



# Assessment of bioclimate conditions in Vojvodina (Northern Serbia)

Biljana Basarin\*, Tin Lukić\*, Aleksandra Kržič, Bojana Janićijević Petrović\*, Sonja Čopić\*, 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:

$$M + W + R + C + ED + E_{re} + E_{sw} + S = 0$$

Where:

**respiration**

M = metabolic rate ( internal energy produced by food oxidation)

W = the physical work

R = the net radiant balance of the body

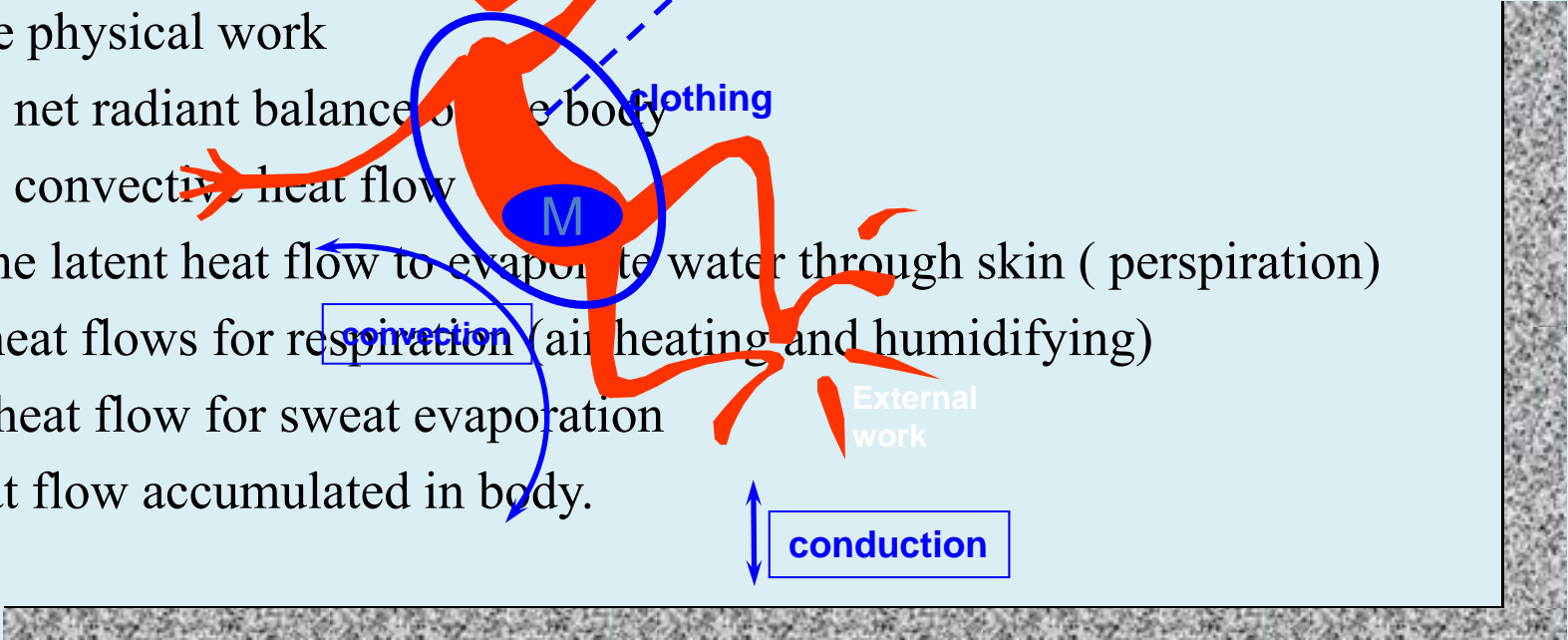
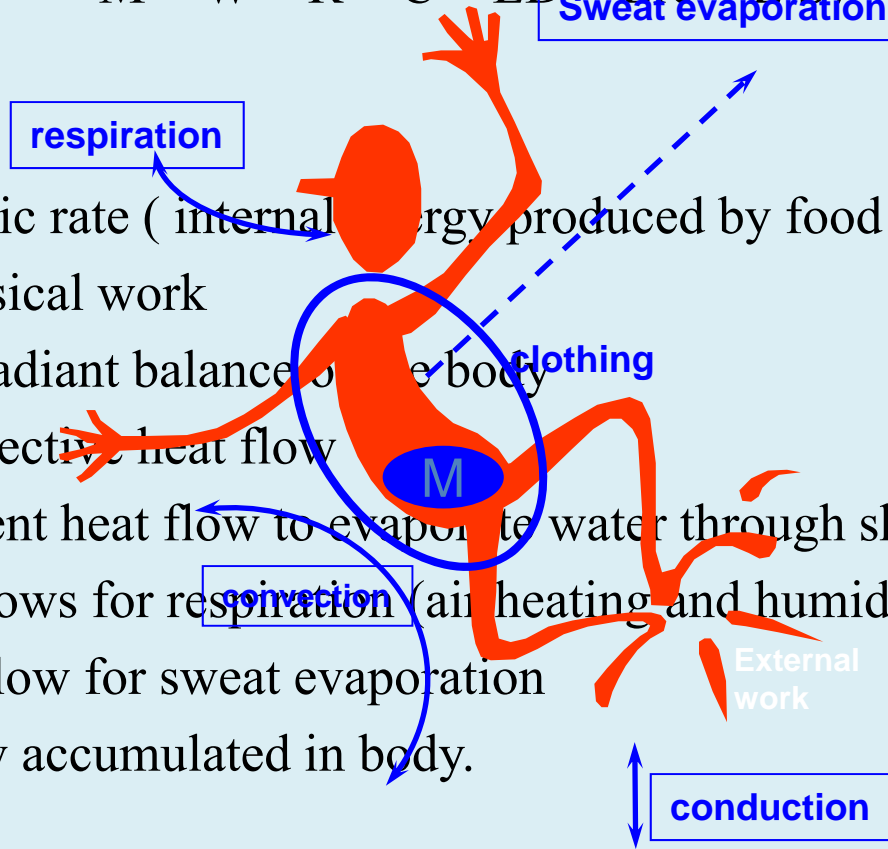
C = the convective heat flow

ED = the latent heat flow to evaporate water through skin ( perspiration)

E<sub>re</sub> = heat flows for respiration (air heating and humidifying)

E<sub>sw</sub> = heat flow for sweat evaporation

S = heat flow accumulated in body.



- 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

### Heat Balancing (MEMI): Summer

$T_a = 30 \text{ }^\circ\text{C}$ ,  $T_{mrt} = 60 \text{ }^\circ\text{C}$ ,  $RH = 50\%$ ,  $v = 1.0 \text{ m/s}$ ,  $PET = 43 \text{ }^\circ\text{C}$

Internal heat production: 258 W

Respiratory heat loss: -27 W

Mean skin temperature: 36.1 °C

Imperceptable Perspiration: -11 W

Body core temperature: 37.5 °C

Sweat evaporation: -317 W

Skin wettedness: 53 %

Convection: -143 W

Water loss: 525 g/h

Net radiation: +240 W

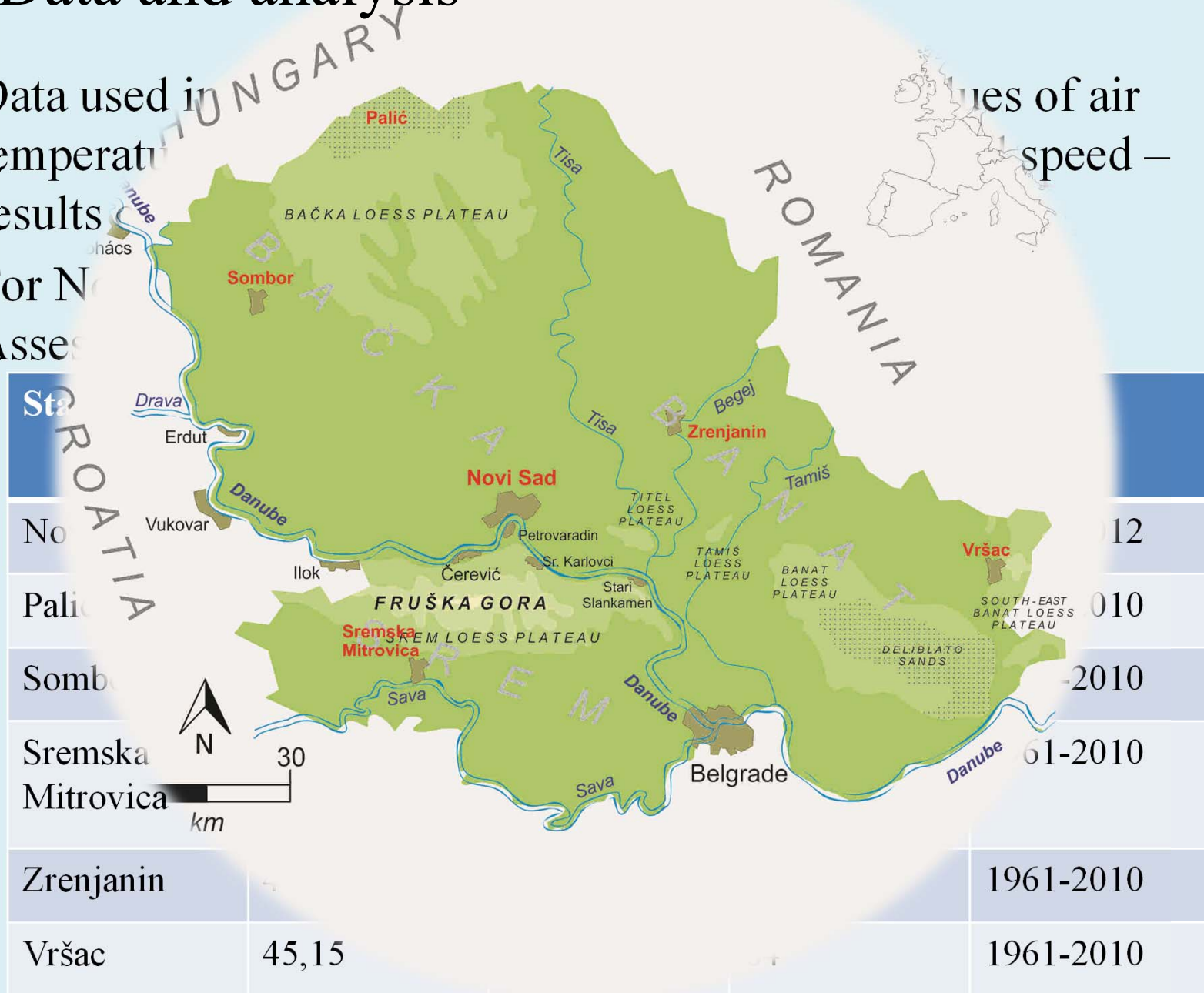


Body Parameters: 1.80 m, 75 kg, 35 years, 0.5 clo, walking (4 km/h)

- 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

## 2. Data and analysis

- Data used in temperature results
- Data used in wind speed results
- For No. 1 Assessment



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

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

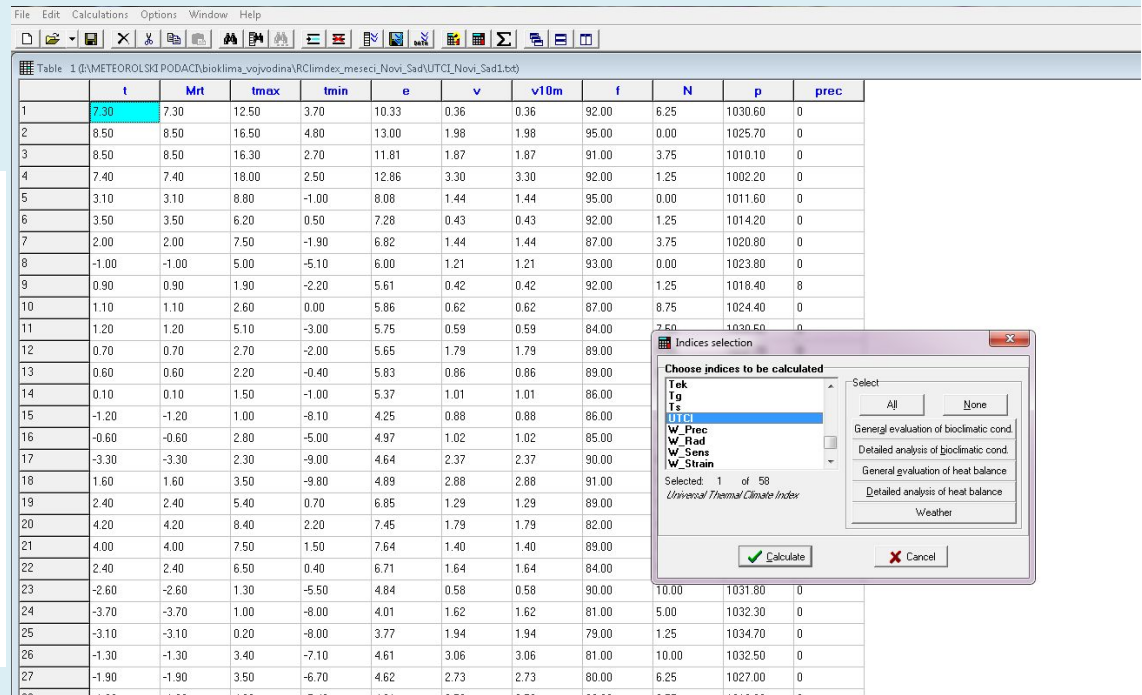
PET (°C)	Thermal sensation	Physiological stress level
<4	Very cold	Extreme cold stress
4–8	Cold	Strong cold stress
8–13	Cool	Moderate cold stress
13–18	Slightly cool	Slight cold stress
18–23	Comfortable	No thermal stress
23–29	Slightly warm	Slight heat stress
29–35	Warm	Moderate heat stress
35–41	Hot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

*Main window of RayMan.*

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

*UTCI assessment scale (Bröde et al., 2012)*

UTCI (°C)	Stress category
> +46	Extreme heat stress
+38 to +46	Very strong heat stress
+32 to +38	Strong heat stress
+26 to +32	Moderate heat stress
+9 to +26	No thermal stress
+9 to 0	Slight cold stress
0 to -13	Moderate cold stress
-13 to -27	Strong cold stress
-27 to -40	Very strong cold stress
<-40	Extreme cold stress



*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.

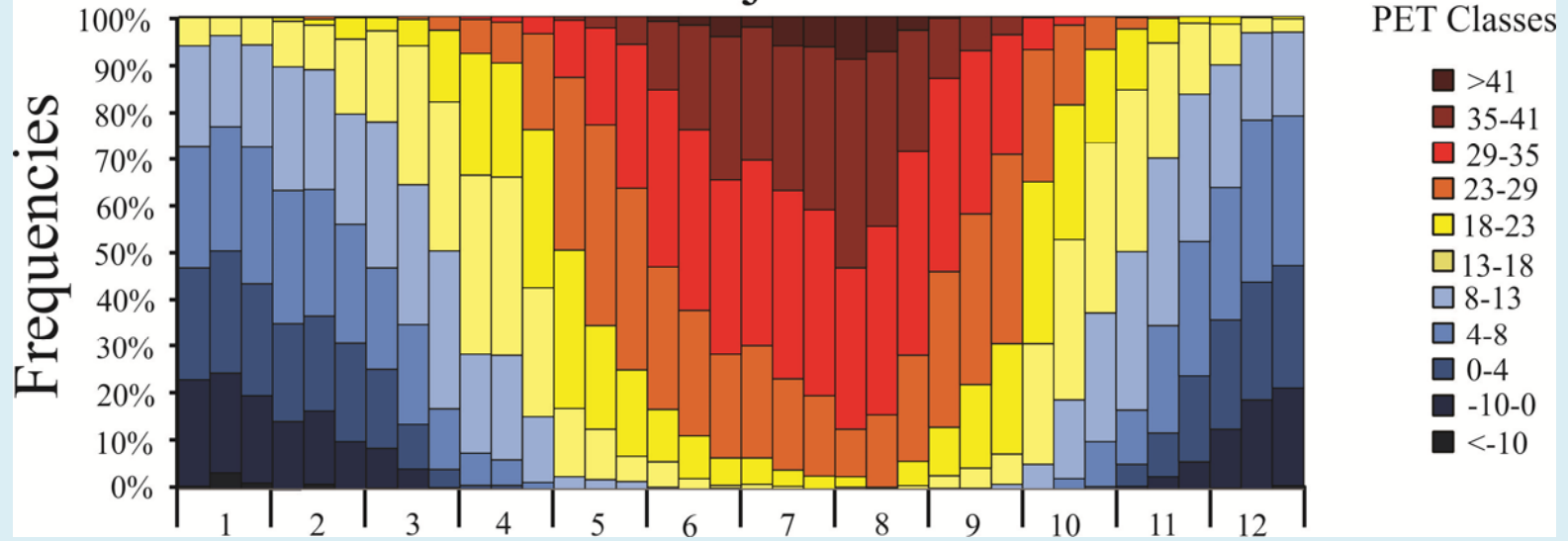
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UTCI (°C)	Stress category
> +46	Extreme heat stress
+38 to +46	Very strong heat stress
+32 to +38	Strong heat stress
+26 to +32	Moderate heat stress
+9 to +26	No thermal stress
+9 to 0	Slight cold stress
0 to –13	Moderate cold stress
–13 to –27	Strong cold stress
–27 to –40	Very strong cold stress
<–40	Extreme cold stress

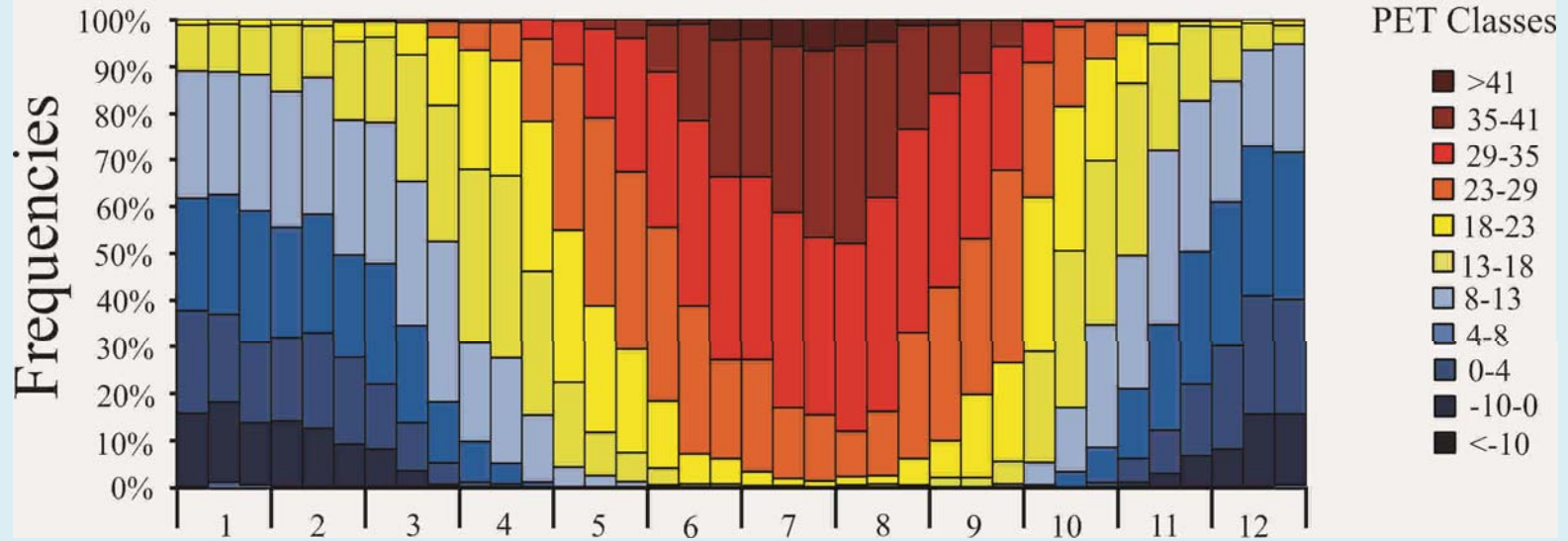


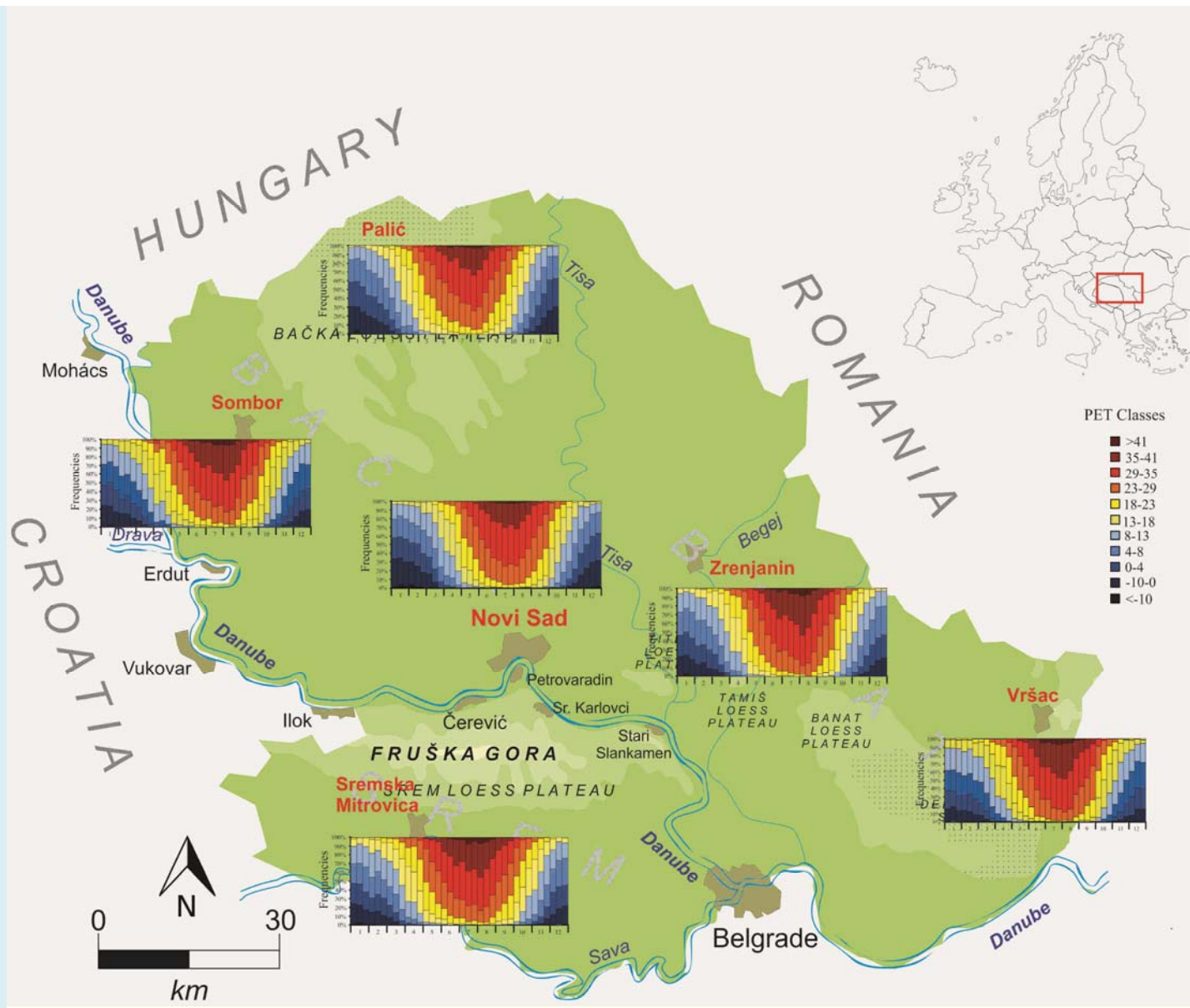


## Zrenjanin

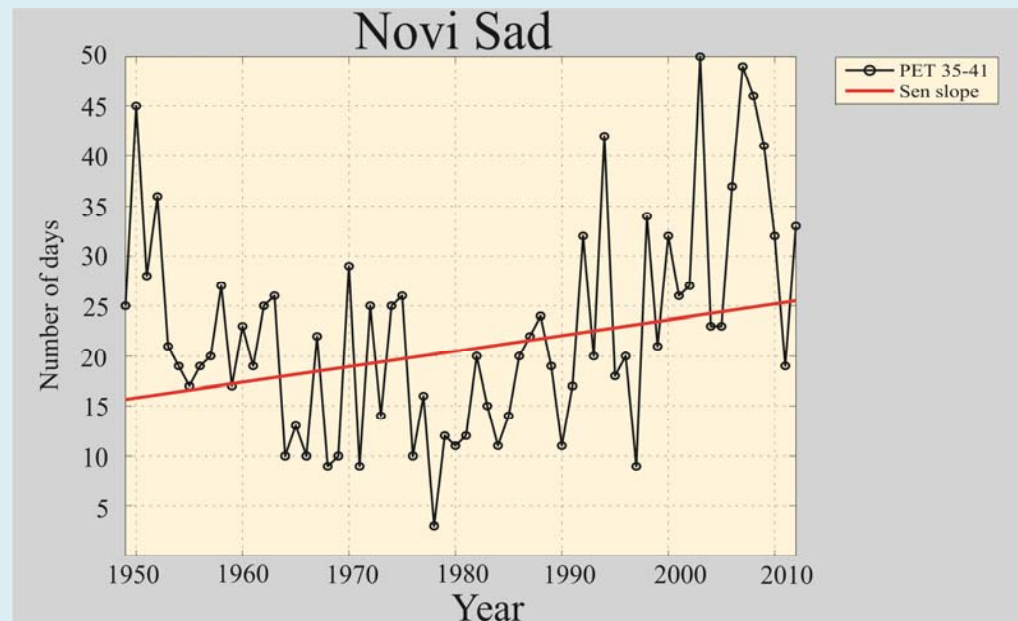
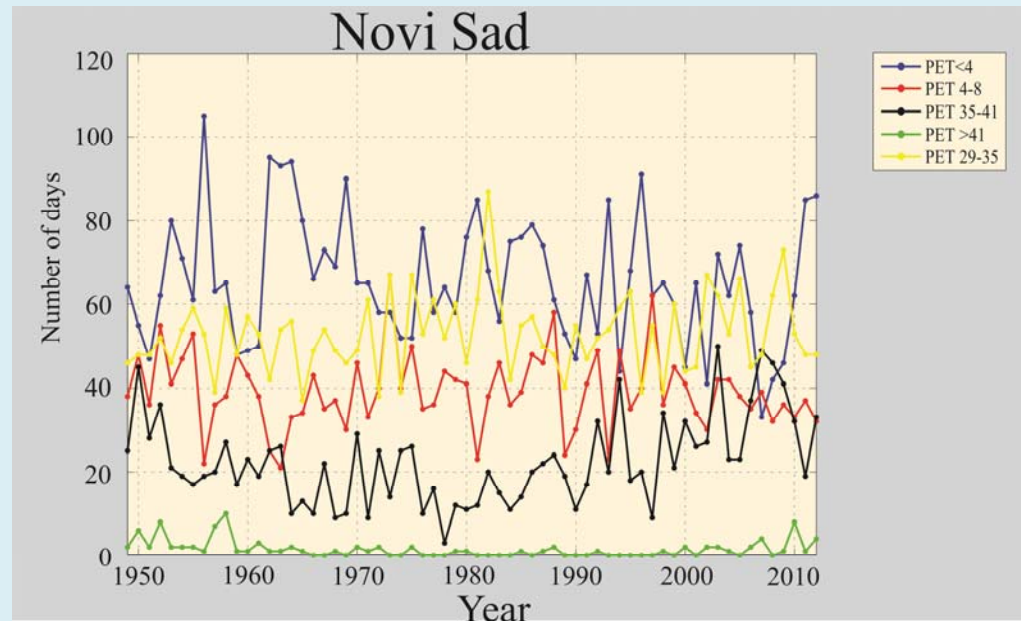


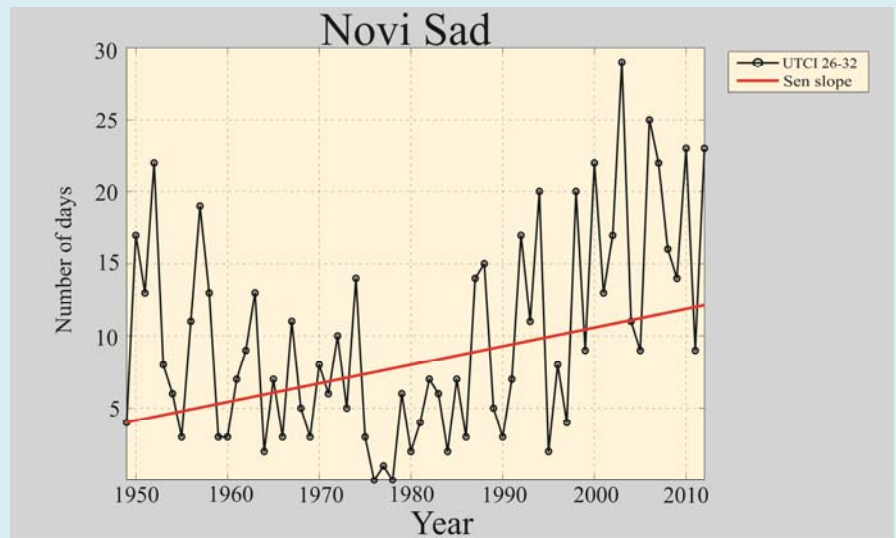
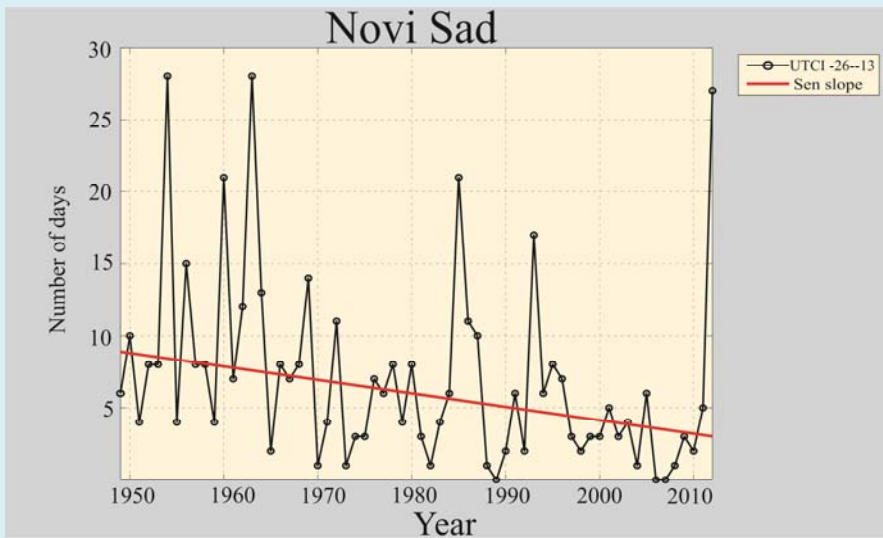
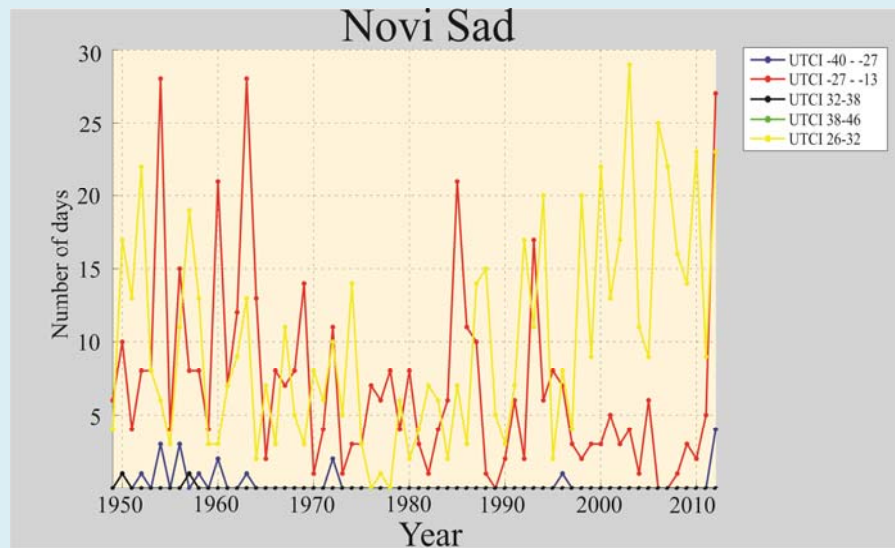
## Vršac

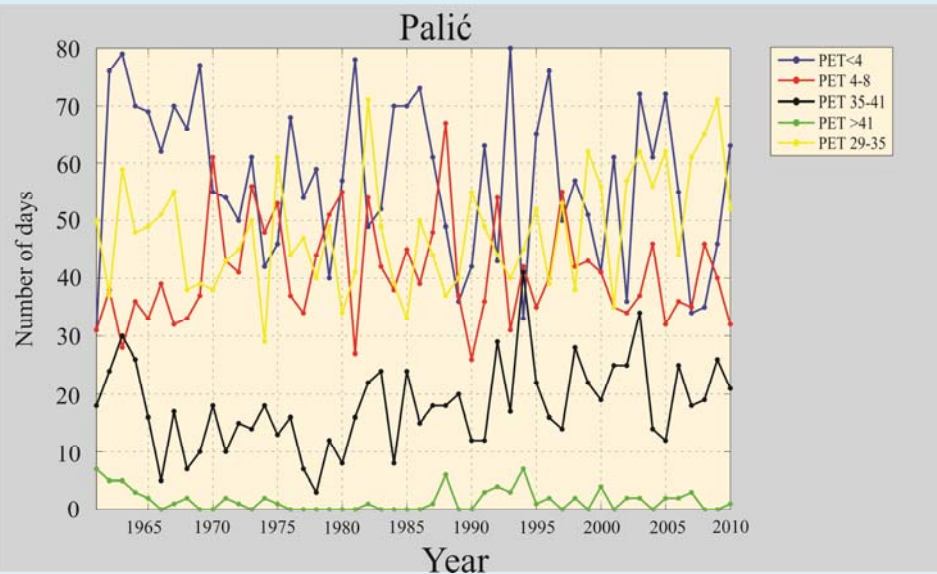




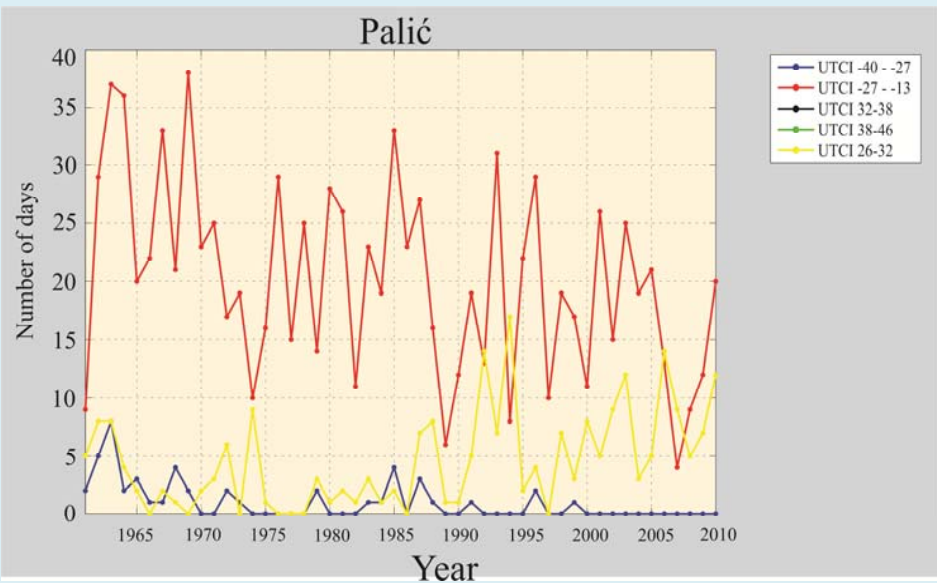
- Time series of annual number of days within extreme classes of mean daily PET and linear trends.





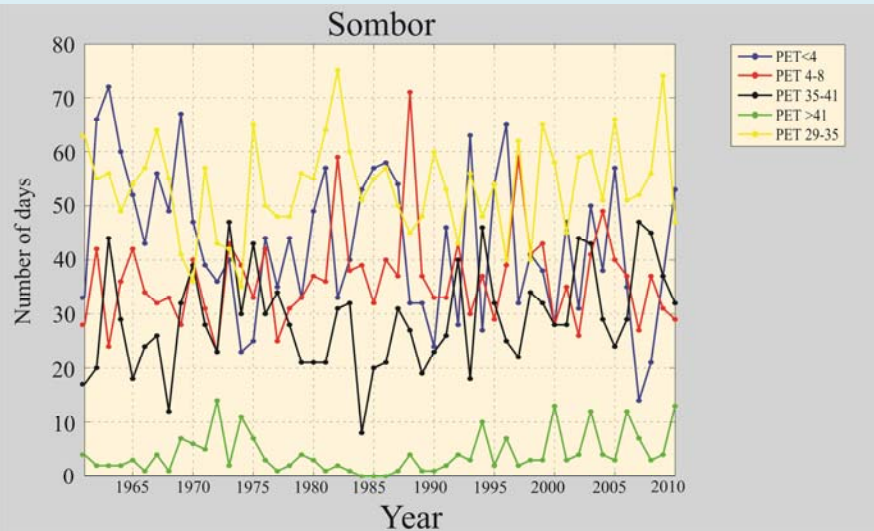


PET classes	P value	Z
29-35° C	0.0199	2.2389
35-41 °C	0.0189	2.3477

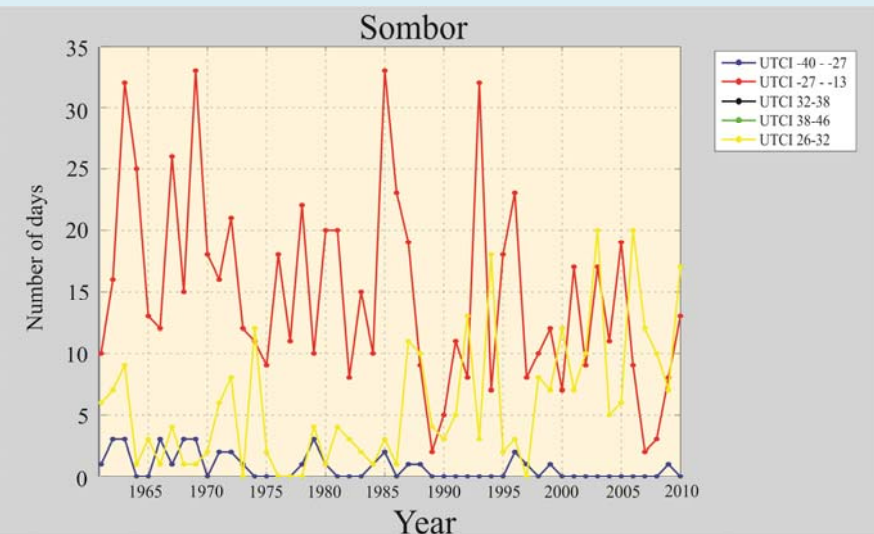


UTCI clases	P value	Z
-27 - -13° C	0.0066	-2.714
26-32 °C	0.0029	2.9816

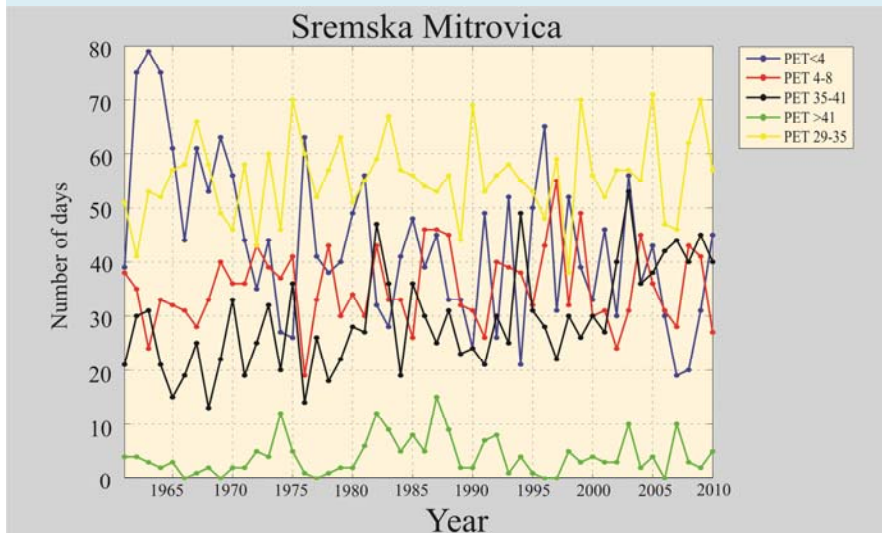




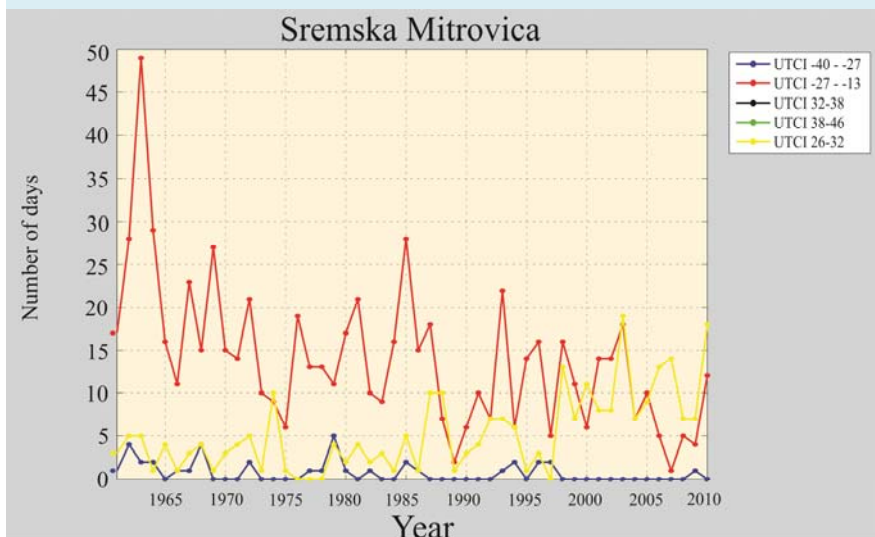
PET classes	P value	Z
<4° C	0.0445	-2.009
35-41 °C	0.0333	2.1283



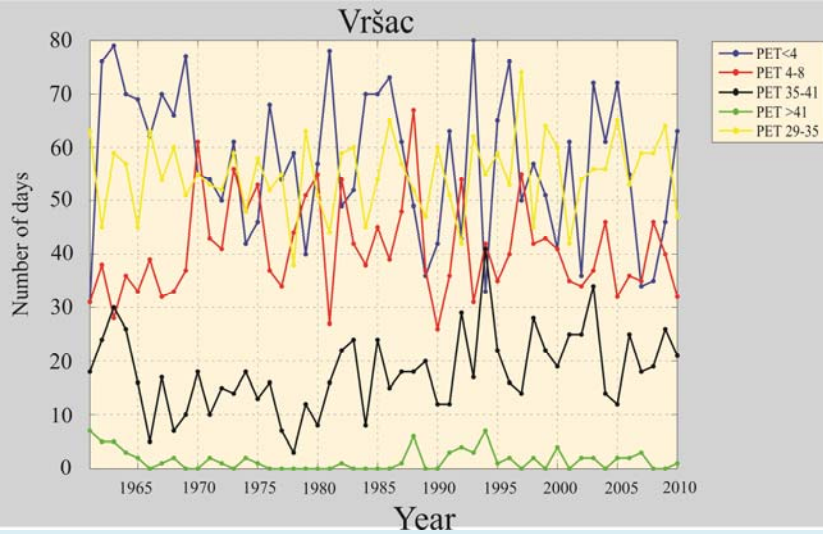
UTCI clases	P value	Z
-27 - -13° C	0.0045	-2.841
26-32 °C	0.008	3.3444



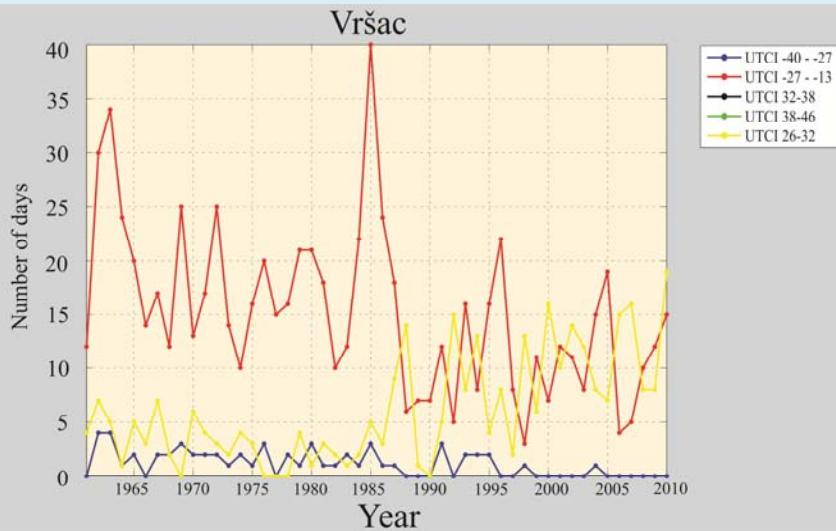
PET classes	P value	Z
<4° C	0.0012	-3.216
35-41 °C	0.0002	4.2408



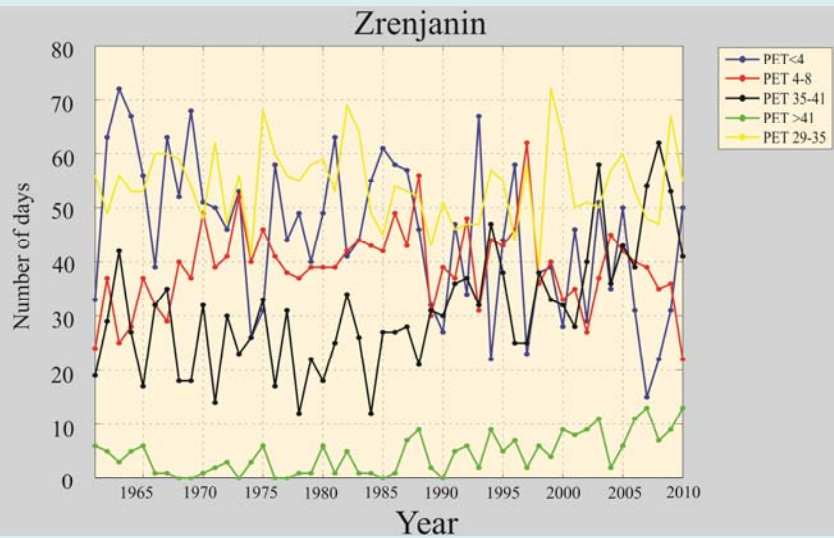
UTCI clases	P value	Z
-27 - -13° C	0.0005	-4.040
-40--26° C	0.0089	-2.614
26-32 °C	0.0001	3.3816



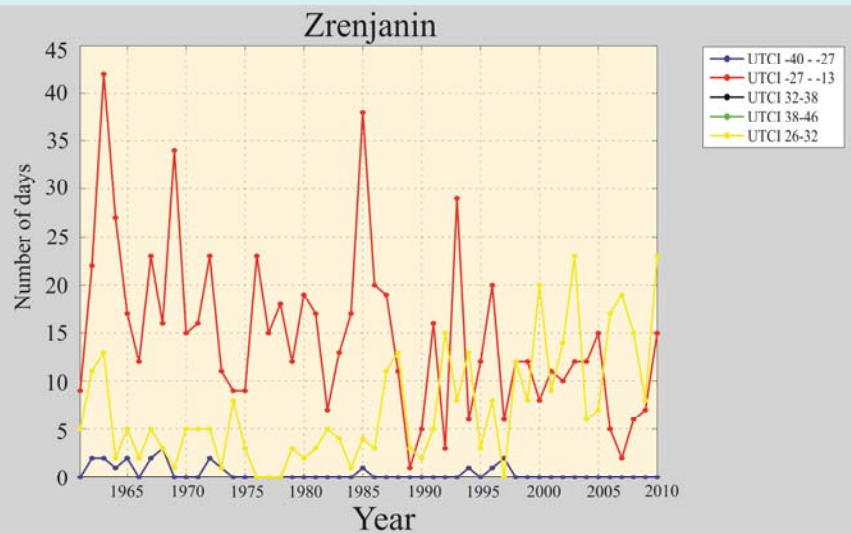
PET classes	P value	Z
35-41 °C	0.0189	2.3477



UTCI clases	P value	Z
-27 - -13° C	0.0007	-3.378
-40--26° C	0.0001	-4.271
26-32 °C	0.0001	3.3863



PET classes	P value	Z
<4° C	0.0006	-3.424
35-41 °C	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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