# A Reference Method to assess the Quality of State of Ground sensors

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## Abstract

For acceptance tests and intercomparisons of state of ground sensors a precise, reliable and verifiable reference is needed. A method is presented that allows a weather observer to determine the state of ground of a remote station in the required way by the use of a web camera, a spotlight and a ground temperature profile.

## Introduction

Observations of the present weather and state of the ground were initially not intended to be reported quantitatively and are qualitative descriptions of the state of the atmosphere and the surface of the earth [1]. The introduction of automatic weather stations required these observations to be measured automatically by apropriate sensors. This implies that these qualitative informations have to be derived from quantitative measurements.

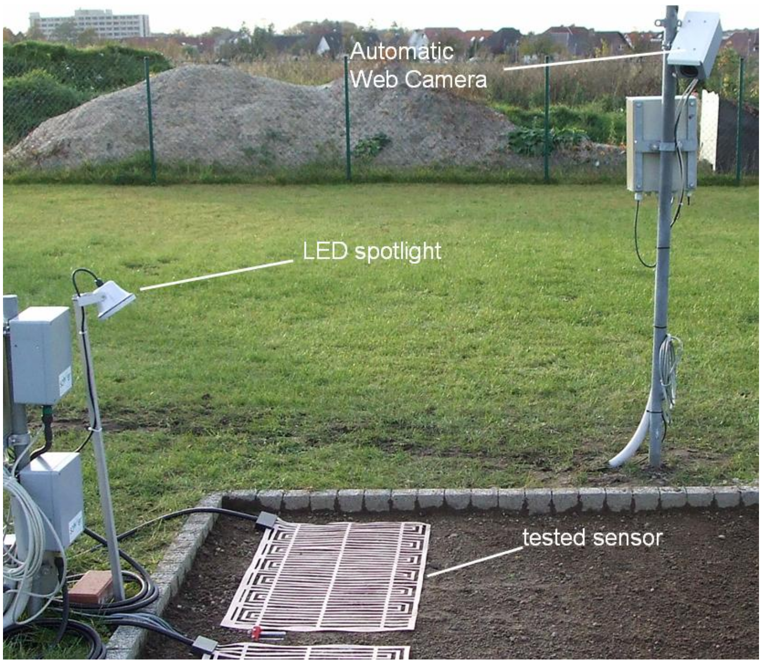


**Figure 1: Setup of the state of ground reference.**

A challenge is posed in the assessment of the quality of such sensors because they have to be compared to human observations. For the purposes of sensor tests, acceptance tests and intercomparisons an objective, reliable and verifiable referene is needed. Moreover the time resolution for the reference data has to be in the order of 1 to 10 minutes at 24 hour operation which is not possible to perform by a human observer without further utilities. This paper describes a suitable and yet easy method that provides such a reference for state of ground sensors.

## Setup of the Reference

All states of the ground with and without snow coverage (WMO codes 0901 and 0975) are defined by the visual appearance of the earth's surface, complemented by descriptions that are using the human sense of touch. To cover this visual appearance, a web camera was used to automatically take pictures in suitable time intervals (e.g. 10 minutes). We were using an industrial video camera (SONY FCB-EX470) in combination with an AXIS video server to attain an acceptable picture quality. Before transmitting the pictures to a remote web server a timestamp was added on the pictures. Useful meteorological parameters such as air temperatures, ground temperatures and present weather were also stamped into the corresponding picture by automatic post processing on the remote server. We were using the Linux software "convert" for this process. Any results that are derived from these pictures are verifiable as the stored pictures are documenting the visual situation.

**Figure 2: High resolution temperature profile of ground temperature in 1 cm steps. The upper probe is +1 cm above ground and the next one directly on the surface at 0 cm.**

In order to better discriminate "moist" from "wet" states of ground a LED spotlight was placed opposite of the camera close to the angle of reflection (Figure 1). Thereby any droplets or patches of water on the earth's surface can easily be recognised in the picture. Additionally the spotlight allows 24 hour observations by the camera. An experienced weather observer was able to identify all states of ground quite easily and effectively also during night time with one exception: "frozen ground", which is mostly defined by its increased soil compression rather than changed visual properties.

To close this gap in the visual observation a high resolution temperature profile was measured by 5 Pt100 temperature probes placed in 1 cm steps at +1 cm above the ground down to -3 cm below the surface (Figure 2). Provided that the state of ground has been "moist" or "wet" before, the knowledge of these temperatures permits a discrimination of frozen and not frozen states. The combined presentation of meteorological parameters on the picture has proven to be very helpful to the observer.

To assure or even increase the accuracy of the high resolution temperature profile a distribution of accumulated frequencies of all temperatures measured during several weeks was plotted with 0.01°C resolution (Figure 3). For each depth a maximum appears exactly at freezing point because the temperature remains constant for a longer time due to phase transition from liquid to solid and vice versa. In this way a "field calibration" for freezing point detection was achieved that could even account for an existing shift of the freezing point due to the salt content in the ground. It must be said that the +1 cm temperature probe has not been useful and can therefore be omitted. Due to the splash effect of rain drops the earth is accumulating underneath the probe and thus changes its characteristics.

The evaluation of a test sensor in comparison with the above described reference can then be performed by using contingency tables, as recommended in the CIMO guide [1, p. I.1-14].

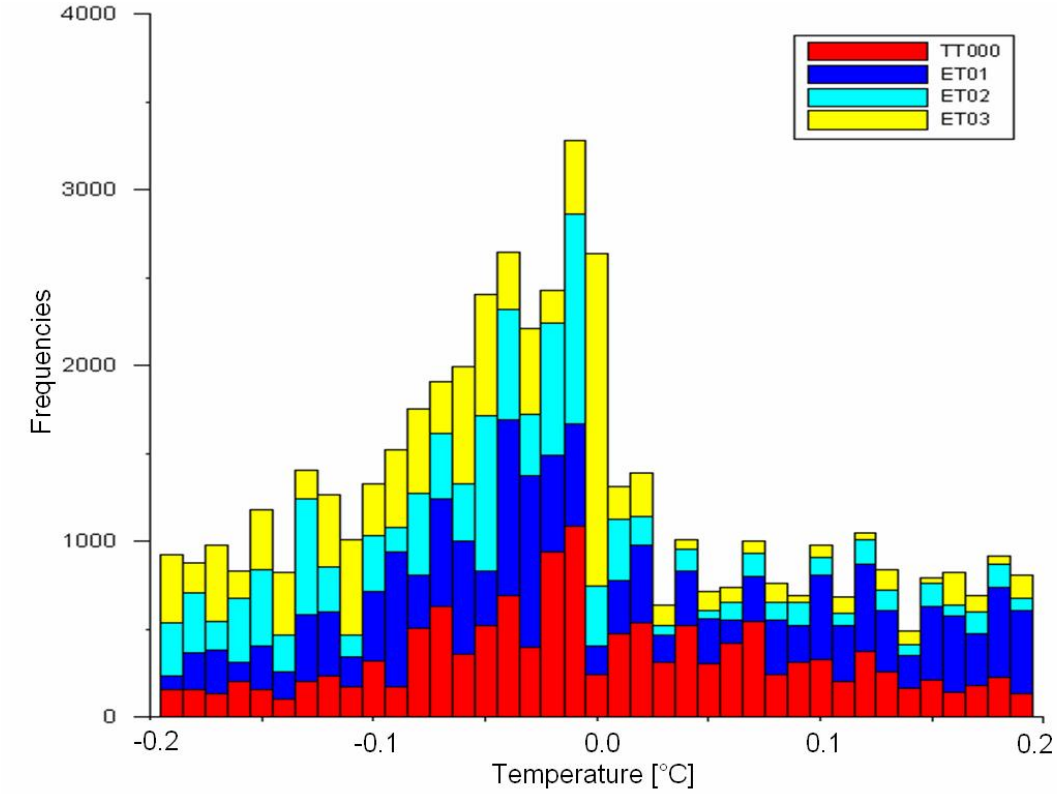


**Figure 3: Accumulated frequency distribution of ground temperatures for measurements directly at the surface (TT000) down to -3 cm below the surface (ET03).**

## Conclusions

By the use of a web camera, a spotlight and a high resolution temperature profile a reference for the state of the ground can be established. The evaluation of pictures of the ground by an experienced weather observer is a feasible, reliable and verifiable way to determine the state of the ground. It should be noted that the use of an appropriate picture viewer (e.g. Irfan View) allows fast forward scrolling through a series of pictures in times when no changes in the state of ground occur thus speeding up the analysis. Therefore this method could also be used for operational observations of the state of ground by using web cameras at remote locations.

## Acknowledgements

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## References

[1] Guide to Meteorological Instruments, WMO-No.8, 7th edition (2008). ISBN 978-92-63-10008-5
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