General Comments:

The authors present the virtual tall tower (VTT) approach applied to a five-year dataset at the ICOS station in Svartberget (SVB). The analysis is based on the co-location of an ICOS atmospheric station and an ICOS ecosystem station, which share the same infrastructure but operate with own separate instrumentation. The central idea is to use CO_2 measurements from already existing ecosystem stations to improve the spatial coverage for CO_2 observations in Europe at heights around 100m above ground which could be used by inverse modelling to estimate fluxes on regional or global scale. By applying an offset correction and testing a set of gradients functions for height correction, the ecosystem measurements around 30 m are extrapolated to the top tall tower level of 150 m. For a valid VTT estimate three filter conditions had to be fulfilled ensuring good data quality of the ecosystem station and a well-mixed boundary layer up to the highest tall tower level. The influence of the chosen filter criteria, variables and parameter of the CO_2 VTT performance are discussed comprehensively, both in a dedicated sensitivity analysis and with respect to the hourly means measured at 150 m. The authors write clearly about the strengths and limitations of the approach and outline the steps required to extend this method to the ICOS ecosystem network. I have no major concerns. I recommend publication once the following minor comments have been addressed.

Specific Comments:

2.1 Site description

Usually, ICOS atmospheric tall tower stations cycle sequentially through their different intake heights (e.g. switching every five minutes to the next level). Consequently, the hourly mean provided by the carbon portal is derived from a subsample of the continuous atmospheric concentration during the hour. In addition, an hourly mean is calculated even if only a single minute of observation is available, resulting in a varying data coverage for the hourly mean. The number of valid data points used each hourly mean is explicitly given in a separate column [Hazan et al., 2016]. Describing this procedure in more detail would improve the readers understanding of the following comparison between the VTT estimate and the atmospheric hourly mean. Could the authors provide more detailed information about the atmospheric station SVB, in particular how the different heights are sampled?

2.2. Dataset

The instrument precision below 50 ppb for an analyzer at ICOS atmospheric stations can only give the lower most limit for the comparison. In a side by side ambient air comparison of two co-located instrument, the observed scatter is likely to be larger, particularly for hourly means derived from a subsample. An approach to derive the r^2, bias and RMSE for ambient air comparison are flask samplings. Do independent ICOS flask samples exist at SVB that would a allow such a comparison, even if they do not cover the same time period? It might be worth to also mention the flask comparison and discuss these numbers in the latter section 4.1 of the VTT approach, as they provide a more realistic lower limit for the metrics used to evaluate VTT performance with respect to subsampled hourly means and without applying filter to the atmospheric dataset.

Could the authors also provide a value for the CO_2 precision at a ICOS ecosystem station?

2.3. Data processing

An additional filter criterion that accounts for the number of measurement points or the standard deviation for the hourly mean calculation of the atmospheric data could further improve the comparison. Since the hourly mean is used both for the post-hoc calibration and for the VTT performance at 150m, a low data coverage may bias the statistical metrics and lead to a misinterpretation of the VTT performance. In particular, during periods of high variability in atmospheric CO_2 concentration, a poor coverage could result in larger deviations or outlier (e.g. visible in figure1b). Could the authors check whether the number of observations used for the atmospheric hourly mean has a systematic influence on the comparison metrics?

4.2 Impact of eddy-covariance calibration and data filtering

The authors state that the “VTT correction only acting as further fine adjustment” (line 273/274). Could the authors provide more information on the magnitude of the VTT correction ΔC (equation 3, section 3.1.2) for the SVB case, for example in the form of a timeseries or a summary statistic?

Technical corrections

- Line 232: 0-5 points from mid September to mid March → Figure2 suggests that there are some days in this period with 6 points or above the gridline at N=5

- Figure3: please add units to the Bias and the Standard Deviation

- Figure5: does the background color has any meaning?

- FigureA1: please add units to the Bias and the Standard Deviation

- format issue CO<sub>2<\sub>, line423 and 432 as well as in line 439

References:

Hazan, L., Tarniewicz, J., Ramonet, M., Laurent, O., and Abbaris, A.: Automatic processing of atmospheric CO2 and CH4 mole fractions at the ICOS Atmosphere Thematic Centre, Atmos. Meas. Tech., 9, 4719–4736, https://doi.org/10.5194/amt-9-4719-2016, 2016.