INVESTIGATION ON THE IMPORTANCE OF FAST AIR TEMPERATURE MEASUREMENTS IN THE SAMPLING CELL OF SHORT-TUBE CLOSED-PATH GAS ANALYZER FOR EDDY-COVARIANCE FLUXES

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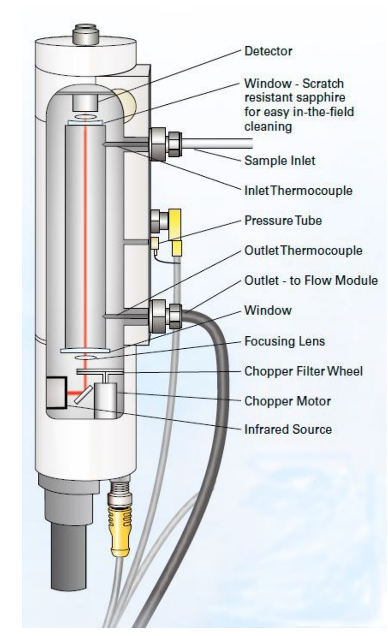
INTRODUCTION

- Enclosed gas analyzer design allows eddy covariance flux measurements using short intake tubes, ≤1m [1]
- Tubes with length-to-diameter ratio < 1000:1 do not eliminate 100% of fast temperature fluctuations [2]
- Fast temperature fluctuations affect gas density measurements and conversion to dry mole fraction [3], thus affecting flux calculations
- Computing fluxes using short-tube instruments requires high-speed temperature measurements of the air stream inside the sampling cell
- Here we examine importance of such measurements, and show flux errors resulted from not using fast temperature of air sample measured inside the cell

METHOD



- Three LI-7200 enclosed gas analyzers with 1 m long 0.005 m diameter intake tubes were used at three experimental sites
- Each analyzer is equipped with two high-speed thermocouples weighed to output correct cell air temperature [1]
- Each analyzer also outputs slow block temperature measured in the metal body next to the cell
- Fluxes computed using high-speed cell air temperature (Tcell) are compared to those computed using slow block temperature (Tblock)

SITES

Site 1:

LI-COR Experimental Research Station
Irrigated short grass, 0.05 m
3.8 m measurement height
Gill R350 + LI-7200 + EddyPro

Site 2:

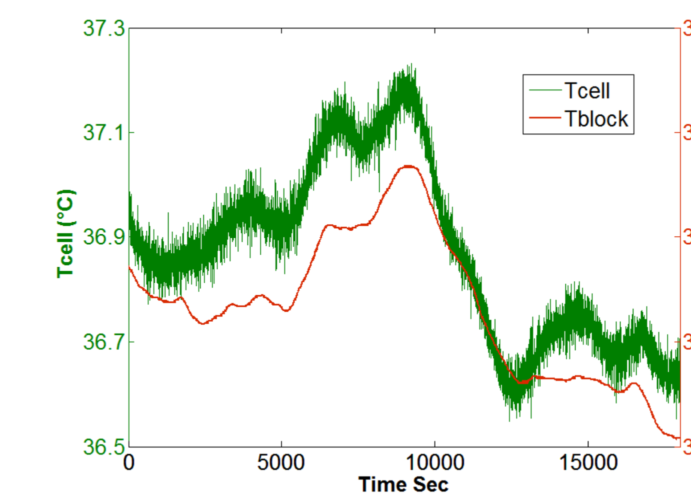
Himmelmoor site, U of Hamburg, Germany
Short grass, 0.05 m
8.0 m measurement height
Gill R3 + LI-7200 + EddyPro

Site 3:

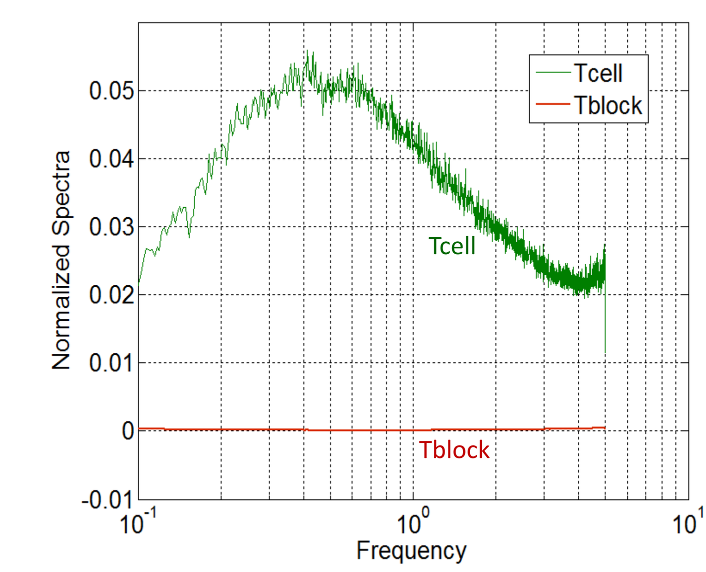
Temporary plot with ryegrass and weeds
Medium variable canopy, 0.1-0.6 m
2.5 m measurement height
CSAT3 + LI-7200 + EdiRe

SAMPLED AIR TEMPERATURE

- Example from Site 1
- Tcell and Tblock are different in means and fluctuations
- The differences are significant

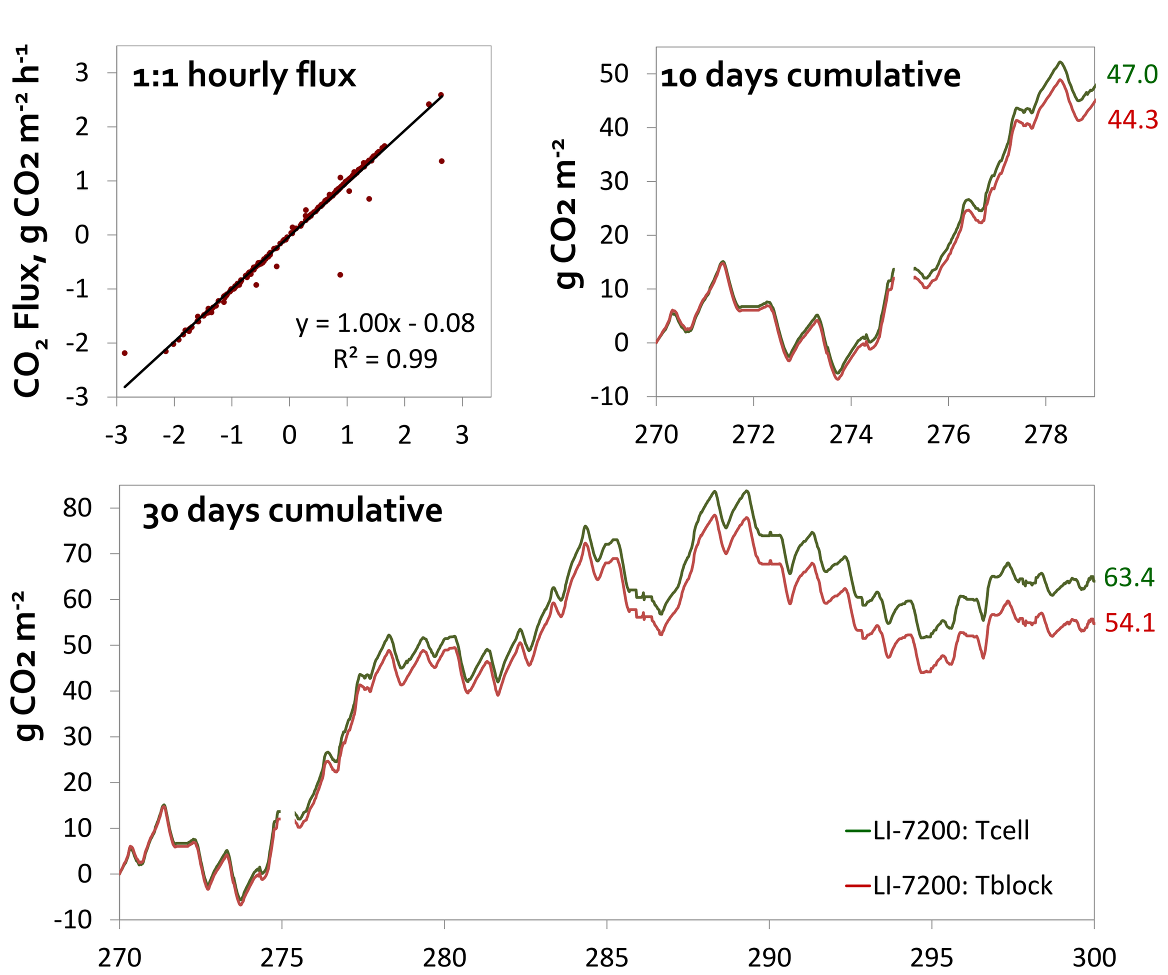


- Spectra of Tcell and Tblock are shown
- Tube does not fully dampen fluctuations
- Residual fluctuations are captured by Tcell but not by Tblock



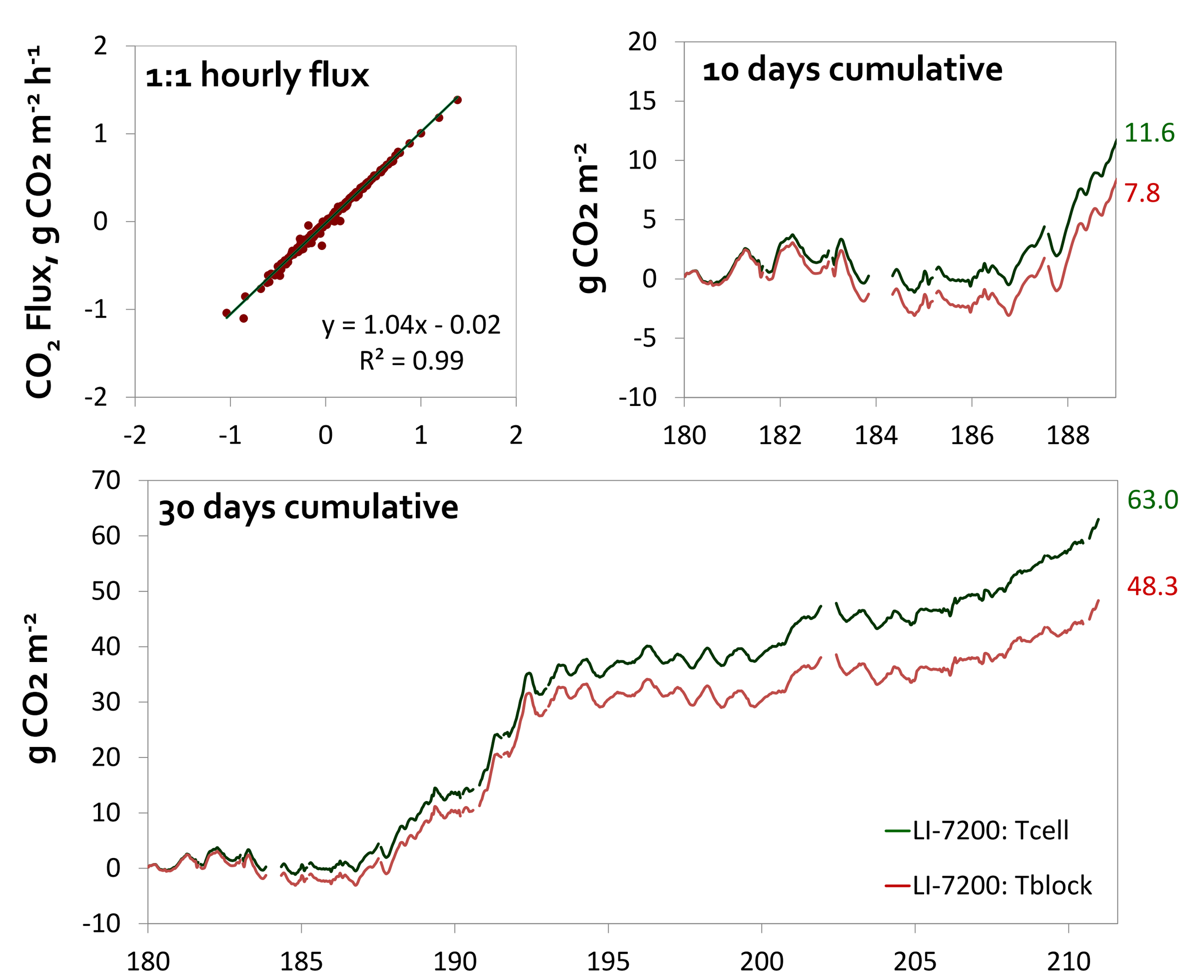
FLUX ERRORS RESULTED FROM USING SLOW TEMPERATURE

Site 1



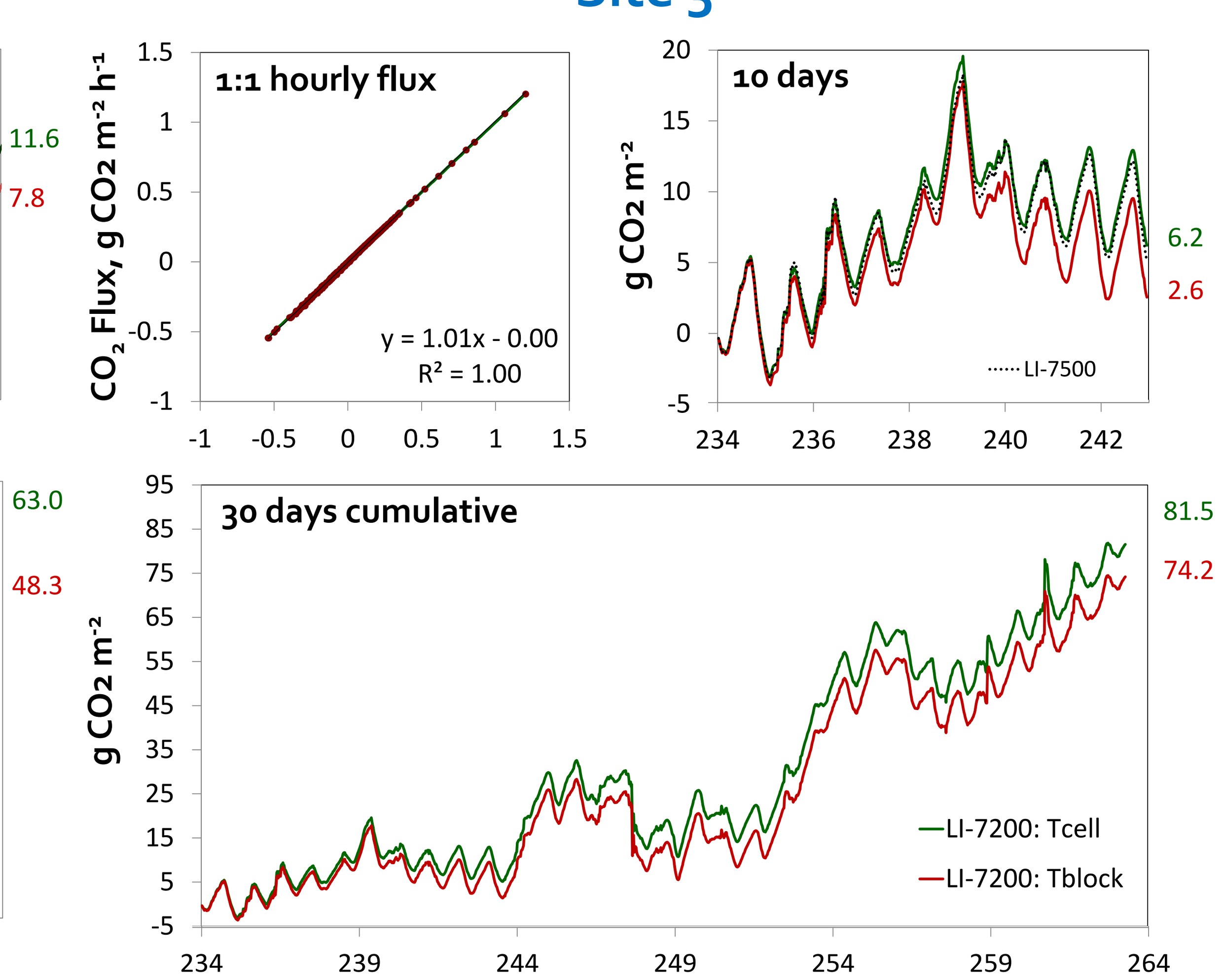
- The hourly 1:1 plot is deceptive, implying similar CO_2 fluxes when using fast Tcell and slow Tblock for calculating fast dry mole fraction.
- However, lack of fast air temperature measurements in the cell leads to accumulated error in CO_2 fluxes, noticeable after first 5 days and reaching 6% by the end of a 10-day period (47.0 vs 44.3 g CO_2 m^{-2}). Over 30 fall days, the error increased to 9.3 g CO_2 (15% of monthly budget).

Site 2



- Similar to site 1, the relatively close match of the 1:1 plot is deceptive (just 4% systematic flux underestimation from), but leads to a rapid accumulation of error in CO_2 flux, noticeable after first day, and significant by the end of the 10-day period (11.6 vs 7.8 g CO_2 m^{-2}).
- The resulted error over 10 days is 3.8 g CO_2, or 33% of CO_2 budget. Over 30 summer days, the error increased to 14.7 g CO_2 (23% of monthly budget).

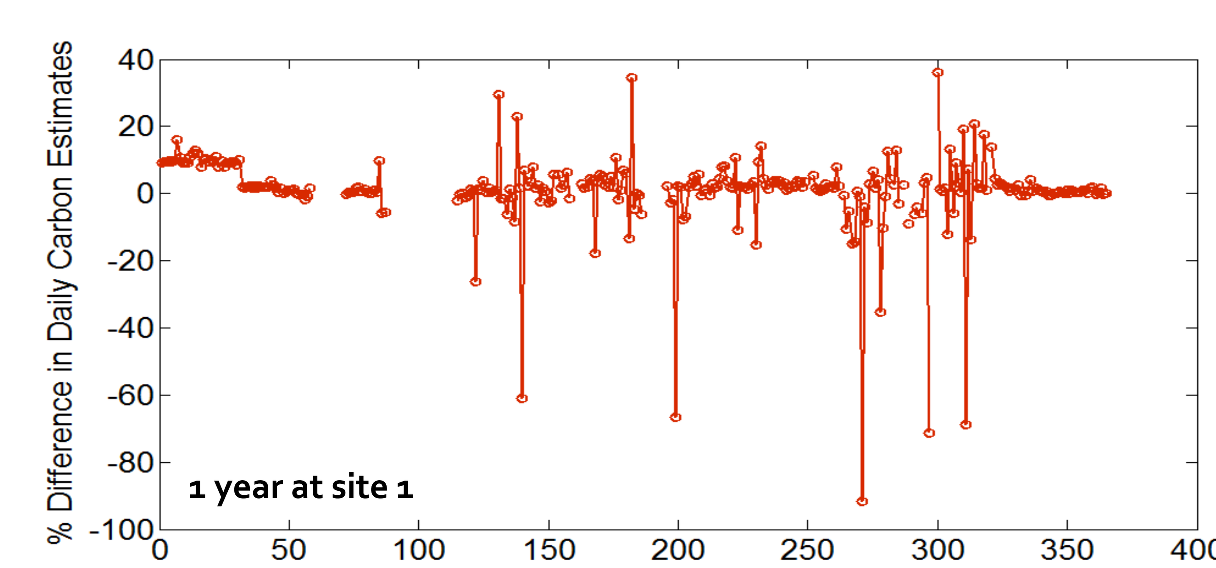
Site 3



- At site 3, fluxes from LI-7200 computed using fast Tcell match open-path fluxes from LI-7500 computed using full WPL density terms
- The lack of fast air temperature leads to errors noticeable after first 3 days, and very significant by the end of the 10-day period (6.2 vs 2.6 g CO_2 m^{-2}).
- The error over 10 days is 3.6 g CO_2, or 58% of the CO_2 budget. Over 30 days of senescence, the error increased to 7.3 g CO_2 (9% of monthly budget).

CONCLUSIONS

- Traditional analyzers used in eddy covariance have to use intake tubes 1000 times longer than the tube diameter to dampen most of ambient temperature fluctuation [2]
- In recently developed short-tube gas analyzers, fast temperature of sampled air must be measured inside the cell to avoid significant errors in CO_2 fluxes and budgets
- When cell block temperature is used instead of properly weighed fast cell air temperature, errors in CO_2 fluxes and carbon budgets can reach 60-90% on specific days, and can be as high as 58% over 10-day period
- Such error are expected to be significant in any environment but particularly detrimental for the sites where 24-hour or yearly budgets have comparable photosynthetic and ecosystem respiration components



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[1] Burba, G., D. McDermitt, D. Anderson, M. Furtaw, and R. Eckles RD, 2010. Novel design of an enclosed CO_2/H_2O gas analyser for eddy covariance flux measurements. *Tellus B*, **62,** 743-748. [2] Rannik, U., Vesala, T., and Keskinen, R., 1997. On the damping of temperature fluctuations in a circular tube relevant to the eddy-covariance technique. J. Geophys. Res., 102 (D11), 12,789-12,794. [3] Burba, G., A. Schmidt, R. Scott, T. Nakai, J. Kathilankal, G. Fratini, C. Hanson, B. Law, D. McDermitt, R. Eckles, M. Furtaw, and M. Velgersdyk, 2012. Calculating CO2 and H2O eddy covariance fluxes from an enclosed gas analyzer using an instantaneous mixing ratio. Global Change Biology, 18(1): 385-399

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