AWS SITE

Surface Instruments Division, O/o the Head, Climate Research and Services, IMD, Pune

भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT

AWS Site Selection Criteria

Norms of AWS site selection criteria and its installation

- **Each AWS is established in a fenced piece of land admeasuring 12 m X 15 m with good exposure conditions**.
- Minimum is 10 m X 10 m.
- **The norms for AWS site selection are**:

- There shall be no obstruction to the transmitting antenna in south-west direction (170 °-230 °) for azimuth orientation and for 50 °-75 °for elevation of the antenna for satellite based AWS

- The site shall be free from nearby tall buildings, trees, large water bodies, industrial heat source and high tension cables (both overhead and underground).

- The site shall be selected in such a way that the distance between the fencing and the AWS tower is at least 5 m. This is to minimize the effect of the fence as horizontal obstruction to the sensors.

- The site with steep slope, high vegetation, low lying place holding water after rain shall not be considered for installation of AWS

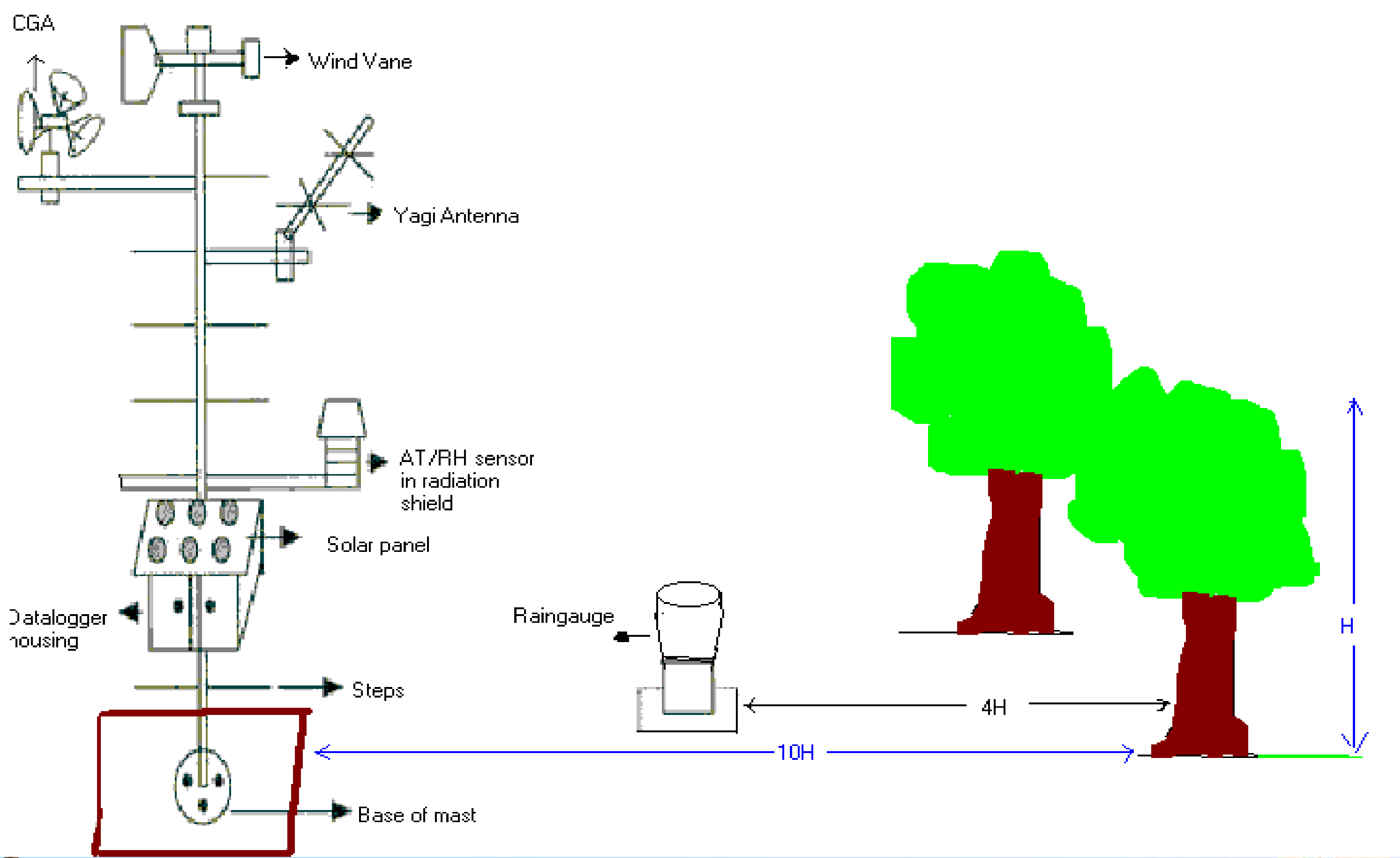
Continue..

- In order to ensure measurement of unperturbed wind, the guidelines required that distance between wind sensor and any obstruction shall be at least 10 times the height of the obstruction (WMO 1996).

- **Conditions to be AVOIDED**

- Obstructions like tall buildings, trees etc.
- Location of the site on the edge of a slope, hillocks, cliff or inside a valley
- Large industrial heat sources
- Location near high-tension power lines
- Rooftops, Steep slopes, sheltered hollows, high vegetation, shaded areas or swamps
- Low places holding standing water after rains.
- Underground obstructions like buried cables or conduits.
- Pollution influence from surrounding farms and towns

A pictorial representation of the AWS site



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Exposure conditions for sensors of meteorological parameters at AWS site

- **Wind speed and direction**

- The wind speed and direction sensors are required to be installed on a mast, at a height of 10m from ground level.
- The sensors are required to be located on the mast, which is installed at a distance of at least ten times the height of nearby buildings, trees or other obstructions.

- **Air Temp & Relative Humidity**

- The standard measurement height for temperature and relative humidity sensor is 1.25 to 2m.
- The sensor is to be located at a distance of at least four times the height of obstructions like trees, buildings etc.
- The sensors are generally located in an open level area that is at least 9m in diameter.
- The site enclosure should be covered by short grass or natural earth.

Large paved areas, bitumen surfaces in the vicinity of at least 30m have to be avoided.

Continue…

❑ **Atmospheric pressure**

- The Atmospheric pressure being an important meteorological parameter, the elevation of the station to which the station pressure relates is very important and hence the chosen site must be located in a flat terrain.

❑ **Rainfall**

- The rainfall sensor (tipping bucket) is placed in an open area as far as possible at a minimum distance of four times the height of any obstruction.

- The standard measurement height is 30 cm above ground level.

❑ **Solar Radiation**

- Solar radiation sensors to be mounted at a minimum height of 3m to ensure easy leveling and cleaning

META DATA

- More specially, station metadata refers to site/location, instrumentation, observation practices, calibration reports, site layout, site condition, site exposure, changes of location etc..

- Climate Metadata have a key role in the process of creating datasets, as the knowledge of the station history provides increased confidence in the statistical techniques employed to ensure that the only variations that remain in a climate time series are due to actual climate variability and change.

- Meteorological data users other than the climatological community, working in fields like agrometeorology, engineering or aeronautics, also benefit from good metadata.

- These professionals also need to extract the maximum accuracy from the observations, and often compare data taken in different places or times.

- A complete knowledge of the measuring conditions will help them to achieve this goal.
- Most metadata have to be derived from the station's documentation, both from current and historical documents.

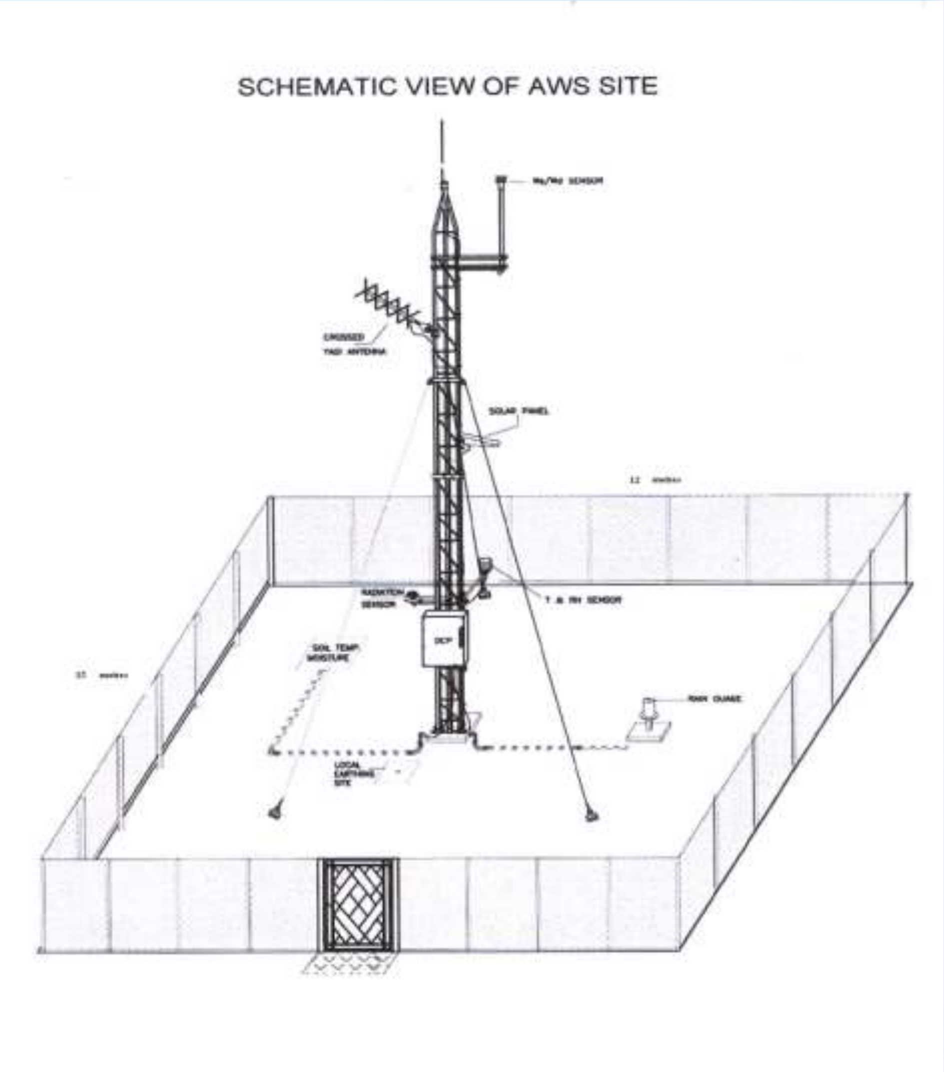
Continue..

- Good metadata are needed to ensure that the final data user has no doubt about the conditions in which data have been recorded, gathered and transmitted, in order to extract accurate conclusions from their analysis
- Meteorological data are influenced by a wide variety of observational practices. Data depend on the instrument, its exposure, recording procedures and many other factors. There is a need to keep a record of all these metadata to make the best possible use of the data.
- This guide will identify the minimum information that should be known for all types of stations, like, for example, location and measurement units.
- Additional information will be of great advantage for the data users, as well as for the providers

- STATION IDENTIFIERS AND GEOGRAPHICAL DATA
  - Name: station names usually refer to the city or village where the data are collected.
  - WMO Code or station number: worldwide, WMO identifies meteorological stations whose data are internationally exchanged with a 5-digit code
  - Type of station: synoptical, aeronautical, agrometeorological, etc.
  - Latitude and longitude: preferably with sufficient accuracy that the station is located within a few hundred meters, e.g. in units of 0.001 degree of latitude

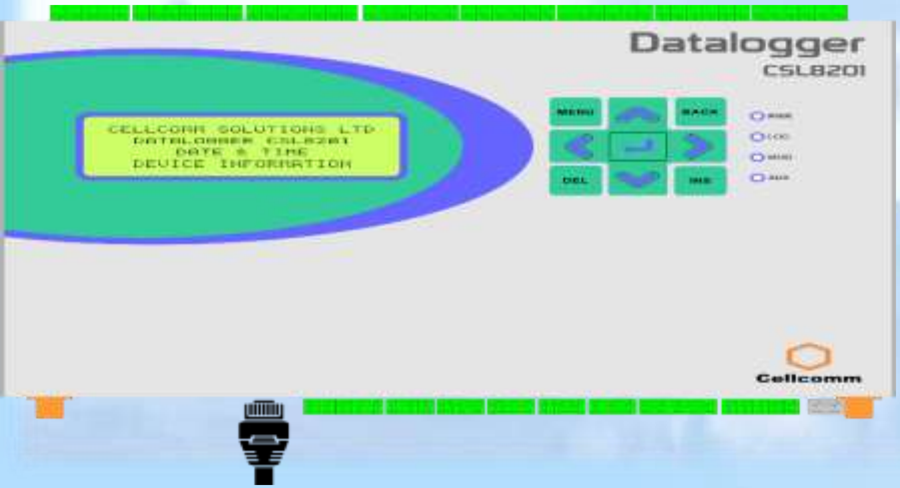
AWS FIELD SITE

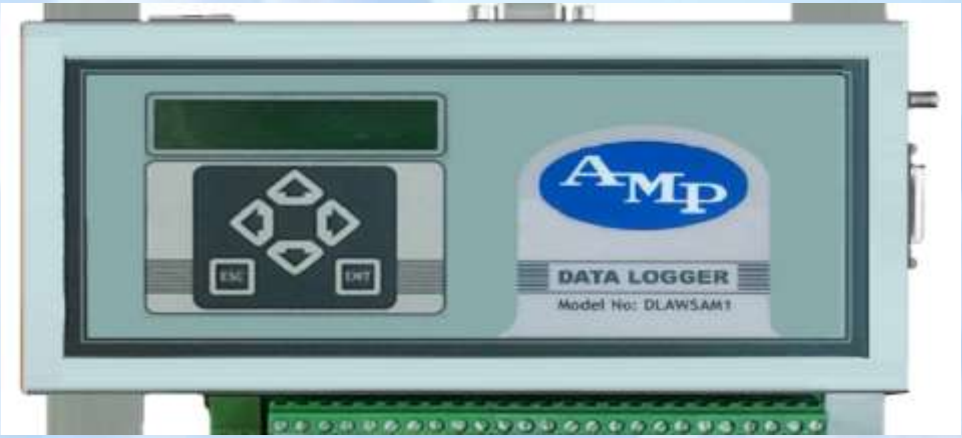
- DATA LOGGER
- UHF TRANSMITTER/ GPRS Modem
- YAGI ANTENNA/ GPRS Antenna
- GPS Antenna
- BATTERY/ SOLAR CHARGER
- SOLAR PANEL
- SENSORS



DATALOGGER

- A DATA LOGGER (ALSO DATALOGGER OR DATA RECORDER) IS AN ELECTRONIC DEVICE THAT RECORDS DATA OVER TIME OR IN RELATION TO LOCATION EITHER WITH A BUILT IN INSTRUMENT OR SENSOR OR VIA EXTERNAL INSTRUMENTS AND SENSORS.
- INCREASINGLY, BUT NOT ENTIRELY, THEY ARE BASED ON A DIGITAL PROCESSOR (OR COMPUTER).





SENSORS

SENSORS INSTALLED ON AWS SYSTEM

- Air temperature and Relative Humidity
- Wind sensors – Wind speed and Wind direction
- TBRG sensors - Rainfall Measurement
- Pressure sensors - Station level Pressure

TEMPERATURE HUMIDITY SENSORS

Continue…

- Air temperature and Relative Humidity is a combined probe with separate sensors for both.
- The sensing element for temperature is a high precision PT 100(platinum resistance) sensor.
- The measuring range of temperature –40° to +60°C corresponds to an output of 0 to 1V.
- The sensor for relative humidity is capacitance based.
- 0-100% RH corresponds to 0 to 1V.

Pressure sensors

- **Pressure sensor** is a device for pressure measurement of gases or liquids

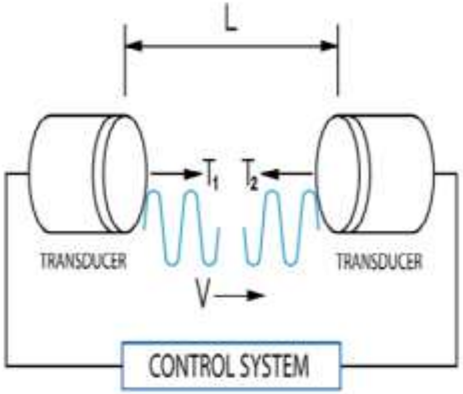
- A barometric **pressure sensor** is a **sensor** that detects **atmospheric pressure**. ...
- A typical example of a barometric **pressure sensor** is a piezo-resistive type that uses silicon semiconductor. ROHM barometric **pressure sensors** are silicon-based piezo-resistive types.
- Aneroid barometer consists of an aneroid cell inside. The aneroid cell expands/contracts when there are small changes to **atmospheric pressure**.

- Low power design makes it ideally suited for remote monitoring applications.
- Capable of operating from elevations of 2300 feet below sea level to 18,300 feet above sea level
- Low power consumption
- Solid state construction

Wind sensors

- Gill-make ultrasonic wind sensor which is a very robust, lightweight unit with no moving parts.
- The measurement range is 0-116 knots (0 to 60 mps) for wind speed and 0-359° for wind direction .
- It requires power supply of 12 V and has digital output as RS 232.

- The Windsonic measures the time it takes an ultrasonic pulse of sound to travel from the North transducer to the South transducer, and compares it with the time for a pulse to travel from S to N transducer.
- The times are also compared between West and East, and E and W transducers.
- WS/WD is obtained by determining which way the wind is going faster.



Continue…

- The transducers fire ultrasonic pulses to the opposing transducers.
- In still air (zero wind speeds) time of flight between the two transducers is same for all pulses, both forward and reverse directions.
- When the wind blows, it increases the time of flight for pulses travelling against the wind.
- So from the changes in the time of flight, the sensor calculates the wind speed and direction.
- For instance if a North Wind is blowing, then the time it takes for the pulse to travel from N to S will be lesser than the time taken for the pulse to travel from S to N whereas the W to E, and E to W times will be the same.
- The wind speed and direction can then be calculated from the differences in the times of flight on each axis.
- This calculation is independent of factors such as temperature, altitude and humidity. The microcontroller embedded in the neck of the sensor computes the wind speed and direction and reports them to the data logger .

L = Distance between transducer faces, C=speed of sound (The speed of sound is the distance travelled during a unit of time by a sound wave propagating through an elastic medium. In dry air at 20°C (68°F), the speed of sound is 343.2 metres per second), V= velocity of gas flow (here air) T1 = Transit time of ultrasound in one direction, T2 = Transit time of ultrasound in the opposite direction

Continue…

$$T_1 = \frac{L}{C+V} \quad \text{and} \quad T_2 = \frac{L}{C-V}$$

Therefore : $V = \frac{L}{2}\left\{\frac{1}{T_1} - \frac{1}{T_2}\right\}$ $\quad C = \frac{L}{2}\left\{\frac{1}{T_1} + \frac{1}{T_2}\right\}$

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In AWS, vector averaging of wind speed and direction is done from the 180 samples (@ one per sec) for the three minutes prior to the top of the hour, say, 57:00 to 60:00/00:00 at which hourly observations are sampled for all the sensors.

Rainfall sensors

- Diameter of the orifice: 20 cm
- 0.5 mm Rainfall is equivalent to 0.05 cm.
- Amount of water (Volume of water) required for one tilt is 3.14*10*10*0.05 = 15.7 cc

The sensor is the tipping bucket mechanism and is mounted at a height of 0.6 to 1 m. The collector diameter is 20 cm.
So 15.7 cc (product of collector area and resolution) of rain water corresponds to 0.5 mm of rainfall.
Each bucket is calibrated to tip when 15.7 cc of rain water is collected in it. At any given time one bucket is always in collection mode. As the bucket tips it causes a magnet to pass by a ruggedized mercury switch, momentarily (0.05 sec) closing the switch. The contact closure initiates event or count accumulation in the data logger. Once the rain is measured, the rain water is directed into drain tubes that allow it to exit through the base of the gauge.

Continue..

- The collector diameter for Astra TBRG is 159.6 mm and collector area is 200 cm^2.
- Since the resolution of the gauge is 0.5 mm, 10 cm^3 / 10 ml (product of collector area and resolution) of rain water corresponds to 0.5 mm of rainfall.
- Each tipping bucket is calibrated to tip when 10 cm^3/10 ml of rain water is collected in it.
- At any given time one bucket is always in collection mode. As the bucket tips it causes a magnet to pass by a ruggedised mercury switch, momentarily (0.05 sec) closing the switch.
- The contact closure initiates event or count accumulation in the data logger.
- Once the rain is measured, the rain water is directed into drain tubes that allow it to exit through the base of the gauge.

- The rainfall accumulated for the 24 hours period ending 03 UTC of today commencing from 03 UTC of the previous day is taken as the cumulative rainfall reported at 03 UTC of today.
- The rainfall value is reset at 03 UTC and fresh logging and accumulation of the rainfall, if any, takes place as per IMD convention.

Agro sensors

- Sensors used in agriculture for smart farming are known agriculture sensors.
- They **provide data that helps farmers to monitor and optimize crops with environmental conditions and challenges**.

- These sensors in agriculture installed and fixed in weather stations, drones, and robots used in the agriculture industry.

- Sensors used in smart farming are known as agriculture sensors. These sensors provide data which assist farmers to monitor and optimize crops by adapting to changes in the environmental conditions.

- They are used in agricultural weather stations.

- These equipments are equipped with sensors which provide information such as soil temperature at various depths, air temperature, rainfall, leaf wetness, chlorophyll, wind direction, solar radiation, relative humidity, atmospheric pressure etc.

Soil sensors

- The Soil Moisture Sensor is a Stevans hydra probe using a SDI-12 output and the unit of measurement of soil moisture is water fraction by volume(wfv).

- The Hydra soil moisture probe determines soil moisture and salinity by making a high frequency (50 MHz) complex dielectric constant measurement which resolves simultaneously the capacitive and conductive parts of a soil's electrical response.
- It's "dielectric impedance" measurement principle differs from TDR, capacitance, and frequency soil sensors by taking into account the energy storage and energy loss across the soil area using a 50 MHz radio frequency wave.

Continue…

- The Delta-T (ML2x) theta probe is used for soil moisture at 20 cm measurement in Agro AWS.
- The sensor determines soil moisture by making a high frequency (50 MHz) complex dielectric constant measurement which resolves simultaneously the capacitive and conductive parts of the soil‟s electrical and conductive response.
- The capacitive part of response is indicative of soil moisture.
- Soil Moisture is measured as volumetric soil moisture content θ_V (m^3/m^3 or % volume).
- Measuring range is from 0 to 1 m^3/m^3.
- It does not require routine maintenance but requires calibration every year with gravimetric method.

SUNSHINE DURATIONS

CSD3 measures sunshine duration. Sunshine duration is defined by WMO as the time during which the direct solar radiation exceeds the level of 120 W/m^2.

It has no moving parts and uses 3 photo-diodes with specially designed diffusers to make an analogue calculation of when it is sunny.

The output is switched high or low to indicate sunny or not sunny conditions. The calculated direct irradiance value is also available

Measurement is performed by instruments called sunshine recorders. For the specific purpose of sunshine duration recording, Campbell–Stokes recorders are used, which use a spherical glass lens to focus the sun rays on a specially designed tape. When the intensity exceeds a pre-determined threshold, the tape burns.

The total length of the burn trace is proportional to the number of bright hours

PYRANOMETER

A **pyranometer** is a type of actinometer used for measuring solar irradiance on a planar surface and it is designed to measure the solar radiation flux density (W/m^2) from the hemisphere above within a wavelength range 0.3 μm to 3 μm.

A pyranometer is a sensor that converts the global **solar radiation** it receives into an electrical signal that can be measured.
Pyranometers measure a portion of the solar spectrum.
As an example, the CMP21 Pyranometer measures wavelengths from 0.285 to 2.8 μm

Solar irradiance is the power per unit area (watt per square metre, W/m^2), received from the Sun in the form of electromagnetic **radiation** as reported in the wavelength range of the **measuring** instrument.

Global radiation is the total short-wave **radiation** from the sky falling onto a horizontal surface on the ground. It includes both the direct solar **radiation** and the diffuse **radiation** resulting from reflected or scattered sunlight.

PAR SENSORS

Photosynthetically active **radiation**, often abbreviated **PAR**, designates the spectral range (wave band) of solar **radiation** from 400 to 700 nanometers that photosynthetic organisms are able to use in the process of photosynthesis.

Photosynthetically active radiation (PAR) is light of wavelengths 400-700 nm and is the portion of the light spectrum utilised by plants for photosynthesis.

Photosynthetic photon flux density (PPFD) is defined as the photon flux density of PAR.

Modern instruments measure light as the rate at which moles (6.02×10^{23} quanta) of PAR land on a unit area (μmol quanta m^{-2} s^{-1}); however, it is sometimes necessary to convert between different units used for measuring light.

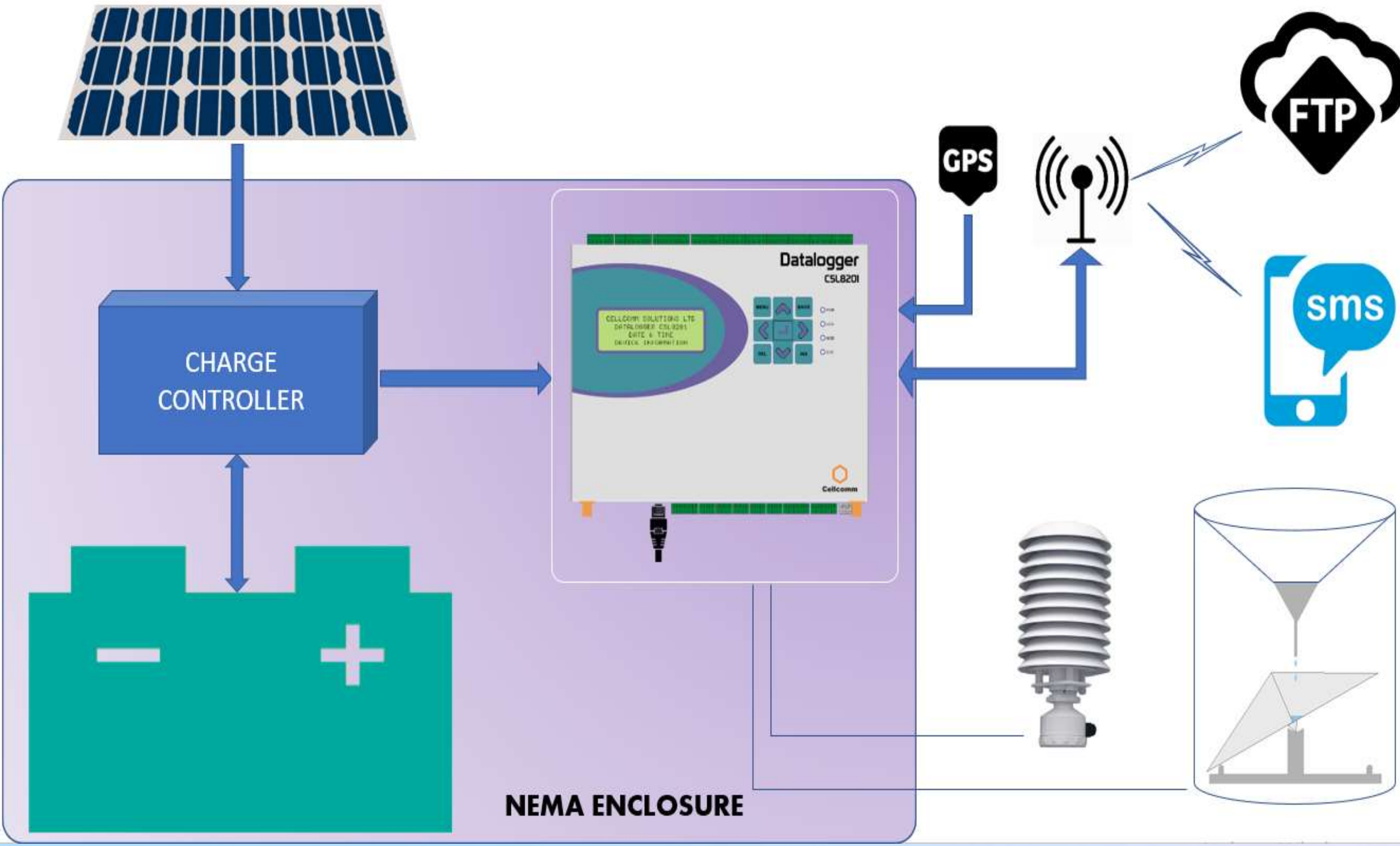
EVAPORATION SENSORS

Evaporation is the process by which water changes from a liquid to a gas or vapor. **Evaporation** is the primary pathway that water moves from the liquid state back into the water cycle as atmospheric water vapor.

An atmometer or evaporimeter is a scientific instrument used for measuring the rate of water evaporation from a wet surface to the atmosphere.

Atmometers are mainly used by farmers and growers to measure evapotranspiration rates of crops at any field location.

ARG STATION


FTP
GPS
sms
CHARGE CONTROLLER
Datalogger
CSL8201
Cellcomm
NEMA ENCLOSURE

ARG SENSORS

SENSORS INSTALLED ON ARG SYSTEM

- Air temperature and Relative Humidity
- TBRG sensors - Rainfall Measurement

ASG STATION

- Automated Snow Weather Stations (ASWS) are weather stations that are installed and maintained to capture four main parameters:

1. Snow water equivalent (SWE),
2. Snow depth (SD),
3. Cumulative precipitation (PC)
4. Ambient temperature (TA).

Snow water equivalent, or the amount of water contained in the snowpack, is the most difficult of the parameters to measure and has traditionally been measured using snow pillows.

Snow pillows are three metre diameter polyurethane pillows, filled with anti-freeze and water, which measure the amount of water in the snowpack through the hydrostatic pressure of snow sitting on top of the pillow.

As snow accumulates on the pillow, the weight of the snow pushes an equal weight of the antifreeze-water solution from the pillow up into an open standpipe.

The distance the antifreeze is pushed up the standpipe relative to the zero value is equal to the SWE in the snowpack.

More recently, snow scales have been used to measure SWE.

Snow scales work essentially the same as a large bathroom scale and measure the weight of the snow directly which is then converted into a traditional SWE value.

Continue..

- **Snow depth** is measured using an acoustic distance sensor that usually sits 3 – 5 metres above the ground and measures the elapsed time between emission and return of an ultrasonic pulse to determine the distance to the snow. A simple calculation is performed from the summer zero value to then produce the current snow depth.

- **Cumulative precipitation** is measured using large diameter Precipitation gauges fitted with pressure transducers installed on the bottom of the pipe. The pressure transducer measures the pressure of the total amount of fluid in the pipe and converts it into a value of equivalent height of water. To prevent the contents of the precipitation gauge from freezing, precipitation gauges are drained and partially filled with a mixture of propylene glycol and ethanol in the summer and the spring.

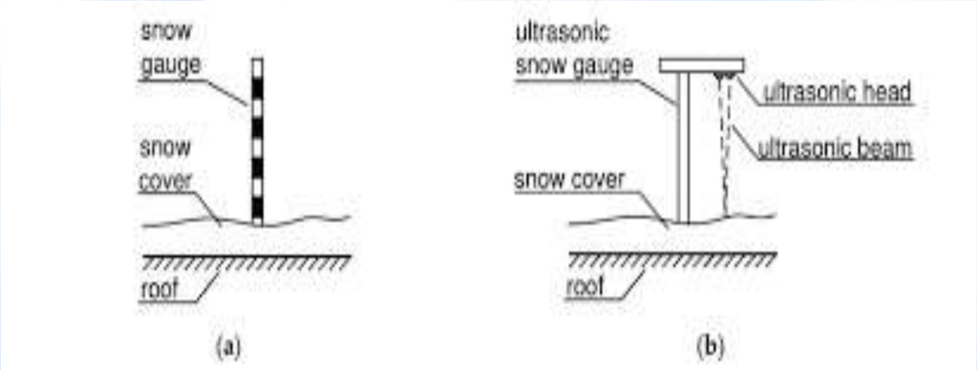
- **Ambient temperature** is recorded using a temperature probe housing inside a radiation shield and mounted away from any object which might affect accurately recording ambient air temperature, such trees or buildings. Sometimes these probes are also able to measure relative humidity.

ASG SENSORS

SENSORS INSTALLED ON ASG SYSTEM

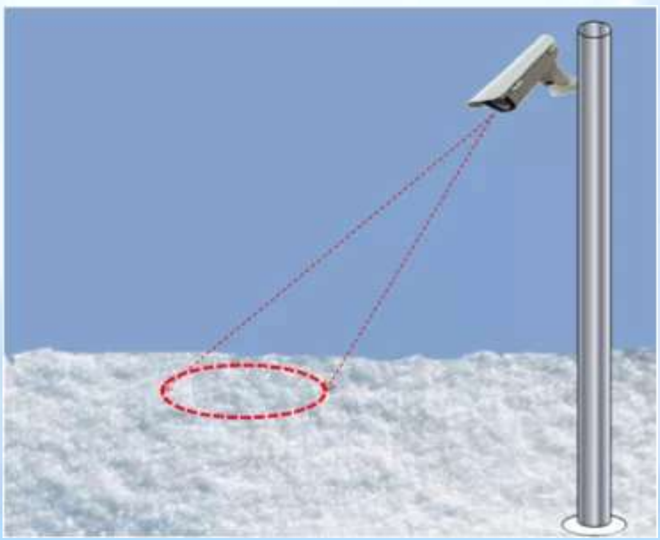
- **Air temperature and Relative Humidity**
- **SNOW sensors - SNOW Measurement**

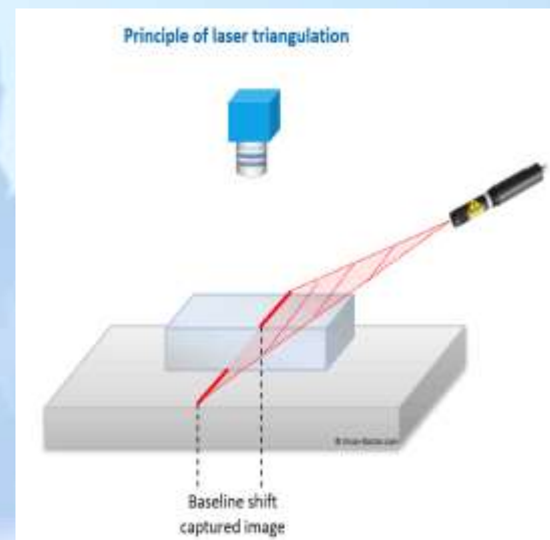
- The Snow Depth Sensor works by **measuring the time required for an ultrasonic pulse to travel to/from a target surface**. An integrated temperature probe with solar radiation shield, provides an air temperature measurement for properly compensating the distance measured by the Snow Depth Sensor.



Laser snow depth sensor

- The principle of the laser snow depth sensor is the optical triangulation method, and the semiconductor laser is focused on the measured object by the lens.
- The reflected light is collected by the lens and projected onto the CMOS array; the signal processor calculates the position of the light spot on the array through the trigonometric function to obtain the distance to the object.
- Optical triangulation methods based on a laser light sheet and digital camera are **used as a surface measurement technique in a wide range of applications**. They allow a fast and accurate determination of surface profiles, while consisting of relatively simple hardware and software configurations





Snow guage

Snowfall is measured either as the depth of snow which has fallen in a stated period, or melted and measured as water.

The depth of snow is usually measured in millimetres and its water equivalent in millimetres and tenths obtained by dividing the snow depth by 10, assuming the density of snow as 0.1.

This value is however, only a rough approximation and varies very much with the depth and texture of the snow.

For accurate measurement of precipitation at stations where snowfall is likely, special snowgauges are used.

Continue…

A snowgauge consists of a cylindrical receiver 203 mm or 127mm in diameter, mounted on an iron stand at such a height as to be well above the average snow level at the station and provided with wind shields. Unshielded gauges are quite unreliable in strong winds because their catch may either be increased by drifting snow or blown off by the wind eddies around the mouth of the gauges.

At the stations where the snow gauges are not available, the snow is measured with the ordinary raingauges if the snowfall is light. In heavy snowfalls, the depth of snow is measured with snow poles and the water equivalent of snow determined; or cut samples of snow taken, melted and measured as water in ordinary 127 mm measure glass.

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POWER SUPPLY

- The main power source for an automatic weather station depends on its usage.
- The purpose of power budget is **to ensure that enough power will reach the receiver to maintain reliable performance during the entire system lifetime**.
- Many stations with lower power equipment usually use **one or more solar panels connected in parallel with a regulator and one or more rechargeable batteries**.

- A solar-powered weather station is **a weather station powered by solar power from natural sunlight**.
- Battery
  - The battery must be maintenance free & it must be of such a capacity that the AWS station will run uninterrupted even in complete cloudy weather for at least 30 days. Solar Panel

CHALLENGES FOR MAINTENANCE OF THE AWS NETWORK

- **Accurate and reliable measurements from AWS are primarily possible with proper calibration of sensors and periodic maintenance schedules especially prior to the onset of monsoon.**
- **The tipping bucket rain gauge has an inherent limitation of missing of pulses during very heavy rainfall and may underestimate the actual rainfall recorded.**
- **Clogging of rain gauge due to leaves, twigs, fine mud deposits due to wind, bird droppings, may further lead to wrong readings.**
- **Regular upkeep of the AWS enclosure by clearing off the bushes and creepers is a must for reliable data.**
- **Theft of equipments like battery, solar panel and other components of an AWS leads to non-functional status of an AWS and hence loss of data.**

CHALLENGES FOR MAINTENANCE OF THE AWS NETWORK

- Awareness among the general public about the valuable nature of weather data in general, and of adverse weather in particular, is required
- Needs to be inculcated as part of the existing network management and in future implementation of the project of commissioning more AWS.
- Most developed countries having automatic weather stations in their network have realized these challenges and hence are not unique to Indian conditions.
- Efforts are being made to overcome the difficulties since modernization is inevitable in the changing technological scenario.

Thank you !