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Evaluation of the IRGASON Integrated CO_2/H_2O Gas Analyzer and Sonic Anemometer

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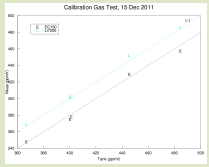
Background

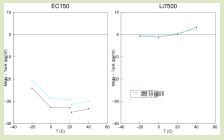
Physical separation between measurements of vertical velocity and H_2O or CO_2 systematically reduces their calculated fluxes and must be corrected. The IRGASON addresses this problem by colocating these measurements, but could introduce errors in the velocity measurements. IRGASON data are available at up to 100 samples/s using 5W total of power.

Conclusions

- IRGASON scalar (T_c, H_2O, CO_2) measurements similar quality to LI-7500. (T_c is derived from speed of sound.)
- No spatial separation correction needed
- Momentum flux measurement significantly compromised

Laboratory Evaluation





Method

Apply 4 calibration gases from tanks to sensor at different temperatures.

Results

- IRGASON had more temperature drift than LI-7500
- IRGASON had large offset

(This IRGASON was replaced due to a faulty component, but this lab test of the new sensor was not repeated.)

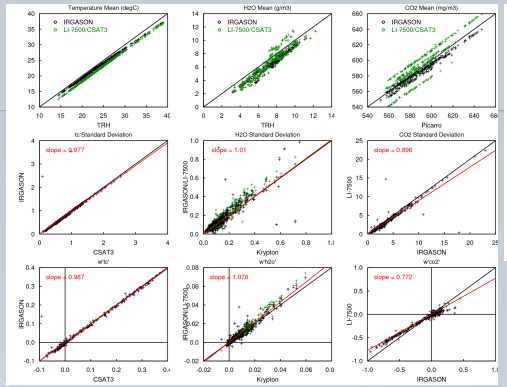
Scalar Flux Measurement Evaluation

Method

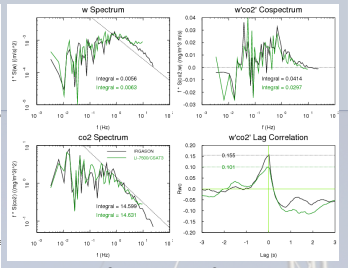
Operate IRGASON in the field side-by-side with CSAT3 sonic anemometer plus LI-7500 open-path IRGA and krypton hygrometer. Field check calibration versus aspirated hygrometer for H_2O and Picarro closed-path analyzer for CO_2.

Results

- Heat fluxes agree within 3% overall
- Both IRGAs must be cleaned! – significant drift in means seen when not done (more in LI-7500)
- A gain difference is seen between IRGANSON and LI-7500 H_2O and CO_2 fluctuation measurements, which explains much of the differences in the fluxes, but is not consistent with the variation of means with respect to the aspirated hygrometer and Picarro references
- Remaining difference in fluxes is consistent with under-correction of LI-7500 fluxes due to spatial separation
- After WPL correction for air density fluctuations, IRGASON fluxes are reasonable (CO_2 uptake during the day and respiration at night)

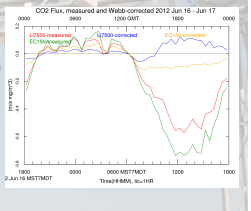


T_c Statistics H_2O Statistics CO_2 Statistics

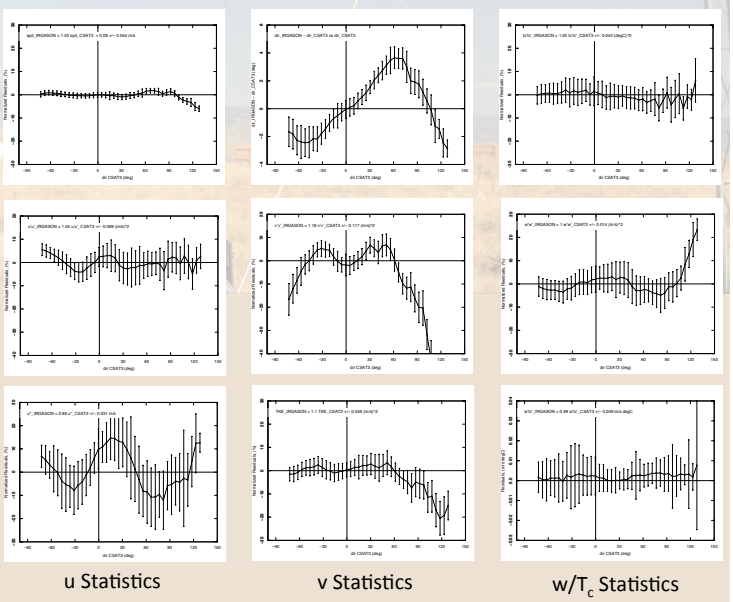


Example of nighttime fluxes: The correlation coefficient between w and CO_2 is 30% lower from the LI-7500, presumably due to path separation. Our model of this separation predicts only a 4% effect, so even corrected fluxes would be underestimated.

IRGASON (center), LI-7500 and krypton with CSAT3 (left), and reference CSAT3 (right). Only wind directions not blocked by adjacent sensors were analyzed.



CO_2 density changes due to changing temperature and to changing CO_2 mixing ratio. After removing the air density change, fluxes are more realistic from the IRGASON, with CO_2 uptake during the day. This implies that our LI-7500 was not well calibrated.



u Statistics v Statistics w/T_c Statistics

Air Flow Distortion Evaluation

Method

Operate IRGASON side-by-side with reference CSAT3 sonic anemometer in the field. Over 500 hours of data with wind speed >2 m/s during 2012 were used. Check variation of mean, variance, and turbulence statistics (u_* and TKE) with wind direction (flow orientation with respect to the sensor head).

Results

- Vertical velocity (w) agrees quite well (variance difference <1%), especially for flow from up to +/-100 degrees from the front
- Horizontal velocity components (u,v) have larger errors: v severely changed for wind directions beyond 80 degrees from front
- Friction velocity (u_*) differences of +/-15% observed even for "good" wind directions