UTCI
The Universal Thermal Climate Index

COST TC April 22-23, 2004 in Langen

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Why UTCI?

- Assessment of the thermal environment: Key issue in human biometeorology
- History: >100 simple thermal indices
- Last 30 years: heat budget modelling
- Integration of new knowledge and concerns
- Need: harmonization $\rightarrow$ UTCI (ISB, WMO)
- COST? (Example: UV-Index)
Key applications

**Daily forecasts**
- Public weather service
- Warnings (heat load (HHWS), cold stress (windchill))
- Advice (clothing, outdoor activities)

**Climate**
- Bioclimatological assessments
- Bioclimate maps in all scales (micro - macro)
- Urban design, engineering of outdoor spaces
- Consultancy for residence
- Outdoor recreation and climatotherapy
- Epidemiology
- Climate impact research
Perceived Temperature PT  August 12, 2003

heat load

- extreme
- strong
- moderate
- slight
- comfortable

cold stress

UTC
13:00
Hypothetical heat warnings in 2003
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\[ \text{height} \]

\[ \text{width} \]

\[ \text{Tair} \]

\[ \Delta \text{TMRT} \]

\[ \text{PT} \]

\[ \text{PT} \]

\[ \text{Tsurface} \]

\[ \frac{|V|}{\text{ms}^{-1}} \]

\[ \text{PT} \]

\[ 42 ^\circ \text{C} \]

\[ 38 \]

\[ 34 \]

\[ 30 \]

\[ 26 \]

\[ 34 \]

\[ 36 \]

\[ 38 ^\circ \text{C} \]

\[ \text{Twall} \]

\[ \text{Twall} \]
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Berlin

frequency of heat load
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July
Δ Perceived Temperature PT (July) 2041-50 and 1971-80, „business-as-usual“ (IS92a)

ECHAM4/T106
DKRZ Hamburg
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The Thermal Environment

PT
The human heat budget

\[ M + W + Q^* + Q_H + Q_L + Q_{SW} + Q_{Re} = 0 \]

- **M**: metabolic rate
- **W**: mechanical power
- **Q^***: radiation budget
- **Q_H**: turbulent flux of sensible heat
- **Q_L**: turbulent flux of latent heat (diffusion of water vapour)
- **Q_{SW}**: turbulent flux of latent heat (sweat evaporation)
- **Q_{Re}**: respiratory heat flux (sensible and latent)
### Thermophysiological Assessment of the Thermal Environment

<table>
<thead>
<tr>
<th>ASHRAE code</th>
<th>Descriptive term</th>
<th>Thermophysiology</th>
<th>Meteorology</th>
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<tbody>
<tr>
<td>PMV</td>
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<tr>
<td>PT*</td>
<td>°C</td>
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<td>PET</td>
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<td>OUT_SET*</td>
<td>°C</td>
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<td>AT 1,2,3</td>
<td>°C</td>
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<td>(WCT)</td>
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<tr>
<td>T_sk</td>
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<tr>
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<td>kgs⁻¹</td>
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#### Heat budget models

(One or two nodes)

- Fanger (1970)
- Jendritzky et al. (1979, 1991)
- Steadman (1984, 1994)
- Hoeppe (1984, 1999)
- Gagge et al. (1986)
- Blazejczyk (1994)
- Horikoshi et al. (1995, 1997)
- Pickup & de Dear (2000)
- Bluestein & Osczevski (2002)
- etc.
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Simulated whole body and local thermophysiological variables

- Mean skin temperature, $T_{sk,m}$
- Head core temperature (hypothalamus), $T_{hy}$
- Total evaporative heat loss from the skin, $E_{sk}$
- Skin wettedness, $w_{sk}$
- Local skin temperatures of face and hands, $T_{sk,f,h}$
- Cooling time for $T_{sk,f,h} < 0^\circ C$

Assessment problem!
Variables for multi-node model simulations

**Meteorological input**

- **Air temperature** ($T_a$): $-40^\circ C < T_a < +45^\circ C$ 5K
- **Mean radiant temperature** ($T_{mrt}$): $-10K < T_{mrt} - T_a < +40K$ 10K
- **Relative humidity** (rh): $5% < rh < 95%$ 15%
- **Relative wind speed** ($v_r$): 1.1, 2.2, 4.4, 8.8, 17.6 m/s (*2)

**Intrinsic clothing** (Icl): 0.4, 0.6, 0.9, 1.3, 1.8, 2.6 clo

⇒ 22680 combinations (partially unrealistic, but which?)
Reference conditions for UTCI temperature*

- Activity walking 4 km/h = 2.3 MET (~135 Wm⁻²)
- Calm wind, i.e. only wind induced by walking (1.1 m/s)
- \( T_{mrt} = T_a \)
- \( \text{rh} = 50\% \)
- \( I_{cl}: \text{variable (0.5 -2.0 clo)} \)

*Temperature of a reference environment that provides the same heat exchange as under the actual thermal conditions
Summary: Basic features of UTCI

- Thermophysiologically significant in the whole range of heat exchange conditions
- Valid in all climates, seasons and scales
- Useful for key applications in human biometeorology
- Steady-state conditions → practically useful results
- Independent of individual characteristics
- Prediction of whole body and local thermal effects
- Based on the most advanced multi-node models
- Temperature scale index
Selected subproblems

• Heat budget modelling
• Assessment of physiological variables
• Acclimatisation
• Meteorological input, in particular radiation $\rightarrow T_{mrt}$
• Definition of areas of validity, requirements
• ?
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