A Comparison of Infrared Gas Analyzers Above a Subalpine Forest:

Sean Burns[1,2], Stefan Metzger[3], Peter Blanken[1], George Burba[4], Edward Swiatek[5], Jiahong Li[4], and Benjamin Conrad[5]

(1) *Department of Geography, University of Colorado, Boulder*

(2) *NCAR Mesoscale and Microscale Meteorology (MMM) Division, Boulder, Colorado*

(3) *National Ecological Observatory Network (NEON), Boulder, Colorado*

(4) *LI-COR Biosciences, Lincoln, Nebraska*

(5) *Campbell Scientific, Inc., Logan, Utah*

2014 American Geophysical Union (AGU) Fall Meeting

19 December 2014

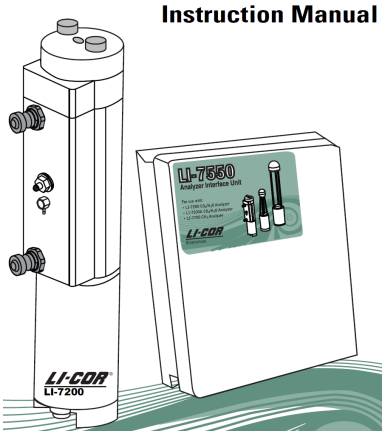
Talk Outline

- Comparison Overview
- Instrument Setup
- **WARNING:** Preliminary Results Ahead
- Results for CO_2 (Mean, Standard Deviation, Covariances, Spectra/Ogives)
- Results for H_2O (Mean, Spectra/Ogives)
- Conclusions

Closed-Path Infrared Gas Analyzers (IRGAs)

LI-COR LI-6262

LI-COR LI-7200



CSI EC155/CPEC200

	LI-6262	LI-7200	EC155
Manufacturer Manual	LI-COR (1996)	LI-COR (2013)	Campbell Scientific (2013)
Alternate Reference	Monson et al (2002)	Burba et al (2010)	Novick et al (2013)
Calibration Gases	0 and ≈400 [μmol mol^{-1}]	None	None
Calibration Frequency	every 4 hrs	N.A.	N.A.
Heated Inlet Assembly	No	Yes (≈ 3.8 W)	Yes (0.7 W)
Tubing Length	≈1000 cm	80 cm	58.4 cm

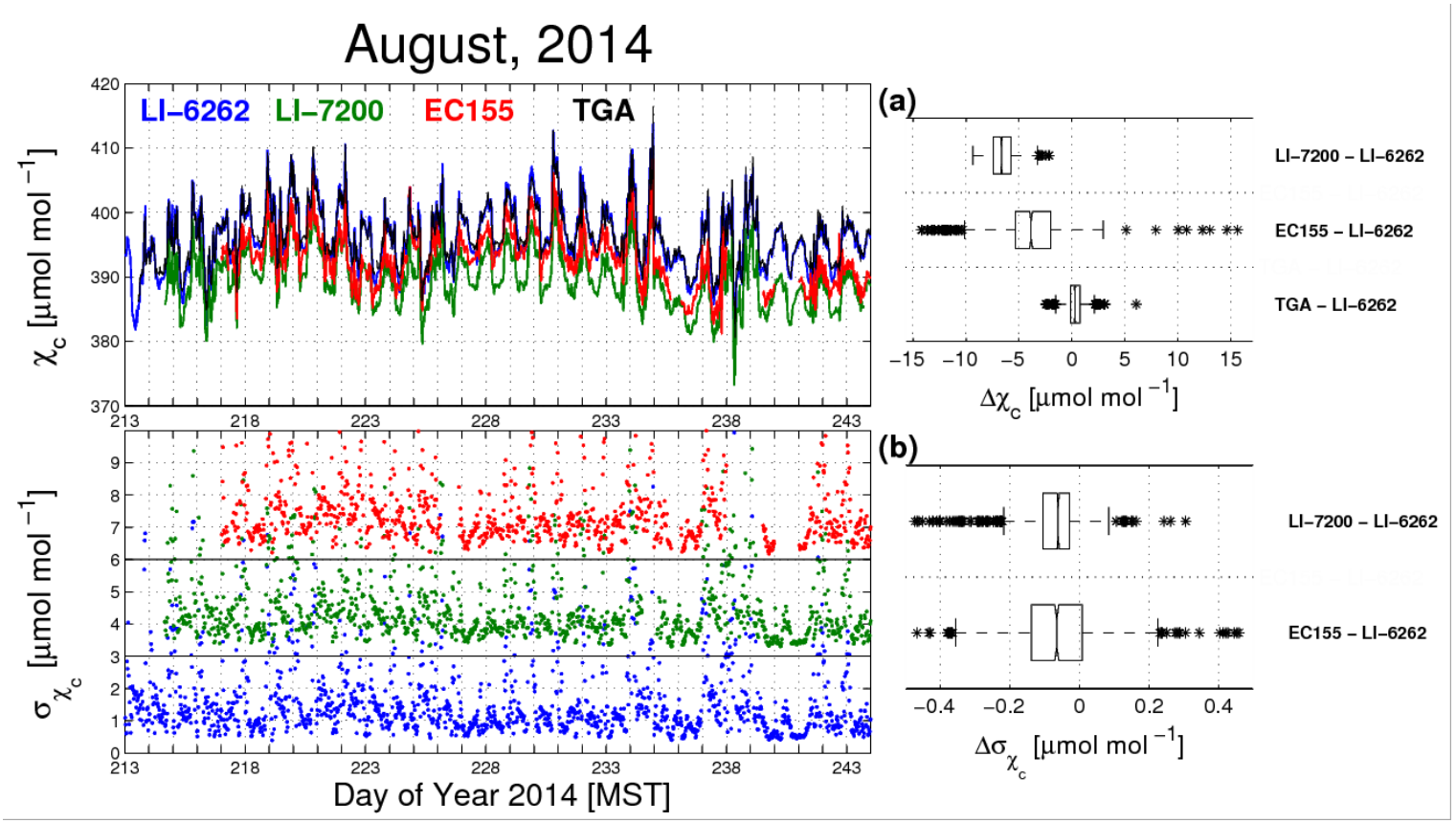
Comparison Overview

- Comparison Concept:
  - Manufacturers check raw data, SpB/SM/PB do analysis
  - Winter results (**Burns et al, 2014**), Summer results (presented here)
  - Since winter comparison, CPEC200/EC155/EC100 firmware updated
- Each IRGA Coupled with a CSAT3/CSAT3A
- Vertical Wind from CSAT3s agree well (not shown)
- LI-6262 Refs: H_2O uses co-located HMP T/RH sensor; for CO_2 span tied to TGA CO_2 (courtesy of Dave Bowling)
- IRGA Freq response is closely related to inlet assembly design and heating (see poster B53A-0145 this afternoon by R. Zulueta, S. Metzger, et al.)
- Results use dry mole fraction (mixing ratio) and (kinematic) covariances
- For simplicity, a constant lag is used for scalars, not optimal for water vapor (e.g., **Fratini et al, 2012**).

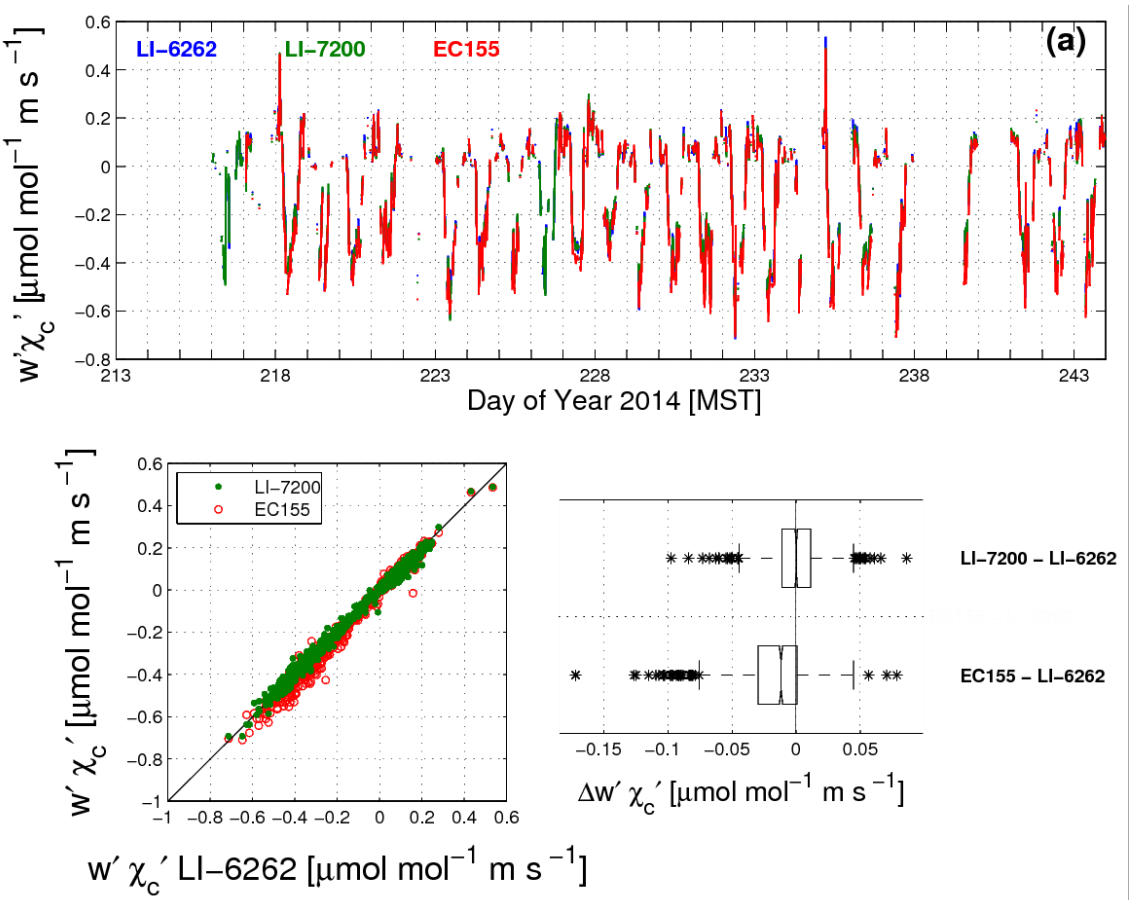
Instrumentation Setup

LI-7200 EC155 LI-6262

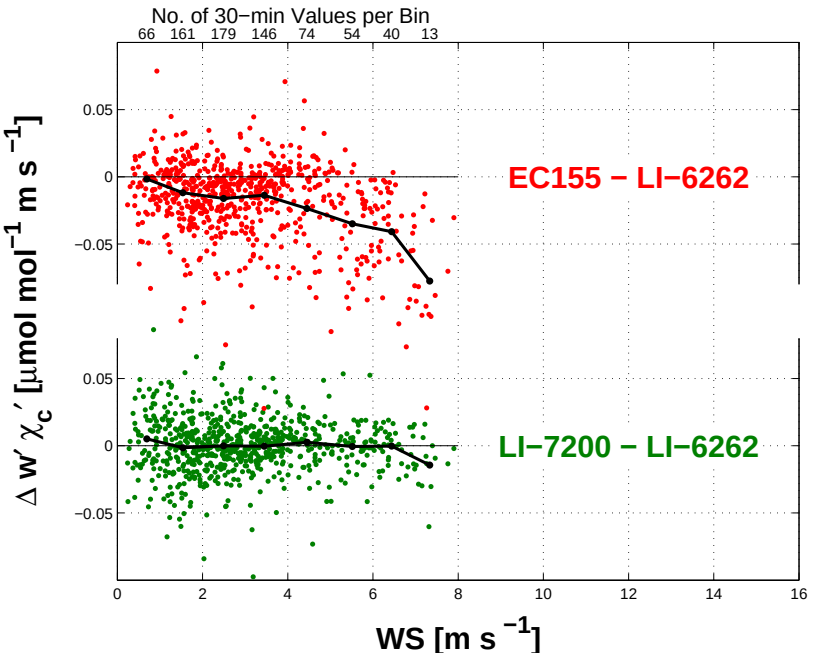
Mean and Standard Deviation of CO_2



Covariance vertical wind and CO_2 ($\overline{w'\chi_c'}$)

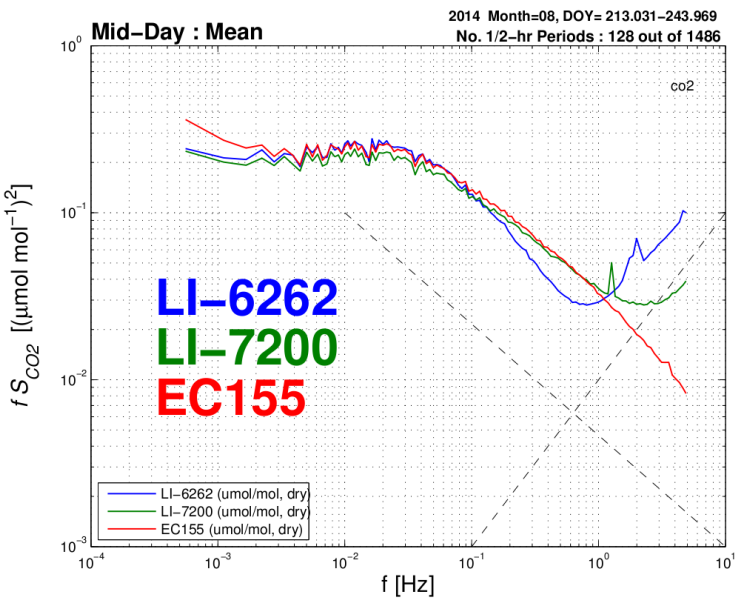


CO_2 Covariance Variations with Wind Speed

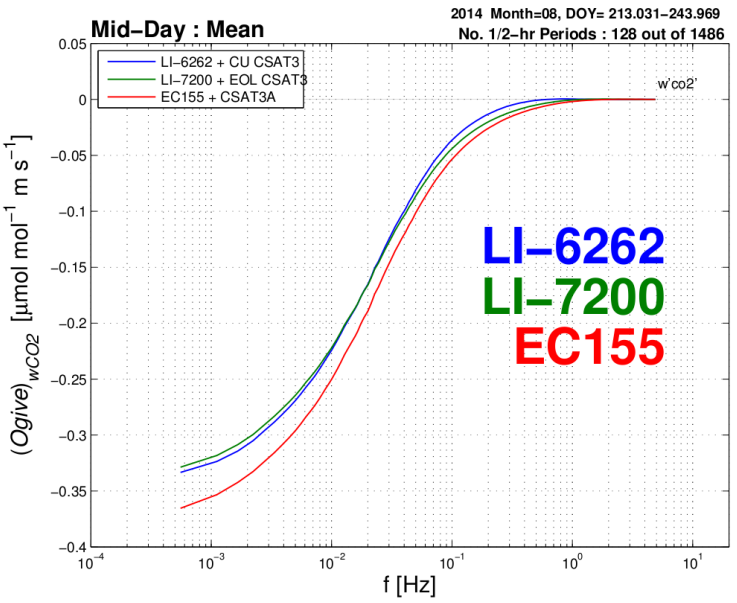


Power Spectra and Ogive of CO_2

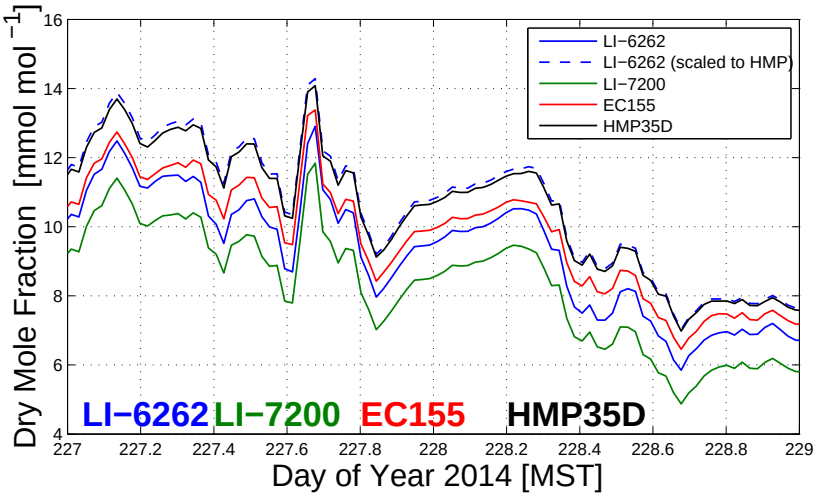
Power Spectra

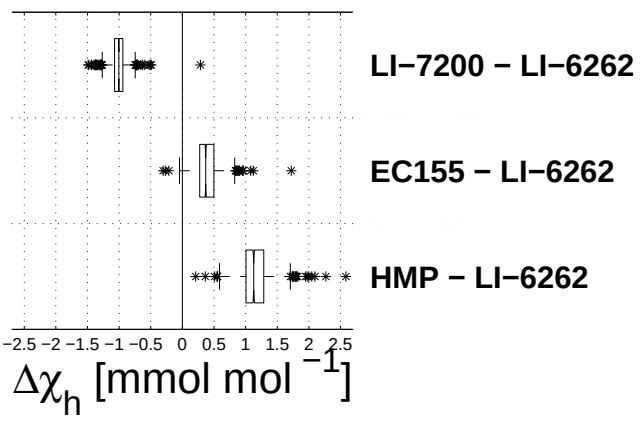


Ogive (cumulative co-spectra)



Mean of H_2O

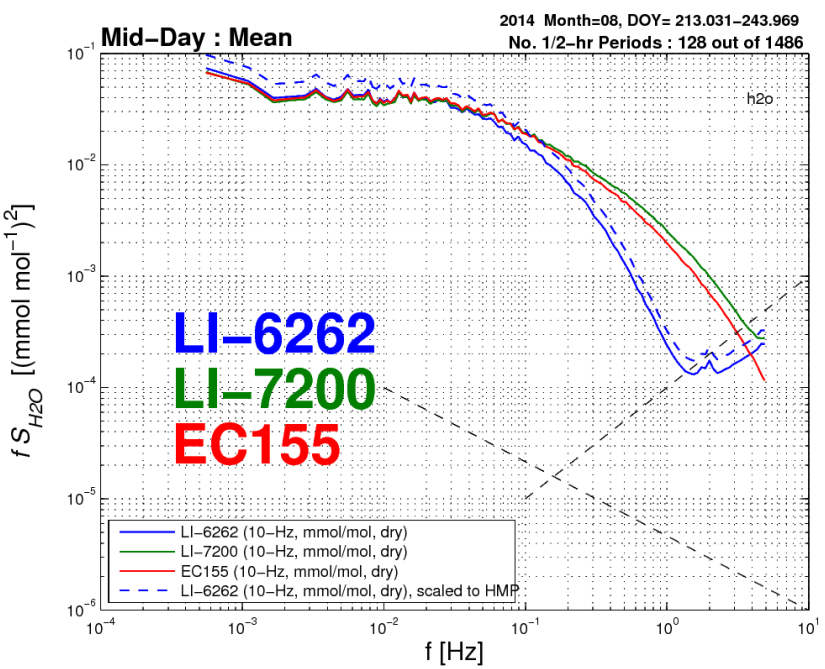




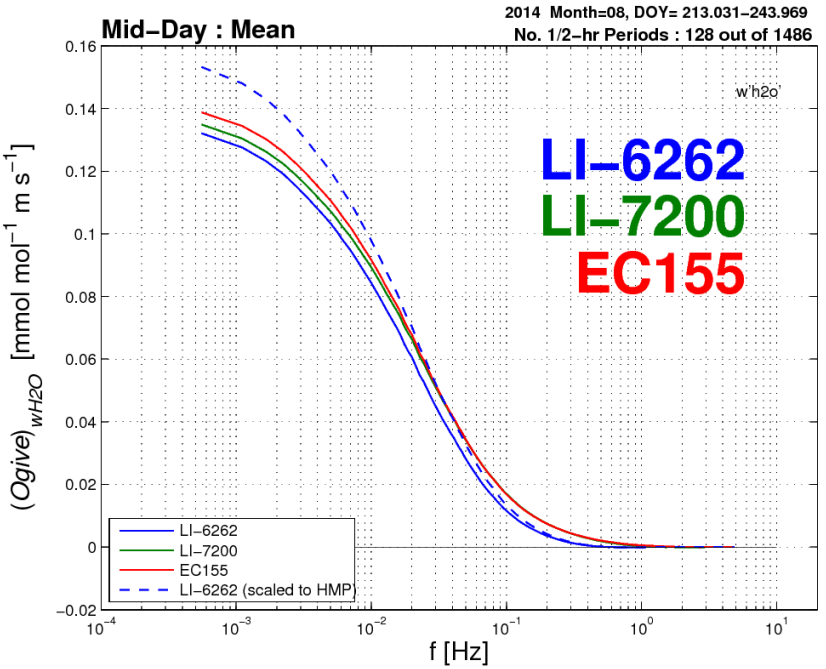
- **Note: Previous side-by-side comparison of 21.5m HMP T/RH sensor in summer 2013 showed that HMP RH was high by about 4% (Chan et al, 2014)**

Power Spectra and Ogive of H_2O

Power Spectra



Ogive (cumulative co-spectra)



Conclusions

- **Regular calibration and cleaning of closed-path IRGAs is critical for quality measurements (using a zero/span gas ensures the highest quality).**
- **The water vapor flux from the LI-6262 is sensitive to the choice of reference sensor which sets the instrument gain.**
- **A wind-speed dependence in the EC155 CO_2 fluxes exists (to be tested again this winter, talk to Ivan Bogoev (CSI) for additional info)**
- **For water vapor, the scalar lag-time dependence on RH needs to be taken into account**

References

For Additional Questions or Comments, email: sean@ucar.edu

References

Burba GG, Mcdermitt DK, Anderson DJ, Furtaw MD, Eckles RD (2010) Novel design of an enclosed CO_2/H_2O gas analyser for eddy covariance flux measurements. Tellus Series B-Chemical And Physical Meteorology 62:743–748

Burns SP, Metzger S, Blanken PD, Burba GG, Swiatek E, Li J, Conrad B, Luo H, Taylor J (2014) A comparison of infrared gas analyzers above a subalpine forest in complex terrain. In: 17th Symposium on Meteorological Observation and Instrumentation, Westminister, CO. American Meteorological Society, 13, URL: https://ams.confex.com/ams/21Applied17SMOI/

Campbell Scientific (2013) EC155 CO_2 and H_2O Closed-Path Gas Analyzer Instruction Manual. Revision 5/13, 66 pp., (Available at www.campbellsci.com)

Chan S, Biraud S, Billesbach D (2014) AmeriFlux QA/QC Report on US-NR1/PECS Comparison between 29 July and 3 August 2013. Tech. rep., Earth Sciences Division, Lawerence Berkeley National Laboratory, Berkeley, CA

Fratini G, Ibrom A, Arriga N, Burba G, Papale D (2012) Relative humidity effects on water vapour fluxes measured with closed-path eddy-covariance systems with short sampling lines. Agric For Meteor 165:53–63

LI-COR (1996) LI-6262 CO_2/H_2O Analyzer Operating and Service Manual. Publication Number 9003-59, 3rd Printing, 120 pp., (Available at www.licor.com)

LI-COR (2013) LI-7200 CO_2/H_2O Analyzer Instruction Manual. Publication Number 984-10564, 5th Printing, 194 pp., (Available at www.licor.com)

Monson RK, Turnipseed AA, Sparks JP, Harley PC, Scott-Denton LE, Sparks K, Huxman TE (2002) Carbon sequestration in a high-elevation, subalpine forest. Global Change Biol 8:459–478

Novick KA, Walker J, Chan WS, Schmidt A, Sobek C, Vose JM (2013) Eddy covariance measurements with a new fast-response, enclosed-path analyzer: Spectral characteristics and cross-system comparisons. Agric For Meteor 181:17–32