Quality control methodology for temperature data of Automatic Weather Stations with non-wooden radiation shield

by

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Abstract

Department of Meteorology (DoM) Sri Lanka is one of the oldest meteorological institutes in Asia uses conventional meteorological instruments for measurement since its inception. Three hourly measurements are taken manually with these instruments. Having more frequent measurements using automated instruments was an immense need. A project comprising thirty eight (38) Automatic Weather Stations (AWS) was initiated under a project funded by Japan International Corporation Agency (JICA) during 2007-2009. Temperature and humidity sensors are placed in metallic radiation shield. The measurement of air temperature is made with Platinum sensor (Pt 100) which is highly accurate and quality sensor. These sensors are set inside the metallic shield to protect the sensor from direct radiation, dust, rain and other environmental phenomenon.

The conventional manned surface observation stations of DoM are the backbone of the country's forecasting network. Air temperature is measured with a mercury thermometer housed in a wooden Stevenson screen. It has been observed from the initial validation of data of AWS which noted deviations in measurement of temperature in some sites specially during 03 UTC (0830 SLST) and less in other synoptic hours. A study is carried out to analyze the variations in one year data in climatologically different locations, Colombo and Katugastota. Inter-comparison of temperature data measured in wooden Stevenson screen and metallic radiation shield was made. Effect of wind, rainfall and solar radiation on air temperature measurements has also been analyzed for both stations. Mathematical correction factors will be developed for all synoptic hours as correction to the AWS temperature measurements.

Key words: automatic weather station, platinum sensor

1. Introduction

Department of Meteorology (DoM) Sri Lanka is one of the oldest meteorological institutes in Asia uses conventional meteorological instruments for measurement since its inception. Three hourly measurements are taken manually with these instruments. Having more frequent measurements using automated instruments was an immense need. A project comprising thirty eight (38) Automatic Weather Stations (AWS) was initiated under a project funded by Japan International Corporation Agency (JICA) during 2007-2009. Temperature and humidity sensors are placed in metallic radiation shield. The measurement of air temperature is made with Platinum sensor (Pt 100) which is highly accurate and also a sensor with high quality.

Conventional air temperature measurement is done with mercury thermometer. Mercury thermometer is housed in a wooden Stevenson screen (Fig. 1) where as Pt 100 temperature sensor (Fig. 2) is normally housed in a metallic shield. Inter comparison of AWS and manual data has been done soon after the commissioning of AWS network in the country. In this particular case study, two meteorological stations were selected namely Colombo and Katugastota, Kandy to investigate the behavior of two temperature devices.

Fig. 1 Wooden Stevenson screen

Fig. 2 Pt-100 Temperature sensor

2. Placement of meteorological sensors

AWS sensors are located in the same meteorological enclosure area in both stations. Solar panels used to power up AWS are also located in the same area (Fig.3).

2.1 Conventional meteorological instruments

All conventional meteorological instruments are placed in a meteorological enclosure. Both Colombo and Katugastota meteorological stations are arranged in accordance with WMO-8 standards. Mercury thermometer is placed in a wooden Stevenson screen.

2.2 Automatic Weather Station

An automatic weather station (AWS) is defined as a meteorological station at which observations are made and transmitted automatically according to the World Meteorological Organization (WMO). At an AWS, sensor measurements are read out or received by a data logger. The collected data from sensor devices can be processed locally at the AWS. Automatic weather stations may be designed as an integrated concept of various measuring devices in combination with the data acquisition and processing unit. The main objective of the usage of AWS is for increasing the number and reliability of surface observations.

Six (6) different meteorological sensors are used in each station. Wind sensor and solar radiation sensors are placed at 10m height mast. Temperature and humidity sensors are placed in metallic radiation shield attached to the mast at 2 m height. Pressure sensor is placed inside the data logger which is at 0.9 m height. Tipping bucket rain gauge is placed about 7 m away from the mast at 0.5 m height. AWS and manual meteorological instruments are located in the same site (Fig. 4).

Fig. 3 Solar panels of AWS

Fig. 4 AWS and manual instruments

2.3 Advantages and disadvantages of AWS

Main advantages and disadvantages of AWS are summarized in Table 1.

Table 1

Advantages	Disadvantages
AWS provide data at a significantly greater frequency (some provide data every minute).	Some elements are difficult to automate (e.g. cloud cover).
It is unmanned.	Some observation process is very difficult to get accurate data such as amount of precipitation.
Can be established in sites which are difficult to access and are harsh. So it can be increased density of an existing network.	AWS are less flexible than human observers.
Observation data can be easily acquired and collected at the central data processor. Climatological evaluations can be made automatically.	Provide security for the AWS site.
AWS provide data in all weather, day and night, 365 days per year.	AWS require a large capital investment.
AWS can be installed in sparsely populated areas.	
Reduce operational or running cost.	

Despite some disadvantages noted on AWS, its characteristics help to automate meteorological data in greater frequency. Country like Sri Lanka, is still in the period of transition from manual observation to automated system. It is extremely difficult to convince the accuracy of meteorological data obtained from the exiting AWS network as compared with manual observations.

3. Characteristics of meteorological instruments

Properties of instruments must be understood when considering their uncertainty. Among many properties of meteorological instruments or sensors, the following are significant.

a. Sensitivity
   It is the change in the response of a measuring instrument divided by the corresponding change in the stimulus.
b. Resolution
   A quantitative expression of the ability of an indicating device to distinguish meaningfully between closely adjacent values of the quantity indicated. It is the smallest change the device can detect (this is not the same as the accuracy of the device).
c. Hysteresis
   It is the property of a measuring instrument whereby its response to a given stimulus depends on the sequence of preceding stimuli.
d. Drift
   It is the slow variation with time of a metrological characteristic of a measuring instrument.
e. Response time
   It is the time interval between the instant when a stimulus is subjected to a specified abrupt change and the instant when the response reaches and remains within specified limits around its final steady value. Normally defined as the time the sensor takes to measure 63% of the change.

Response time can be calculated as;

$$y = A\ (1-e^{-t/\tau}) \qquad (1)$$

where y is the change after elapsed time t; A is the amplitude of the step change applied; t is the elapsed time from the step change; and τ is a characteristic variable of the system having the dimension of time.

4. Methodology

Temperature data from 3rd December 2009 to 6th December 2009 between manual thermometer and AWS sensor has been compared. Fig. 5 shows shift of temperature for 3 days in Colombo and Fig. 6 shows temperature behavior of two devices at Katugastota.

Pt-100 temperature sensor is placed in metallic radiation shield which is attached to the AWS mast. Conventional mercury thermometer is placed in wooden Stevenson chamber. Manual observation which is taken at every synoptic hour is compared with the correspondent temperature value obtained at the same time.

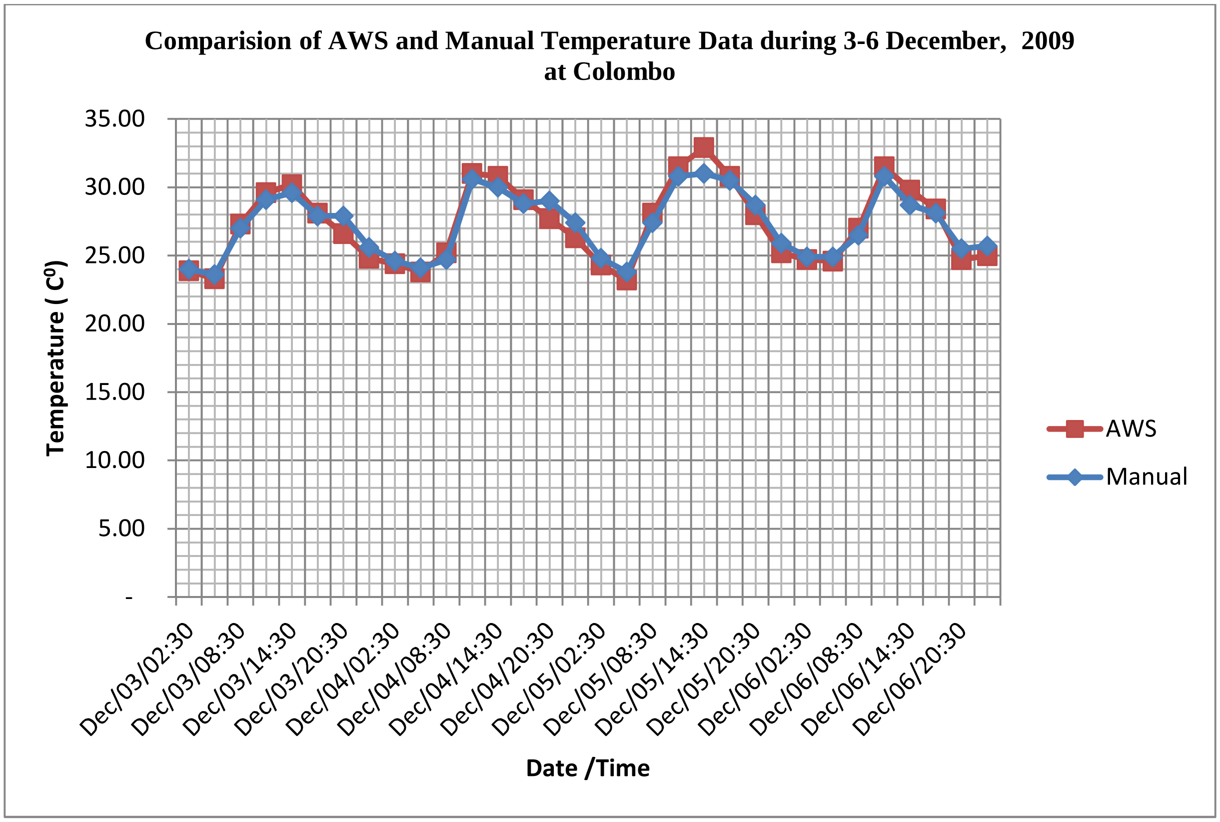

Fig. 5 Comparison of AWS and manual temperature data at Colombo

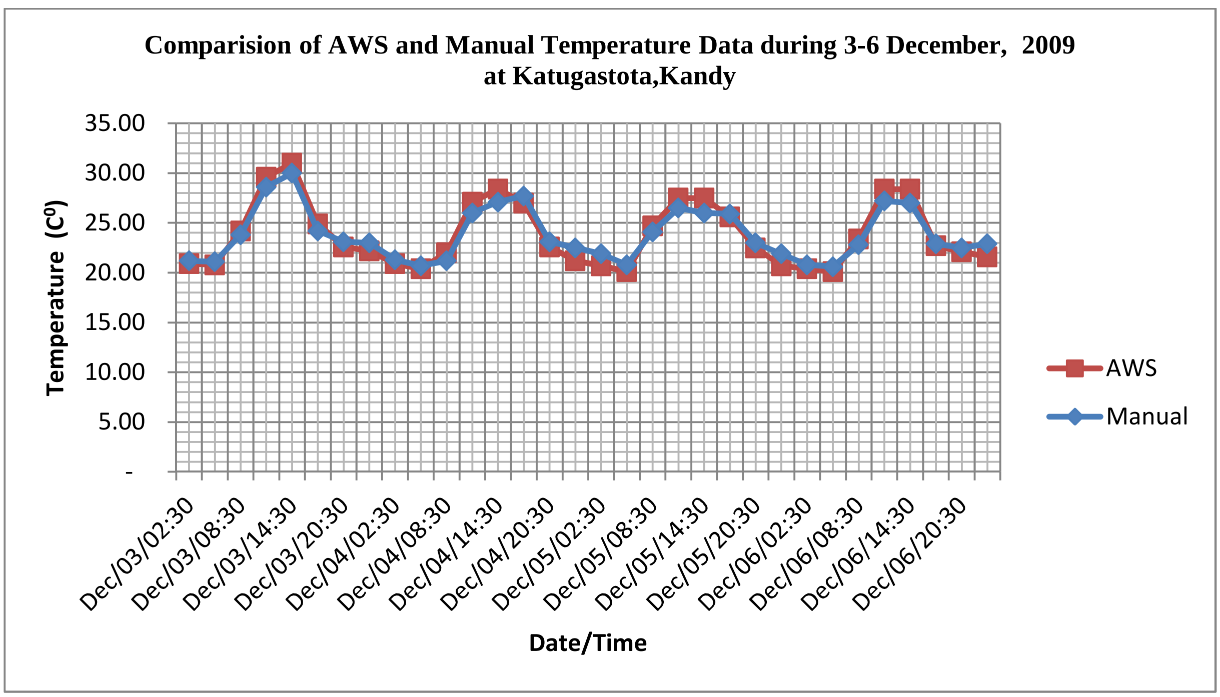

Fig. 6 Comparison of AWS and manual temperature data at Katugastota

5. Conclusions

In day time (7AM to 16PM), temperature of AWS is higher. In night time (16PM to 7AM), data obtained from the conventional thermometer is higher. The difference is existing in night time with less influence for solar radiation. This difference is due to response time for sensor device and/or heat capacity for radiation shield and Stevenson screen. It is noted that metallic radiation shield absorb solar energy during the day time and remained inside more time than the wooden screen. This may lead Pt-100 temperature sensor to response fast as compared with the mercury thermometer which is in the wooden screen. During the night time, metallic shield get cooled more faster than the wooden screen, therefore, AWS reading is bit lower than the thermometer. Nevertheless, overall behavior of both devices is almost equal.

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