

# UTCI

## The Universal Thermal Climate Index

**COST TC April 22-23, 2004 in Langen**

**Gerd Jendritzky**

**Deutscher Wetterdienst, Freiburg, Germany**

# 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 → UTCI (ISB, WMO)
- COST? (Example: UV-Index)

## Key applications

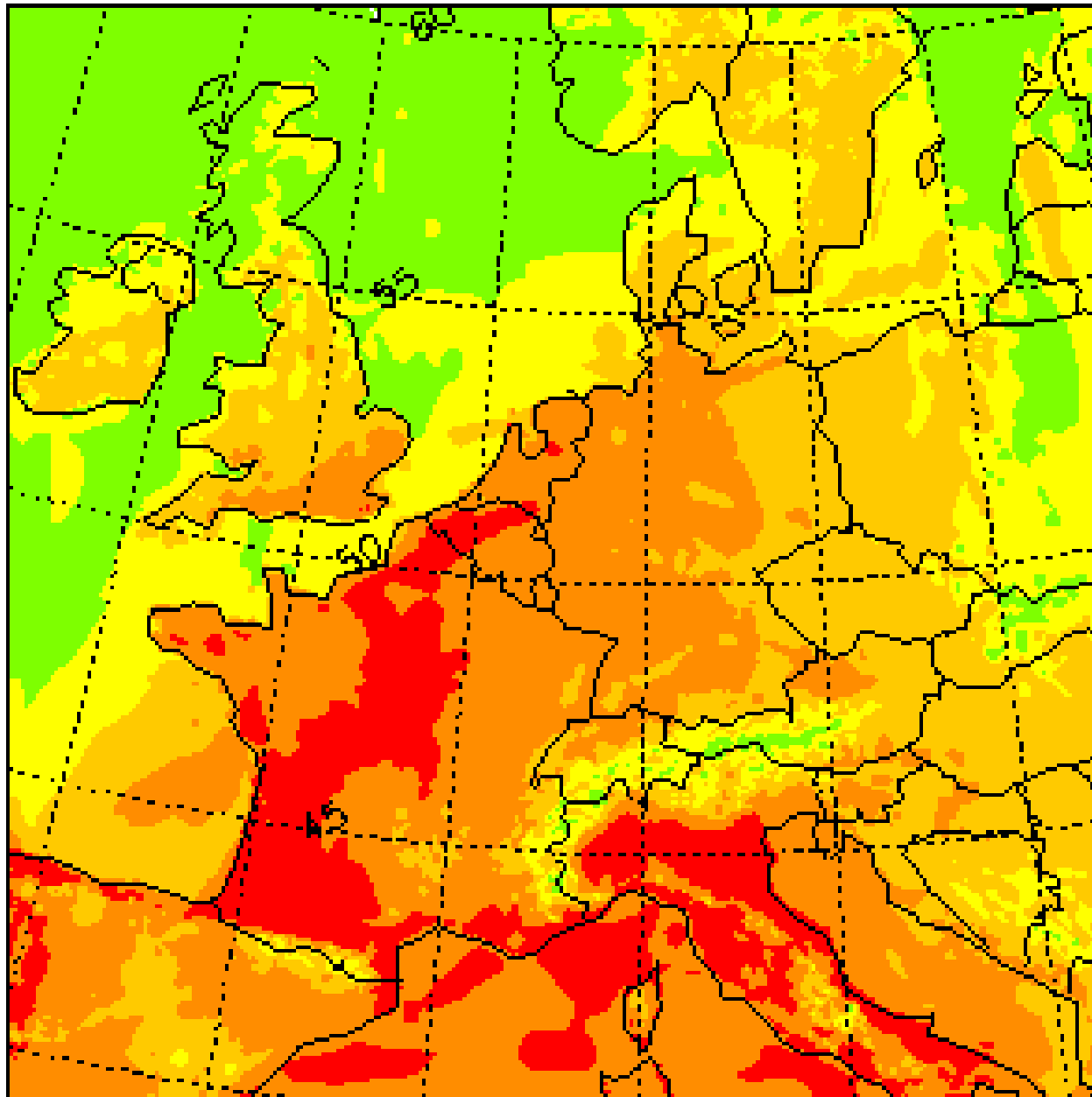
### Daily forecasts

- 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



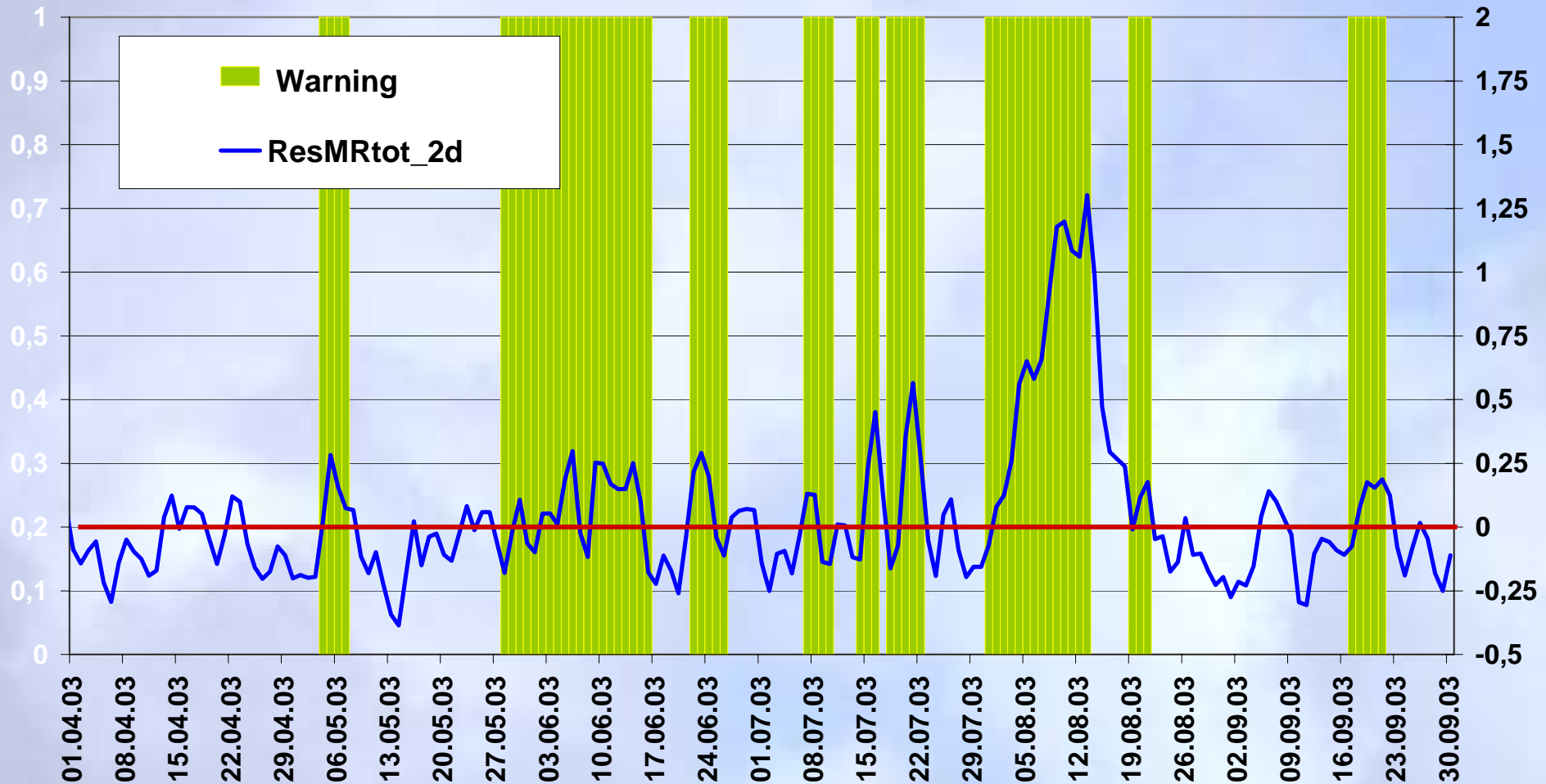
heat load



cold stress

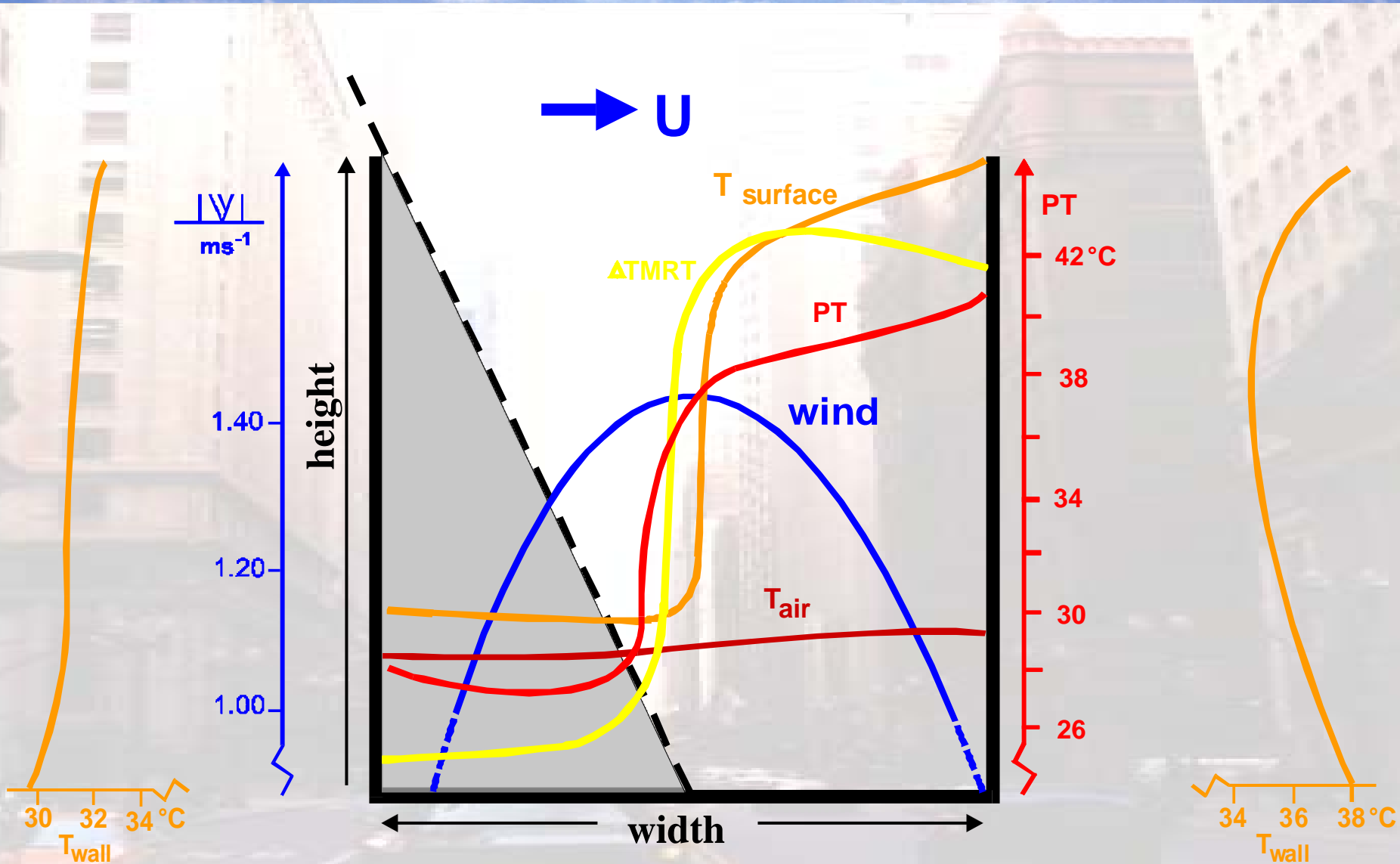
UTC  
13:00

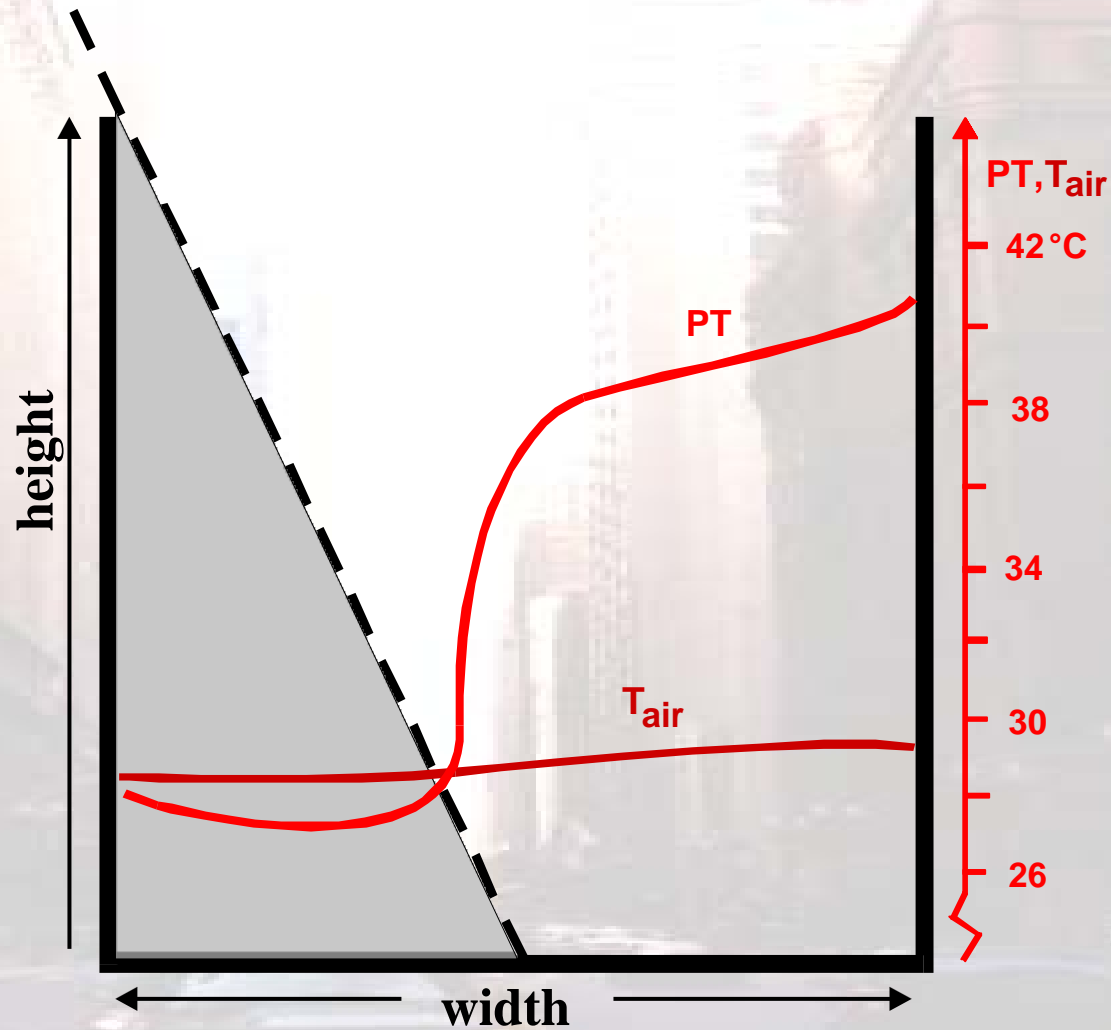
## Hypothetical heat warnings in 2003



# Deutscher Wetterdienst

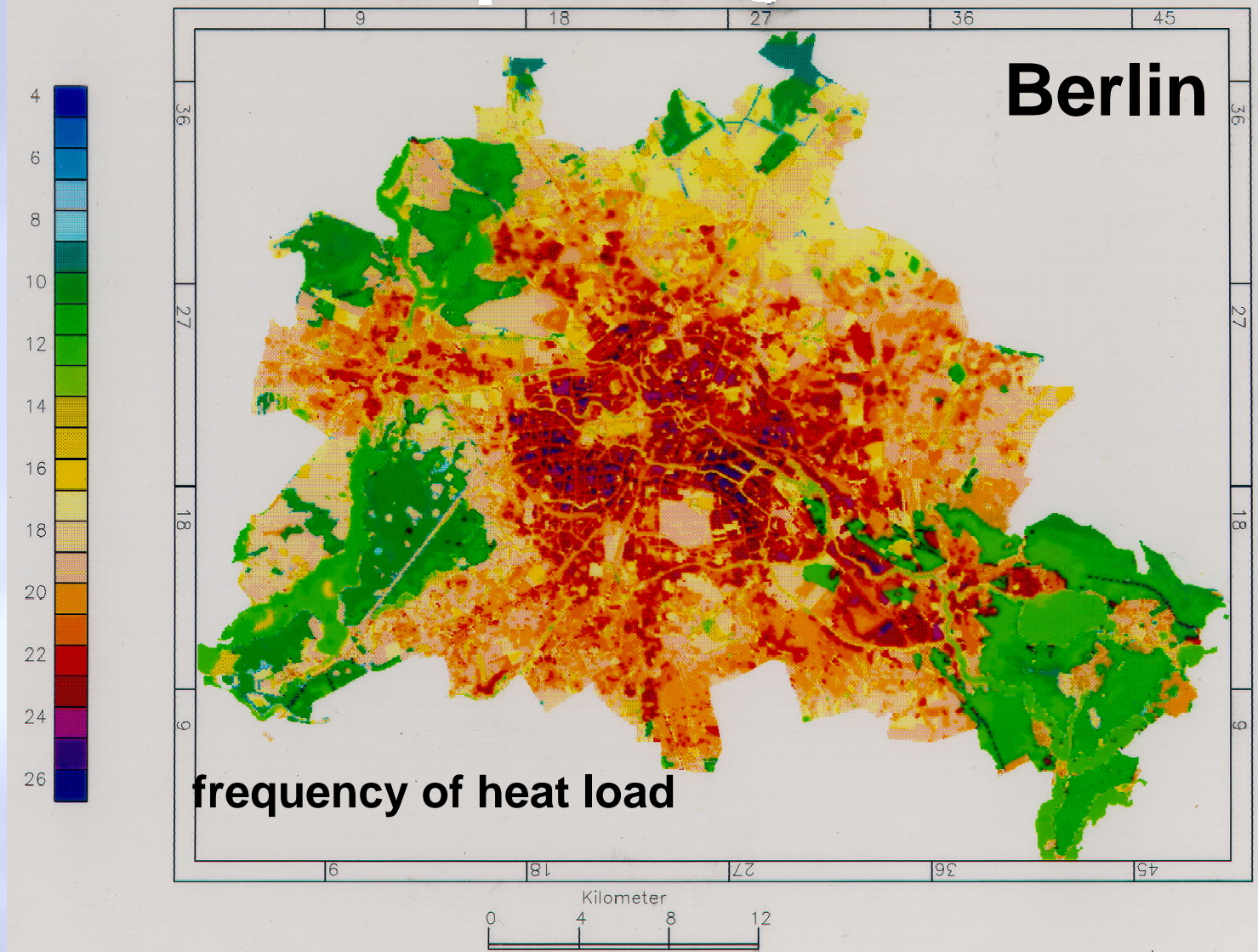
## Human Biometeorology





# Deutscher Wetterdienst

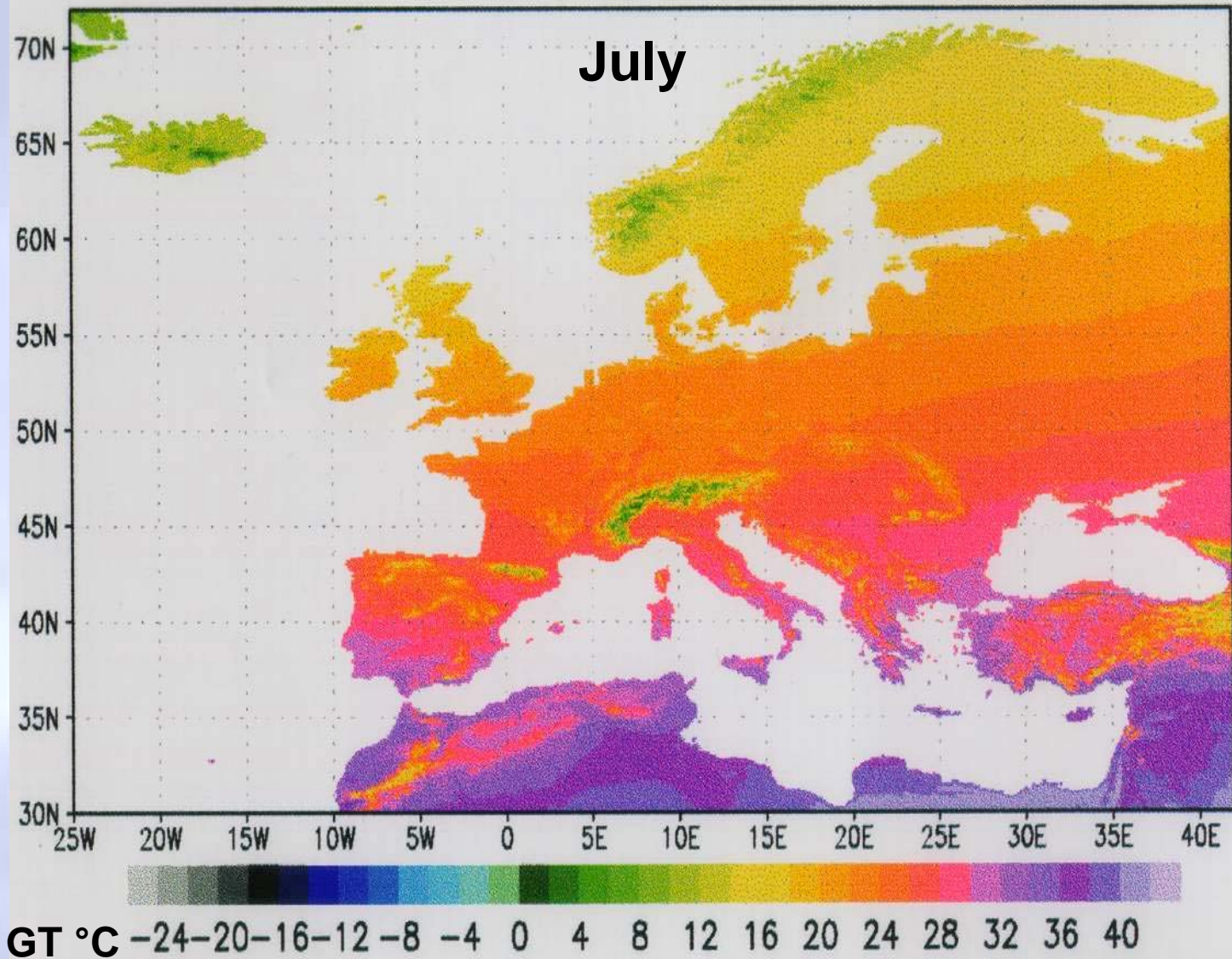
## Human Biometeorology





# Deutscher Wetterdienst

## Human Biometeorology

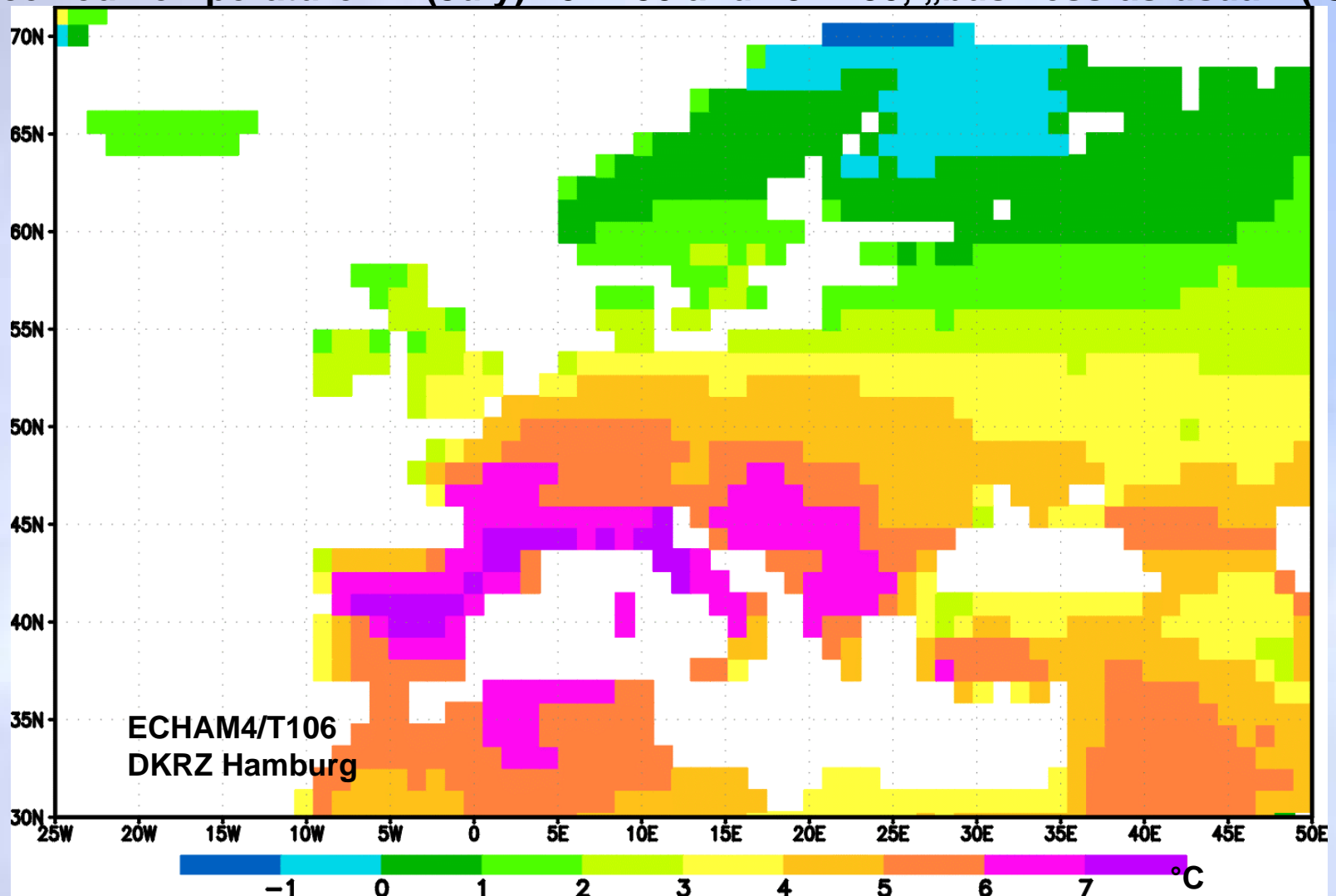


# Deutscher Wetterdienst

## Human Biometeorology



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

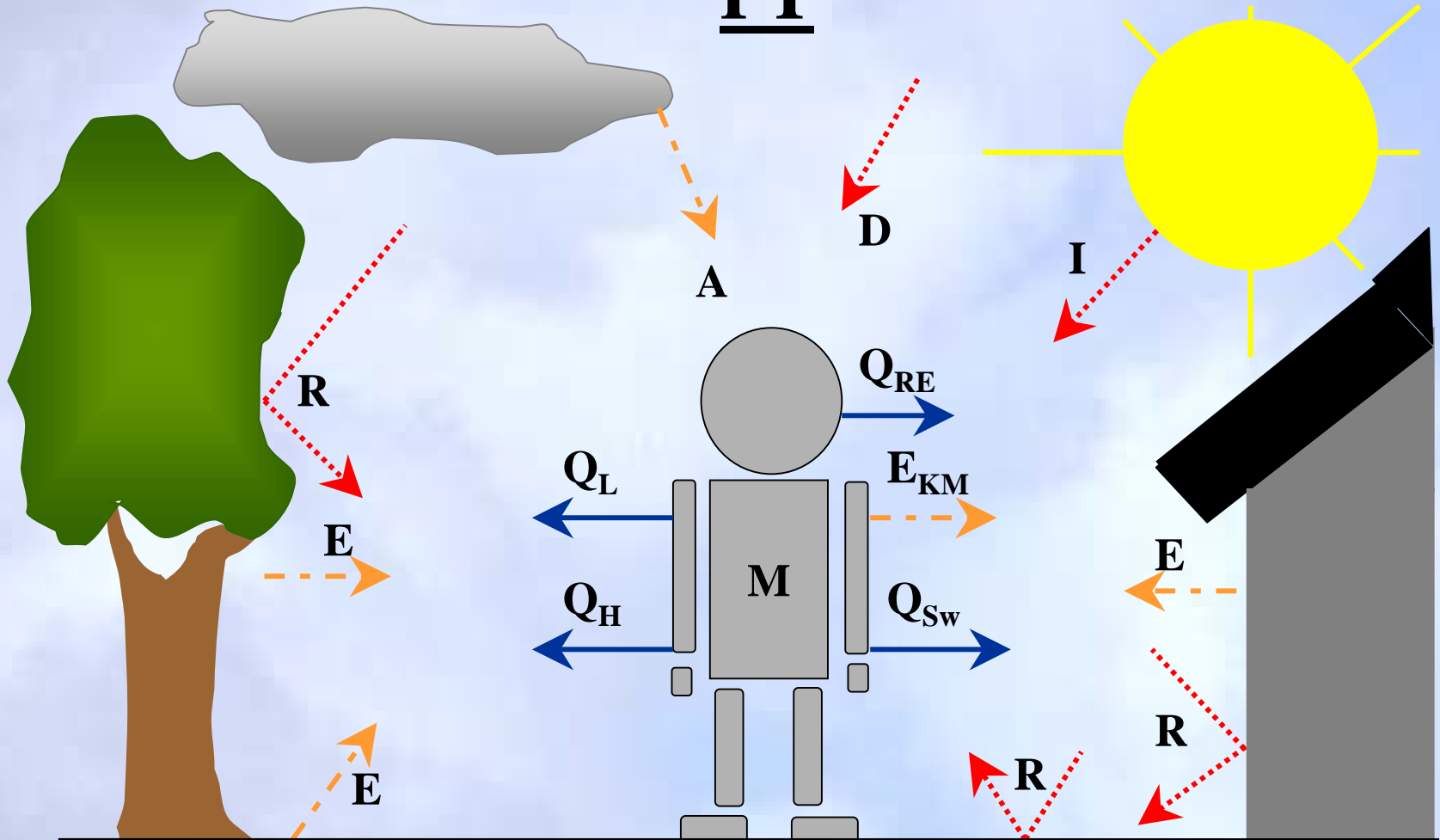


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# The Thermal Environment

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

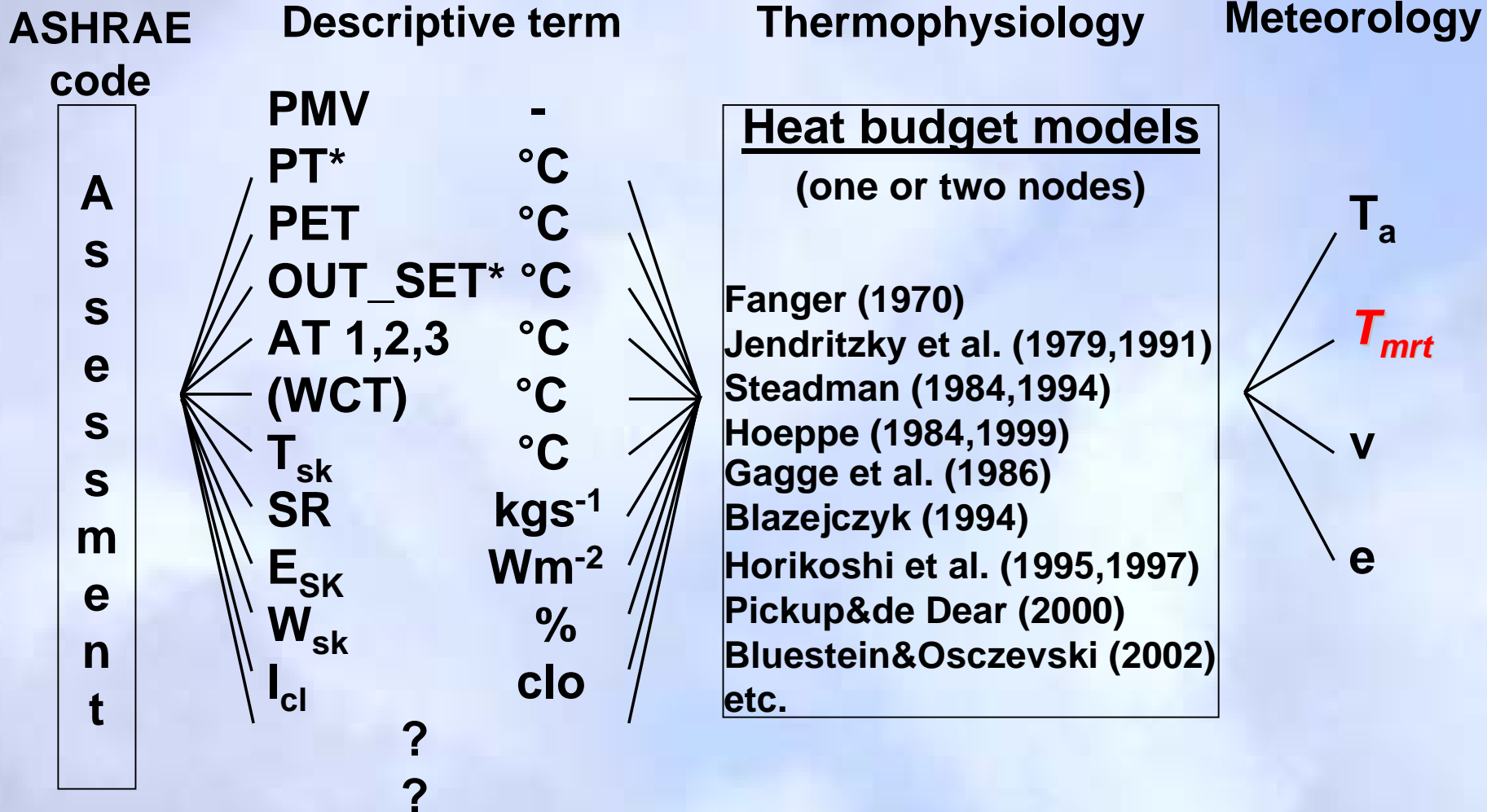
**Q<sub>H</sub>** turbulent flux of sensible heat

**Q<sub>L</sub>** turbulent flux of latent heat (diffusion of water vapour)

**Q<sub>SW</sub>** turbulent flux of latent heat (sweat evaporation)

**Q<sub>Re</sub>** respiratory heat flux (sensible and latent)

# Thermophysiological Assessment of the Thermal Environment

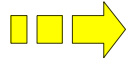


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Fiala et al. 2001

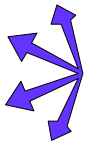
SHORT WAVE RADIATION



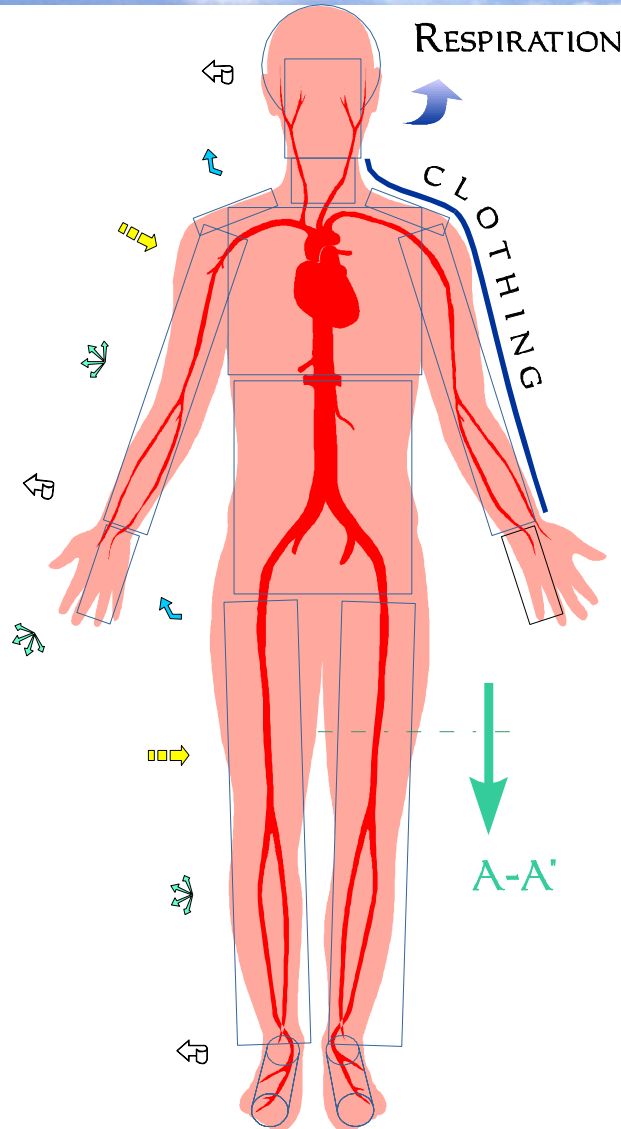
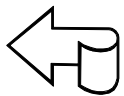
EVAPORATION



LONG WAVE RADIATION



CONVECTION



SECTION A-A' :

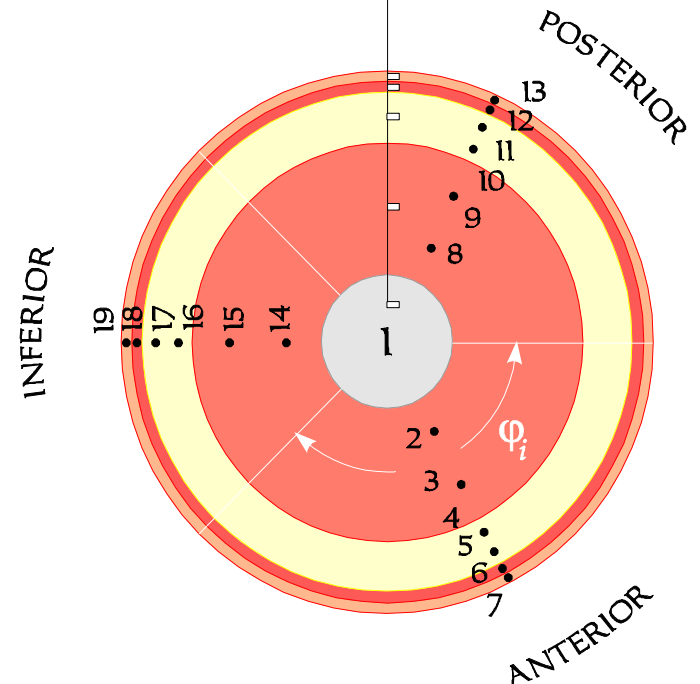
OUTER SKIN

INNER SKIN

FAT

MUSCLE

BONE (CORE)





# 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  $T_{sk,f,h} < 0^{\circ}\text{C}$

**Assessment problem!**

# Variables for multi-node model simulations

## Meteorological input

Δ

Air temperature ( $T_a$ ):  $-40^{\circ}\text{C} < T_a < +45^{\circ}\text{C}$  5K

Mean radiant temperature ( $T_{mrt}$ ):  $-10\text{K} < T_{mrt} - T_a < +40\text{K}$  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 ( $\sim 135 \text{ Wm}^{-2}$ )
- Calm wind, i.e. only wind induced by walking (1.1 m/s)
- $T_{\text{mrt}} = T_{\text{a}}$
- $\text{rh} = 50\%$
- $\text{Icl}$ : 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

- **Thermophysiologicaly 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 →  $T_{mrt}$
- Definition of areas of validity, requirements
- ?

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# Deutscher Wetterdienst

## Human Biometeorology

