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UTCI – FIRST TEST IN THE CZECH REPUBLIC

UTCI – Pierwsze testy w Republice Czeskiej

Streszczenie. UTCI (Universal Thermal Climate Index) to nowy wskaźnik, który opisuje wpływ warunków termicznych na standardowe ludzkie ciało. Wskaźnik ten był testowany w skrajnych warunkach pogodowych w Czechach w ciągu kilku ostatnich lat – w najzimniejsze dni w sezonie zimowym 2009/2010, w najgorętsze dni lata 2010 r. i podczas przechodzenia orkanu „Kyrill" (18–19.01.2007 r.). Wyniki są prawidłowe w przypadku obu badanych okresów ze skrajną temperaturą (najzimniejszego i najgorętszego), ale wystąpiły problemy z wartościami UTCI w czasie skrajnie wietrznych dni (orkan „Kyrill"). Nietypowe wartości UTCI rozpoczynały się, kiedy prędkość wiatru przekraczała 20 $m \cdot s^{-1}$.

Słowa kluczowe: bilans cieplny, komfort cieplny/dyskomfort, biometeorologia, prognozy biometeorologiczne, UTCI
Key words: heat balance, thermal comfort/discomfort, biometeorology, biometeorological forecast, UTCI

INTRODUCTION

An assessment of thermal comfort/discomfort is important for a human biometeorological application including a biometeorological forecast (BMF). The BMF model in the Czech Republic doesn't include an appropriate description of the complex action of the air temperature, humidity, wind and radiation fluxes on the human body. The CHMI debated about an application of indices pair – Wind Chill Temperature Index (WCTI) and Heat Stress Index (HSI) a few years ago. Both indices are calculated from two factors only. The WCTI uses air temperature and wind speed, the HSI uses air temperature and humidity. The definition of developed Universal Thermal Climate Index (UTCI)

satisfied BMF requests (Jendritzky et al. 2002). Development of the Universal Thermal Climate Index (UTCI) was finished in the frame action COST 730 in last year (2009).

MATERIALS AND METHODS

The concrete UTCI values were calculated through the use of a web calculator (www.utci.org/utcineu/utcineu.php). Most of inputs in the calculator form are directly measured at ordinary meteorological stations (air temperature at 2 m level, relative humidity at 2 m level and wind speed at 10 m level). The mean radiation temperature (T_{mrt}) isn't measured but value of this variable (respectively a difference between this variable and the air temperature) is possible to assess from other meteorological (sunshine duration and/or sunshine intensity, cloudiness) and astronomical (solar height above the horizon) data. There were used a meteorological data from three selected station: Praha-Karlov and Brno-Žabovřesky as classical urban stations for Bohemia (Praha) and southern Moravia (Brno) and Bedřichov as mountain station – see tab. 1.

Table 1. Geographical information about used meteorological stations
Tabela 1. Położenie geograficzne wybranych stacji meteorologicznych

Name of station	Latitude	Longitude	Altitude
Praha – Karlov	50°04'03"	14°25'07"	303 m asl
Brno – Žabovřesky	49°13'00"	16°33'58"	235 m asl
Bedřichov	50°48'55"	15°09'35"	780 m asl

The significant situations were selected for tests of the UTCI behaviour. The first situation (December 20, 2009) is the coldest day at Praha-Karlov station during the whole last winter season (2009–2010). The second situation (July 16, 2010) is the hottest day of last summer in the Czech republic. Data from all three stations were used for this date because difference between an urban areas and mountains is interesting in a hot summer especially. The third situation (January 18–19, 2007) is an extremely windy episode known as "Kyrill".

All situations were studied with using a high time resolution. There were used 15 minutes meteorological data (10 minutes for 2010–07–16). The differencies between T_{mrt} and air temperature (T) was assessed from solar duration data. The calculation UTCI values was added by $UTCI_{max}$ values for the "Kyrill" episode and 2009–12–20. The $UTCI_{max}$ is UTCI which is calculated from maximal windgust Fmax for each 15 minutes interval. The maximal stress in this interval was determined by this method.

RESULTS AND CONCLUSIONS

The first situation (Fig. 1) is an example of a day without a significant windgusts, the differences between windspeed (F) and maximal gusts (F_{max}) are similar during the whole day. Nevertheless, this difference is enough for an improve stress for a human body. The minimal values of the UTCI agree with the category "very strong cold stress" (Błazejczyk et al. 2010) but $UTCI_{max}$ is lower. The minimal values of the $UTCI_{max}$ are in match with "extreme cold stress". A dependence of the UTCI on wind speed is marked – daily amplitude of the air temperature was 5°C, the amplitude of the UTCI was above 20°C. The UTCI values haven't reached the category "extreme hot stress" even on the hottest day of this year (Fig. 2), at both urban stations they were in the "very strong heat stress" category and at Bedřichov station they were "strong heat stress" only.

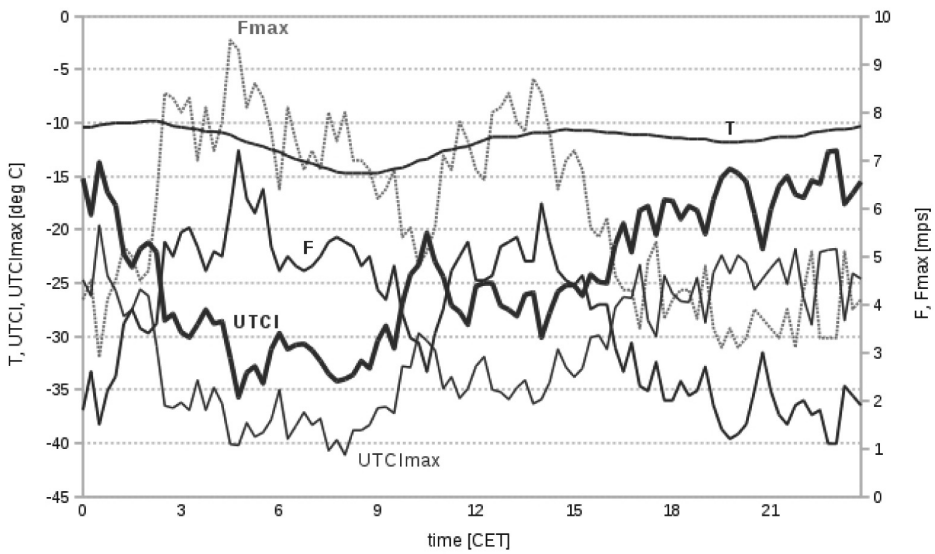

Fig. 1. The UTCI [a function of the air temperature (T), relative humidity (h), difference between T and mean radiant temperature (ΔT_{mrt}) and wind speed at 10 m (F)] and the $UTCI_{max}$ [a function of the air temperature (T), relative humidity (h), difference between T and mean radiant temperature (ΔT_{mrt}) and maximal wind speed (gust) at 10 m (F_{max})] during the coldest day of the winter season 2009/2010 (2009–12–20) at Prague (at Praha-Karlov station)

Ryc. 1. UTCI [w funkcji temperatury powietrza (T), wilgotności względnej (h), różnicy między T i średnią temperaturą promieniowania (ΔT_{mrt}) i prędkości wiatru na 10 m (F)] i $UTCI_{max}$ [w funkcji temperatury powietrza (T), wilgotności względnej (h), różnicy między T i średnią temperaturą promieniowania (ΔT_{mrt}) i maksymalnej prędkości wiatru (poryw) na 10 m (F_{max})] podczas najzimniejszych dni w sezonie zimowym 2009/2010 (20.12.2009) w Pradze (Praha-Karlov)

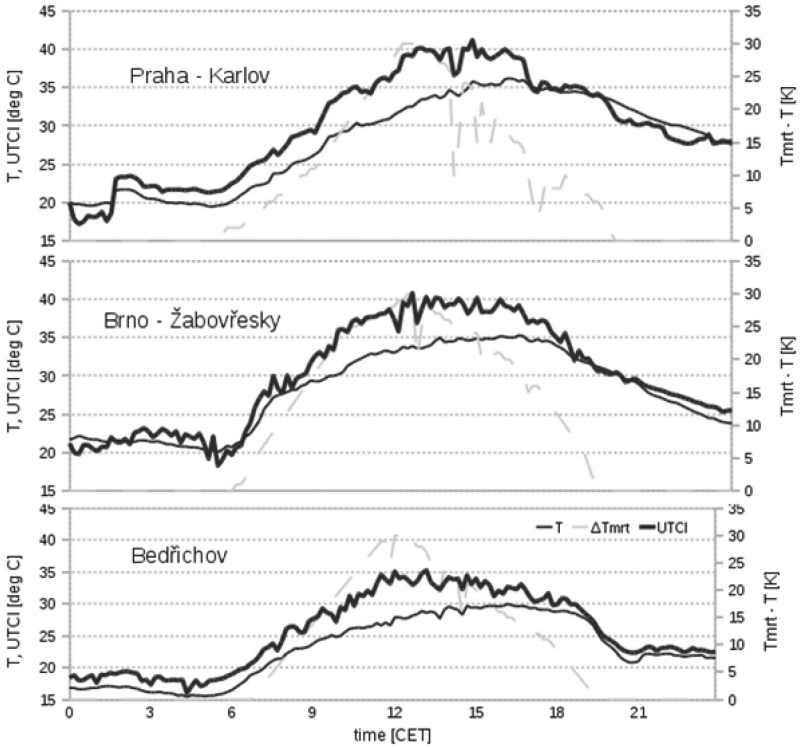

Fig. 2. The UTCI [°C], air temperature T [°C] and $\Delta T_{mrt} = T_{mrt} - T$ [K] during the hottest day of the summer 2010 in the Czech republic at selected stations (2010–07–16)
Ryc. 2. UTCI [°C], temperatura powietrza T [°C] i $\Delta T_{mrt} = T_{mrt} - T$ [K] podczas najgorętszych dni lata 2010 r. w Czechach na wybranych stacjach (16.07.2010)

In figure 4 is showed the dependence of the UTCI on a wind speed but this graph is for wind speed to 10 $m \cdot s^{-1}$ only. However, average wind speed above 30 $m \cdot s^{-1}$ and windgusts over 40 $m \cdot s^{-1}$ were measured during the "Kyrill" episode. The time behaviour of the UTCI and $UTCI_{max}$ (Fig. 3) has detected a problem with UTCI calculate for wind speed over 20 $m \cdot s^{-1}$ (see gray selected area in Fig. 3). If the wind speed crosses a 20 $m \cdot s^{-1}$ border, values of the UTCI begin to increase. This situation would be normal if wind had warm effect but it's false.

The results of the UTCI ($UTCI_{max}$) forced us to study a dependence of the UTCI and wind speed for wider range of the wind speed values. The UTCI was tested with this conditions: T = 5°C, h = 70% and T_{mrt} = T. Figure 5 shows a strange behaviour of the UTCI for wind speed values between 20 to 30 $m \cdot s^{-1}$, the problematic interval is marked by the gray area.

A big problem occurs for wind speed over 30 ms^{-1} too. The UTCI values begin to quickly descend (Fig. 5 and 6) with increasing wind speed and they are falling under absolute zero (0 K) limit!

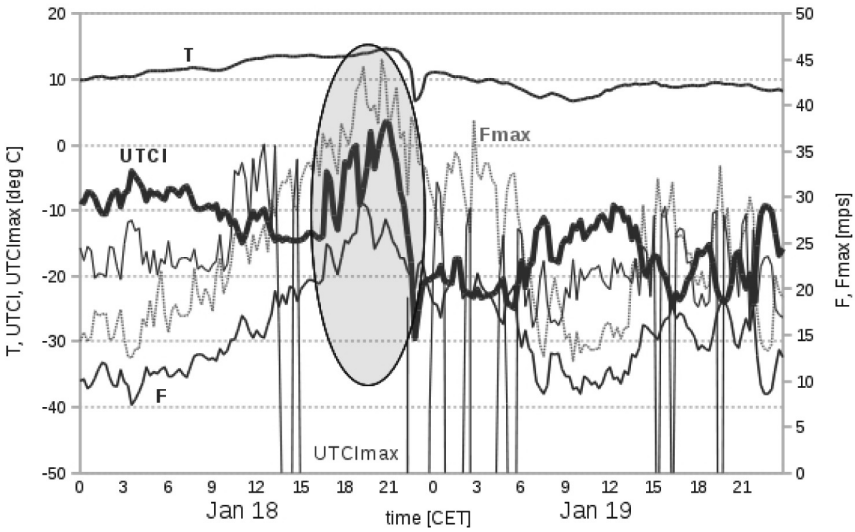

Fig. 3. The UTCI and the $UTCI_{max}$ during "Kyrill" episode (January 18–19, 2007). The selected area is an example of the UTCI strange behaviour (the UTCI increases with rising wind speed)

Ryc. 3. UTCI i $UTCI_{max}$ podczas orkanu „Kyrill" (18–19.01.2007 r.). Zaznaczony obszar jest przykładem nietypowych wyników UTCI (wzrost wartości UTCI ze wzrostem prędkości wiatru)

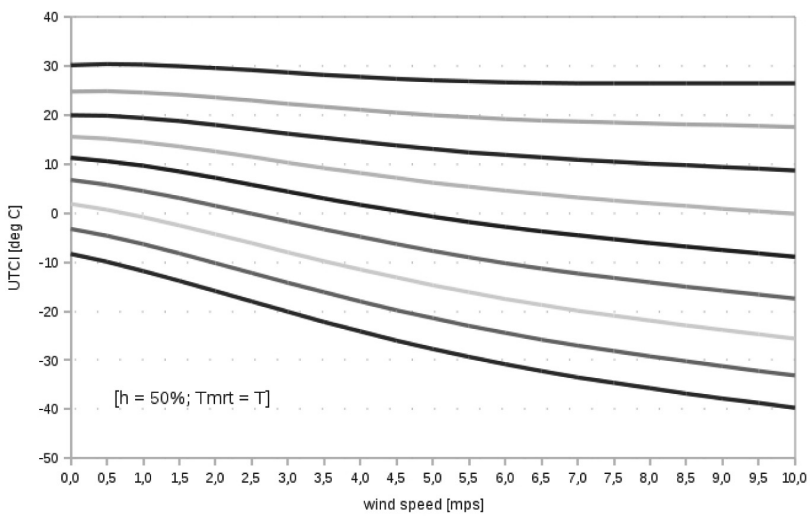

Fig. 4. The cooling effect of the wind speed for range < 0;10 $m \cdot s^{-1}$ > in the UTCI construction for air temperatures in the interval from –10 °C (lower line) to +30 °C (upper line) with step 5 °C

Ryc. 4. Efekt chłodzenia przy prędkości wiatru w przedziale < 0; 10 $m \cdot s^{-1}$ > w konstruowaniu wskaźnika UTCI w temperaturze powietrza w przedziale od –10°C (dolna linia) do +30°C (linia górna) z krokiem co 5°C

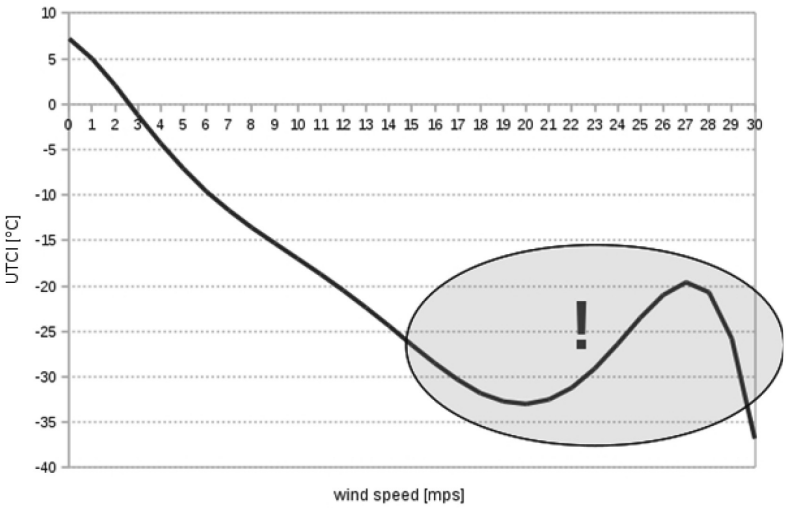

Fig. 5. The relation between UTCI and wind speed (for T = 5 °C, h = 70 %, ΔT_{mrt} = 0 K) for wind speed F in interval from 0 to 30 m·s^{-1}. The area of the UTCI strange behaviour is selected (gray)

Ryc. 5. Związek między UTCI i prędkością wiatru (przy T = 5°C, h = 70%, ΔT_{mrt} = 0 K) przy prędkości wiatru F w przedziale 0–30 m·s^{-1}. Obszar nietypowych wartości UTCI zaznaczono kolorem szarym

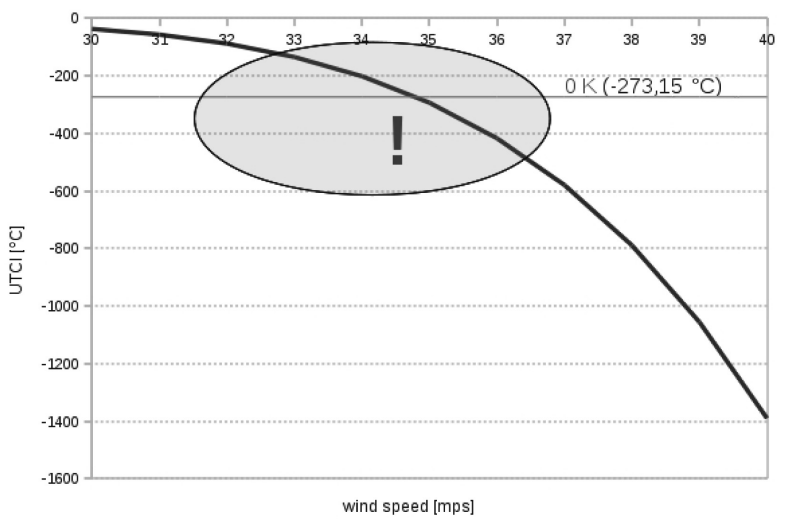

Fig. 6. The relation between UTCI and wind speed (for T = 5 °C, h = 70%, ΔT_{mrt} = 0 K) for wind speed F in interval from 30 to 40 m·s^{-1}. The area of the UTCI strange behaviour (fall under 0 K!) is selected (gray)

Ryc. 6. Związek między UTCI i prędkością wiatru (przy T = 5°C, h = 70%, ΔT_{mrt} = 0 K) przy prędkości wiatru F w przedziale 30–40 m·s^{-1}. Obszar nietypowych wartości UTCI (spadek poniżej 0 K!) zaznaczono kolorem szarym

The UTCI is index which is designed for an operational use (Jendritzky et al. 2009). Such index has to be defined for extreme situations too but the current version of the UTCI don't fulfil this requirement for all situations. This situation has a provisional resolution – it is possible to substitute the wind speed values over 20 $m \cdot s^{-1}$ by constant value 20 $m \cdot s^{-1}$.

ACKNOWLEDGEMENT

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UTCI *Calculator.* URL: <http://www.utci.org/utcineu/utcineu.php> [cit. 2010–12–08]