Meteorology 432

Static Calibration/Static Performance

Spring 2013

What is it?

- Characterize the static performance of a sensor
  - Performance of sensor when input is constant or slowly varying.
  - Varying one input, usually in a stepwise fashion, over a range of values while holding other inputs constant.

- Output is observed in steady-state conditions.
  - Input is held constant long enough for output to stabilize.

- Objective 1: Define instrument accuracy

- Objective 2: Develop input-output, or transfer equation.

- Example: calibration of thermocouples in a water bath.

- Dynamic Performance: The performance of a sensor when the input is rapidly varying.

Definitions

- Static Sensitivity: slope of the transfer curve
  - $S_s \equiv$ d(raw output)/ d(input)
    - Straight line: S_s = constant, linear sensor
    - Otherwise: non-linear sensor

- Range: Measured interval over which a sensor is designed to respond.

- What would you want out of an ideal instrument in terms of S_s and range?

  - Large, constant static sensitivity over the whole range

- A sensor with $S_s = 0$ is a useless sensor.
  - Using a brick for a pressure sensor, for example.

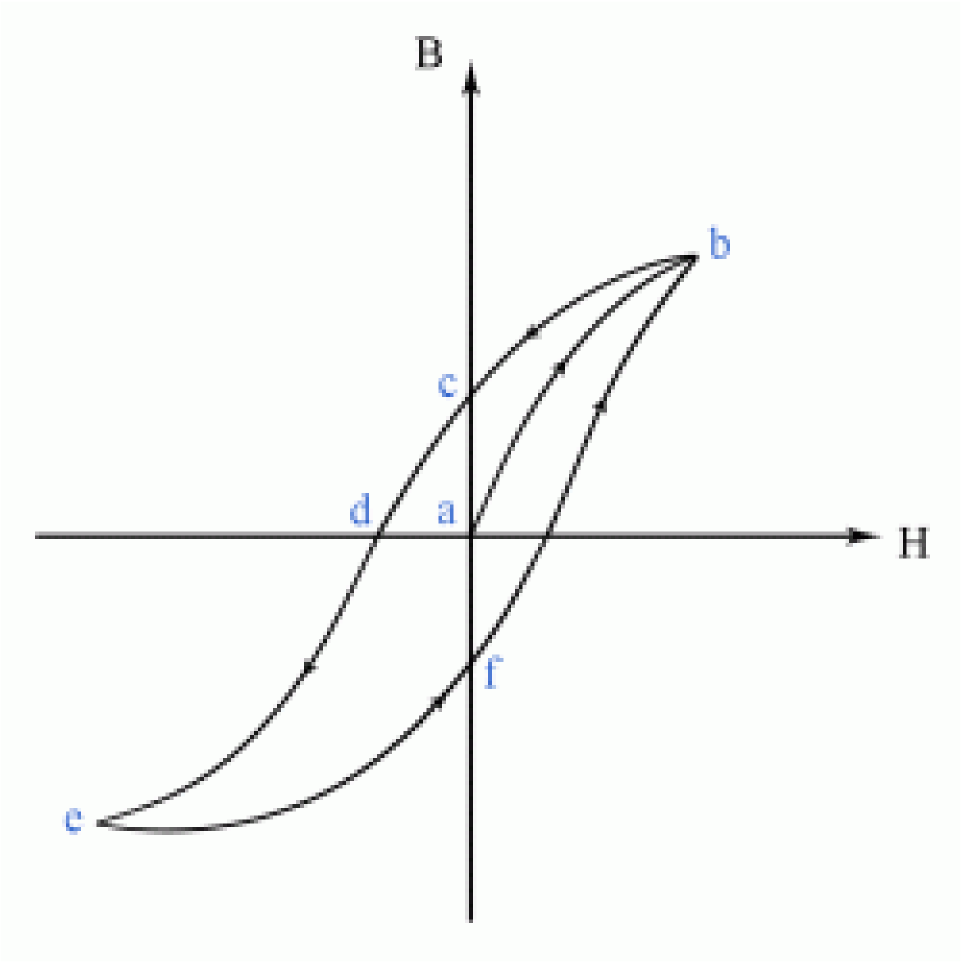
Definitions cont.

- Resolution: Smallest change in the input that produces a detectable change in the output.
  - Higher the sensitivity, the higher the resolution.
  - Resolution is not a function of sensitivity only.
    - Friction and noise can also reduce resolution.

- Hysteresis: Present when the sensor output for a given input depends upon whether the input was <u>increasing</u> or <u>decreasing</u>.

- Stability: An instrument is said to be stable and free from drift if repeated calculations over some period of time produce the same transfer curve.
  - Period can vary from days to years.

Hysteresis Graph



Calibration Procedure

Objective: Develop a transfer equation that can be used to convert the observed output Y_i to an estimate of the know input X_i.

1. Development of transfer plot.
   - Accurate measurement of X_i, the primary input, and Y_i, the primary output, at N points over the design range of the sensor.

2. Development of a transfer equation.
   - Fit a straight line, or curve if necessary, to the data, using the least-squares procedure.
   - Objective: equation that can be used to convert output Y_i to an <u>ESTIMATE</u> of the observed input, X_i.

3. Development of a calibration equation.
   - Objective: equation that allows us to determine the observed quantity from the sensor output.

Calibration Equation

- Final result of the calibration procedure.
- Converts sensor readings into the measurable quantity we are interested in.

Bias and Imprecision

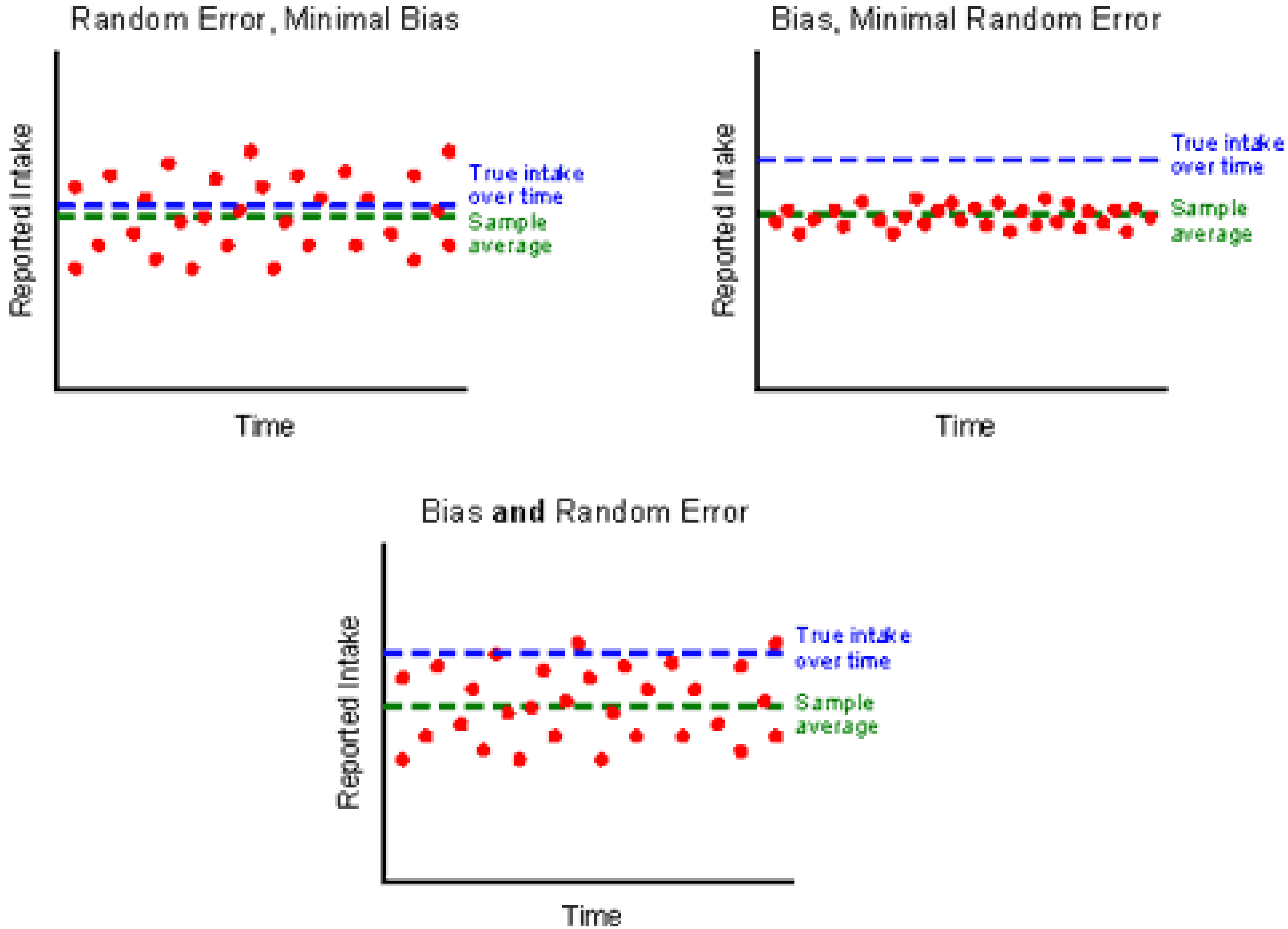
- Both can be used to measure the quality of our calibration.

- Bias
  - Systematic error that can be corrected by calibration.

- Imprecision: By convention, typically one or two σ.
  - Uncertainty in a single measurement.

- After calibration:
  - Bias should be zero.
  - Drift could change this.

- Inaccuary ≡ Bias ± imprecision


Random Error, Minimal Bias
Reported Intake
True intake over time
Sample average
Time
Bias, Minimal Random Error
Reported Intake
True intake over time
Sample average
Time
Bias and Random Error
Reported Intake
True intake over time
Sample average
Time