







# Assessment of bioclimate conditions in Vojvodina (Northern Serbia)

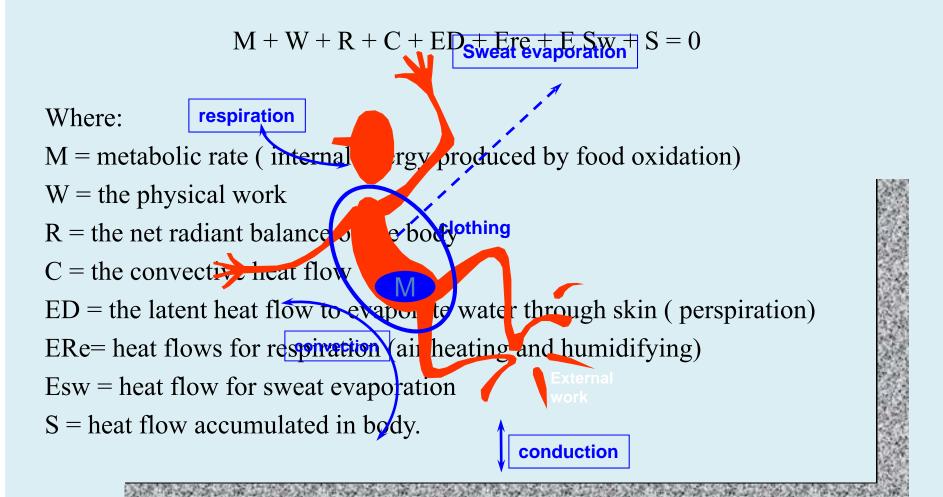
Biljana Basarin\*, Tin Lukić\*, Aleksandra Kržič, Bojana Janićijević Petrović\*, Sonja Ćopić\*, Dragana Matić\*



### 1. Introduction

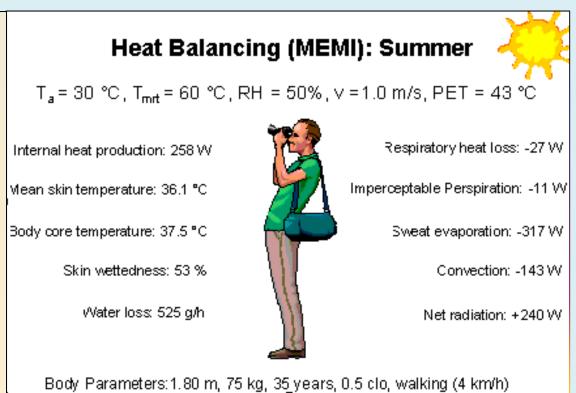
- "Biometeorology" is defined as "an interdisciplinary science that considers the interactions between atmospheric processes and living organisms (plants, animals and humans)"(International Society of Biometeorology (ISB) 2013).
- The central question within the field is "*how does weather and climate impact the well-being of all living creatures*?" (ISB, 2013).
- Over the last two decades biometeorology has experienced a renaissance, a result of the growing concern about the impact of weather and climate on living organisms and the effects of human activities on the atmospheric environment, especially in the context of global environmental change (McGregor, 2011).

• The conventional heat balance equation which describes energy flows body/environment is:

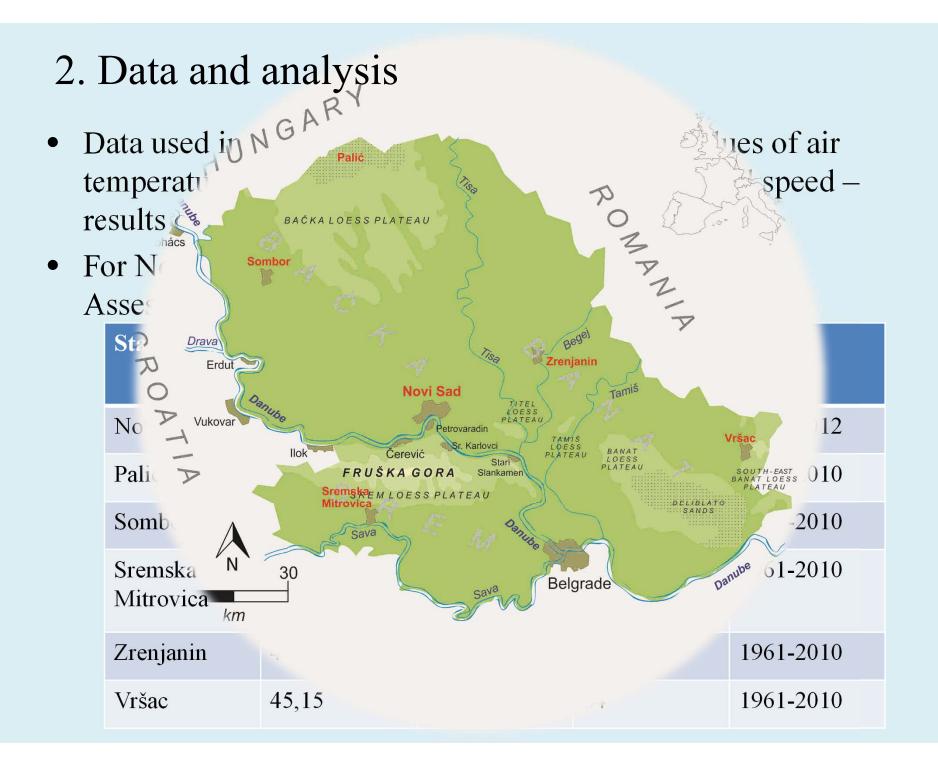


• Physiological equivalent temperature (PET) and Universal Thermal Climate Index (UTCI) are indices derived from heat budget models.

Indices derived from heat budget models. PET is based on the Munich Energy-balance Model for Individuals (MEMI) which describes the thermal conditions of the human body in a physiological relevant way



- The universal thermal climate index (UTCI) is an international standard performed by the European Cooperation in Science and Technology (COST) Action 730, based on recent research in human response-related thermo-physiological modeling (COST 2011).
- Thermo-physiologically significant in the whole range of heat exchange conditions
- Valid in all climates, seasons and scales
- Independent of individual characteristics
- Temperature scale index



- In the calculations of *PET* RayMan model was used.
- Meteorological variables used air temperature, relative humidity, vapour preasure, wind velocity and radiant temperature. Human parameters influencing *PET*, such as activity, heat resistance of clothing, height, and weight are usually standardized in MEMI.

PET (°C)	Thermal sensation	Physiological stress level
<4	Very cold	Extreme cold stress
4-8	Cold	Strong cold stress
8–13	Cool	Moderate cold stress
13-18	Slightly cool	Slight cold stress
18–23	Comfortable	No thermal stress
23–29	Slightly warm	Slight heat stress
29-35	Warm	Moderate heat stress
35-41	Hot	Strong heat stress
>41	Very hot	Extreme heat stress

Thermal sensation, physiological stress level and PET classes for Western/Middle European classes (Matzarakis & Mayer, 1996)

RayMan 1.2		
File Input Output Table Language Date and time Date (day.month.year) 14.10.2013 Day of year 287	Current data Air temperature Ta (*C) Vapour pressure VP (hPa)	20.0
Local time (h:mm) 10:37	Rel. Humidity RH (%) Wind velocity v (m/s)	53.5 1.0 New
Geographic data Location: ZRENJANIN Add location Remove location	Cloud cover C (octas) Global radiation G (W/m,) Mean radiant temp. Tmrt (*C	
Geogr. longitude (*'E)         45*24'           Geogr. latitude (*'N)         20*21'           Altitude (m)         80	Personal data       Height (m)     1.75       Weight (kg)     75.0       Age (a)     35 🛫	Clothing and aktivity Clothing (clo) 0.9 Aktivity (W) 80.0
time zone (UTC + h) 1.0	Sex m	<u>i</u> <u>C</u> lose

Main window of RayMan.

- In the calculations of UTCI Bioklima software was used.
- Meteorological variables used air temperature, relative humidity, vapour preasure, wind velocity and radiant temperature.

File Edit Calculations Options Window Help

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		- t	Mrt	tmax	tmin	е	v	v10m	f	N	р	pre	c
UTCI assessment scale (Bröde et al., 20	12)	7.30	7.30	12.50	3.70	10.33	0.36	0.36	92.00	6.25	1030.60	0	
or or assessment scale (broac crail, 20	2	8.50	8.50	16.50	4.80	13.00	1.98	1.98	95.00	0.00	1025.70	0	
	3	8.50	8.50	16.30	2.70	11.81	1.87	1.87	91.00	3.75	1010.10	0	
		7.40	7.40	18.00	2.50	12.86	3.30	3.30	92.00	1.25	1002.20	0	
JTCI (°C) Stress category	6	3.10	3.10 3.50	8.80	0.50	8.08	1.44 0.43	0.43	95.00 92.00	0.00	1011.60	0	
		2.00	2.00	7.50	-1.90	6.82	1.44	1.44	87.00	3.75	1020.80	0	
> +46 Extreme heat stre	ess 8	-1.00	-1.00	5.00	-5.10	6.00	1.21	1.21	93.00	0.00	1023.80	0	
	9	0.90	0.90	1.90	-2.20	5.61	0.42	0.42	92.00	1.25	1018.40	8	
-38 to +46 Very strong heat	stress 10	1.10	1.10	2.60	0.00	5.86	0.62	0.62	87.00	8.75	1024.40	0	
	11	1.20	1.20	5.10	-3.00	5.75	0.59	0.59	84.00	7.50	1030 E0 es selection	0	
-32 to +38 Strong heat stres		0.70	0.70	2.70	-2.00	5.65	1.79	1.79	89.00				
-26 to +32 Moderate heat st	13 13	0.60	0.60	2.20	-0.40	5.83	0.86	0.86	89.00	Tek	indices to be ca	alculated	Select
20 to 152 Woderate heat st	14	0.10	0.10	1.50	-1.00	5.37	1.01	1.01	86.00	Tg Ts			Aļi <u>N</u> one
-9 to +26 No thermal stress	S 15	-1.20	-1.20 -0.60	1.00	-8.10 -5.00	4.25	0.88	0.88	86.00 85.00	W_Prec	c		General evaluation of bioclimatic co
		-0.80	-3.30	2.30	-9.00	4.57	2.37	2.37	90.00	W_Pred W_Rad W_Sen	j Iș		Detailed analysis of bioclimatic con
-9 to 0 Slight cold stress	18	1.60	1.60	3.50	-9.80	4.89	2.88	2.88	91.00	W_Stra	ann : 1 of 58		General evaluation of heat balance
to -13 Moderate cold st		2.40	2.40	5.40	0.70	6.85	1.29	1.29	89.00	Universa	v Thermal Climate Ir.	ndex	Detailed analysis of heat balance
to =15 Wodefale cold st	20	4.20	4.20	8.40	2.20	7.45	1.79	1.79	82.00		-		Weather
-13 to -27 Strong cold stres	S 21	4.00	4.00	7.50	1.50	7.64	1.40	1.40	89.00		✓ <u>C</u> alculate		🗶 Cancel
6	22	2.40	2.40	6.50	0.40	6.71	1.64	1.64	84.00				Cancer
-27 to -40 Very strong cold		-2.60	-2.60	1.30	-5.50	4.84	0.58	0.58	90.00	10.00	1031.80	0	
40 Extreme cold str	24	-3.70	-3.70	1.00	-8.00	4.01	1.62	1.62	81.00	5.00	1032.30	0	
<-40 Extreme cold str	ess 25	-3.10	-3.10	0.20	-8.00	3.77	1.94	1.94	79.00	1.25	1034.70	0	
	26	-1.30	-1.30	3.40	-7.10 -6.70	4.61	3.06	3.06	81.00	10.00	1032.50	U	
	27	-1.90	-1.90	3.50	-6.70	4.62	2.73	2.73	80.00	6.25	1027.00	0	

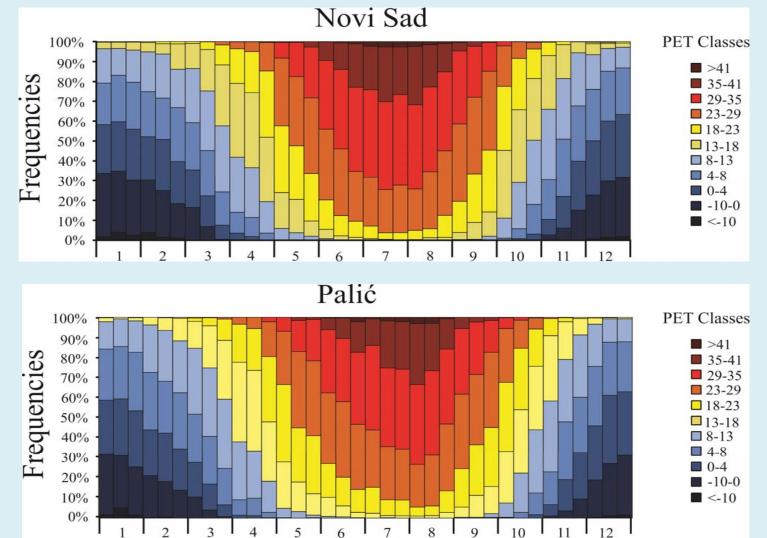
Main window of BioKlima.

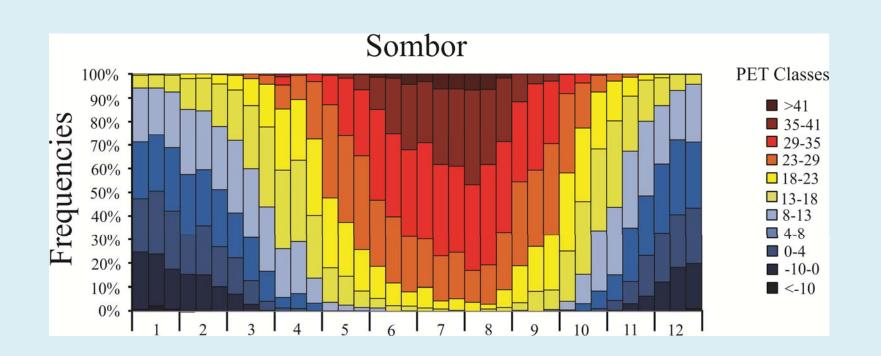
• The Mann–Kendall rank statistic method was applied concerning the trends of the time series of annual number of days with mean daily PET/UTCI falling in the extreme classes of PET/UTCI.

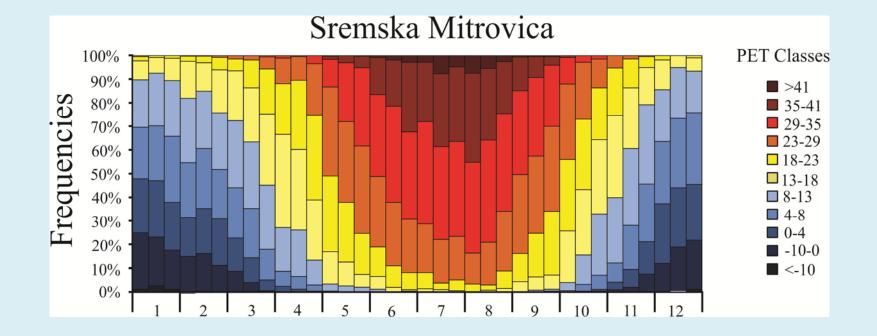
PET (°C)	Thermal sensation	Physiological stress level	UTCI (°C)	Stress category
<4	Very cold	Extreme cold stress	> +46	Extreme heat stress
4-8	Cold	Strong cold stress	+38 to +46	Very strong heat stress
8–13	Cool	Moderate cold stress	+32 to +38	Strong heat stress
13-18	Slightly cool	Slight cold stress	+26  to  +32	Moderate heat stress
18-23	Comfortable	No thermal stress	+ <u>9 to +26</u>	No thermal stress
23–29	Slightly warm	Slight heat stress	+9  to  0	Slight cold stress
29-35	Warm	Moderate heat stress	0 to -13 -13 to -27	Moderate cold stress Strong cold stress
3 <u>5–41</u>	Hot	Strong heat stress	-13  to  -27 -27  to  -40	Very strong cold stress
>41	Very hot	Extreme heat stress	<-40	Extreme cold stress

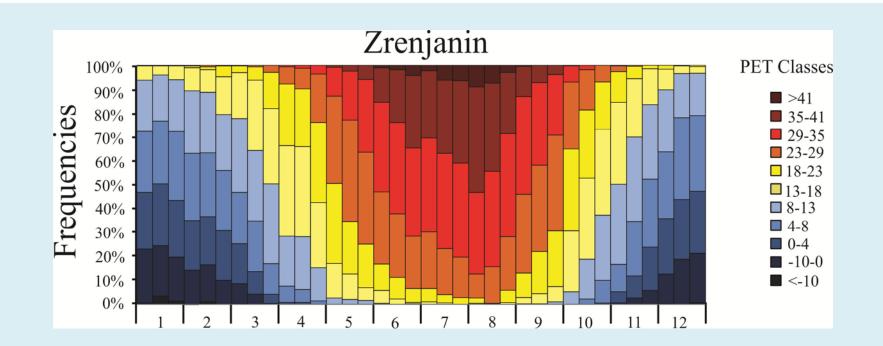
### 3. Results and discussion

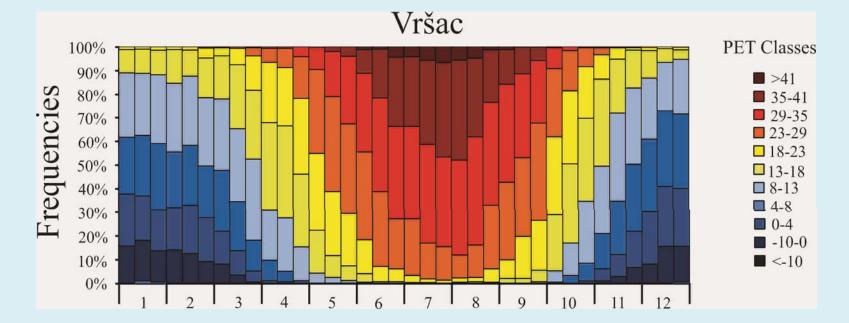
The human thermal bioclimatic conditions are expressed in percentages of the occurrence of PET classes for each month.

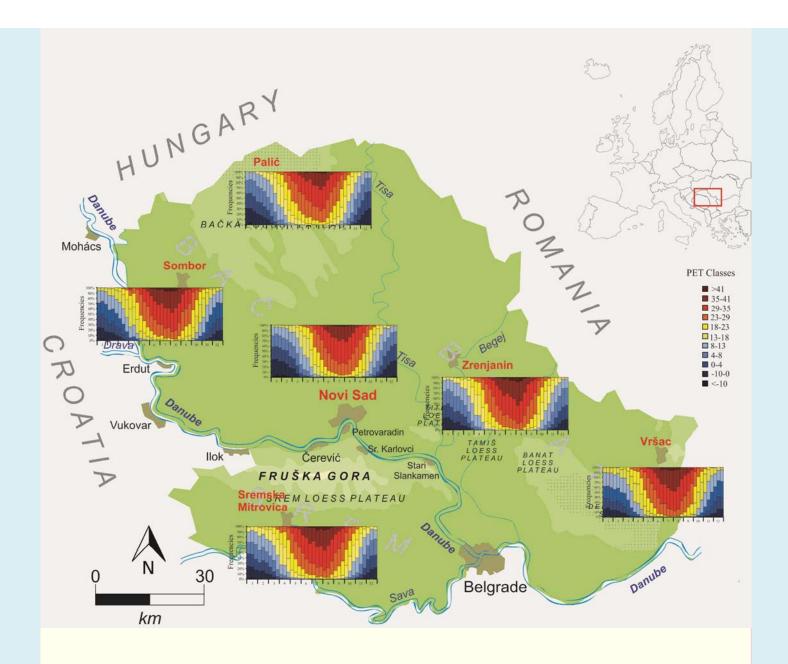




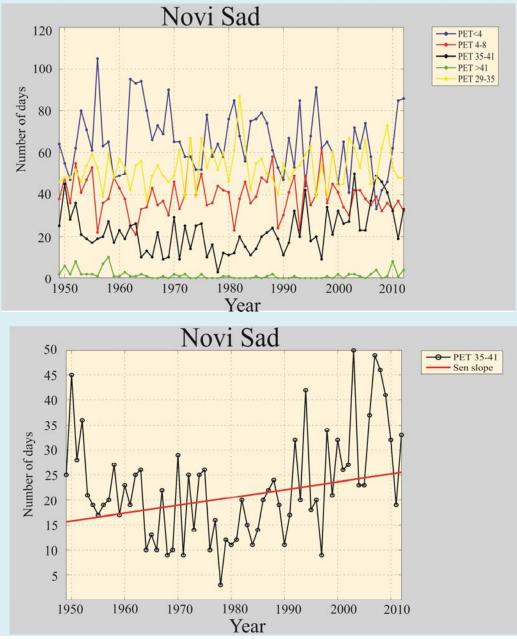


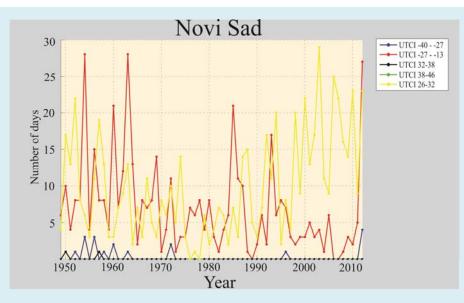


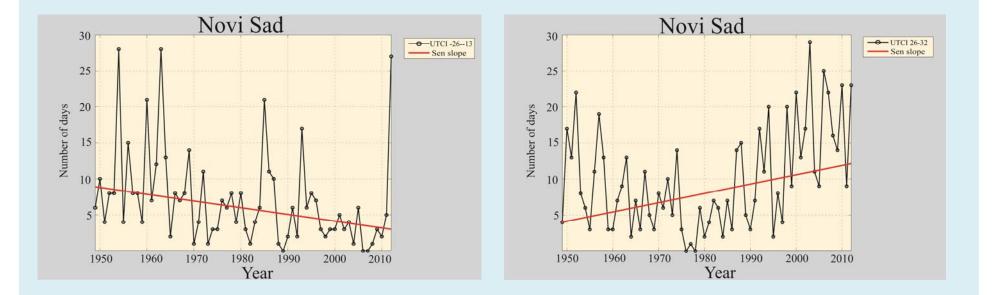


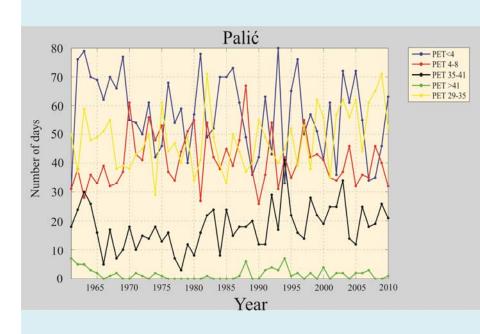


• Time series of annual number of days within extreme classes of mean daily PET and linear trends.

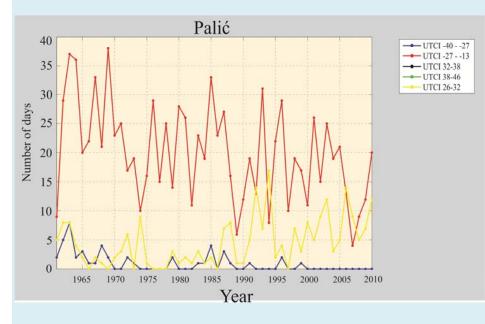






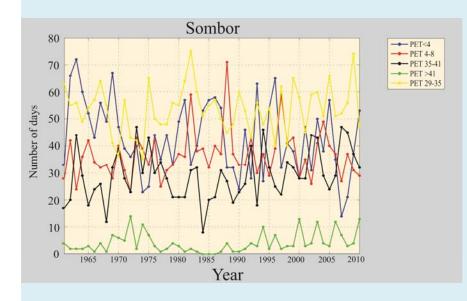


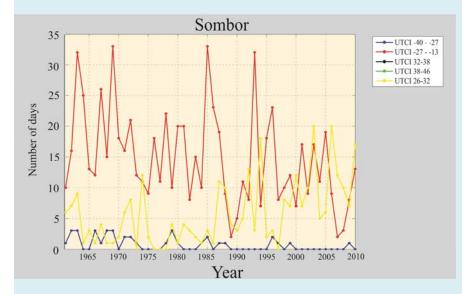
PET clases	P value	Z
29-35° C	0.0199	2.2389
35-41 °C	0.0189	2.3477



UTCI clases	P value	Z
-2713° C	0.0066	-2.714
26-32 °C	0.0029	2.9816

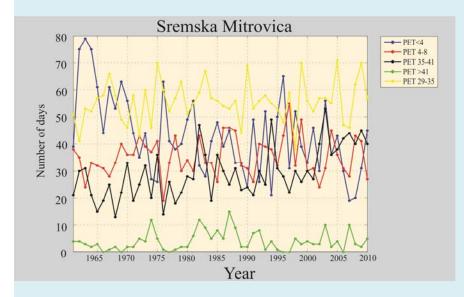
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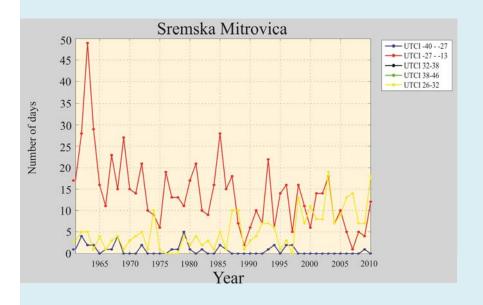


PET clases	P value	Z
<4° C	0.0445	-2.009
35-41 °C	0.0333	2.1283

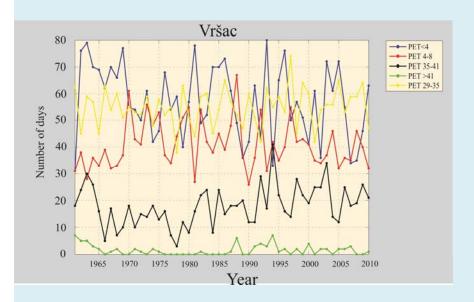
UTCI clases	P value	Z
-2713° C	0.0045	-2.841
26-32 °C	0.008	3.3444



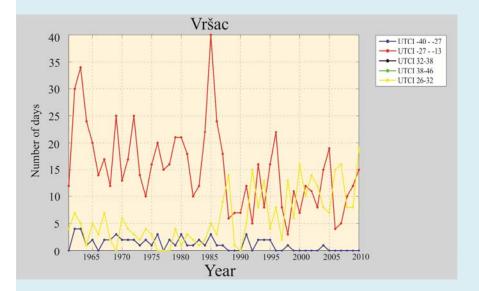
PET clases	P value	Z
<4° C	0.0012	-3.216
35-41 °C	0.0002	4.2408



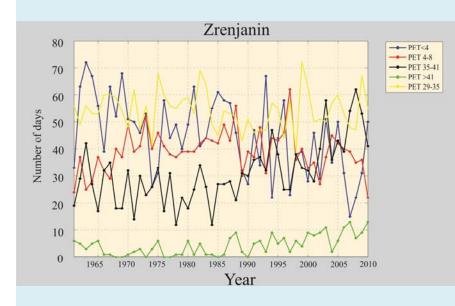
UTCI clases	P value	Z
-2713° C	0.0005	-4.040
-4026° C	0.0089	-2.614
26-32 °C	0.0001	3.3816

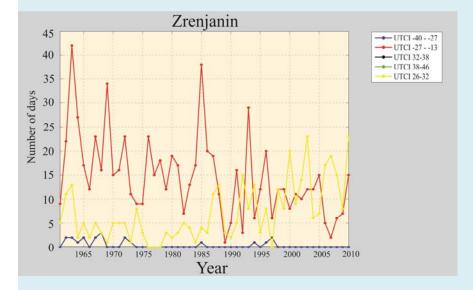


PET clases	P value	Z
35-41 °С	0.0189	2.3477



UTCI clases	P value	Z
-2713º C	0.0007	-3.378
-4026° C	0.0001	-4.271
26-32 °C	0.0001	3.3863





PET clases	P value	Z
<4° C	0.0006	-3.424
<b>35-41</b> °С	0.0008	4.4546
>41 °C	0.0004	4.083

# • This study presents the first results of biometeorological parameters for Vojvodna, North Serbia.

- The results indicate that the PET comfort class takes up approximately 40-50 % of the spring and autumn months.
- The strong and extreme cold stress class are limited to 5 to 20 % of the winter months.
- Extreme and strong heat stress class can be seen in summer months and take up more than 20 % during July.
- With regard to climate change it is very important to take a closer look at the current climate situation but also to future changes and climate change mitigation strategies.









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