NEWSLETTER

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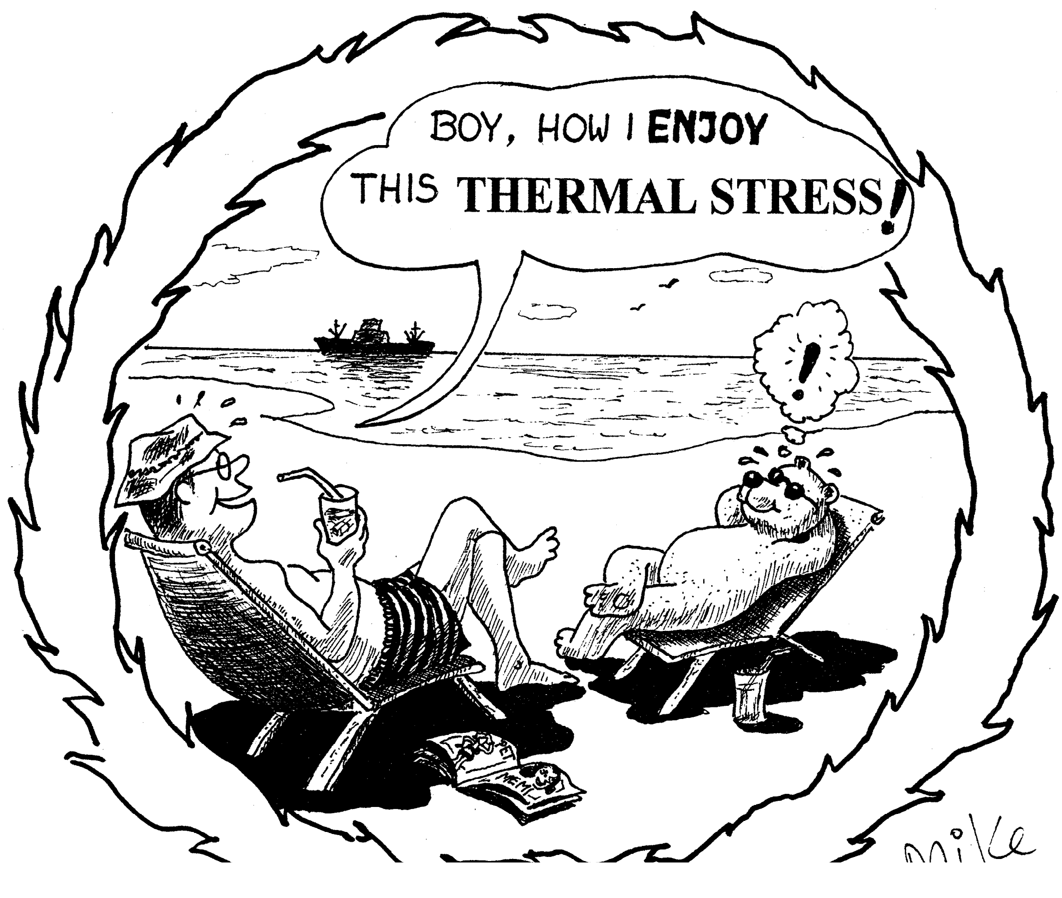


ANOTHER KIND OF ENVIRONMENTAL STRESS: THERMAL STRESS

A. Matzarakis and H. Mayer
Meteorological Institute, University of Freiburg, Germany

Cause and effect relations between the atmospheric environment and human health or human comfort can be analyzed by a human biometeorological classification [1, 2] that distinguishes:

- the thermal complex
- the air pollution complex
- the actinic complex
- and biofropy.

The thermal complex comprises the meteorological factors air temperature, air humidity and wind velocity, and also contains the short- and long-wave radiation that thermo-physiologically affects humans in indoor and outdoor climate. ·This complex is relevant to human health because of a close relationship between the thermoregulatory mechanism and the circulatory system.
The air pollution complex includes those solid, liquid and gaseous natural and antropogenic compounds that cause adverse health effects in humans, indoors as well as outdoors. The relevance of air quality conditions to human health depends on the emission sources and the transmission conditions (dispersion, dilution, possible chemical reactions, wash out and rain out of air pollutants). These factors are determined by atmospheric layers (grade of turbulence), wind, precipitation, and possibly humidity and solar radiation.
The actinic complex comprises the visible and ultraviolet range of the solar radiation that shows - apart from mere thermal effects - direct biological effects.
Biotropy deals with the biological effects of the weather. There are three possible reactions of the human organism to the weather: body reactions, slight and intense meteorosensitivity.

The fact that air pollution can seriously affect human health has long been acknowledged and resulted in numerous limit, guide and threshold values for air pollutants. Its importance is not least due to the fact that air pollution occurs all year - though for different pollutants at different levels - and that hardly any individual protection can be taken against it.
The thermal complex, however, is often underestimated, especially in the Central European climate region, although long-term data statistics show increased mortality rates at extreme thermal conditions (heat or cold stress).

Human biometeorological studies have already been conducted for some time. In the past indices were frequently used in order to estimate the thermal environment. These indices were based on single or composite meteorological parameters, such as humidity temperature or equivalent temperature.
In the seventies some scientists began to use physiologically relevant indices that were derived from the human energy balance for the assessment of the thermal complex [3]. A model for the human energy balance is MEMI (**M**unich **E**nergy Balance **M**odel for **I**ndividuals), which uses the assessment index PET (**P**hysiologic **E**quivalent **T**emperature). This model is described in VDI Guideline 3787, part 2 (draft) "Methods for the Human-Biometeorological Assessment of Climate and Air Hygiene for Urban and Regional Planning" [4].

The following meteorological parameters were taken into account in MEMI:

- air temperature
- vapour pressure
- wind velocity
- mean radiation temperature.

Body parameters, as used by MEMI are:

- human activity and body heat generation
- heat transfer resistance of clothing.

Like the frequently used PMV index (**P**redicted **M**ean **V**ote) PET makes it possible to assess thermo-physiologically the thermal conditions of surrounding indoor and outdoor air, as point calculations or in form of charts (see Table 1).

As an example, various results are depicted in Figures 1 to 3. Figure 1 shows that - compared with a similar street without trees - the thermal load is reduced on a radiant summer day in a street running in North-South direction and lined with pyramid-poplars, because of the shading effect of the tree crowns.

The bars in Figure 2 show the course of PET in Athens at 12 UTC for the years 1980 to 1989 [7]. Cold stress does not occur frequently in Athens, while extreme heat stress is rather common. The graph indicates heat waves that can have negative consequences to human comfort [8]. Area information on the thermal complex can be taken from bioclimate maps. Figure 3 shows a classified number of days of intense heat load in Greece (PET > 35° C). This map is based on point calculations of PET for the years 1980 to 1989. A statistic model was used in order to transfer the point results spatially. The results make clear that the thermal load is most intense in lowland areas and in coastal regions surrounded by large masses of land.

Results of the human biometeorological analysis of different spaces are of interest because of their possible application in the fields:

- urban and landscape planning, for instance regarding investigations of impacts of big constructional projects,
- medicine, for instance for the analysis of thermal stress situations,
- tourism, for instance for the selection of holiday areas or the duration of holidays, and
- giving advice concerning the location of residental areas.

Table 1 : Assessment Indices PMV (Predicted Mean Vote) and PET (Physiologic Equivalent Temperature), Thermal Sensitivity and Grades of Physiological Stress, according to Mayer and Matzarakis [5, 6].

PMV	PET	Thermal Sensitivity	Grade of Physiological Stress
		very cold	extreme cold stress
-3,5	4 °C		
		cold	strong cold stress
-2,5	8 °C		
		cool	moderate cold stress
-1,5	13 °C		
		slightly cool	slight cold stress
-0,5	18 °C		
		neutral (comfortable)	*no thermal stress*
0,5	23 °C		
		slightly warm	slight heat stress
1,5	29 °C		
		warm	moderate heat stress
2,5	35 °C		
		hot	strong heat stress
3,5	41 °C		
		very hot	extreme heat stress

Figure 1: Assessment of the Thermal Climate Component in Different Built-up Surroundings in the Munich Area on a Radiant Summer Day according to PET (Physiological Equivalent Temperature) [2].

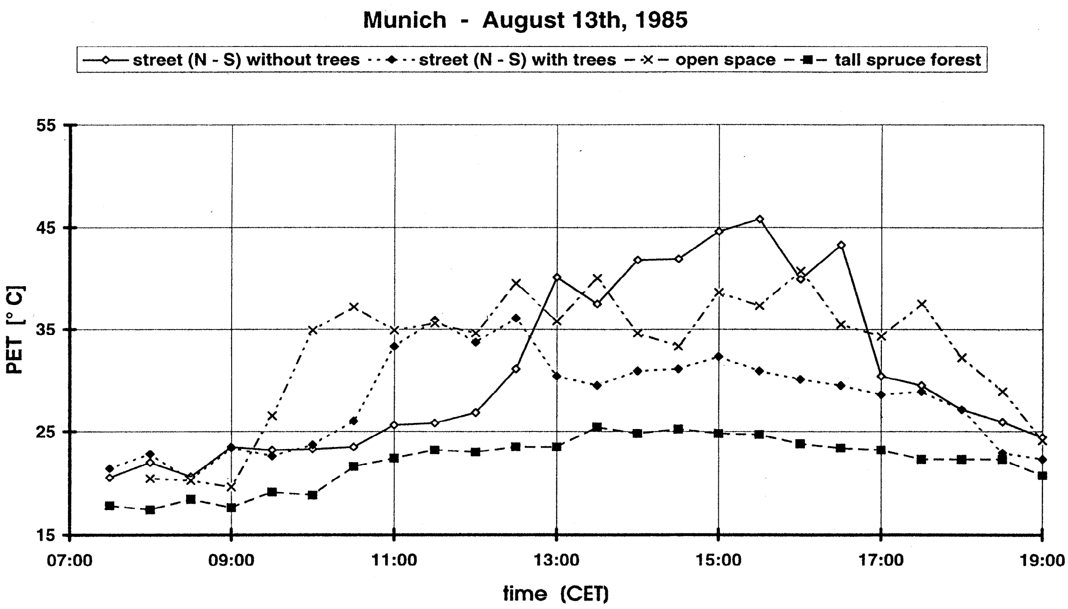


Figure 2: PET in Athens in the years 1980 to 1989

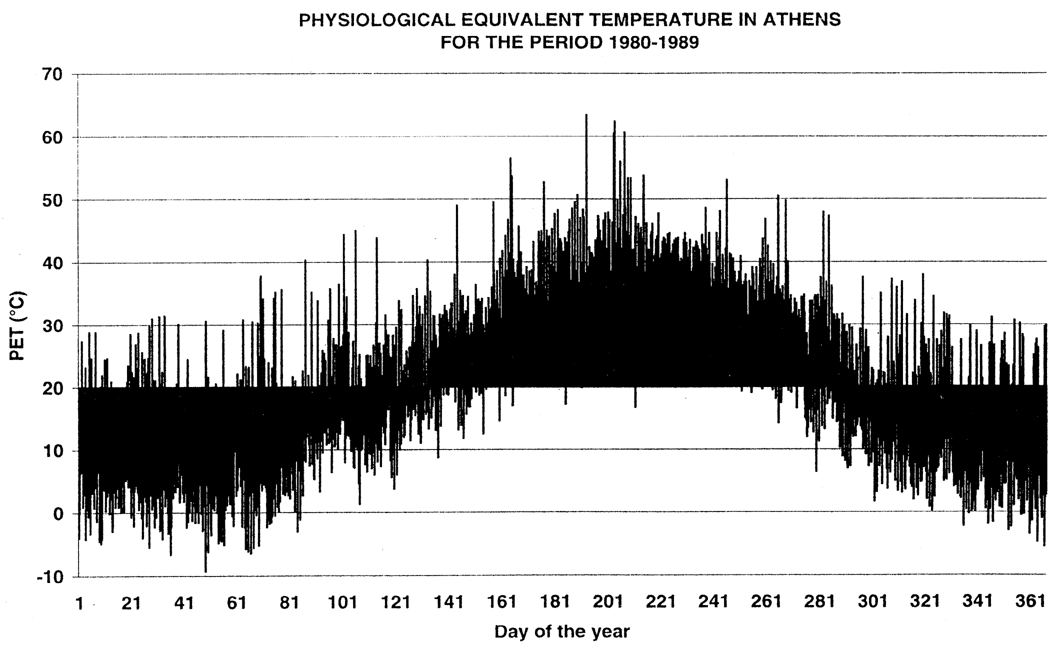
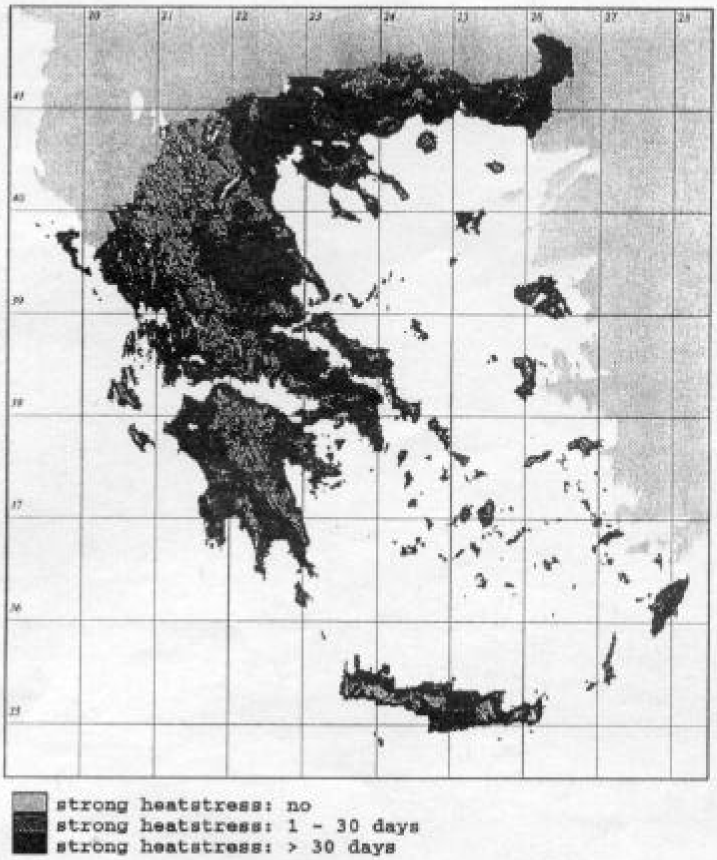


Figure 3: Numbers of Days of Heat Stress (PET > 35°C) in Greece



References:

[1] Jendritzky, G.: Wirkungen von Wetter und Klima auf die Gesundheit des Menschen. Handbuch der Umweltmedizin VI-3, (eds.: H. E. Wichmann, H.-W. Schlipköter, G. Fülgraff), ecomed, Landsberg, 1992, pp 1-14.

[2] Mayer, H.: Urban bioclimatology. Experientia 49, 1993, pp 957-963.

[3] Höppe, P.: Heat balance modelling. Experientia 49, 1993, pp 741-746.

[4] VDI, Verein Deutscher Ingenieure: VDI-Richtlinie 3787 Blatt 2 (Entwurf) "Methoden zur humanbiometeorologischen Bewertung von Klima und Lufthygiene für die Stadt- und Regionalplanung. Teil I: Klima". VDI, 1996, Düsseldorf. (VDI Guideline 3787, part 2 (draft): "Methods for the Human-Biometeorological Assessment of Climate and Air Hygiene for Urban and Regional Planning - Part 1: Climate" Until approved by VDI: German only).

[5] Mayer, H.: Human-biometeorologische Probleme des Stadtklimas. Geowissenschaften 14, 1996, pp 233-239.

[6] Matzarakis, A. and H. Mayer: Human-biometeorologische Untersuchungen in den höheren Lagen des Schwarzwaldes. Proceedings of the 24th International Conference on Alpine Meteorology, 1996, pp 417-423.

[7] Matzarakis, A.: Human-biometeorologische Bewertung des Klimas von Griechenland. Dissertation. Aristotelian University of Thessaloniki, 1995, Thessaloniki.

[8] Matzarakis, A. and H. Mayer: The extreme heat wave in Athens in July 1987 from the point of view of human biometeorology. Atmospheric Environment 25B, 1991, pp 203-211.

For more information, please contact:

Dr Andreas Matzarakis or Prof Dr Helmut Mayer, Meteorological Institute, University of Freiburg, Werderring 10, D-70985 Freiburg, Germany, phone: +49-761-2033590, fax: +49-761-2033586, e-mail: matzarak@mif.uni-freiburg.de or: hmayer@mif.uni-freiburg.de, Internet: http://www.mif.uni-freiburg.de