Instrument Maintenance and Calibration

Maintenance

- Site Maintenance is the most overlooked and underappreciated task when operating an Eddy Covariance System
  - You only have one opportunity to collect real-time data events as they occur.

Maintenance

- Monitor Measured Values
- Monitor Diagnostics

Monitor Measured Values

- Air Temperature & Air Pressure
- Sonic Temperature
- Dew Point
- Gas Concentrations
- Covariances
- Fluxes

Monitor Diagnostic Values

- AGC or Signal Strength
- Diagnostic Value
  - Detector Temperature Regulation
  - Chopper /Optical Filter Wheel Temperature Regulation
  - Sync
- Pressure Sensor
- Thermistor

General Guidelines

- Make a plan to regularly check instruments and follow it as much as possible
- Use LI-COR provided software whenever possible
- Have backup data collection (on USB or computer) whenever possible
- Collect diagnostic variables as much as possible

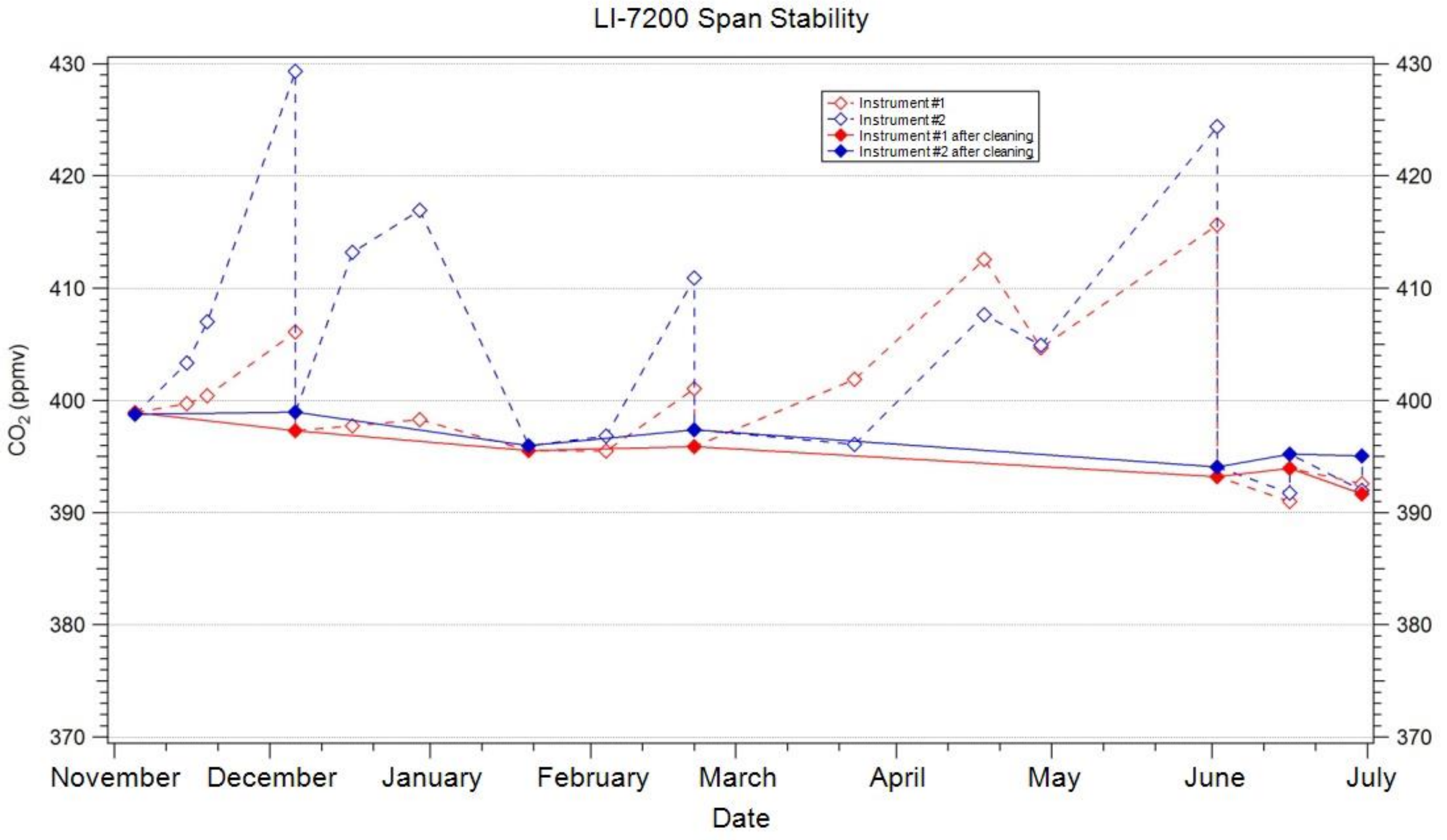
LI-7500/LI-7500A Checklist

Every Site Visit	Seasonally
Check readings	Check calibration
Check diagnostics	Check/Replace Internal Chemicals
Check and tighten cables	
Clean optical windows	

Keeping the sensors clean

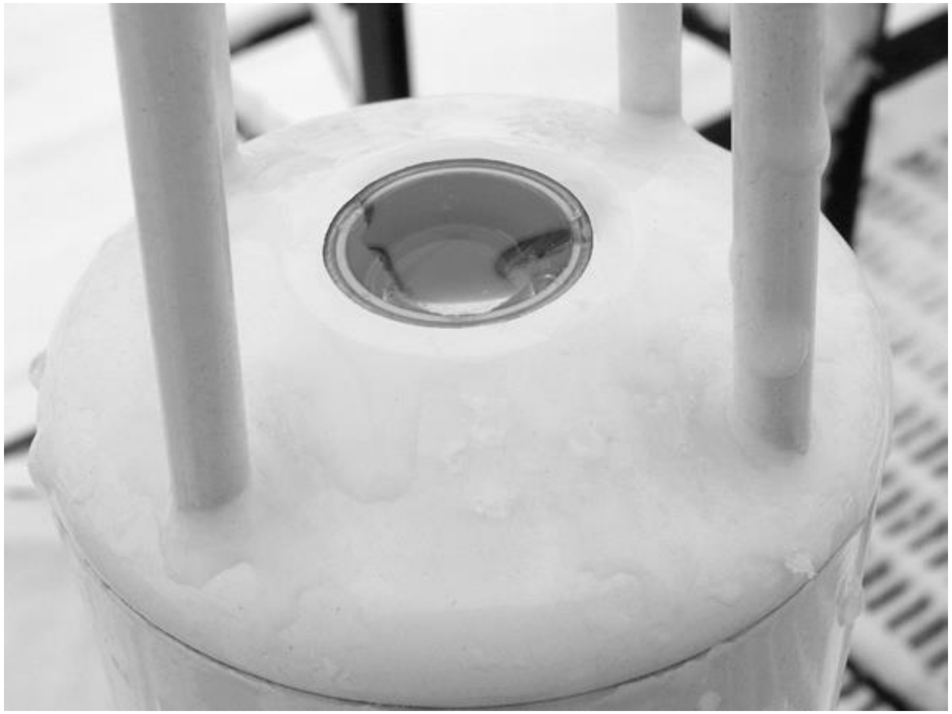
- Sources of contamination
  - Pollen
  - Ash (forest fires)
  - Agricultural activities
  - Urban effects
- Clean the optical path

Keeping the sensors clean



Most important maintenance action

- Window contamination and cleaning
  - Signal blocking (AGC & RSSI)
  - Particle size effects

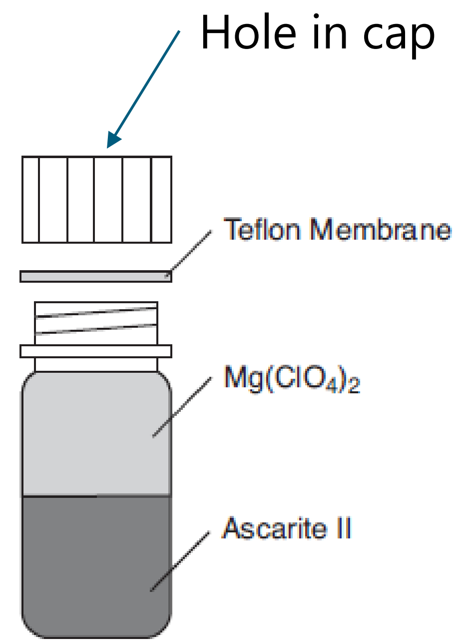


Other maintenance topics

- Changing the Internal Chemicals

Replacing the chemicals

Figure 6-3. Remove the thumbscrew, thread into the bottle covers and pull straight out to access the scrubbing bottles.



Other maintenance topics

- Temperatures
  - Big effect on mole fraction, little effect on density

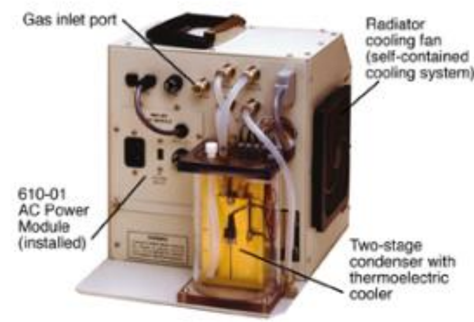
Calibration

Calibration

- Factory Calibration
  - Generates polynomials that convert the raw detector outputs into CO_2/H_2O density
  - Characterizes instrument response across temperature ranges
  - Characterizes instrument response across concentration ranges

Gas standards for a LI-COR calibration

- Span gases
  - Traceable Standards (NOAA/WMO)
  - LI-610 Dew Point Generator



- Zero gas
  - N_2

Calibration

- Factory Calibration for H_2O
  - A 3rd order polynomial generated based on fitting data points collected by measuring the detector output at 5 different dew points at 3 different temperatures.
  - The 5 water vapor concentrations are generated with a temperature controlled dew point generator, the LI-610 which is certified by NIST to have an absolute accuracy of 0.2 °C

Factory Calibration – H_2O

$$\rho_{H_2O} = P*(Ax + Bx^2 + Cx^3)$$

$$x = \frac{\alpha_w * S_w}{P}$$

$$\alpha_w = \left(1 - \frac{Sample}{\mathrm{Re}ference} * Z_w\right)$$

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Calibration

- Factory Calibration for CO_2
  - A 5th order polynomial generated based on fitting data points collected by measuring the detector output at 13 different CO_2 concentrations running from 0 ppm to 3000 ppm and at 3 different temperatures.
  - The 13 CO_2 working standard tanks are calibrated against Primary Standards from WMO/NOAA which have 0.06% accuracy

Factory Calibration – CO_2

$$\rho_{co_2} = P_e * (Ax + Bx^2 + Cx^3 + Dx^4 + Ex^5)$$

$$x = \frac{\alpha_w * S_w}{P_e}$$

$$\alpha_w = \left(1 - \frac{Sample}{Reference} * Z_w\right)$$

$$P_e = P(1 + .15x_w)$$

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Factory Calibration

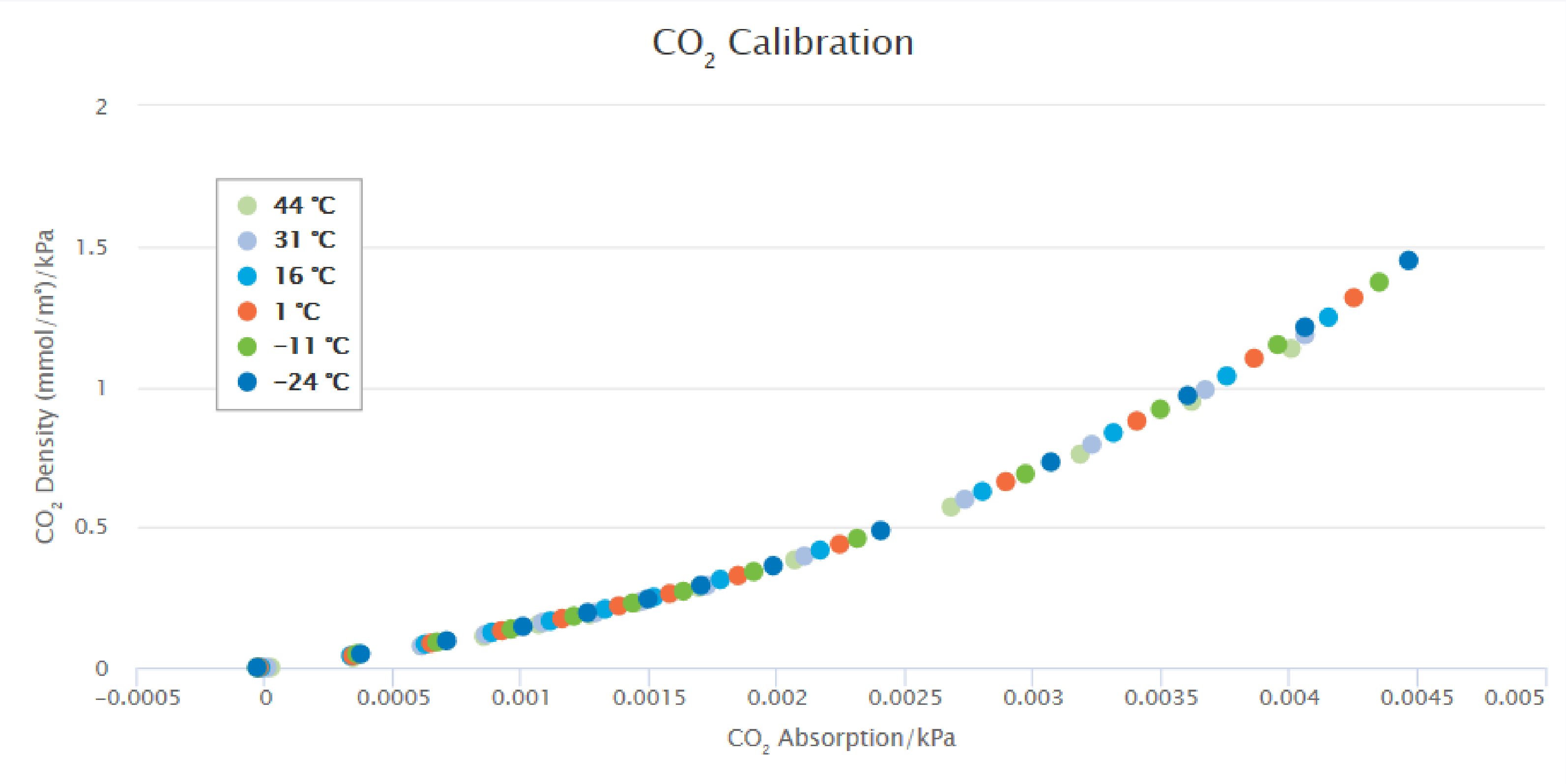
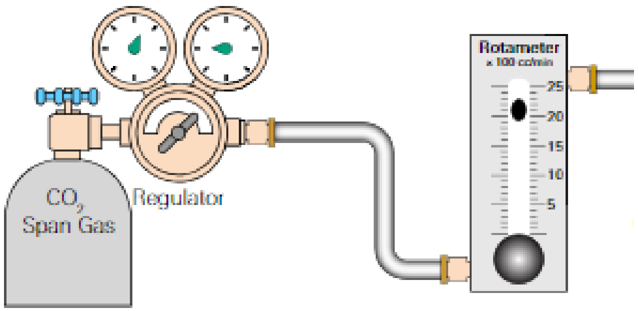


Figure 2. CO_2 calibration curves for an LI-7500RS gas analyzer at 6 temperatures. The relationship between CO_2 density and absorption is consistent across the full temperature range of -24 to 44 °C.

How often should I calibrate?

Gas standards for a User calibration

- Span gas
  - For CO_2, use a known concentration in a balance of **air** (1% or better)
  - For H_2O, use a Dew point generator (LI-610)
- Zero gas
  - For CO_2 and H_2O use a cylinder of 'CO_2-free air' or N_2
  - If no cylinders, use chemicals (Ascarite, soda lime, magnesium perchlorate, Drierite, etc) to scrub the air from CO_2 and H_2O



User calibration

- Trust but verify
  - For LI-7500: Done at two points (zero and span)
    - Adjusts Z and S values.
  - For LI-7500A/RS/DS: Can add a third point (zero, span and secondary span)
    - Adjusts Z and S1 and S2 values.

How often should I send the analyzer back for factory calibration?

- Can you calibrate?
- Is there significant drift?
- Did you check and perform all the maintenance items?

Difference between Drift and Contamination…

- Contamination
  - When on the windows, can cause significant changes to the light
  - Could cause positive or negative offsets
  - Location dependent
  - Several ways to minimize this
- Drift
  - Short-term: daily/weekly temperature and pressure changes
    - These are compensated by the software (factory calibration)
  - Long-term: aging components may begin to change the characteristics of the measurement
    - Typically long-term drift is very minor (1% per year)

Contamination effects on CO_2 for LI-7500/A and LI-7500RS/DS

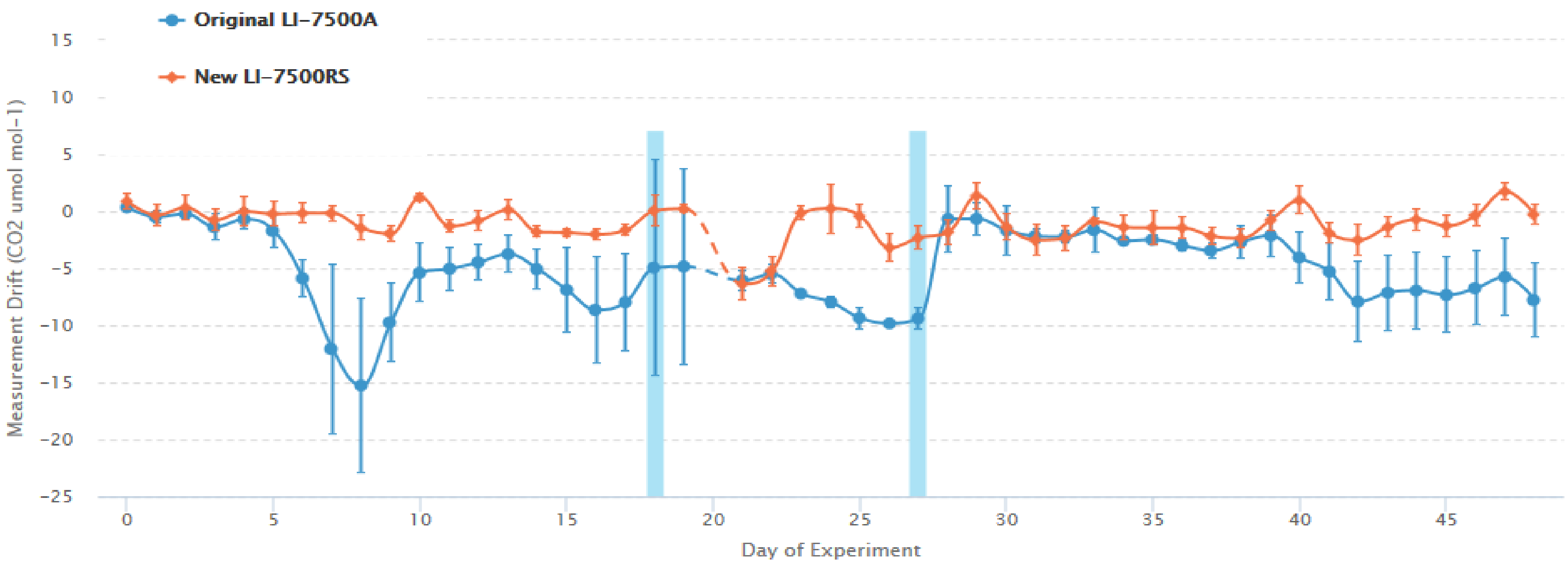


Figure 1. CO_2 measurements from three LI-7500RS analyzers and three LI-7500A analyzers (average and spread). The y-axis shows the deviation from a control reference. CO_2 measurements from the LI-7500RS analyzers drifted considerably less and had smaller instrument-to-instrument variability than those from the original LI-7500A models. Data show the typical improvement expected from the LI-7500RS analyzer.

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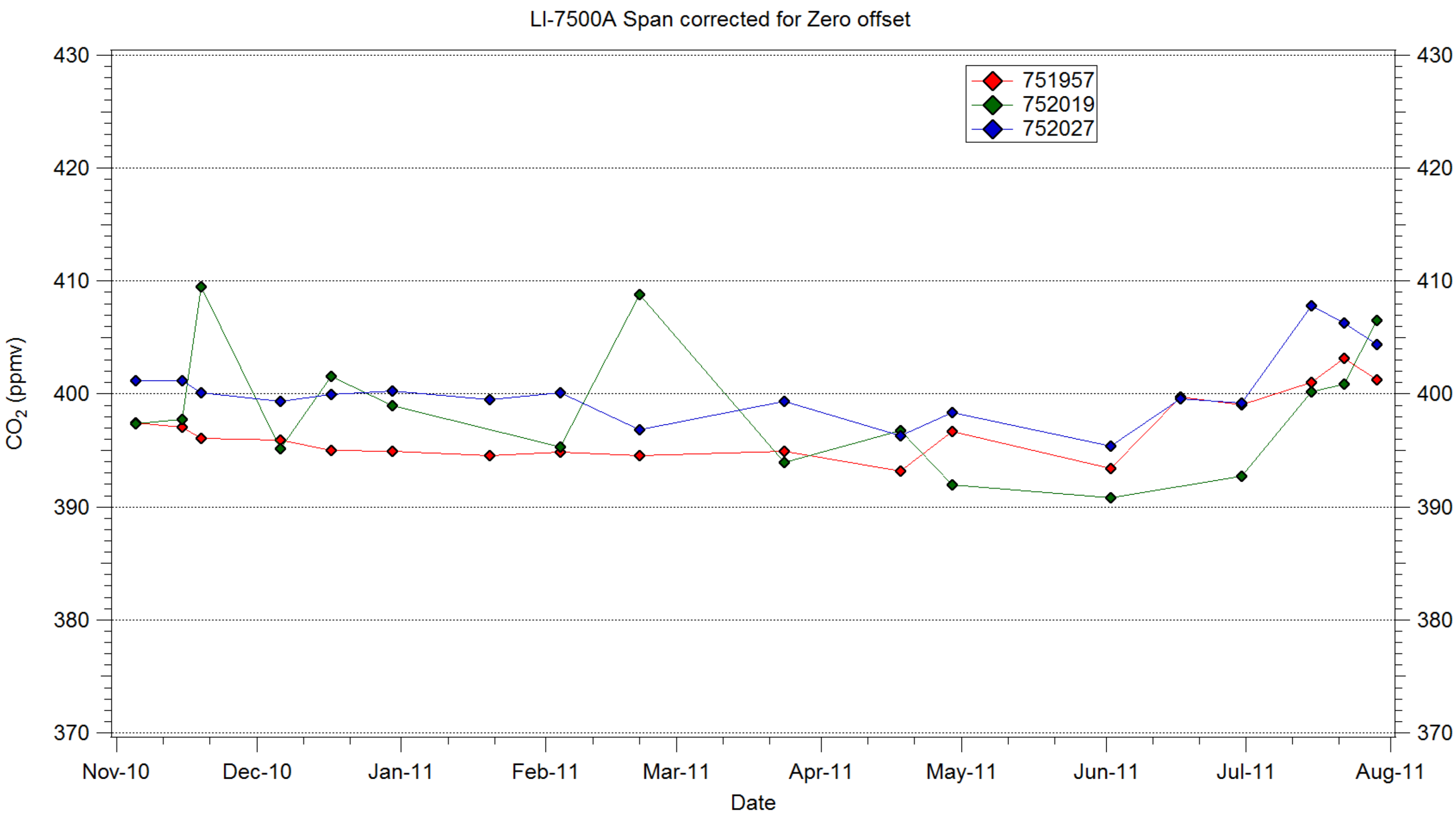
Drift effects @ span (LI-7500A)



Latest Gas Analyzer innovations

- New LI-7500RS Analyzers
  - Improved optics
  - New temperature controls
  - More stable concentrations — even when not cleaned for weeks or months
  - Drift can be reduced by orders of magnitude

Upgrade from an LI-7500**A**

- For current owners of the LI-7500**A**
- New optical hardware
  - Improves stability of measurements over time
  - Reduces contamination-related drift
  - Reduces site maintenance requirements
- Refined temperature control algorithms for the optical source and detector
- Full factory calibration and performance validation

Thank You

Questions?