LOW TEMPERATURE SETTING TO MEDIATE SURFACE HEATING EFFECT FOR OPEN-PATH GAS ANALYZERS IN COLD ENVIRONMENTS

G.G. Burba*, D.K. McDermitt, D.J. Anderson, J.R. Hupp, and R.D. Eckles

LI-COR Biosciences, Lincoln, NE, USA; *george.burba@licor.com

INTRODUCTION

- Open-path CO_2/H_2O analyzers are useful, low-maintenance, low-power, stable instruments, with excellent frequency response
- Open-path approach may offer serious advantages, especially for long-term remote studies, despite data loss during precipitation
- Surface heating effect is not an issue in warm environments, and is relatively small in the cold environments, well below the standard WPL and closed-path frequency corrections, but it may not always be negligible [1-3]
- To minimize or eliminate such effect, while keeping all the advantages of open-path design, a new LI-7500A analyzer was constructed with two instrument temperature settings:

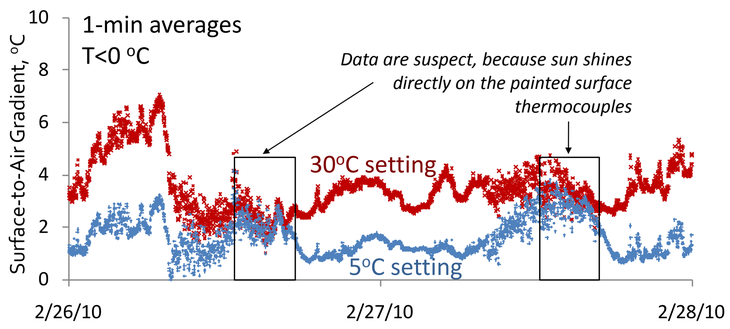
  - the traditional +30°C setting for warm conditions
  - the new +5°C setting for cold conditions

- Here we present experimental data on LI-7500A field performance at these two settings in terms of power and heat dissipation, instrument surface temperatures, and CO_2 fluxes

CONCEPT

- LI-7500 has a single +30°C setting, and LI-7500A has two settings: +30°C for warm environments, and +5°C for cold ones
- In warm environments, LI-7500A and LI-7500 open-path analyzers measure fluxes similar to the closed-path analyzers, such as LI-7200 and LI-7000 [1-6, and this work, not shown]
- It is because instrument surface heating is not a problem for open-path analyzers in warm environments
- In cold environments, especially <-10°C, LI-7500 sometimes shows unreasonable CO_2 uptake due to excessive instrument surface heating [1-3], unseen in closed-path analyzers [1-6]
- Changing temperature control for LI-7500A from +30°C to +5°C in cold environments is expected to reduce heating effect and to produce CO_2 fluxes similar to the closed-path standard
- Effects of switching LI-7500A from +30° to +5°C setting was tested over snow-covered field in winter 2010 against LI-7500 as a +30°C reference, and against LI-7200 as a closed-path standard

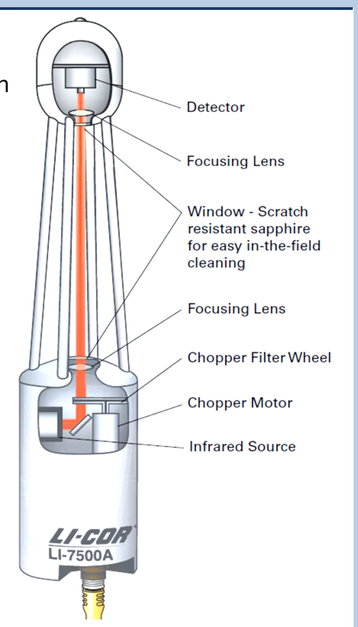
SURFACE TEMPERATURE



- +5°C setting led to 2-50 times reduction in the 1-minute averaged T-gradient between bottom window and ambient air

LI-7500A DESIGN

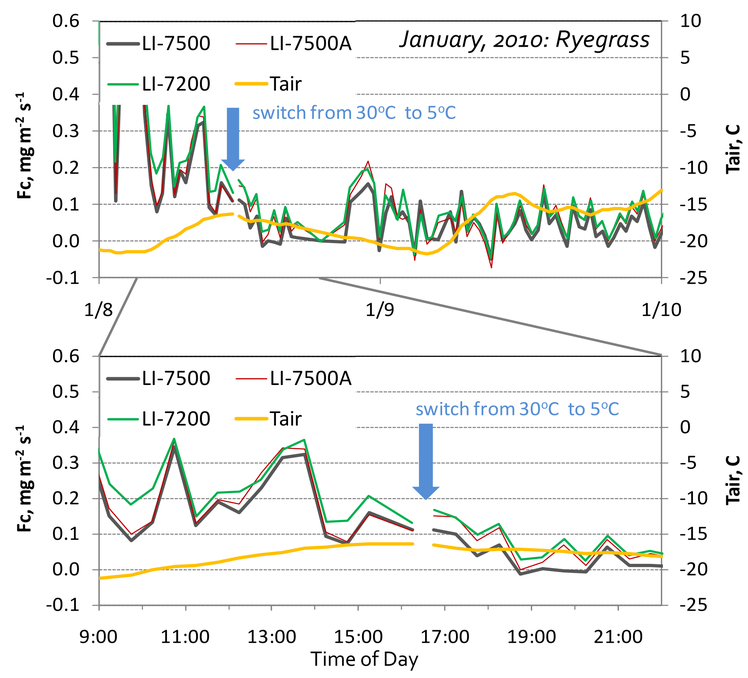
- Fast open-path CO_2/H_2O gas analyzer with low power dissipation
- Low dissipation achieved by two temperature settings for chopper housing
- The settings expected to lessen heating of the instrument surface and air in the path
- Low sensitivity to cell contamination helps long deployments without cleaning
- Optimized for Eddy Covariance, but works with other flux and gas monitoring applications



- Has fast on-board logger for signals from the analyzer and from the sonic anemometer for a full Eddy Covariance dataset

IMMEDIATE EFFECT ON FLUXES

- The +30°C setting was switched to +5°C setting for LI-7500A on 1/8/2010 at 4 pm, while LI-7500 remained at +30°C setting
- Ambient temperature at the time of the switch was -16°C
- Before the switch, the weather was very cold with air temperature (Tair) ranging from -25 to -10C, and after the switch the weather was variable, ranging from -25 to +5°C
- CO2 fluxes from LI-7500A before the switch closely followed those from LI-7500, and were below fluxes measured with closed-path LI-7200 standard
- This was expected as both open-path instruments produced similar amount of surface heat due to +30°C settings
- After the switch to +5°C setting, fluxes from LI-7500A changed immediately, and generally followed the closed-path LI-7200 standard, while fluxes from LI-7500 stayed below the standard

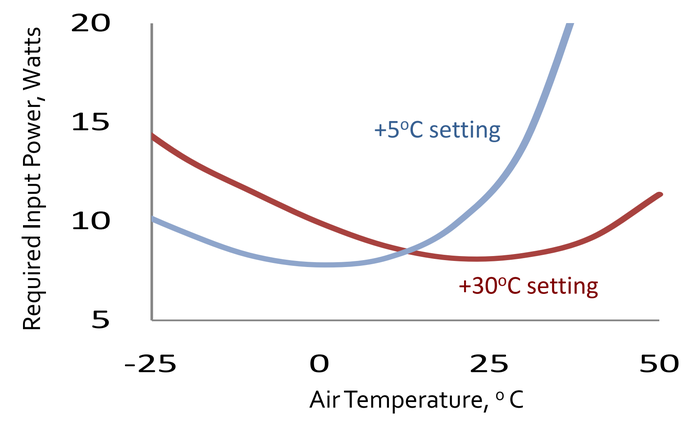


SUMMARY & CONCLUSIONS

- When +5°C setting was activated on LI-7500A, the following changes were observed in the operation and fluxes from the instrument:
  - ✓ **heat dissipation from the surface reduced several folds**
  - ✓ **surface-to-air temperature gradients reduced 2-50 times**
  - ✓ **number of false uptake hours reduced 3.5 times, to the same level as closed-path standard**
- Advantage of the +5°C setting was also observed in the magnitude of CO_2 fluxes throughout the experiment, and especially in cold weather below -10°C
- At such cold temperatures, CO_2 fluxes from +30°C controlled LI-7500 were 19% below the standard, while fluxes from +5°C controlled LI-7500A were, on average, within 1% of standard
- These are strong experimental evidence that open-path instrument heating could be substantially reduced or eliminated via instrumental solution by controlling the amount of heat dissipated from electronics into the open path of the instrument

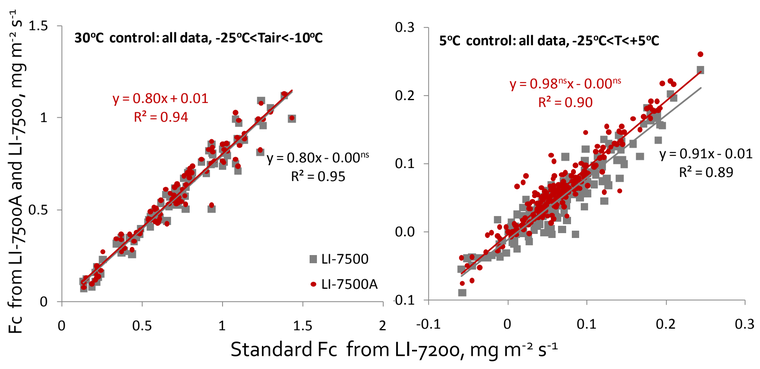
POWER & HEAT DISSIPATION

- New open-path CO_2/H_2O gas analyzer, LI-7500A, is based on the LI-7500 model
- At +30°C temperature setting, the LI-7500A and LI-7500 operate nearly identical from power and heat dissipation standpoint
- Addition of +5°C setting in LI-7500A is designed to keep power dissipation in single Watts, in both warm and cold environments

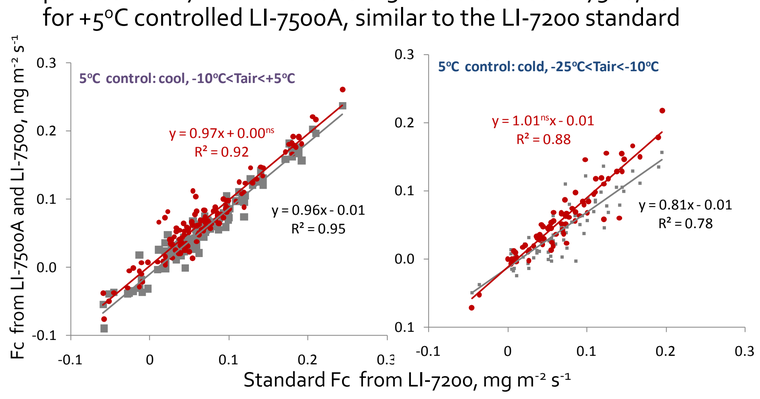


OVERALL EFFECT ON FLUXES

- At +30°C settings, both LI-7500A and LI-7500 measured nearly identical CO2 fluxes, both were about 0.01-0.1 mg m^{-2} s^{-1} (20% on average) below those from the LI-7200 closed-path standard
- At +5°C settings, fluxes from LI-7500A became within 2% of LI-7200 standard (not statistically different, ns), while +30°C controlled LI-7500 was on average 9% below the standard



- Advantage of +5°C setting over +30°C setting was marginal at air temperatures from -10 to +5°C, leading to 1% improvement in the slope and 0.01 mg m^{-2} s^{-1} in offset *vs.* LI-7200 standard
- Advantage of +5°C setting became very significant in cold weather, -25<Tair<-10°C, leading to 18% improvement in slope
- Use of +5°C setting in cold weather also reduced CO_2 uptake periods from 7% of all data for +30°C controlled LI-7500, to <2% for +5°C controlled LI-7500A, similar to the LI-7200 standard



LOGGING & REMOTE SITES

- Open-path analyzers are especially desirable for remote unattended deployment at solar- or wind- powered sites
- Such deployments also require large capacity data logging to store fast data for weeks or months at a time
- The power demand of LI-7500A is about 12 W
- LI-7500A has on-board fast data logging, accepts all major models of sonic anemometers, LI-7700 low-power CH_4 analyzer, and supports analog, serial, Ethernet and SDM communications
- The LI-7500A and built-in logger are designed to be easily powered by solar panels or wind generators
- Low power and fast logging enable operations in remote environments, and on mobile and portable towers
- Such remote unattended long-term deployments become increasingly important as modern flux research moves into less studied ecosystems and gases, which always require fast H_2O data for WPL term, and usually benefit from simultaneous CO_2 measurements to determine the state of studied ecosystem

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