Calculating UTCI Equivalent Temperatures

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"Towards a Universal Thermal Climate Index UTCI for Assessing the Thermal Environment of the Human Being"
http://www.utci.org

UTCI Equivalent Temperature (ET) of an actual thermal condition is the air temperature of the reference condition causing the same dynamic physiological response

The Dynamic Whole Body Response

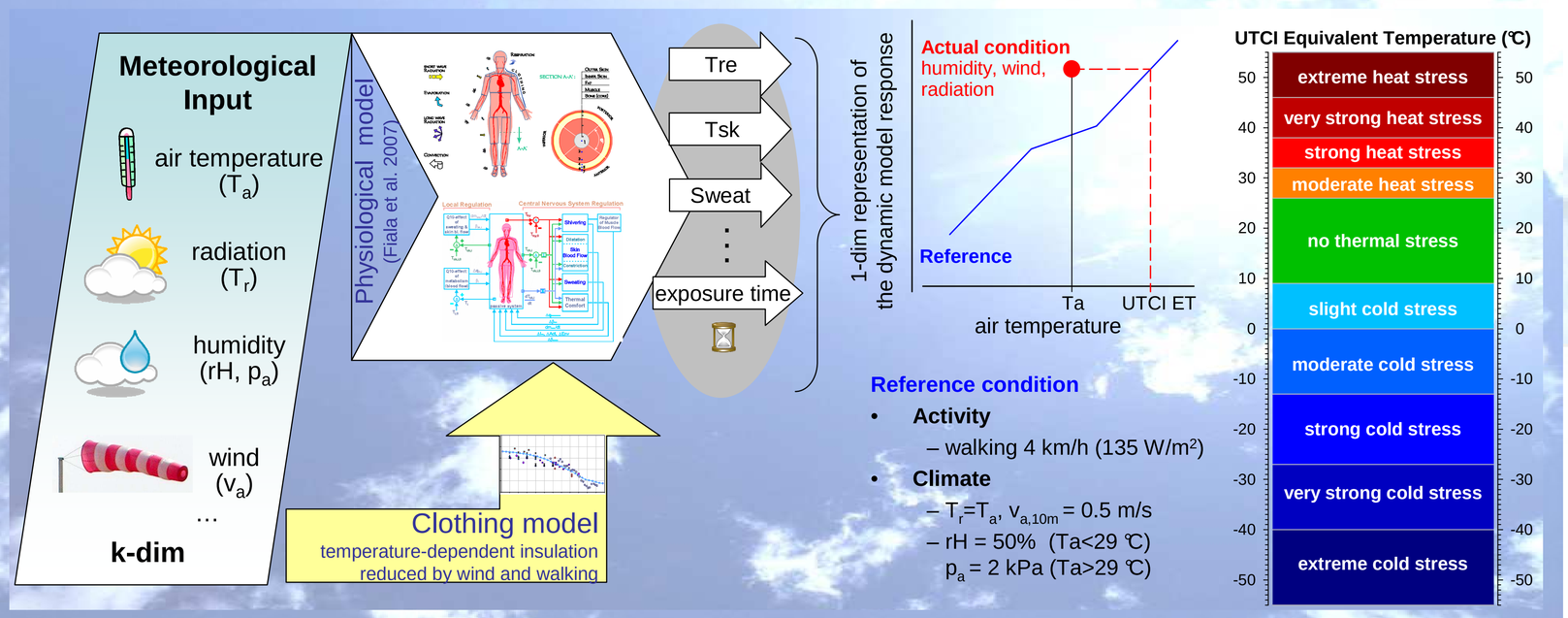
Thermoregulatory simulation model (Fiala et al. 2007) : extensively validated (Psikuta et al. 2007), coupled with a clothing model (Richards & Havenith 2007, ISO 9920)

Response index (Fig. 1) , a 1-dim representation necessary for executing the comparisons to the reference conditions, was computed as the 1st Principal Component (PC) from the early (30 min) and late (120 min) reactions of

7 indicators of thermal strain : rectal temperature, mean and face skin temperatures, skin blood flow, sweat rate, skin wettedness, shivering

UTCI Equivalent Temperature

- Accelerated computation with acceptable error (Fig. 2)
- Categorisation in terms of thermal stress derived from single variables' responses in reference conditions (Fig. 3)
- Plausible effects of radiation and wind (Fig. 4), humidity response similar to human strain (Kampmann & Bröde 2009)



"The" Physiological Response – A Latent Variable in the Multidimensional Output of the UTCI Model – Multivariate Analyses

Simulation Runs

Grid Data (N = 104692)

- Cover relevant range of meteorological input parameters
- -50 °C $\leq T_a \leq$ +50 °C ($\Delta = 1$ K)
- -30 °C $\leq T_r - T_a \leq$ +70 °C ($\Delta = 5$ K)
- v_a (10 m above ground): $0.5, \ldots, 30.3$ m/s
- $rH = 5, \ldots, 100\%$ or max. $p_a = 5$ kPa

Reference Data (N = 926)

- Cover range of expected ET values
- -110 °C $\leq T_a \leq$ +75 °C ($\Delta = 0.2$ K)
- $T_r = T_a$
- $v_{a,10m}$ = 0.5 m/s
- $rH = 50\%$ ($T_a < 29$ °C)
  p_a = 2 kPa ($T_a > 29$ °C)

Model output at 30, 60, 90 and 120 min of simulated exposition time

Variable	abbr.	Unit
rectal temperature	Tre	°C
mean skin temperature	Tskm	°C
face skin temperature	Tskfc	°C
hand skin temperature	Tskhn	°C
total net heat loss	Qsk	W
evaporative heat loss	Esk	W
sweat rate	Mskdot	g/min
metabolic heat production	Metab	W
heat generated by shivering	Shiv	W
skin wettedness	wettA	% of body area
skin blood flow	VblSk	% of basal value
cardiac output	sVbl	% of basal value

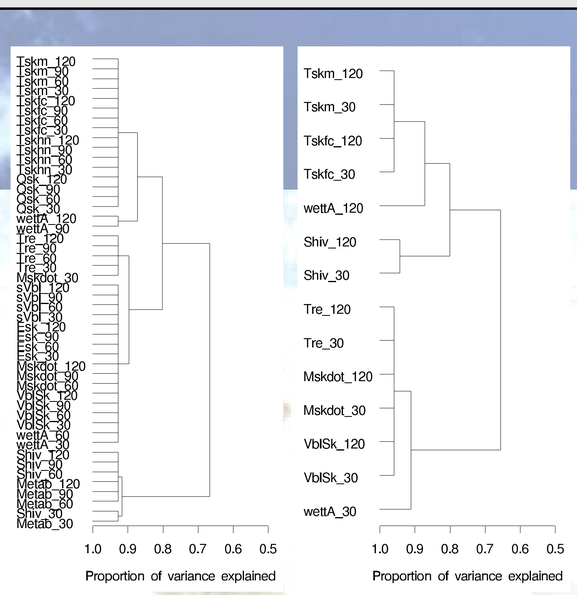


Figure 1: *Dendrograms from hierarchically clustering 48* ***(a)*** *and 14* ***(b)*** *variables.* ***(c)****: Response index for the reference conditions calculated as 1st PC from 48 and 14 variables.* ***(d)****: Correlation of early and late reactions of 7 parameters of thermal strain with the response index.*

Fast Computation

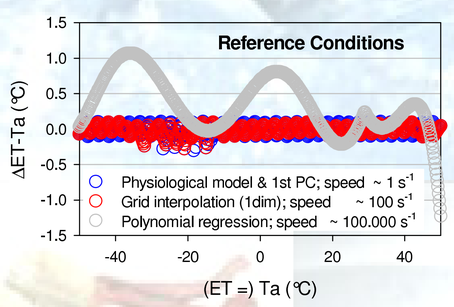


Figure 2: *Error in approximating the "exact solutions" ($ET = T_a$) in reference conditions by 3 procedures differing in speed.*

Stress Categories derived from Responses in Reference Conditions, e.g.:

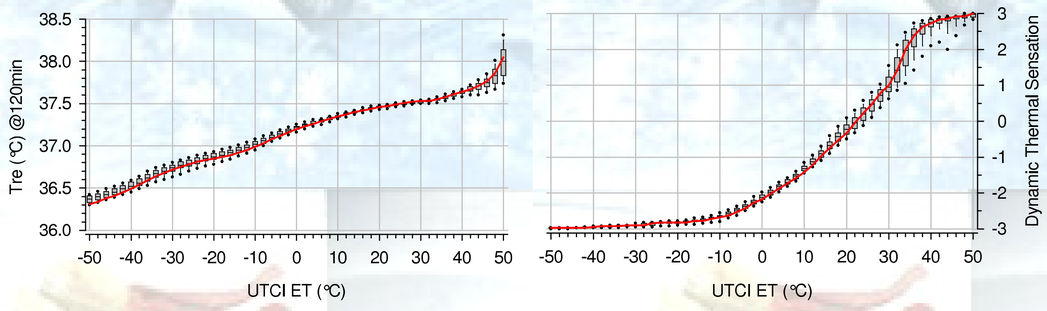


Figure 3: *Rectal temperature after 2 h (T_{re}) and dynamic thermal sensation (Fiala et al. 2007) averaged over 2 h exposition time related to ET. Box-Plots derived with ET rounded to 2 K wide bins. Dots mark the 5th and 95th percentile, red lines mark values of reference conditions.*

Sensitivity to Humidity, Radiation and Wind (non-considered climatic parameters set to reference conditions)

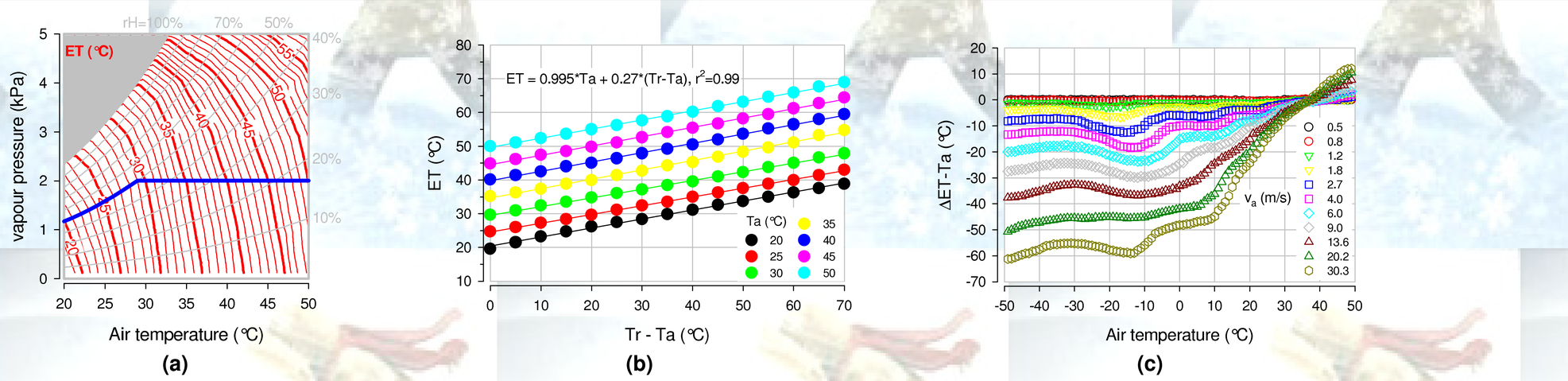


Figure 4: *ET in the psychrometric chart with the blue line indicating reference humidity* ***(a)****, effects of thermal radiation on ET* ***(b)****, and of wind speed on the offset ($\Delta ET - T_a$)* ***(c)****.*

References

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