

How Well Tall Tower Measurements Characterize the Mid-Planetary Boundary Layer (PBL) CO₂ Mole Fraction

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Characteristic PBL CO₂ mole fraction data are needed by 3-dimensional transport models, carbon budget models as input and validation, as well as calibrations for space-borne observations. Tall tower CO₂ mole fraction measurements (10 - 115 m above ground) at a rural site in Hungary and regular airborne vertical mole fraction profile measurements (136 vertical profiles) above the tower, allowed us to estimate how well a tower of a given height could estimate the mid-PBL CO₂ mole fraction. Taking into account the significantly different dynamics of the lower troposphere in the different seasons, the statistical evaluation of the bias between the real mid-PBL CO₂ mole fraction (measured by the aircraft), and the measurement at a given elevation above the ground was performed separately for the summer and winter half years. Under the low elevation, mid-continental conditions at the site of the experiment, a tower of <100 m overestimates the mid-PBL CO₂ mole fraction by 1.1 - 1.3 $\mu\text{mol mol}^{-1}$ (median) in winter and underestimate it by 2.1 $\mu\text{mol mol}^{-1}$ at 10 m above the ground in summer. The median bias falls below 0.2 $\mu\text{mol mol}^{-1}$ above 220 m and 350 m, respectively. It was also studied whether additional vertical flux measurements and the application of the Virtual Tall Tower (VTT) concept could improve the mid-PBL CO₂ mole fraction estimations. In summer, in the case of a tower of 10 m height, the VTT method could improve the estimation by 0.8 $\mu\text{mol mol}^{-1}$ (median). In the case of a tower taller than 100 m and in winter, when the vertical mixing of the atmosphere is limited, the improvement is insignificant.

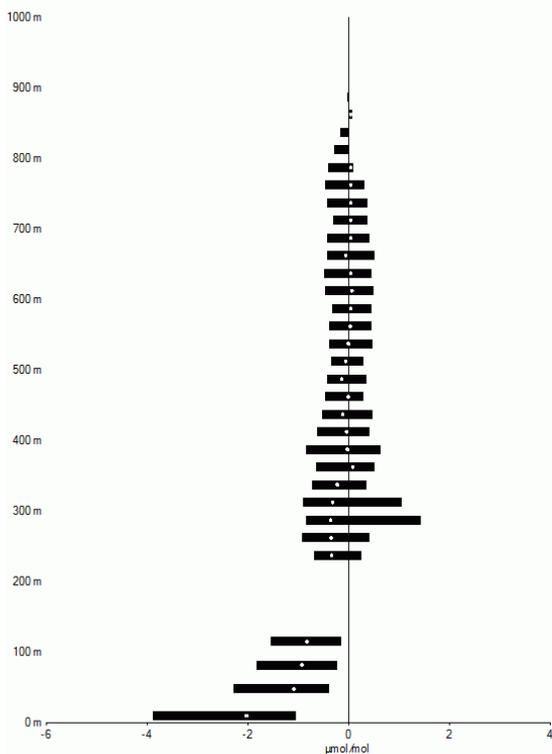


Figure 1. Frequency distribution (25-percentile/median/75-percentile) of the deviation between the mid-PBL CO₂ mole fraction and the mole fraction measured at a given elevation above the ground in summer half year (April-September).