO₂ mole fraction would be helpful.

P11548 L23: the comparison of measurements made at the top level to mixed layer averaged mixing ratios reminds me a bit on the “virtual tall tower” concept by K.J. Davis (unfortunately I could not find the corresponding publication detailing this). In that concept, CO₂ measurements made at around 10 meters above ground are corrected for a vertical gradient to represent CO₂ measurements from a tall tower. May be the authors can discuss this, and may be think about a similar correction that turns tall tower based CO₂ into mixed layer averaged CO₂.

P11549 L10: replace “largest” with “larger”

C4072

P11551 L6: the authors probably meant “lay” instead of “lied”

P11552 L10: From figure 5 it appears that the seasonal minimum is around day 230, which is more August 20 than July 20.

Fig 3 figure caption: please rewrite the first sentence

Fig 7: please add “CO₂” to the axis and the legend

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C4073