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# SNOW TEMPERATURE MEASUREMENT EVALUATION ACCORDING TO THE AUTOMATIC WEATHER STATION AT CHOPOK DURING DEC. 1999 – MAR. 2000

*Abstract:* The snow cover is studied in submitted contribution from the view of meteorological influences. It was shown that the most important factor which influences snow cover height and quality (assuming there's no new snow fall) is air temperature and accumulated heat (cold) inside the snow cover. As an indicator of air temperature effects on snow cover, snow temperature was taken. Our effort was to indicate changes in snow cover caused by meteorological influence and propose automatic measurements with 24 h regime and data transfer to evaluation centre.

*Key words:* snow temperature, snow cover height, sensors, automatic weather station.

## 1. Introduction

At the present time the snow temperature measurement is only a question of aptitude and accessibility of financial resources. Snow temperature has been measured up to now only by Centre of Avalanche Control according to their procedure 2 times weekly, as needed. These measurements were done on the mountain slope and sequentially uncovering snow cover and detected the temperature in snow profile always in other place. At the same time snow structure and character were explored. Because of demand of snow cover evolution knowledge with the meteorological respect in continuous regime we started snow temperature measurements at the most vulnerable place of Slovakia, at Chopok (where the snow cover is found during the majority of the year), from December 1999. Because of strong wind and low temperatures the automatic snow temperature measurement is inevitable in this locality.

## 2. Methods and Forms of Measurement

Automatic weather station VAISALA was used and the main sensors were electrical impedance thermometers (similar to ground thermometers), fixed on shoulder of metallic mast (Fig.1). Number of sensors was limited by communication ability of automatic weather station. Snow temperature detection was specified to 0 cm, 20 cm 50 cm and 100 cm levels. Now we realise the need of more sensors to be put into operation and also the need of the snow cover surface measurement. Because the height of the snow cover is almost 300 cm at the end of the winter, it is clear that our measurements tell us only about the changes that took place from the profile 0 to 100 cm above the ground and about the extent of air temperature influences on daily snow temperature course. Measurement frequency is 1 minute, in this contribution we discuss hourly measurements to better illustrate the daily course.

## 3. Results

First results obtained by automatic measurements and data transfer from meteorological station Chopok are from December 1999, when in the beginning of the month snow cover height was less then 30 cm (more or less during the first days) up to 112 cm in the end of December. In that period cases when the sensors measured the air temperature above the snow surface instead of the snow temperature occurred what latter seemed to be quite useful because of determining the temperature gradient between the snow and screen temperatures at 2 meters height. Since the snow height measurement is not possible to be done by automatic weather station (at that moment), we had to use the data from the climatological term of measurement at 7 a.m. We assume, that it caused not precise determination of measurement time when the sensors started to measure the air temperature instead of snow temperature. Snowfall is not abnormal in 2000 m altitude, the height of the snow cover changes during the day in both directions - increase – drifts or decrease up to ice layer. Measurements evaluation showed us, that if the sensors are situated above the snow surface they reflect air temperature course from tenths to several degrees of °C in both directions in fact. This is related with wind lull and more intensive heat exchange between snow and adjacent atmosphere that happened on 16-17 Dec., 23-24 Dec. 1999 at 100 cm above the ground with 60 and 70 cm snow cover height respectively, or 40 and 30 cm above snow respectively (Fig. 2), proving strong snow cover radiation cooling. In Figure 2 the opposite course of temperature differences ($T_{200\ cm}$ - $T_{100\ cm}$) and wind speed can be seen. The lower wind speed the higher differences were observed and in addition the screen temperature was higher than the temperature above snow cover. In both cases weather was similar - no snowfall, fog or low clouds, no strong wind, but strong ice coating.

As soon as these sensors are below the snow, they reflect the air temperature in different regime. How fast and intensive the changes can be detected depends on snow layer above sensors, snow quality and age, permeability, pore geometry and thermal conductivity. Generally the higher snow pack the lower amplitude observed.

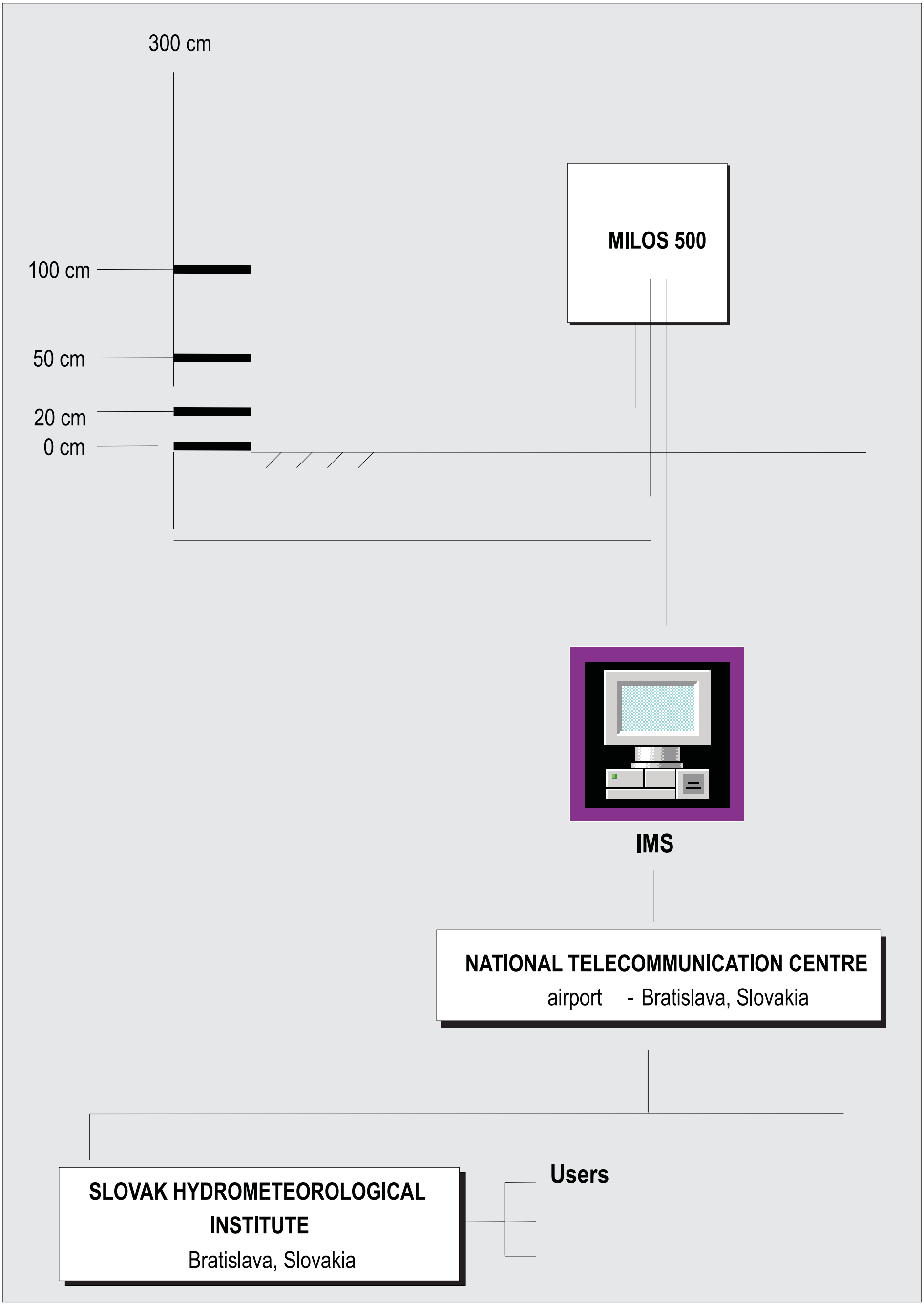


Fig. 1. Data Communications from automatic weather station (Chopok).

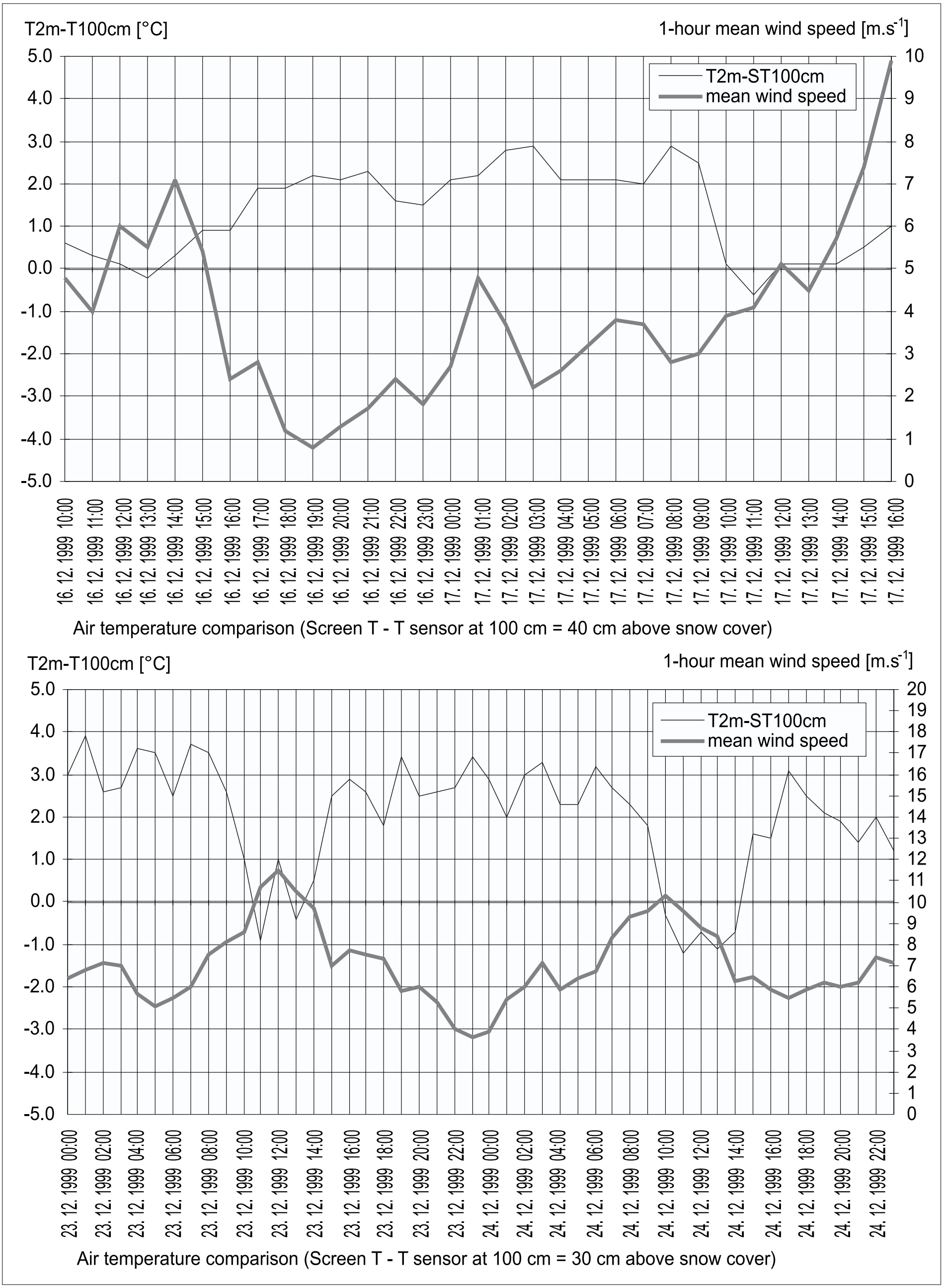


Fig. 2. Special differences between screen temperature and detecting point for snow temperature, Chopok.

If the layer above sensors is small the snow temperature is close to air temperature up to 10-15 cm depth. When there is a thick snow pack above the sensors the differences grow up and delay. In order to avoid the small variations in air temperature and to detect only essential changes in snow temperature we used weighted arithmetic mean of hourly data. The delay in 30 cm deep snow pack is from several hours up to day and longer if temperature decreases and shorter if temperature increases (Fig. 3). When snow depth above the sensor at 0 cm is large enough (more than 50 cm) the changes at the ground are small. Even if the air temperature is very low (e.g. air temperature -21.5°C, snow cover height 115 cm, 24 Jan. 2000) no strong evidence in snow temperature at 0 cm height above the ground (Fig. 4) is found. In real measurements up to 30 cm snow cover height and air temperature from -0.5 to –14.0°C, the changes in snow temperature at 0 cm were in interval from -1.5 to -4.5°C. As the result of snow accumulation during the winter the interval decreased (even though the air temperature changed rapidly in both directions) and approached to -1.8°C in March when 260 cm snow cover height occurred. Considering the sensor at

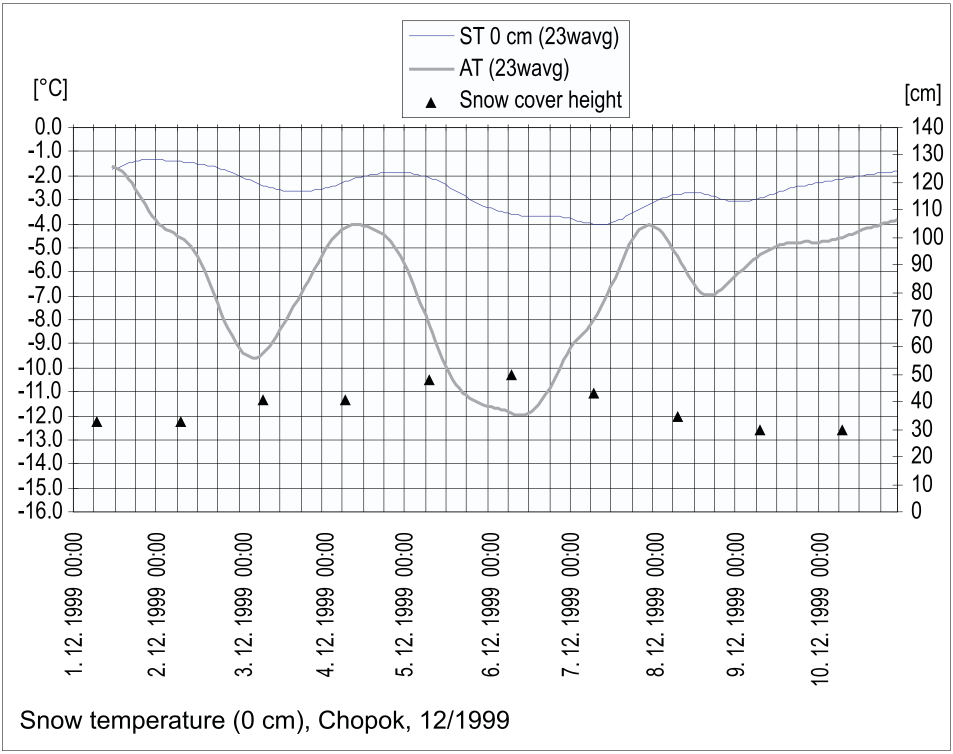


Fig. 3. Weighted mean of snow temperature (0 cm above ground) in comparison with weighted mean of air temperature in screen and snow cover height (30-40 cm).

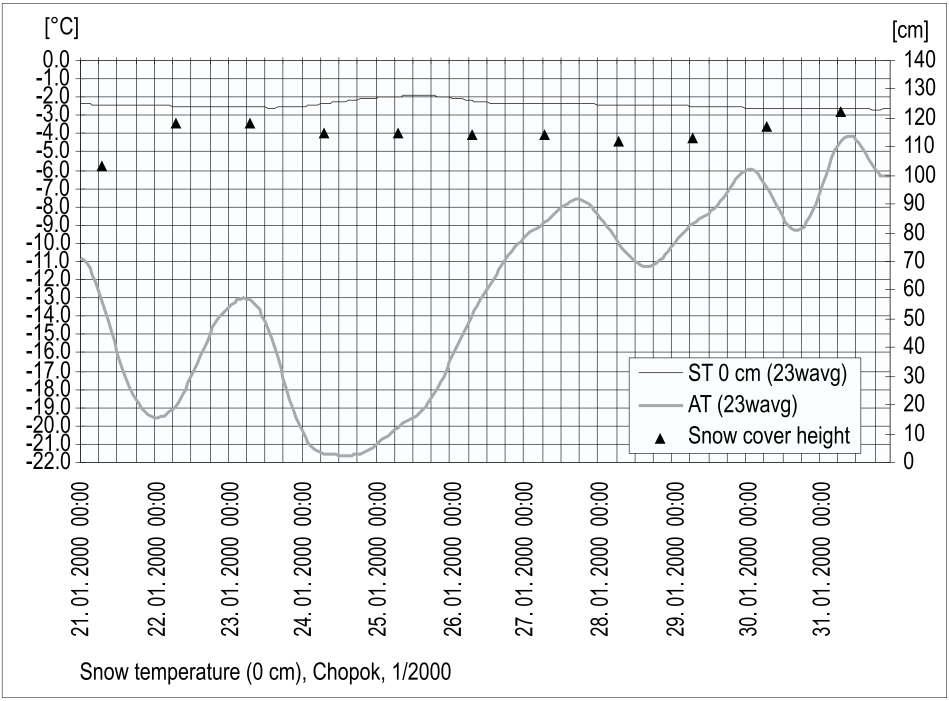


Fig. 4. Weighted mean of snow temperature (0 cm above ground) in comparison with weighted mean of air temperature in screen and snow cover height (30-40 cm).

20 cm above the ground the changes are faster than at 0 cm according to air temperature and in better coincidence with immediate air temperature. Snow temperature interval during December to March reached values from -2 to -6°C with -2°C at the and of March.

Snow temperature in 50 cm could be detected from 14 Dec. 1999 because of snow cover height. In the previous period the sensor measured the air temperature above the snow in good coincidence with it. Using weighted averages it was found that snow temperature delay comparing with air temperature in minimum and maximum point was 14 hours in 6 to 15 cm depth above sensor. When the depth is bigger the delay is longer and depends on other meteorological factors but also on snow structure and quality (blown and deposited).

The sensor at 100 cm measured the air temperature in good coincidence with screen temperature when the snow was below it, with the exception of cases mentioned before (Fig. 3) and several others. First measurements of snow temperature started on 21 Jan. 2000 when snow cover height was for a longer period above 100 cm (Fig. 5). Because the snow depth was not more than 10-20 cm during this period, the delay deviations (snow and air) were from one to several hours. As in the beginning of the

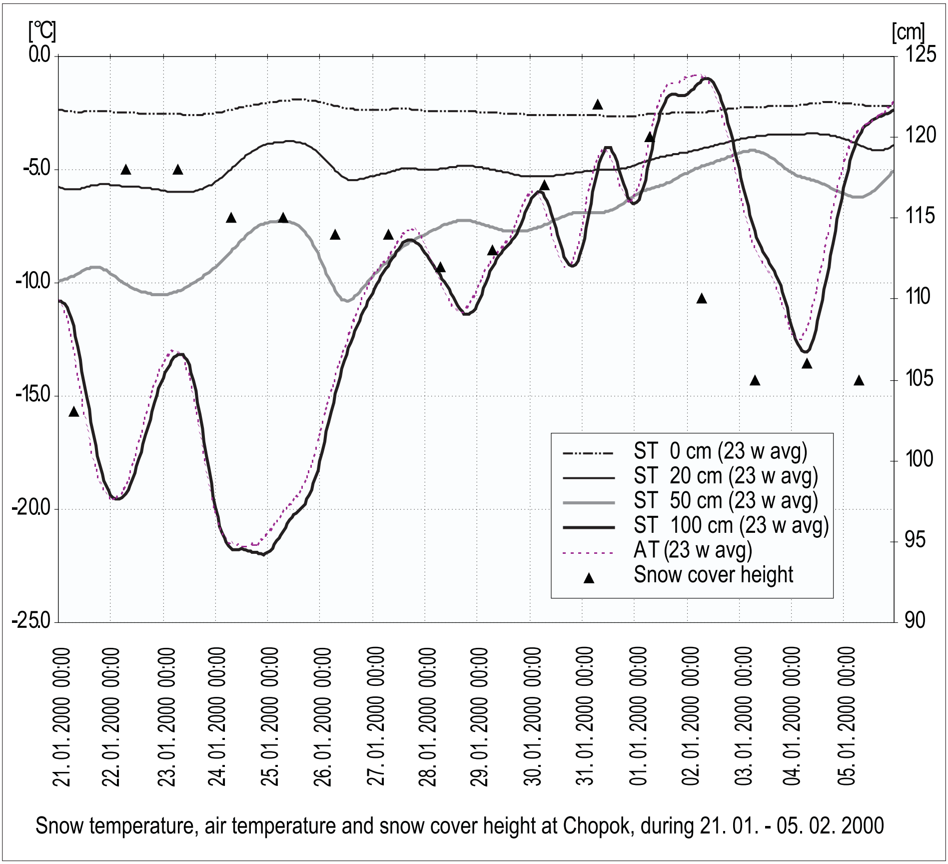


Fig. 5. Comparison of snow temperature weighted means measured by sensors (0 cm, 20 cm, 50 cm and 100 cm heights above ground), Chopok.

observations the sensor measured only the air temperature, the values detected were close to it and reached from 3 to -23°C, but in the end of March approached to -2.8°C as a constant value.

## 4. Conclusion

Snow temperature measurement executed by automatic weather station was the first one of that kind performed on meteorological station at Slovak territory. We are conscious of snow temperature limitation (more sensors could be more effective) that will be eliminated in the future. It is difficult to compare and predict the delay even at the same height above a sensor, because the structure, thermal and mechanical properties, conductivity and gradients, water vapour fluxes, etc. are not the same. At first we thought that the snow temperature could be similar to soil temperature. In some respect it is. Using a simplification we indicate some rules for snow temperature:

1. Snow temperature in all horizons depends on air temperature.
2. The larger snow depth above sensor, the smaller amplitude occurs.
3. More frequent changes in air temperature (alternately up and down) do not need to have influence on snow cover especially if snow depth is large enough (e.g. 1.5 - 2 m in mountain region, 0.7-1 m in lowland).
4. The longer air temperature increase (decrease) period the better maximum (minimum) registry could be detected in context of delay.

We plan in the future to co-operate with the Centre of Avalanche Control and to establish a project of automatic temperature and snow cover height measurements in mountain regions. In conclusion, we are aware that results of character and quality of snow cover research may be useful for tourists protection in mountains (alpine activities), for predicting and study of the hydrological regime (runoff) and for organisation of sport events.

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