Overarching Automated Weather Station (AWS) Issues

Van der Meulen, Jitze P.
Royal Netherlands Meteorological Institute (KNMI),
De Bilt, the Netherlands
meulenvd@knmi.nl

Abstract

Automatic Weather Stations (AWS) have become the major components of the surface based in-situ observation systems. We see a significant grow in automated observing systems transmitting data in real time. For more than three decades a transition is recognized were the manned weather stations, managed by the meteorological services are replaced by AWS. This transition, together with new weather related observing systems, like on satellites and data services by third parties is a complex process underestimated by many weather services. In this paper a historic overview is presented on the introduction of AWS. It is explained that this introduction can only be successful if it is well prepared and based on well determined management and maintenance strategies. These strategies shall be based on a national approach to have a redundant composite observing system for which all available data sources are regarded and integrated.

1. INTRODUCTION

Automatic measuring instruments, developed to provide weather information from remote areas are introduced more than a century ago. Using analog signals transported over long distant wires or by using telegraph facilities, observational data was received in real time and informed forecasters about significant changes in the weather to be expected within a couple of hours. Further developments in digital communications and improved automatic equipment provided the opportunity to install measuring systems reporting a set of variables useful for weather forecast and climate. The opportunity to install automatic weather stations in addition to manned stations was well recognized long ago and in 1966 a two-week Technical Conference on Automatic Weather Stations was convened by WMO in Geneva[1]. It is interesting to notice that at that time (half a century ago) communications were by telex and most of the instruments had analog output only, so performance, communication and electric standards were the focal issues. In those days the advantage of an AWS was mainly to have extra observation reports from remote areas, relevant for weather forecasting but located on unpopulated spots.

The last 30 years we see a strategic change and trend with a focus on cost reduction, but also with the advantage to design new networks based on AWS to be located at more appropriate and better distributed sites. The introduction of such new and more effective networks will cause manned stations to disappear or abolish, a huge challenge for future climate research. A great advantage is the flexibility of AWS based networks to rearrange locations by moving AWS to more appropriate sites, *e.g.* due to urbanization or natural developments.

[1] WMO, 1966: Meteorological Observations from Automatic Weather Stations. World Weather Watch Planning Report No. 10 (WMO, Geneva).

Although an Automatic Weather Station must be regarded as a traditional weather observing station, at present we see a significant trend in all kinds of reported observational data, generated by an increasing variety of systems and sensors. Note that a weather station is well defined by WMO in the Manual of the GOS (WMO-No. 544). How to site and install an AWS is well described in the CIMO Guide (WMO-No. 8) and the Guide to the GOS (WMO-No. 488) and the many guidance reports published by CIMO (IOM reports). However the installation of weather observing systems (*e.g.* instruments sited on a single pole or just a simple all-in-one box) becomes more and more popular and used in practice. Although these type of systems suffer from large, unknown measurement uncertainties, the systems are frequently called AWS and used in meteorological applications, appreciated by the users. So, not only the introduction of automated systems replacing manned observations and measurements, new techniques delivering weather related data, not typically designed for observing the weather will influence the present practices in exchanging weather data.

2. CHANGING PERFORMANCES CAUSED BY AUTOMATION

Manned Weather Stations can be characterized by two categories of observations: instrument read-out and direct visual observations. The observer has the leading role and the instruments should be considered as a tool (*e.g.* a liquid in glass thermometer). For instrument measurements modern electronics has made it possible to develop measurement technologies with digital processing and communication to measure and transmit observational data fully automatically (*e.g.* digital thermometer transmitters) without the interference of an observer. Such a practice is more effective and efficient. Moreover the process can be standardized improving the objectivity and consistency of the data. Visual observations however are hard to automate providing unchanged performances. To investigate the challenges CIMO organized two expert team meetings end of the '90s last century. Most discussed items were related with the findings of the present weather intercomparison carried out before. The second meeting in 1999 was organized in collaboration with CBS and attended by experts from many Technical Commission (see photo, published in WMO Bulletin 48(3)).

De Bilt, Netherlands, April 1999 — The participants in the Automatic Weather Stations Expert meeting behind bars, pending successful completion of the session!

Photo: K. Schulze

This meeting also focused on the development of functional specifications for AWS and stated clearly that automated visual or present weather observations should be reported as quantities, *i.e.* objective data rather than in terms of the traditional qualitative, subjective formats (like 'heavy precipitation'). To implement this, appropriate BUFR templates should be developed replacing the old fashioned Traditional Alphanumerical Code (like with w_aw_a). Also, to improve further documentation on user requirements and functional specifications (a task for CBS) an expert team on AWS (ET-AWS) was established later-on by CBS, which produced many recommendations adopted by CBS and published in the Guide to the GOS. During the same period (1995-2004) four conferences were organized on experiences with AWS (ICEAWS), to exchange experiences and advices by the users, who had implemented AWS[2].

A serious bottleneck is that it is not possible to automate all types of visual observations. So a 100% transition is impossible. Also, modern optoelectronics still suffer from many false interpretations and many corrective tricks in software applications must be used to get an acceptable skill score. Moreover such a skill score is hard to define in terms of objective accuracy requirements (*e.g.* for the detection of under cooled precipitation or cloud coverage). On the other hand, many alternative non *in situ* based technologies are available today. We have satellite based observations and other surface based remote sensing techniques (*e.g.* weather radar, wind profilers). These technologies make it possible to fill in the gap aroused after implementing further automation. The solution here is to find the best practices in how to integrate all these types of observation technologies and to design a composite observing network to guarantee sufficient redundancy[3].

3. PRINCIPLES IN AWS NETWORK DESIGN

In the past manned weather stations were the only source of short term weather information. Typically *in situ* observations (at surface level or in the upper air) were the backbone of all meteorological methods of observation. Therefore the classical set of variables to be observed and reported were logically the traditional thermodynamic and aeronautic quantities (nowadays also referred as essential climate variables). So, the functional specifications were a logical consequence of this approach, resulting in a data chain visualized by:

As shown, the user was just a user, not participating in defining the observing systems, which was entrusted to instrument developers, mainly at the NMHS.

As explained, the number of sources and technologies providing observational related data today is a multiple of the number of sources in the historical set provided by a weather station network. Much data is provided by satellite related agencies and third parties (*e.g.* AMDAR). Moreover, sensors on board transport systems (*e.g.* temperature sensors on

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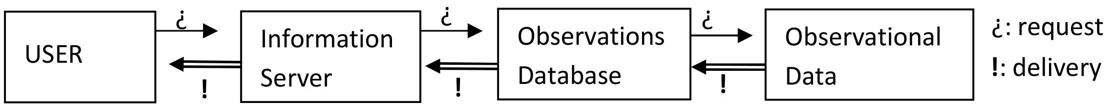
[2] see ICEAWS under "7. Selected Conference Procedures" on the Knowledge Sharing Portal of the WMO IMOP/CIMO home page

[3] See *e.g.* Van der Meulen, KNMI (Eumetnet, 2003); E-PWS-SCI: Exploratory Actions on Automatic Present Weather Observations (final report).

board private cars or on mobile phones communicating over the world wide web) and home based devices with Internet-of-Things related sensors will provide *real time* data, all freely available to the public. Another relevant source with increasing importance is crowd sourcing. Although already familiar with climate reports send in by volunteers (like the daily precipitation reports), simple and small automatic weather measuring systems, connected with the world wide web provide now data in real time mode[4]. May be the measurement uncertainty of single observations are questionable, the whole set of observations provided from many locations give a good and up-to-date overview of the present weather. Therefore, when designing an AWS network its components to be installed at each side has become a challenging task. To be successful, it is essential to be well prepared and appropriate functional requirements and an adequate management and maintenance plan must be determined in the first place. This process is very challenging and requires many human resources with different backgrounds and attitudes. Starting any implementation beforehand will end in failure and waste. All parties involved in observational data shall be involved, especially the data user. In fact, the scheme presented above must be replaced by:



Note that this scheme is typically opposite to the classical scheme. Also other parties are involved, typically for data communication and data processing. Be convinced that data communication and processing is an essential but complex part of this data-chain (local data services, central processing, distributed databases, metadata, data archiving, real-time services are typical issues not so easy to solve.) The whole process is based on an appropriate interaction between users, data managers and instrument engineers and managers. It can be that within this context the AWS network is only a small part of the whole observational data communication chain (*i.e.* inclusive of satellite data, other remote sensing data and third party data). The key issue is to determine the most effective and efficient solution in how to integrate all these data sources and as a consequence to find the best practice for *in situ* observations by AWS (inclusive dedicated algorithms for the determination of the required variables). Within this context the functional requirements will state clear quality and performance figures. Therefore the necessary quality assurance shall be part of the management and maintenance plan. This is a strong requirement because the responsibility for delivering trustworthy data is with the NHMS and not with any other party of instrument manufacturer. These plans must include local management to control and inspect the facilities frequently because remote control only is not sufficient. An AWS may never be regarded as un unattended system. In fact it requires more sophisticated maintenance than with the traditional manned stations.

4. CONCLUSIONS

The design, implementation, management and maintenance of AWS based networks is far more complicated today than the classical networks in the past. Automation cannot fully replace manned observation and new technologies deliver data through alternative sources.

[4] See *e.g.* the *Weather Observations Website* (WOW) provided by the Met Office and KNMI.

An approach based on a well prepared and determined national plan is essential to have a successful and sustainable implementation. In this plan the AWS networks shall be part of an integrated approach based on all available techniques, including third party data. The total composite observing system with sufficient redundant components will be leading in finding solutions to define AWS networks.