Performance of Agro Automatic Weather Stations in the Indian Subcontinent

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Abstract

India Meteorological Department has established a network of 125 state-of-art Automatic Weather Stations (AWS) during 2006-2007.First time, a network of 25 Nos. of Soil temperatures sensor and Sun shine duration sensor were installed at agriculture research institutions and 5 Nos. of soil moisture sensor installed at Anand, Dapoli, Pune, Rahuri and Rajgurunagar to analyse the data quality and can be used for agriculture related forecast. The performances of these sensors have been monitored during last two SW Monsoon periods (2007, 2008 and 2009) and found encouraging. From these analyses, it is found that to receive real time soil moisture observation from well distributed network of agromet observatory would be useful. These data would be utilized in water balance study for getting information on the soil moisture deficiency/excess water which would be utilized to obtain a overall picture of the soil moisture status over the country. For assessing the irrigation requirement of crop, real

time data of soil moisture, rainfall, soil temperature, sun shine duration, evaporation can be used for crop specific irrigation schedule.

The soil temperature sensor data have been compared with manually used thermometers soil temperature at agromet observatory, Pune. The performances of soil temperature sensor in expanded network of Automatic Weather Station are very encouraging since their installation**.** The sunshine duration sensor data have been compared with radiation observatory of Pyronammeter. The performances of sunshine duration sensor in expanded network of Automatic Weather Station are very encouraging since their installation .The comparison of soil moisture is not possible with manual gravimetric method as both principle of measurement and units of measurement are different. A Soil water content is mostly measured in the agromet observatory using gravimetric methods. A data analysis of gravimetric method and FDR method have been done using data of agrimet observatory,Pune.Though, automated soil moisture sensors are widely used in agronomy and environmental sciences. However, to sense properly the amount of water retained in the soil matrix, a calibration with gravimetrically observed values is required. This is laborious and not appropriate when the soil physical properties change during the wetting and drying cycles due to swelling and shrinkage, respectively. Weekly observed soil moisture data from one depth, and hourly data from one depth for FDR sensor in two adjacent plots subject to different tillage practices were used to validate the method.

On basis of 25 Agro AWS, performance, India Meteorological Department are under process of installation a network of 127 Agro AWS during 2009-2010 with additional sensors-leaf wetness and leaf temperature.

Key words: AWS

1. Introduction.

India Meteorological Department has established a network of 25 Agro AWS for testing purpose during 2006-2007.

The monsoon dependent agriculture has greater seasonal rainfall variability, uncertainty and recurrent drought. If farmers are provided with weather information on real time basis without time lag there is possibility for risk management. This can be accomplished only by good network of observatories to the domain level of blocks with fast communication facilities. Installation of Agro Automatic Weather Station is the cheaper and best way of getting real-time weather data, which will help the scientists to develop location specific forecast for farm management decisions. This will enable local farmers to move from low productivity risk-aversion orientation approach to a tactical 'response' approach that optimizes production potential towards sustainability while also reducing their vulnerability to climate extremes.

2. Agro Automatic Weather Station

An Agro Automatic weather station (AWS) is defined as a "meteorological station at which observations are made and transmitted automatically. The sensors interfaced with the system measure data for meteorological parameters Air Temperature, Relative Humidity, Atmospheric Pressure, Rainfall, Wind Speed and Wind Direction. Apart from these parameters, at few selected stations; additional sensors for Global Solar Radiation, Soil Temperature and Soil Moisture are also interfaced.

a) Soil Moisture sensor

The Stevens Hydra Probe is used for soil moisture and soil temperature measurement at five stations viz. Anand, Rahuri, Dapoli, Pune and Rajgurunagar. The sensor determines soil moisture by making a high frequency (50 MHz) complex dielectric constant measurement. A complex dielectric constant measurement resolves simultaneously the capacitive and conductive parts of a soil's electrical and conductive response. The capacitive part of response is indicative of soil moisture. Soil temperature is also determined using a calibrated thermistor incorporated into the probe head.

b) **<u>Solar Radiation sensor</u>**:

LICOR make silicon photodiode type pyranometer (LI-200SZ) is used in the network for measurement of global solar radiation. It is a rugged and low cost sensor. However, the spectral response of the sensor is not uniform over entire solar radiation usually taken to be 0.3-4.0 µm. The sensor is useful to the extent that it is used for measurement of solar radiation and not under conditions of altered spectral distibution. The sensor is calibrated against an Eppley Precision Spectral Pyranometer (PSP). The uncertainty of calibration relative to Eppley standard is specified to be 5%. The pyranometer is mounted at a height of 2 m on a shaft away from 10 m tower to minimize the effect of reflection.

c) <u>Soil Temperature sensor</u>

Campbell Scientific model 107 temperature probe is used for soil tempeature measurement at a depth of 20 cm. This is a thermistor designed to be buried in soil or submerged in water. The probe accuracy is a combination of thermistor's interchangeability specification, the precision of the bridge resistors and the polynomial error. In a worst case, all errors add to an accuracy of ± 0.4 ˚C over the range -24˚C to +48 ˚C.

3. Soil Moisture

- Soil water is essential for plant growth and is the vehicle for solute transport, including nutrients and soil contaminants.
- Accurate measurement of soil water is crucial for the better management of irrigation water and rainfall capture.
- Crop yields are generally more closely related to soil water availability than to any other soil and meteorological variable.
- Soil water is a highly dynamic entity, exhibiting substantial variation in both time and space.

- Continuous monitoring of soil water content can be a valuable part of agricultural.
- Power supply is the most important consideration when selecting an automated system for measuring soil water content.

a) Classical Methods used for Soil Water Content Measurement and its disadvantages

- The gravimetric method is a direct, absolute technique for estimating the total (both plant-available and plant-unavailable) water content of soils. The method involves drying a soil sample in an oven (105^0 C for 24 hours) to determine the soil moisture content.
- Water content (grams of water per grams of soil) equals the initial field soil weight minus the oven-dry weight.
- The best method is to take a soil sample of known volume (usually 60 cubic cm) so that the soil moisture content can be expressed in terms of percent water by volume or inches of water per foot of soil.

But its <u>main disadvantages</u> is

- This technique is time-consuming, labor-intensive, and difficult in rocky soils.
- A lab oven or microwave oven, soil sampling equipment, and lab scale are required.

b) New Techniques used for Soil Water Content Measurement and its Advantages
(Di-electric constant soil moisture probe method (TDR and FDR))

- TDR (Time Domain Reflectometers) and FDR (Capacitance) probes or sensors both measure the difference in capacity of a non-conductor (soil) to transmit high-frequency electromagnetic waves or pulses, which is related through calibration to soil moisture content.

- The difference is that the TDR measures the time it takes for an electromagnetic wave to travel through the soil between the probes. The FDR uses radio frequency waves to measure soil capacitance.

c) Soil Moisture sensor used in Agro AWS

- The soil moisture sensor used at all Agro AWS is Steven Hydro Probe and kept at depth of 20 cm and is shown in Fig 1.
- The Hydra soil moisture probe determines soil moisture and salinity by making a high frequency (50 MHz) complex dielectric constant measurement.
- The capacitive part of the response is most indicative of soil moisture while the conductive part reflects predominantly soil salinity.
- The unit of water fraction by volume (wfv) was chosen for the Hydra probe soil moisture sensor.
- For example a water content of 0.20 wfv means that a one liter soil sample contains 200 ml of water. Full saturation (all the soil pore spaces filled with water) occurs typically between 0.3-0.45 wfv and is quite soil dependent.
  The comparison of soil moisture is not possible with manual gravimetric method as both principle of measurement and units of measurement are different.

Figure .1

- The Soil moisture data of Agro AWS at Pune has been analyzed for Year 2007 and its graph is shown below in fig 2.

➢ Soil Moisture sensor is kept at 20 cm depth.

➢ Graphical presentation of Soil Moisture for year 2007.

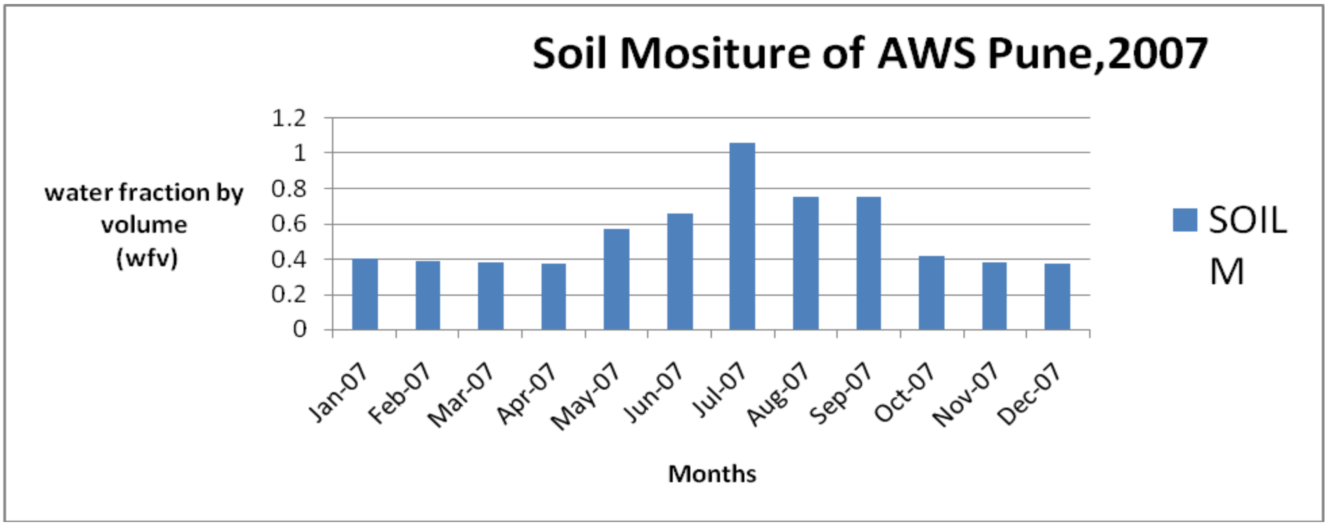

Figure-2

- During SW Monsoon period, one month (June 2007) soil moisture have been analyzed and its graphs have been shown in Figure-3.

➢ Soil Moisture sensor is kept at 20 cm depth.

➢ Variation of soil moisture value with rainfall.

➢ It has been observed from bar graph (June 2007)

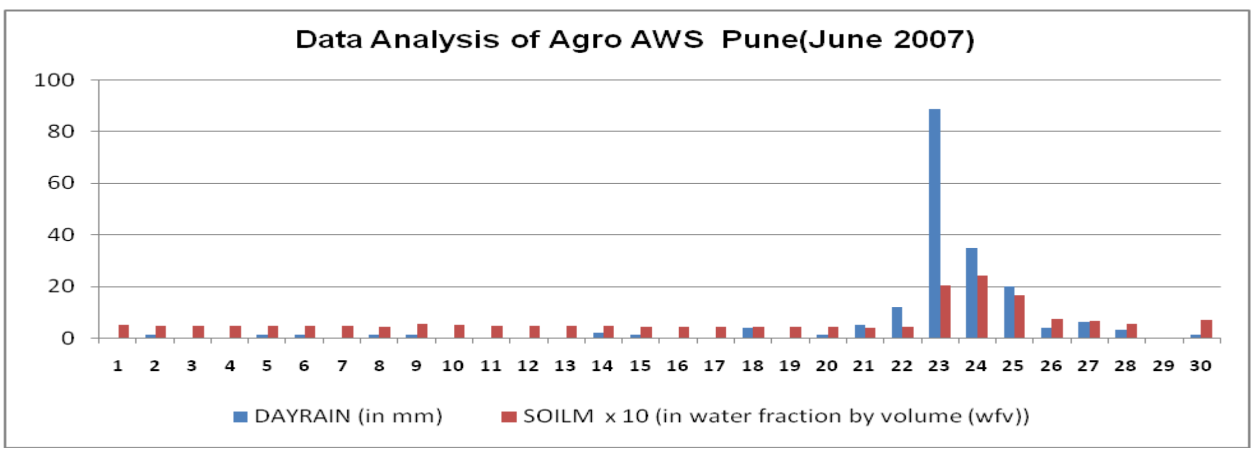

Figure -3

4. Global Radiation sensor used in AWS

- A pyranometer is an instrument for measuring solar radiation received from a whole hemisphere.
- It is suitable for measuring global sun plus sky radiation. Solar radiation varies significantly among regions.
- Season and time of day are major considerations, but surrounding terrain elevation, man-made obstructions, and surrounding trees can also cause large variations in locations of a small area.
- Often, the most required measurement is the energy flux density of both direct beam and diffuse sky radiation passing through a horizontal plane of known unit area (i.e. global sun plus sky radiation).
- It is generally used as sunshine duration for Agro AWS.The sensor used in Agro AWS is shown in Figure-4.

Global Radiation sensor used in AWS

Figure -4

- **Data for a day have been taken from Pune Agro-AWS and graph have been drawn to analyze the sunshine duration and its graph is shown in Figure-5.**

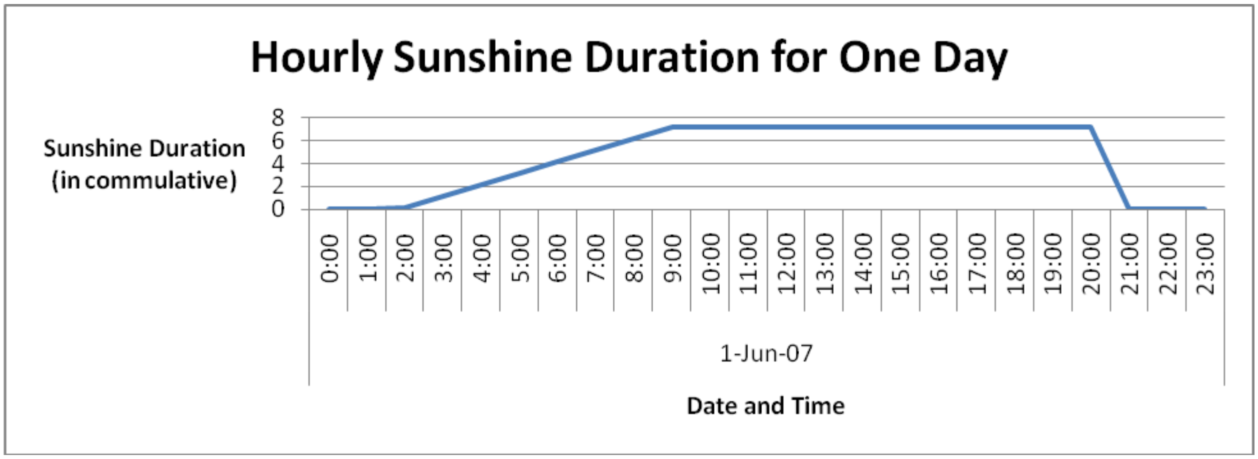

Figure-5

5. Soil Temperature sensor

The sensor used in the Agro-AWS network is Model 107 temperature probe to measure soil temperature and its make is Campbell Scientific.
This sensor has been installed at 25 places all over India during 2006-2007 for testing purpose. Its performance is satisfactorily but still more work has to be done.

Figure-6

- Data of Agro AWS Pune have been analyzed for single day and less variation have been observed so much for a single day.

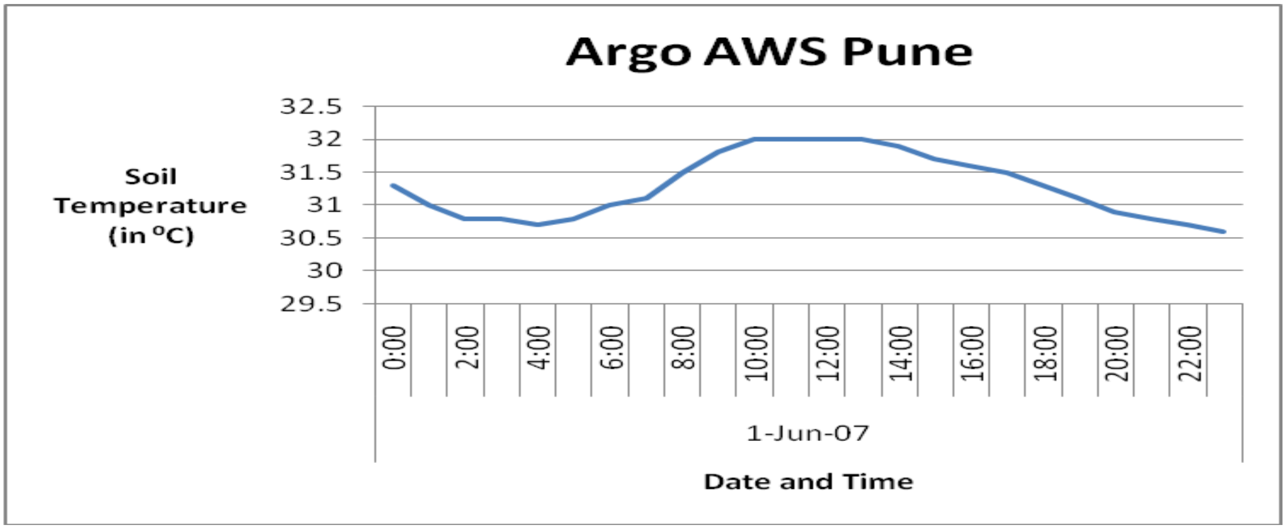

Figure-7

- **Data of Agro AWS,Pune for one week have been analyzed but soil temperature do not have more variation and its graph have been drawn and shown in Figure-8**

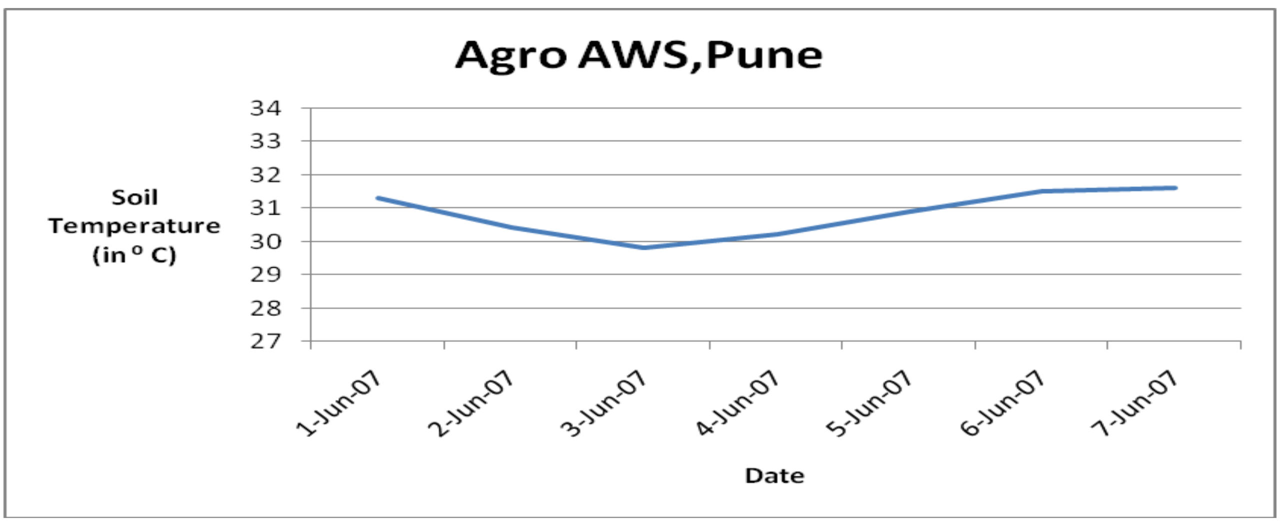

Figure-8

6. Conclusion

- The dependability on Agro-AWS has increased considerably and the capabilities of Agro-AWS will aid as an **additional and reliable tool** for agro related weather forecasters.
- The comparison of soil moisture is not possible with manual gravimetric method as both principle of measurement and units of measurement are different.
- As part of the modernization programme of IMD, 550 AWS (including 127 Agro-AWS in all AMFUs) 1350 Automatic rain gauge stations are to be procured in the first phase.
- Leaf temperature and leaf wetness measurement is also possible in 127 Agro-AWS.
- Possibility of a **dense observational network** enabling hourly availability of data from remote and inaccessible terrains to aid better forecasting of weather.

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