AUTOMATIC MEASUREMENT OF ICING ON THE WEST OF THE CZECH REPUBLIC

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1 INTRODUCTION

We report our experience with the automatic measurement of the mass of icing accumulated on the collector of icing sensor developed in the Institute of Atmospheric Physics, Prague, Czech Republic. First, we will briefly describe the measuring device and give its basic specifications. Then we will give a short description of sites were the measurements were performed and present the selected data. Next we will discuss the results of the measurements and experience with the sensor, and outline its possible improvement.

2 DESCRIPTION OF THE INSTRUMENT

The icing sensor (from here further "Icemeter") developed in our Institute of Atmospheric Physics, Prague, Czech Republic measures the mass of icing accumulated on the surface of its collector. The first prototype was described in [1], together with a short review of previous methods of ice measurements that were applied in the Czech Republic. Primary, it was considered for the investigation of the most favourable meteorological conditions for in cloud icing growth and the investigation of accumulation of in-cloud icing and its chemical analyses. Therefore, we have chosen the vertical orientation of the cylinder, in order to eliminate the detection of wet snow as much as possible. Nevertheless, the "Icemeter" can find its application also in the monitoring system of power lines, wind power station, and traffic roads; the vertical orientation of the collector can be changed to horizontal one, if required.

The mass of accumulated ice is measured by means of a tensometric bridge (strain gage load sensor), the output of which is tied to the precise AD converter. The digital signal is preprocessed by a micro-controller, which assigns the time and stores the data into the device memory.

In order to prevent the freezing of the horizontal rod, which couples the cylindric collector to the tensometer, which is located together with the electronics in the housing, the passage through the housing may be heated. Whether it is heated or not, depends on the passage temperature. A testing electro-mechanical impulse is applied each hour to verify the free force transition to the tensometer, and thus to check whether the acquired data are reliable or not. These "technological" data are acquired separately.

„Icemeter" can operate autonomously as data logger; it has memory for approximately 50 days of operation with 10 min sampling interval, or can pass the data on request to the PC. In the case of power supply failure, the Real Time Clock circuit is powered from the backup rechargeable battery, so the information about proper time is not lost.

The basic technical specification of the instrument is concluded in Table 1.

Table 1: Basic technical specification of Icemeter

Measuring range	0...10 kg
Resolution	1 g

Accuracy	±5 g
Surface area of the sensor	0,05 m^2
Mass of the device	4,25 kg
Interface	RS232 (optionally RS485, RS422)
Capacity of the memory	~7500 data points incl. date and time
Voltage Supply	12-15 V
Electricity consumption	~50 … 230 mA depending on heating
Operating temperature range	-30°C …50 °C

3 SITING

Milesovka: Most of the measurements were carried out at the top of “Milešovka” mountain, which is the highest peak of the tertiary volcanic range of “České Středohoří”. A synoptic meteorological station, now belonging to our Institute, was built on Milesovka’s summit (837m a.s.l.). Milesovka has a shape of isolated forested cone, which exceeds the surrounding terrain by approximately 300 m. The steepness of slopes ranges from 20° to 30°. Concerning temperature, the long time average is 5.1 °C, absolute minimum was -28.3 °C and absolute maximum reached 34.7 °C. The average of annual precipitation is 564 mm. The mean wind speed is 7.7 m/s with most frequent winds from northwest, west and southwest. From the winter 2003/2004 two Icemeters, situated at different height above the ground (see Figure 1), have been operated.

Nová Ves: Since 2005, one piece of Icemeter has been situated close to the wind turbine in Krušné hory (Ore mountains), near to the village of Nová Ves. Krušné hory is the region most suitable for wind energy production in the Czech Republic. Unfortunately that region is also affected by severe icing. It is probably most exposed region in the whole country, concerning the severe ice episodes.

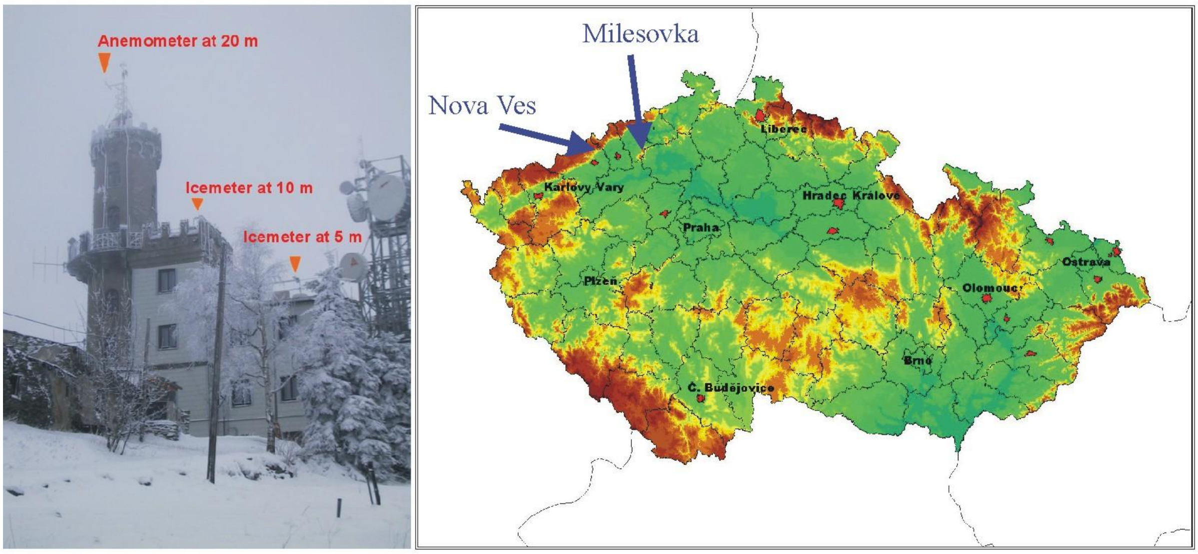

Fig. 1: left – Observatory at the Milesovka peak with marked position of Icemeters; right – location of Milesovka mountain and Nova Ves in the Czech Republic.

Other sites:

Two pieces of Icemeter have been in operation in Austria (Obersthralbach, Sternstein), both of them situated close to wind power station.
One piece was tested in Luosto, Finland during the winter 2004/2005
The Icemeter was also located temporarily in other sites in the Czech Republic. Due to a short time of location at these sites, we don't take them into account.

4 RESULTS OF MEASUREMENTS, EXPERIENCE WITH THE ICEMETER OPERATION

Examples of measurement:

The Icemeter has been operated on the Milesovka peak from 2000. The maximum icing load was detected in the end of 2002, when more than 2.5kg accumulated on the collector of length 48 cm with surface area 0.05 m^2 (see Figure2), thus the accumulated icing was about 1.26 kg/m^2. At that time several masts were broken due to heavy icing in the Czech Republic.

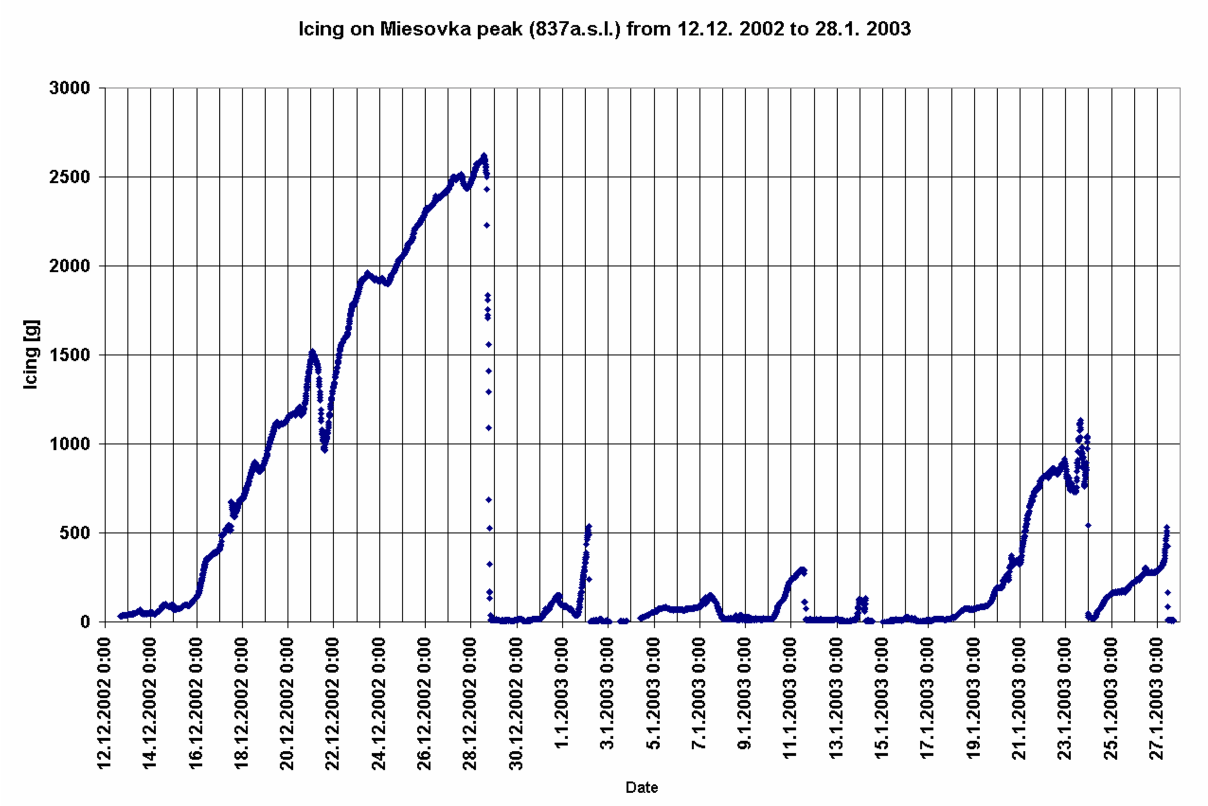

Fig. 2: The severe icing recorded at Milesovka peak in the end of 2002

Figure 3 presents the example of measurements from different height above the ground at the Milesovka observatory. We can see that significantly higher mass of icing accumulates at the higher position. The shape of the curve – record is similar, but not exactly the same during the presented period (January/February 2005). Interesting is the comparison with the measurement in Nova Ves, which is situated ~30km west from Milesovka at about the same altitude. Here, the icing lasted quite longer. At the Milesovka the remarkable icing lasted just about two days from the evening 16.2.2005 to 18.2005, whereas in Nova Ves it lasted more than one week up to 1.3.2005 (see Figure 4). The accumulated mass was however comparable. Note that the records are not from the same time period. They overlap only partially.

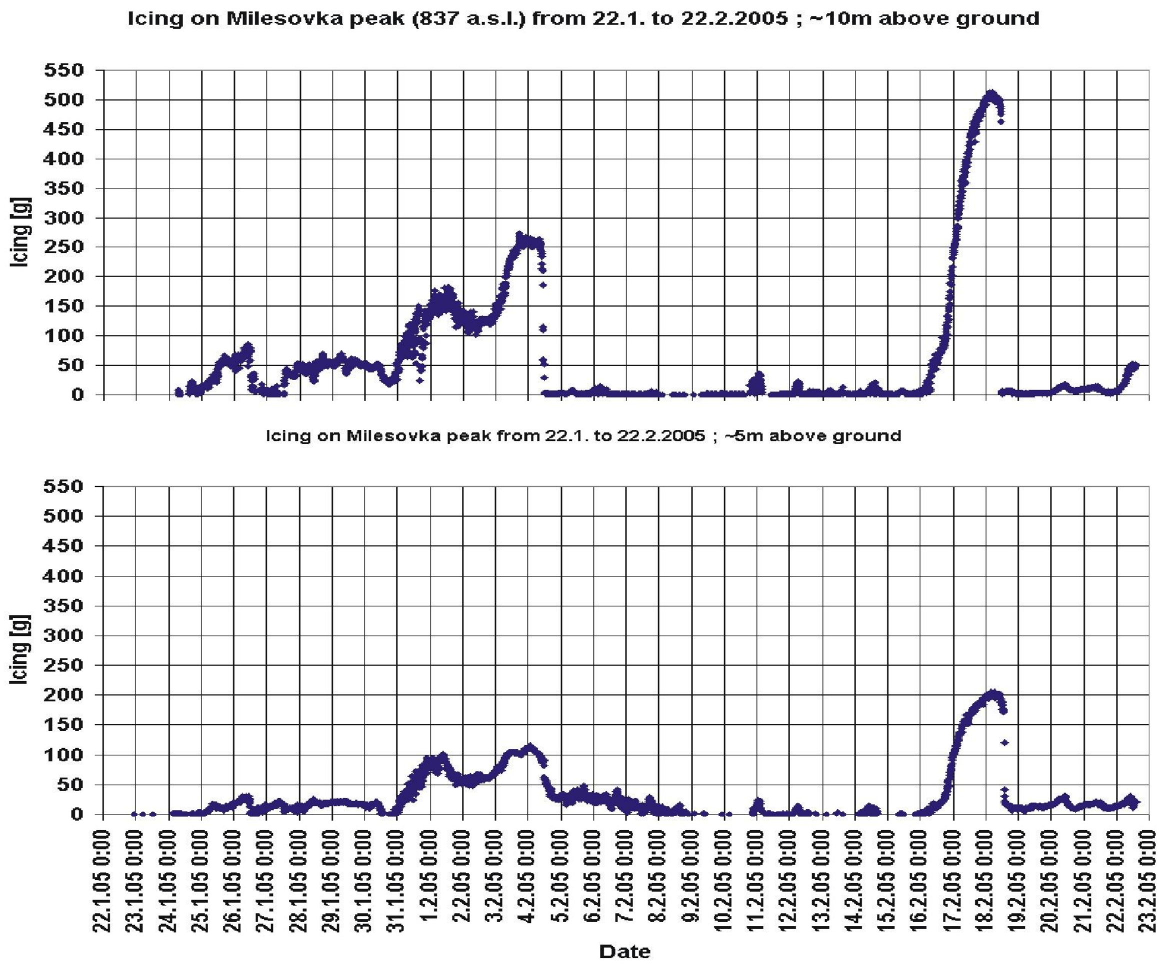

Fig. 3: Example of icing measurment at different heights on Milesovka peak.

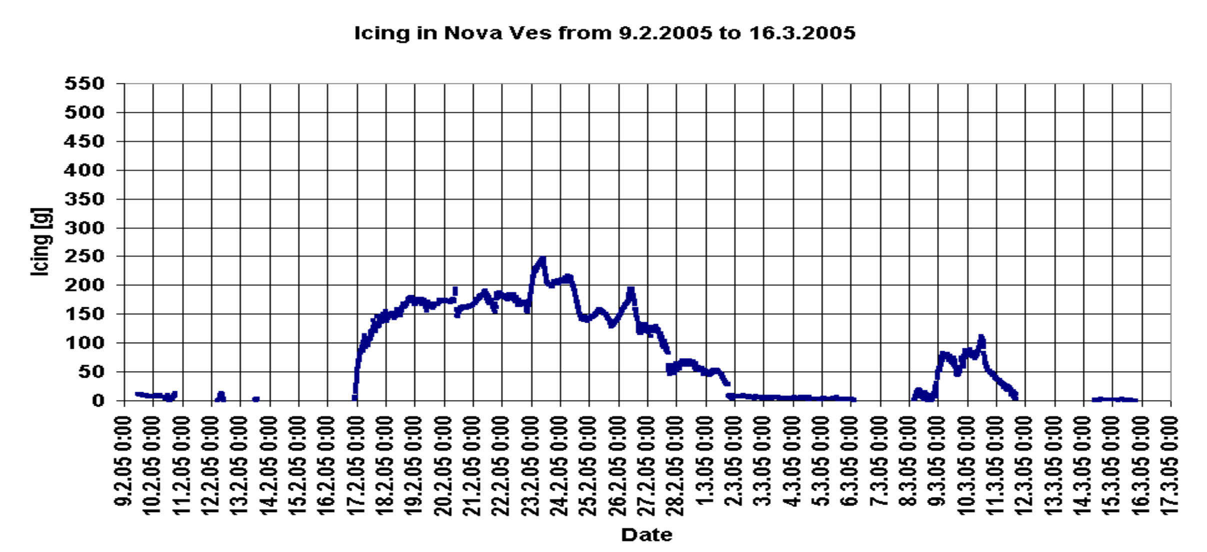

Fig. 4: Example of recently (February 2005) installed icing measurment in Nova Ves.

Problems of operation

Although the Icemeters installed in the Czech Republic measured correctly most of the time, there occurred also time periods, when the instruments gave obviously wrong values, often the negative ones. These time periods can usually be associated with the time periods, when the horizontal rod coupling the tensometer with the vertical collector became icebound to the instrument housing. Thus there was no free force transition. We could identify that from the fact that we didn't see the proper electromechanical pulse (see section 2) in the technological data. The periods of freezing – malfunctioning can be seen in Figure 4 as data gaps. The instrument gave the wrong negative values. Note that the location in Nova Ves has more severe cold and wind condition, than Milesovka. The freezing has been very rare on Milesovka.

We have learned that the distinct problems with freezing occurred in the test site in Luosto, Finland. However, we have not received detailed information. As far as we know, the Icemeters located in Austria have been working correctly most of the time.

5 DISCUSSION, CONCLUSIONS, FUTURE PLANS

Although we have reasonably good data from most of the time of operation in the Czech Republic, it seems that we should enhance the available heating power in order the Icemeter could operate in cold climate conditions. We consider it should be no problem, provided there is no limitation to power consumption. Additionally, we suppose to improve wind shielding of the passage of the coupling rod through the housing. (Now the heating power is only ~ 2 W maximum. Since we haven't had many problems with freezing on Milesovka, where we have got most of our experience, we have applied the heating power as low as possible to be sure that the heat doesn't prevent the icing to grow.)

Except the enhancement of available heating power, we will try to follow future recommendation for ice sensors that may occur. For example, we will consider the possibility to build an instrument with rotating collector. Probably we will mainly continue in focusing on sensors that measure accumulated icing.

We had preliminary talks about the possible placement of the Icemeter in the test site in Switzerland, and in a site in Bulgaria.

Regarding the investigation of conditions favourable for icing growth in the Czech Republic, we will make the comparison of icing measurement with the measurement of liquid water content on Milešovka peak. Such comparison should be possible at Milesovka beginning from the winter 2005/2006. We believe that such measurements could improve our knowledge of icing. The recent attempts to simulate icing measurements by using temperature, wind and humidity records haven't shown sufficiently good results.

REFERENCES

[1] Fišák. J., Chum J., Vojta J., Tesař M.: Instrument for measurement of the amount of the solid precipitation deposit - ice meter, *J. Hydrol. Hydrolmech* 49, 3-4, ISSN 0042-790X, Ústav pro Hydrologiu SAV, Bratislava a Ústav pro Hydromechaniku AVČR, Praha (2001) p 187-199