



Long-term variability in thermal comfort conditions based on the Universal Thermal Climate Index over Romania



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Motivation

- “ ERA4CS-INDECIS (www.indecis.eu)-> develop a set of common indicators regarding the monitoring and early warning of extremes events like heat/cold waves, droughts and flashflood
- “ UTCI -> bio-meteorological aspects of heat/cold events
- “ UTCI -> based on human heat balance models
 - > designed to be applicable in all seasons and climates and for all spatial and temporal scales
 - > good skills for global probabilistic forecasting at 4-6 days lead time
- “ In Romania: official heat/cold monitoring and warning procedures -> **THI** (Temperature-Humidity Index) & and **WCT** (Wind Chill equivalent Temperature chart index)
 - > investigate the added-value brought by UTCI and the way to provide this information in addition to the official use of THI and WCT.

Data and methods

- “ $UTCI=f(T_{air}, \text{humidity, wind speed, radiation})$
- > **meteorological data from ROCADA** (Dumitrescu and Birsan, 2015)
(10 km spatial resolution; daily; 1961-2013; 9 parameters)
- “ Long-term (**1981-2010**) seasonal spatial distribution
- “ PDF of annual and seasonal daily values of UTCI for 3 periods:
1961-1980, 1981-2000, 2001-2010.
- “ changes in the number of days with **high/low values of UTCI**
- “ comparison with **THI** and **WCT**.
- “ analysis for the warm season -> **6 cities** in Romania
characterized by different thermal stress level during summer
(i.e. number of days with THI above the alert threshold).



UTCI – assessment scale

(after Błażejczyk et al, 2013)

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

$$THI = (T * 1.8 + 32) - (0.55 - 0.55 * RH / 100) * (T * 1.8 - 26)$$

$$THI \geq 80$$

$$WCT = 13.12 + 0.6215 * T - 11.37 * FF^{**0.16} + 0.3965 * T * FF^{**0.16}$$

$$WCT \leq -32$$

T = air temperature (°C) ; FF = wind speed (km/h); RH = Relative humidity (%)

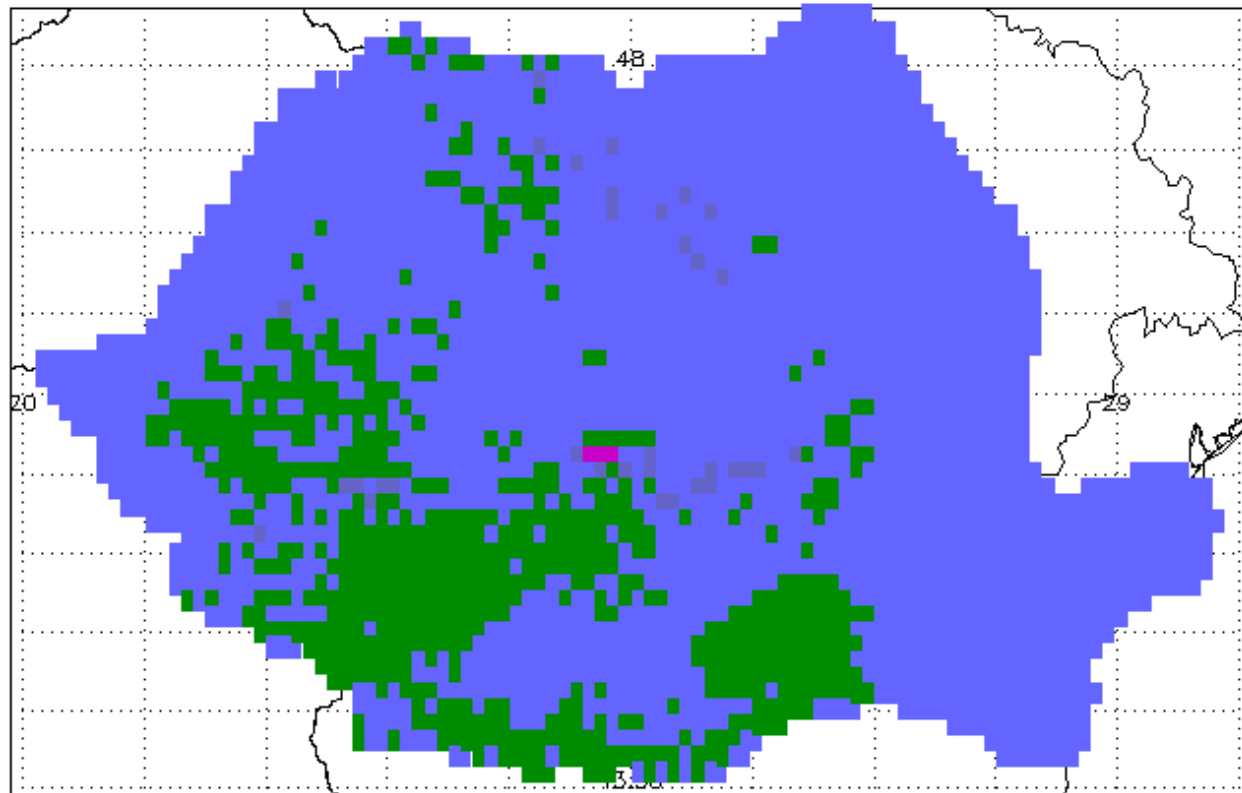
(Dobrinescu et al, 2015)



Long-term (1981-2010) seasonal spatial distribution

UTCI - class with largest population (largest frequency) 1981-2010 – cold season (ONDJFMA)

- 1=Extreme cold stress
- 2= Very strong cold stress
- 3= Strong cold_stress
- 4= Moderate cold stress
- 5=Slight cold stress
- 6=No_thermal_stress
- 7=Moderate heat stress
- 8=Strong heat stress
- 9=Very strong heat stress
- 10=Extreme heat stress

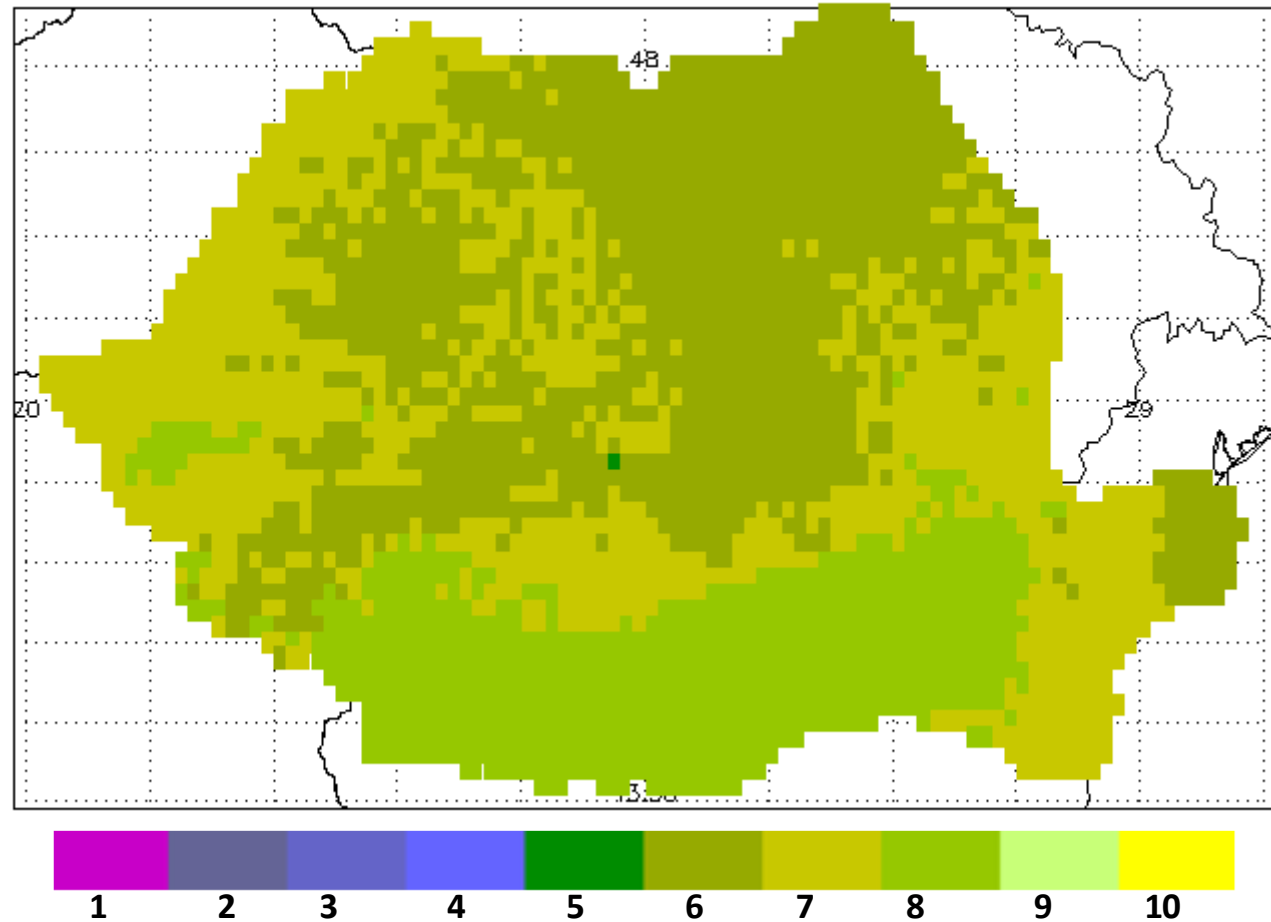




Long-term (1981-2010) seasonal spatial distribution

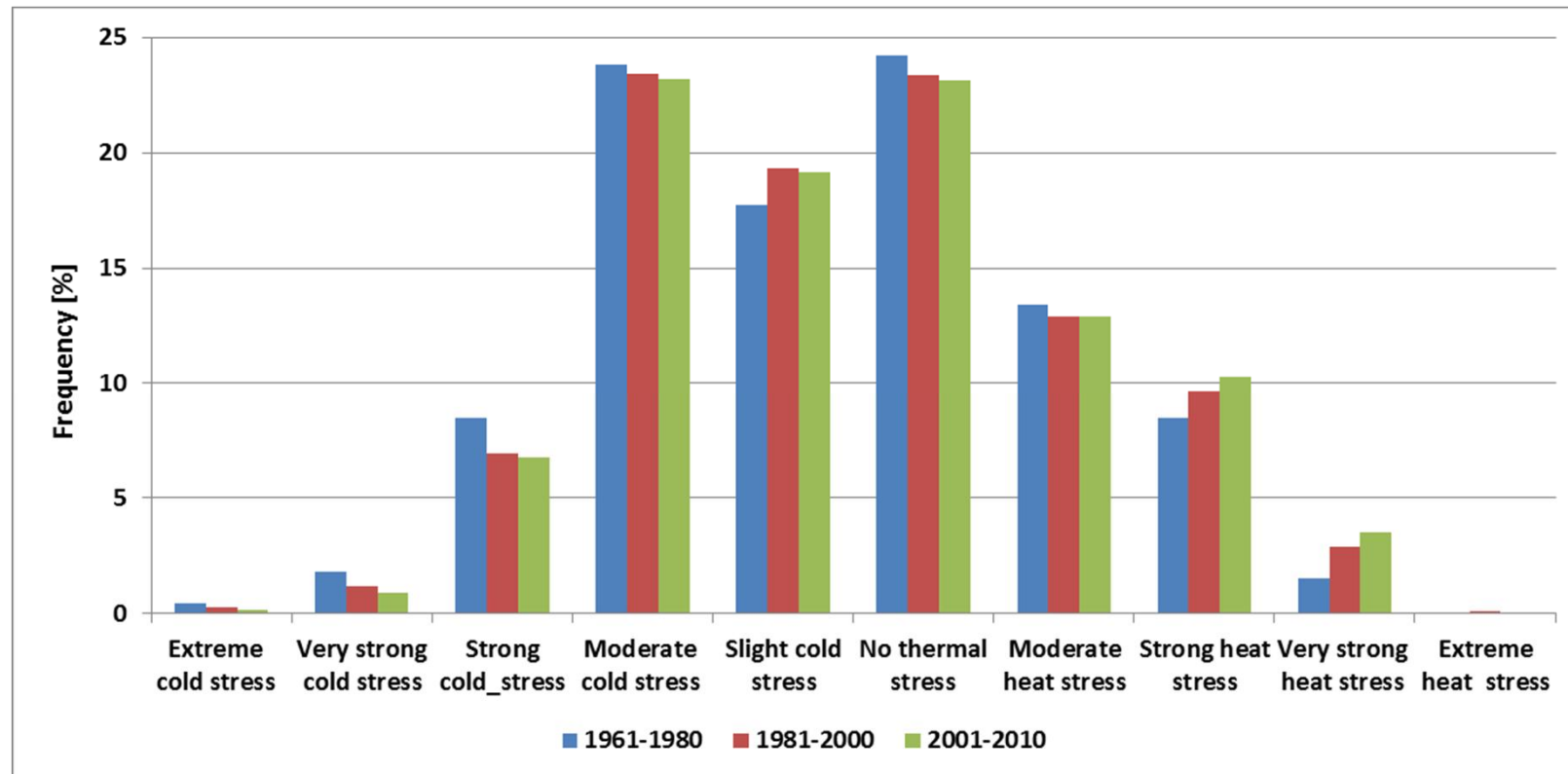
UTCI - class with largest population (largest frequency) 1981-2010 –warm season (MJJAS)

- 1=Extreme cold stress
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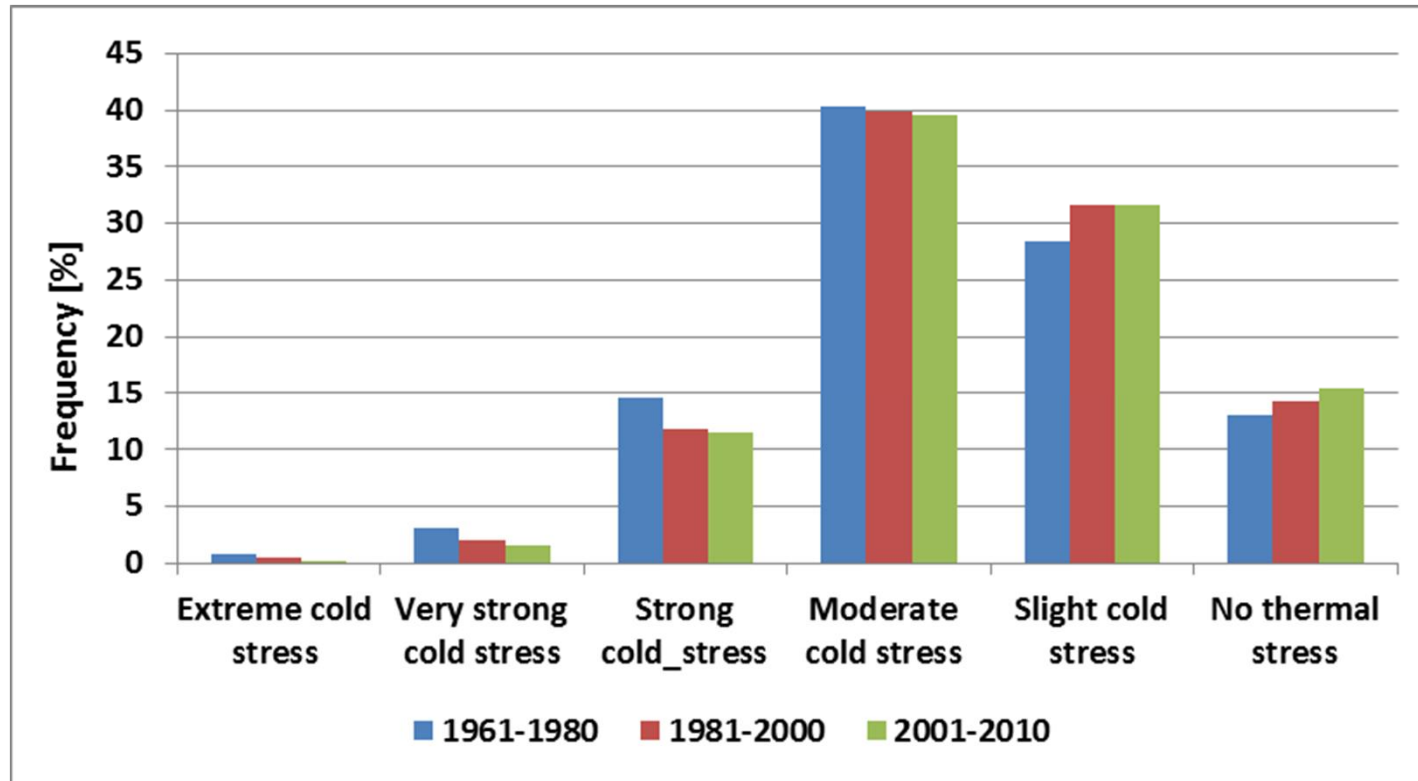
Annual UTCI classes (frequency of distribution)–comparison between 1961-1980, 1981-2000 and 2001-2010, for the entire territory



The period 1981-2000 is characterized by a lower frequency of cases with significant cold stress (categories *extreme*, *very strong*, *strong*, *moderate cold stress*); also, a decrease of frequency for *no thermal stress* and *moderate heat stress* classes is found. Instead, more cases in the *strong* and *very strong heat stress* categories are observed. A similar pattern is found for 2001-2010 period.



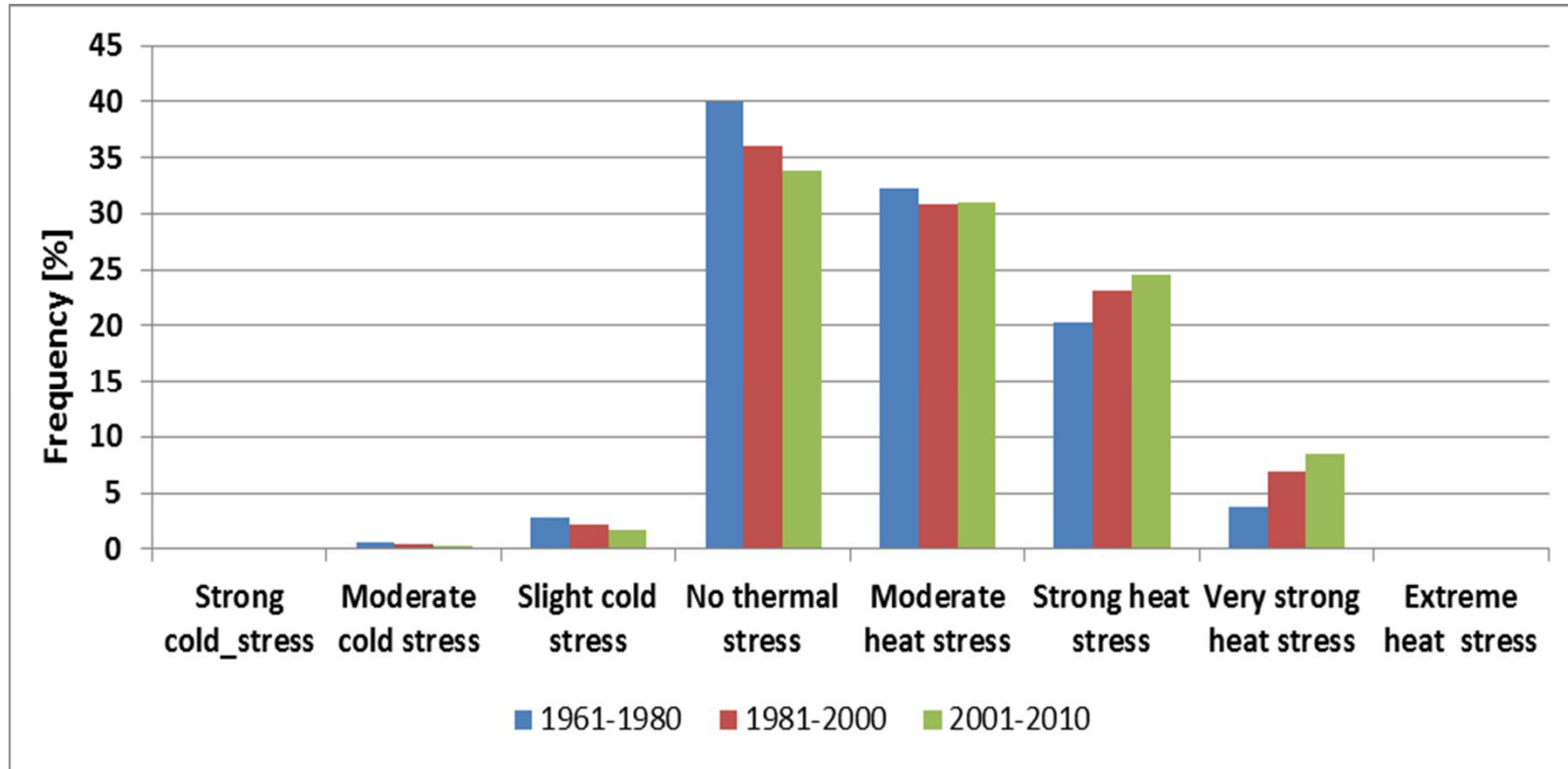
UTCI classes (frequency of distribution) –comparison between 1961-1980, 1981-2000 and 2001-2010, for the entire territory -for the cold season



The frequency of cases with *extreme*, *very strong* and *strong cold stress* is decreasing from **18.32%** during **1961-1980** to **13.27%** during **2001-2010**. *Slight cold stress* and *no thermal stress* classes have larger frequency during the last 30 years in the cold season.



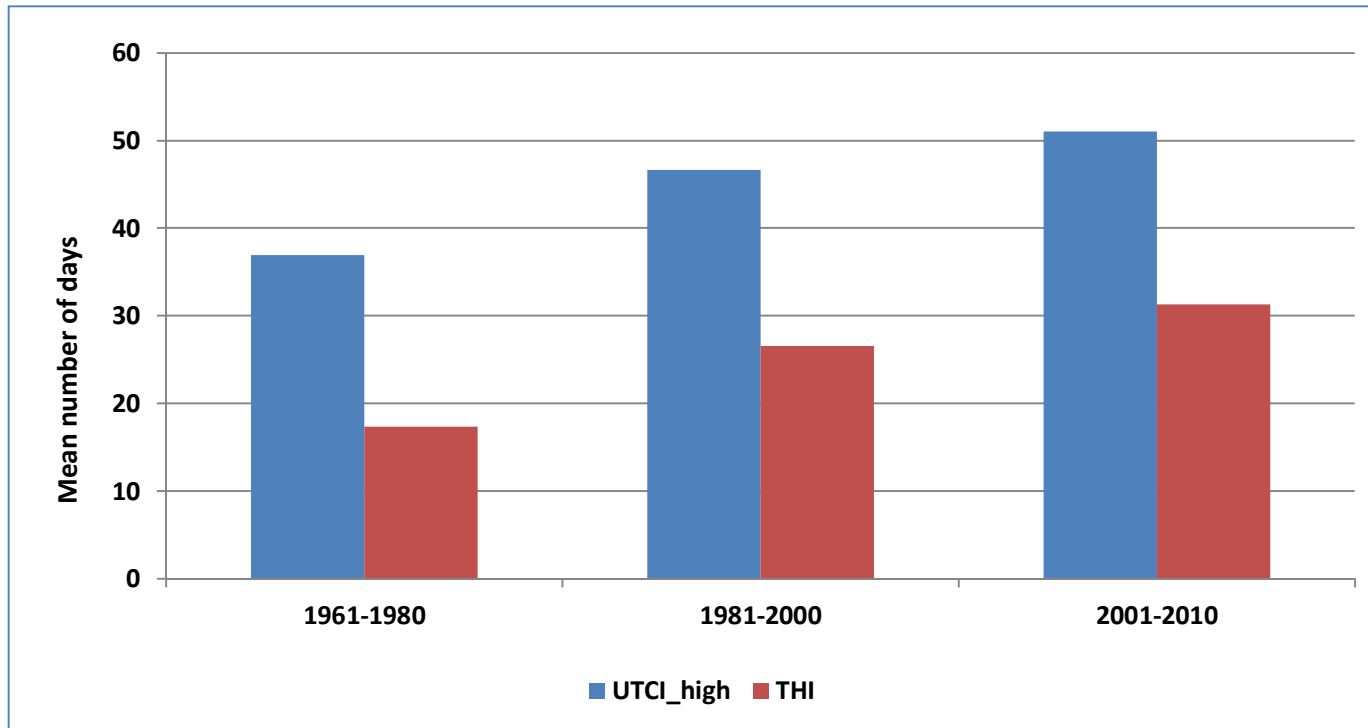
UTCI classes (frequency of distribution) –comparison between 1961-1980, 1981-2000 and 2001-2010, for the entire territory -for the warm season



Pronounced thermal discomfort during the warm season (*strong, very strong and extreme heat stress*) is more often experienced during 1981-2000 (**30.4%**) and 2001-2010 (**33.2%**) compared to 1961-1980 (**24.1%**).



Changes in the mean number of days with **high UTCI** (classes: *extreme, very strong and strong heat stress*) and the seasonal mean number of days with **THI \geq 80**, for the entire territory

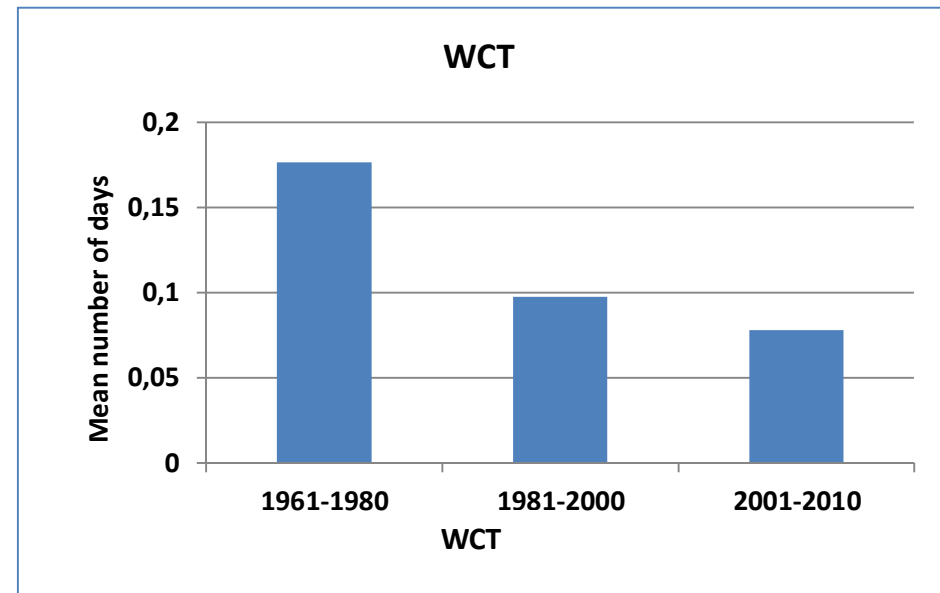
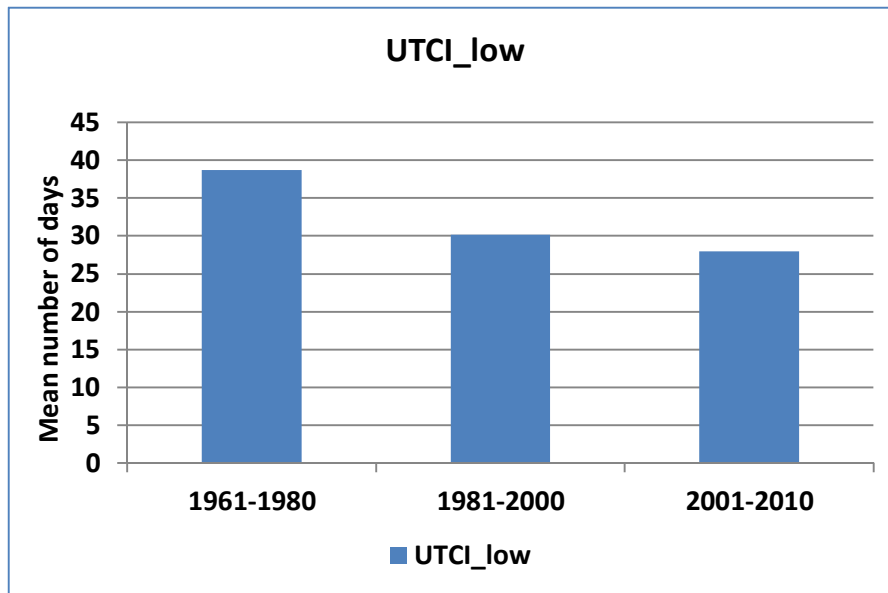


The mean number of days with pronounced thermal discomfort during the warm season as expressed by THI and UTCI_high presents a similar increasing tendency between the periods analyzed, with UTCI_high warning for more days with pronounced thermal discomfort in a season

(-> the warning may be disregarded by population due to the high frequency of occurrence)



Changes in the mean number of days with **low UTCI** (classes: *extreme, very strong and strong cold stress*) and number of days with **WCT ≤ -32** , for the entire territory



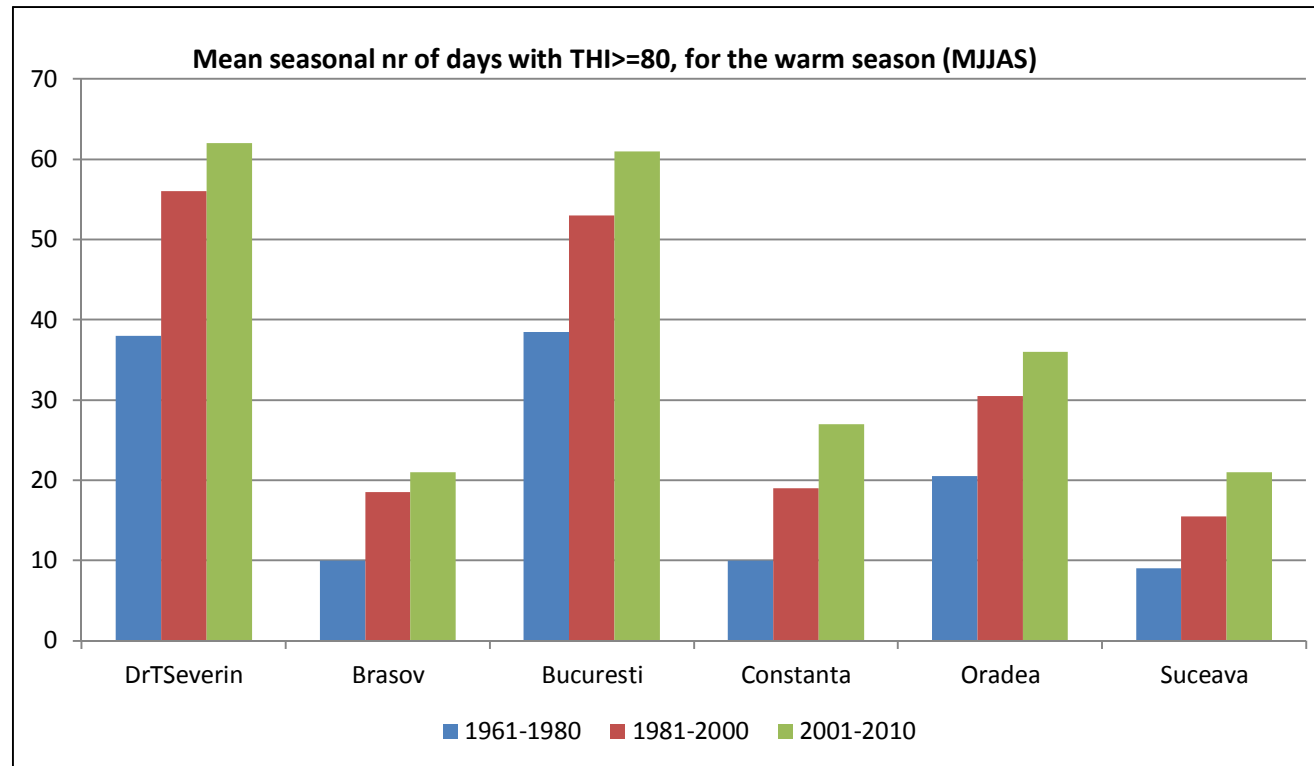
The very low number of cases with WCT reaching the alarm threshold suggests that this index may not be sufficiently relevant in the present climate conditions (-> **UTCI may bring an added-value** in the heat/cold health-related warning system).

Selected Romanian cities





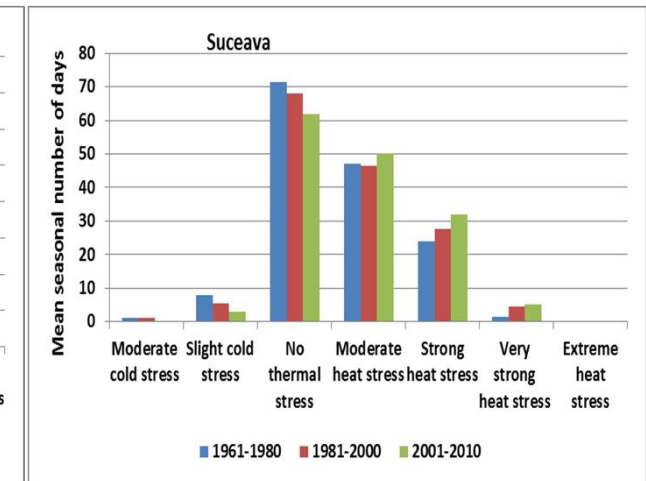
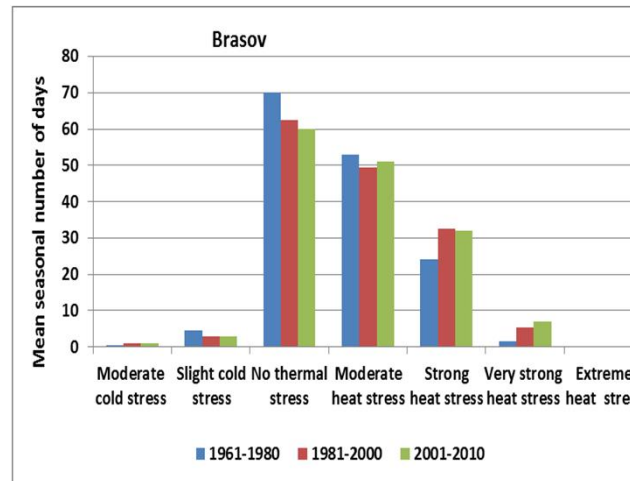
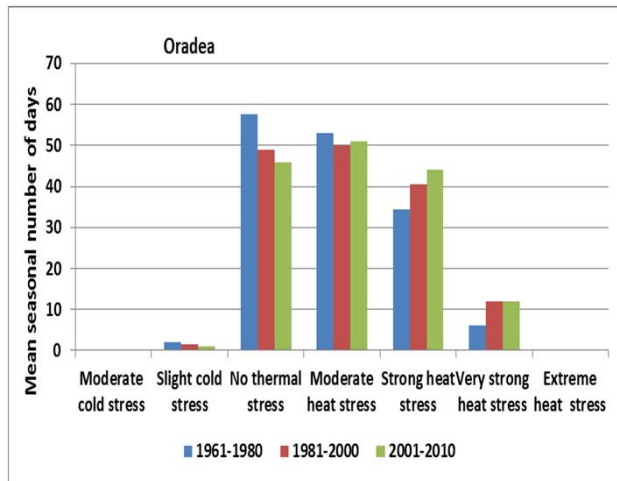
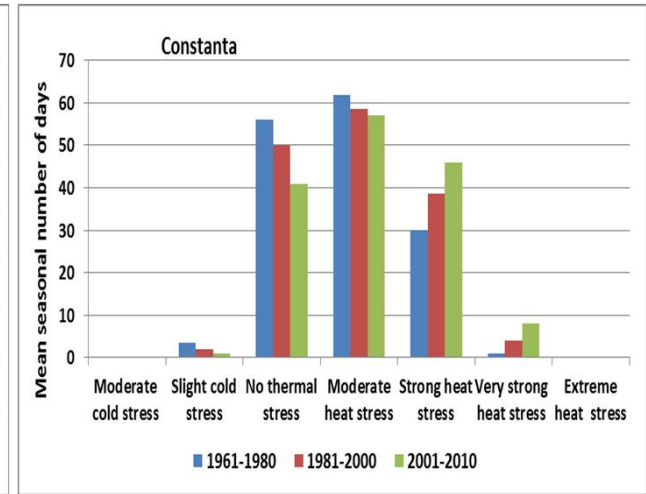
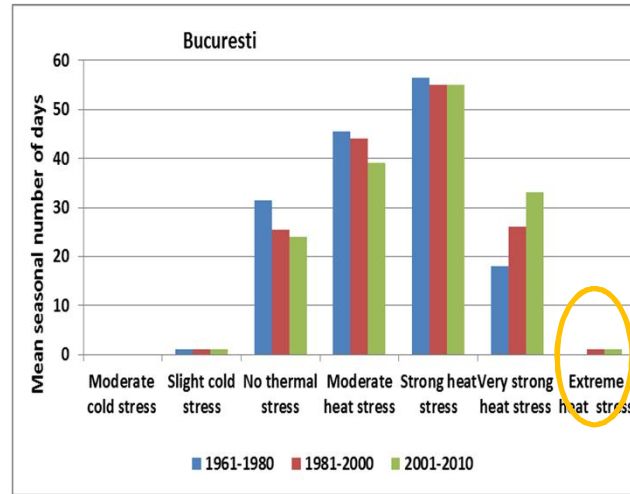
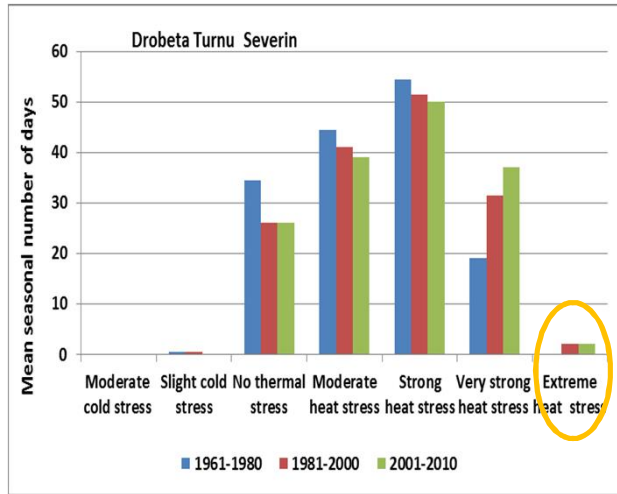
Changes in the mean seasonal number of days with THI>80 for 6 Romanian cities for periods 1961-1980, 1981-2000 and 2001-2010



The increase in the frequency of pronounced thermal discomfort during the warm season as expressed by THI is stronger for cities with cold-temperate climate (e.g. Suceava, Brasov) where during 2001-2010 the mean number of days with THI>80 almost **doubled** compared to 1961-1980.



Changes in UTCI classes frequency during the warm season for 6 Romanian cities for periods 1961-1980, 1981-2000 and 2001-2010



Summary and conclusions

- “ During the cold season, the Romanian territory is characterized mainly by **moderate cold stress**. The frequency of *very strong* and *strong cold stress* decreases during the last 30 years compared to 1961-1980.
- “ During the warm season, the **South** of the country experiences **strong heat stress**, the **Western and Eastern regions** – **moderate heat stress**, while **no thermal stress** is felt in **the mountainous and sub-mountainous areas** as well as in **NW regions**.
- “ The frequency of cases of **strong, very strong** and even **extreme heat stress** is increasing in all regions during the last 30 years (1981-2000, 2001-2010), even in cities/regions characterized by cold and temperate climate (e.g. Suceava).
- “ The increase of number of cases with pronounced thermal discomfort during the warm season is visible also in the mean number of days with THI above the alarm threshold.
- “ The frequency of pronounced thermal discomfort during the cold season is better highlighted with UTCI index (compared to WCT) -> **UTCI** may bring an added value in the heat/cold health-related warning system, especially during the **cold season**.

References

- “ Błażejczyk et al (2013): An introduction to the universal thermal climate index (UTCI), *Geographia Polonica*, 86:1, pp. 5-10, <http://dx.doi.org/10.7163/GPol.2013.1>
- “ Dumitrescu, A. and Birsan, M.V. (2015): ROCADA: a gridded daily climatic dataset over Romania (1961–2013) for nine meteorological variables, *Nat. Hazards*, 78:2, pp 1045-1063, doi: 10.1007/s11069-015-1757-z.
- “ Dobrinescu, A., Busuioc, A., Birsan, M.V., Dumitrescu, A. & Orzan, A., 2015. Changes in thermal discomfort indices in Romania and their connections with large-scale mechanisms, *Clim. Res.*, 01/2015; DOI:10.3354/cr01312.