Geographia Polonica 2013, 86, 1, pp. 29-36

Geographia Polonica
Volume 86, Issue 1, pp. 29-36
http://dx.doi.org./10.7163/GPol.2013.4

INSTITUTE OF GEOGRAPHY AND SPATIAL ORGANIZATION
POLISH ACADEMY OF SCIENCES
www.igipz.pan.pl

www.geographiapolonica.pl

THE UTCI INDEX IN LESKO AND LUBLIN AND ITS CIRCULATION DETERMINANTS

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Abstract

In Lesko and Lublin, Poland, from 1981 to 2005, the *UTCI* values were calculated for 8 observation terms a day. The frequency of the *UTCI* classes determined as ‘cold stress’ was dominant in Lesko and in Lublin (65-66%). The frequency of classes determined as ‘heat stress’ was observed in 3% of all situations. On the other hand, restricted to the 12 UTC July and August term, the frequency of heat stress classes exceeded 40% in Lublin. Correlation between the *UTCI* in Lesko and Lublin (Poland) was stronger in spring and autumn than in summer and winter. Correlation between the *UTCI* and the meridional circulation index was more significant than between the *UTCI* and zonal circulation index in the period from April to November in both stations. The opposite situation occurred in February.

Key words

UTCI • cold stress • heat stress • atmospheric circulation • zonal circulation index • meridional circulation index

Introduction

The first objective of this paper was to determine the frequency of occurrence of the Universal Thermal Climate Index (*UTCI*) in individual classes of human organism thermal stress. The second objective was to determine the correlation of the *UTCI* and daily zonal and meridional circulation indices (calculated following formulas by Lityński 1969, 1970) analysed.

The *UTCI* resulted from calculations of human body heat balance. Values of the index depend on short- and long-wave radiation flux reaching the human body and long-wave radiation flux emitted by the human body as well as on ambient temperature, humidity and wind speed. The index values exceeding 26°C represent heat stress, and values below 9°C – cold stress. Four classes of heat stress are distinguished as well as five classes of cold stress, and a ‘no thermal stress’ class (see articles in the current issue Błażejczyk et al. 2013; Bröde et al. 2013).

Material and methods

In this paper, *UTCI* values from terms 00 UTC to 21 UTC (every 3 hours) in Lesko and Lublin-Radawiec were used. In Lesko, the IMGW weather station is located in the south-east part of the city (ϕ=49°28'N, λ=22°21'E), at an altitude of 420 m a.s.l. The Sanocko-Turczańskie Mountain region (the Carpatians) is located in this area. The IMGW weather station in Radawiec (ϕ=51°13'N, λ=22°24'E) is located within the Bełżyce Plateau area, at an altitude of 238 m a.s.l. The north area of the meteorological station grounds borders the grassy airport Aeroclub of Lublin Radawiec. The Lublin-Radawiec station is located on flat land. Lesko, on a local scale, has a convex relief form. On the other hand, the Lesko station situated in the mesoscale, has a concave relief form. The mountain ridges are about 120-200 m higher than the meteorological station and these ridges are situated 4-8 km SW and NE from Lesko (Nowosad 2007).

The analysis covered the period from 1981 to 2005. The values were calculated with the application of BioKlima 2.6 software (Błażejczyk 2011).

Daily values of zonal and meridional circulation indices (ZI and MI) were calculated following formulas by Lityński (1969, 1970). These indices are published on the Internet (Nowosad 2012). They are based on daily values of surface level pressure (SLP) available from NCEP/NCAR reanalysis (Kalnay et al. 1996). Calculations of ZI were based on differences in mean SLP on parallels 40° and 65°N (between 0° and 35°E with 2.5° step). Calculations of MI were based on differences in the average pressure on 35°E and 0° meridians (between 40° and 65°N, also with 2.5° step). Hence, ZI and MI characterize the daily large-scale pattern of general circulation valid for Poland and are the base of a synoptic climatology (Lityński 1969, 1970; Nowosad 2011).

The frequency of occurrence of specific thermal stress classes (according to the *UTCI*) in individual months in Lesko and Lublin was determined. Thermal stress classes proposed earlier, were adopted (see articles in the current issue Błażejczyk et al. 2013; Bröde et al. 2013). Frequencies corresponding to 12 UTC are presented in Table 1.

Linear correlation coefficients were calculated between *UTCI* values in Lesko and Lublin. Correlation coefficients for the same observation term at both stations, were calculated. Correlation coefficients were also calculated for the situation in which observation terms at both stations were different. Calculations covered the entire year (the 9,131 days of the 25 years), and all 4 seasons of the year (MAM, JJA, SON, DJF).

The relationship between the *UTCI* and circulation indices was analysed by determining partial correlation coefficients and creating multiple regression models in relation to individual months. Analysis of this correlation was based on *UTCI* values from 6, 12, and 18 UTC, as well as 24 UTC (i.e. 00 UTC of the following day; Table 3). Such an approach results from the situation in which the circulation index is specified for the entire day, and it is difficult to justify analysis of *UTCI* dependency at 0 UTC on circulation which occurs later.

Multiple linear regression models were constructed in relation to individual months, where independent variables are zonal and meridonal circulation indices, and the dependent variable is the *UTCI* (in Lesko and Lublin, respectively).

In the preparation of this article, Statistica 10.0 as well as Excel 2007 software was used.

Frequency of occurrence of *UTCI* classes in Lesko and Lublin

During the summer (JJA) there were days which had a 'no thermal stress' *UTCI* class. Dominance of this class in summer concerned all of the 8 terms analysed. The 'no thermal stress' class was recorded in the summer in Lesko from 49% at 3 UTC in June to 89% at 18 UTC in July and August, and in Lublin from 52% at 3 UTC in June to 88% at 18 UTC in June. This class was also dominant (both in Lesko and Lublin) from 9 UTC to 18 UTC in May and September. The frequency of occurrence of the 'no thermal stress' class was significant in April and October from 9 to 15 UTC (from 32% to 48%). Frequencies corresponding to 12 UTC are presented in Table 1.

Classes representing heat stress did not occur from 21 to 3 UTC. At 6 UTC, they occurred with insignificant frequency from May to August with the maximum occurring in July (11% in Lesko and 16% in Lublin). At 9, 12, and 15 UTC, the classes were recorded from April to September. In October, occasional cases of heat stress were recorded at 12 UTC (Lesko and Lublin) and at 9 UTC (Lesko). A single occurrence of heat stress was also observed in March (Lesko at 12 UTC).

Table 1. *UTCI* frequency in Lublin-Radawiec and Lesko at 12 UTC (1981-2005) in %.

A. Lublin-Radawiec	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Very strong heat stress	·	·	·	·	·	·	0.1	0.1	·	·	·	·	0.0
Strong heat stress	·	·	·	·	1.5	3.9	10.7	9.8	0.3	·	·	·	2.2
Moderate heat stress	·	·	·	2.5	17.0	23.9	30.4	30.9	10.0	1.0	·	·	9.7
No thermal stress	·	2.1	14.7	48.0	62.5	61.7	53.3	55.4	67.2	45.0	9.0	0.3	35.1
Slight cold stress	7.5	15.6	27.6	25.2	14.5	9.6	5.4	3.2	18.9	30.2	25.2	8.4	15.9
Moderate cold stress	48.5	46.2	40.1	19.7	4.4	0.9	0.1	0.6	3.6	22.5	47.9	51.6	23.7
Strong cold stress	40.3	32.4	16.4	4.5	0.1	·	·	·	·	1.3	16.8	36.5	12.3
Very strong cold stress	3.6	3.7	1.2	0.1	·	·	·	·	·	·	1.1	3.2	1.1
Extreme cold stress	0.1	·	·	·	·	·	·	·	·	·	·	·	0.0
Resume	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

B. Lesko	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Very strong heat stress	·	·	·	·	·	·	·	·	·	·	·	·	·
Strong heat stress	·	·	·	·	0.8	3.5	6.1	6.2	0.1	·	·	·	1.4
Moderate heat stress	·	·	0.1	0.9	11.0	16.8	27.2	29.9	10.3	1.5	·	·	8.2
No thermal stress	2.3	6.1	16.3	44.4	65.2	67.8	60.8	58.1	62.4	48.0	18.0	2.5	37.8
Slight cold stress	17.2	18.4	28.5	30.0	18.8	10.8	5.0	5.7	22.4	28.8	26.1	15.7	18.9
Moderate cold stress	44.7	43.2	38.8	19.9	4.1	1.1	0.9	0.1	4.8	20.1	42.0	47.1	22.1
Strong cold stress	30.7	28.0	15.6	4.7	0.1	·	·	·	·	1.6	13.1	31.4	10.4
Very strong cold stress	4.5	4.0	0.7	0.1	·	·	·	·	·	·	0.8	3.2	1.1
Extreme cold stress	0.6	0.3	·	·	·	·	·	·	·	·	·	0.1	0.1
Resume	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

The highest occurrence frequency of biothermal stress having a heat stress quality (total frequency of moderate, strong, and very strong heat stress) was in July and August (at 9 and 12 UTC in Lesko and Lublin, at 15 UTC in Lublin). The maximum frequency exceeded 40% at 12 UTC (in Lublin both in July and August). Classes representing heat stress occurred at 9 and 12 UTC in May in 12-19% of the situations, and in June in 20-28% of the situations. 'Moderate heat stress' was recorded in both stations from April to October (in Lesko one case on March, 19 1990). 'Strong heat stress' occurred from 15 May to 1-3 September. It was recorded at 9, 12, and 15 UTC. The highest frequency of the 'strong heat stress' class was recorded in Lublin in July at 12 UTC (11%). 'Very strong heat stress' did not occur in Lesko. It was recorded in Lublin twice, on July 31, and August 2, 1994.

Cold stress (the total contribution of classes from 'slight cold stress' to 'extreme cold stress') occurred in all months in each of the 8 observation terms. In January and February from 18 UTC to 6 UTC, only classes representing cold stress were recorded. From 9 to 15 UTC, cold stress frequency amounted to 98-100% (January) and 94-100% (February). The lowest occurrence frequency of cold stress was in July and August (from 9 to 15 UTC), amounting to 4-6%. 'Slight' and 'moderate cold stress' were observed in Lesko and Lublin throughout the year. 'Strong cold stress' occurred in Lublin from 1 October to 9 May. In Lesko, it even occurred in summer (June 15, 1982; July 5, 1984 and June 15, 1985). 'Very strong cold stress' occurred from 3 November to 12-14 April. The highest frequency of such biothermal stress was recorded in January and February (7-9% of situations). 'Extreme cold stress' was recorded sporadically, from 30 November (Lesko) and from 16 December (Lublin) to 18 February.

Analysis of all of the 8 observation terms from the 25 year period, revealed that situations determined as having 'no thermal stress' occurred with a 31% frequency in both stations. 'Heat stress' classes occurred with a frequency of 4% in Lublin and 3% in Lesko. The values for 'cold stress' situations were 65% in Lublin and 66% in Lesko.

When taking only noon (12 UTC) into consideration, 'no thermal stress' occurred with a frequency of 35% in Lublin and 38% in Lesko, 'heat stress' 12 and 10%, respectively, and 'cold stress' 53 and 52%, respectively (Tab. 1).

Correlation between the *UTCI* in Lesko and Lublin

Correlation coefficients between the daily *UTCI* values in Lesko and Lublin, calculated with the same term in mind, amounted to 0.88-0.92. The correlations, calculated with a time shift from 3 to 21 hours, are also strong and statistically significant (correlation coefficients 0.82-0.92). The coefficients, calculated based on 9,131 data pairs (daily values from the 25 year period), showed a highly significant correlation between the *UTCI* in Lesko and Lublin.

Correlation coefficients between *UTCI* values in Lesko and Lublin were also calculated by individual seasons of the year (MAM, JJA, SON, DJF). High covariance occurred for both spring and autumn. In spring, at the same time in both stations, the correlation coefficient amounted to 0.81-0.87, and in autumn 0.80-0.87. With a time shift from 3 to 21 hours, the correlation coefficient reached values of 0.69-0.86 and 0.72-0.86, respectively.

In summer, covariance of the *UTCI* in Lesko and Lublin, turned out to be lower than in spring and autumn. Correlation coefficients calculated for the same terms in summer varied from 0.67 to 0.78, and with a time shift from 3 to 21 hours, from 0.38 to 0.77. Relatively low values of correlation coefficients were obtained for winter. For the same terms, they varied from 0.57 to 0.67, and with a time shift, from 0.42 to 0.64.

The observed correlation between the *UTCI* in Lublin and Lesko, was stronger in transitional seasons (spring, autumn) than in summer and winter. An underlying trend was revealed. For example, ambient temperature markedly increased from March to May and thus, improved the correlation, whereas the data dependent trends were less distinct in summer and winter.

The multiple regression analysis for *UTCI* with the circulation indices

In order to analyse the extent of the effect of zonal and meridional circulation indices on the *UTCI* value, partial correlation coefficients were determined for the *UTCI* with MI and ZI as independent variables (Tab. 2). The coefficients measured the actual correlation between *UTCI* and MI as well as *UTCI* and ZI, after elimination of the latter circulation index's influence.

An example scatterplot shows (Fig. 1) that the linear relation between the *UTCI* and the circulation index (here MI) is not very strong. The significance of the linear correlation coefficient (at the level α=0.05) allows for the drawing of a regression line on the chart. April was chosen as an example because in this case, one variable was non-significant and the graph could be represented on the surface.

The Universal Thermal Climate Index is significantly positively correlated with the MI in all months, in both stations. The highest correlation was observed from April to September. Therefore, an increase in intensity of advection from the south is accompanied by an increase in the average *UTCI* value. The positive correlation of the MI and *UTCI* can be explained by the fact that advection from the south results in an increase in air temperature, and from the north – its decrease. The annual course of the meridional circulation index was presented by Nowosad (2011). Positive average values of this index occurred from mid-September to mid-April, and negative average values were from approx. 10 April to the end of August.

Partial correlation coefficients between the *UTCI* and the zonal circulation index adopted the highest positive values, and significant in January, February, and March. In those months, an increase in the average *UTCI* values was observed with intensified advection from the West. However, in July, significant negative correlation was observed between the *UTCI* and ZI. A decrease in the average *UTCI* values particularly occurred with intensified advection from the West, which could probably be associated with the cooling effect of maritime air masses originating from

Table 2. Partial correlation coefficients between the *UTCI* in Lublin and Lesko at 12 UTC and circulation indices MI and ZI (in bold – significant at the level α=0.05).

Station	Term UTC	Index	Month I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Lublin	6	ZI	**0.33**	**0.44**	**0.24**	0.01	-0.03	0.06	**-0.16**	-0.00	**0.08**	**0.14**	**0.19**	**0.19**
		MI	**0.18**	**0.20**	**0.19**	**0.36**	**0.32**	**0.37**	**0.44**	**0.34**	**0.31**	**0.21**	**0.23**	**0.16**
	12	ZI	**0.26**	**0.41**	**0.26**	0.05	-0.02	0.03	**-0.21**	-0.01	**0.08**	**0.20**	**0.26**	**0.22**
		MI	**0.27**	**0.30**	**0.29**	**0.43**	**0.33**	**0.45**	**0.49**	**0.42**	**0.41**	**0.39**	**0.40**	**0.29**
	18	ZI	**0.34**	**0.50**	**0.30**	0.06	0.03	0.06	**-0.15**	-0.01	**0.10**	**0.19**	**0.25**	**0.26**
		MI	**0.22**	**0.20**	**0.26**	**0.43**	**0.38**	**0.44**	**0.51**	**0.42**	**0.41**	**0.23**	**0.31**	**0.20**
	24	ZI	**0.34**	**0.46**	**0.28**	**0.09**	0.02	0.01	**-0.21**	-0.03	**0.09**	**0.18**	**0.22**	**0.23**
		MI	**0.22**	**0.21**	**0.26**	**0.45**	**0.43**	**0.48**	**0.51**	**0.45**	**0.41**	**0.23**	**0.32**	**0.20**
Lesko	6	ZI	**0.21**	**0.31**	**0.15**	-0.01	0.00	**0.09**	**-0.10**	**0.08**	**0.12**	**0.09**	**0.07**	0.07
		MI	**0.23**	**0.18**	**0.26**	**0.38**	**0.29**	**0.34**	**0.37**	**0.30**	**0.36**	**0.23**	**0.30**	**0.19**
	12	ZI	**0.13**	**0.23**	**0.18**	0.03	0.06	**0.10**	**-0.14**	0.06	**0.13**	**0.09**	**0.10**	-0.03
		MI	**0.31**	**0.26**	**0.36**	**0.44**	**0.34**	**0.41**	**0.44**	**0.40**	**0.40**	**0.40**	**0.42**	**0.35**
	18	ZI	**0.20**	**0.31**	**0.24**	0.06	**0.08**	0.07	**-0.13**	0.05	**0.09**	**0.13**	**0.10**	**0.12**
		MI	**0.23**	**0.16**	**0.20**	**0.42**	**0.31**	**0.35**	**0.43**	**0.27**	**0.33**	**0.26**	**0.33**	**0.22**
	24	ZI	**0.23**	**0.30**	**0.15**	0.03	0.05	0.03	**-0.18**	0.01	**0.10**	**0.13**	**0.09**	**0.10**
		MI	**0.26**	**0.18**	**0.24**	**0.41**	**0.32**	**0.32**	**0.42**	**0.32**	**0.35**	**0.30**	**0.34**	**0.22**

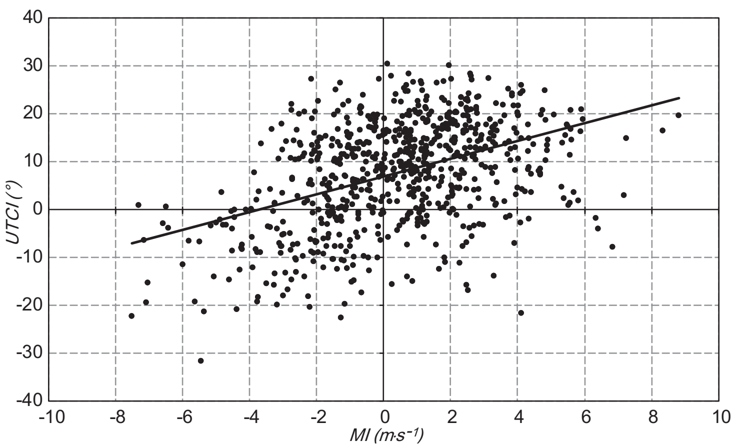

Figure 1. Scatterplot of MI and the *UTCI* in Lublin at 12 UTC in April (1981-2005).

above the Atlantic Ocean. Logically consistent with the opposing effects in winter and July, no significant effect could be determined in April and only non-significant or very weak effects in May and June (depending on the time of observation and place). There was an increase in the correlation in the remaining months of the year, starting from the usually non-significant correlation in August.

In the period from April to November, the *UTCI* was more significantly affected by meridional than zonal circulation. In February, zonal circulation prevailed. In December, January, and March, the partial correlation coefficients were significant, however, they differed only slightly between ZI and MI and the prevailing dependence varied with the specific time (Tab. 2).

Multiple linear regression models were also constructed for specific months in both stations based on observations at 12 UTC.

The models explain from 11% to 20% (Lesko) and to 26% (Lublin) of the original *UTCI* variability based on MI and ZI values (Tab. 3). Atmospheric circulation indices MI and ZI explain (by means of multiple linear regression models) the least *UTCI* variability in May (11-12%), and the most in July (20-26%).

Table 3. Percent of *UTCI* (at 12 UTC) variance (coefficient of multiple determination) explained by regression models of MI and ZI values.

Station	Month											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Lublin	13	23	13	19	11	21	26	18	17	18	20	13
Lesko	11	11	15	19	12	18	20	17	18	16	18	12

Four example models from months representing consecutive seasons of the year based on the *UTCI* values from Lublin are presented below.

The multiple regression formula

$$UTCI_{II} = -12.23_{(\pm 0.38)} + 0.84_{(\pm 0.07)} \cdot ZI + 0.82_{(\pm 0.10)} \cdot MI \ (\pm 8.48) \quad (1)$$

explains 23% of the *UTCI* variability in February. The predictive value of the model is not very high, because a large proportion of *UTCI* variance does not result from changes in circulation indices, but from other factors not analysable by the model. All variables included in the model are significant, and errors of estimated parameters and error of the entire model are minor.

Estimated positive regression coefficients indicate that an increase in indices ZI and MI by 1 $m \cdot s^{-1}$, results, on the average, in an increase in *UTCI* by 0.84°C and 0.82°C, respectively.

The last component in the formula presented above, is the standard error of estimate (Stanisz 2007). This means, the predicted (using the formula) *UTCI* values vary from the values observed, on the average, by 8.48°C. Parameters obtained in the regression model are accompanied by average errors of their estimate in brackets. Index 0.84 with variable ZI was estimated with an average error of 0.07, which constitutes approx. 8% of the value of the estimate, and suggests high precision of estimation. Similarly, an estimate of the slope coefficient with MI of 0.82 involves an average error of 0.10 which constitutes approx. 12% of the estimated value. An estimate of the constant term of -12.23 involves an average error of 0.38, which means only 3% error in the estimation of this parameter (Stanisz 2007).

In April, due to an insignificant effect of zonal circulation, the model is reduced to simple regression (Fig. 1)

$$UTCI_{IV} = 6.88_{(\pm 0.37)} + 1.86_{(\pm 0.14)} \cdot MI \ (\pm 9.95) \quad (2)$$

The above model explains 19% of *UTCI* variance. An increase in index MI by 1 $m \cdot s^{-1}$ results in an increase in the *UTCI*, on average, by 1.86°.

In July, the multiple regression formula is as follows

$$UTCI_{VII} = 25.80_{(\pm 0.29)} - 0.84_{(\pm 0.14)} \cdot ZI + 2.39_{(\pm 0.15)} \cdot MI \ (\pm 6.54) \quad (3)$$

and it explains 26% of *UTCI* variance. In this month, a decrease in western and an increase in southern circulation by 1 $m \cdot s^{-1}$ is accompanied by an average increase in *UTCI* by 0.84° and 2.39°, respectively.

In order to illustrate the dependency of the *UTCI* on circulation indices in autumn, the following regression model for November was developed, accounting for 20% total *UTCI* variance

$$UTCI_{IX} = -7.01_{(\pm 0.41)} + 0.71_{(\pm 0.10)} \cdot ZI + 1.08_{(\pm 0.09)} \cdot MI \ (\pm 8.61) \quad (4)$$

The average increase in the *UTCI* with increased indices ZI or MI by 1 $m \cdot s^{-1}$ amounts to 0.71 and 1.08, respectively.

Discussion and conclusions

The Universal Thermal Climate Index reflects the impact of a variety of meteorological variables on the human body heat balance in a thermo-physiologically exact manner. Thus, the index enables general meteorological information to be transformed into evidence for human-biometeorological applications, e.g., for assessing tendencies to heat load or to cold stress.

The daily *UTCI* values from 25 years, calculated for several terms, in two distant places – Lesko and Lublin, are strongly correlated. This result positively answers the question about whether correlation of circulation indices and the index based on human body thermal balance is justified. Lesko and Lublin belong to the same large-scale climatic region. The main features of seasonal courses in meteorological elements, especially of ambient temperature and short- and long-wave irradiances, are more or less comparable and contribute with high amounts to the overall variability. These features cause relative high correlation coefficients in linear regression.

The circulation indices MI and ZI have an important role in the formation of weather conditions in Poland and are the base of a synoptic climatology (e.g. Lityński 1969, 1970), i.e., they are linked with typical deviations from long-term seasonal climatology. The impact may vary with the season, e.g. the warming effect of the Atlantic air masses in winter and cooling in summer. Multiple linear regression models indicate that MI and ZI can explain 11 to 26% of *UTCI* variability in individual months. On the one hand, the *UTCI* can significantly reveal the thermo-physiologically based phenomena linked with the synoptic scale, which is the subject of this paper. On the other hand, regional, and in particular local conditions, were responsible for 74 to 89% of the variance observed in the *UTCI*. For example, MI and ZI are defined as the speed of geostrophic wind (Lityński 1969, 1970): on the regional and local level these indices influence on wind speed observed 1.5 m above ground and relevant for the *UTCI* is, among others, strongly modulated by the roughness length of the surface layer. The roughness regionally is higher in the more mountainous terrain around Lesko.

The study on *UTCI* variability in Lesko and Lublin, and variability of atmospheric circulation indices (MI and ZI) led to the following conclusions:

Both in Lesko and Lublin, classes representing 'cold stress' (65-66% of all situations and 52-53% of situations at 12 UTC) were dominant. 'Heat stress' was recorded in 3% of all situations (10-12% of situations at 12 UTC). 'No thermal stress' occurred in 31% of all situations (35-38% of situations at 12 UTC).

The highest occurrence frequency of biothermal stress with a heat stress character, was recorded in July and August at 9 and 12 UTC (in Lublin also at 15 UTC). The maximum frequency exceeded 40% (Tab. 1).

In January and February, almost only the situations determined as 'cold stress' can be expected. At 9, 12, and 15 UTC, 'cold stress' frequency amounted to 94-100%. In the remaining terms (from 18 to 6 UTC), only 'cold stress' classes were recorded.

The correlation between the *UTCI* in Lublin and Lesko was higher in spring and autumn than in summer and winter.

A positive, statistically significant correlation in all 12 months between the *UTCI* and MI was observed. Values of the partial correlation coefficient between the *UTCI* and MI are higher from April to September than in the period from October to March (Tab. 2).

A positive, statistically significant correlation between the *UTCI* and ZI were found in January, February, and March. Advection from the west was usually accompanied by an inflow of relatively warm air, which can be reflected in *UTCI* values calculated during that time. Positive values of partial correlation coefficients were also typical of the period from September to December (although the coefficients are not always significant at the level α=0.05). In April, May, June, and August, correlation either did not occur or was weak. In July, negative correlation was observed, i.e. an increase in intensity of circulation from the west resulted in a decrease in the *UTCI*.

In the period from April to November, the *UTCI* was affected more by meridional than zonal circulation. In February, the *UTCI* was affected more by zonal than meridional circulation.

Acknowledgements

NCEP Reanalysis data were provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their Web site at http://www.esrl.noaa.gov/psd/ (Kalnay et al. 1996).

We would like to thank the two anonymous Reviewers for important comments, which helped as to improve the original manuscript.

Editors' note:
Unless otherwise stated, the sources of tables and figures are the author(s), on the basis of their own research.

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Article first received • February 2012
Article accepted • May 2012