MeteoSwiss acceptance procedure for automatic weather stations

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ABSTRACT

MeteoSwiss is the national weather service of Switzerland and the national meteorological authority in Switzerland. Over the last years MeteoSwiss has started to integrate into its Data Warehouse (central data platform) surface observations from other partners and private networks as well. This integration of 3rd party data sources raises the question of the quality associated with the data at disposal. MeteoSwiss has decided to develop accordingly a new "certification procedure", or acceptance procedure, that will allow to qualify each data source and deliver to our data users information with known quality flags. MeteoSwiss is currently implementing this procedure. This paper describes the principles and difficulties associated to this process, and shows the interest of having an acceptance procedure that in turn is used both for MeteoSwiss own surface network as well as for AWS sites from partner networks. This application may provide sound background information and tool for decision makers in other National Meterological Services.

1 Introduction

In 2010 the national weather service MeteoSwiss decided to develop a quality assurance tool to assess automatic weather stations (codename "AWSCheck"). The reason was that MeteoSwiss started to use meteorological data from both public and private partners and wanted to be able to check the quality of meteorological data. Thus the goal of AWSCheck is to make a statement about the quality of data provided by an AWS and to be able to label it according to its field of application. AWSCheck uses standards defined in meteorology and climatology to assess and rank an instrument as fully compliant (green), compliant (yellow) or not compliant (red).

The following paper describes AWSCheck in detail and publishes first results obtained by applying AWSCheck on MeteoSwiss' own SwissMetNet. These findings were used to optimize AWSCheck.

Assessment of partner stations are planned for 2013 and will be conducted by a neutral third-party organization not related to MeteoSwiss. In this paper the organization conducting the assessment is called "auditor" whereas the owner of the AWS is called "operator" (e.g. MeteoSwiss or a private company with their own weather stations).

2 Obtaining good measurements

According to WMO-CIMO (2010a) accurate surface observations measurements are obtained by:

1. Selecting the proper sites
2. Designing the proper frame for holding the Automatic Weather Stations (AWS)
3. Using high quality instruments
4. Ensuring proper maintenance and troubleshooting procedures
5. Working with a well trained staff

AWSCheck includes these different criteria for each instrument on an AWS. In AWSCheck each instrument is assessed separately: a given site can be well suited for one parameter (e.g. temperature) but not appropriate for another one (e.g. precipitation or wind).

3 Quality assurance process using AWSCheck

The assessment process for an automatic weather station consists of three steps:

1. Pre-analysis: Does the AWS meet basic requirements to be certified? What instruments are installed? Can the operator provide AWS maintenance and history documentation?
2. Audit on site: Auditor and operator fill out the provided forms at the location of the AWS. As a result, AWSCheck gives a 1st level immediate assessment for each instrument using the categories green, yellow and red (see below).
3. Final acceptance procedure: Based on at least one year of data certain operating figures and quality checks are calculated: What is the data availability of the AWS? Maximum downtime of an instrument? Does the AWS provide data fast enough?

In a first step the auditor contacts the operator of an AWS and asks for documents containing:

- The exact location, warden contact information and other metadata about the AWS
- Lists of installed instruments, plans, station history, etc.
- Maintenance: Duties and responsibilities of warden and operator, maintenance frequency
- Calibration documentation for each instrument
- If possible a set of at least one year of meteorological data

Using this information the auditor is able to fill out parts of the AWSCheck assessment report. The next step consists of visiting the AWS together with the operator and/or warden. Filling out the report should be a mutual process. Reaching a consensus on parameters can be challenging (e.g. evaluation of site classification in mountainous region). In cases where no agreement is possible, the auditor is responsible for taking a decision but adds the operators objections into his final report. This step can include an agreement on certain improvements done by the operator (like cutting trees, adjusting measurement heights, modernizing instruments, etc.) which lead to a higher classification of the AWS. The agreement should also include how these measures are checked by the auditor after they have been completed (sending pictures, signed agreement or re-visiting of AWS).

Based on the completed report AWSCheck provides an assessment of each instrument installed on an AWS. The instruments are labelled using the following three categories:

fully compliant	green label	All WMO/CIMO requirements fulfilled, useable for climatology, meteorology and warning purposes
compliant	yellow label	Most requirements fulfilled, useable for meteorology and warnings.
not compliant	red label	Some important WMO requirements not fulfilled! Be aware of the limitations and use data with caution e.g. for weather warnings.

Table 1: The three quality categories that AWSCheck uses to label instruments on an AWS

After at least one year of collected meteorological data, the auditor can complete the last step of the assessment. An automatic data analysis tool implemented by MeteoSwiss calculates following parameters and checks if the defined threshold has been reached. These include:

- Measurement and transmission interval: do they comply with defined requirements?
- Data delivery time: Is the data delivered to the MeteoSwiss Data Warehouse within one sampling step after the integration time of the previous sample (typ. in less than 10 minutes after a measurement)?
- Data availability: how many data were delivered in total over a one year period of time (typ. threshold of better than 96% versus the maximum data achievable in 1 year) ?
- Maximum downtime of an instrument: Is it below 3 days (green) or 5 days (yellow) in 80% of the cases?
- Data quality and plausibility checks based on calculations using parallel measurements, neighbouring AWS or interpolations
- Other quality parameters that can be calculated and checked automatically

The data analysis step is planned for 2014 and will be implemented directly into the Data Warehouse of MeteoSwiss delivering on a regular basis reports for each AWS.

4 Assessment of the automatic weather station and instruments

The assessment of an AWS includes so far the basic following meteorological variables: temperature, humidity, pressure, precipitation, wind, radiation and sunshine duration. An extension of AWSCheck including more variables will be considered in the future. For each variable AWSCheck contains parameters which can roughly be grouped into three categories:

Part I: Instruments: Precision, heating, ventilation, protection against direct sunlight etc.

Part II: Measurement site classifications and mounting arrangement of instruments

Part III: Maintenance and monitoring

Part I: AWSCheck already includes lists with the most commonly used instruments and their manufacturer's specifications (data sheet) including sensitivity and accuracy, but also technical information such as ventilation, heating, etc. These values are based on what manufacturers have published for their products and are checked against the values published in the CIMO guide (WMO, 2010a) and rated accordingly. The auditor is also able to enter manual values if a certain instrument is not yet included in the list.

Part II includes a site classification according to Leroy (WMO, 2010b; p. 48), examination of correct mounting arrangements, mounting heights and emplacement. This part is likely to produce some lively discussions between the auditor and the operator. Nevertheless it must be stated that this part also contains a lot of potential for improvement of the measuring quality (e.g. by cutting trees that influence the measurement, choosing a better site, adjusting measurement height etc.).

Part III looks at how often the instruments are calibrated, controlled and maintained and also if there is an automatic monitoring system or a dual measurement to detect faulty instruments.

5 Adaptations for Switzerland

The CIMO guide gives guidelines with some degree of adaptation on certain parameters. MeteoSwiss as the Swiss national weather service uses these guidelines and also considers the specific mountainous orography and harsh environment in our country.

- Measurement height: CIMO guide indicates a measurement height for precipitation and temperature between 1.2m – 2m. MeteoSwiss fixed the measurement height for precipitation at 1.5m and for temperature/humidity at 2m.
- Calibration: CIMO guide recommends calibration of pressure sensors on a yearly basis. MeteoSwiss' experience shows that certain sensors require new calbration every 5 to 8 years, depending on the model. These adaptive criteria are also considered within AWSCheck.
- Maintenance: The CIMO guide recommends daily cleaning of pyranometer. MeteoSwiss does rely on a weekly cleaning by the warden.
- Sunshine duration: CIMO defines threshold for sunshine with 120 W/m^2. MeteoSwiss uses for historic reasons a threshold of 200 W/m^2
- Precipitation: WMO allows rain gauges with surface of 200 to 500 mm^2, SMN only tolerates a surface of 200 mm^2

Special considerations are taken into account when it comes to siting of instruments in Switzerland. In certain regions of Switzerland like mountainous terrain it is not possible to strictly follow the CIMO recommendations.

- Measurement height: In mountainous regions above 1000m the snow level can reach 1.5m and more. Therefore sensors are sometimes installed higher than 2m. To respect this AWSCheck does allow a measurement height of up to 3m for mountain stations.

- Topography: The Leroy site classification defines a flat terrain without any obstacles. In mountain regions or in steep valleys some of the Leroy criteria cannot be met. Therefore AWSCheck allows higher Leroy classes at sites considered as “special topography”.

All these specific adaptations for Switzerland are duly documented and referred in the AWSCheck documentation: the goal for AWSCheck is to become an objective tool for this certification process. Its final rating (fully compliant-compliant-not compliant) must be traceable for the user (the auditor) and as well for the AWS sites operator. This opens the opportunity to understand why a site has not reached a given degree of certification and possibly to upgrade the AWS site and improve accordingly the rating of this certification.

6 Possible implementation of AWSCheck

Currently AWSCheck has been realized using Excel. This approach has certain limitations and therefore the aim is to create a mobile application usable on a tablet or mobile device in the field. Figure 1 shows a possible implementation of the AWSCheck app.

Figure 1: Mock-up of a possible AWSCheck-App for mobile devices and tablets

7 First results

AWSCheck has been applied as a test on five SwissMetNet stations. The findings from these tests were used to improve the assessment procedure. Most important findings:

- All sensors used on SwissMetNet stations were fully compliant to WMO standards (high precision, correct ventilation and shielding etc.)
- Site classification according to Leroy is the most challenging parameter and requires an experienced auditor. If an instrument failed according to AWSCheck then the Leroy site class was in most cases responsible for the label “red” of a SMN station.
- There is a gap between the defined maintenance interval for certain tasks and how in reality the warden fulfils the tasks. In some cases the grass was not cut to an adequate height or the instruments were not clean. Since the audits were snapshots done without notification of the warden, it is not clear if the lack of maintenance was an exception or the normal case. But AWSCheck only assesses the defined maintenance intervals; checking if those commitments are met by the warden is the operators job.
- Wind height is measured in most cases at 10m, even if the terrain roughness would require the sensor to be installed higher. See Figure 5 for more information.

Some examples of fully compliant, compliant and not compliant stations:

Figure 2: A fully compliant low-land (left) and mountain (right) AWS using high quality instruments, very good measurement site according to Leroy and very well maintained (not visible in picture).

Figure 3: Two AWS with high quality instruments but due to obstacles and lower Leroy classification most instruments are ranked as “compliant”. Some instruments on the left picture could reach “fully compliant” level if trees are cut!

Figure 4: Measuring precipitation on a roof (left), temperature on a tower (middle) or next to a road (right) is not compliant according to climatological and meteorological standards.

Furthermore the measurement heights of 160 MeteoSwiss stations was compared to the AWSCheck guidelines. The results show that for temperature, precipitation and wind in about 90% of the cases the WMO requirements are fully met. In the other cases either the AWS is at a location with lots of snow in winter and thus parameters are measured above expected maximum snow level or the sensors are installed on a tower (eg. radio/IT communication tower, see Figure 4) on purpose (to measure upper air conditions).

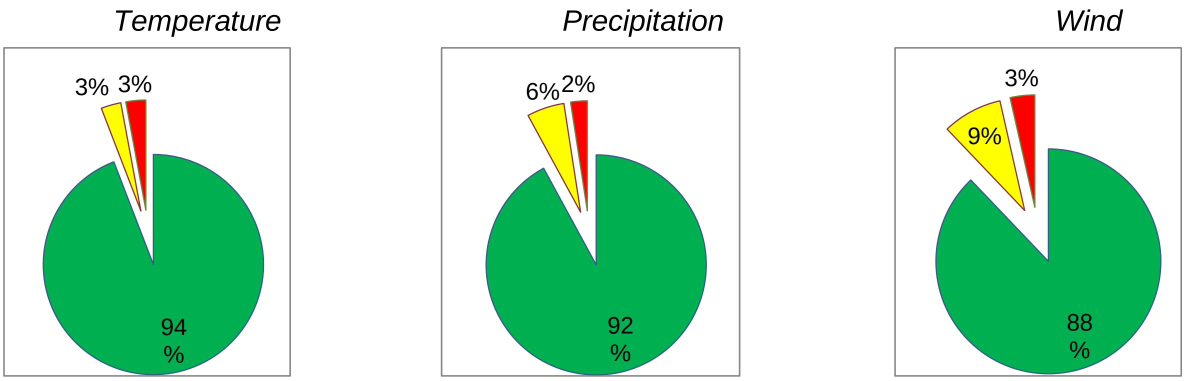

Figure 5: Measurement height for 160 MeteoSwiss AWS compared with AWSCheck guidelines. Green is fully compliant to WMO guidelines, yellow is partly compliant and red is not compliant.

8 Conclusion

With AWSCheck it is possible to flag data based on an assessment of the automatic weather station (AWS) where the data is collected. But this quality assessment should be treated with caution because the label green does not in every case stand for best data and vice versa (a station flagged as “red” can deliver perfect data but collected e.g. at 5m instead of 2m, see below). MeteoSwiss therefore considers this tool not as a bulletproof certification procedure but as a set of guidelines data providers have to fulfil (comparable e.g. to the guidelines defined by the German weather service DWD, 2001). Furthermore AWSCheck can be used to improve an AWS by giving specific suggestions on what to change (e.g. measurement height, replace instrument, better siting, etc.) in order to achieve a higher data quality.

The aim of AWSCheck is at first to provide metadata about how the surface observations are achieved. The user can decide if this information is useable for his work even if AWSCheck classifies an AWS site as not being suitable for the specific field of application. An example could be a climate researcher including temperature data collected at 5m above ground from alpine weather stations. Due to high snow levels the WMO recommendation of 2m above ground cannot be fulfilled, thus AWSCheck flags the data as being usable for warning only (“red”). It’s the first goal of AWSCheck, to create awareness on how meteorological data is collected and what its possible field of application is. But allowing a National Met service to use surface observation from 3rd party networks and to deliver this information to other data users having full confidence about the quality of the information provided is a second and as important goal for this process.

9 References

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