Lecture 8/16/21

Terminology

Transducer – A device that converts a nonelectrical quantity into an electrical signal and vice versa

- **Sensor** – A device that converts a nonelectrical quantity into an electrical signal
  - An input transducer
  - Examples: pressure sensor, accelerometer

- **Actuator** – A device that converts an electrical signal into a nonelectrical quantity
  - An output transducer
  - Examples: motor, light bulb, electric heater

Measurand – the quantity being measured by the sensor (such as pressure or temperature)

Size

Macro – 2mm and larger (us: 6’ = 1.8288m) – our world

Meso – 2mm down to 500μm (small fire ant is 2mm long) – her world

Micro – 500μm down to 0.5μm (paramecium is 100μm to 300μm long, human red blood cell has a 6μm to 8μm diameter)

Nano – 0.5μm down to 1nm (spherical influenza virus: 50nm to 120nm diameter with 10nm to 14nm spikes on surface)

Human Hair: ~100μm diameter

Modern Transistor: <100nm dimensions

MEMS: acronym for "Microelectromechanical Systems"

Definition: Any device or system partially or fully manufactured using microfabrication techniques

Microsensor: a sensor with at least one sub-mm physical dimension

MEMS Characteristics

(1) Typically based around a silicon substrate

(2) Typically use batch fabrication processing borrowed from microelectronics fabrication technology

Batch Fabrication: many devices fabricated in parallel

- Reduces Cost per Device

(3) Sometimes compatible with microelectronics fabrication

(4) But often not compatible with microelectronics fabrication

Sensor and Sensing Characteristics

(1) Accuracy – how correct the sensor readings are

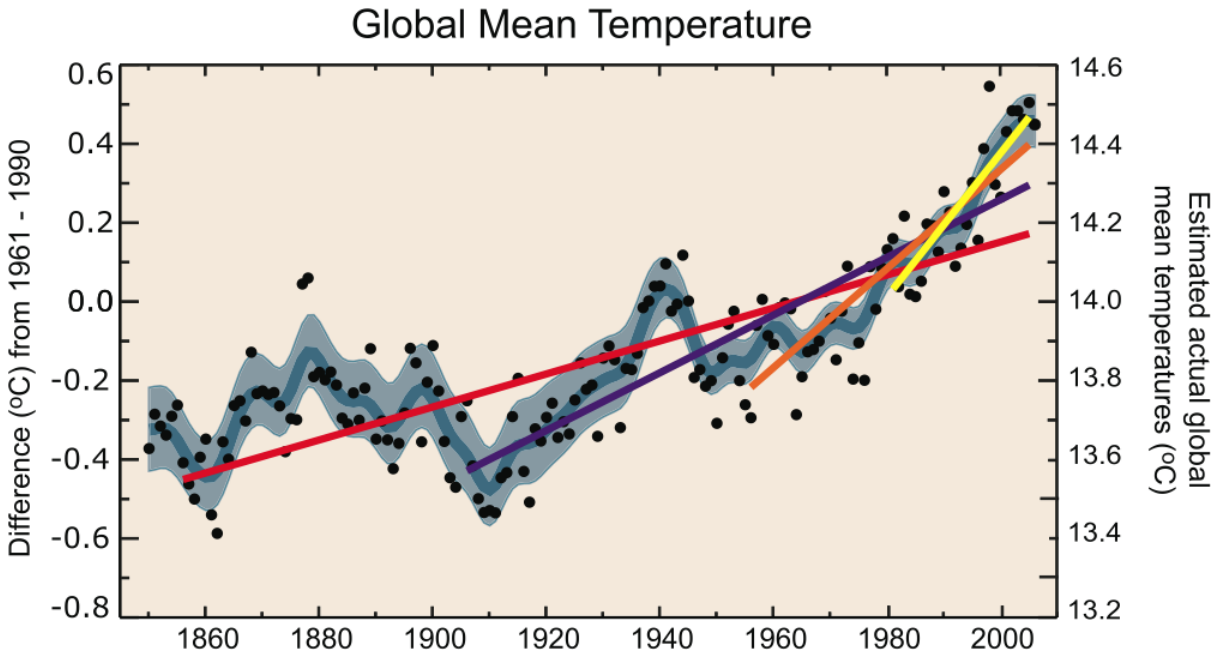
(2) Precision – the resolution of the sensor

(3) Range – defines the minimum and maximum measurand levels that can be sensed

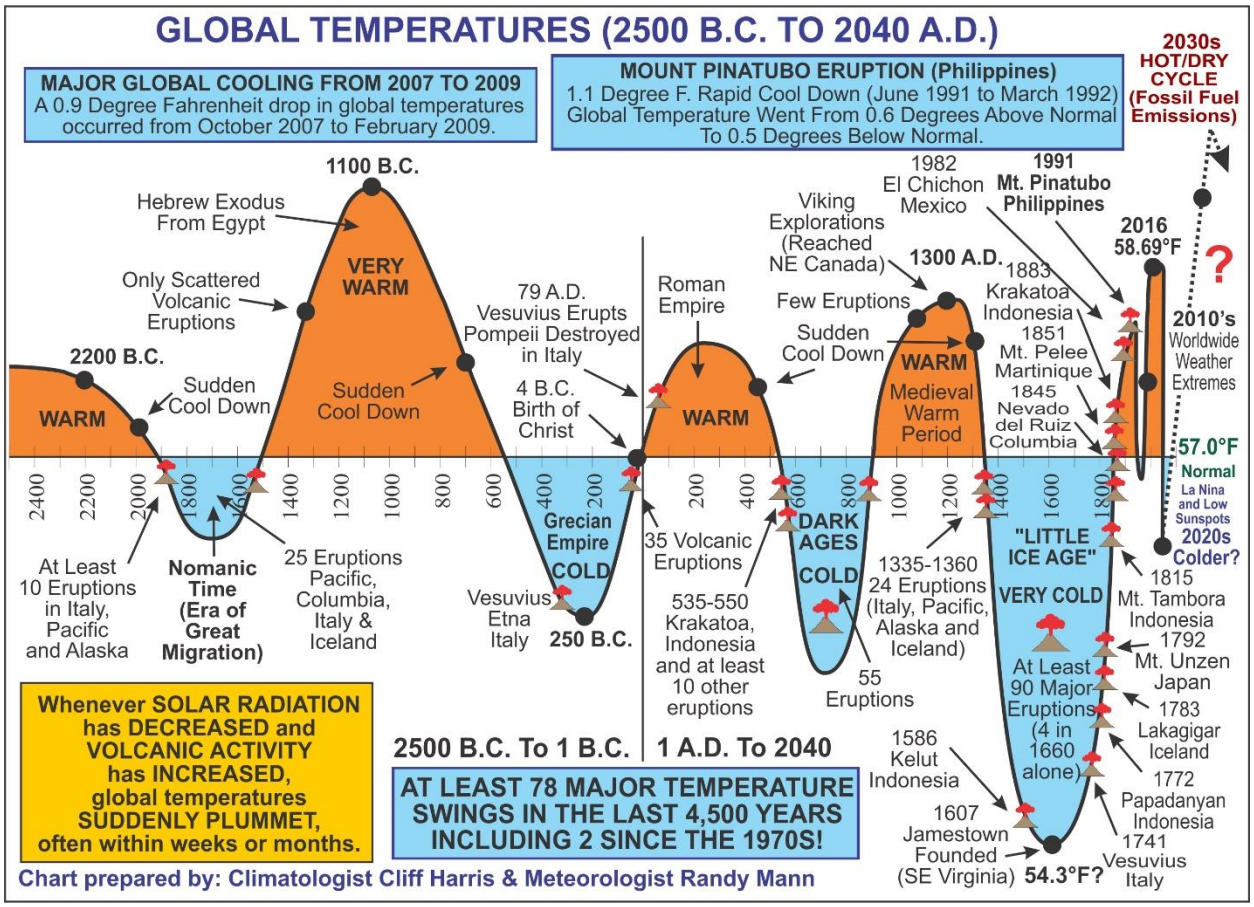
(4) Minimum sampling rate – must be at least twice the highest frequency present in the data to avoid aliasing

(5) Minimum sample collection period – must be long enough to capture any trends present in the data (see example on next page)

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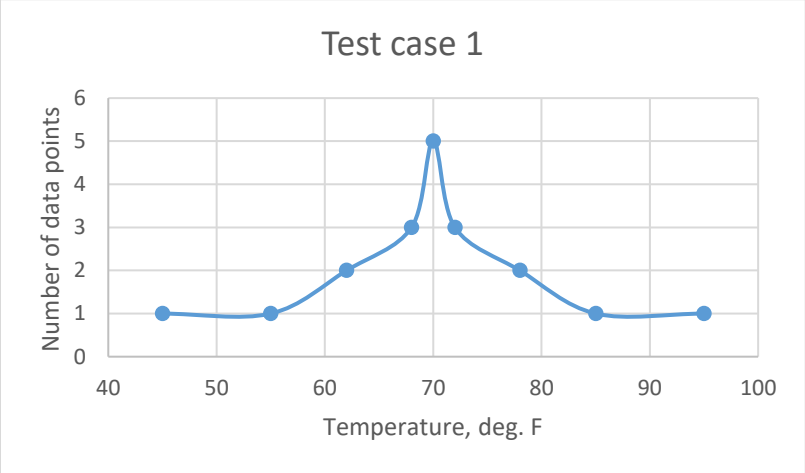
https://wg1.ipcc.ch/publications/wg1-ar4/faq/wg1_faq-3.1.html



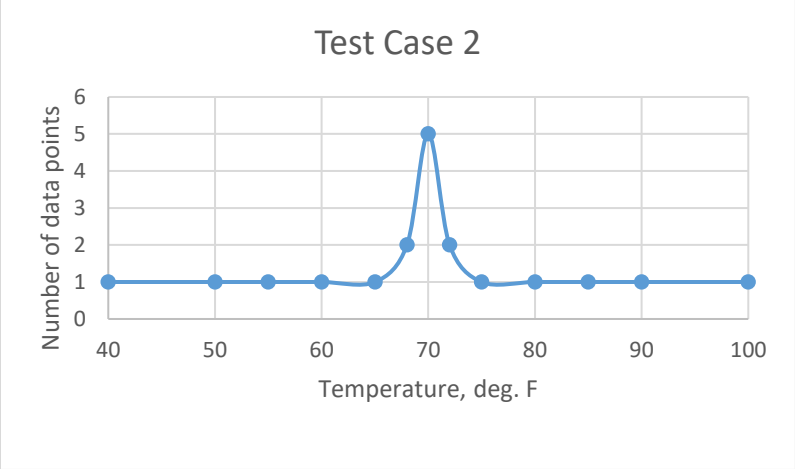
http://www.longrangeweather.com/global_temperatures.htm

Statistics of Sensor Data

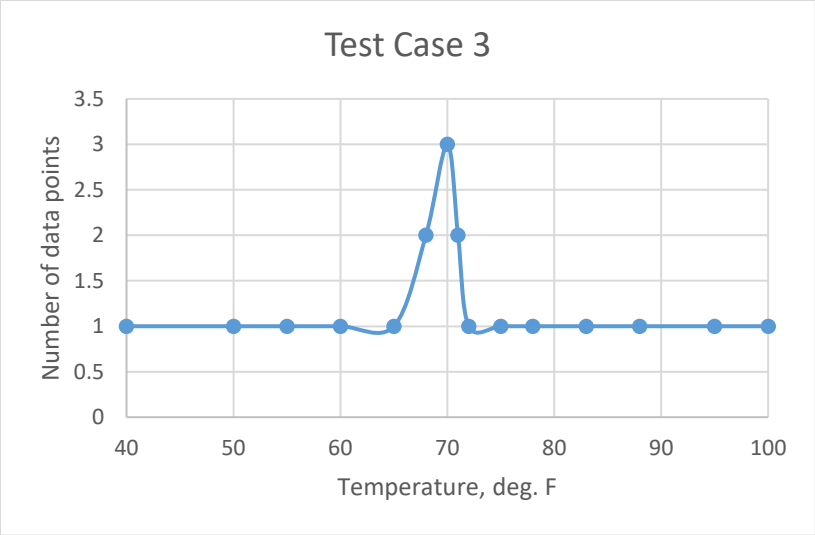
(1) Average (mean) – sum total of the values divided by the number of values of the data set
(2) Median – the middle value of the data set. Same number of data points above and below the median.
(3) Standard Deviation (σ) – a measure of the amount of variation in a set of data values. 68.27% of the data set lies within ± 1 σ. 95.4% within ± 2 σ.



Symmetrical Distribution
Average = 70 F
Median = 70 F
σ = 10.2 F



Average = 70 F
Median = 70 F
σ = 13.2 F



Skewed Distribution (most data points are below the average)
Average = 71 F
Median = 70 F
σ = 14.1 F