

MOROCCAN APPROACH PROVIDING MODERN ALTERNATIVES TO REPLACE DANGEROUS AND OBSOLETE METEOROLOGICAL INSTRUMENTS

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ABSTRACT

Since 2008, the National Meteorological Service of Morocco has initiated a project aiming to modernize the national observing meteorological network and in particular it's two components: surface and upper air stations.

Due to a national law entered into force in 2011, the use, import or export of mercury thermometers is forbidden. As a consequence, the NMS of Morocco has introduced progressively some modern alternatives in order to withdraw mercury based instruments and to replace obsolete instruments such as traditional autographic recorders. Thus, new automatic alternatives were experienced and tested and applied as backup of the automatic weather stations implemented in all synoptic stations.

The benefit of the use of these alternative solutions was obtained in terms of real time data collection and access, data archive and also in terms of cost.

For example, the NMS of Morocco has introduced, as an alternative of autographic self-recording rain gauges (SRRGs) such as Udographs, automatic self recording tipping bucket rain gages associated to internal or external dedicated dataloggers that are functioning with internal alkaline batteries. This alternative solution is allowing the same functions: determining rain episode duration (starting and ending time) and also the computation of rainfall quantity and intensity but had the advantage that all these data are recorded in electronic files that could be easily exported to Excel datasheet.

The new equipment is functioning with alkaline batteries for a long time and could be used either for delayed time data access using laptop in very distant or isolated sites or for real time measurement if the equipment is directly connected to the computer of the meteorological station using RS232 connection for short distance. In terms of cost, the price of this automatic self-recording rain gauge is at least 50% cheaper than the traditional autographic tipping bucket rain recorder.

Other examples are presented in the paper and concerning modern alternatives to replace dangerous and obsolete instruments in common use in the most observing networks of developing countries.

Lessons learned from the Moroccan experience could be useful for other members of AR I and in particular those countries that have already signed the Minamata convention on mercury.

INTRODUCTION

Taking into accounts recent reports on the use of obsolete and hazardous meteorological instruments, it was noted that most of developing countries have either withdrawn mercury instruments or are commencing or planning to do so. The easiest way for this purpose is to implement an automatic weather station (AWS) which guarantees an integrated solution for the replacement, at once, of all mercury and obsolete instruments in the station. However, it must be ensured that all

parameters hitherto measured by conventional instruments are obtained from automated equipments as well.

The use of solar panels and rechargeable batteries constitute an alternative to overcome problems linked to the non-existence of reliable and secure electric power in many places in the world. Most of the NMHSs still resist the switch-over, mainly because they are unable to ensure the necessary associated measures (regular maintenance, calibration, training, spare-parts etc.). The major point, in this case, is the fear that once the automatic weather system is out of service for any possible reason, it will take much time to be repaired and there will be no alternative to make observations at the station.

The second and fundamental reason is related to the cost of the automatic devices which is considered much more expensive (acquisition and exploitation) compared to the traditional instruments.

The third reason is related to the belief that some mercury based instruments and in particular, the mercury barometer is more reliable seeing their long term stability but forgetting that this metrological characteristic is only one component among others allowing the computation of the global uncertainty of the instrument.

The Minamata convention entered into force in 2013 offers the political framework to plan a project at the national level to replace mercury and obsolete instruments in the surface observing network before the deadline of 2020 from which production, import and export of instruments containing mercury for meteorological purposes would be banned. Meanwhile, manufacturers are requested to invent new generations of Automated Weather Observing Systems (AWOS) integrating new technologies in the design of sensors, data collection and telecommunication devices.

In this part of this report, some automated alternatives to mercury based and obsolete instruments that have been successfully experienced in a developing country such as Morocco have been introduced. In this country, automatic weather stations were implemented in all synoptic stations of the national surface observing network. The alternatives presented below were introduced as back-up solution in the station functioning in parallel to the existing AWS. The benefit of the use of these alternative solutions was obtained in terms of real time data collection and access, data archive and also in terms of cost.

1. Alternatives of Udographs

An alternative of the autographic self-recording rain gauge (SRRG) such as the udograph is the use of an automatic self recording tipping bucket rain gauge associated to an internal or external dedicated data logger that functions with internal alkaline batteries.

This alternative solution allows the same functions: definition of rain episode duration (starting hour and ending hour) and the computation of rainfall quantity and intensity. The advantage of the suggested alternative is that all those data are automatically generated and recorded in electronic files that could be easily exported to Excel datasheet.

The new automatic self-recording rain gauge includes: the tipping bucket mechanism, an internal data logger functioning with alkaline batteries, special internal battery for time, internal memory and RS232 port. The equipment has the following characteristics:

- functions with alkaline batteries for a long time,
- is used in very distant or isolated sites for delayed time data access using laptop,

- could be also used for real time measurement if the equipment is directly connected to the computer of the meteorological station using RS232 connection for short distance or using RS232/RS485 convertor for a long distance,
- data archive includes: date and time, beginning and end of rain episode and also intensity if requested.

Many manufacturers provide such equipment and in terms of cost, the price of this automatic SRRG, as reported by the Moroccan NMHS experiencing these alternatives, is at least 50% cheaper than the traditional autographic tipping bucket rain recorder.

Few other manufacturers provide the same equipment but offer solar panel and rechargeable battery for long time use and wireless telecommunication for distant and isolated sites.

2. Alternatives to measure atmospheric pressure

As an alternative of the mercury barometers, aneroid barometers and barographs, it is possible to use first class digital barometers with one, two or three internal and independent sensors and if needed with LCD screen for direct display of the barometric pressure.

The benefit of the digital barometer is that data are directly read and also archived in the internal memory of the instrument. Very simple software could be developed internally or provided by the manufacturer to either have access to real time data or archived data and to compute derived parameters such as QNH, QFE and tendency etc. These derived parameters could also be read directly on the display of the instrument.

This alternative solution is easily calibrated using automatic pressure generators or by direct comparison to a pressure standard. The power supply could be provided from the power electric source of the station or from rechargeable battery connected to solar panel.

Based on the Moroccan experience, the cost of the acquired digital barometer including two internal independent sensors and screen display is three times cheaper than the cost of the mercury barometer. Moreover, the readings are easier to note down and more accurate (meaning that the associated uncertainty is lower) than mercury barometers, including the fact that there is no need of thermal and gravity corrections and that the instrumental correction is generally also included.

3. Alternatives for measuring temperature and humidity

For the measurement of air temperature and humidity, the conventional instruments consist of a set including:

Psychrometer, thermograph, hair hygograph and mercury thermometer for the measurement of the maximum temperature of the day and alcohol thermometer for the measurement of the minimum temperature of the day.

The digital reading system taking measurements from an integrated temperature/humidity sensor is an appropriate alternative solution for all these traditional instruments. The digital system functions with alkaline batteries and displays the measurements on an LCD screen interfaced with the system.

Two types of this equipment were experienced by the Moroccan meteorological service. The first one is a data logger with internal memory allowing data archive and RS232 port for data transfer to laptop. Dedicated software provided by the manufacturer allows the real time readings and also the access to archived data in the internal memory of the data logger. The minimum and maximum

temperature of the day could be extracted from the daily record (each 30 second measurement). The system (sensor and data logger) is functioning with alkaline batteries but could also function using local electric power supply or by using rechargeable battery connected to solar panel. The second type is a simple reading unit with a screen for real time data display.

The inconvenience in these kinds of equipments is that the alkaline batteries allow a continuous use of the instrument only for a few (three or four) days. 72 hours is the duration of use for the second type as reported in the manufacturer datasheet.

4. Measurement of soil temperature

As a replacement of the traditional mercury thermometers used for the measurement of soil temperature (at -5cm, -10cm, -20cm, -50cm and -100cm in the ground), a dedicated data logger can be used allowing, in the same time, the acquisition and the processing of data coming from a combined probe measuring air temperature and humidity and several soil temperature Pt100 sensors. The same data logger, related to the first solution presented above, can be used adding a specific accessory to connect four Pt100 temperature sensors. The measured data is recorded by the same data logger and displayed on the screen for direct reading or accessible through laptop.

Data can be accessed in real time mode using a computer in the station connected to the data logger using a suitable wire and RS232 connection. Based on the experience of the NMHS of Morocco, it is observed that the cost of this alternative is cheaper than the combined total cost of a thermograph, hair hygrometer, psychrometer and soil mercury thermometers.

5. Alternatives to measure wind

The alternative solution to replace the anemograph or the autographic systems for the measurement of wind velocity and direction is the use of appropriate data logger and dedicated software for the visualization and archiving of winds measurements. As an example, the experience of the NMHS of Morocco is presented here. For the measurement of surface wind, the NMHS of Morocco uses a traditional wind autographic recorder using specific autographic chart (Fig. 1.). Each year, the cost of the needed annual quantity of these autographic charts for the entire network is prohibitively expensive. The spare parts of this system were also too costly and sometimes hard to pick up



Fig. 1. Wind mast and data logger

So the NMHS of Morocco acquired a new automatic equipment for wind measurements (Fig.2) as backup for the measurements made by the AWOS in airports. The solution includes: Solar panel, mast, ultrasonic wind sensor and data logger, display screens for both the air traffic control tower (ATC TWR) in the airport and the meteorological station, wireless connection (radio, wi-fi) between the sensor (near to the runway) and the air traffic control tower (TWR) and finally the dedicated software (2 minutes wind average, gust, archiving...etc).

The total price of the project of the acquirement of new automatic backup solution for wind measurement was cheaper than the cost of renewing the existing autographic equipment.



Fig. 2. Wind measurement and display in airports

6. Combined alternative solutions

Many manufacturers offer combined alternative solutions that have the advantage of including only one data logger connected to various sensors. Meteo-France have experienced a dedicated automatic solution for the replacement of the voluntary surface observing network that include, at each station, a rain gauge and daily extreme temperature devices. The benefit of this solution is that the automatic alternative is providing at the display screen the daily quantity of rainfall and daily extreme temperature. Other telecommunication devices could be added for distant and centralized data collection.

Many manufacturers offer small AWS at reasonable prices for the measurement of temperature, humidity and rainfall quantities. The cost factor of the instruments, reliability, accuracy and seamless availability of spare-parts need to be ascertained / compared before operationally adopting such AWS.

The use of PTU (combined pressure, temperature and humidity sensor) instrument could be also an alternative for measuring atmospheric pressure and air temperature and humidity. In this case, the digital barometer serves as a data logger also collecting data from the combined temperature and humidity sensor as well, which needs to be kept in a screen shield to avoid direct exposure of the sensor to sunlight.