On the calculation of daytime CO_2 fluxes measured by automated closed transparent chambers

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Background

Automated chambers have gained increasing popularity in recent years to continuously measure trace gas fluxes between the surface and the atmosphere. Most of these studies were focused on the measurement with dark chambers at bare soil surfaces rather than transparent chambers on vegetated surfaces for which a standardized procedure for data processing and quality control is still unavailable. Modelling of the CO_2 concentration changes over time in the chamber headspaces is more complicated for vegetated surfaces than for bare soil surfaces since additional processes such as photosynthesis and plant respiration have to be considered.

Objectives

- To test the performance of automated transparent chambers
- To find the optimal calculation procedure from linear and exponential regressions for daytime CO_2 flux estimation
- To improve the reliability of daytime chamber CO_2 flux estimation over short-statured canopies

Methods

- **Instrumentation**: LI-8100-104C x 3 + Li-840a or LI-8100A
- **Field campaigns**

Site	Terrain	Elevation	Meas. Periods
Fendt (FT) DEU	Shallow valley	595 m	July 2016
Hochhäuser (HH) AUT	Steep slope	1010 m	May 2016
Neustift (NT) AUT	Deep valley	970 m	Oct. 2016
M. Bondone (MB) ITA	Undulating	1550 m	Oct. 2015

- **Flux calculations**

Eq. (1) $$F = \frac{10VP_0(1-\frac{W_0}{1000})f_0}{RS(T_0+273.15)}$$

Eq. (2) $$f_0 = \frac{\partial C}{\partial t}|_{t=t_0}$$

Eq. (3) $$C = a_0 + a_1 t$$

Eq. (4) $$C = C_x + (C_0 - C_x)e^{-k(t-t_0)}$$

Eq. (5) $$C = C_x + k'(t-t_0) + (C_0 - C_x)e^{-k(t-t_0)}$$

Method	Equation	Obs. Length
Lin1	Eq. (3)	150 s
Lin2	Eq. (3)	Dependent on t_s*
Exp1	Eq. (4)	150 s
Exp2	Eq. (4)	Dependent on t_s*
Exp3	Eq. (5)	150 s

* t_s: the first stationary point in the time series of the observed CO_2 mixing ratio.

Results

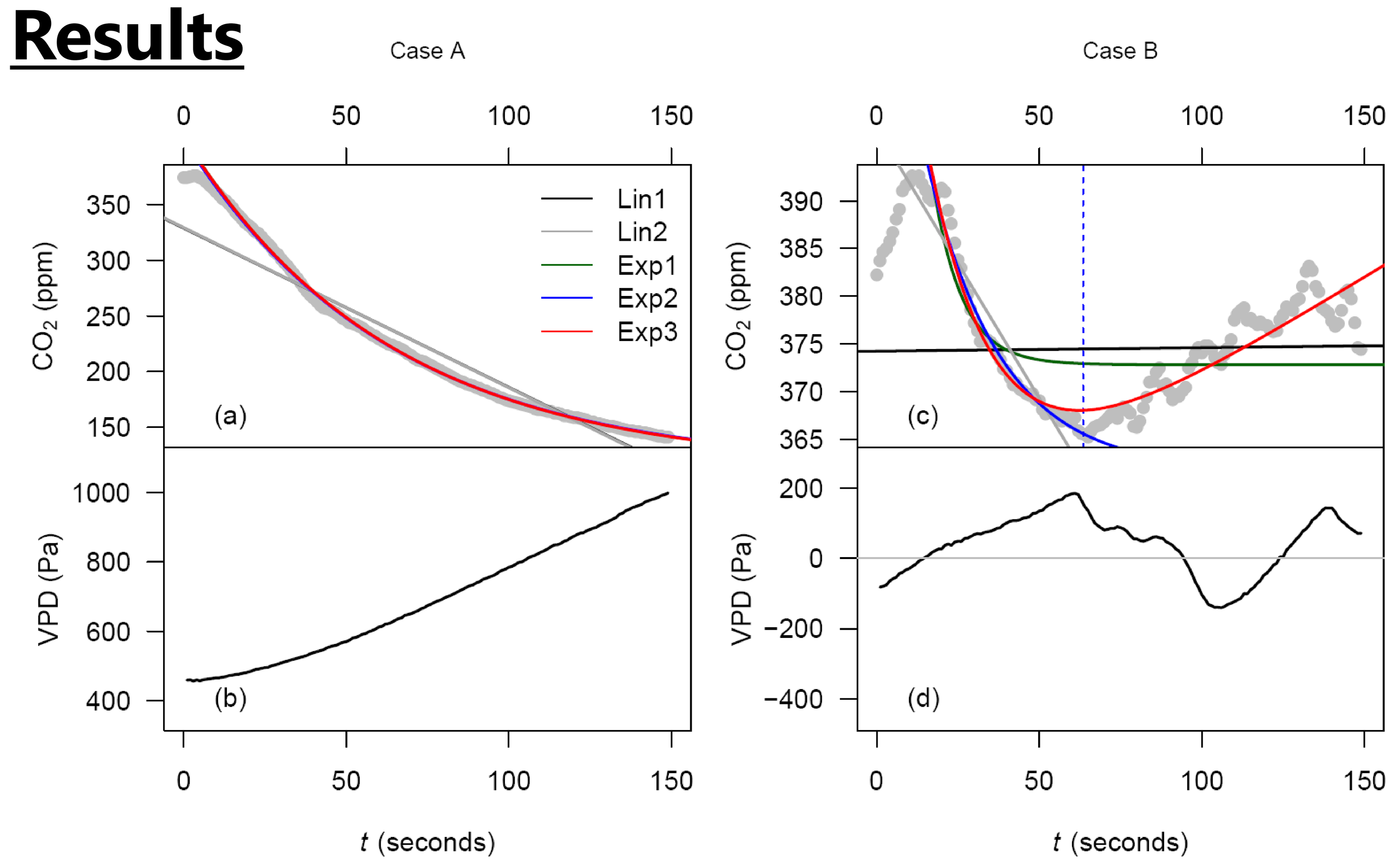

Fig. 1. Case study of the CO_2 evolution in chamber flux measurements.

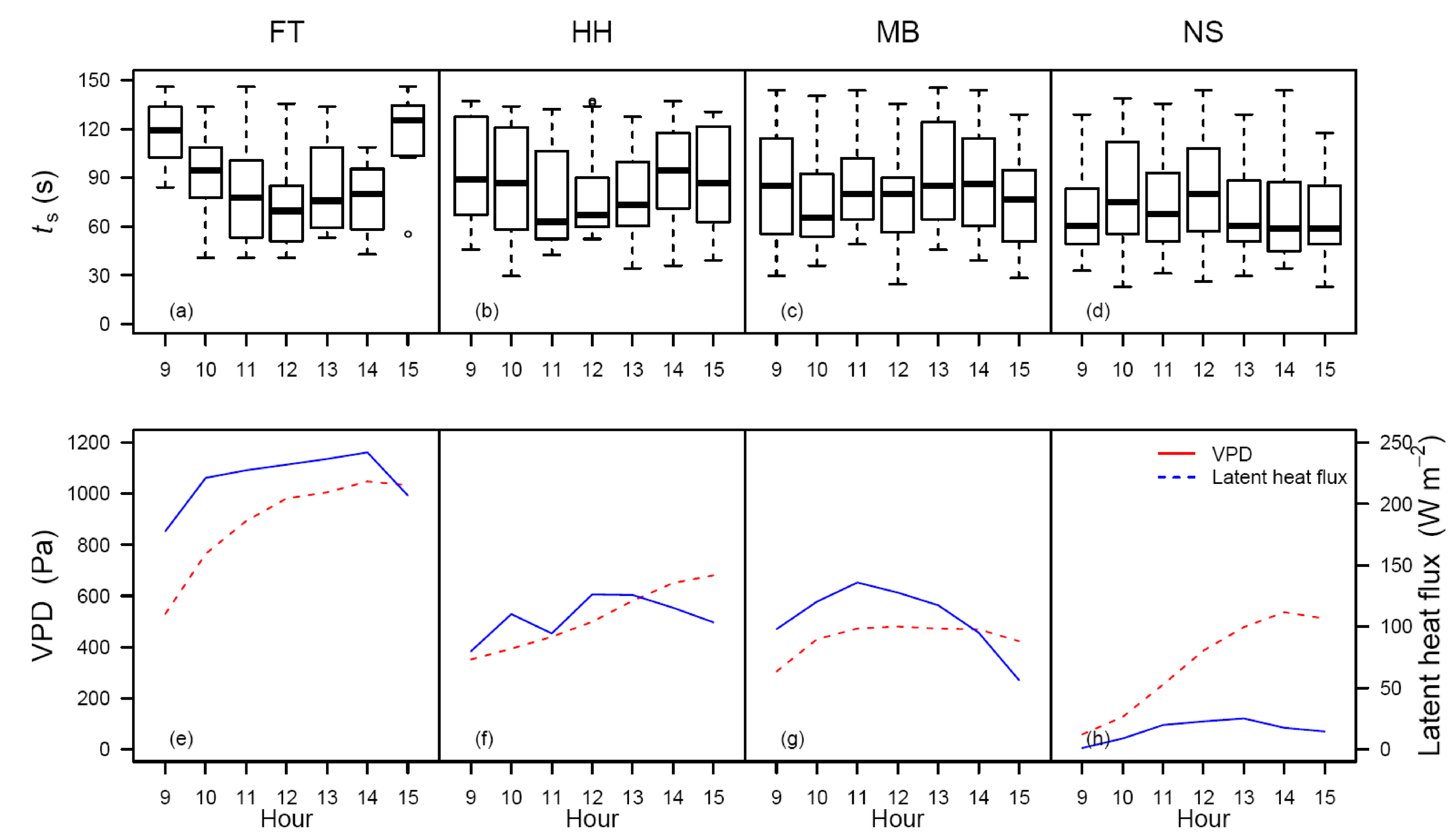

Fig. 3. Diurnal patterns of the stationary-point time (t_s), latent heat fluxes, and ambient vapour pressure deficit.

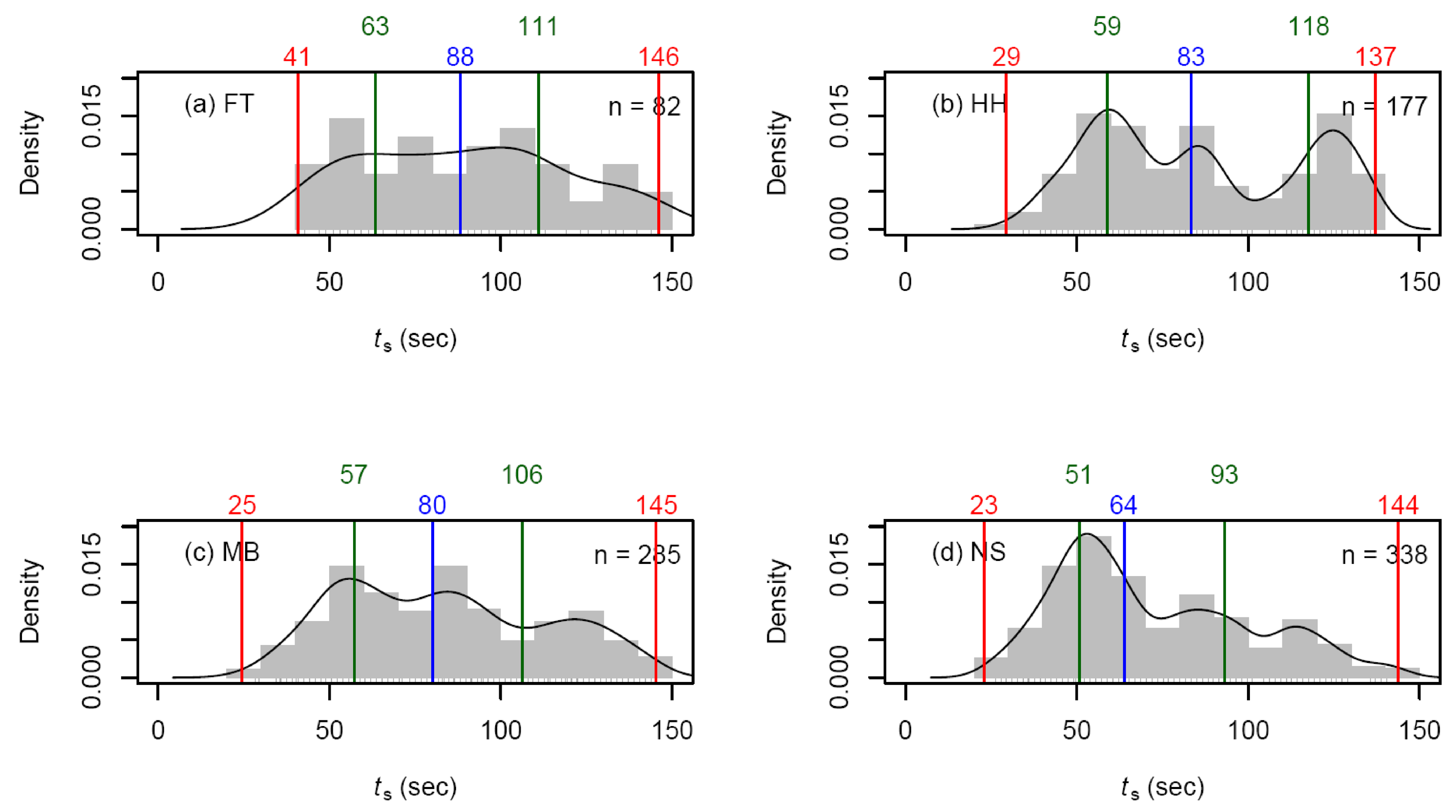

Fig. 2. Distribution of the stationary-point time (the median, the first and third quartiles, and the minimum and maximum).

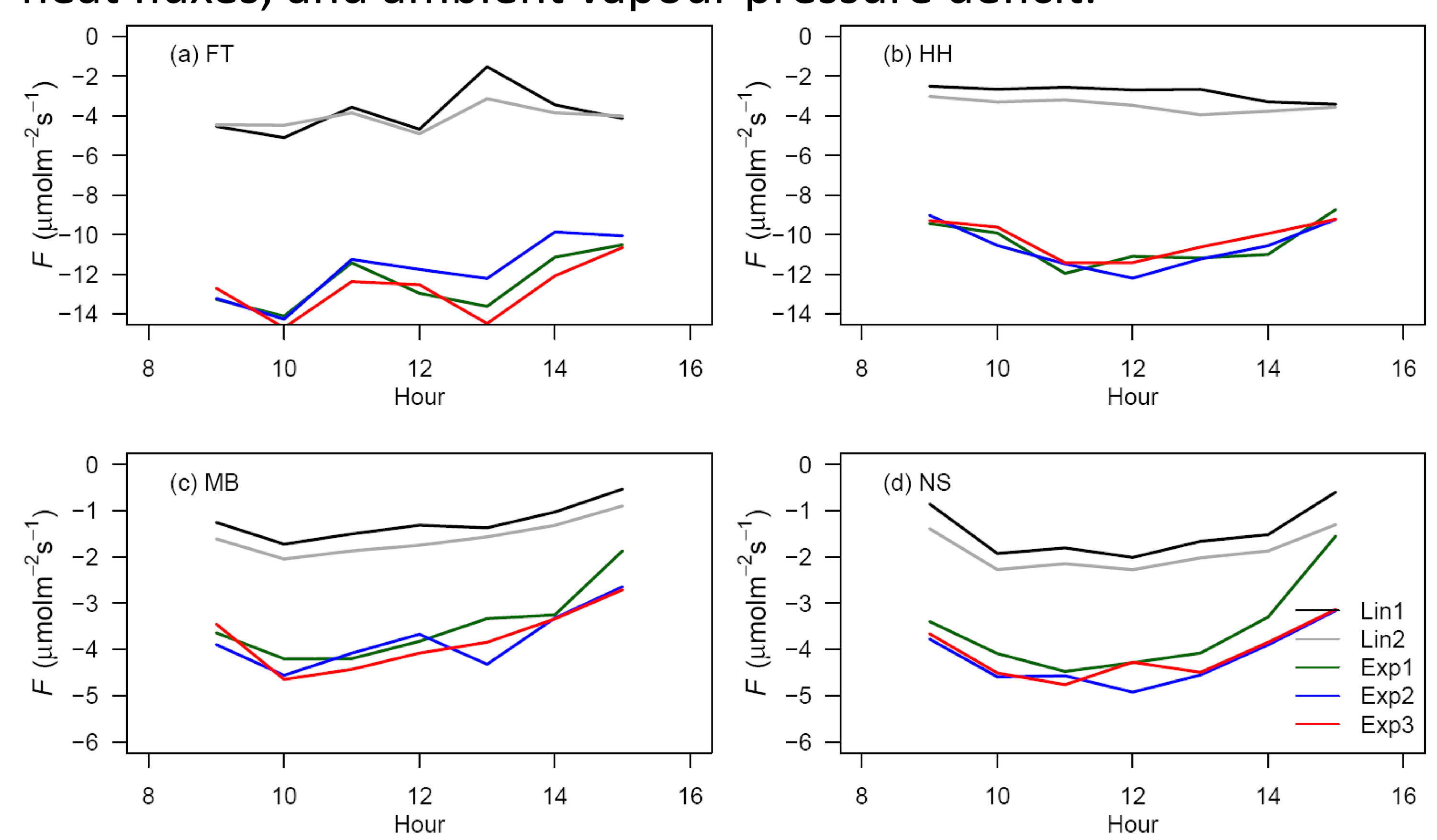

Fig. 4. Comparison of daytime CO_2 fluxes of all regression algorithms for four sites.

Conclusions

- The linear regression method should be abandoned in transparent chamber measurement for daytime CO_2 fluxes.
- The condensed water drops on the inner wall of the chamber dome, due to the evapotranspiration of the soil and vegetation, affected the CO_2 evolution in the daytime chamber measurement.
- The exponential regression should use a short observation time determined by the mathematic stationary point in CO_2 time series or simply < 60 s.
- Exp3 could represent an alternative to estimate the CO_2 flux and the influence of condensed water.

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