



# Discussion of site instrument maintenance/calibration



AmeriFlux Data-Tech Workshop  
May 11, 2023; Berkeley, CA



AMERIFLUX

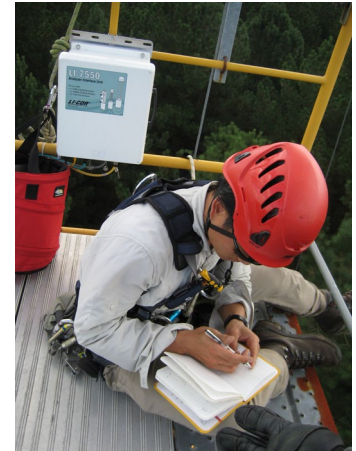
# Interact: Where are your sites?

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High-quality data collection can be ensured by implementing **strong maintenance** and **calibration** programs.

- Good documentation of maintenance during site visits, helps with post-processing data QA/QC.
- Good documentation of calibration procedures aims to maintain traceability of measurements to (international) standards.



US-NC2



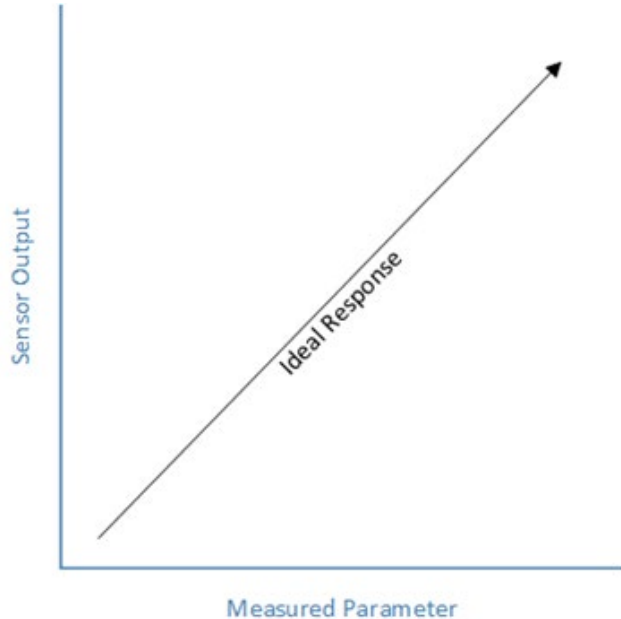
# Calibration, a definition



From the **International Bureau of Weights and Measures (BIPM)**:

"Operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties (of the calibrated instrument or secondary standard) and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication."

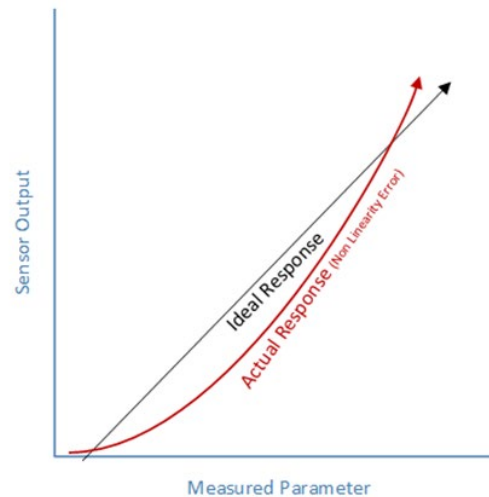
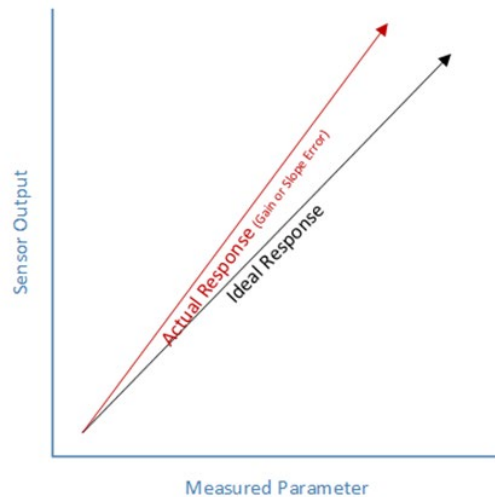
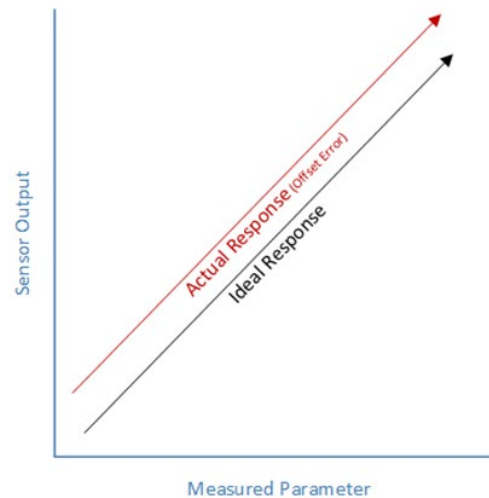
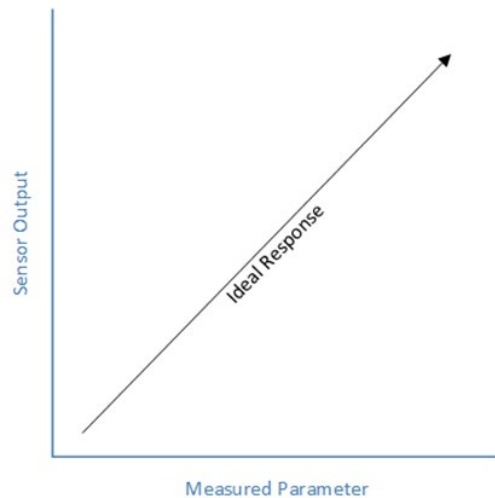
# Why calibration?



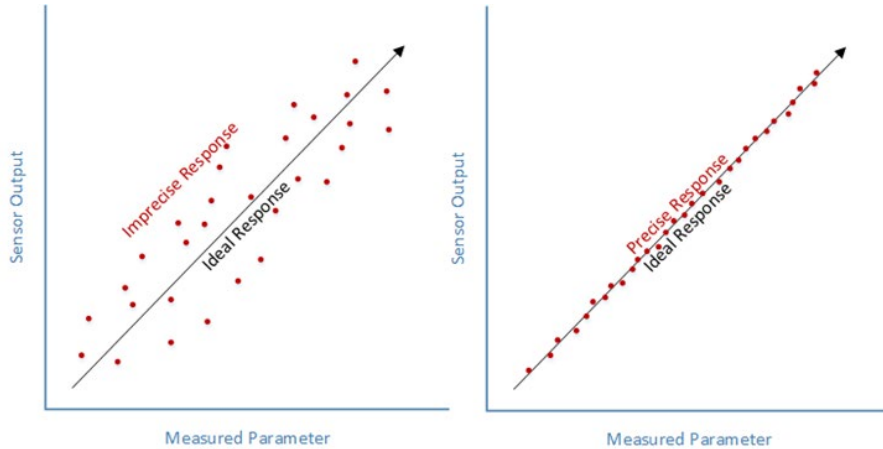
No sensor is perfect:

- ★ Manufacturing variations means two sensors from same manufacturer may provide different readings
- ★ Different sensor designs will respond differently in similar conditions
- ★ Sensors could be affected by change in heat, cold, humidity...
- ★ Sensors age and their response will change over time

# Theoretical sensor responses



# What is calibration?



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# Why calibrate?

- ★ The goal of calibration is to **minimize any measurement uncertainty** by ensuring the accuracy of test equipment.
  
- ★ Calibration quantifies and controls errors or uncertainties within measurement processes to an acceptable level.



# Interact: how do you decide when to calibrate?



[https://jamboard.google.com/d/1SqlbUqiPloCoWrIN\\_AulgcF\\_5PB5dt\\_0GOVKeAEJDxU/viewer?f=1](https://jamboard.google.com/d/1SqlbUqiPloCoWrIN_AulgcF_5PB5dt_0GOVKeAEJDxU/viewer?f=1)





# When to calibrate?

Calibration may be required for the following reasons:

- ★ Purchase of a new instrument;
- ★ After maintenance or repair;
- ★ When a specified time period has elapsed;
- ★ When a specified usage (operating hours) has elapsed;
- ★ Before and/or after a critical measurement;
- ★ Whenever observations appear questionable or instrument indications do not match the output of similar instruments
- ★ As specified by a requirement, e.g., instrument manufacturer recommendation.

# Example 1: Automated calibration

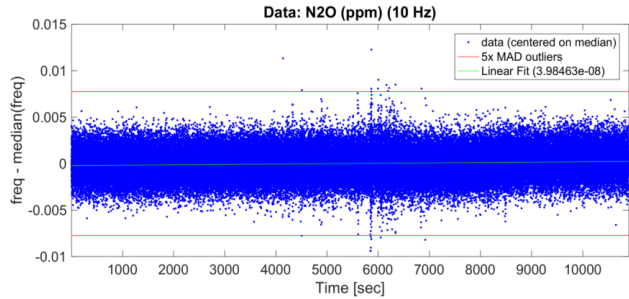
Some instruments have built-in mechanisms for calibration procedures.

- ❖ Campbell CPEC200 (EC155) closed-path gas analyzer for EC
  - Solenoids control flow of gas standards (zero, span)
  - Similar approaches could be built for other closed-path IRGA
- ❖ Hukseflux soil heat flux plate (HFP01SC)
  - Automatically re-calculates new coefficients

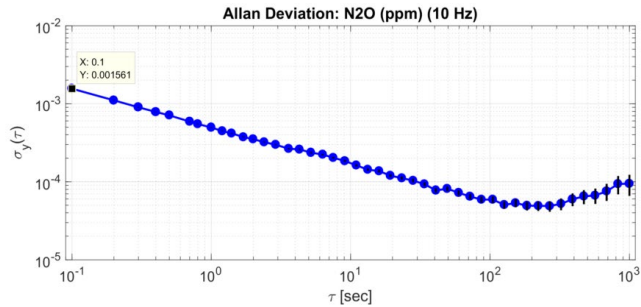


- ❖ Do you have other examples?

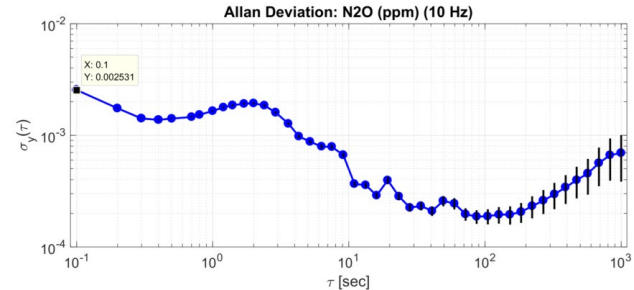
# Example 2: new instrument evaluation



Campbell Scientific TGA200a

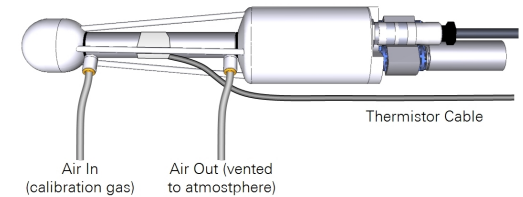


## Allan deviation test with extra noise



# Example 3: IRGA calibration

- ★ Where is the 'best' place to perform an IRGA calibration?
  - Field vs. laboratory
  - Ambient conditions vs. controlled environments
- ★ Reference gas sources
  - Compressed gas cylinders (zero reference and CO<sub>2</sub> span)
- ★ Water vapor calibration
  - Dew point generator is one of the few 'span' options available
  - Setting appropriate span value



Example of procedure:

<https://www.licor.com/env/support/LI-7500RS/topics/calibration-procedure.html>





# Maintenance >> calibration



Regular instrument maintenance and service may reap larger benefits compared to calibration.

- Keeping sensors clean is priority #1.
  - ◆ Dirty sensors can be noisier and have reduced signal
- Keep sensors dry.
  - ◆ Replace desiccant packs
  - ◆ IRGA scrubbers/desiccant bottles
  - ◆ Electricity + water = bad
- Check that sensors are level.
  - ◆ Especially radiometers.



# Best practice checklist

Visit: <https://ameriflux.lbl.gov/tech/technical-resources/>

[https://ameriflux.lbl.gov/wp-content/uploads/2020/08/AMP-Best-practice-checklist\\_20200811.pdf](https://ameriflux.lbl.gov/wp-content/uploads/2020/08/AMP-Best-practice-checklist_20200811.pdf) (or use QR code)

Preventive maintenance:

- Weekly schedule
- Monthly schedule
- Semi-annual schedule





# Manufacturer's recommendations

Most instrument manufacturers will specify a *calibration interval* but some instruments don't have service intervals.

We find that 2 years is a fairly common recommended calibration interval (ex. Campbell dataloggers, many radiation sensors (including PAR), barometers).

IRGA calibration intervals vary considerably based on environmental conditions and often specify seasonally.



# AmeriFlux loaner program

- Calibration gases ( $\text{CO}_2$  and  $\text{CH}_4$ ). PAR sensors. Gas analyzers (LI-COR / Campbell Scientific). Sonic anemometers (Campbell Scientific / Gill / ATI). Leaf area index sensor. Dew point generator.
- **Need something else? Contact us!**





# Calibration / maintenance metadata

How do you document calibration and maintenance activity?

What 'data' do you collect?

- ★ When, where, what was done?
- ★ What about instrument configurations, coefficients, and parameters?
- ★ Where/how do they get stored for future retrieval/analysis?



THANK YOU

US-Aud