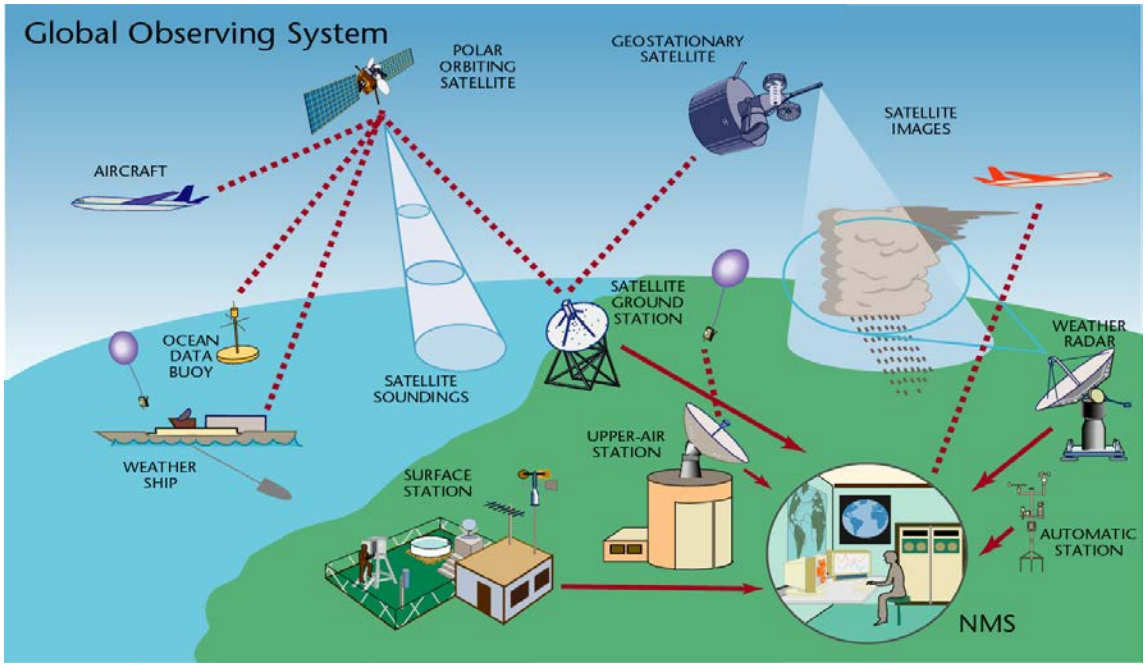
The Course of
Meteorological Instrumentation and Observations



MUSTANSIRIYAH UNIVERSITY
COLLEGE OF SCIENCES
ATMOSPHERIC SCIENCES DEPARTMENT

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SECOND STAGE

Welcome Students! ☺

TO LECTURE ONE

Principles of Measurement and Instrumentation

What are covered in this course?

1. Introduction to Met Instruments

2. Observing System

3. Temperature and Moisture measurement
   - Basic principles
   - Sensor types
   - Response time

4. Precipitation measurement
   - Rain gauges
   - Radars for precipitation

5. Pressure measurement
   - Basic principles
   - Sensors

6. Wind measurement
   - Mechanical method
   - Electrical method

8. Clouds measurement

9. Upper atmosphere measurement

7. Radiation
   - Basic principles
   - Sensors

10. Weather radar

11. Satellite observations

12. Weather Maps and how to represent Weather Phenomena

Meteorological observations are made for a variety of reasons:

- for the real-time preparation of weather analyses, forecasts and severe weather warnings,
- for the study of climate,
- for local weather dependent operations (for example, local aerodrome flying operations,
- construction work on land and at sea),
- for hydrology and agricultural meteorology,
- for research in meteorology and climatology.

OBSERVING PARAMETERS

PARAMETER	SENSOR	UNIT	MEASURING RANGE
Wind speed	Anemometer	m/sec, knot	0..75 m/sec
Wind direction	Wind vane	Degree	0..360 o
Air temperature	Thermometer	o C	-60 o C..+60 o C
Wet bulb temp.	Thermometer	o C	0...+40 o C
Dew point	Thermometer	o C	-60 o C...+50 o C
Rel. Humidity	Hygrometer	%	0%...100%
Soil Terre. Temp.	Thermometer	o C	-60 o C...+70 o C
Soil temp.	Thermometer	o C	-50 o C...+70 o C
Soil moisture	Moisture sensor	% H_2O	Undefined

OBSERVING PARAMETERS

PARAMETER	SENSOR	UNIT	MEASURING RANGE
Pressure	Barometer	hPa	600....1100 hPa
Precipitation	Pluviometer	mm	Unlimited
Snow depth	Depth sensor	cm	0..1000 cm
Evaporation	Evap. Pool	mm	0...100 mm/day
Global radiation	Pyranometer	Watt/m2	0...1500 W/m2
Direct radiation	Pyrheliometer	Watt/m2	0...1500 W/m2
Diffuse radiation	Pyranometer	Watt/m2	0...1500 W/m2
Net radiation	Pyranometer	Watt/m2	Undefined
Sunshine duration	Heliometer	Hour	120 W/m2 (threshold)

OBSERVING PARAMETERS

PARAMETER	SENSOR	UNIT	MEASURING RANGE
Leaf wetness	Wetness sensor	Kg/m2, capacity%	Undefined
Soil heat flux	Flux sensor	Watt/m2	Undefined
Lightning	Lightning Detector	Count	0....9999
Cloud height	Ceilometer	M, feet	30...25.000 m
Visibility	Transmissometer Forward scatt.	M, km	25....50.000 m
Present weather	Pre. Weat. Sen.	Phenomen a code	----

A **measurement** is a quantity that has both a **number** and a **unit**.

2.34 g **36.1 mL** **996 hPa**

Measurements are fundamental to the experimental sciences. For that reason, it is important to be able to MAKE measurements and to *decide* whether a measurement is CORRECT.

We can make these observations in two ways:

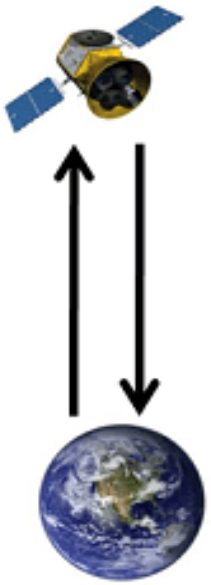
In situ measurement

- measurements obtained through direct contact with the respective object (basically you take measurements of the parameters right were you are)
- they measure the parameters from where they are located at that moment, Surface (stations, ships, or, buoys), or upper-air(rockets; balloons, and aircrafts)

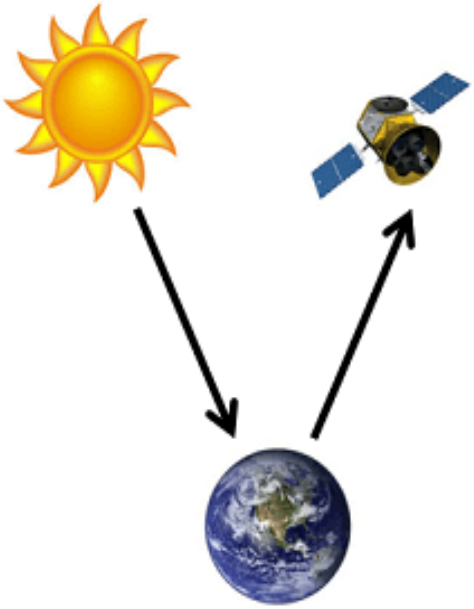
Remote sensing measurement

- acquisition of information of an object or phenomenon, by the use of either recording or real-time sensing devices that are wireless, not in physical or intimate contact with the object.
- It has two types: active and passive remote sensing

Active remote Sensing: Makes use of sensors that detect reflected responses from objects that are irradiated from artificially-generated energy sources, such as radar(send out radiation, hoping to get it back to analyze it).



Active remote sensor



Passive remote sensor

Passive Remote Sensing:
Makes use of sensors that detect the reflected or emitted electro-magnetic radiation from natural sources (wait for radiation to come to them so that they can analyze the data)

Steps needed to make measurements for a specific application:

1. Define and research the problem (literature review is advised).
- What parameters are required and what must be measured.
- What is the frequency of the observations that will be required?
- How long will the observations be made?
- What level of error is acceptable?

2. Know and understand the instruments that will be used (consider cost, durability, and availability).

3. Apply instruments and data processing (consider deployment, and data collection).

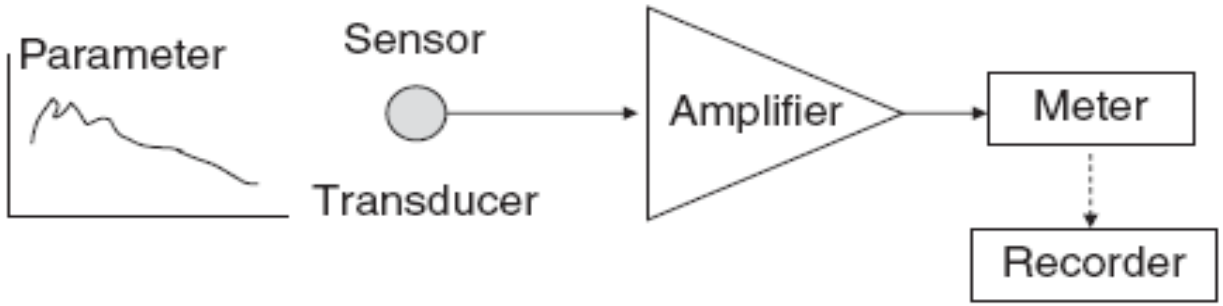
4. Analyze the data (apply computational tools, statistics, etc..).

Instruments and measurement systems

determining the magnitude of a physical environmental parameter (ex. Temp.)	sensing technology is able to respond the quantity to be measured	a method of quantifying the response	a recording technique for the quantified response

- Closely related is the need to **evaluate** how well the quantity has been measured, to provide an assessment of the associated uncertainty.

The sensor responds to the specific parameter measured.
(In some cases, energy exchange by a transducer may also be required, to convert the sensor's response into something which can be more conveniently measured.)
An amplifier is used to increase the magnitude of the changes produced by the sensor. Amplifiers operate on a variety of principles, for example mechanical, chemical, optical or electronic. As well as increasing the signal, an amplifier usually increases other random variations (noise) present as well.
The meter provides the final readout in terms of a magnitude, and can be digital or analogue.
A recording device of some form may be attached to the meter, such as a chart recorder, a computerized logging system or, more simply, an observer with a notebook.



Term	Explanation
Parameter	The variable physical quantity to be measured, such as pressure, temperature, speed, time.
Sensor	A device which responds directly in some way to changes in the parameter to be measured. For example, the rotating cups on a cup anemometer.
Transducer	An energy transfer device to convert the response of a sensor into another quantity, which can be more conveniently measured (e.g. to an electrical signal) or recorded. In some instruments, such as a photovoltaic light meter, the functions of sensor and transducer are combined.
Amplifier	This magnifies a small change, for example turning a small voltage change into a larger voltage change; amplifiers are, however, not necessarily electronic.
Gain	The ratio of the output signal amplitude to the input signal amplitude of an amplifier stage.
Meter	This measures and displays the output from a transducer or sensor (meters are often electrical, in that they display a voltage, but may also be mechanical).
Recorder	A device employing a retrieval method (paper, film, electronic etc.) by which a series of successive meter readings can be preserved.

Descriptions of parts of an instrument