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Comparison of manual and automatic measurements of air and soil temperature in the Czech Republic

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Abstract

Differences between manual and automatic measurements of air temperature and soil temperature should not be neglected. The average difference between the manual and the automatic measurements of air temperature varied between 0.3 and 2.8 ◦C during suitable weather conditions (wind speed less than 3 m/s, bright and sunny day) throughout the year, during both daytime and nighttime hours. Comparative measurements showed that average monthly differences of air temperature between manual and automatic measurements varied between -0.5 and 0.29 ◦C; differences of soil temperatures at a depth of 5, 10 and 20 cm between 0.3 and 0.83 ◦C, respectively at a depth 50 and 100 cm between -0.13 and 0.28 ◦C.

Key words: Measurements; air and soil temperature; comparison; climatology

Introduction

Many short-term comparative measurements in wind tunnels and field experiments have been performed in connection with the transition to automated measurements. The studies have revealed relatively large differences in measurements due to variations in instruments' protection from radiation. Differences have been greatest under particular weather conditions (e.g., calm, bright and sunny days with snow cover). Most experiments have investigated differences over monthly and seasonal time scales (Brock et al., 1995; Barnett et al., 1998; Lin et al., 2001; Van der Meulen and Brandsma,

2008). Comparisons among thermometer screens have been reviewed by several authors (Petäjä , 2004; Nagy, 2006; Lacombe et al., 2011).

Materials and methods

Comparative measurements were conducted in the observatory of the Czech Hydrometeorological Institute (CHMI) in Doksany (50◦ 27’ 31’ N, 14◦ 10’ 14’ E, 158 m a.s.l.) between April 2000 and December 2013 (comparative period). The observatory is one of four reference climatological stations of the CHMI. It is situated in a warm and dry area; long-term climatological norms for the years 1961–1990 include an average annual air temperature of 8.5 ◦C and an average annual total precipitation of 456 mm. All measurements of air temperature were conducted at a height of 2 m above a flat, open terrain with short-cut grass cover. The instrument was placed in the middle of a 0.75-hectare plot with no nearby obstacles that may have affected measurement.

Manual measurement of the air temperature was conducted by a station thermometer in a standard Czech-Slovak thermometer screen; the soil temperatures using thermometers placed within the natural soil profile under a closely-cropped grass cover at climatological observation times of 7 a.m., 2 p.m. and 9 p.m. of local mean solar time. For the automated measurements of temperature, platinum resistance temperature sensors Pt100 (four wires, class A) were used. The automated measurements of air temperature were conducted in the naturally ventilated multi-plate shield Met-Cover3.

Results and discussion

The median air temperature difference between the automat and manual measurements for the comparative period was positive for the average daily air temperature (M = 0.11 ◦C, standard deviation SD = 0.4 ◦C) and the daily minimum air temperature (M = 0.26 ◦C, SD = 0.84 ◦C) and negative for the daily maximum air temperature (M = −0.63 ◦C, SD = 0.92 ◦C). The differences between the automat and manual measurements for the average, maximum and minimum temperatures were statistically significant at the 5% significance level.

Average monthly differences between the automat and manual measurements for the comparative period fluctuated between –0.5 ◦C and 0.29 ◦C (Figure 1). Deviations were negative in the winter half-year (October to March), indicating that temperatures measured under the automat were lower than those measured by the manual; the opposite pattern was found in the summer half-year (April to September). A similar distribution was found for the average monthly differences in daily minimum air temperatures, for which the mean differences fluctuated between –0.45 ◦C and 0.96 ◦C. In contrast, the average monthly differences in daily maximum air temperatures were consistently negative; the mean differences fluctuated between –1.22 ◦C and –0.21 ◦C. The average difference in the winter half-year period was –0.19 ◦C for average air temperatures, –0.44 ◦C for maximum air temperatures and –0.25 C for minimum air temperatures. The average difference during the summer was 0.21 ◦C for average air temperatures, –1.13 ◦C for maximum air temperatures and 0.73 ◦C for minimum air temperatures. The average difference between the automat and manual measurements was 0.01 ◦C for the average annual temperature, 0.24 ◦C for the average annual minimum temperature and –0.78 ◦C for the average annual maximum air temperature. Mozny et al. (2012) showed that the differences between automatic and manual measurements of air temperature were caused by the transition measurements from the Czech-Slovak thermometer screen at the multi-plate shield. Size difference depends on meteorological conditions (wind speed, amount of cloudiness and the surface-reflected radiation).

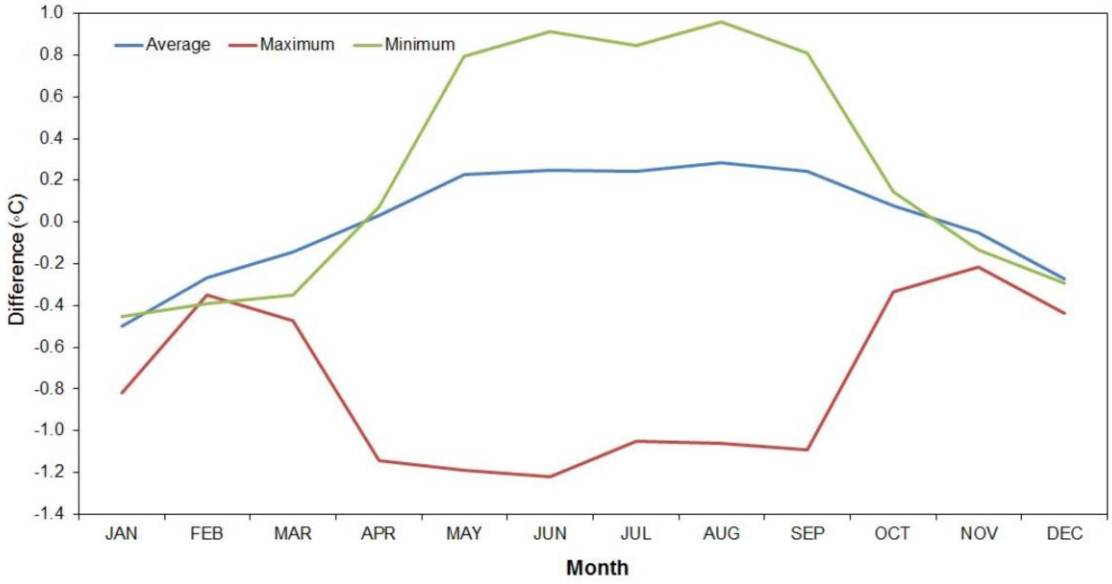

Figure 1 The average monthly differences in average, minimum and maximum air temperature between the automat and manual measurements from April 2000 to December 2013.

The median temperature difference between the automat and manual measurements for the comparative period was positive for the average daily soil temperature at a depth of 5, 10 and 20 cm (M = 0.6 ◦C, standard deviation SD = 0.4 ◦C) and at a depth of 50 and 100 cm (M = 0.12 ◦C, SD = 0.3 ◦C). The differences between the automat and manual measurements for the all depth were statistically significant at the 5% significance level.

Average monthly differences between the automat and manual measurements for the comparative period fluctuated between –0.31 ◦C and 0.83 ◦C at the depth of 5, 10 and 20 cm (Figure 2). Deviations were positive in the all months, indicating that temperatures measured under the automat were higher than those measured by the manual. In contrast, the average monthly differences at the depth of 50 and 100 cm were negative in March and April; the mean differences fluctuated between –0.13 ◦C and 0.28 ◦C. Volume changes in the soil in March and April were affected the differences.

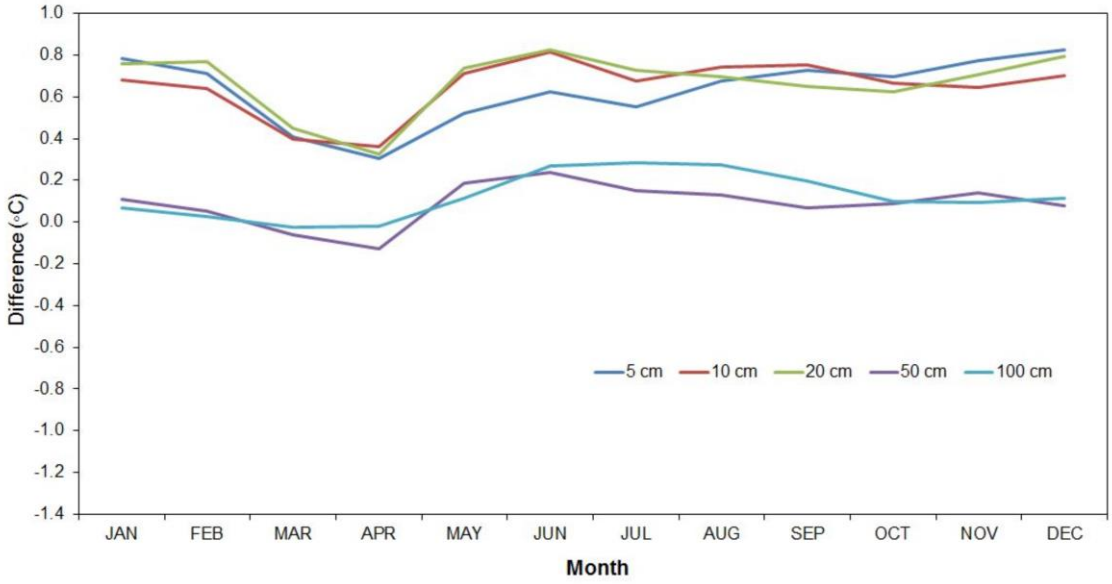

Figure 2 The average monthly differences in soil temperatures between the automat and manual measurements at the depth of 5, 10, 20, 50 and 100 cm from April 2000 to December 2013.

Conclusion

The average air temperature difference between the automat and the manual varied between 0.3 ◦C and 2.8 ◦C. The error increased during bright days with wind speed less than 3 m/s, and temperature deviations up to 4.1 ◦C occurred in the presence of snow cover. Differences between the automat and the manual average air temperature were less than 0.2 ◦C during overcast conditions when the wind speed exceeded 3 m/s.

The median temperature difference between the automat and manual measurements for the comparative period was positive for the average daily soil temperature at the all depth.

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Summary

Předpokladem studia změn klimatu je vyhodnocení souběžných měření prováděných automatickým a manuálním způsobem. V rámci České republiky došlo u měření teploty vzduchu v rámci automatizace k zásadní změně – k přechodu od měření v meteorologické budce k měření pod radiačním štítem. Tato změna statisticky významným způsobem ovlivnila měření teploty vzduchu. Vlivem automatizace došlo k mírnému „zvýšení“ minimálních teplot a naopak „snížení“ maximálních teplot. Diference teplot mezi budkou a štítem závisí na meteorologických podmínkách (rychlosti větru, oblačnosti a odraženém záření od povrchu).

Automatické měření teploty půdy v hloubce 5, 10 a 20 cm pod travnatým povrchem vykazuje mírný „nárůst“ teploty ve všech měsících oproti manuálnímu měření.

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