The Universal Thermal Climate Index UTCI
Goal and state of COST Action 730

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INTRODUCTION

One of the fundamental issues in human biometeorology is the assessment and forecast of the outdoor thermal environment in a sound, effective and practical way. This is due to the need for human beings to balance their heat budget in any climate to a state very close to thermal neutrality in order to optimise their comfort, performance and health.

The heat exchange between the human body and its environment takes place by sensible and latent heat fluxes, radiation and (generally negligible) conduction. Consequently dealing with the thermo- physiologically significant assessment of the thermal environment requires the application of a complete heat budget model that takes all mechanisms of heat exchange into account. Input variables include air temperature, water vapour pressure, wind velocity, mean radiant temperature including the short- and long-wave radiation fluxes of the atmosphere, in addition to metabolic rate and clothing insulation. Based on current advances in science of heat budget modelling there is a need for harmonisation of the development and dissemination of a universally valid health related climate index.

ISB recognised this issue some years ago and established a Commission "On the development of a Universal Thermal Climate Index UTCI". Since 2005 the COST Action 730 (Cooperation in Science and Technical Development) provides the basis that at least the European scientists can join together on a regular basis in order to achieve significant progress to derive such an index as a standard (www.utci.org).

The main objective of the Action is to develop and make easily available a physiologically relevant assessment model of the thermal environment in order to significantly enhance applications related to health and well-being. The core issues of human biometeorology range from daily forecasts and warnings of extreme weather, to bioclimatic mapping, urban and regional planning, environmental epidemiology and climate impacts research. This covers the fields of public weather service, the public health system, and precautionary planning. The model to be developed will be based on the-state-of-the-art in the cause-effect related assessments of the outdoor thermal environment.

The Universal Thermal Climate Index UTCI (working title) must meet the following requirements:

1) Thermo-physiological significance in the whole range of heat exchange conditions of existing thermal environments
2) Valid in all climates, seasons, and scales
3) Useful for key applications in human biometeorology (see later).

METHODS

The process of developing a UTCI will address the following issues:

a) Heat budget modelling of the human body
b) Physiologically relevant assessment of heat budget model outcomes including acclimatisation
c) Testing results against available field data
d) Identification and pre-processing of meteorological input data
e) Estimating radiation quantities
f) Addressing the specific needs of various applications

The interdisciplinary issue of the development of UTCI becomes evident. Topics a), b) refer to thermo-physiology, c), d) to atmospheric science (meteorology), and e) to a wide range of meteorological applications. According to this, the above listed topics will be addressed by three working groups:

WG1 Thermo-physiological modelling and testing
WG2 Meteorological and environmental data
WG3 Applications

The Commission on UTCI of the International Society of Biometeorology (ISB) has defined that, when fully developed, the UTCI should feature the following:

- The most advanced multi-node thermo-physiological models as reference to obtaining the key results from systematic simulations.
- Include the capability to predict both whole body thermal effects (hypothermia and hyperthermia; heat and cold discomfort), and local effects (facial, hands and feet cooling and frostbite).
- Represent a temperature-scale index, (i.e. the air temperature of a defined reference environment providing the same heat exchange condition).

This COST Action will follow this reasonable convention.

Mathematical modelling of the human thermal system goes back 70 years. Most of the work has been done in the framework of occupational medicine or indoor climate conditions design. Numerous procedures have been published as ISO- or ASHRAE standards. In the past four decades more detailed, multi-node models of human thermoregulation have been developed, e.g. Stolwijk (1971), Konz et al. (1977), Wissler (1985), Fiala et al. (1999 and 2001), Havenith (2001), Huizenga et al. (2001), and Tanabe et al. (2002). Parsons (2003) gives a comprehensive overview. These models simulate phenomena of the human heat transfer inside the body and at its surface taking into account the anatomical, thermal and physiological properties of the human body. Heat losses from body parts to the environment are modelled in detail considering the inhomogeneous distribution of temperature and thermoregulatory responses over the body surface (see Figure 1). Besides overall thermo-physiological variables, multi-segmental models are thus capable of predicting 'local' characteristics such as skin temperatures of individual body parts (which are the critical variables in the risk of frostbite and skin damage). Validation studies have shown that recent multi-node models reproduce the human dynamic thermal behaviour over a wide range of thermal circumstances (Fiala et al. 2001; Havenith (2001); Huizenga et al. 2001). Verification and validation work using independent experiments revealed good agreement with measured data for regulatory responses, mean and local skin temperatures, and internal temperatures for the whole spectrum of environmental conditions. Based on the model comparisons WG 1 decided to base the further development on the meanwhile 340-node Fiala model.

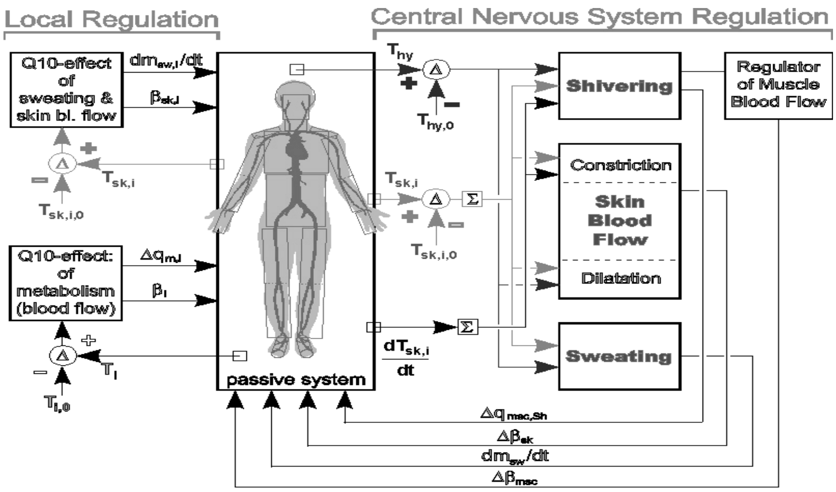

Figure 1 Schematic presentation of a physiological model of human thermoregulation (Fiala et al., 2001)

RESULTS

The main objective of the actions is the availability of a Universal Thermal Climate Index UTCI for health and well-being related thermo-physiologically relevant assessments of the atmospheric environment for the human biometeorological core applications, such as:

- Public weather service.
- Public health system.
- Precautionary planning.

- Climate impact research in the health sector.

In all recommendations for the above listed issues statements will be made on representativeness, time-/ space-resolution, data needs, uncertainties and coverage.

CONCLUSIONS

The development of UTCI requires co-operation of experts from thermo-physiology, thermo-physiological modelling, occupational medicine, met data handling and in particular radiation modelling, application development etc. In order to achieve significant progress it is necessary that the relevant scientists join together on a regular basis. It is thus evident that for such a multidisciplinary task a COST Action provides the best framework to derive a health related climate index as a standard. The interdisciplinary development strategy, the actual state of the UTCI development, and selected examples for typical applications in the above mentioned core issues will be given.

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