UTCI

The Universal Thermal Climate Index

COST Action

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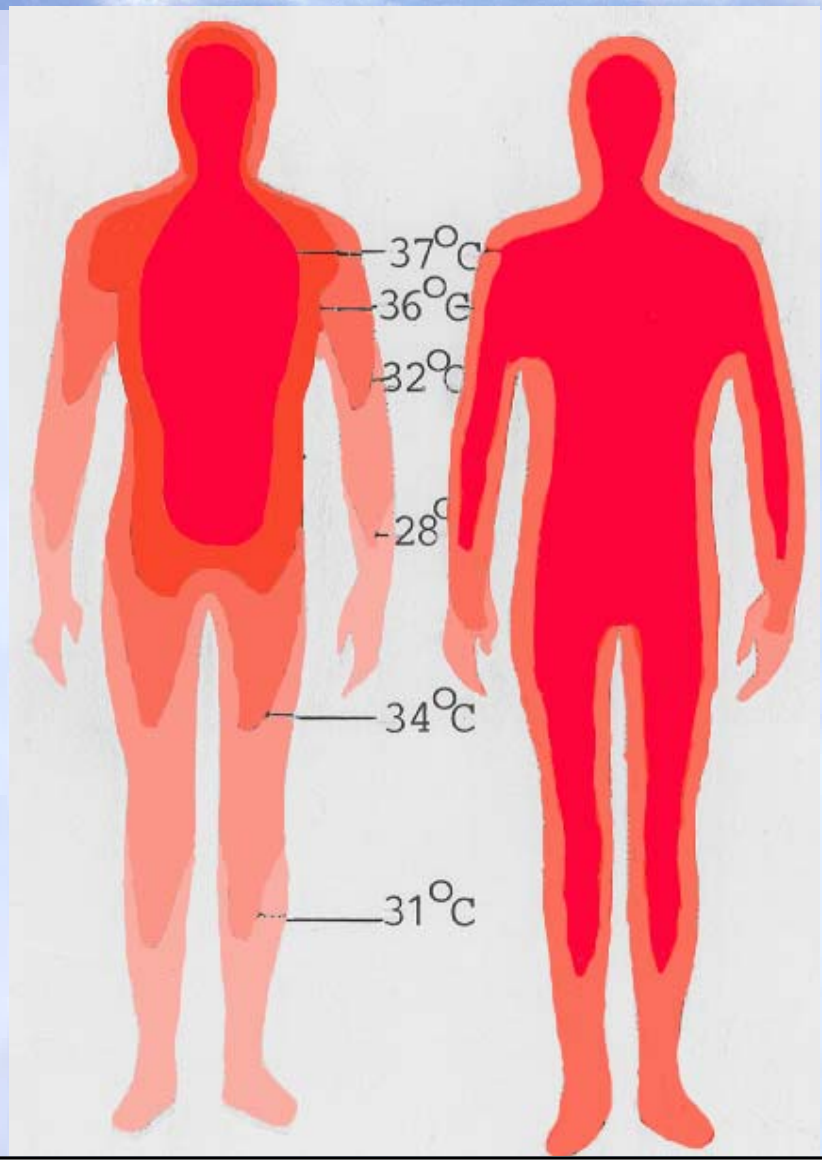
ISB WMO

Why UTCI?

- **Assessment of the thermal environment: Key issue in human biometeorology**
- **History: >100 simple thermal indices**
- **Last 35 years: heat budget modelling**
- **Integration of new knowledge and concerns**
- **Need: harmonization → UTCI (ISB, WMO)**
- **COST Action (Example: UV-Index)**

cold



warm

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 where to live
- Outdoor recreation and climatotherapy
- Epidemiology
- Climate impact research

Key applications

Examples

- Klima-Michel-model with Perceived Temperature PT
- Assessment standard of DWD for the thermal environment
- Based on Fanger‘s PMV equation and Gagge‘s PMV* correction
- Application specific treatment of the meteorological input data (Tmrt!)

- All other complete heat budget models would provide comparable results (more or less).

Key applications

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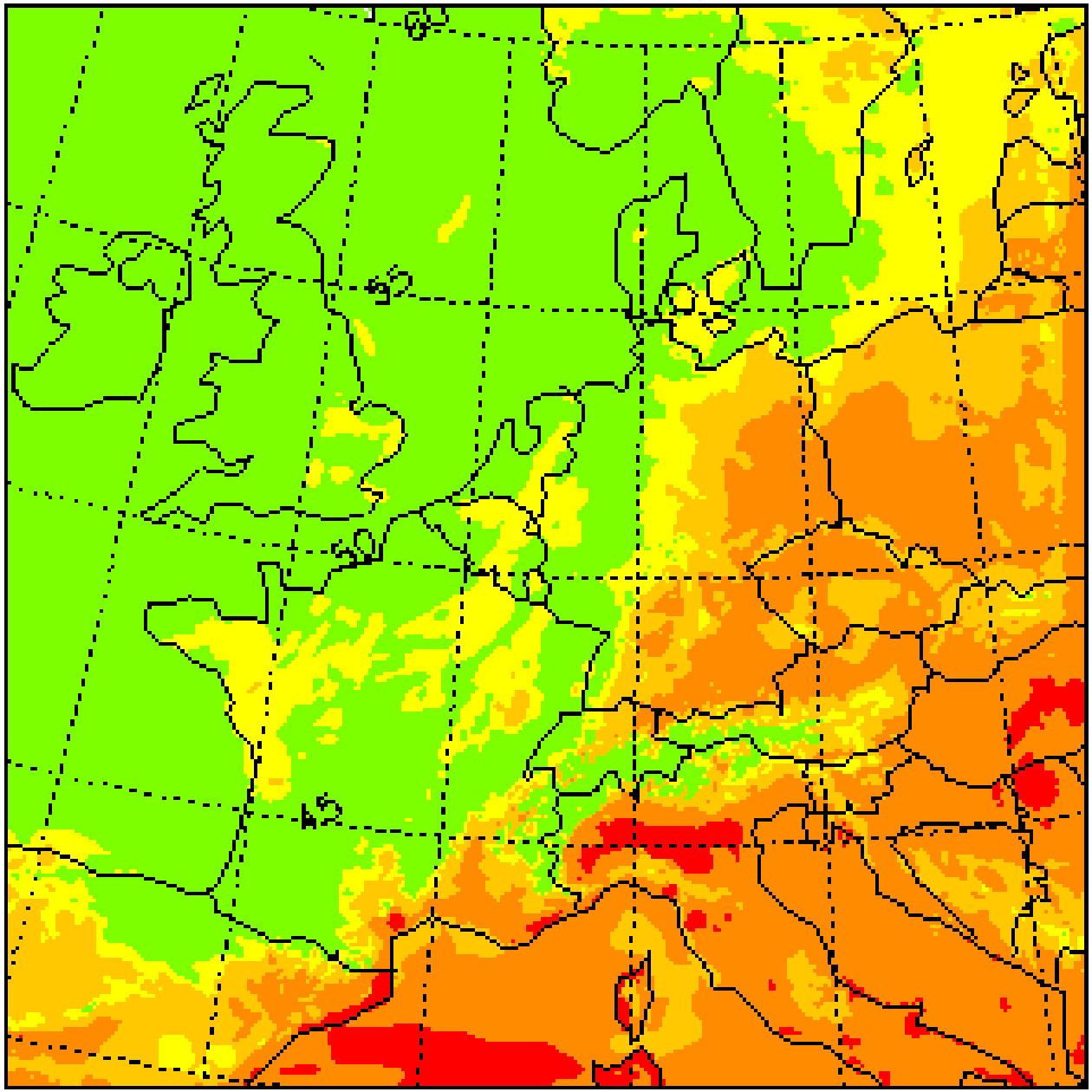
Perceived Temperature PT July 27, 2003



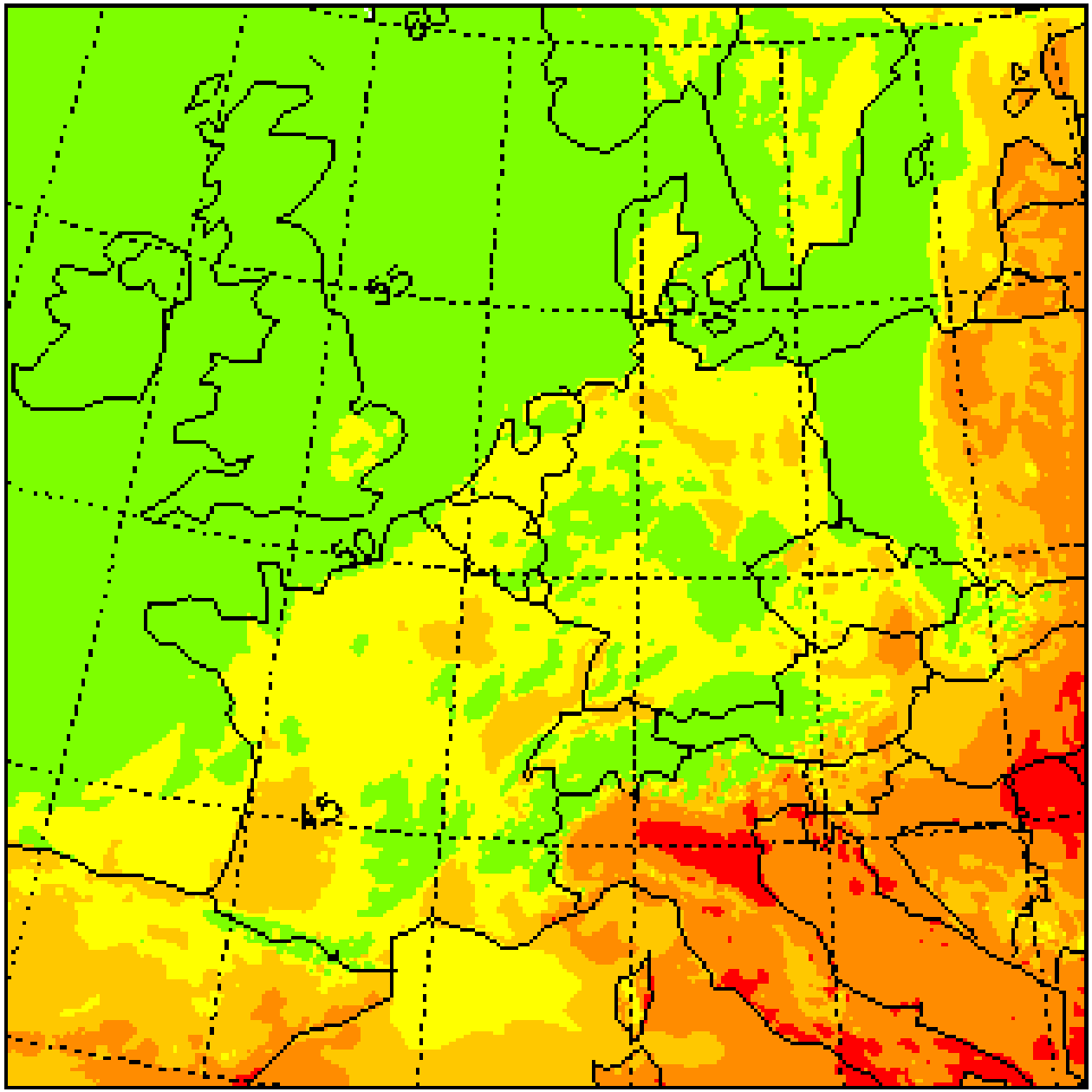
heat load

°C
38 extreme
32 strong
26 moderate
20 slight
0 comfortable
−13 slight
−26 moderate
−39 strong
extreme

cold stress

UTC
13:00

Perceived Temperature PT July 28, 2003



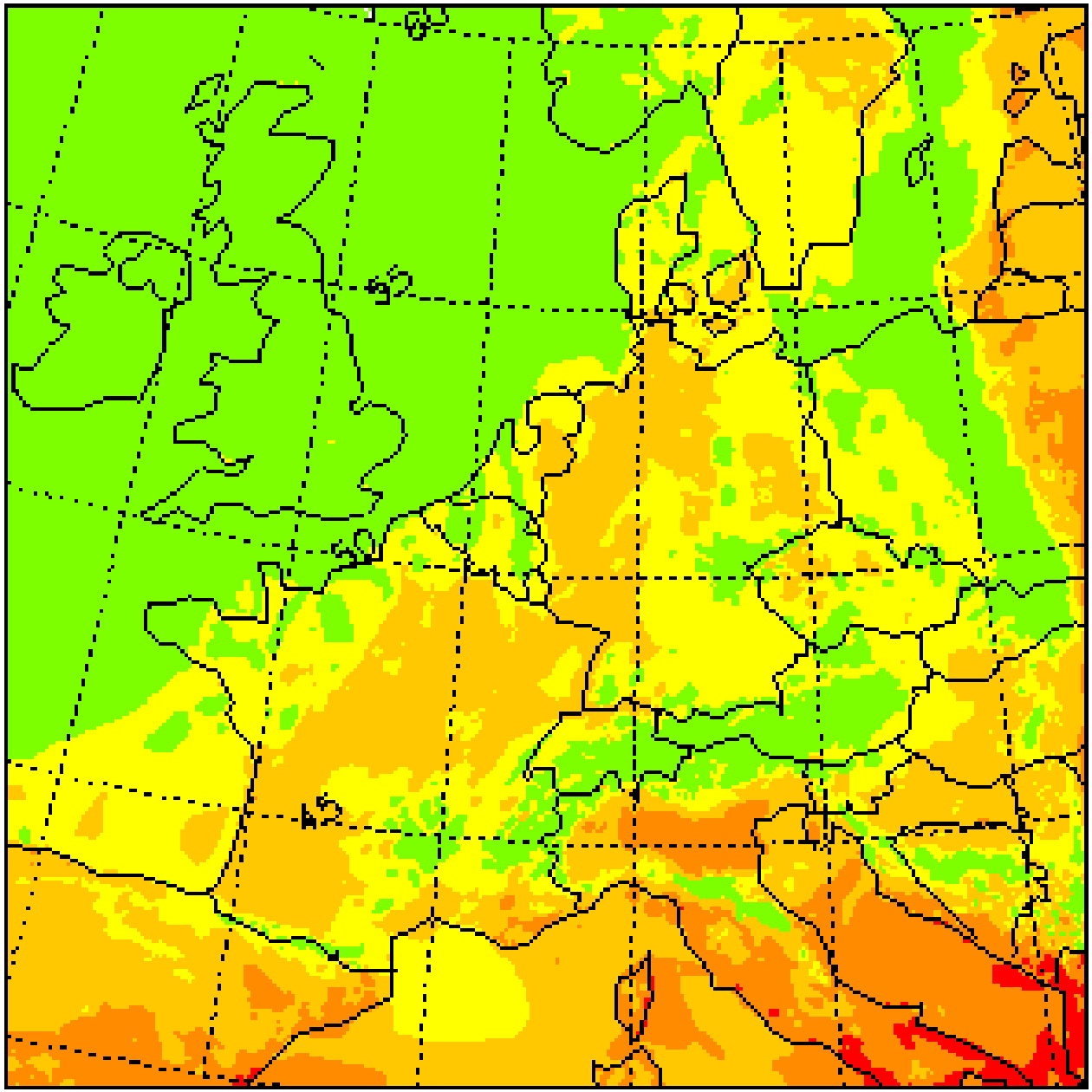
heat load

°C
38 extreme
32 strong
26 moderate
20 slight
0 comfortable
−13 slight
−26 moderate
−39 strong
extreme

cold stress

UTC
13:00

Perceived Temperature PT July 29, 2003



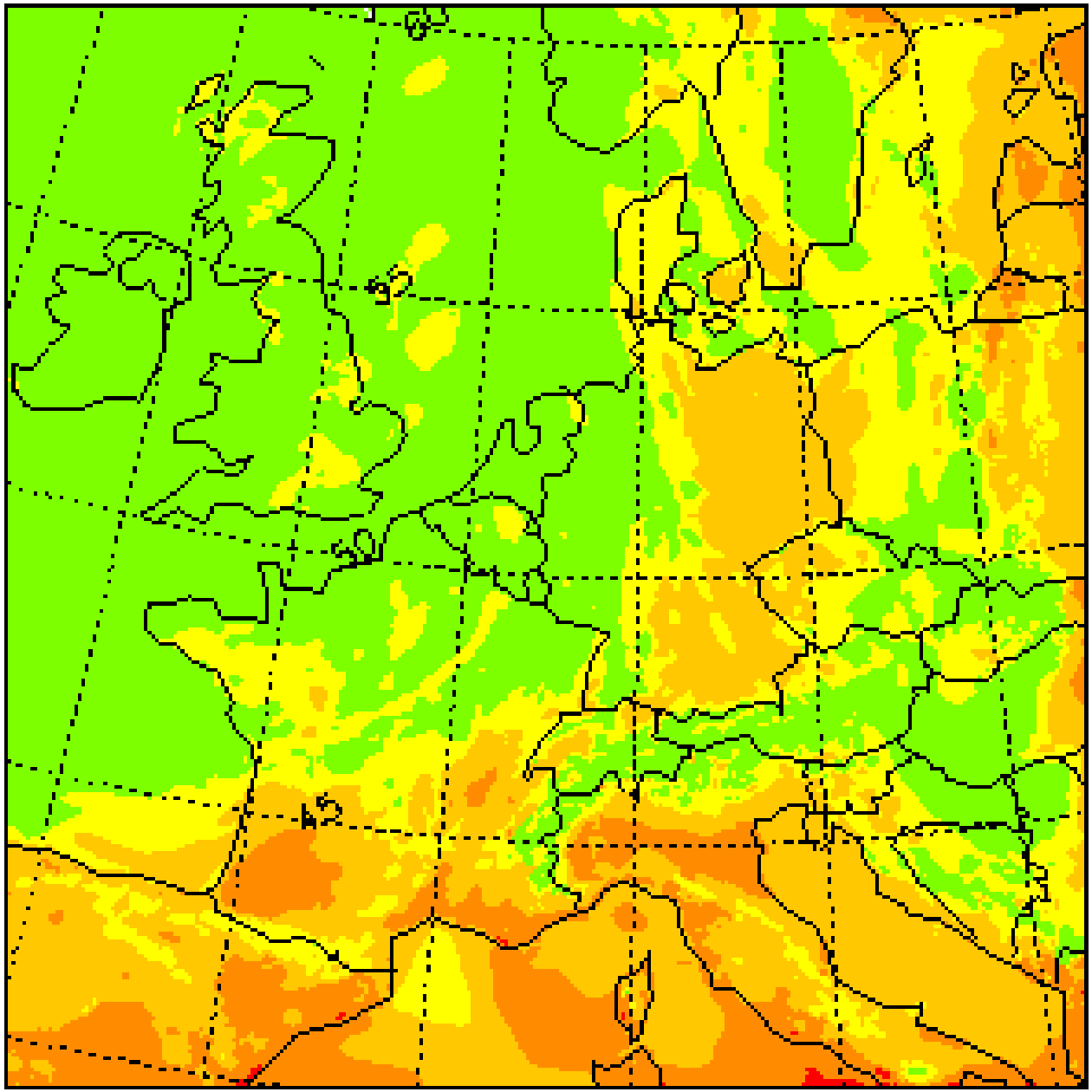
heat load

°C
38 extreme
32 strong
26 moderate
20 slight
0 comfortable
−13 slight
−26 moderate
−39 strong
extreme

cold stress

UTC
13:00

Perceived Temperature PT July 30, 2003



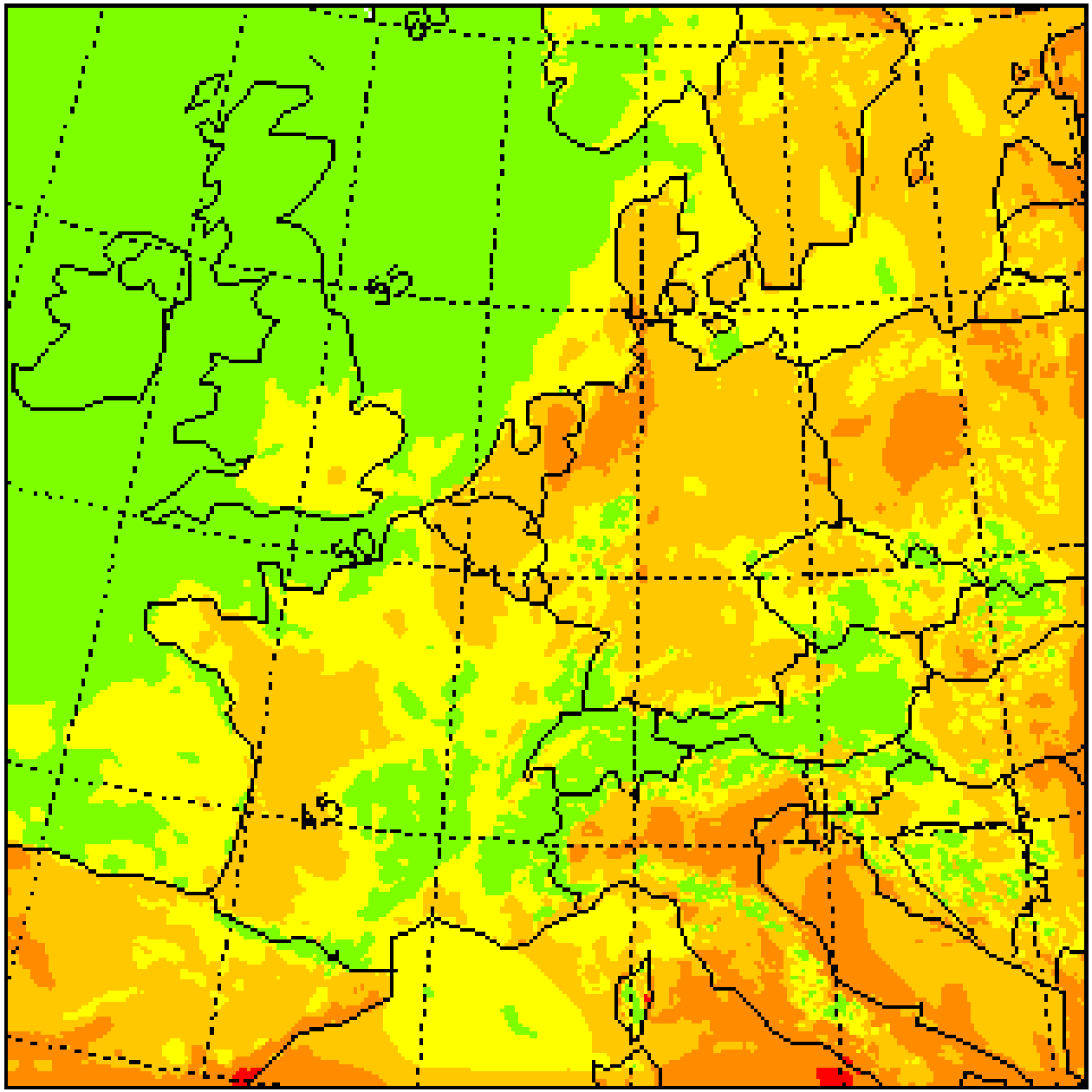
heat load

°C
38 extreme
32 strong
26 moderate
20 slight
0 comfortable
−13 slight
−26 moderate
−39 strong
extreme

cold stress

UTC
13:00

Perceived Temperature PT July 31, 2003



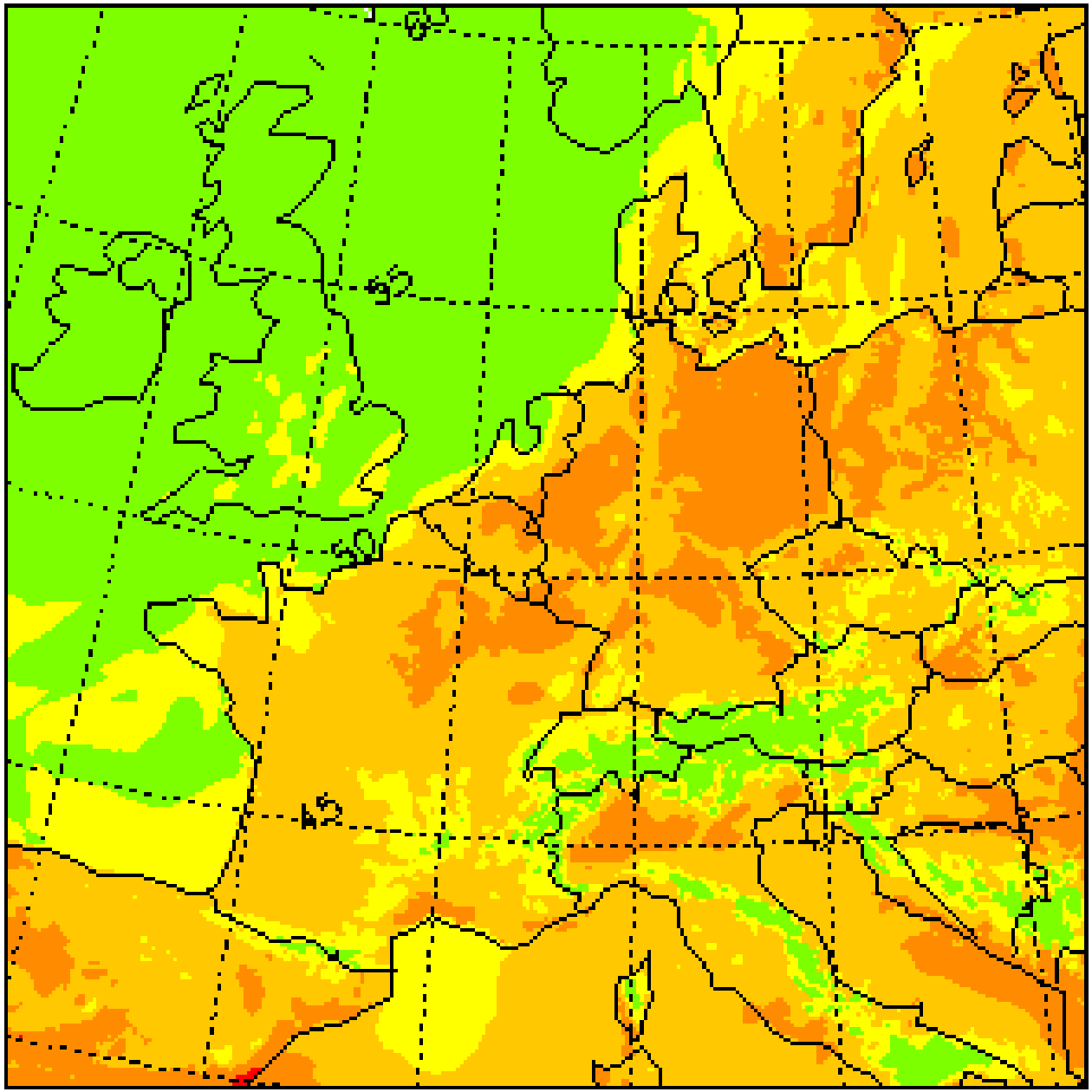
heat load

°C
38 extreme
32 strong
26 moderate
20 slight
0 comfortable
−13 slight
−26 moderate
−39 strong
extreme

cold stress

UTC
13:00

Perceived Temperature PT August 1, 2003



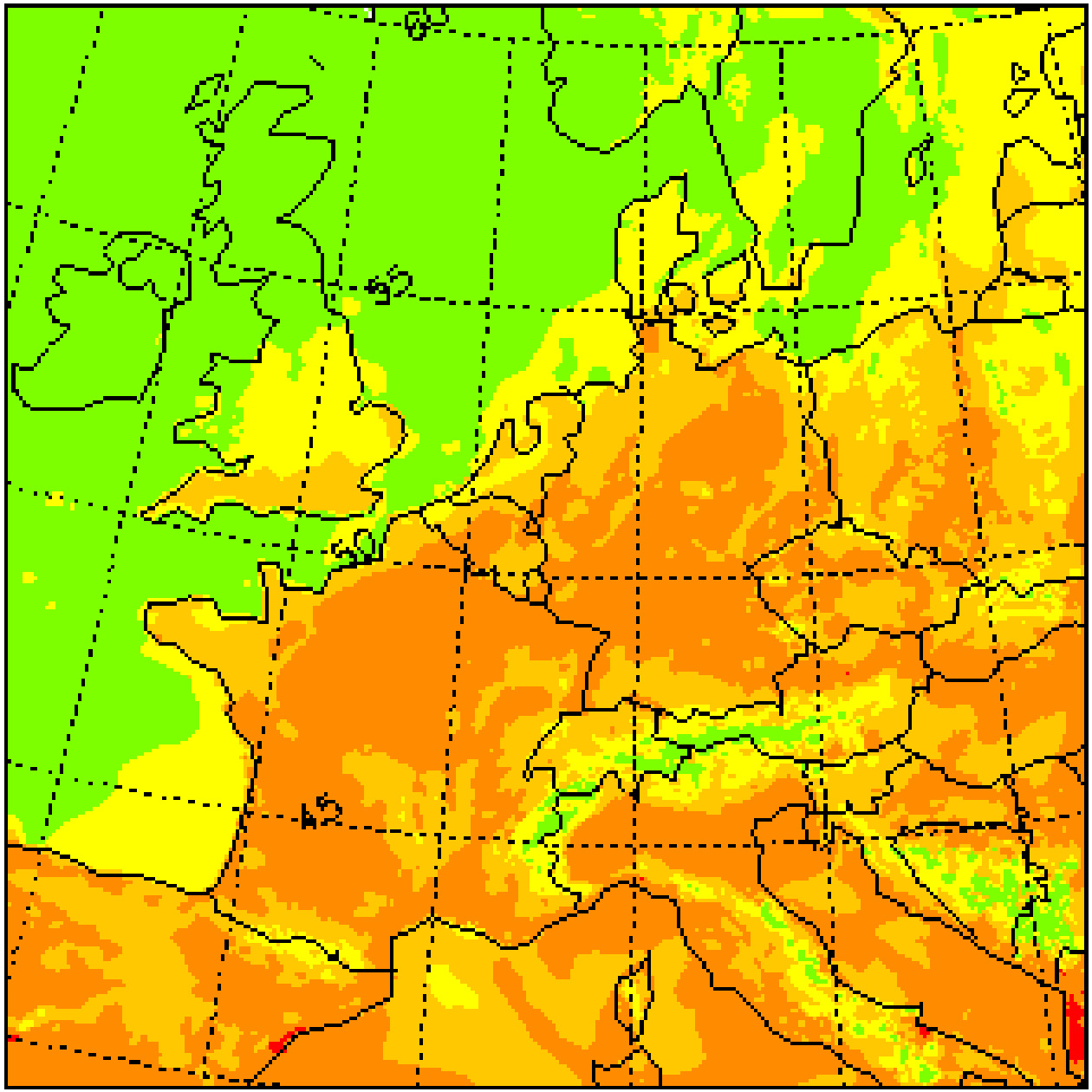
heat load

°C
38 extreme
32 strong
26 moderate
20 slight
0 comfortable
−13 slight
−26 moderate
−39 strong
extreme

cold stress

UTC
13:00

Perceived Temperature PT August 2, 2003



heat load

°C
38 extreme
32 strong
26 moderate
20 slight
0 comfortable
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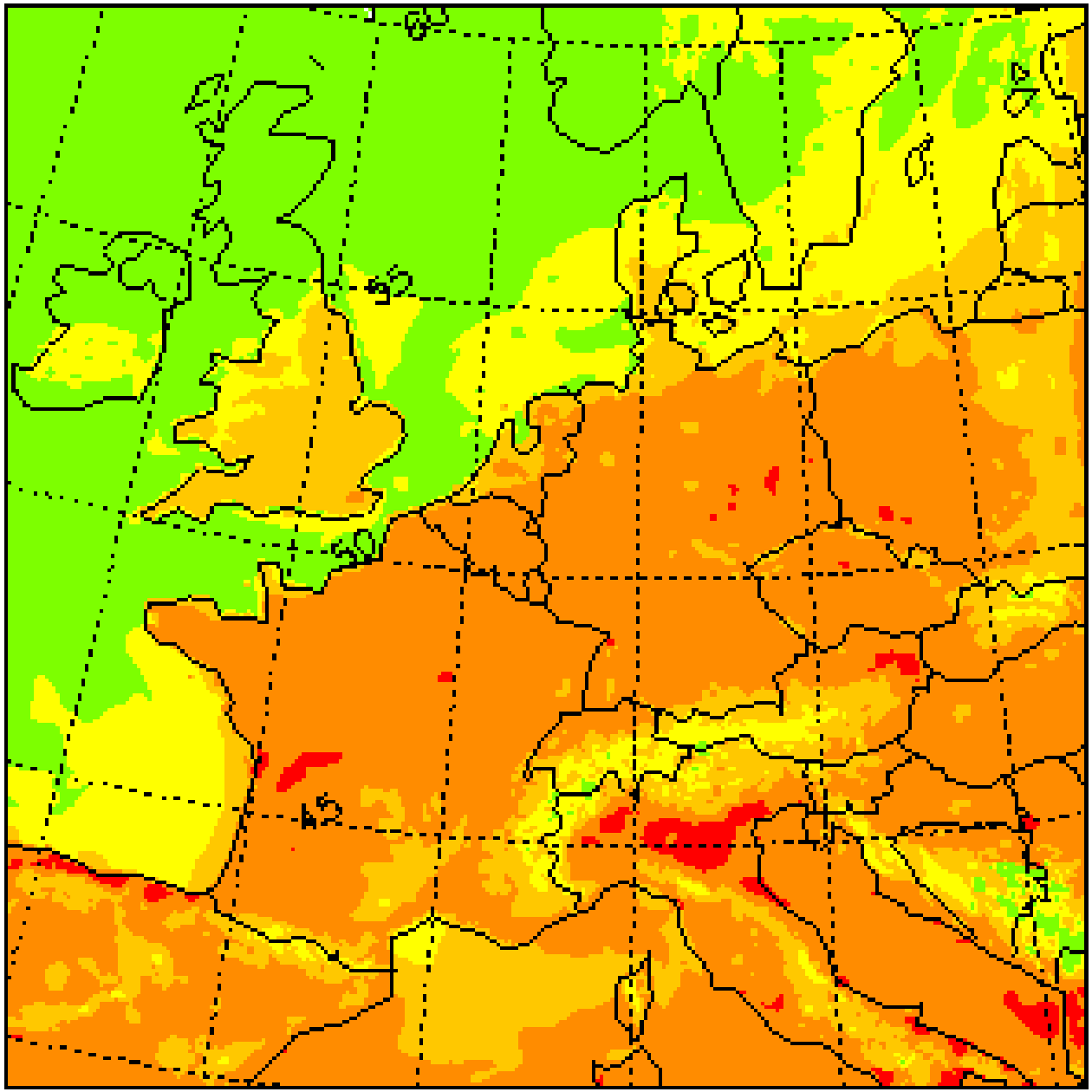
−26 moderate
−39 strong
extreme

cold stress

UTC
13:00

Perceived Temperature PT August 3, 2003



heat load

°C
38 extreme
32 strong
26 moderate
20 slight
0 comfortable
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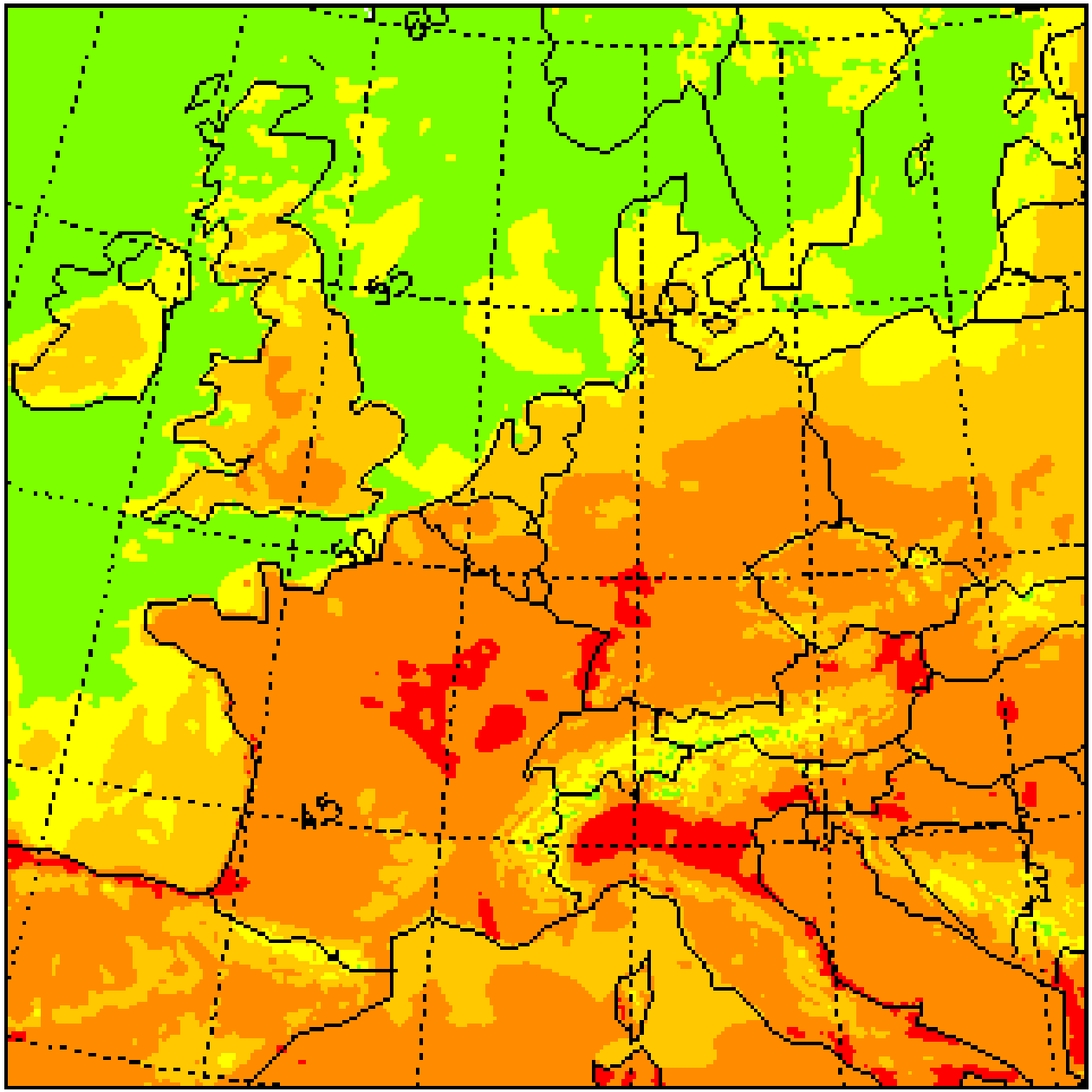
−39 strong
extreme

cold stress

UTC
13:00

Perceived Temperature PT August 4, 2003



heat load

°C
38 extreme
32 strong
26 moderate
20 slight
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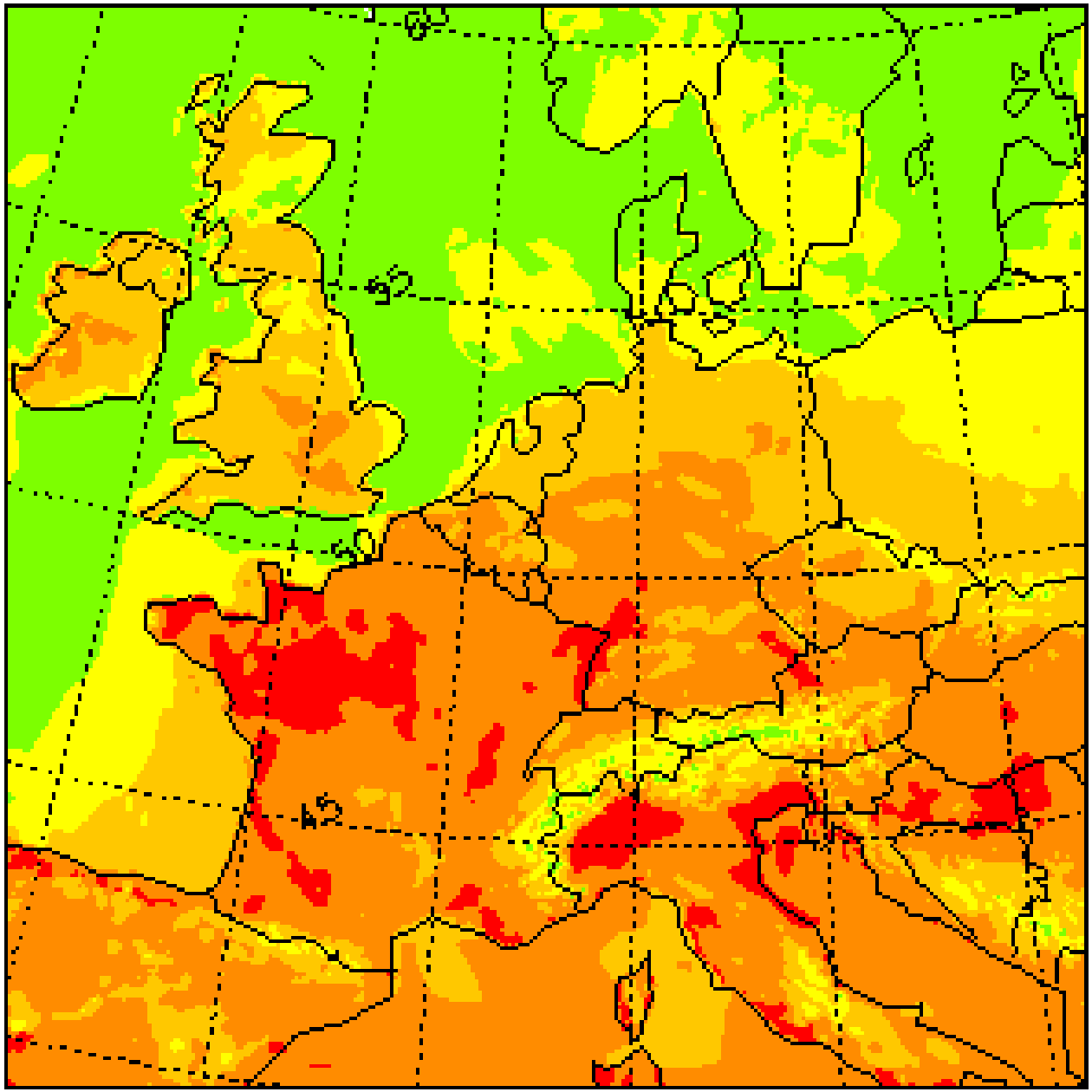
−39 strong
extreme

cold stress

UTC
13:00

Perceived Temperature PT August 5, 2003



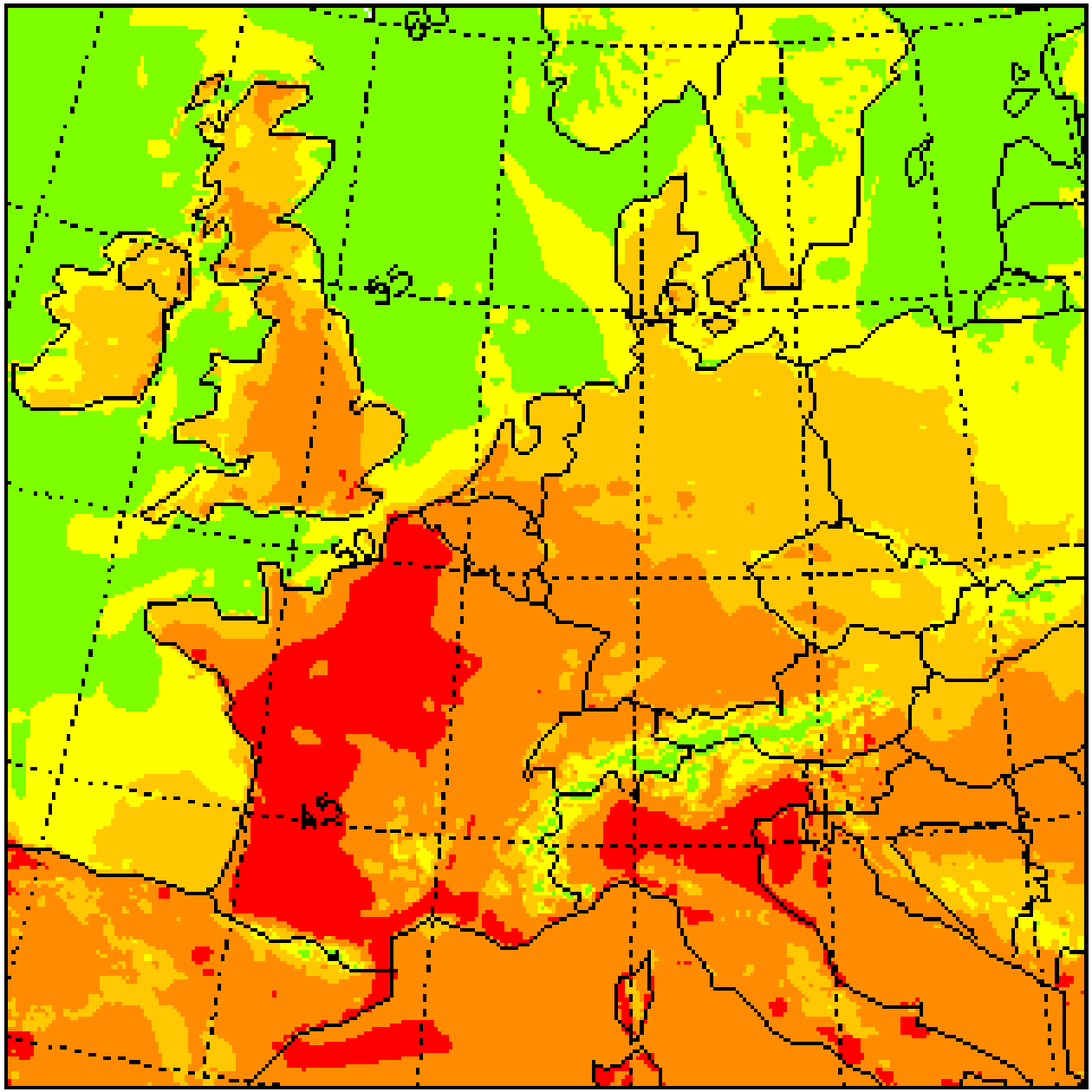
heat load

°C
38 extreme
32 strong
26 moderate
20 slight
0 comfortable
−13 slight
−26 moderate
−39 strong
extreme

cold stress

UTC
13:00

Perceived Temperature PT August 6, 2003



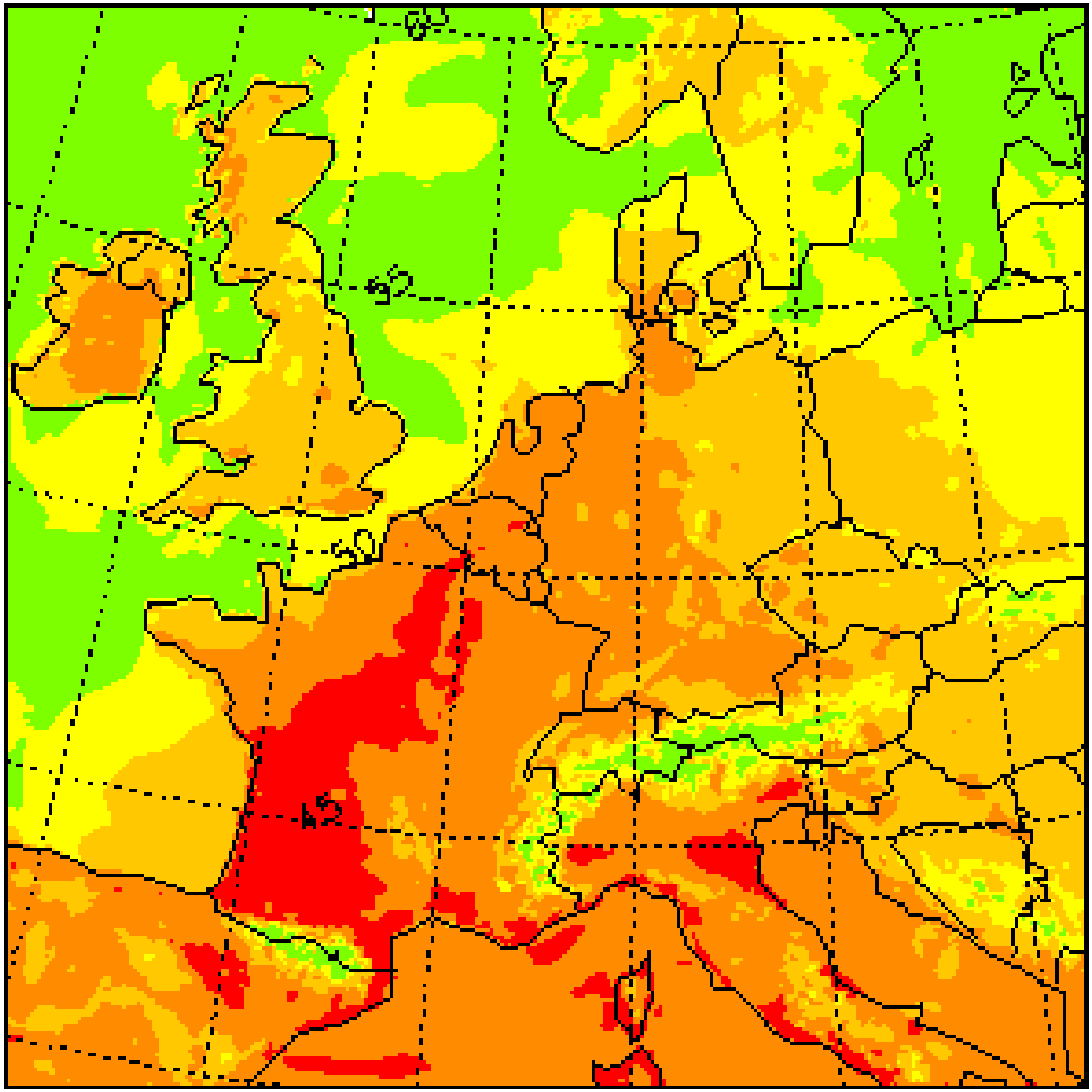
heat load

°C
38 extreme
32 strong
26 moderate
20 slight
0 comfortable
−13 slight
−26 moderate
−39 strong
extreme

cold stress

UTC
13:00

Perceived Temperature PT August 7, 2003



heat load

°C
38 extreme
32 strong
26 moderate
20 slight
0 comfortable
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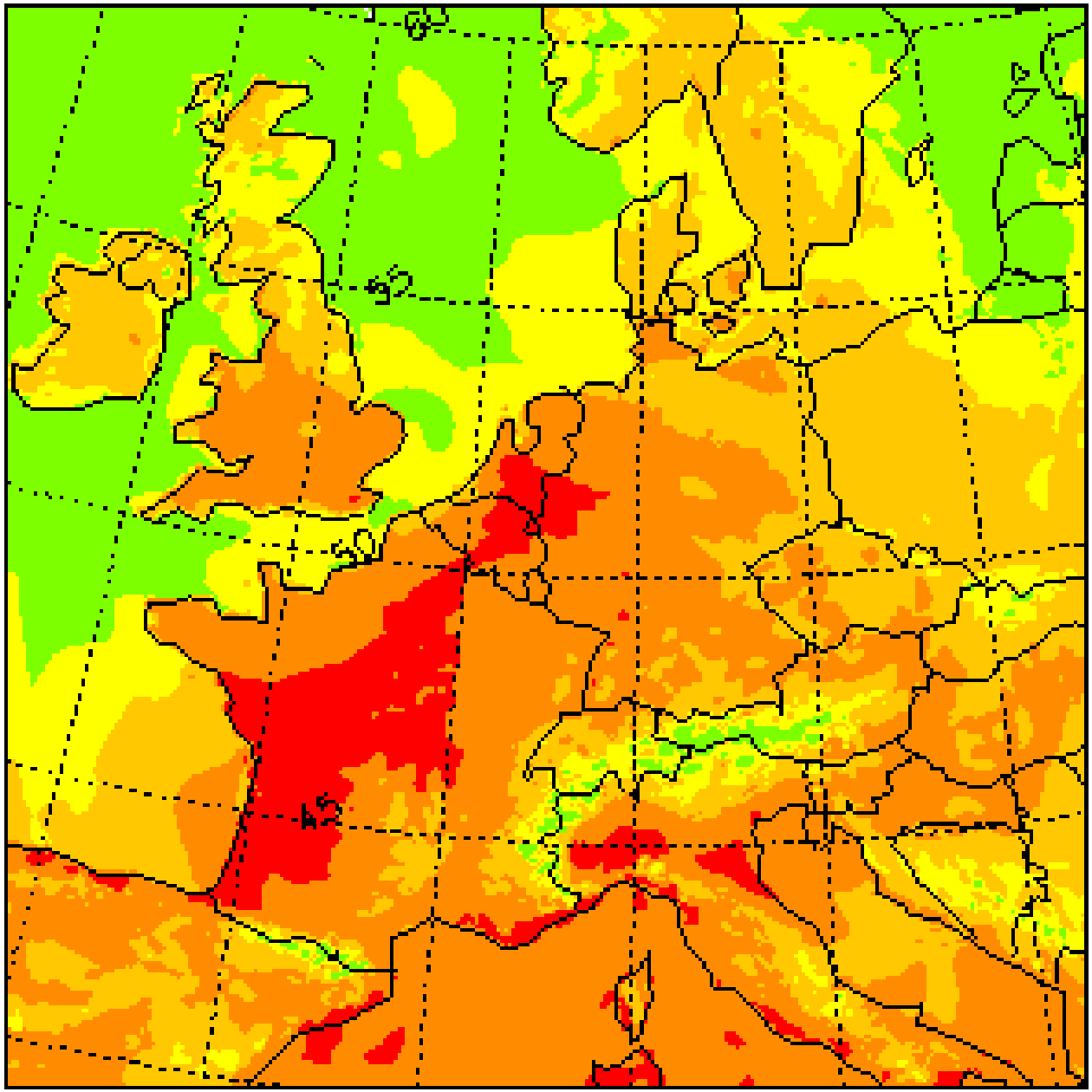
−39 strong
extreme

cold stress

UTC
13:00

Perceived Temperature PT August 8, 2003



heat load

°C
38 extreme
32 strong
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20 slight
0 comfortable
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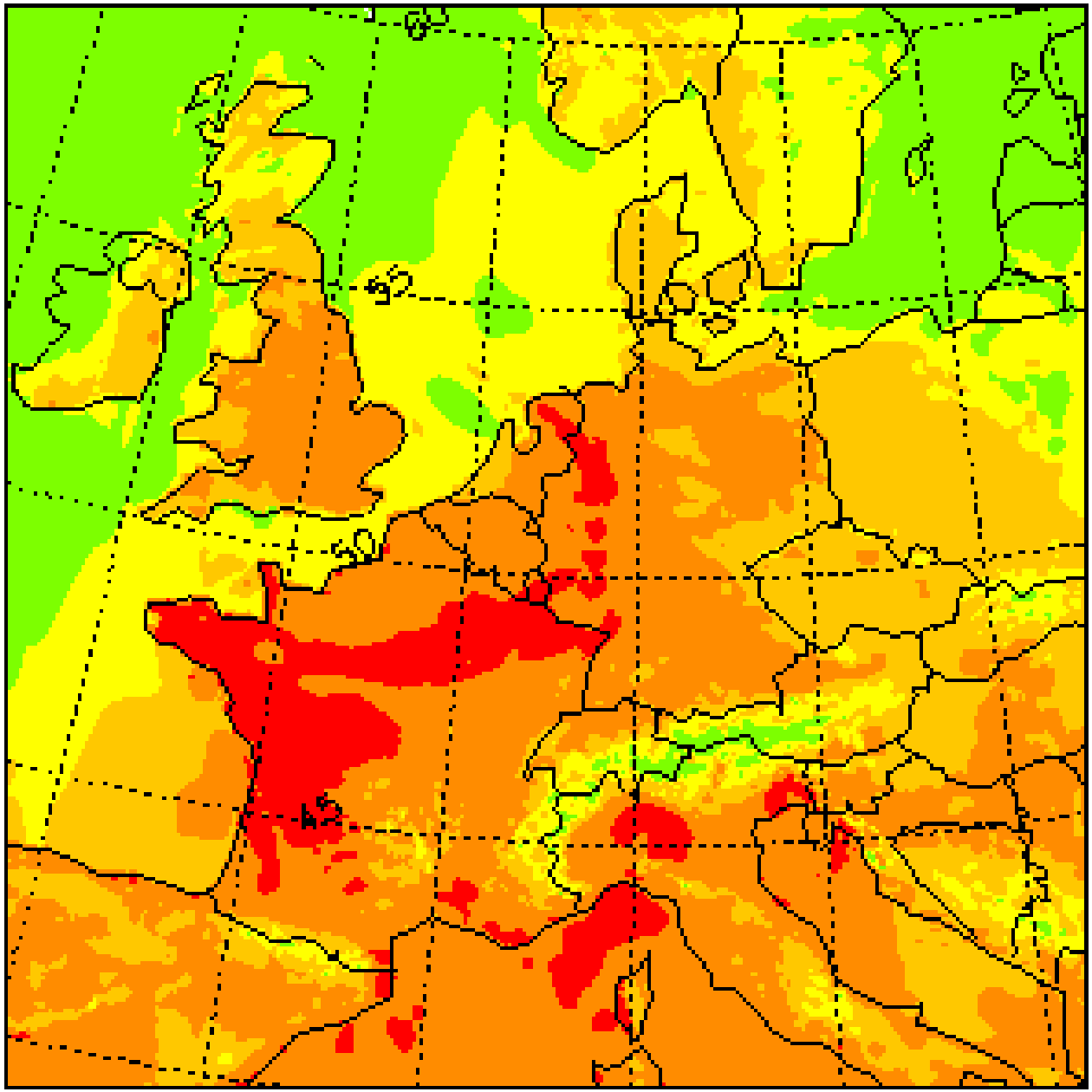
−39 strong
extreme

cold stress

UTC
13:00

Perceived Temperature PT August 9, 2003



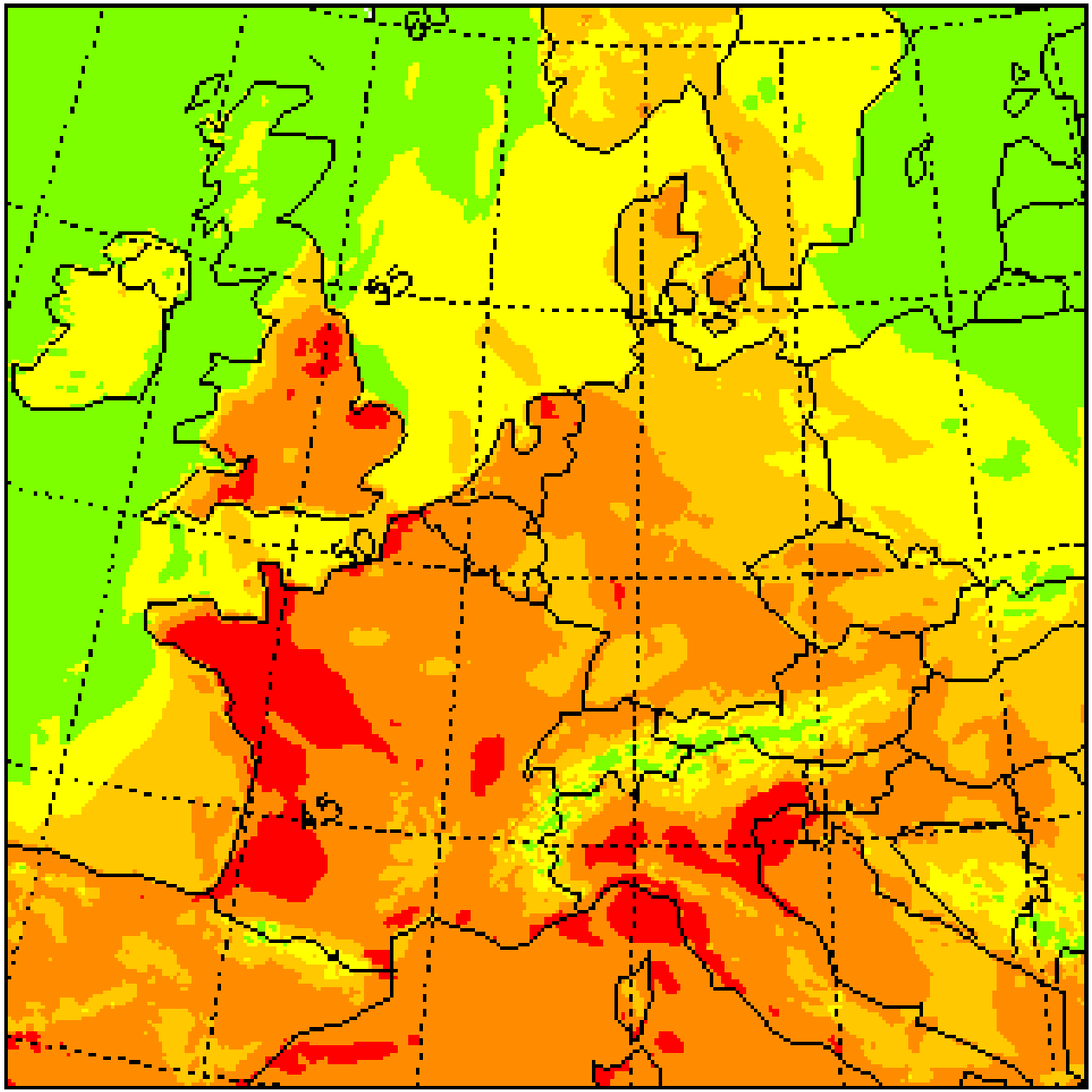
heat load

°C
38 extreme
32 strong
26 moderate
20 slight
0 comfortable
−13 slight
−26 moderate
−39 strong
extreme

cold stress

UTC
13:00

Perceived Temperature PT August 10, 2003



heat load

°C
38 extreme
32 strong
26 moderate
20 slight
0 comfortable
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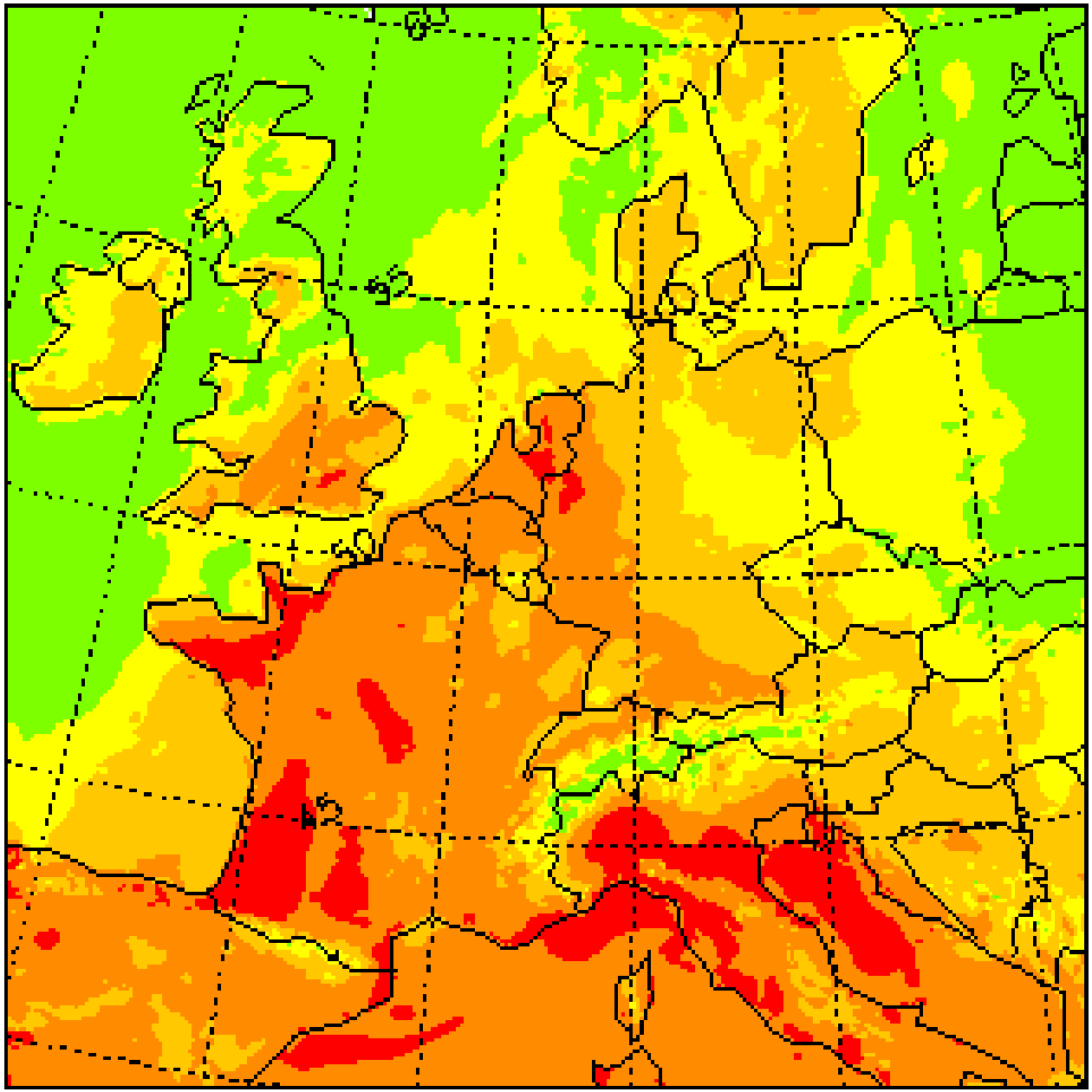
−26 moderate
−39 strong
extreme

cold stress

UTC
13:00

Perceived Temperature PT August 11, 2003



heat load

°C
38 extreme
32 strong
26 moderate
20 slight
0 comfortable
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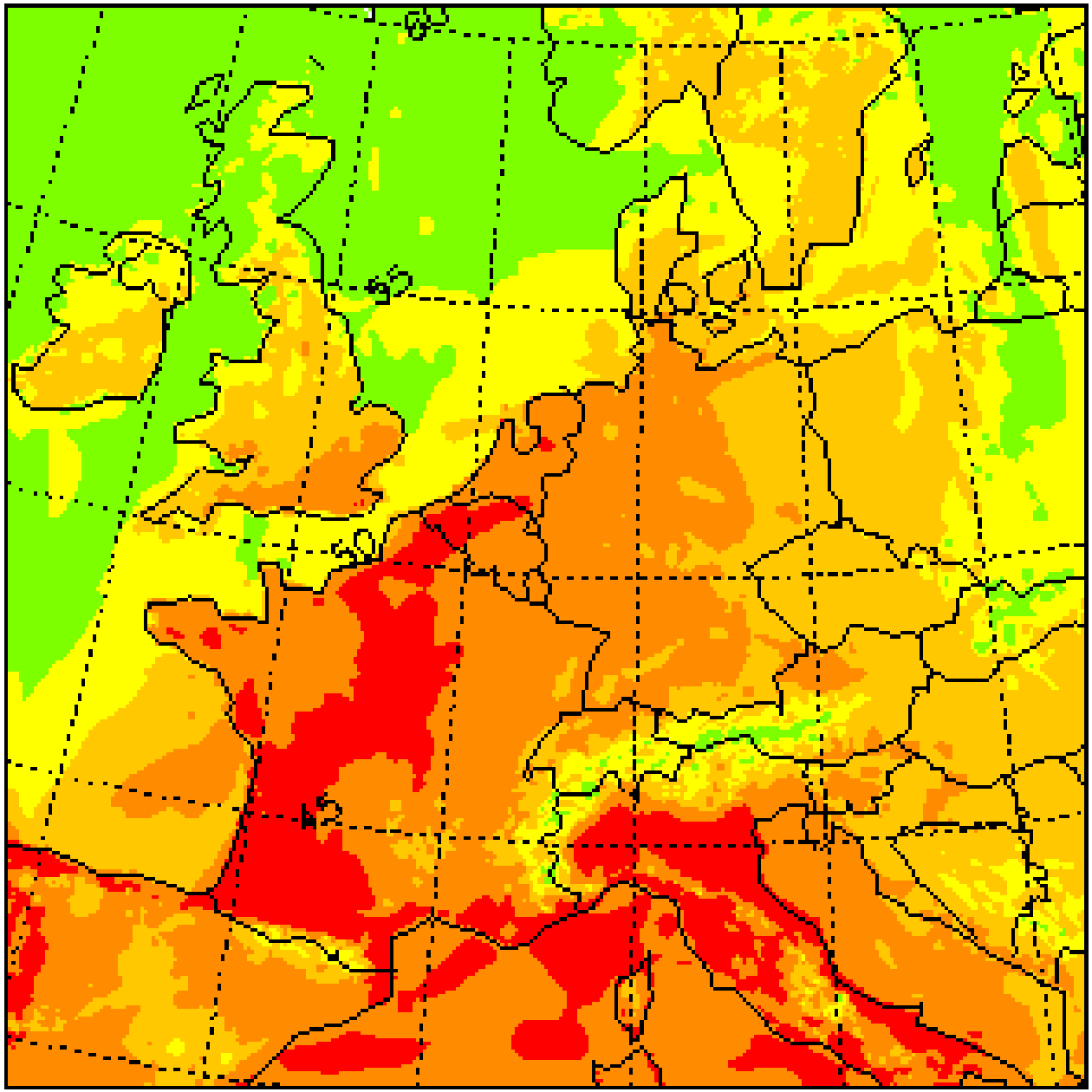
extreme

cold stress

UTC
13:00

Perceived Temperature PT August 12, 2003



heat load

°C
38 extreme
32 strong
26 moderate
20 slight
0 comfortable
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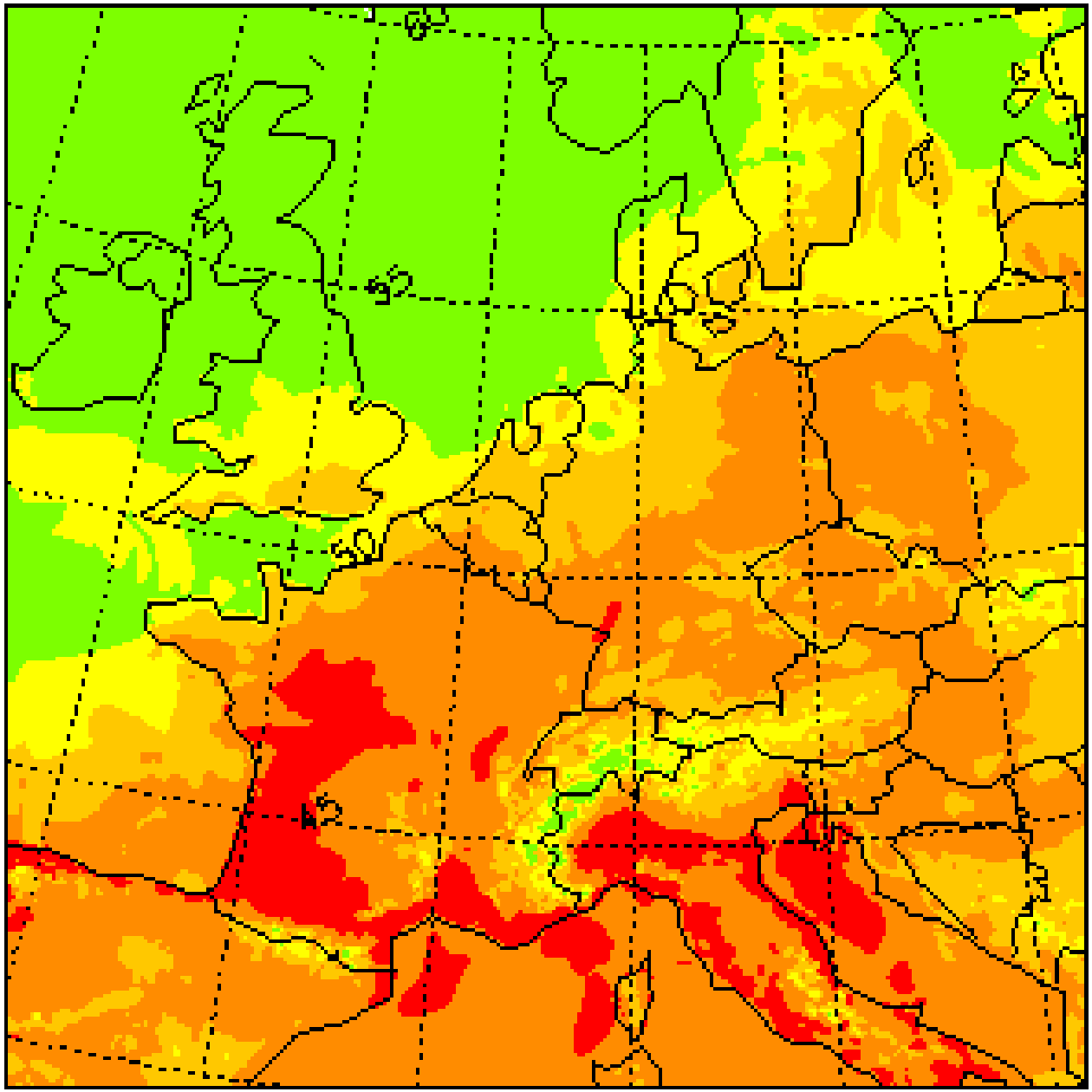
−26 moderate
−39 strong
extreme

cold stress

UTC
13:00

Perceived Temperature PT August 13, 2003



heat load

°C
38 extreme
32 strong
26 moderate
20 slight
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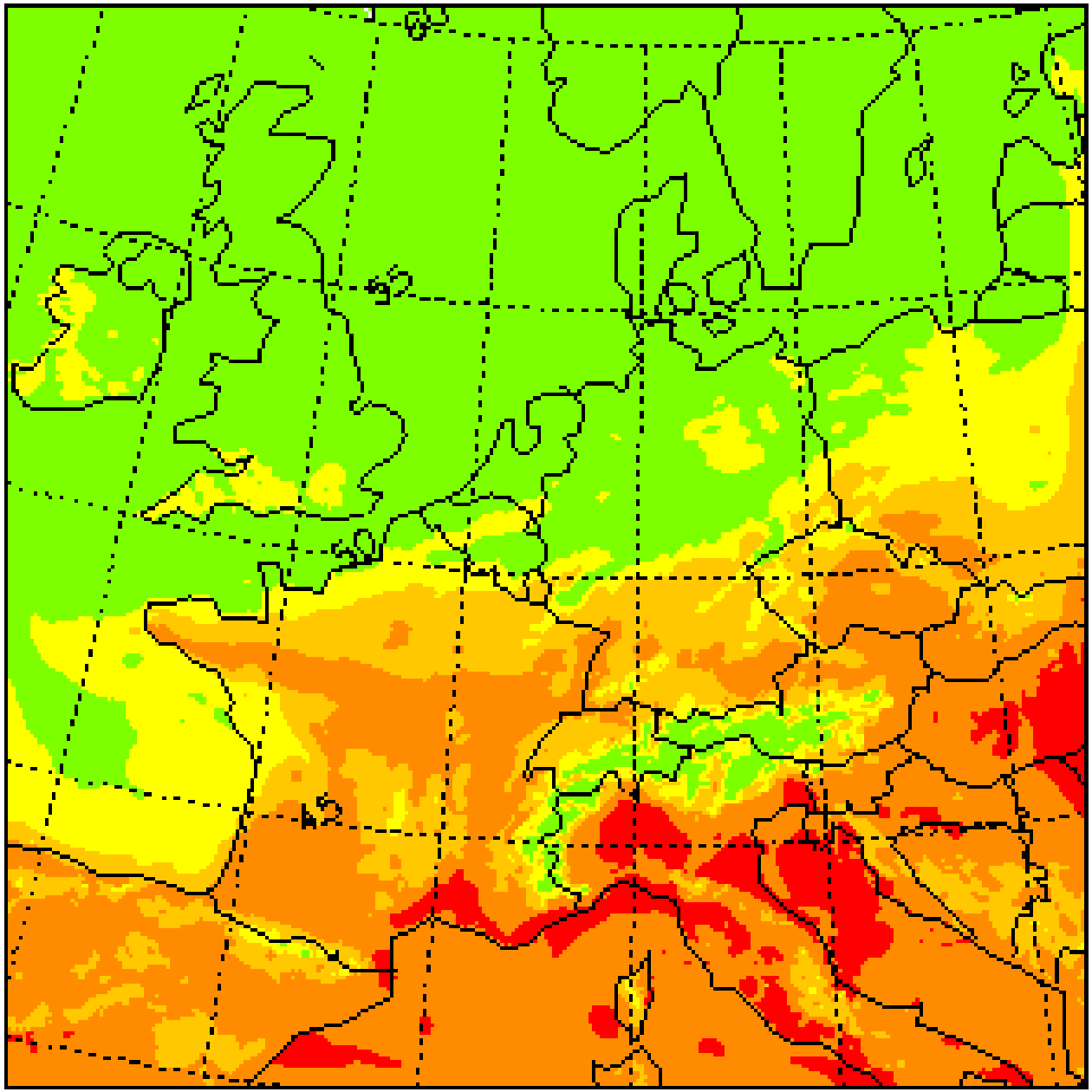
−39 strong
extreme

cold stress

UTC
13:00

Perceived Temperature PT August 14, 2003



heat load

°C
38 extreme
32 strong
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20 slight
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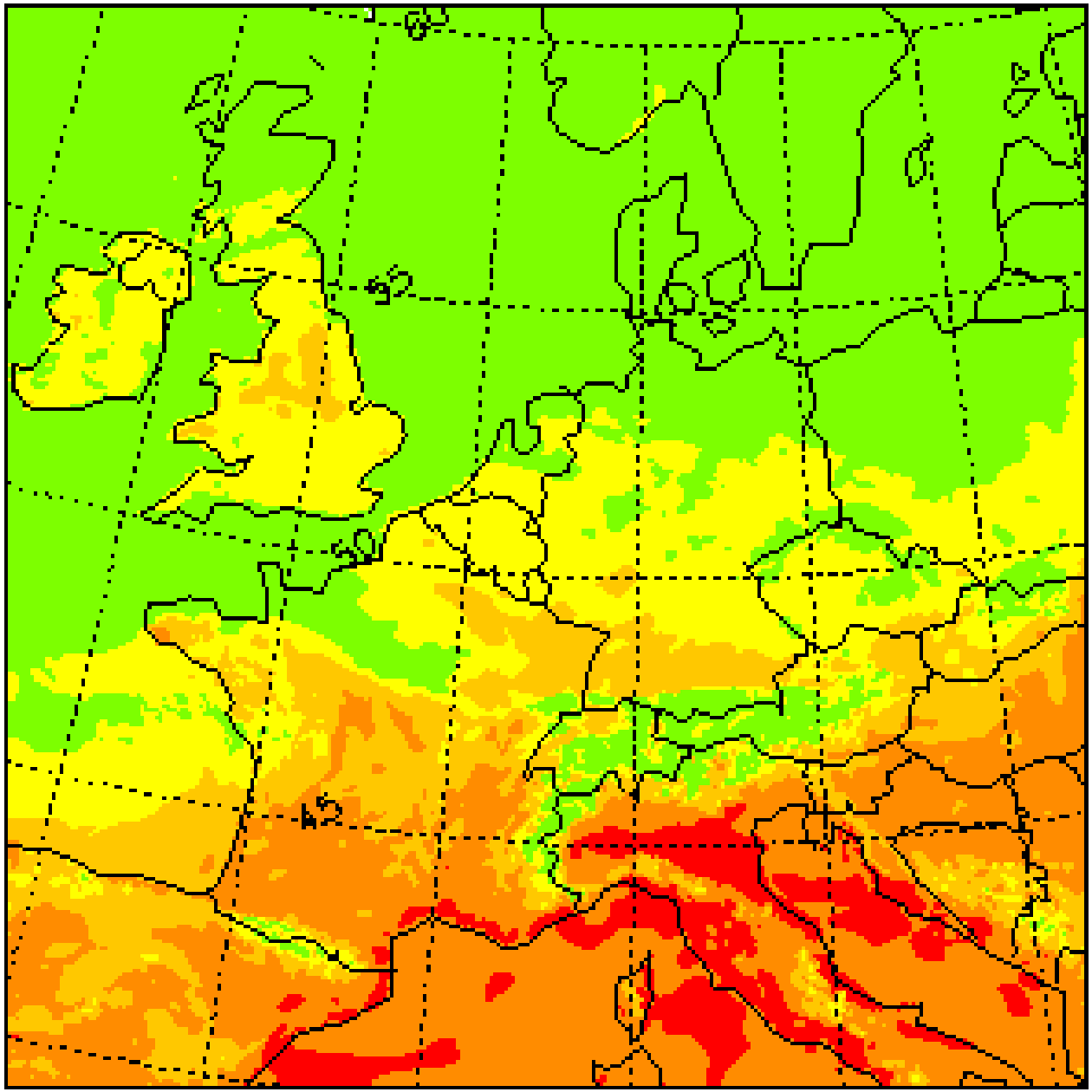
extreme

cold stress

UTC
13:00

Perceived Temperature PT August 15, 2003



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°C
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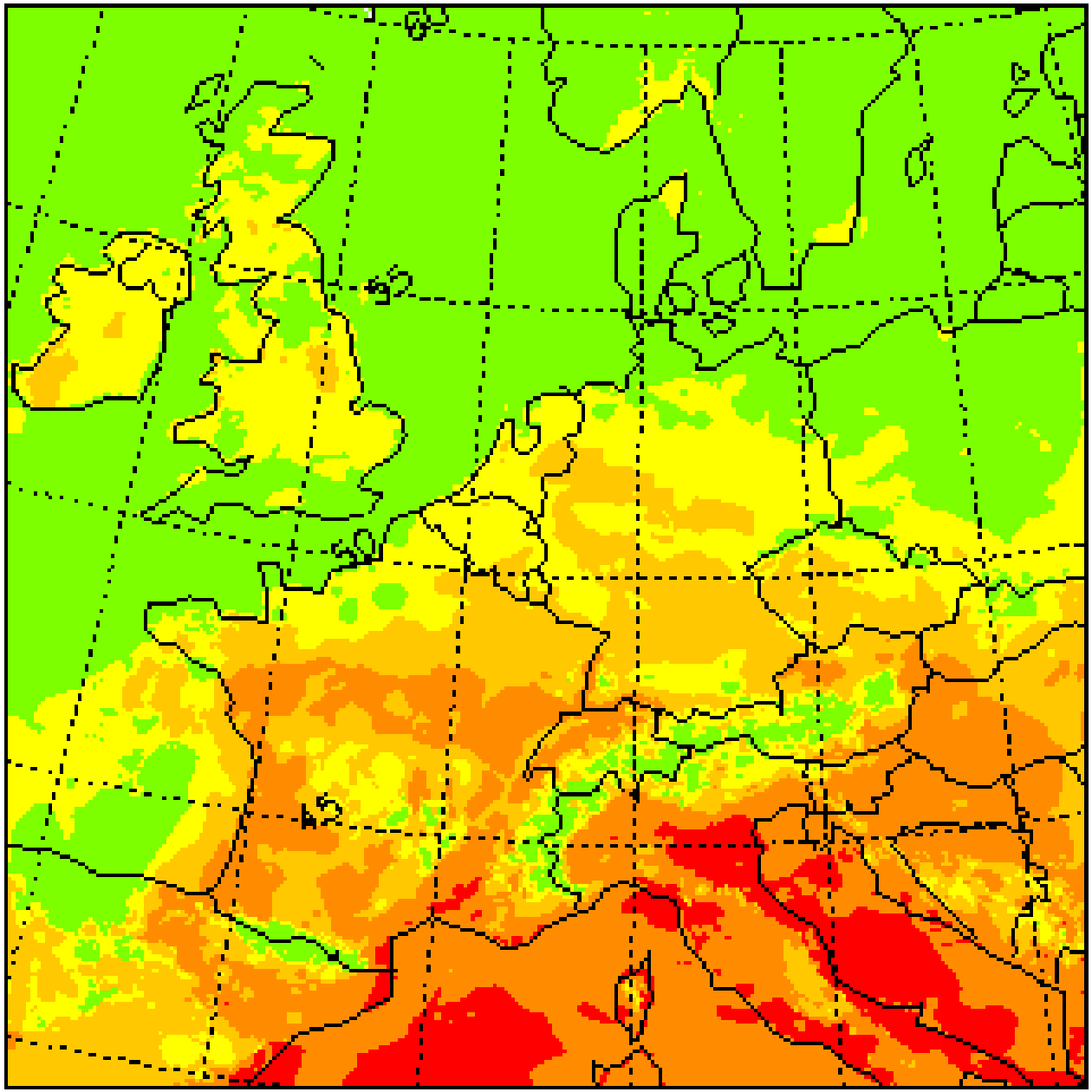
cold stress

UTC
13:00

Perceived Temperature PT August 16, 2003



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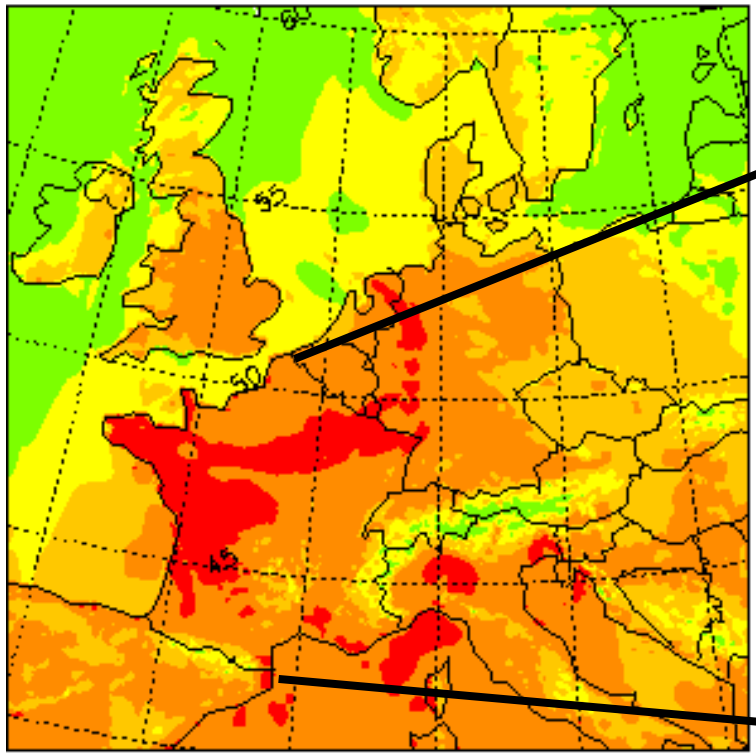
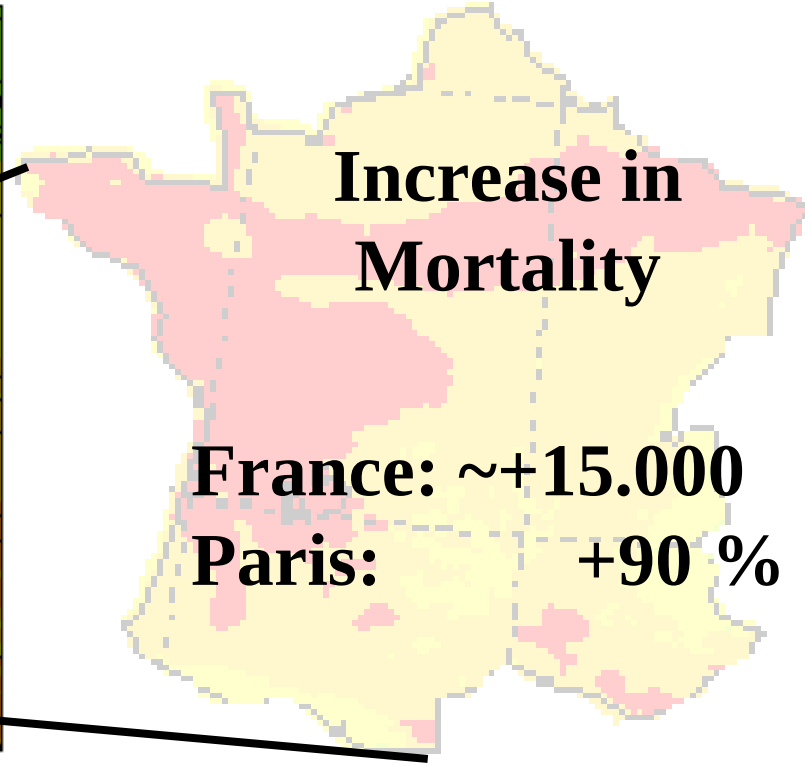
extreme

cold stress

UTC
13:00



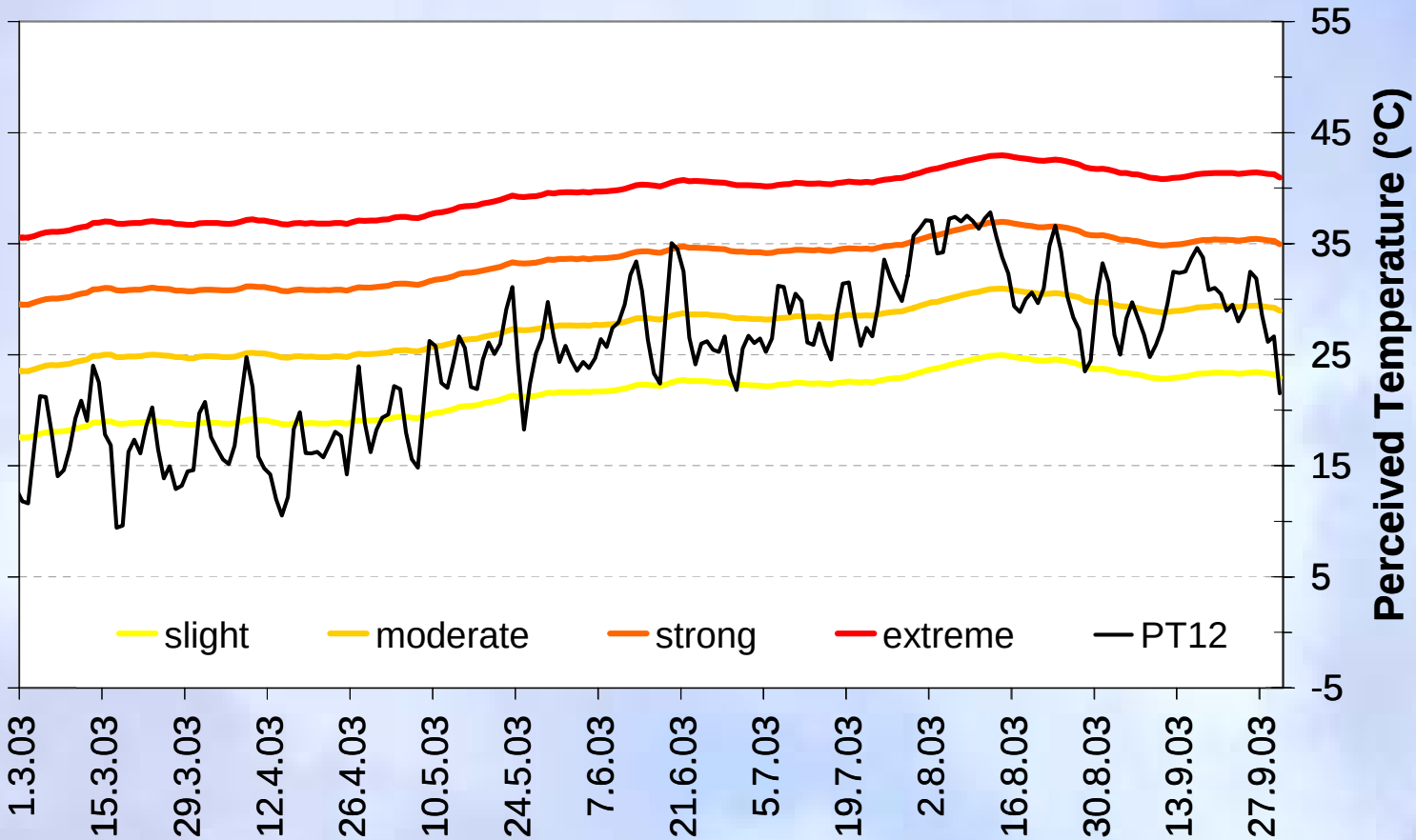


Urgent need for HHWSs
based on WMO/WHO/UNEP Showcase Projects

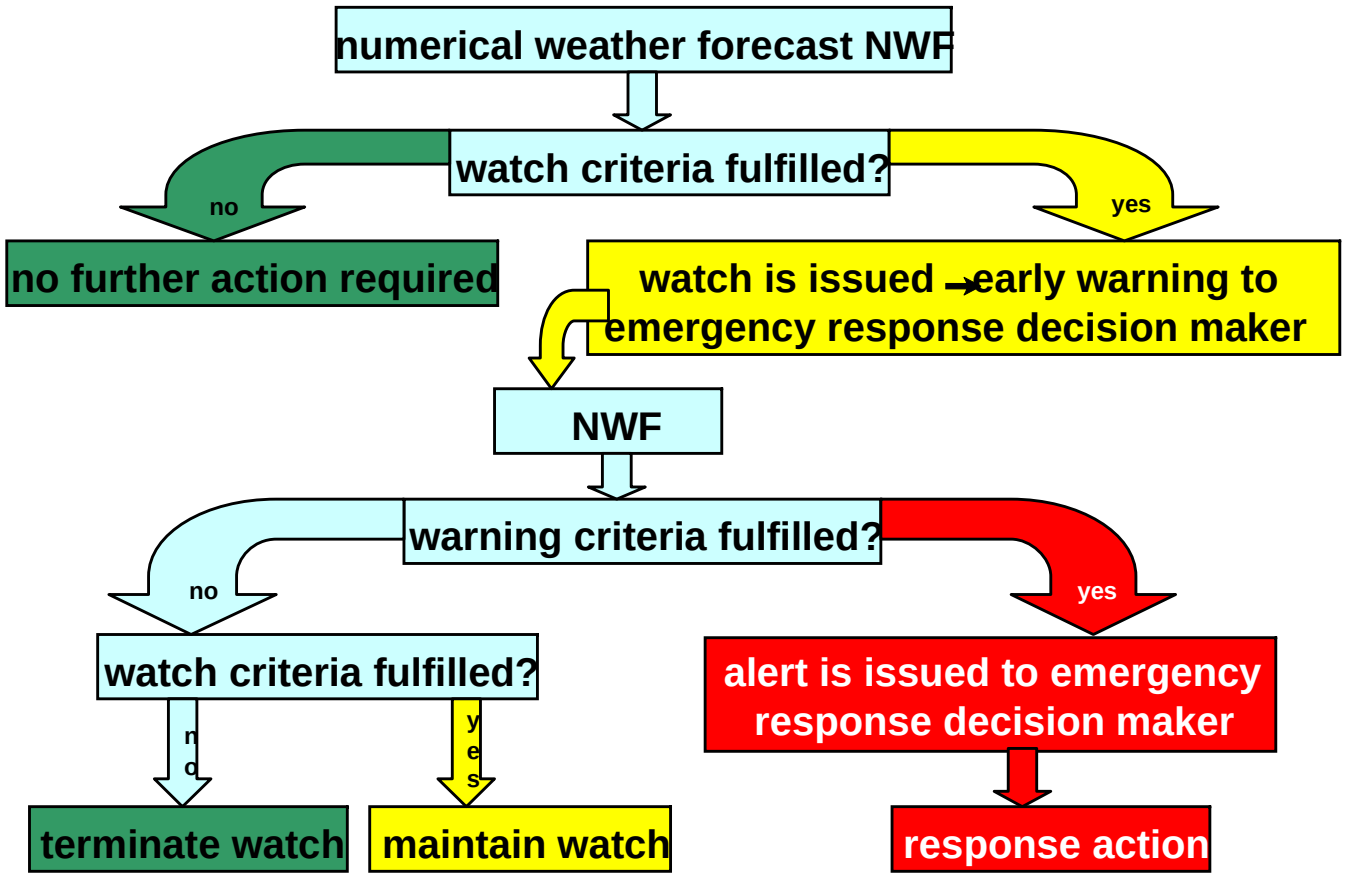
- thermophysiologially relevant approach (PT, UTCI)
- acclimatisation to local climate
- locally adjusted intervention measures
- operationally based on services of NMSs

DWD thresholds

Lisbon 2003



Stepwise Watch/Warning Procedure



Key applications

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- Consultancy for where to live
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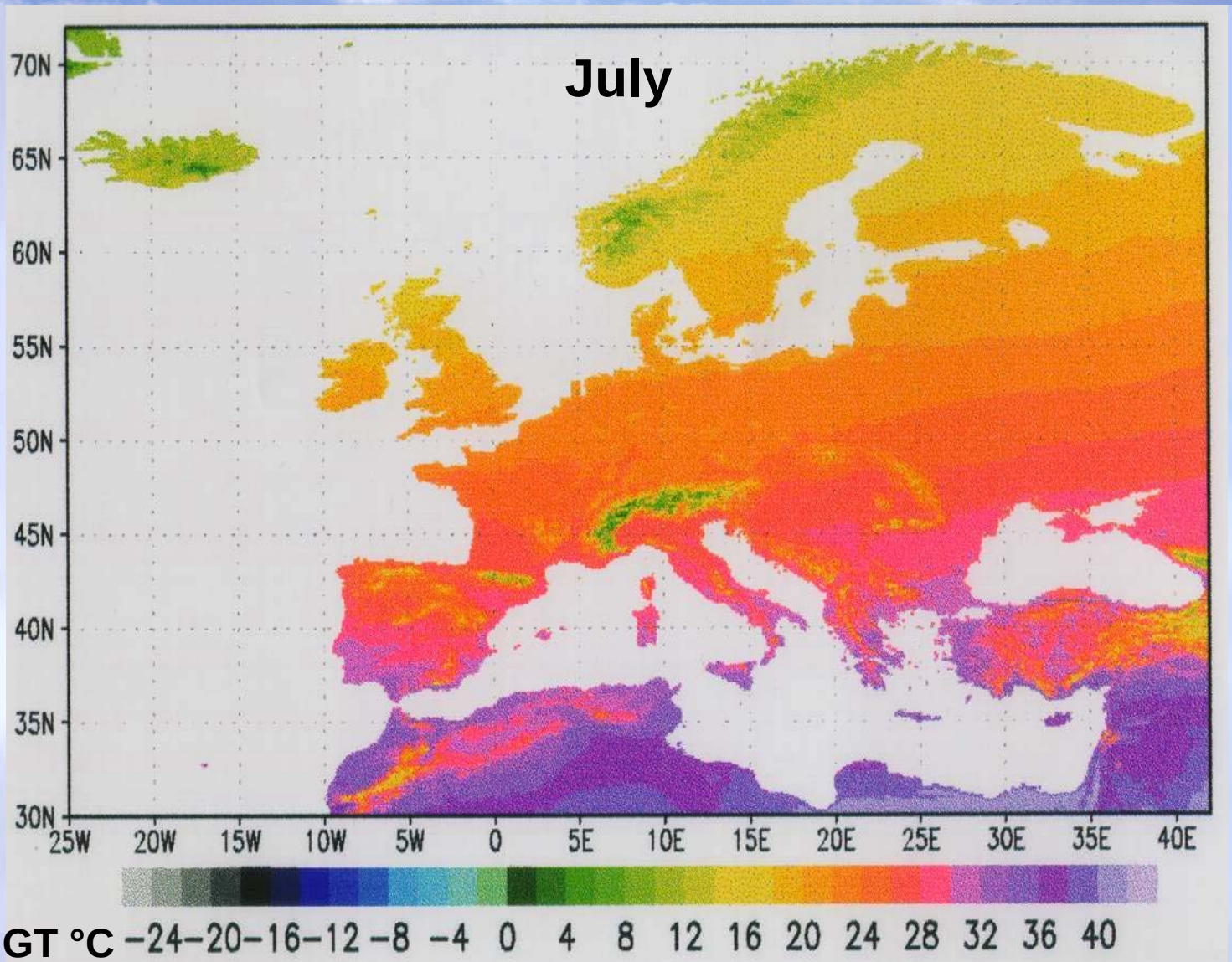
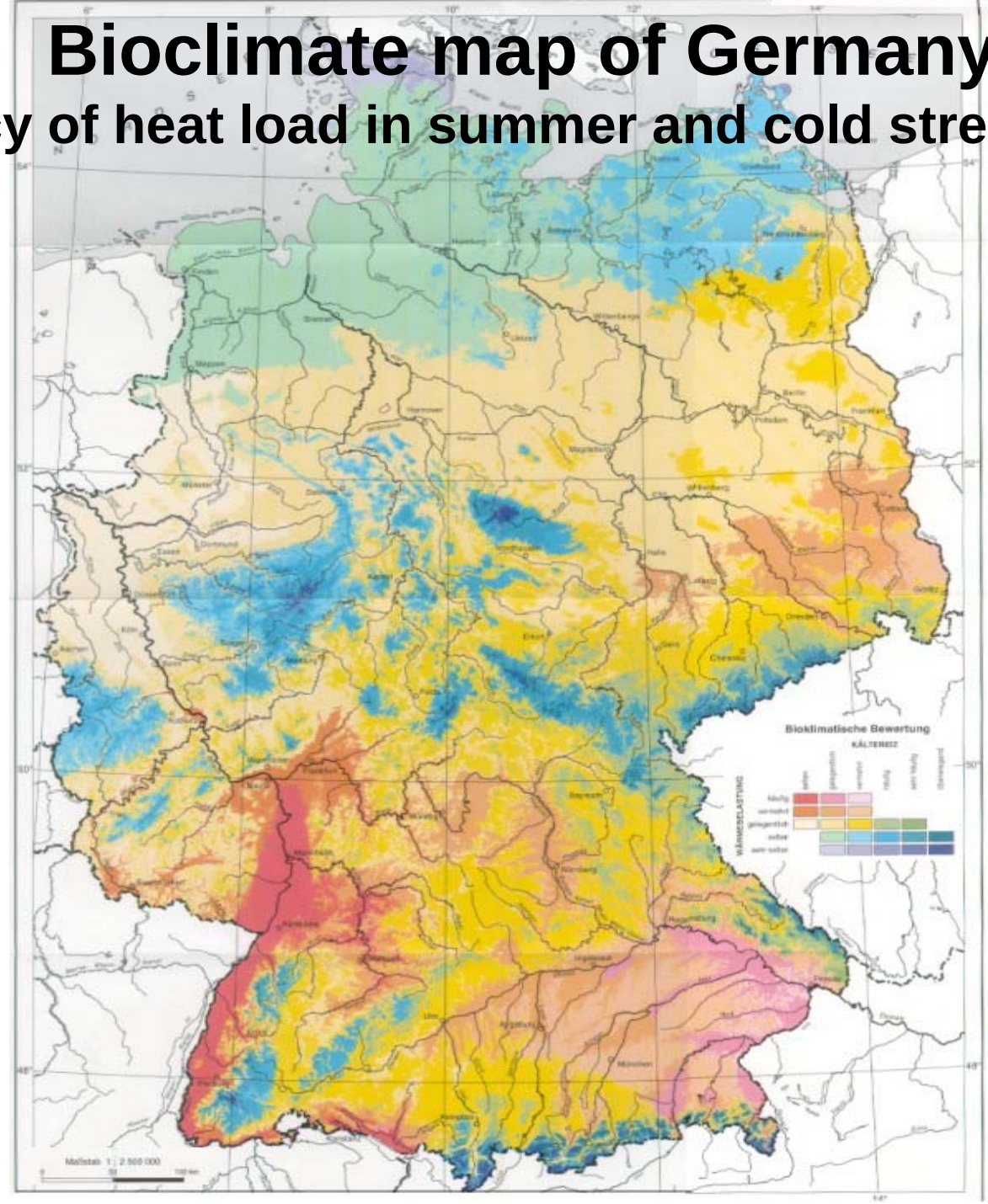


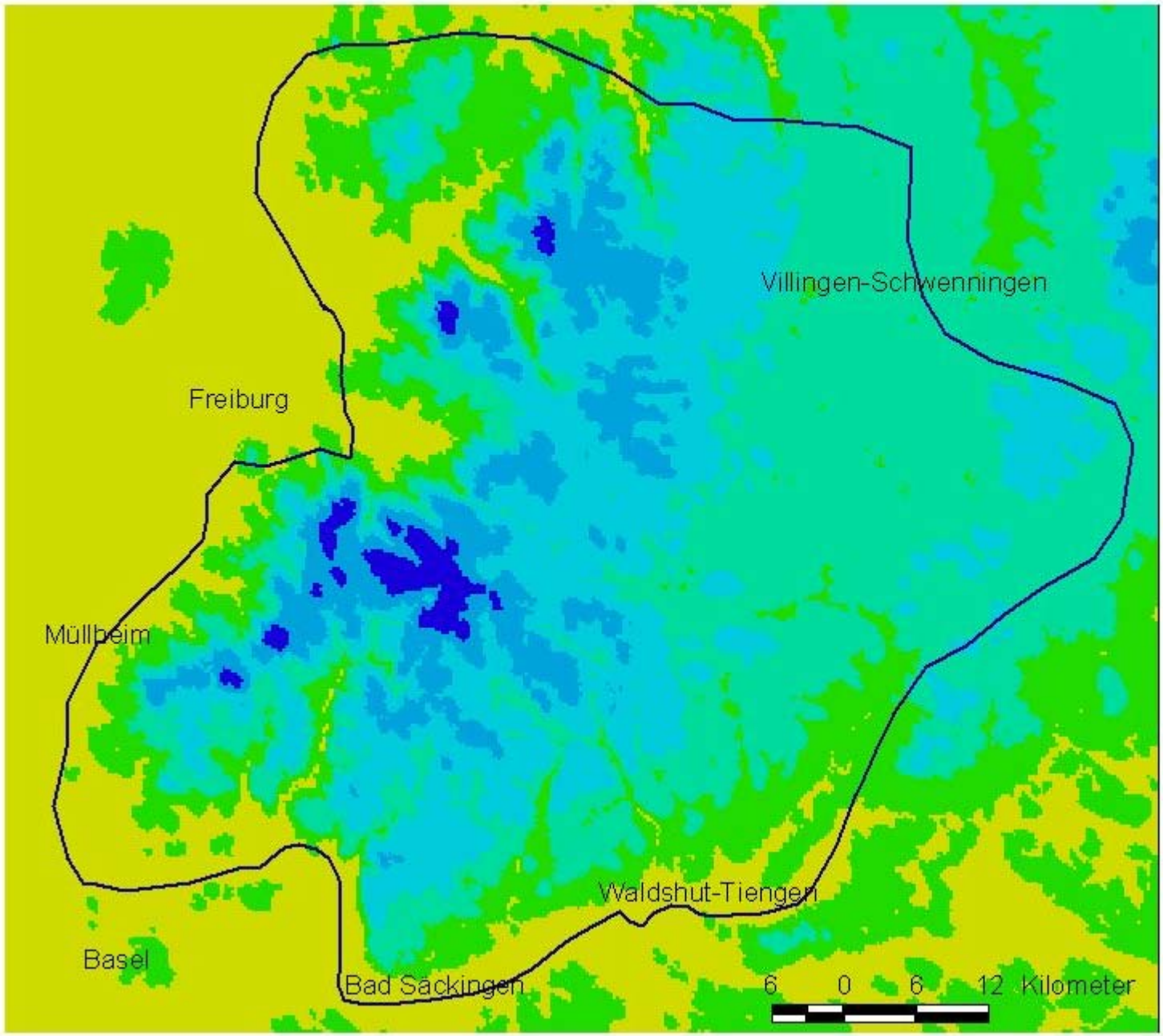
birger.tinz@dwd.de

Bioclimate map of Germany

Frequency of heat load in summer and cold stress in winter



1971-2000



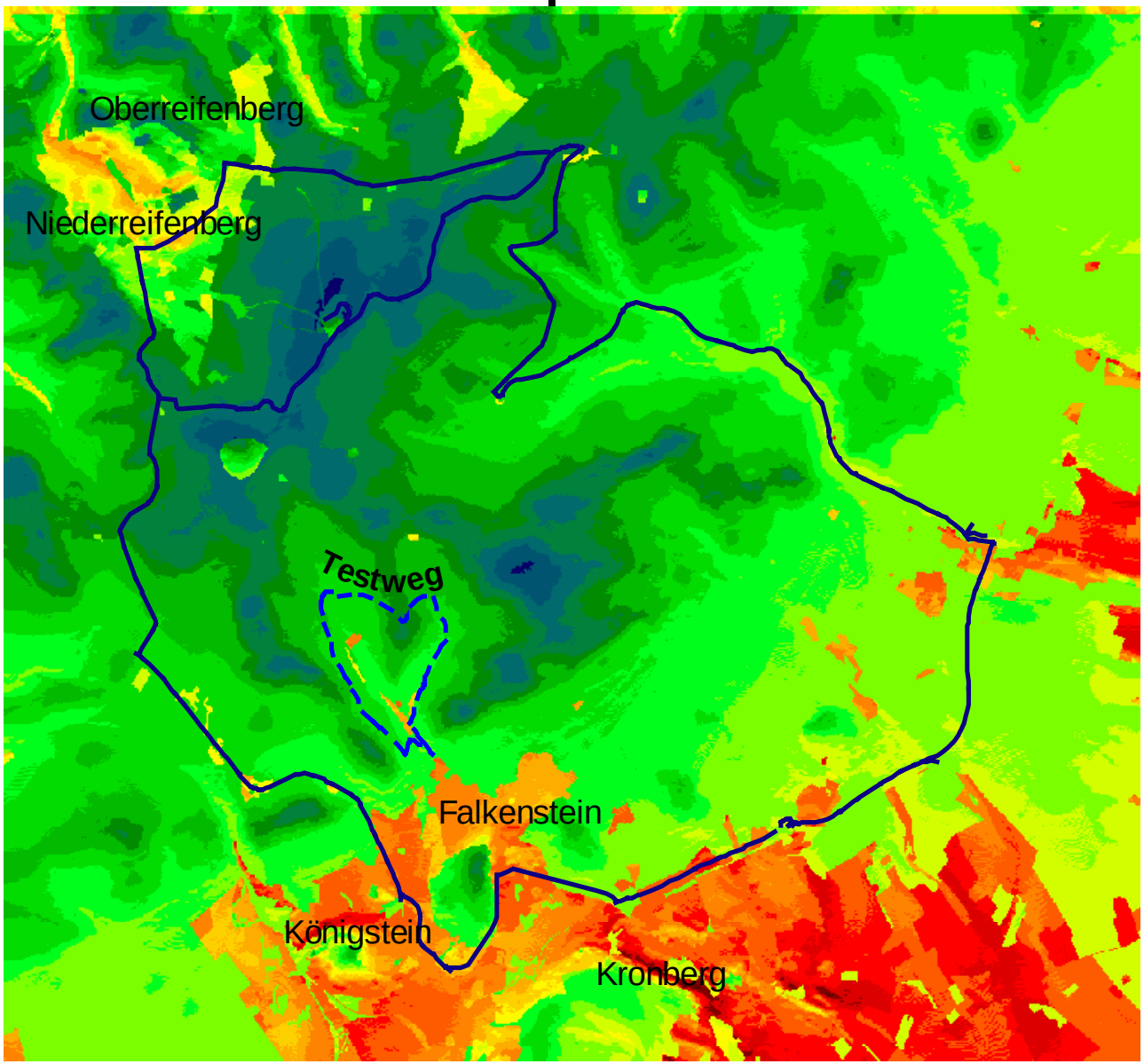
Bioklima
- Winter -

Naturpark
Südschwarzw

Auftreten von
Kältereizen

- selten
- gelegentlich
- vermehrt
- häufig
- sehr häufig
- überwiegend

Heilklimapark Hochtaunus

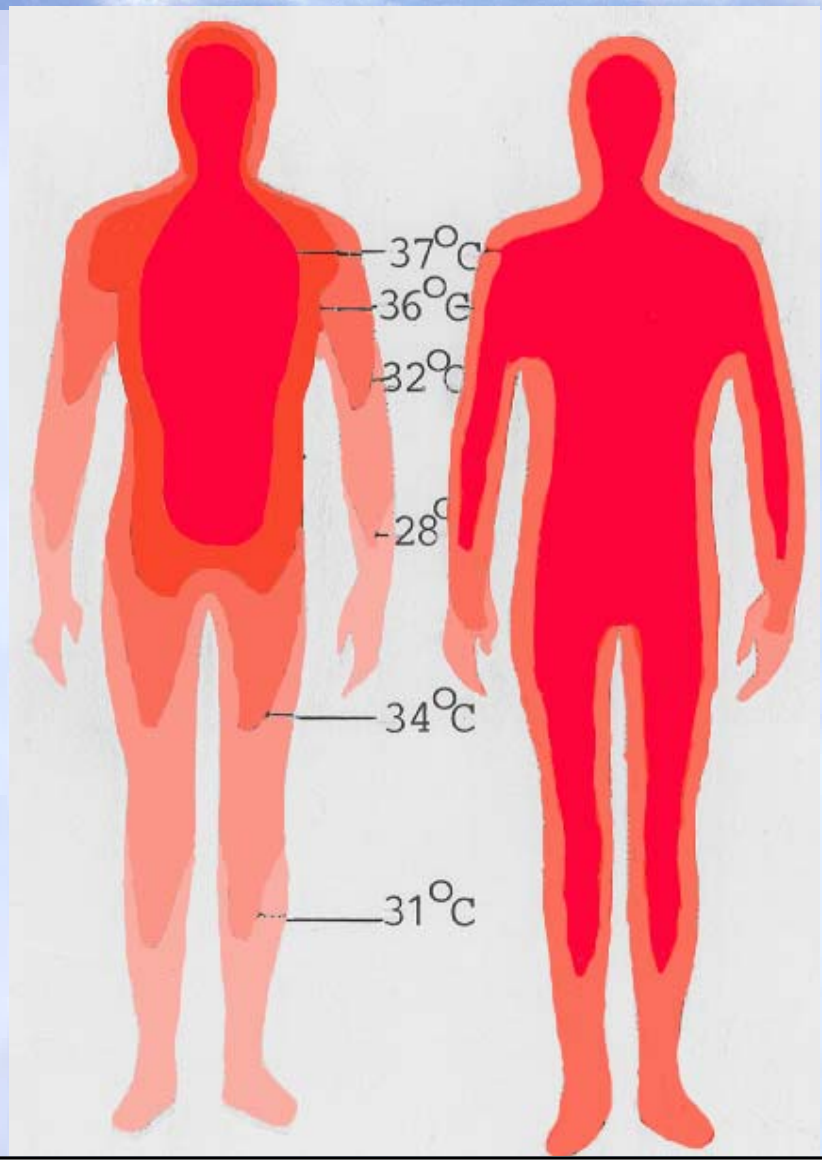


Testweg

Gefühlte Temperatur in °C

127 - 140
141 - 150
151 - 160
161 - 170
171 - 180
181 - 190
191 - 200
201 - 210
211 - 220
221 - 230
231 - 240
241 - 250
251 - 260
261 - 270
271 - 280
281 - 290
291 - 300
301 - 310
311 - 330

cold



warm

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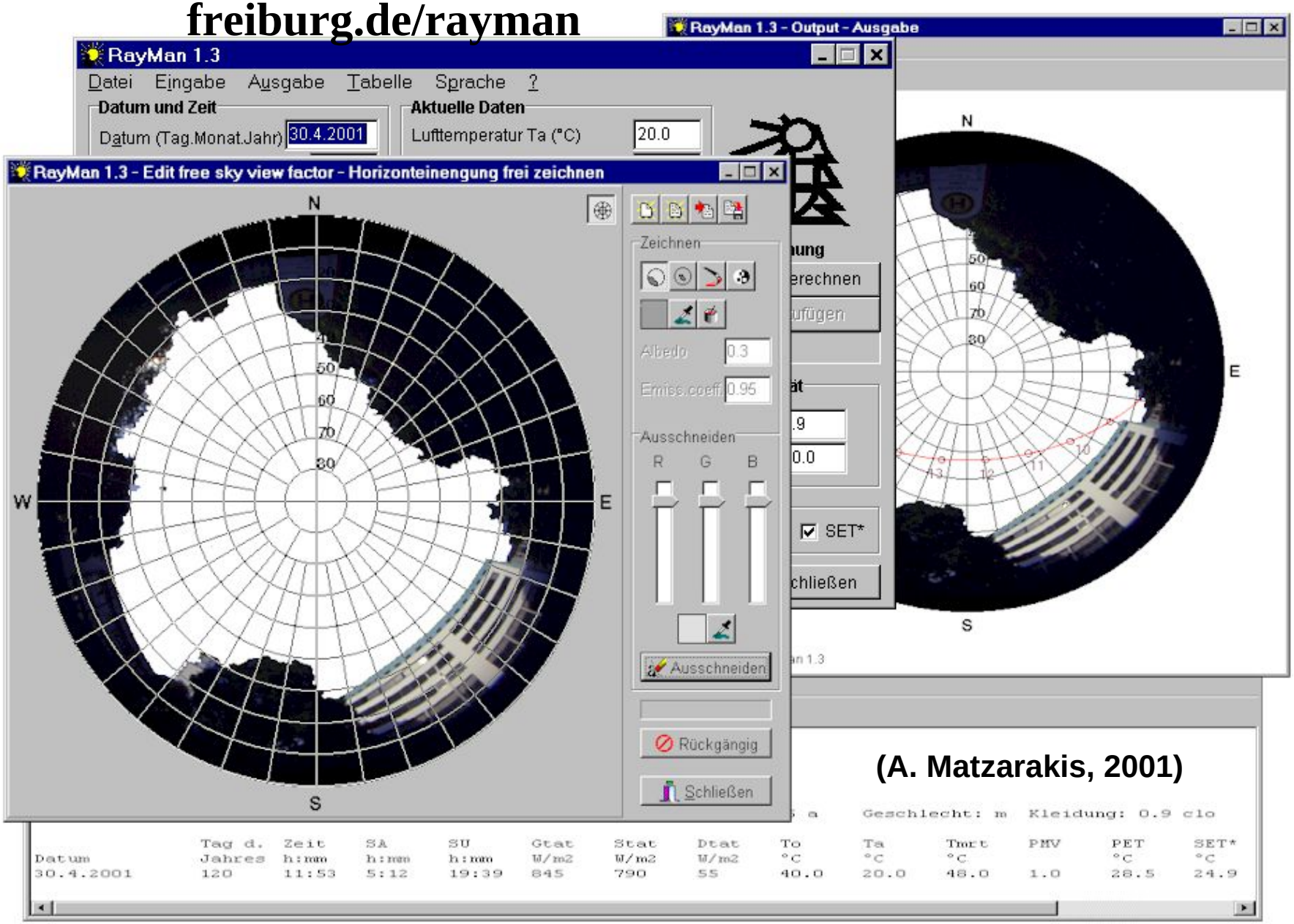
Deutscher Wetterdienst

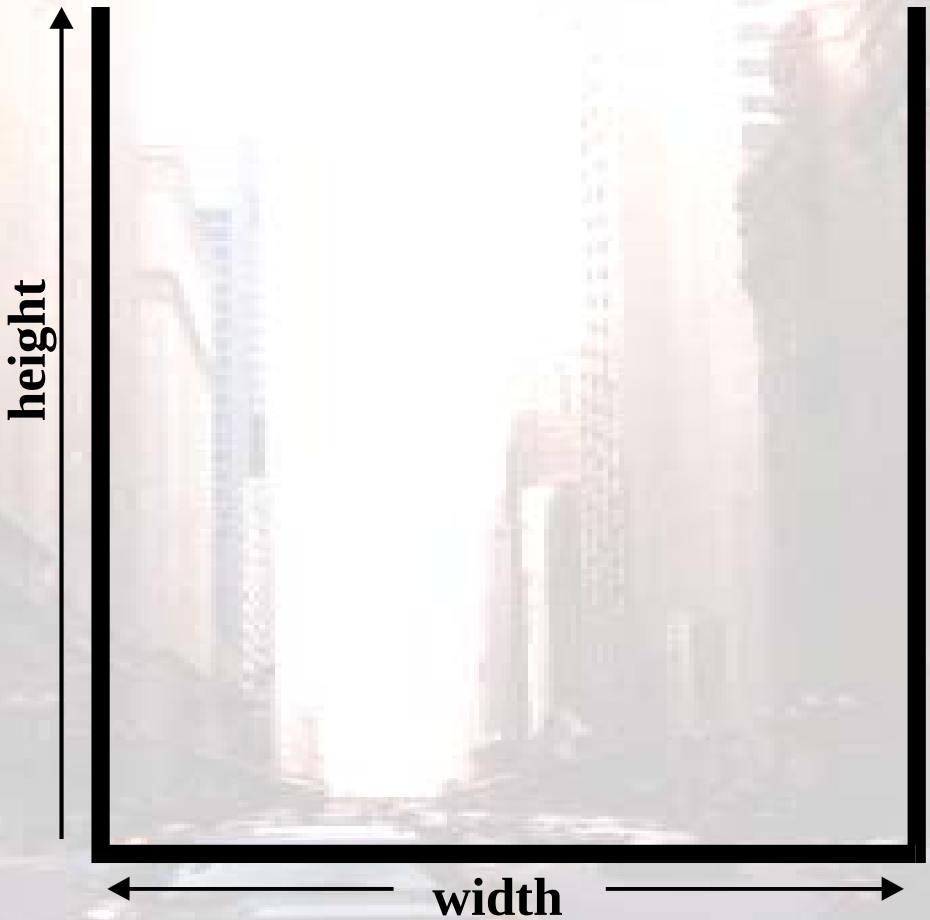
Business Unit Human Biometeorology

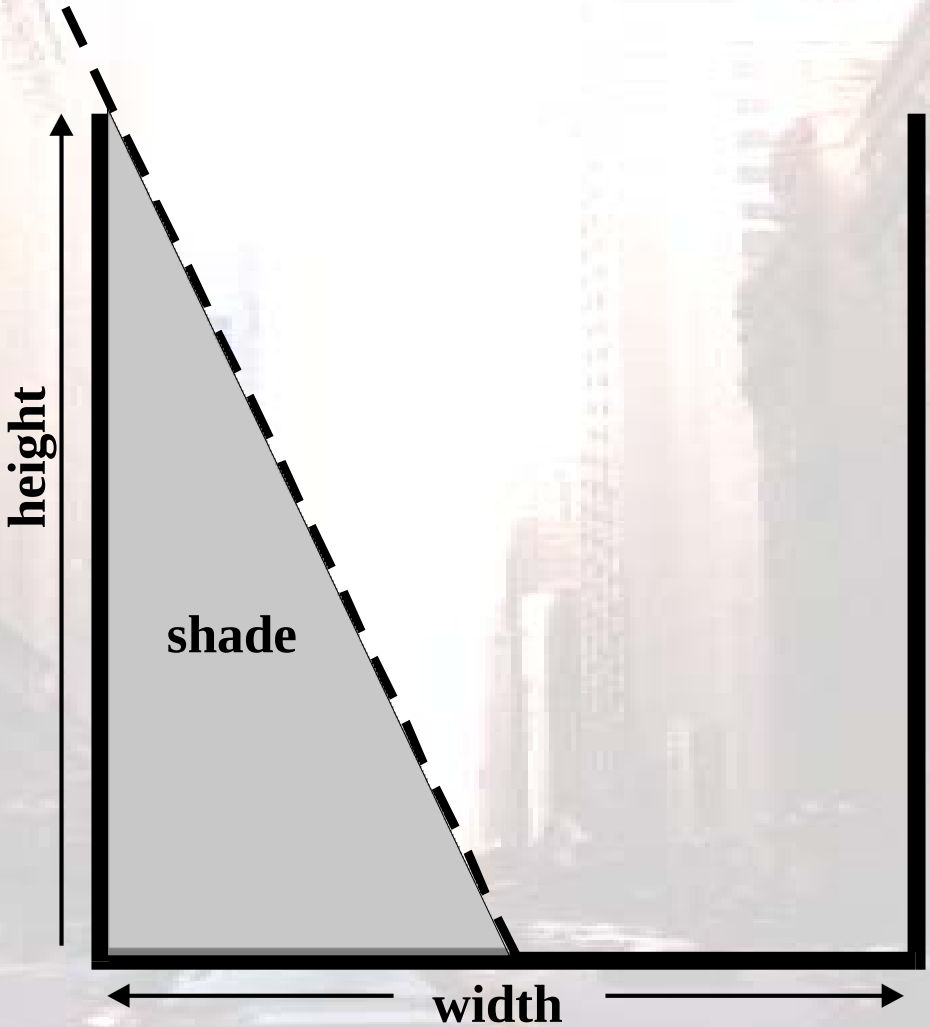
RayMan – http://www.mif.uni-freiburg.de/rayman



(A. Matzarakis, 2001)

Cross section street canyon




height
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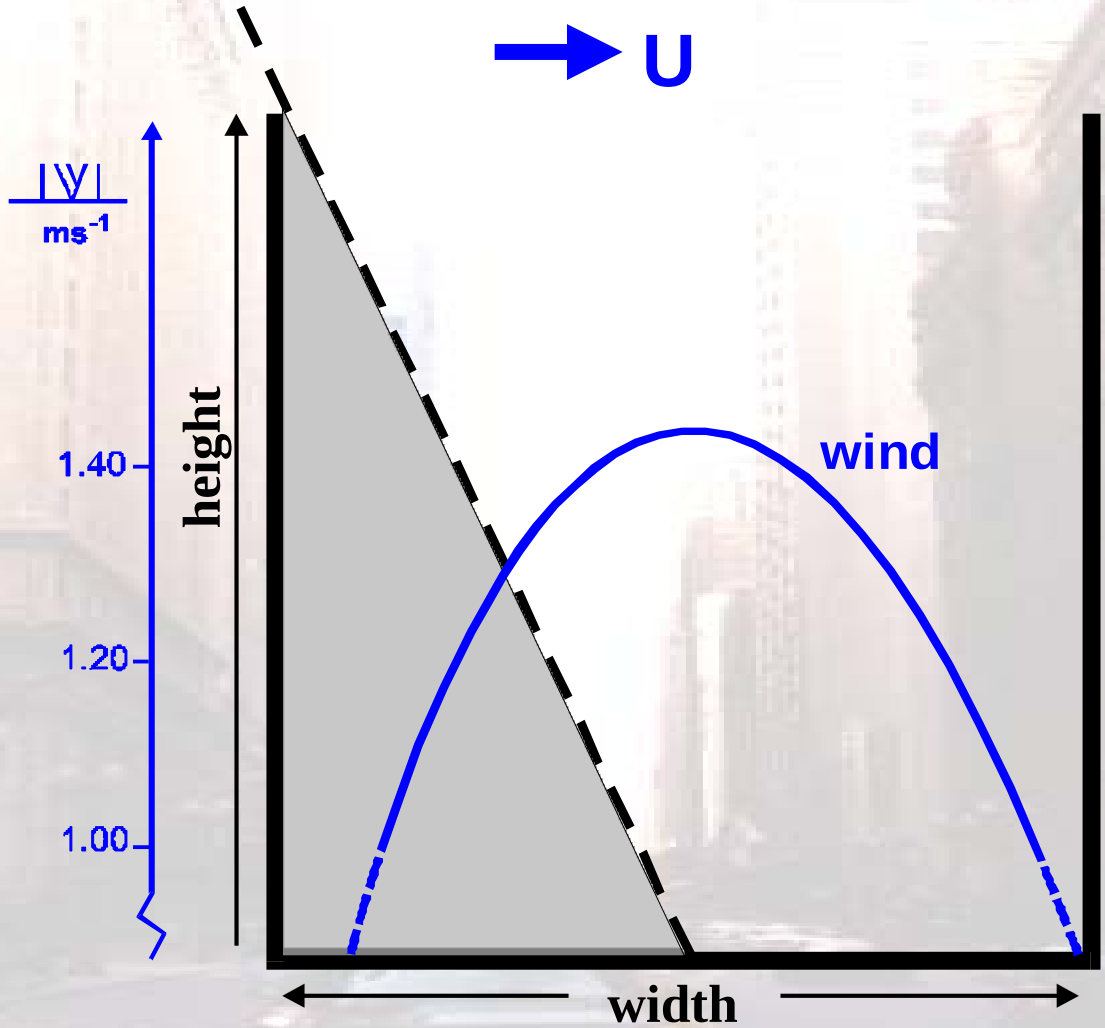
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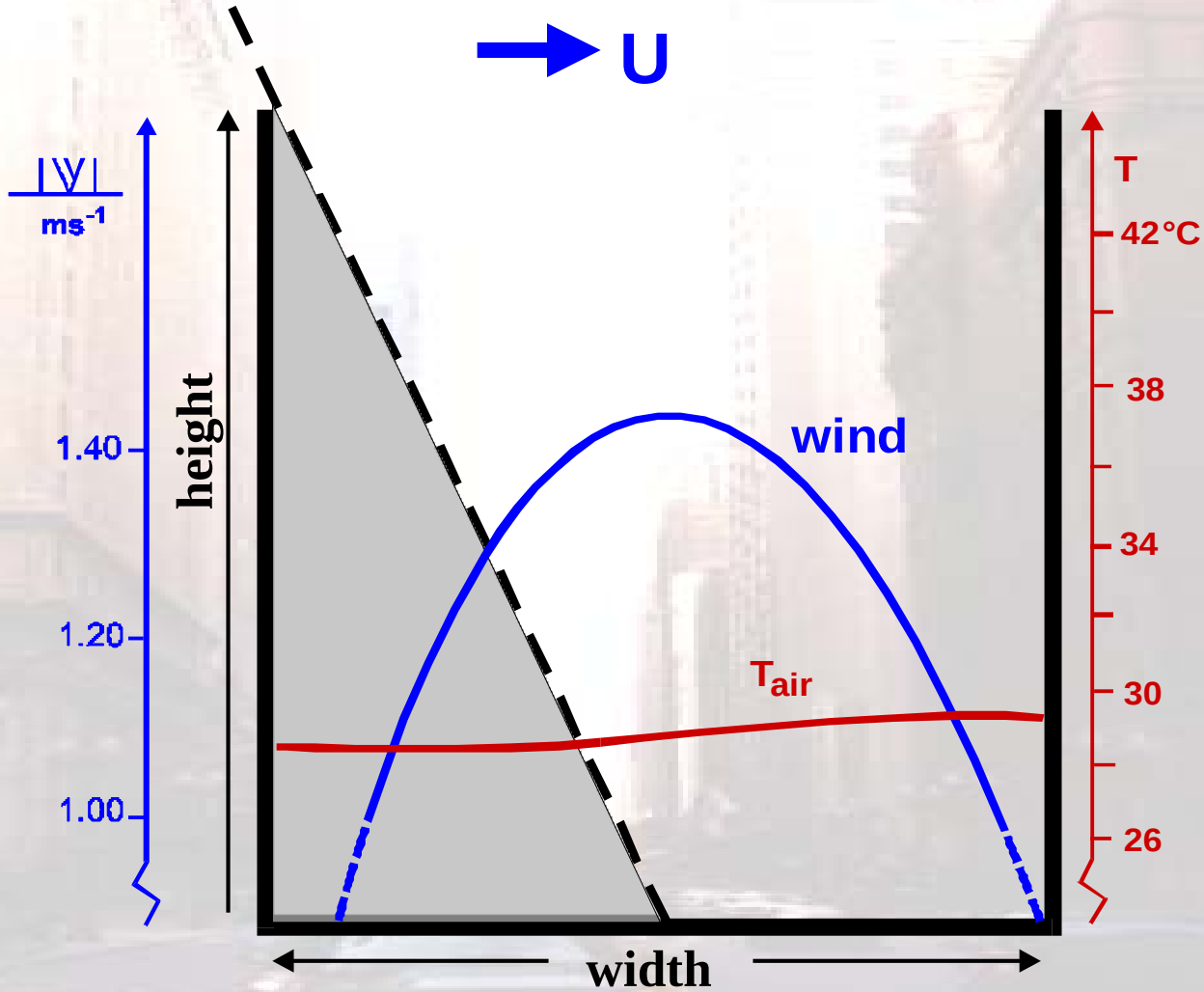
1.40
1.20
1.00
height
wind
width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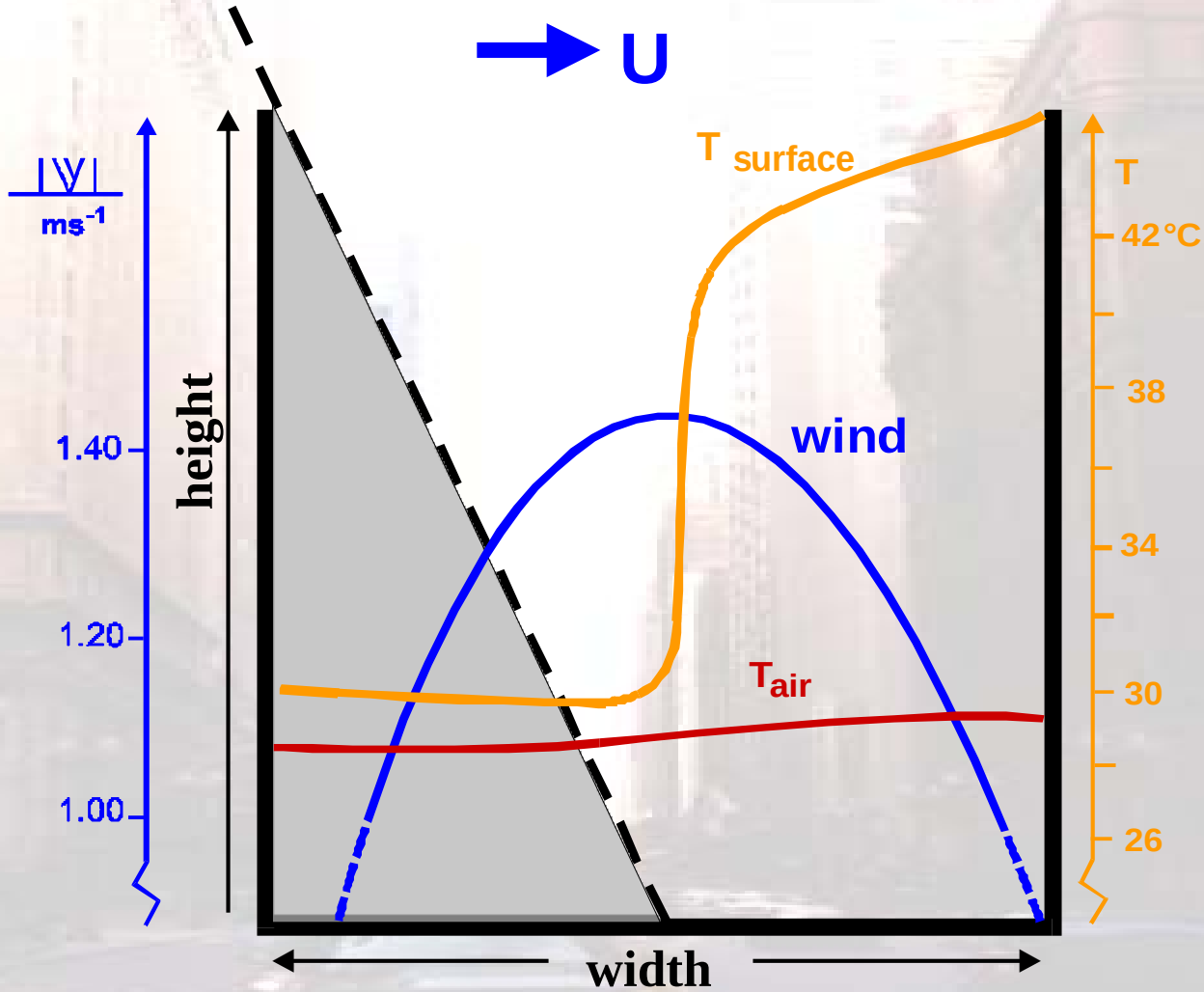
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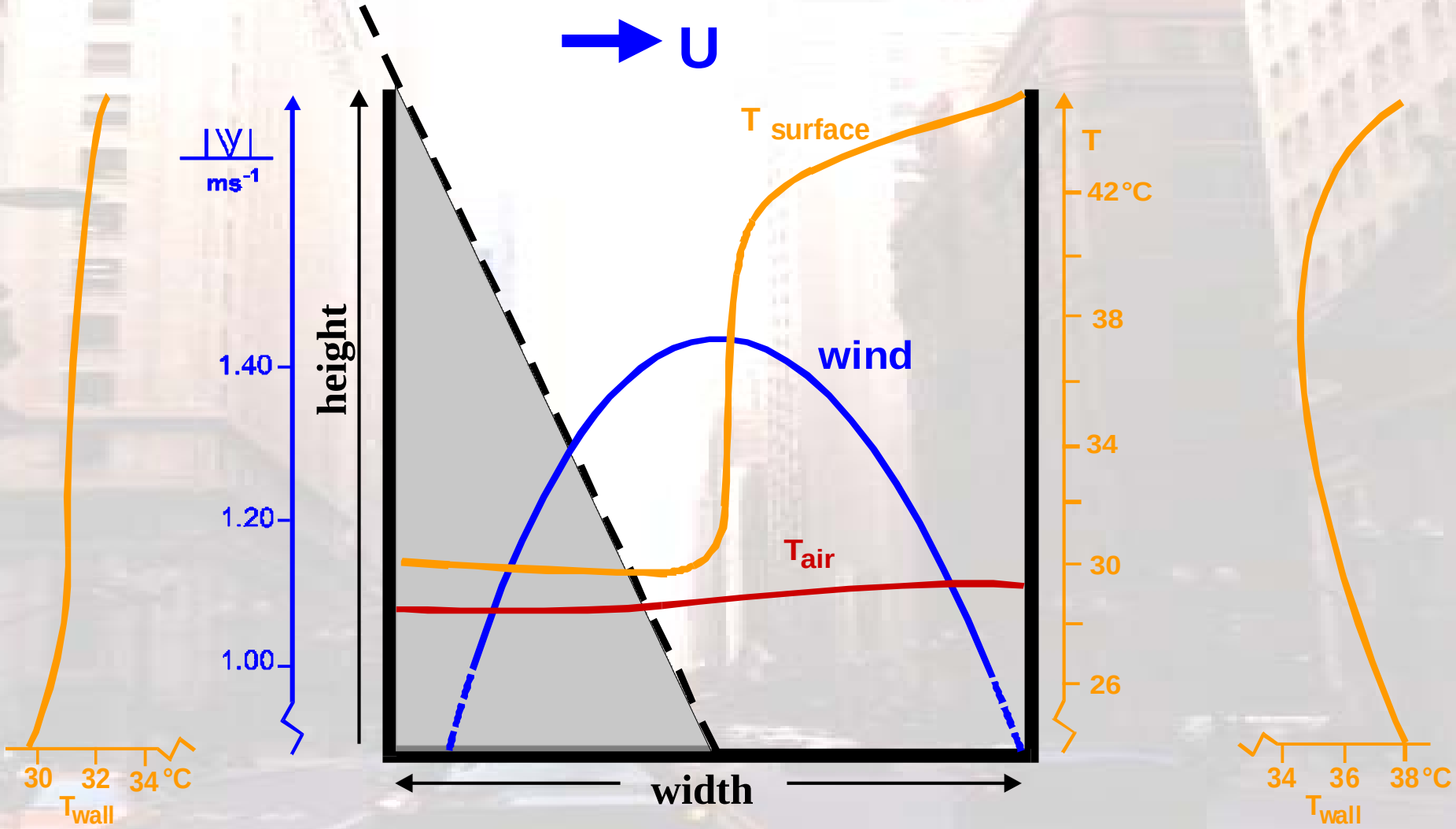
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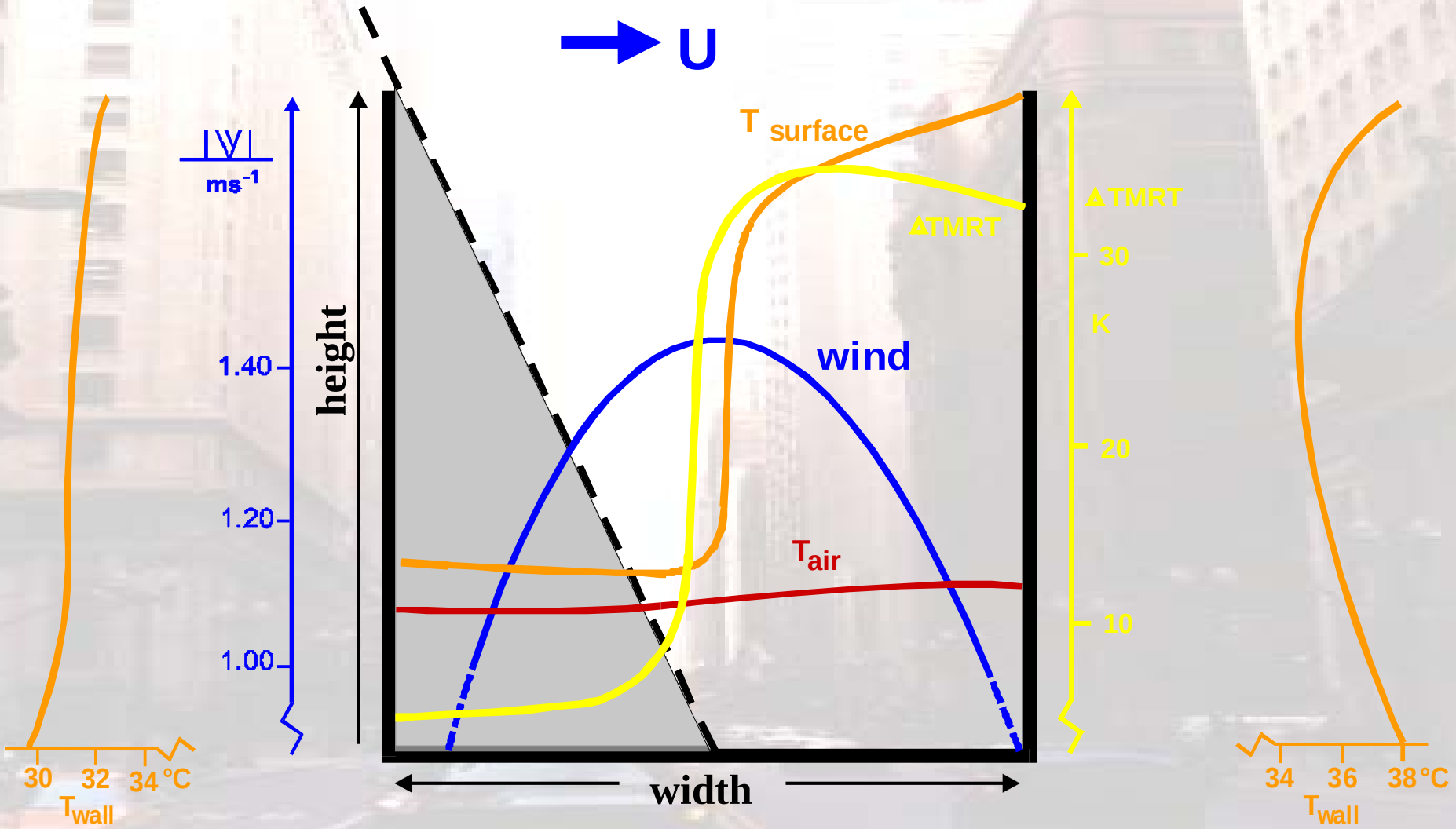
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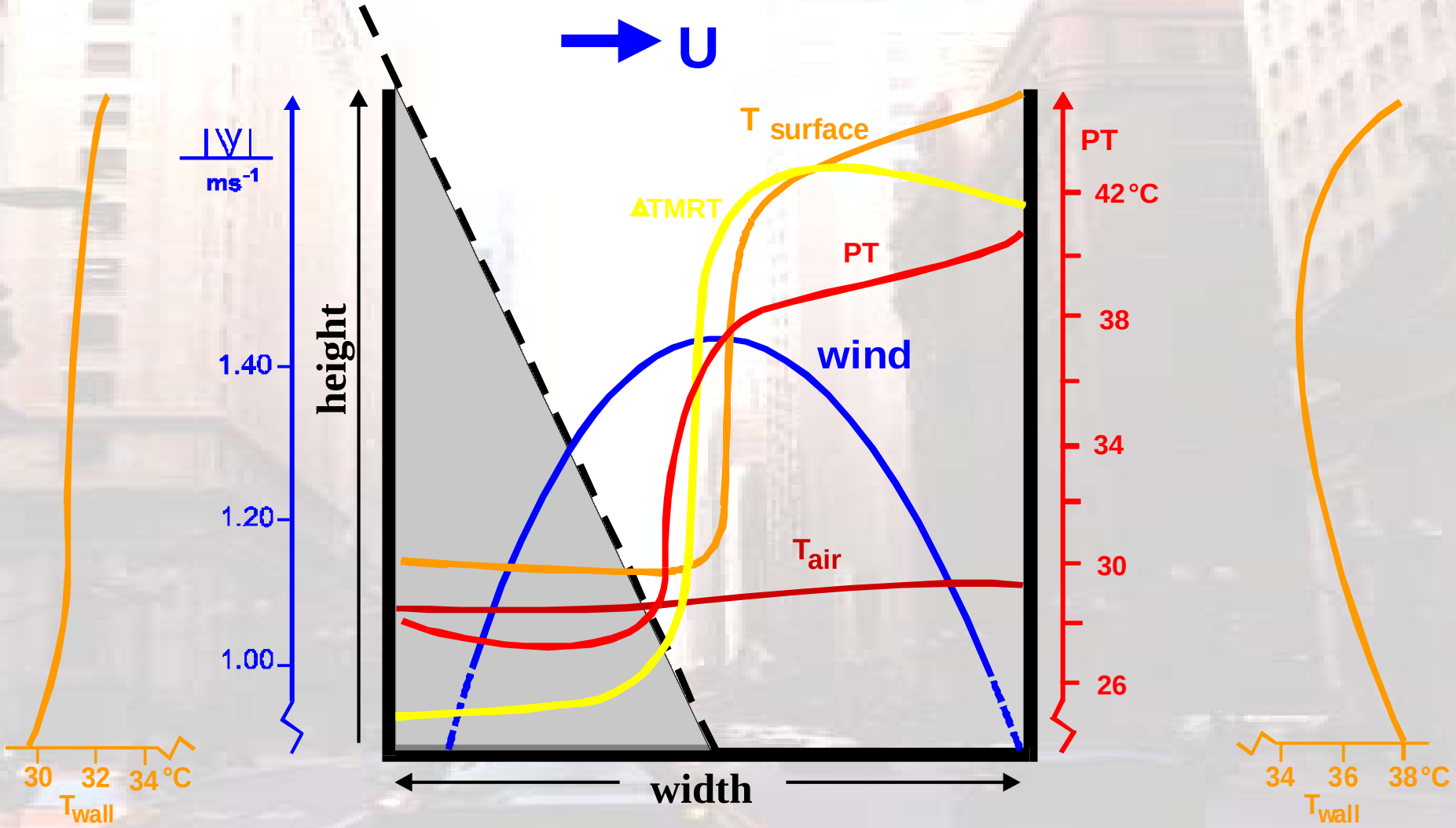
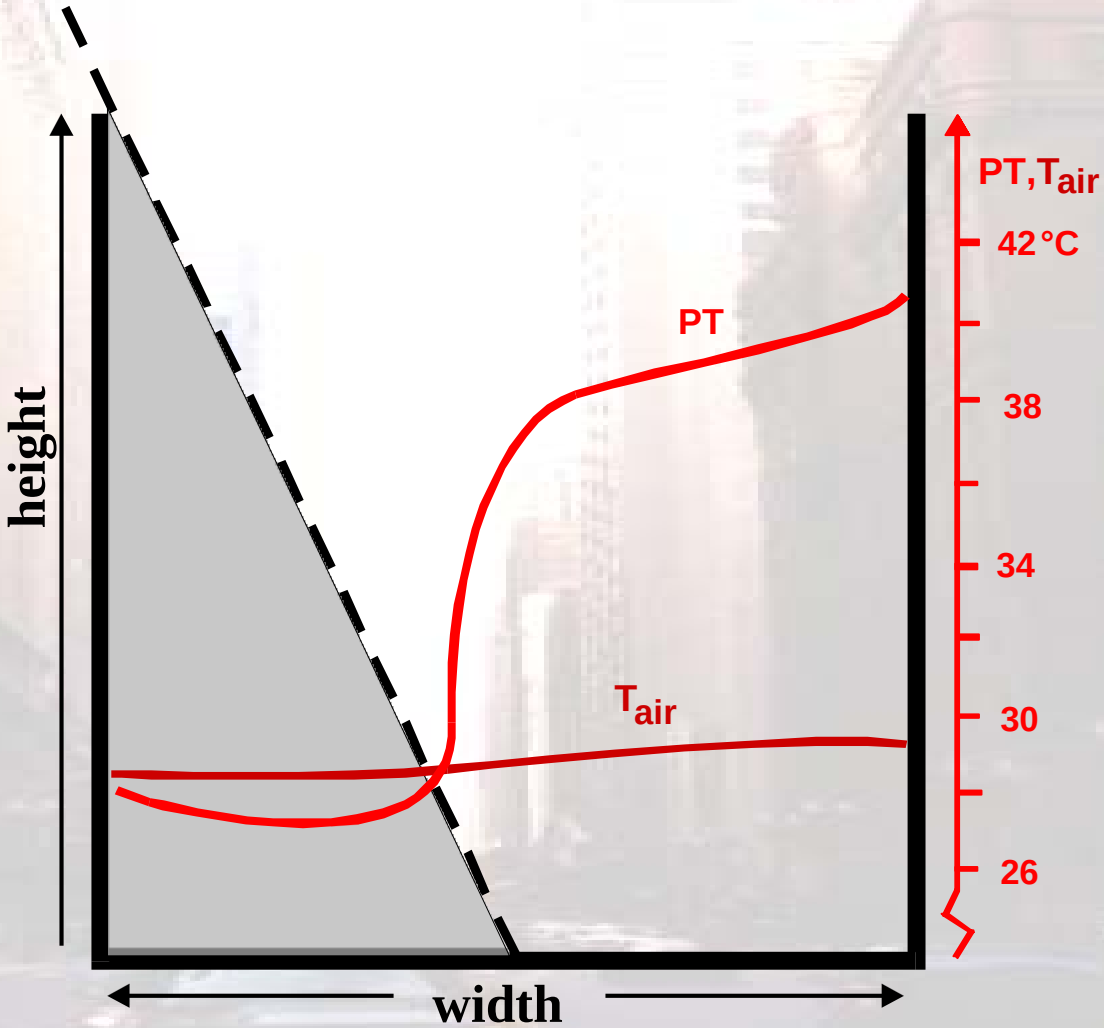
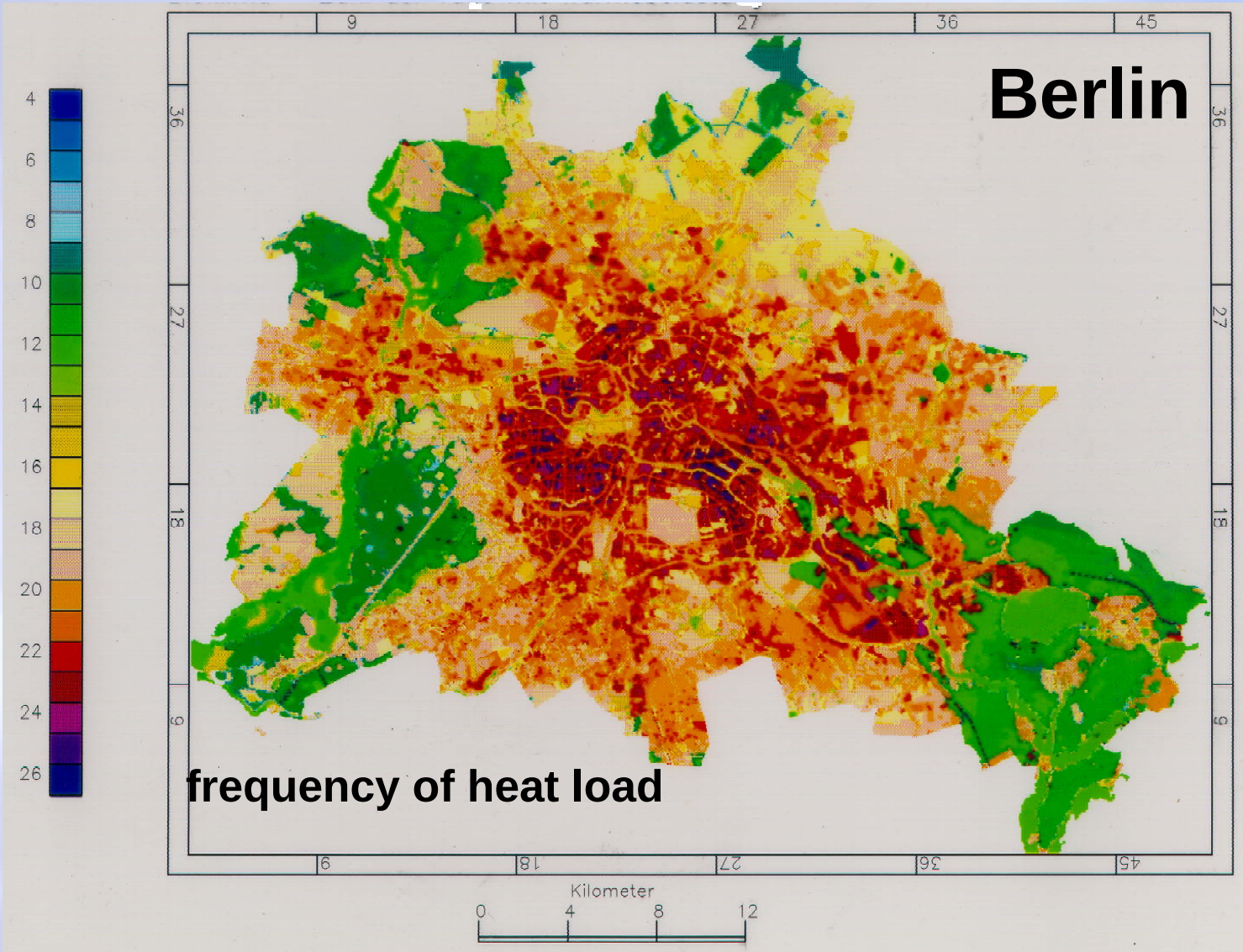
Twall
34 36 38 °C
Twall


U
T surface
ΔTMRT
PT
wind
T air
height
width
|v|
ms-1
1.40
1.20
1.00
PT
42 °C
38
34
30
26
30 32 34 °C
Twall
34 36 38 °C
Twall


height
width
PT
T_{air}
PT,T_{air}
42 °C
38
34
30
26



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Key applications

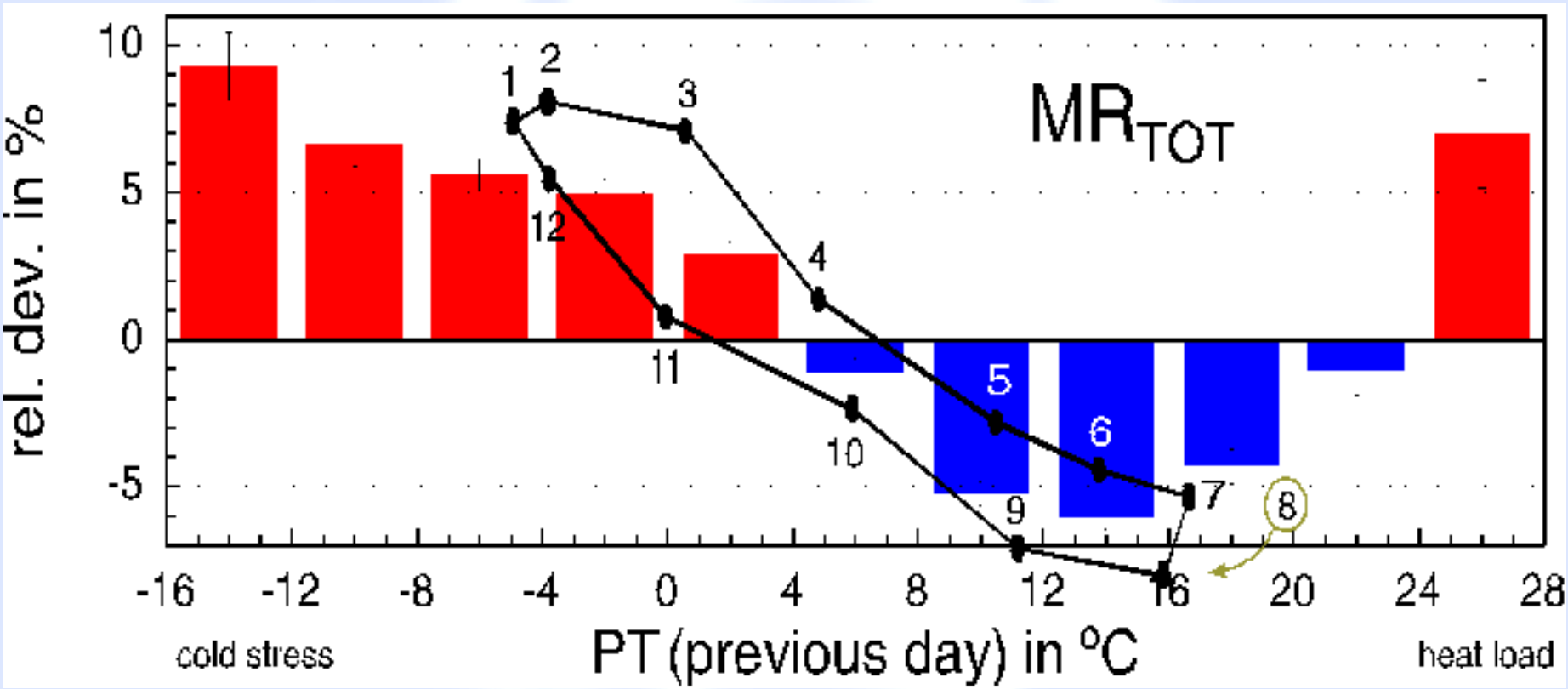
Daily forecasts

- 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 where to live
- Outdoor recreation and climatotherapy
- **Epidemiology**
- **Climate impact research**

Total Mortality MR_{TOT} and Perceived Temperature PT



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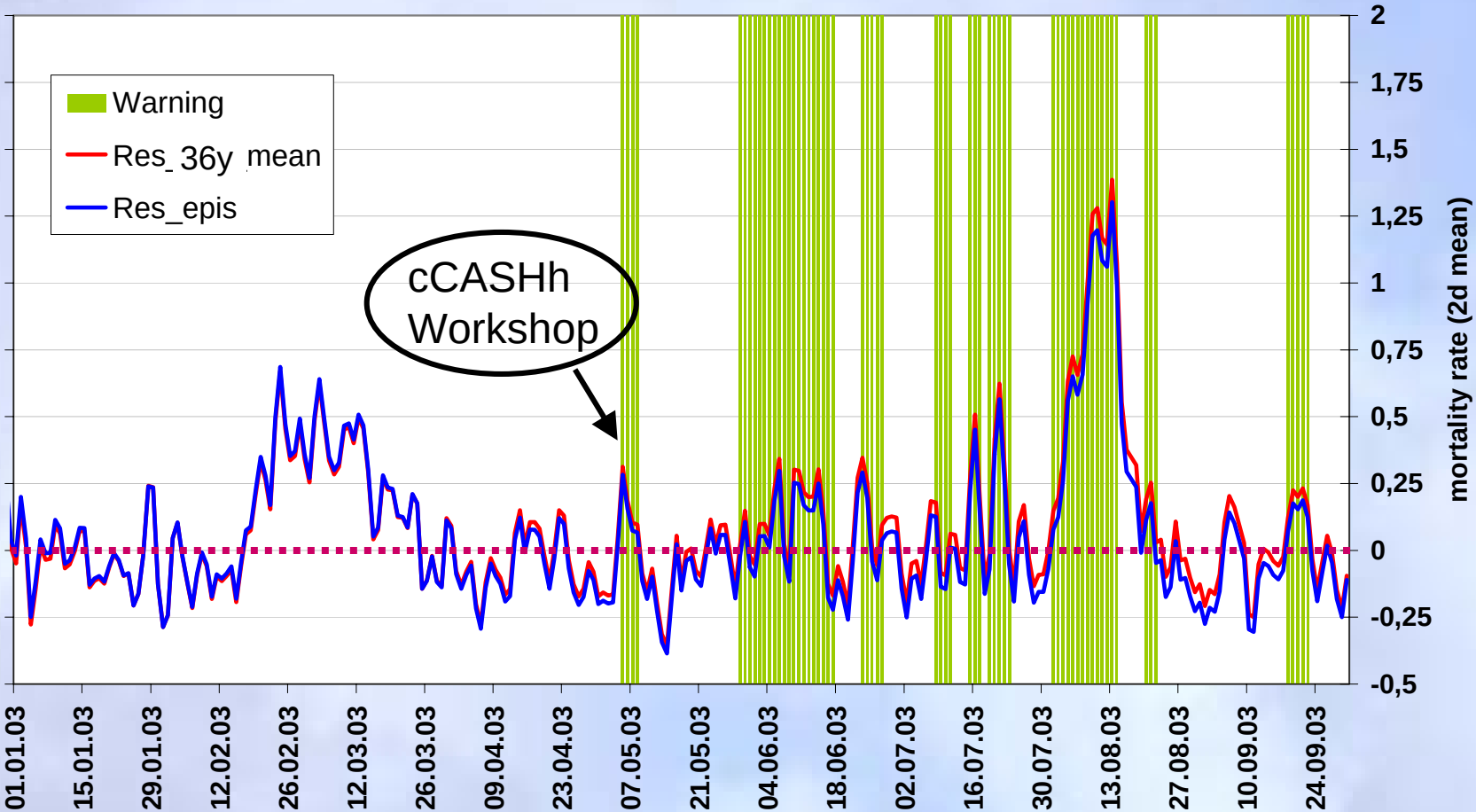
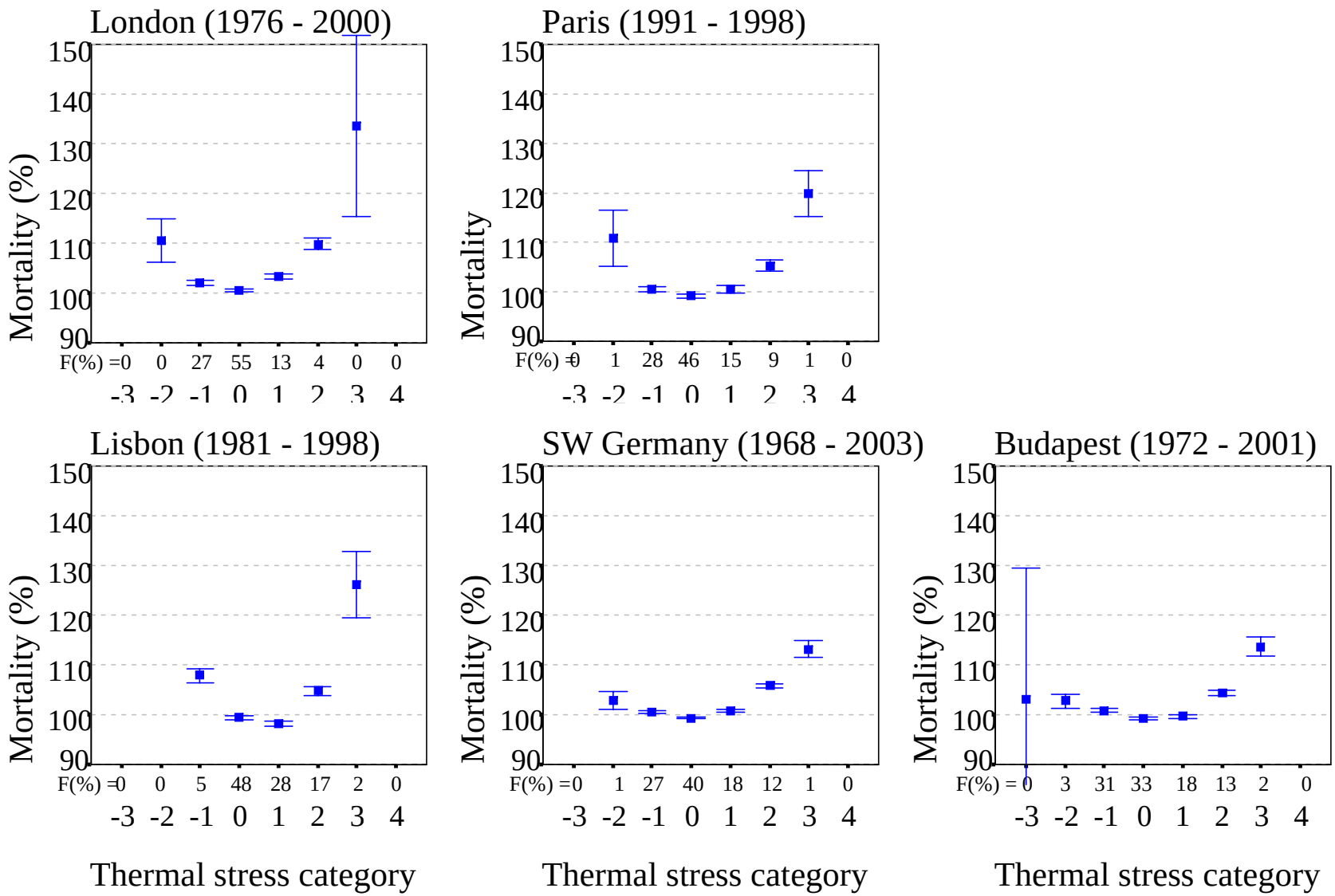
Hypothetical heat warnings in 2003



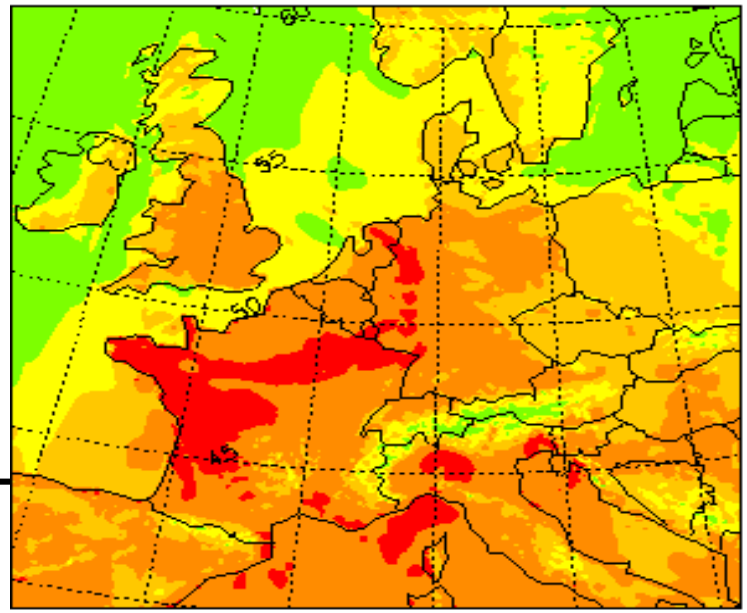
Mortality in relation to the expected value

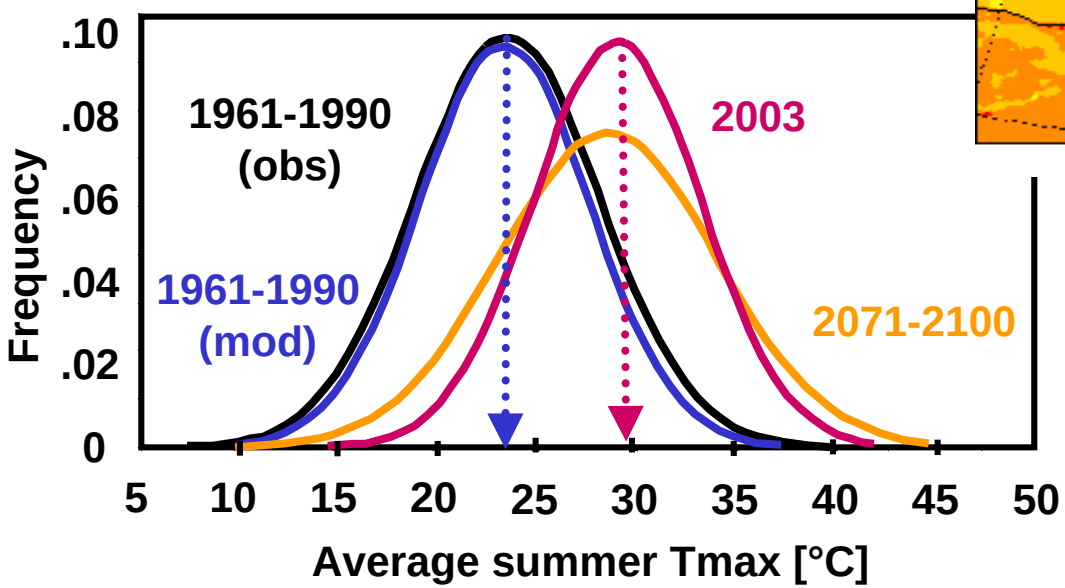


The heat wave 2003 in Europe: A unique feature?

IPCC WGI, 2001:

"Higher maximum temperatures and more hot days over nearly all land areas are very likely"





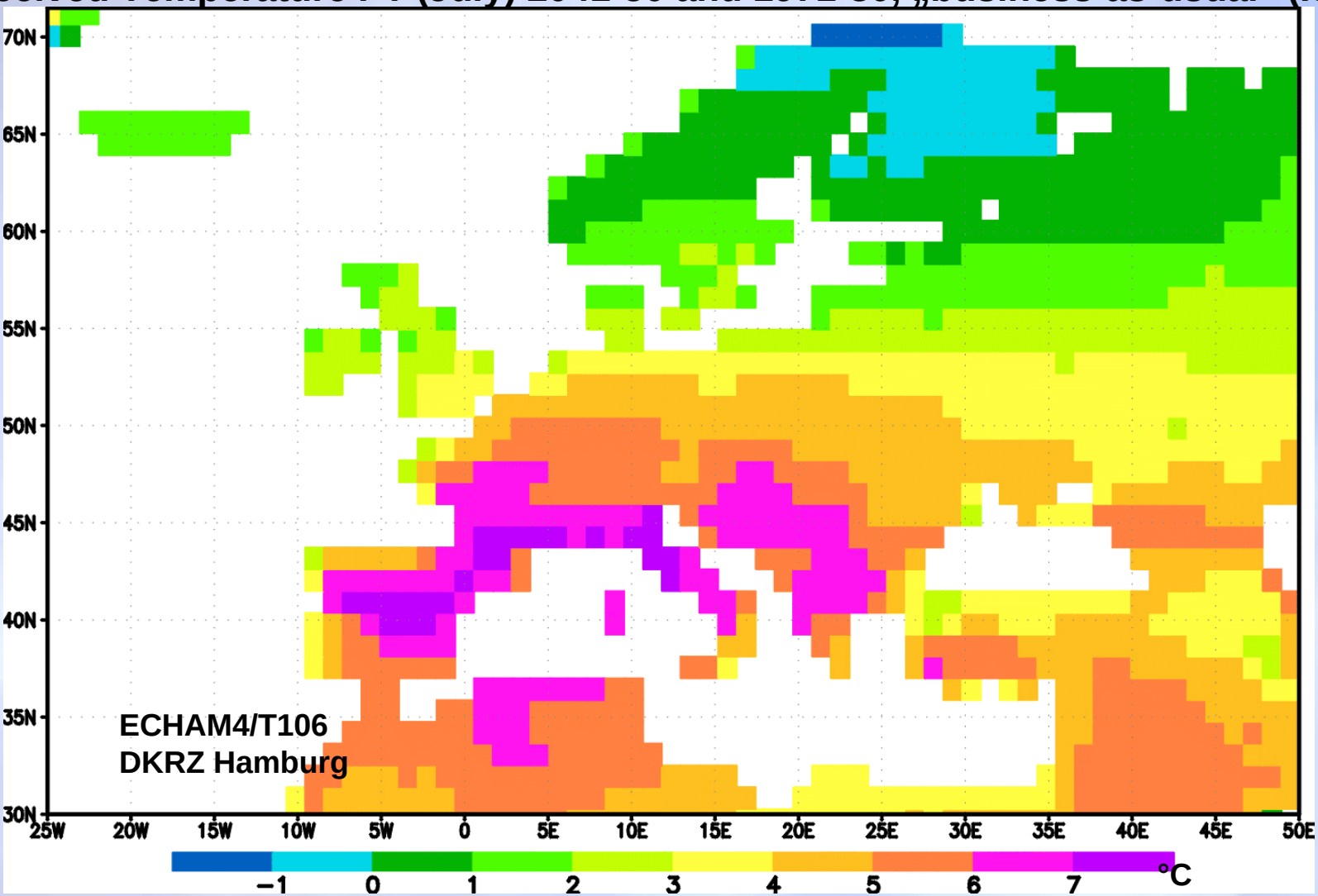
⇒ **Need to adapt**

Beniston, 2004

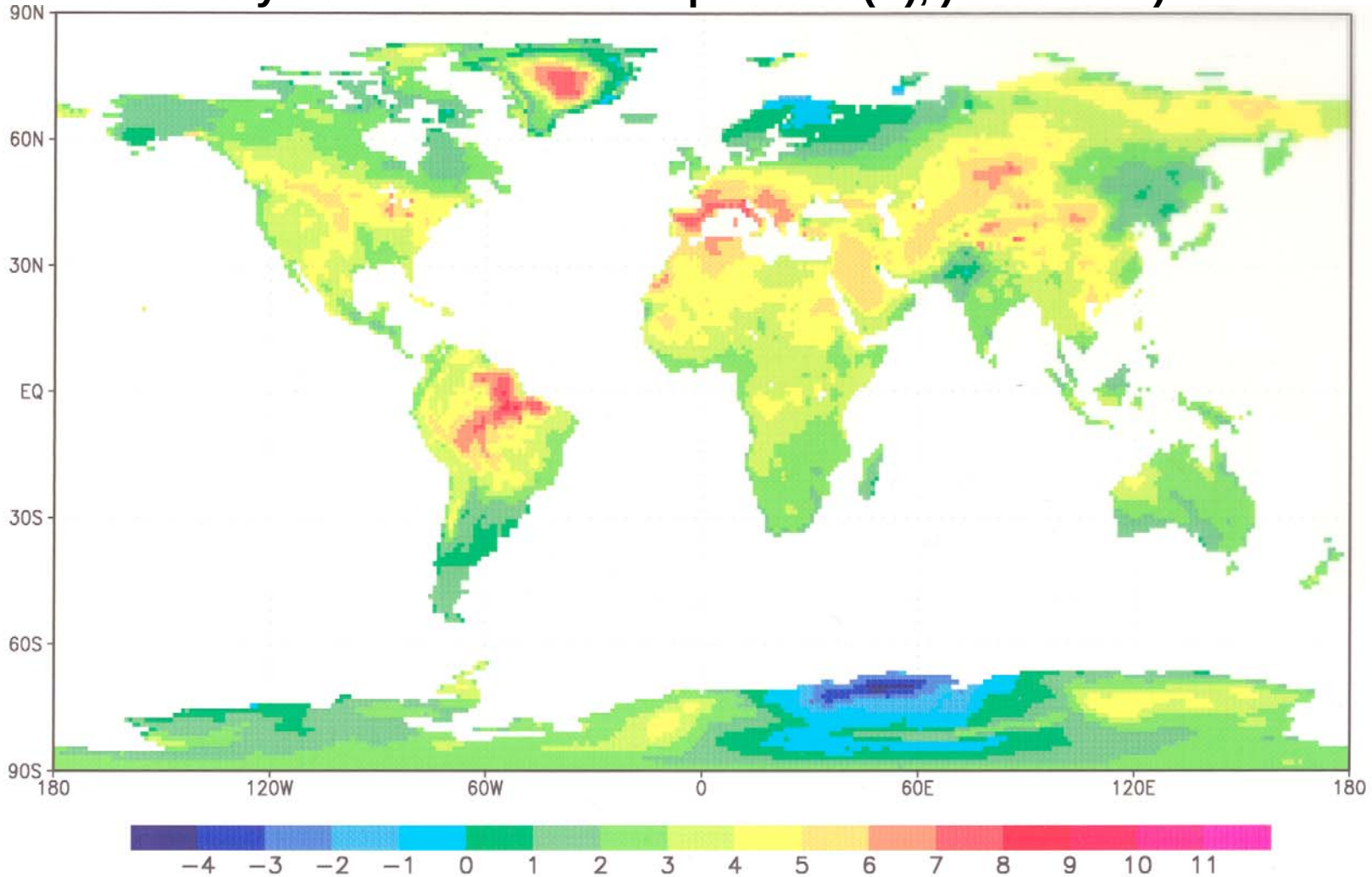
Deutscher Wetterdienst

Human Biometeorology

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



July Delta Perceived Temperature (K),)IS92a-CTL)



data: Deutsches Klimarechenzentrum Hamburg; ECHAM4/T106

Why UTCI?

- Assessment of the thermal environment: Key issue in human biometeorology
- **History: >100 simple thermal indices**
- Last 35 years: heat budget modelling
- Integration of new knowledge and concerns
- Need: harmonization → UTCI (ISB, WMO)
- COST Action (Example: UV-Index)

I $M + W + Q^* + Q_H + Q_L + Q_{SW} + Q_{Re} = 0$

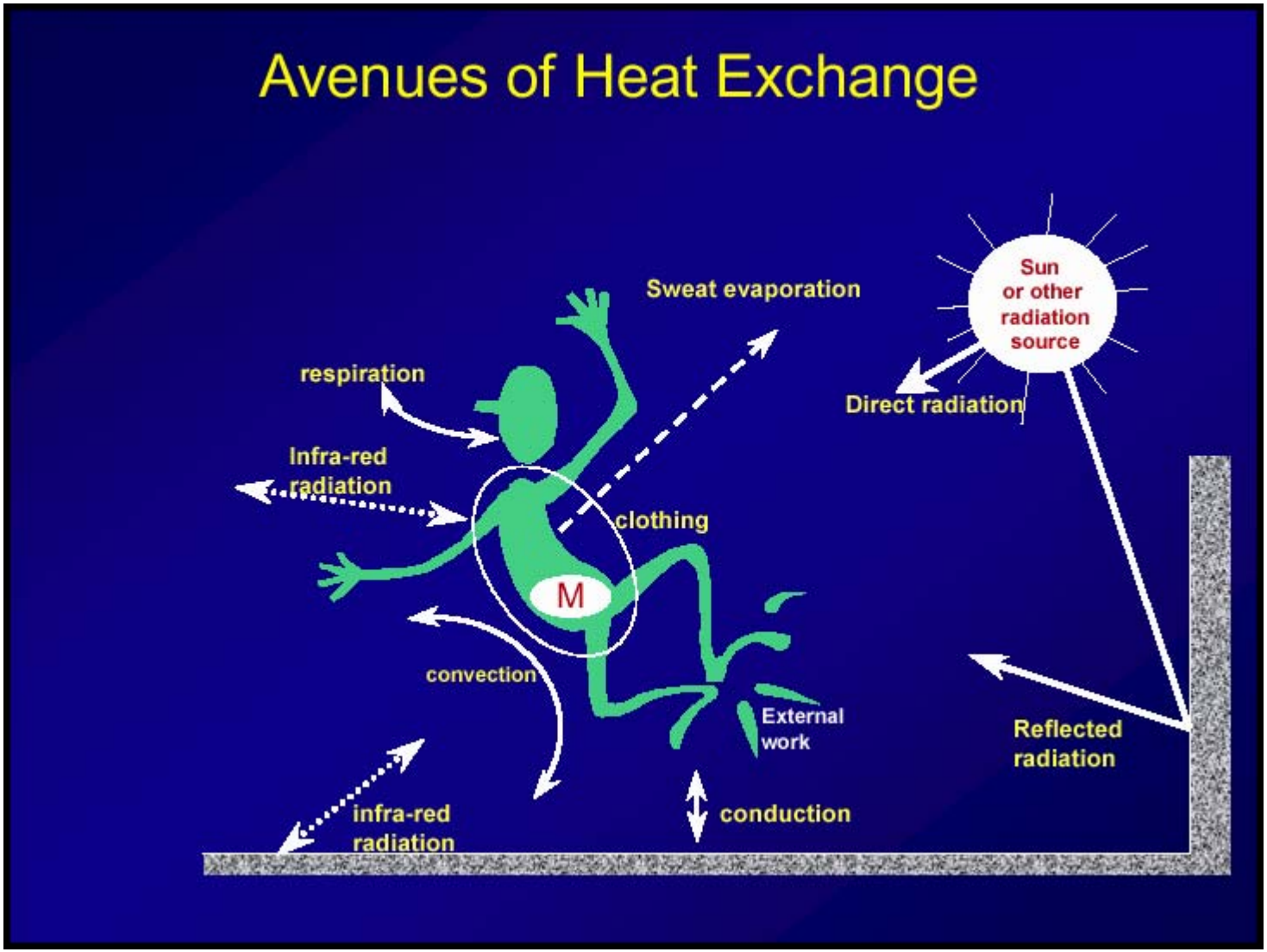
II Simple indices

III Heat budget modelling

IV Multi-node models

V UTCI

Avenues of Heat Exchange



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)

Principle

Each index value

must result in the same thermophysiologial effect

regardless of the combinations the meteorological input values

No simple index is able to fulfill this requirement!

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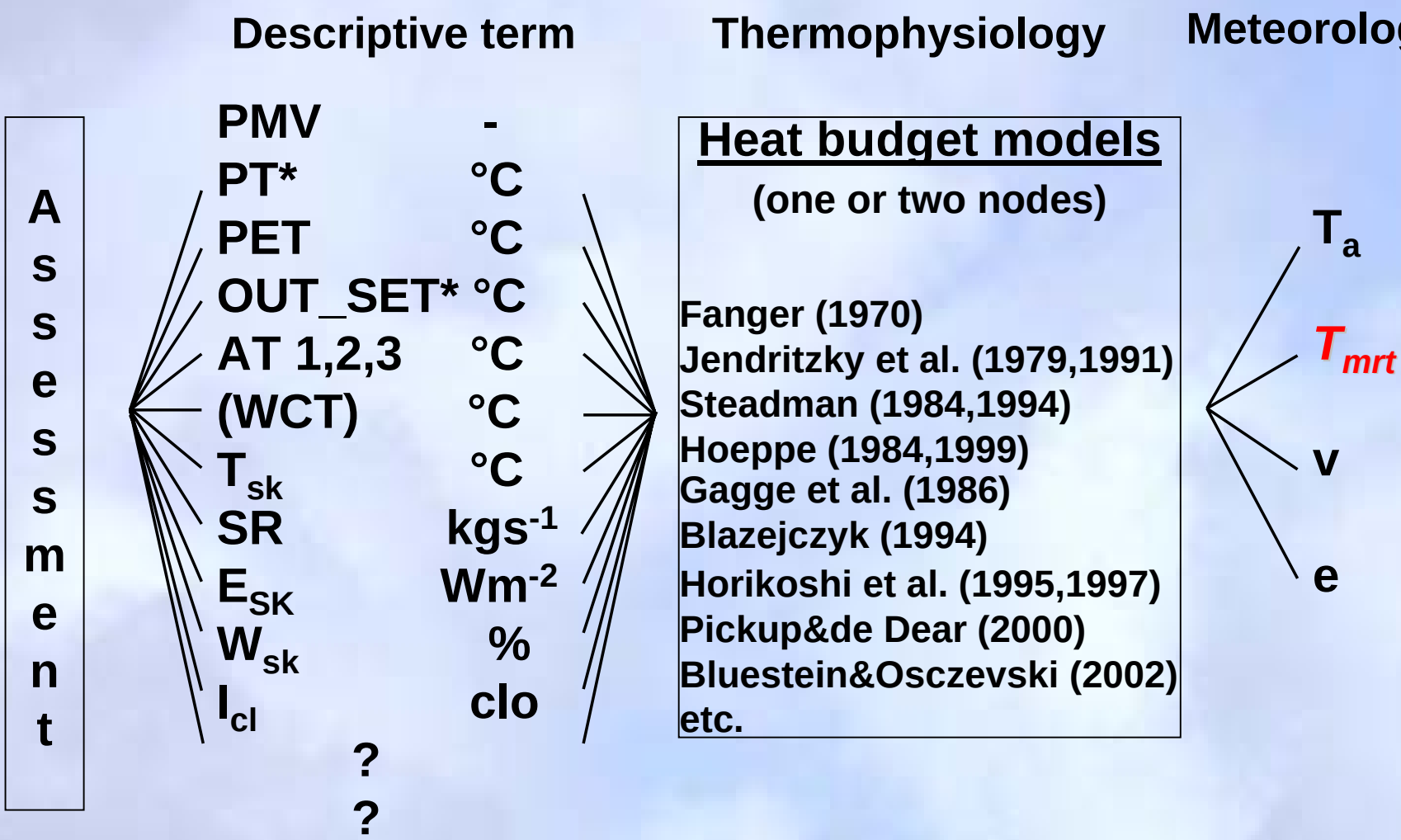
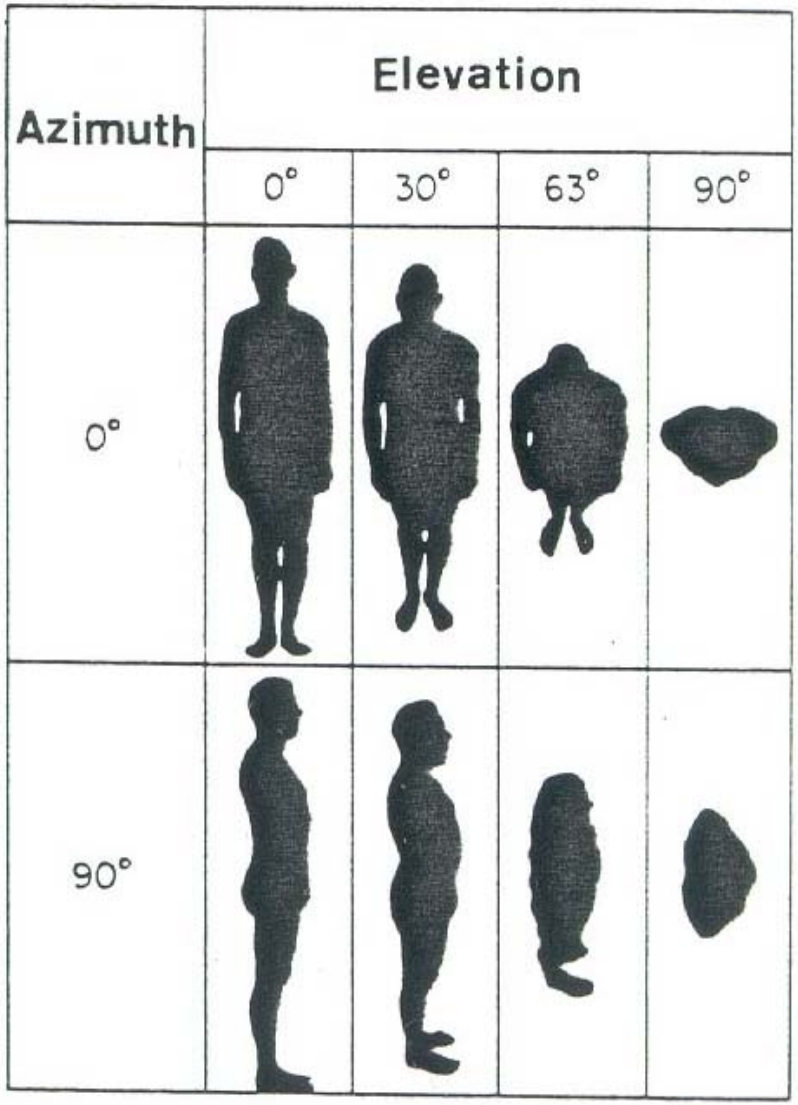
Thermophysiological Assessment of the Thermal Environment



Tmrt

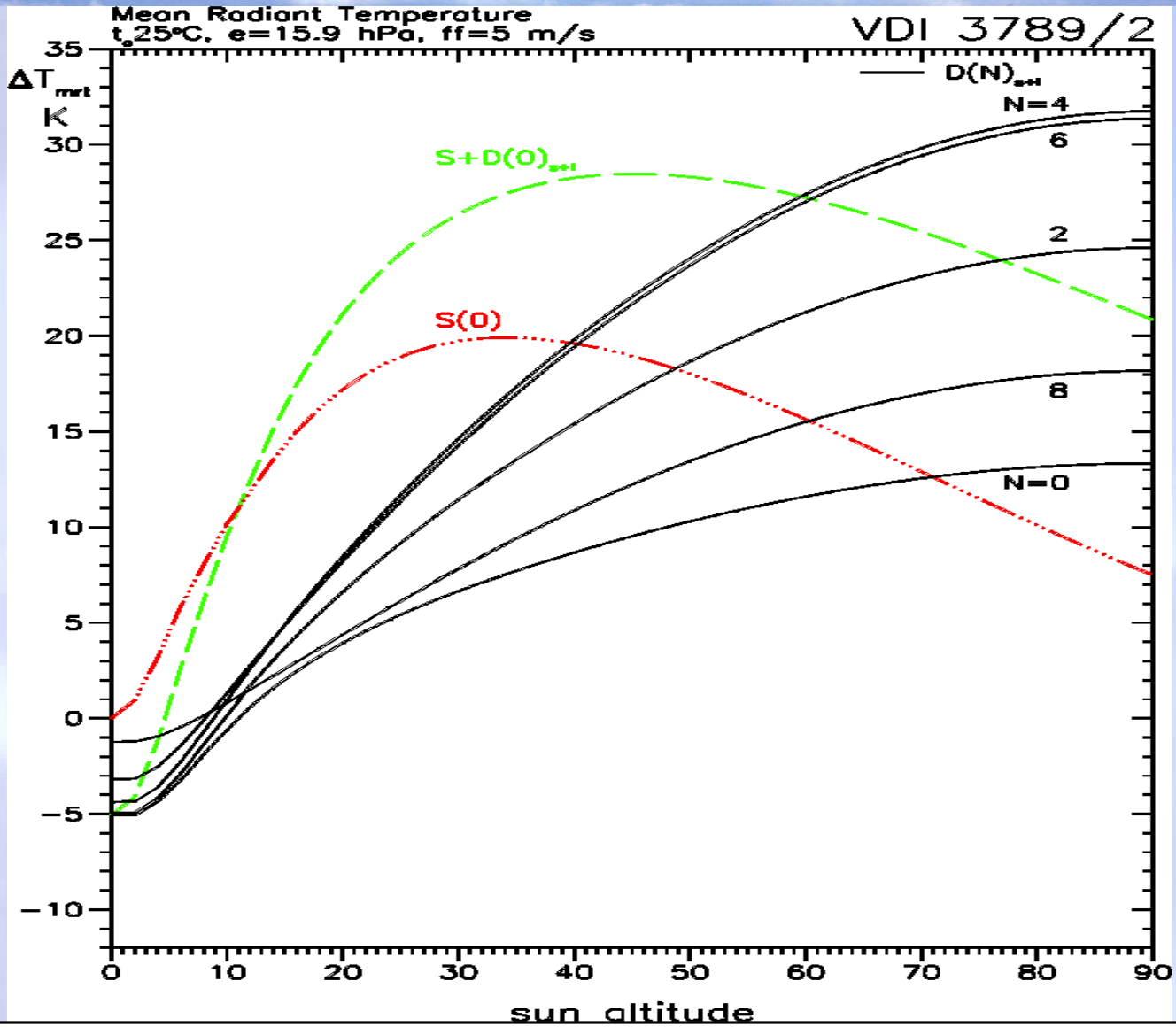
Uniform temperature of a black body enclodure that results in the same radiant heat exchange as under actual conditions

- **Direct solar radiation**
- **Diffuse solar radiation**
- **Reflected solar radiation**
- **Infrared radiation from the sky**
- **Infrared radiation from the surroundings**


Azimuth
Elevation
0°
30°
63°
90°
0°
90°

Deutscher Wetterdienst

Human Biometeorology



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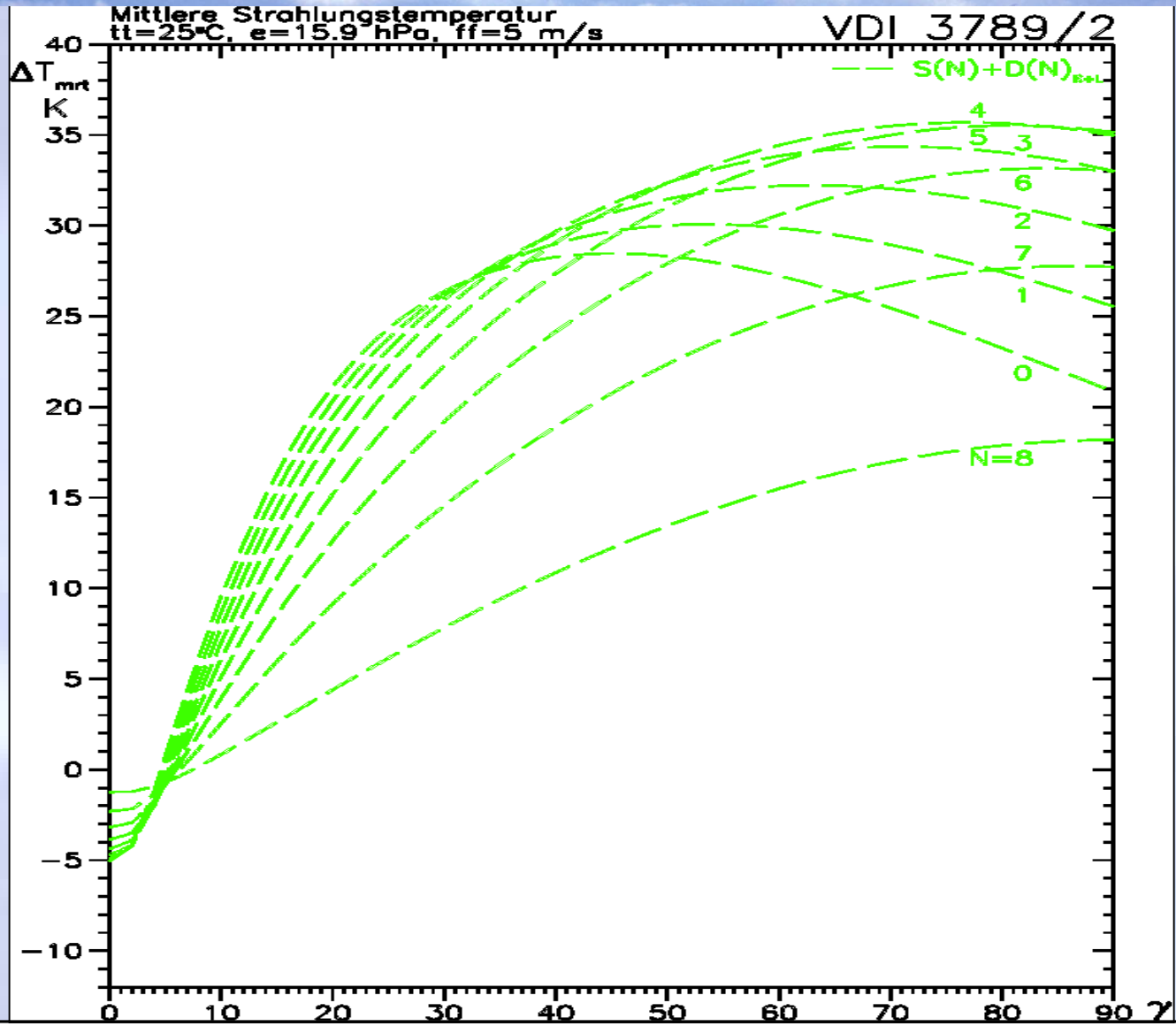
Human Biometeorology



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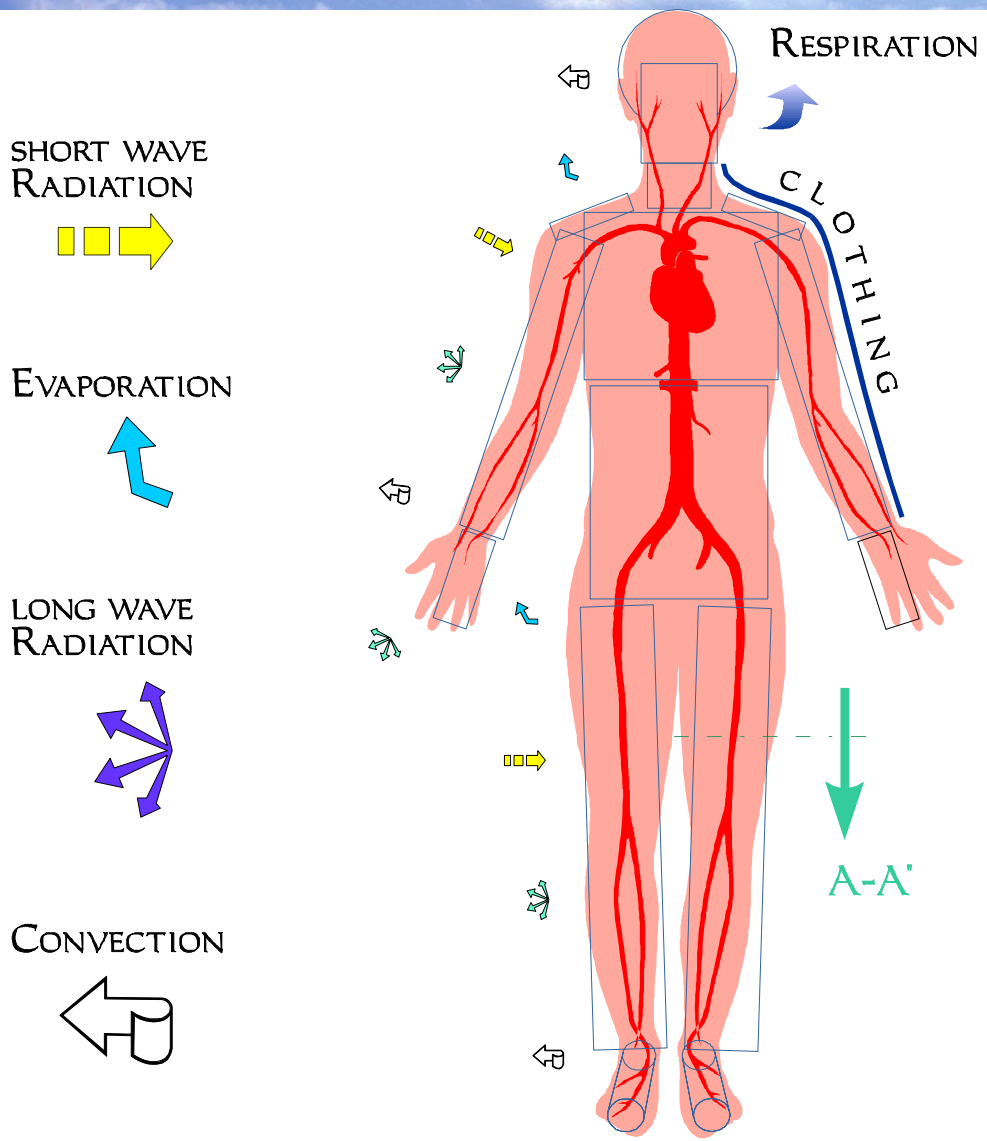
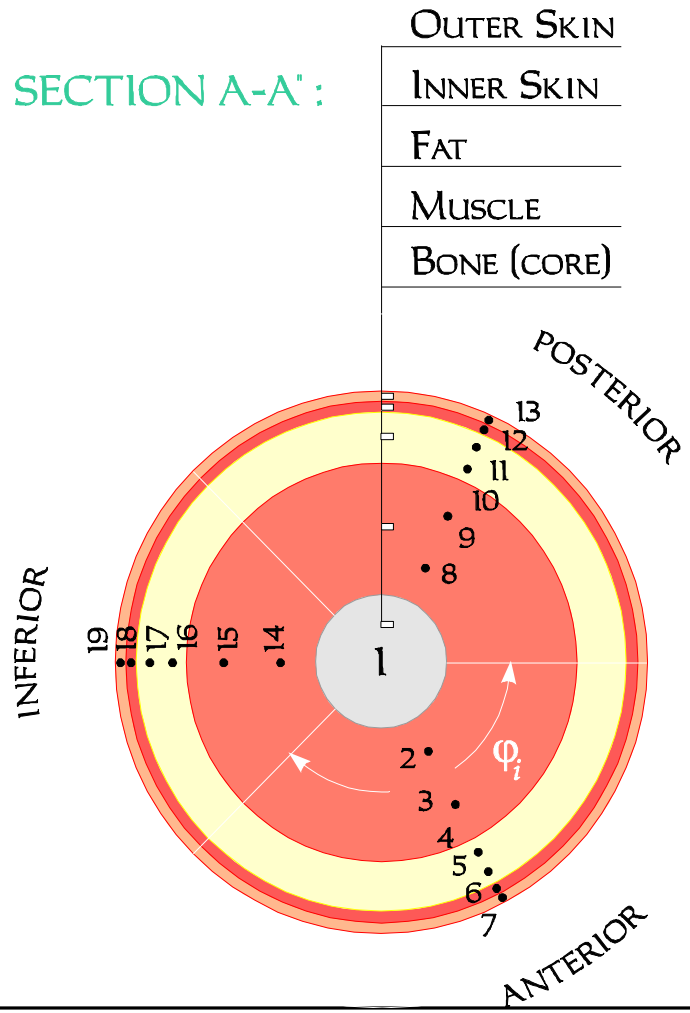
Fiala et al. 2001





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 Tsk,f,h < 0°C

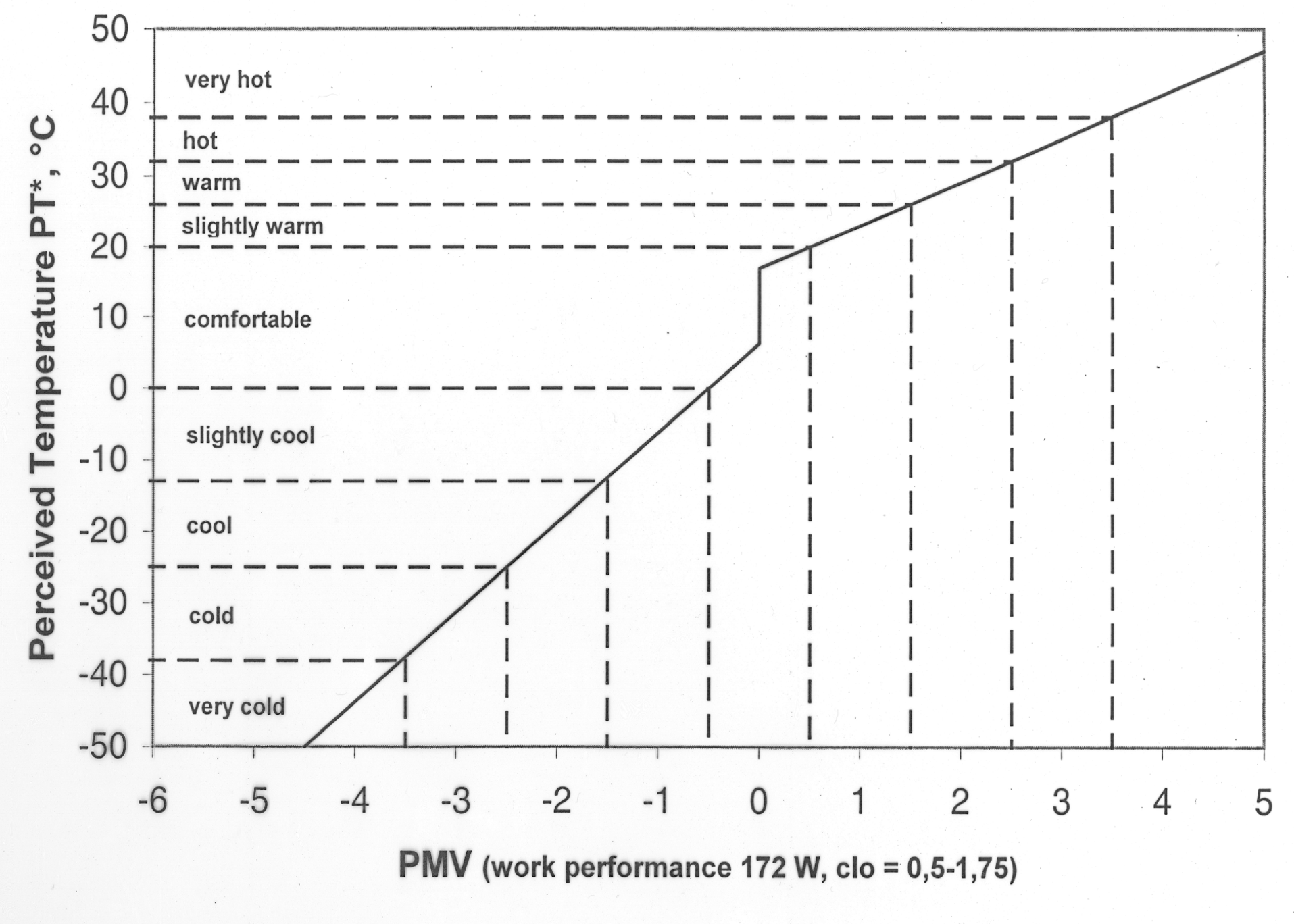
Assessment problem!

Variables for multi-node model simulations

Meteorological input		Δ
Air temperature (T_a):	-40°C < T_a < +45°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?)



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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)
- $T_{mrt} = T_a$
- rh = 50%
- 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

- 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 subproplems

- Heat budget modelling
- Assessment of physiological variables
- Acclimatisation
- Meteorological input, in particular radiation ➔ T_{mrt}
- Definition of areas of validity, requirements
- Applications
- ?

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