Biothermal features of air masses in Warsaw with respect to their presumed meteorotrophy

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Introduction

The Spatial Synoptic Classification (SSC) is the air mass classification, in which masses are determined according to the values of meteorological elements, such as: air temperature, difference between air temperature and dew point temperature, average cloudiness, atmospheric pressure at sea level from 3:00, 9:00, 15:00 and 21:00 UTC, as well as amplitude of air temperature and amplitude of dew point temperature (Davies and Kalkstein 1990, Sheridan 2002, Bower et al. 2007). In the SSC, the weather situation is treated as a set of meteorological elements and therefore sometimes is considered as a classification of weather types. This makes it useful for biometeorological research on the influence of air masses on morbidity or mortality.

In Poland, the most popular air mass classification is the geographical classification, where each air mass category is determined by its source region. Fig. 1 presents how SSC air masses correspond to the geographical air masses in Warsaw.

As reported, dry tropical (DT) or moist tropical (MT) air masses, are related with excessive mortality due to cardiovascular disease in warm season (Urban and Kysely 2018). Especially MT+ subtype is considered to be very offensive (Kalkstein et al. 2011), although in the following study it has been included into the MT category, as it's occurrence in Central Europe is rather low.

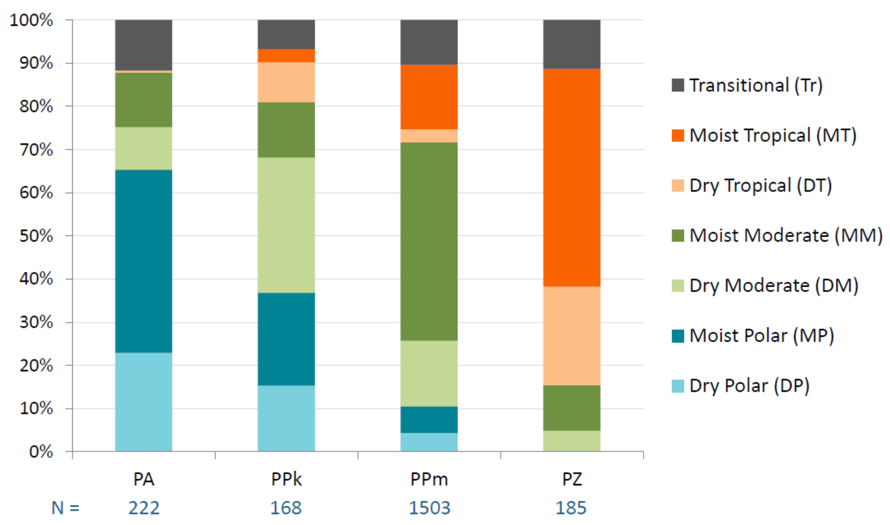

Fig. 1. The relationship of SSC air masses to geographical air mass types in Warsaw (2013-2017)

*Geographical air masses: arcitc air (**PA**), polar maritime air (**PPm**), polar continental air (**PPk**) and tropical air (PZ)*

The aim of the study is to analyze the biothermal potential of air masses in Warsaw to influence morbidity due to selected health conditions.

Air masses in Warsaw

In Warsaw prevail the moist types of air masses during the year. The most frequent air mass is MM (36.5%), especially in autumn and winter (Fig. 2). In summer, there is also a significant contribution of warm and humid MT air, which can induce sultriness. The warmest and potentially oxygen-deficient is DT air mass, but it occurs in Warsaw least often (4.6%). In winter, the coolest and most polluted by PM_{10} is DP air, while in other seasons the lowest mean air temperature is observed in MP air mass. Physical properties of air masses change remarkably during the year. Their main meteorological characteristics are presented below (Tab. 1).

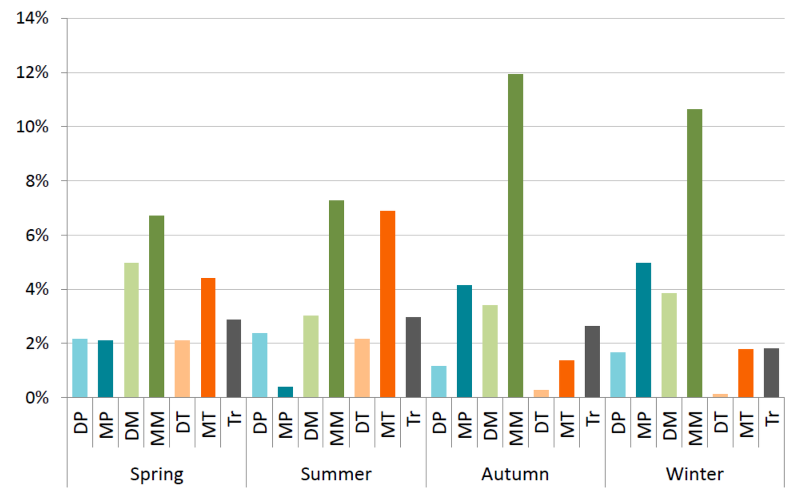

Fig. 2. Frequency (%) of air masses in Warsaw (2013-2017)

Tab. 1. Properties of air masses in Warsaw in particular seasons (2013-2017)

t – air temperature, e – vapour pressure, Ov – oxygen volume, PM_{10} – concentration of particulate matters ≤ 10μm

SSC	Spring				Summer				Autumn				Winter			
	t (°C)	e (hPa)	Ov (g/m³)	PM_{10} (μg/m³)	t (°C)	e (hPa)	Ov (g/m³)	PM_{10} (μg/m³)	t (°C)	e (hPa)	Ov (g/m³)	PM_{10} (μg/m³)	t (°C)	e (hPa)	Ov (g/m³)	PM_{10} (μg/m³)
DP	4.4	5.5	286.6	22.2	16.2	11.1	273.4	17.5	6.2	6.4	285.8	33.0	-8.8	2.4	305.4	51.6
MP	3.1	6.8	287.6	28.0	13.4	12.9	275.3	16.1	3.7	7.3	289.2	29.7	-4.2	4.0	299.4	46.7
DM	8.8	6.7	281.6	34.5	18.6	12.1	270.8	22.5	12.9	10.3	276.2	33.3	2.1	5.4	289.4	37.5
MM	7.7	8.6	282.7	28.0	17.0	14.7	271.4	18.4	9.5	10.5	280.7	32.1	2.3	6.5	289.7	38.2
DT	15.8	9.8	271.7	40.8	24.0	14.4	264.3	31.4	22.8	16.3	263.5	36.4	7.0	6.7	281.1	17.9
MT	15.4	12.1	272.0	32.7	22.0	17.3	265.1	24.7	17.0	13.9	269.6	28.8	6.9	7.7	283.9	20.0
TR	8.3	7.7	281.1	31.0	19.9	14.9	267.4	22.6	10.0	10.1	279.4	28.1	-0.2	5.2	293.3	31.9

Thermal stress in air masses in Warsaw (according to UTCI values)

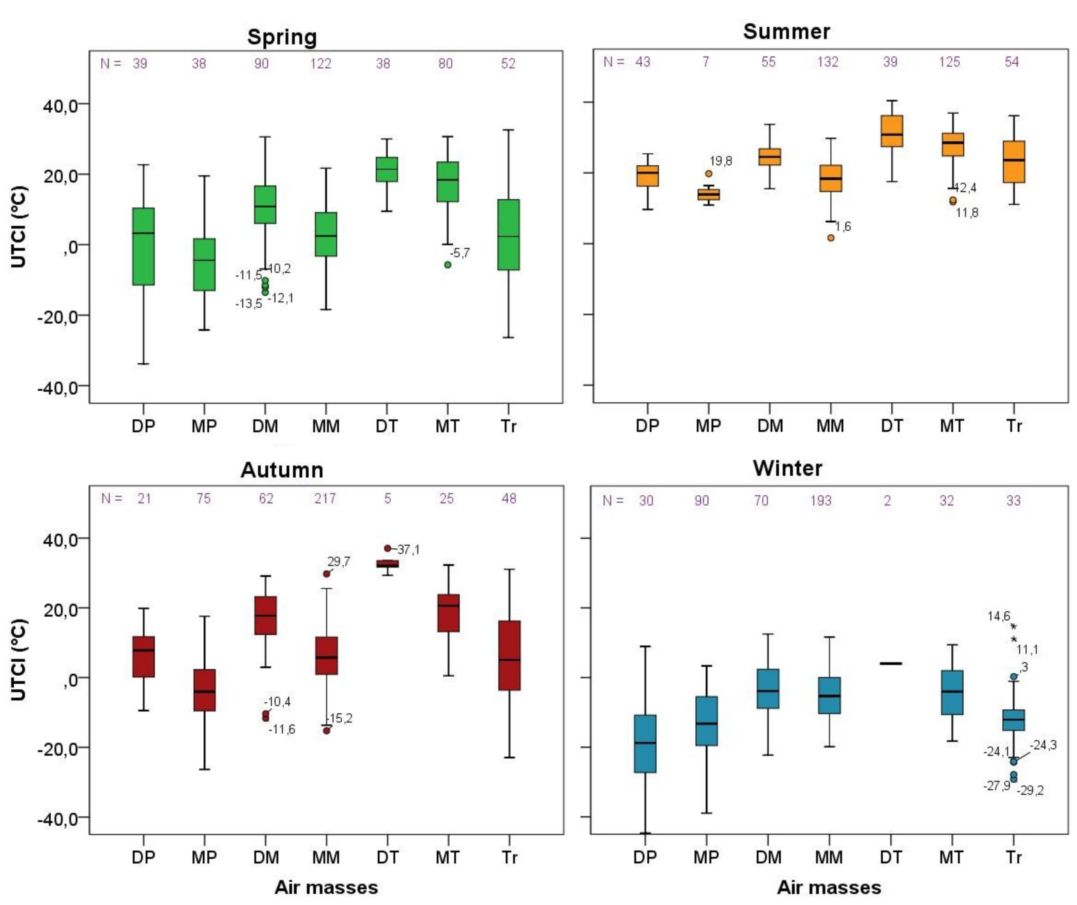

Fig. 3. The extent of *UTCI* values at 12:00 UTC in air masses in particular seasons in Warsaw (2013-2017)

To determine thermal stress occurrence in Warsaw, Universal Thermal Climate Index (*UTCI*) for 12:00 UTC was calculated. The highest, and also least differentiated *UTCI* values during the season are observed in summer - for both DT and MT air masses, median of *UTCI* is higher than 20°C (Fig. 3) and heat stress is reported most frequently (Fig. 4a). In the analysed period, very strong heat stress occurs only twice in DT in summer (Fig. 4a). Heat load is also typical for DT air in autumn (Fig. 4a), but this air mass is very rare during this time of the year (Fig. 3).

The biggest thermal contrasts and the widest range of *UTCI* values are observed in transitional seasons, especially in transitional situations (Tr) (spring and autumn) and in DP air mass (spring) (Fig. 3). The interquartile ranges (IQR) are higher than 20°C, what confirms high heterogeneity of biothermal conditions in that cases.

Cold stress in spring and autumn is mostly associated with polar air masses (DP and MP) (Fig. 4b). In winter, all air masses, except for DT, can cause at least moderate cold load for human organism. Very strong cold stress occurs from December to February in DP, MP and Tr. In the analysed period, extreme cold stress was observed only once, in DP.

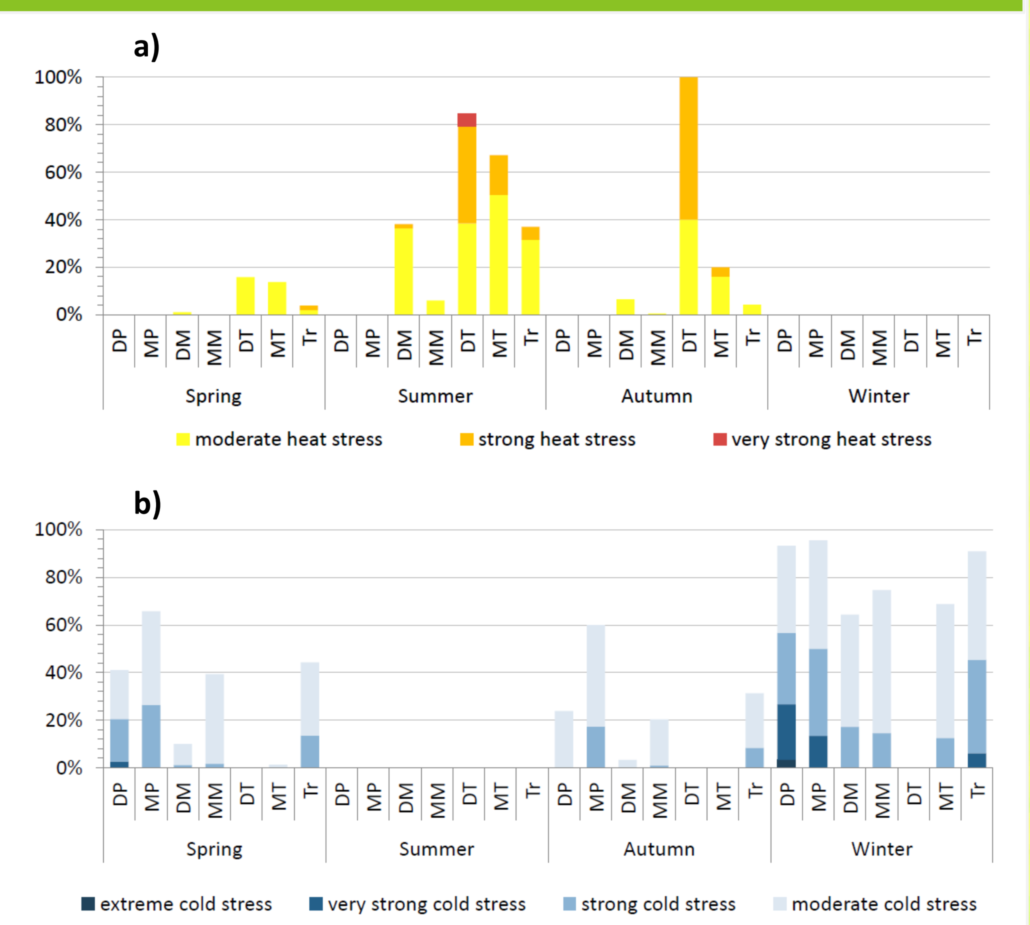

Fig. 4. Frequency (%) of a) heat stress and b) cold stress categories of UTCI at 12:00 UTC for each air mass in seasons in Warsaw (2013-2017)

Morbidity in air masses in Warsaw – a case study

The relationship between SSC air mass types and morbidity due to **acute myocardial infarction** (I21 according to ICD-10) and **other chronic obstructive pulmonary disease** (J44) was tested, applying methodology developed by McGregor et al. (1999). An admission rate index (AR) was calculated according to the formula:

AR = (daily admission / season average admission)·100%.

This index standardises the admissions data with respect to individual seasons.

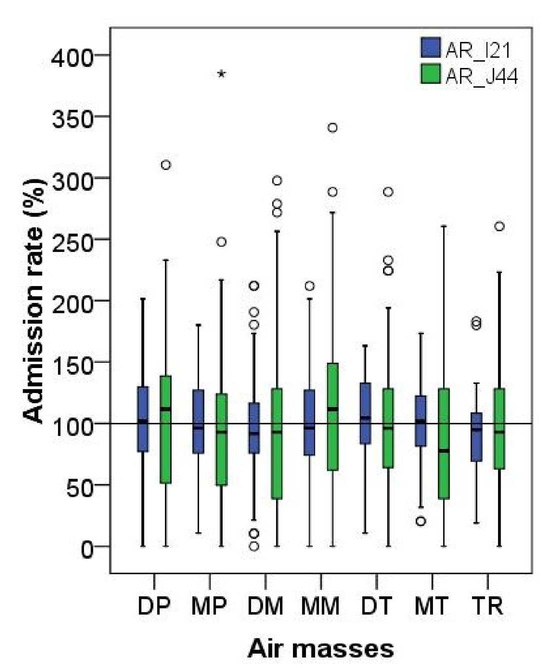

Fig. 5. Differentiation of admission rate (AR) due to acute myocardial infarction (I21) and other chronic obstructive pulmonary disease (J44) in particular air masses in Warsaw (2013-2014)

Daily admission rate fluctuates more in J44 than in I21 cases, regardless of the air mass type, what confirms higher IQR of AR_J44 (Fig. 5). Higher AR_I21 values are in general connected with DP, as well as DT and MT air occurrence, while higher AR_J44 values are observed upon advection of DP or MM air mass. Chi-square analysis revealed a significant dependence (p<0.0001) of daily AR values on air mass types during the year, with the contingency coefficient equal 0.669 for I21 and 0.554 for J44. However, this dependency is insignificant when taking into account particular seasons, with the exception of winter AR_I21 (p<0.0001; C = 0.728).

The 719 daily AR values were partitioned into three classes (AR <100%, 100-150% and ≥150%) and subjected to conditional probability analyses. Conditional probabilities were calculated as the probability that admission rates will exceed a certain AR level, given the occurrence of a specified air mass.

DT air in summer and spring, as well as polar masses (DP and MP) in winter contribute to higher morbidity due to I21, while higher AR due to J44 is associated with DP air masses, with the exception of spring (Tab. 2).

Chi-square analysis reveals a significant dependence (p<0.0001) of daily AR values on *UTCI* thermal stress categories during the year (C_I21 = 0.76; C_J44 = 0.699), hence, the increased AR due to I21 and J44 in particular air masses could be partially explained by the biothermal conditions.

Tab. 1. Conditional probabilities for admission rate index due to acute myocardial infarction (AR_I21) and other chronic obstructive pulmonary disease (AR_J44) by air mass type in Warsaw in particular seasons (2013-2014)

AR_I21		SSC air masses						
		DP	MP	DM	MM	DT	MT	TR
Spring	<100%	63.2	62.5	70.3	43.2	37.9	60.9	53.8
	100-150%	26.3	37.5	24.3	**37.8**	**41.4**	26.1	46.2
	≥150%	10.5	·	5.4	**18.9**	**20.7**	13.0	·
Summer	<100%	36.4	*66.7*	56.8	52.3	31.6	39.0	66.7
	100-150%	**50.0**	*33.3*	31.8	38.6	**57.9**	**56.1**	33.3
	≥150%	**13.6**	·	11.4	9.1	**10.5**	**4.9**	·
Autumn	<100%	60.0	45.8	48.5	50.6	*66.7*	57.1	84.6
	100-150%	33.3	**37.5**	**42.4**	43.4	*33.3*	42.9	7.7
	≥150%	6.7	**16.7**	**9.1**	6.0	·	·	7.7
Winter	<100%	36.4	48.9	65.9	52.3	*100.0*	50.0	62.5
	100-150%	**54.5**	**28.9**	31.7	32.3	·	50.0	25.0
	≥150%	**9.1**	**22.2**	2.4	15.4	·	·	12.5

AR_J44		SSC air masses						
		DP	MP	DM	MM	DT	MT	TR
Spring	<100%	68.4	75.0	62.2	48.6	51.7	87.0	53.8
	100-150%	21.1	8.3	21.6	**24.3**	24.1	8.7	38.5
	≥150%	10.5	16.7	16.2	**27.0**	24.1	4.3	7.7
Summer	<100%	40.9	*83.3*	56.8	50.0	52.6	48.8	66.7
	100-150%	**22.7**	·	22.7	22.7	26.3	**19.5**	33.3
	≥150%	**36.4**	*16.7*	20.5	27.3	21.1	**31.7**	·
Autumn	<100%	33.3	62.5	54.5	41.0	*33.3*	71.4	53.8
	100-150%	**60.0**	33.3	33.3	**44.6**	***33.3***	14.3	15.4
	≥150%	**6.7**	4.2	12.1	**14.5**	***33.3***	14.3	30.8
Winter	<100%	36.4	62.2	61.0	58.5	*100.0*	50.0	87.5
	100-150%	**27.3**	17.8	2.4	12.3	·	·	·
	≥150%	**36.4**	20.0	36.6	29.2	·	50.0	12.5

In **red and bold** are given the increased AR probabilities in air mass types, where AR ≥ 100% probability was higher than 0.5.

In *grey and italic* are marked those probabilities values, that were calculated from less than 10 cases. They are considered unreliable due to the small statistical sample.

Conclusions

- The most frequent air mass in Warsaw – MM (36.5%) is potentially not offensive to human health, as it is rarely associated with thermal stress. On the other hand, thermal load is observed most often in winter, when all air masses, except for DT, can cause at least moderate cold stress.
- Although there is significant dependence of daily admission rate (AR) values on air mass types, this relationship is not statistically confirmed in particular seasons. In this case, too small sample (N < 200 for each season) may be an explanation.
- DT in summer and spring is frequently related to heat stress and at the same time is associated with higher AR due to acute myocardial infarction (I21).
- DP and MP in winter are frequently related to cold stress. and at the same time are associated with higher AR due to acute myocardial infarction (I21).
- The above observations suggest that these particular air masses in these particular seasons, increase the risk of acute myocardial infarction, which may be attributed to their thermal stress potential.

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