Looking beyond our Eddy-Covariance Backyard

Vertical profiles at ecosystem stations

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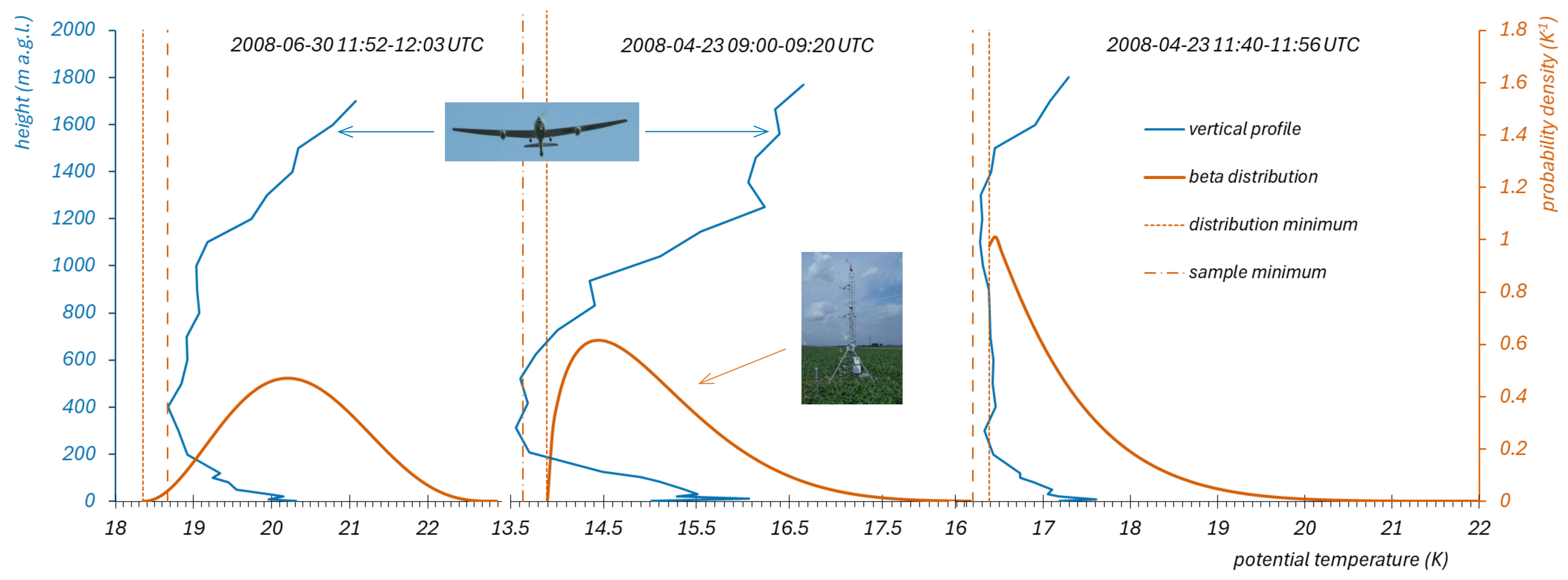
The well-equipped eddy-covariance (EC) stations of the ICOS ecosystem network are ideal testbeds for tentatively measuring or estimating additional variables relevant to monitoring or modelling global change. A common limitation of a standard EC station is the confinement of most variables to the EC measurement height, which is typically limited by factors such as footprint size, the need to avoid the roughness sublayer, and tower construction costs. Few (mostly forest) stations provide some measurements **below** this height, and almost none offer measurements **above** it. Here, we present past and ongoing efforts to close these gaps.

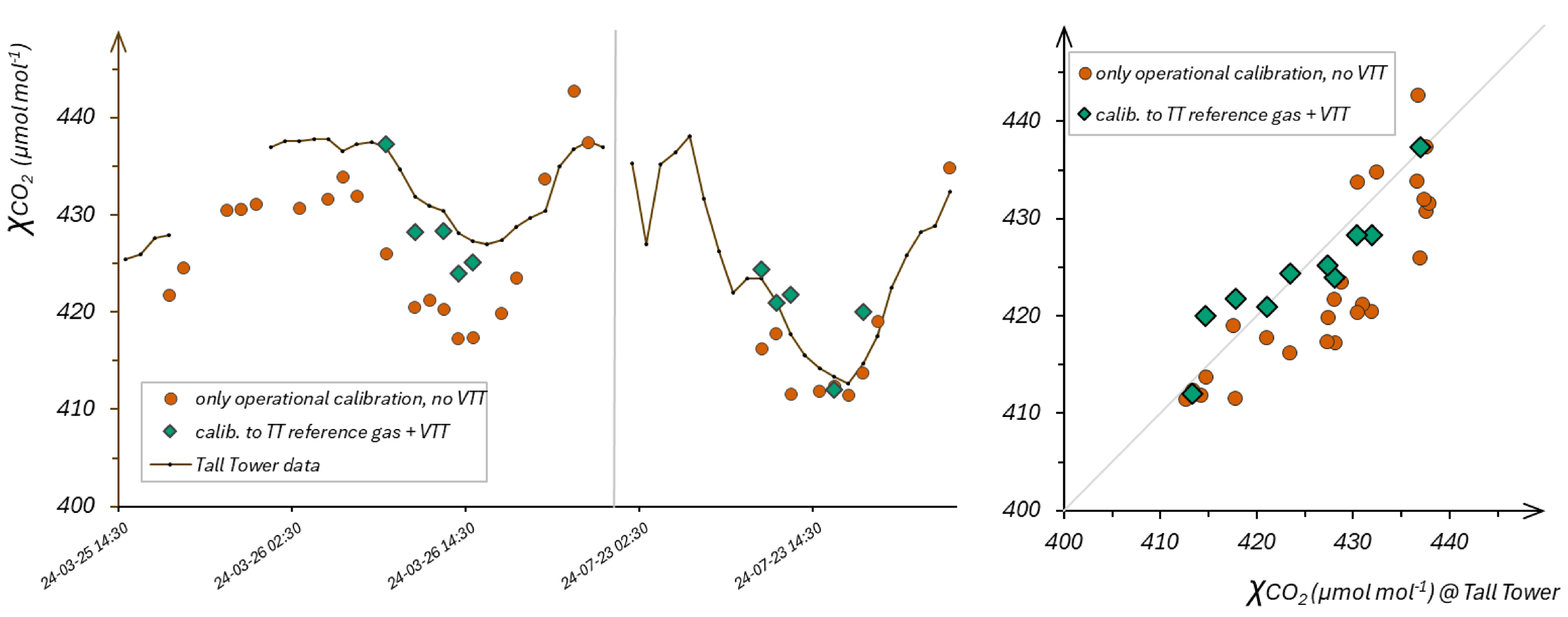
above

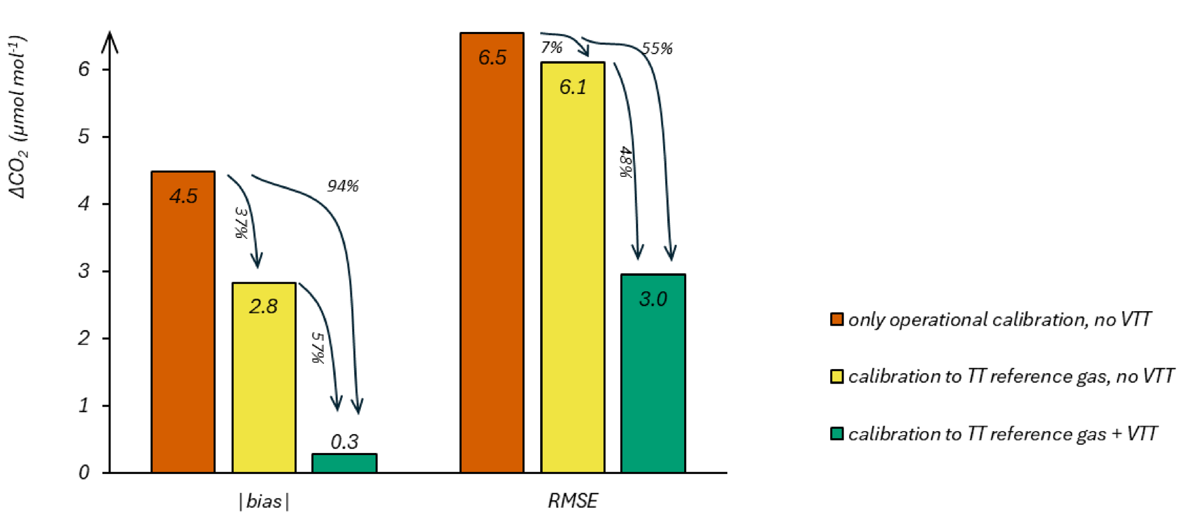
We demonstrated previously (Graf et al. 2010) that the potential temperature of the well-mixed part of the convective planetary boundary layer can be estimated from turbulent temperature data of the EC:



In the German Integrated Greenhouse Gas Monitoring System (ITMS) project FeaViTa, we test the **Fea**sibility of **Vi**rtual **Ta**ll Tower Approaches, including existing methodologies (Davis 2003, Haszpra et al. 2015) and one based on the results by Graf et al. (2010). If positively evaluated, the spatial data density of existing atmospheric stations (in particular Tall Towers, TT) of monitoring systems like ITMS and ICOS could be significantly increased by using EC stations as virtual tall Towers (VTT), supporting atmospheric inverse modelling estimates. A preliminary evaluation of two test periods in March and July 2024 showed:

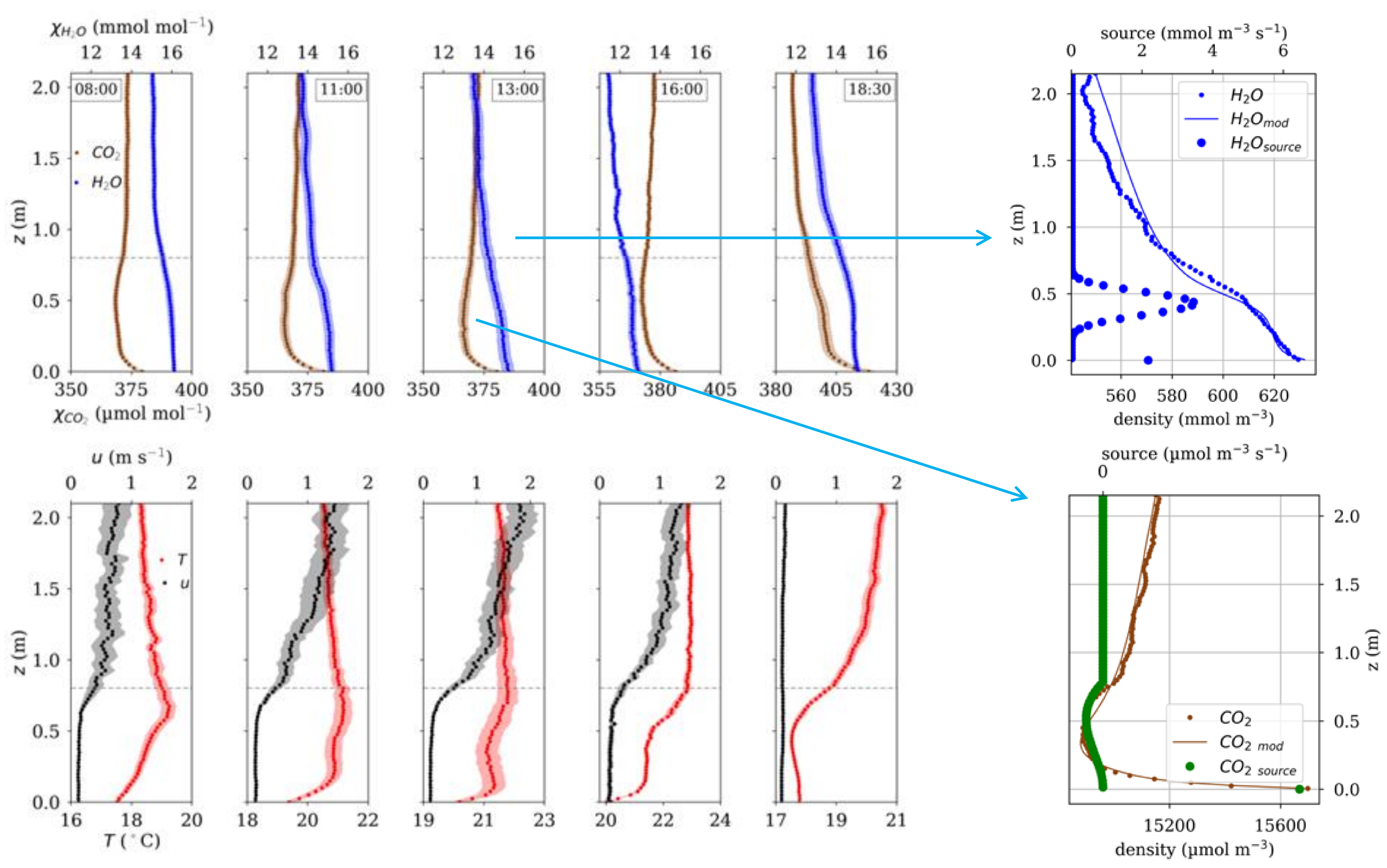
- Calibration of EC to the TT reference gas (indirectly via a temperature-controlled closed-path gas analyzer) contributed >1/3 to the overall bias reduction,
- the calibration only remained valid for a few days (figure data filtered for max. 48 h post calibration).
- For an operational VTT network, EC stations thus need to be supplemented by either highly stable additional gas analyzers, or an automated daily (1 or 2 point) calibration routine.
- Further refinement of the method is necessary to reduce the Root Mean Square Error (*RMSE*).



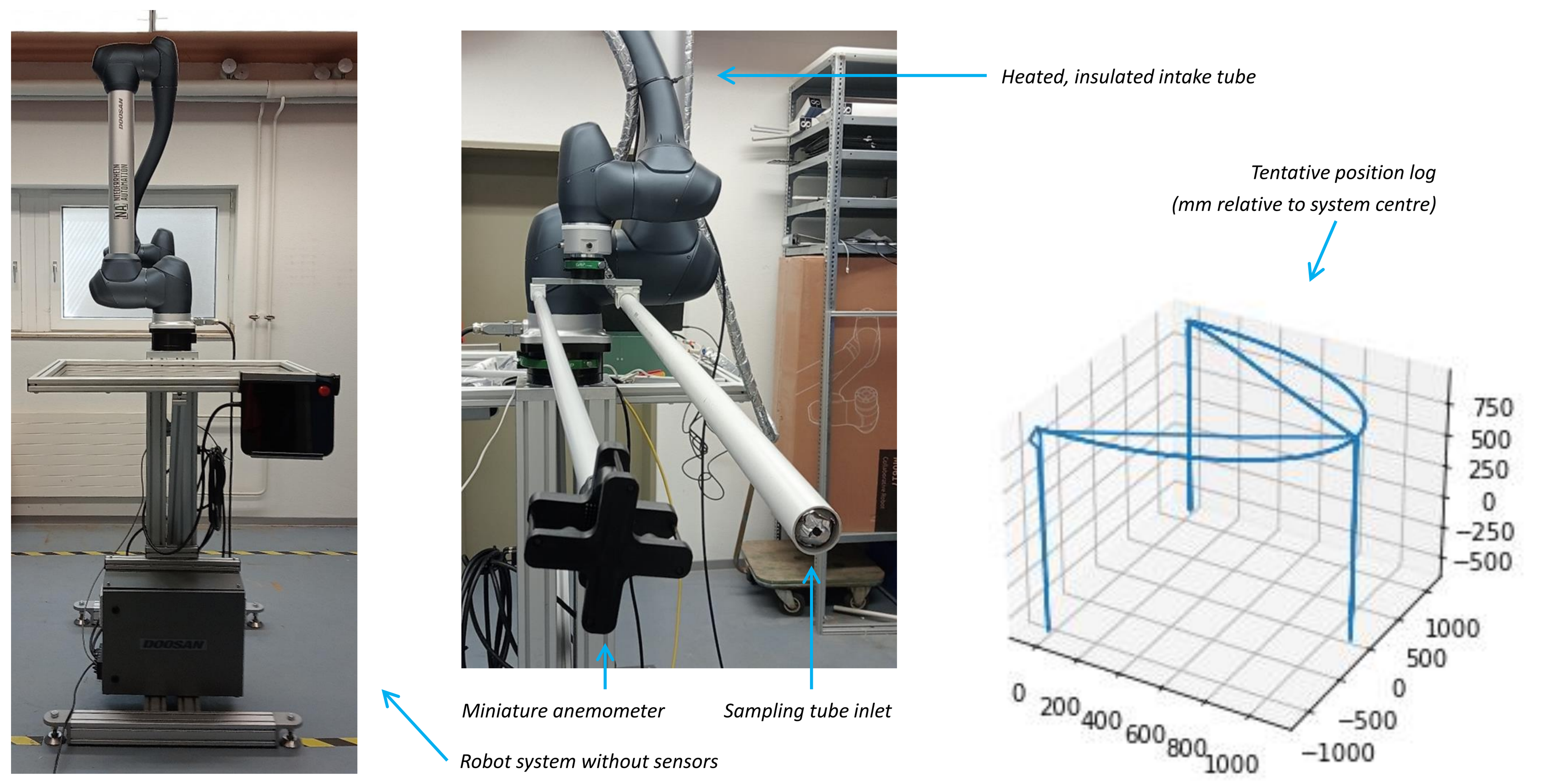


below

For scalars and wind below the EC height, we developed a profiling system, that mitigates calibration issues and sensor costs by moving sensors and tubes within crop canopies and their roughness sublayer (Ney and Graf 2019). The first version of the system moves up and down continuously at one location, yielding (after delay correction and averaging over turbulent fluctuations) a half-hourly mean profile of CO_2, H_2O, wind speed and temperature at cm-scale resolution. The figure below shows an example from an intensive observation day during the CloudRoots campaign (Vilà et al. 2020), June 15 2018 when winter wheat was growing at the DE-RuS site (dashed line = canopy height). It also demonstrates an application of vertical source partitioning according to Santos et al. (2011, right).



Currently we develop a robot-arm based system to enhance flexibility in movement speed, robustness, and sensor payload, and enable intermittent measurements on several nearby locations (e.g. crops or treatments) by the same system. First laboratory tests focused on movement control, position logging and sensor mounting:



Acknowledgements

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