Environmental Classification of RMI Automatic Weather Station Network

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Abstract

The Royal Meteorological Institute of Belgium (RMI) operates a network of 18 automatic weather stations (AWS) recording meteorological parameters such as pressure, temperature at different levels, relative humidity, wind speed and direction, radiation and precipitation. In this paper we present the classification of the RMI AWS network according to the CIMO guide "Siting Classification for Surface Observing Stations On Land". We also share the experience gained during the classification exercice, the used tools (with a focus on automation) and the possible ways to improve the classification of our stations.

1 Introduction

RMI is responsible for the Belgian civilian meteorology. Civilian and military aviation AWS are managed by Belgocontrol [4] and Meteo Wing [12] which also is responsible for the road safety warnings. Environmental measurements and monitoring are under the responsibility of the three Belgian regions (Brussels-Capital region [5], Walloon region [1] and Flemish region [11]).

The first AWS has been installed in the RMI headquarters at Uccle in 1995. Since then additional stations have been added all over the country. Over the years, the AWS network has shown several weaknesses and several devices have become obsolete. This was an opportunity to build a new generation of AWS based on gained experience during the last 20 years. Since 2010 a complete update of the whole measurement chain from calibration laboratory [6], data processing and instrumentation has been deployed [9]. The back bone is a data base which stores all the information and meta data needed to accurately interpret the measurements.

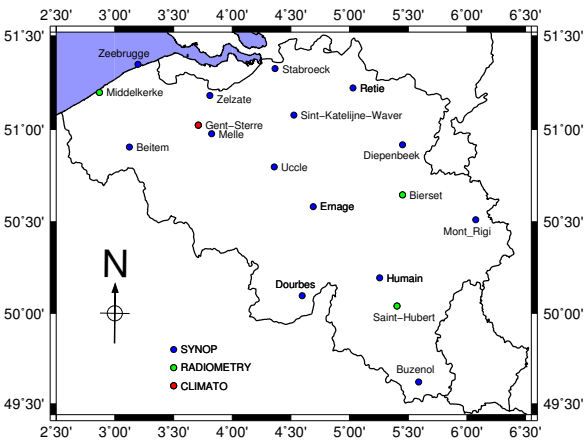

Figure 1.1: RMI AWS Network (courtesy of Cédric Bertrand)

Besides this AWS network, RMI also administrates a network of more than 200 manual stations spread over Belgium recording daily precipitation amount and and daily extremes temperatures in 3/5 of them. This manual observations are performed by volunteers.

2 WMO environmental classification

The measurement accuracy depends on the instrument specification, how it is installed to avoid influence from other atmospheric parameters and how it is maintained. In addition, the environment plays

a role that should not be neglected. For each site a complete description of the environment should be done. Nevertheless this information is not always easy to interpret and share.

In the 2010 update of the CIMO guide[13], WMO published an environment classification in 5 classes based on the seminal work of Leroy [8]and others. One of the main purposes of the classification was to simplify communication of the environment quality. This classification was not supposed to replace the complete description of a site which is of uttermost importance [2].

3 RMI AWS Network Classification

At RMI, neither structured meta data or even a simple textual site description was available. The classification of the sites was the opportunity to develop a data base of site description. The classification has been started in 2015 and should be completed by the end of this year (2016). Five measurements are classified by WMO: temperature/relative humidity, precipitation, wind speed/direction, global solar radiation and direct solar radiation. All these 5 classifications have been done for each visited site.

3.1 Hardware Tools

We didn't carry out tests to find a good tool to make the classification: we relied on Norwegian Meteorological Institute (NMI) experience [14] and use a Leica DISTO^{TM} D810 touch with a tripod. This solution was supposed to improve the deficiency observed by NMI. The built-in camera with zoom and the level has shown to be very useful when taking the sun shade diagram. Unfortunately, the compass can't be displayed at the same time. A manual compass has then been used. With this laser distance meter, there are several ways to make indirect measurements thanks to the camera: perpendicular measurement to the laser beam has been particularly very useful when measuring the sensors booms length on a wind mast. Other features have not been very useful in this context: Bluetooth connection to an additional Android/IOS/Windows 8.0 device and data saving is less practical than the traditional paper and pencil method. In addition, the measurement direction (compass) can't be correctly measured when the tilt angle significantly differs from 0°. This is a clear limitation of this kind of tools. The use of a tripod has also really improved the measuring performance.

Figure 3.1: Leica DISTO 810 with tripod and FTA360 high precision tripod adapter

3.2 Software Tools

The use of free GIS software has been tested (GRASS [10]). After a trial period, it has been concluded that the use is cumbersome considering to what is needed for WMO environmental classification. It has been preferred to use an easier tool (Google Earth Pro [7] which is free since beginning of 2015). It also offers the following advantages besides beeing free: a user friendly interface, the free geographic data and the user data saved in a open readable format based on XML (kml). Nevertheless it has also several drawbacks: only available on Windows OS, crashes very often, no easy tool to automatize. For the last point, it is possible to write automatic retrieval of data using the Google Map API: nevertheless there is a strong limitation regarding the number of request per day that can be done and the asynchronous retrieval of data (AJAX) can be difficult to program [3].

3.3 Classification of stations

For each station, the following information has been gathered:

- the exact position (latitude, longitude and height) of each instrument
- the perturbation surfaces
- the horizon shading chart

- the topography (elevation and slope)
- the roughness length

The exact position (latitude, longitude and height) of each instrument

This information has been introduced in the database for each instrument placed in each station

The topography (elevation and slope)

Elevation and slope have been automatically generated from the station coordinates and the Google Map API. An example is displayed in figure 3.2.

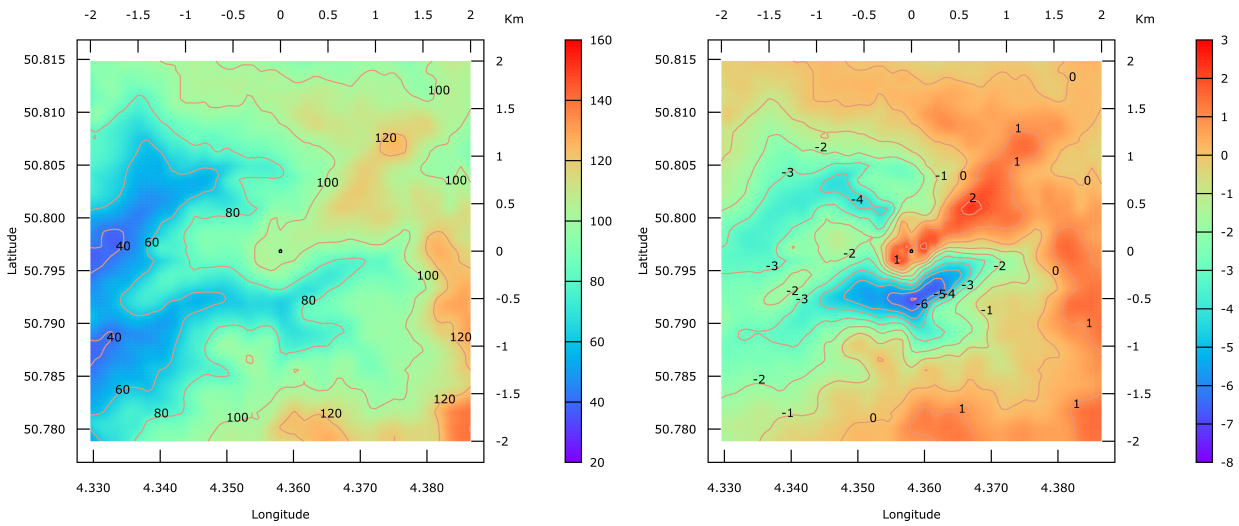

Figure 3.2: Uccle Synoptic station (6447) elevation and slope

The perturbation surfaces

The perturbation surface have been drawn on Google Earth and saved in kml format but this information is not stored in the AWS database. The classification of perturbation surfaces has been found hard to manage and a visual description of the limits has been preferred . The figure 3.3 is given as an example for one of our station (Uccle-6447). The horizontal and vertical axis should be interpreted as the distance to the center of the temperature shelter. There are two types of colored strips: larger strips are linked to disc surface area while shorter ones are for annulus surface area. The angular axis is the percentage amount of perturbed surface. It is in logarithmic scale. The values should be read for example for yellow strip: the amount of perturbation surface for a 10m radius disc surface is 13%. When a strip is in-between two values in the vertical axis, the amount of perturbation surface is for the annulus between the higher and lower values. For example the magenta strip is the annulus between 10m and 30m.The black radial segments are the maximum limits for a particular class which is annotated at the left of the segment. If a strip exceeds a black radial segment, the class is higher than the associated class. For example the yellow

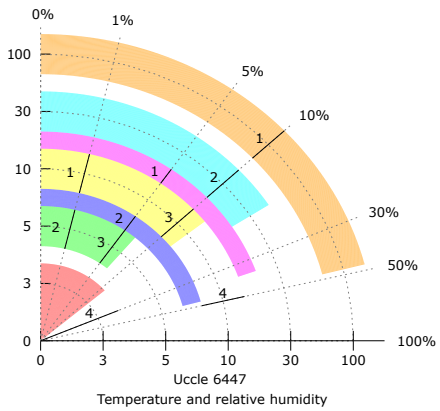

Figure 3.3: Temperature and relative humidity perturbation surface and siting class for Uccle Synoptic station (6447).

strip exceeds the radial segment annotated class 3. So the class is at best 4. Repeating the same argument for each strip, the final class is the highest found among all the strip classes.

The horizon shading chart

The shading diagram is taken manually with the laser distance meter, the tripod and an analogue compass. The figure 3.4 is then automatically generated based on the gathered data in a simple text file of direction and horizon height. The sun path is computed according to the equations in Annex 7.D of [13].

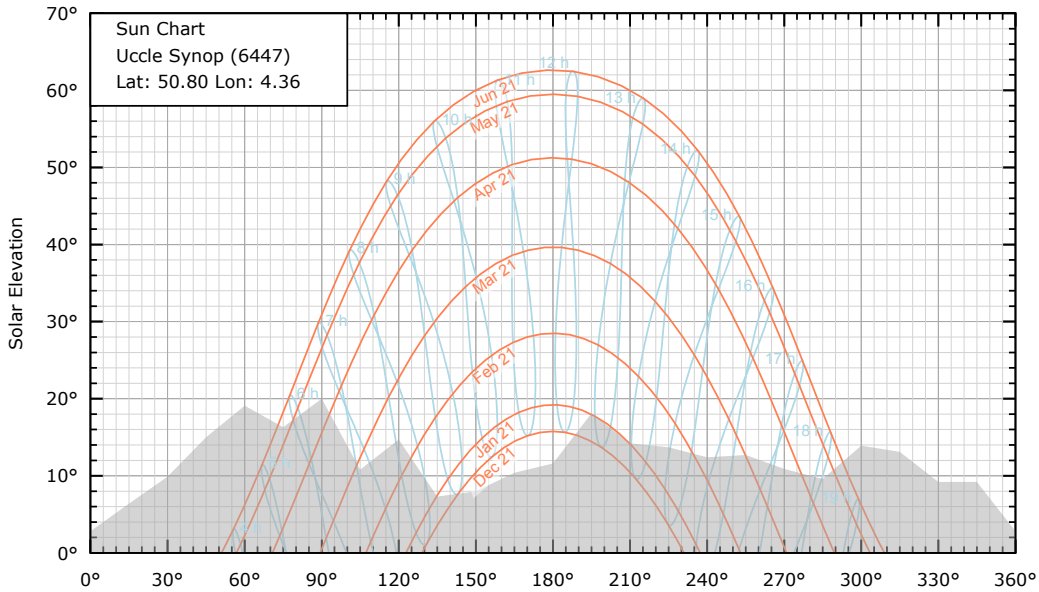

Figure 3.4: Sun shade diagram for Uccle Synoptic station (6447)

The roughness length

For the wind classification, the roughness length is used to estimate the quality of the environment. For each station with wind measurement, the roughness length has been estimated according to the annex of chapter 5 of CIMO guide [13]. The standard deviation of the wind direction has been used for this estimation. At Uccle (urban area), the displacement height has also been estimated. For the renovated stations the roughness length can also be estimated from the standard deviation of the wind speed: this could give some insight on the obtained accuracy.

Figure 3.5: Roughness Length for Uccle Synoptic station (6447). The size of the image is 4km by 4km centered at the wind mast.

In table 1, the classification of each automatic station of the network is given. As it can be seen from this table the classification is quite poor for most of the stations. For each station, some recommendations have been proposed to improve the situation. Most of these recommendations will not be easy to fulfill. There are two main issues: the protected area is not sufficient and

there are too high trees. The stations are usually surrounded by crop fields that do not belong to RMI.

During the classification work, some difficulties emerged from the definition:

- the slope should be clearly defined as it depends on the available resolution of topographic data
- it is unclear how the criteria of roughness length should be applied when data is available for sectors from measured data (the maximum for all the sectors has been used as site roughness length for RMI classification). In addition, for one station, the classification would change according to the limits and size of the sectors (30° or 40°).
- the use of sharp limits for classification criteria is probably unavoidable for simplicity reason but classification in some case is just one class higher for some decimal digits.

Station	WMO ID	Temperature/RH	Precipitation	Wind	Global Radiation	Direct Radiation	Comment
Uccle	6447	4	2	3	5	5	Park in headquarters of RMI. Urban area.
Uccle Clim	-			-	-	-	This station is the historical reference station. It is 50m away from the synoptic station.
Uccle Rad	-	-	-	-	3	4	The measurements are done at 16m above ground.
Humain	6472	2	1	3	1	1	Road and trees
Beitem	6414	5	2	3	1	2	Surrounded by crop fields
Ernage	6459	3	1	3	1	2	Surrounded by crop fields, semi-urban area
Retie	6464	4	1	3	3	4	Surrounded by crop fields and trees
Melle	6434	3	1	3	2	3	Surrounded by crop fields, three very close wind mills
Sint-Katelijne-Waver	6439	4	1	3	3	4	Surrounded by crop fields and trees
Buzenol	6484	4	1	3	3	4	Surrounded by crop fields and trees
Zeebrugge Dam	6418	5	5	2	3	4	Station is on a dyke
Middelkerke	6407	N/A	N/A	N/A	N/A	N/A	N/A
Stabroek	6438	N/A	N/A	N/A	N/A	N/A	N/A
Zelzate	6431	N/A	N/A	N/A	N/A	N/A	N/A
Dourbes	6455	4	2	4	4	4	Surrounded by trees, on a top of a hill
Saint-Hubert	6476	N/A	N/A	N/A	N/A	N/A	Airport
Diepenbeek	6477	N/A	N/A	N/A	N/A	N/A	N/A
Mont Rigi	6494	4	1	4	3	2	Surrounded by trees and stone path
Gent Sterre	-	N/A	N/A	-	-	-	Urban

Table 1: Classification of the RMI AWS network according to the WMO 2010 environmental classification. "N/A" means that the classification has still to be done. "-" means that this type of measurement is not performed in this station.

4 Future

Some stations still need to be classified. The classification in itself is not very time consuming (3 hours by station). In our case, since environmental information was not initially available, traveling to the

stations, collecting and recording the information has revealed to be a very long task. The creation of automatic tools to ease the whole process was also time consuming. As recommended by the WMO, a complete classification will be done every 5 years. In the meantime, technicians are now aware of the environmental influence and will report any modification in a station.

5 Conclusion

The exercise of classifying the stations has been very useful: besides all the advantages already mentioned in the literature as better communication with a single number and improvement hints, the classification has been a strong incentive to start a complete meta data recording of our stations environment.

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