Thermal Comfort Atlas for residential Buildings

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Thanks to technical and legal developments and changes, the thermal quality of new and renovated buildings has increased permanently. Today, a level has been reached that makes new ways of heat transfer into rooms thinkable.

This could open the doors to a whole range of advantages: By placing heaters on internal walls, building costs would not only drop due to shorter pipe lengths, but also due to simplified floor constructions, which in return would lead to a less complex building process. Even further simplifications could be achieved in combination with ventilation systems, especially those with central air intake and outlet, by making double use of installation space needed anyway. At the same time, energy consumption and heat losses in the heat distribution system would be reduced.

Until now, the potential for cost and energy reduction have been used hesitantly only. One probable reason might be insecurities regarding the effects, that heating systems still considered unusual might have on thermal comfort. Case wise studies of the indoor climate to be expected by applying up-to-date simulation techniques are possible, but are due to economic reasons hardly practical in the planning process for residential buildings.

This led to the idea of a catalogue, in which typical rooms of varying façade qualities and layouts, heating and ventilation systems are tested and compared for their thermal comfort conditions. The investigations were carried out using indoor flow simulations plus additional software tools, that have been developed during earlier research projects.

It is obvious that such a catalogue can not cover all possible architectural and technical room variations. But it tries to meet a selection, that is representative for a broad range of rooms found in reality. The resulting 144 room models are distinguished by the following attributes:

- four façade layouts,
- five heating concepts (incl. hot air heating),
- four ventilation concepts (incl. hot air heating),
- three thermal façade qualities.

To make the results comparable, the heating in each room model is controlled to keep the air temperature within a range of 22 ± 0,05°C at a control position in the rooms centre and 1.3 m above floor level. The resulting indoor climate at control position and within a defined occupied zone is evaluated in accordance to DIN 1946/2 and ISO 7730. Additionally, a thorough analysis of the convective and radiative heat balance and numerous graphical evaluations are supplied for each room under investigation. The final report (in German language) is supplemented by introducing chapters on physiology and analytical methods for evaluating indoor climates.

Some exemplary evaluations for one of the room models are given on the following pages.

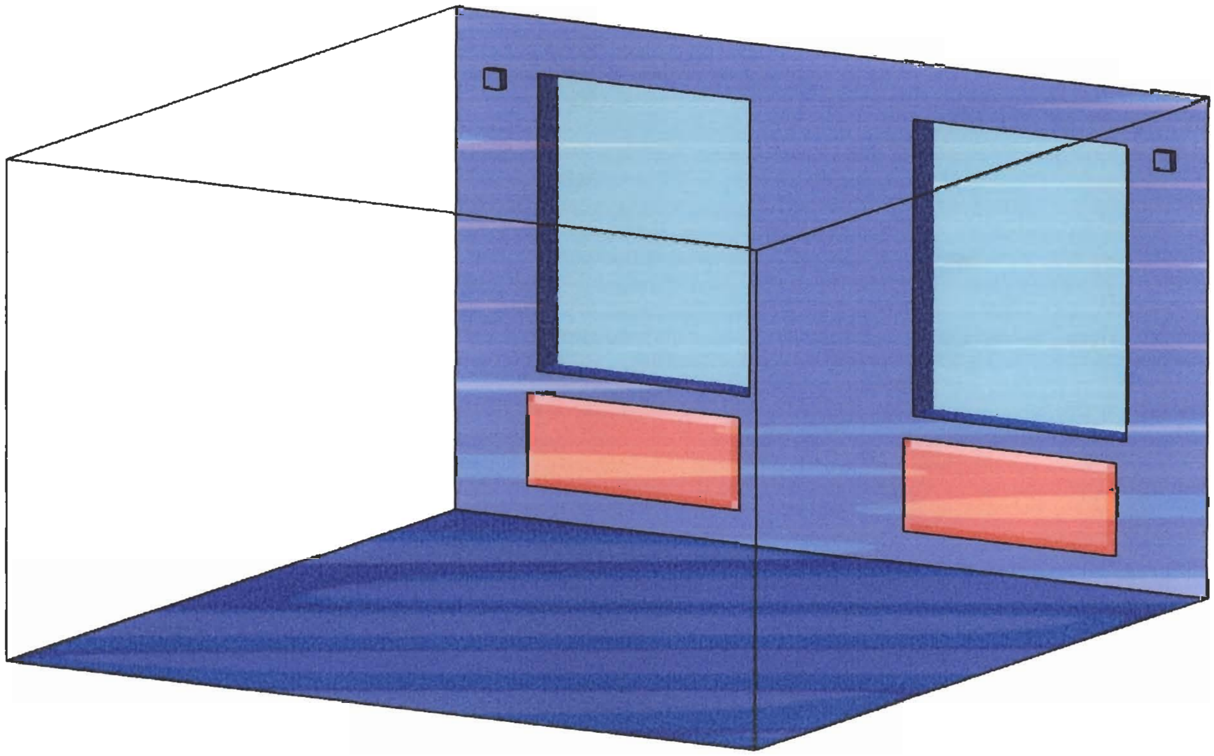

Figure 1 Room and façade geometrie, heaters

Control Position	Value	Unit
Air temperature	22.0	°C
Radiation temperature	21.6	°C
Globe (operative) temperature	21.7	°C
Air velocity	0.01	m/s
PMV	-0.4	--
PPD	7.8	%
Horizontal radiation temperature asymmetry	0.0	K
Vertical radiation temperature asymmetry (warmer surface below)	0.3	K

Occupied Zone	Average	Maximum	Minimum	Unit
Air temperature	21.8	22.6	20.5	°C
Radiation temperature	21.7	24.4	20.6	°C
Globe (operative) temperature	21.7	23.3	21.2	°C
Air velocity	0.04	0.10	0.01	m/s
PMV	-0.4	-0.2	-0.6	--
PPD	8.4	12.5	5.5	%

Radiation temperature asymmetry	Average	Maximum	Unit
Height = 1.30 m			
horizontal	0.2	2.1	K
vertical (warmer surface below)	0.7	3.3	K
Height = 1,75 m			
horizontal	0.6	3.3	K
vertical (warmer surface below)	0.4	1.2	K

Air Temperature/Gradient	Average	Maximum	Minimum	Unit
Temperature in 0,1 m	20.6	21.1	20.2	°C
Temperature gradient from 0.1 m to 1.1 m	1.2	1.6	0.6	K

Wärmestrom	radiative	convective	total	Unit	radiat. fraction
Heizkörper	250.1	241.9	492.0	W	50.8 %
Lüftung	0.0	-263.8	-263.8	W	0.0 %
Fenster	-114.3	-35.6	-149.9	W	76.3 %
Außenwand	-117.2	21.1	-96.1	W	66.4 %
Innenwand	-15.4	15.4	0.0	W	50.0 %

Surface temperature	Average	Maximum	Minimum	Unit
Heater	41.1	41.1	41.1	°C
Window	16.1	17.2	14.3	°C
Exterior wall	21.5	36.0	11.8	°C
Interiour wall	21.6	25.1	15.6	°C
Floor	21.6	23.7	21.3	°C

relative error of total energy balance = -1.8 %

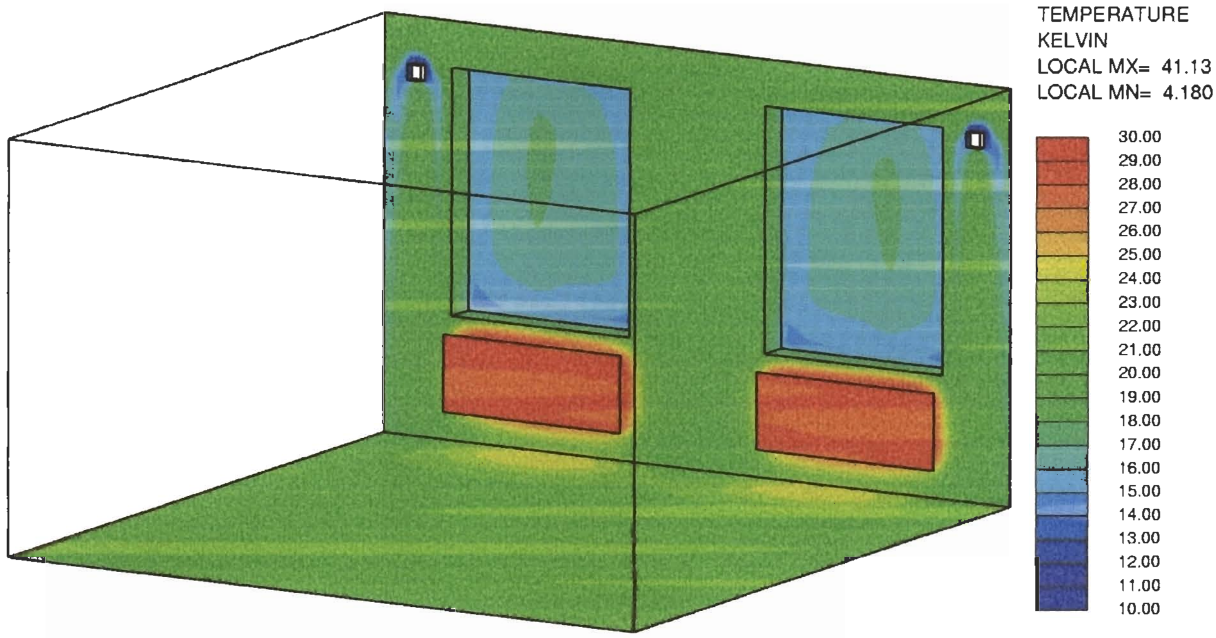

Figure 2 Surface temperature

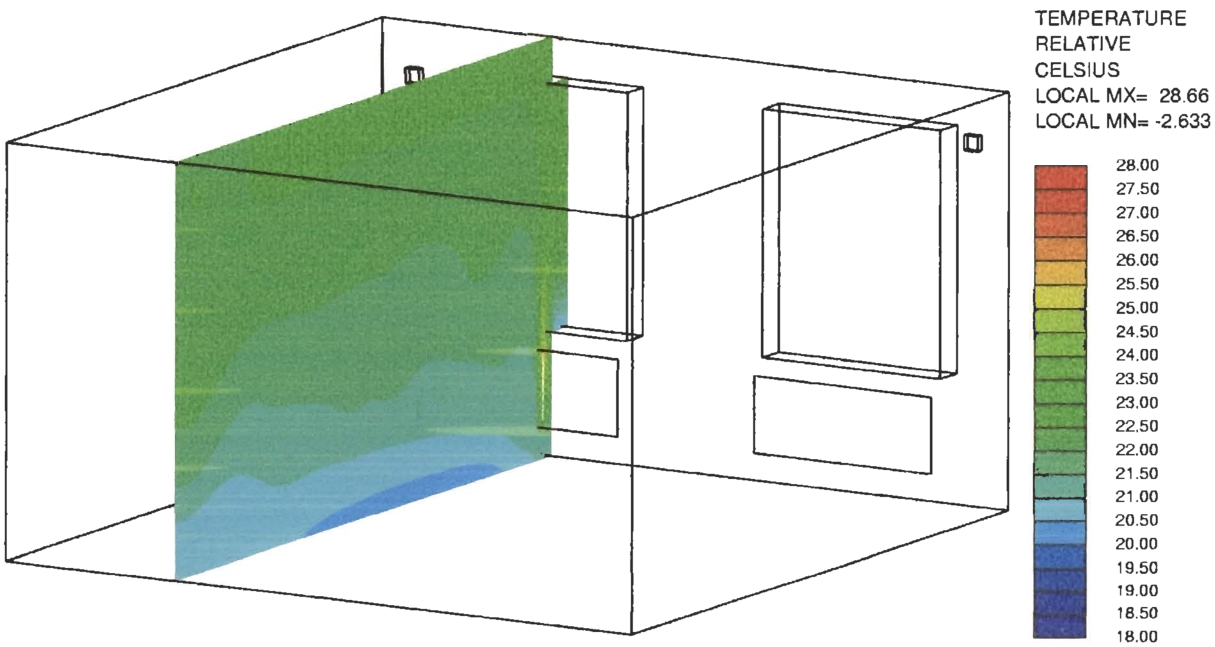

Figure 3 Air temperature

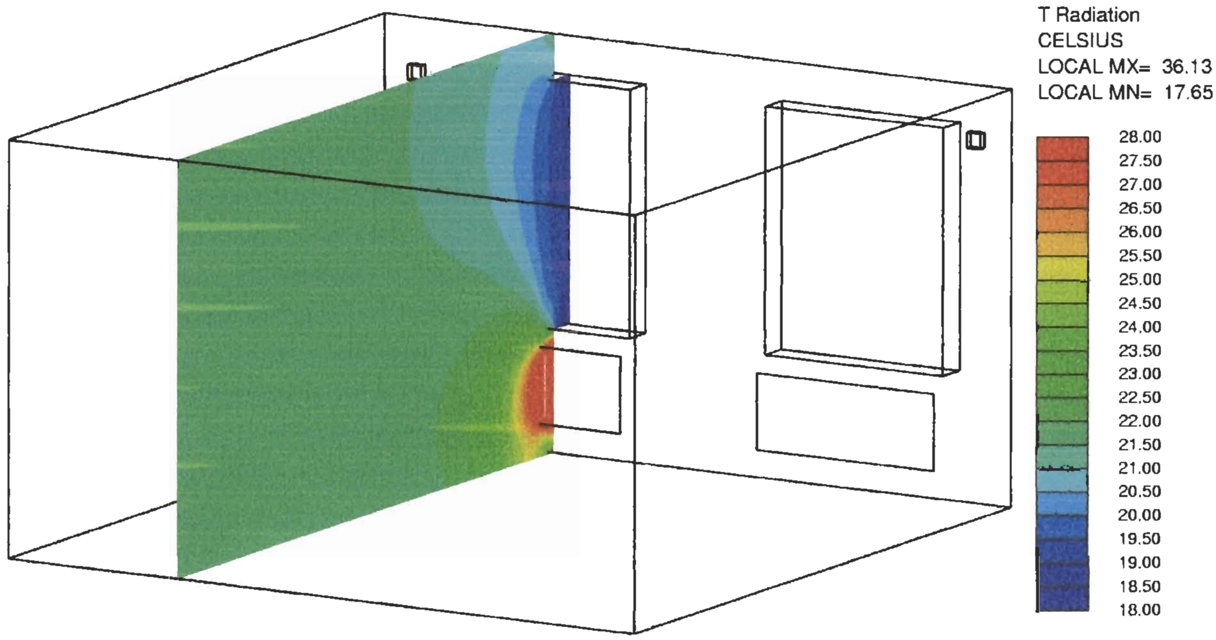

Figure 4 Radiation temperature

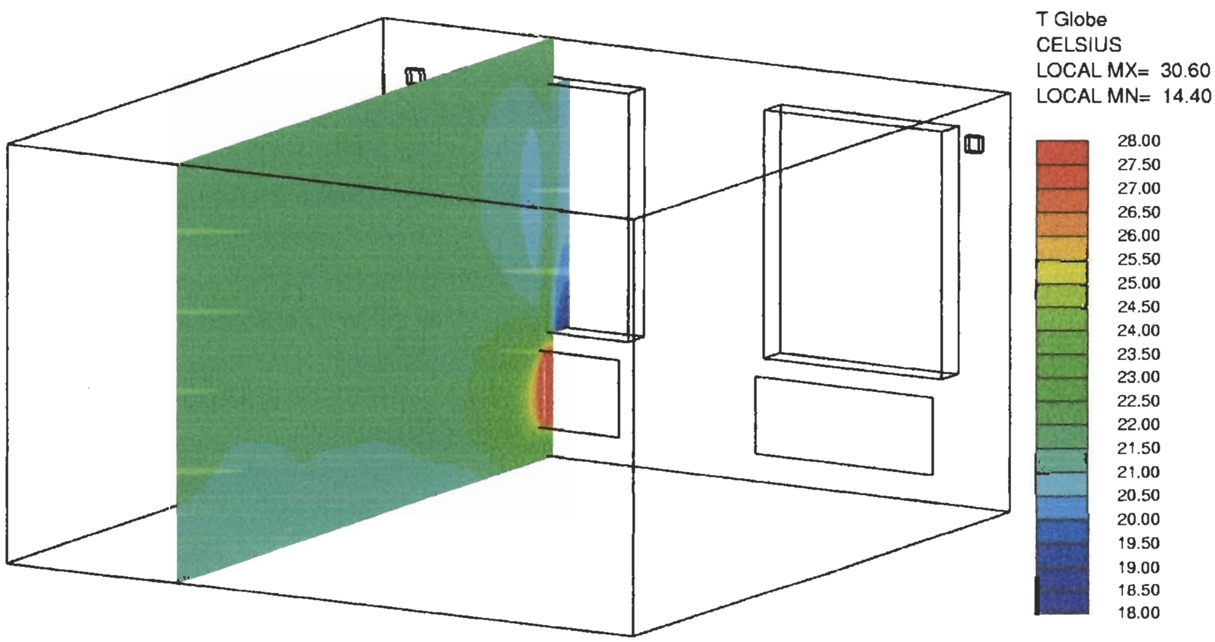

Figure 5 Globe (operative) temperature

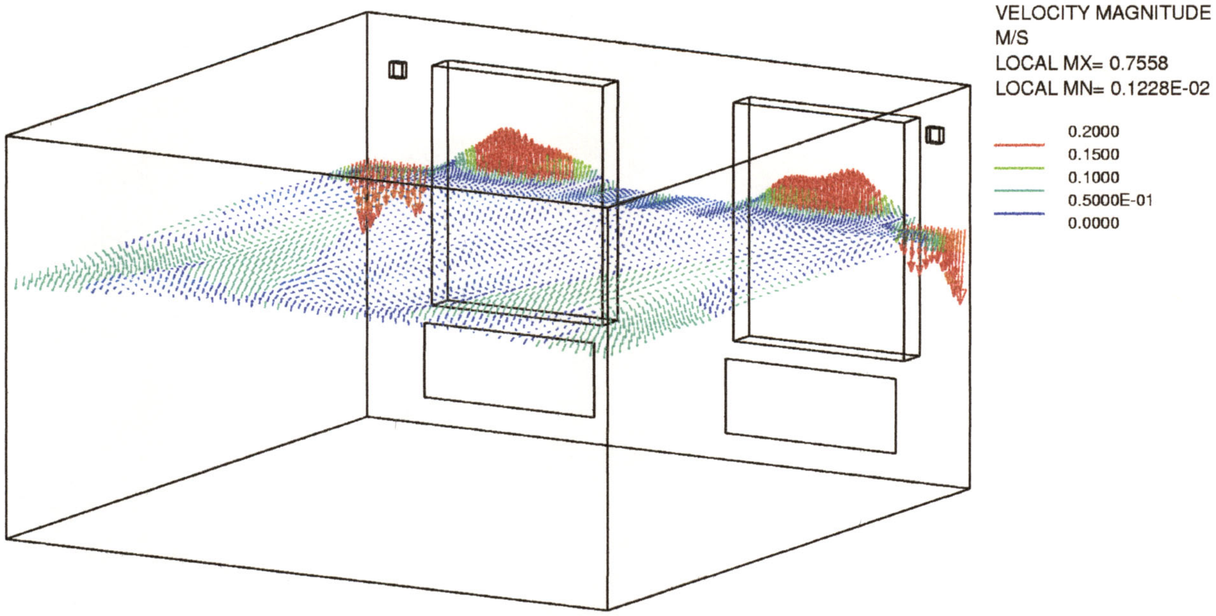

Figure 6 Air velocity

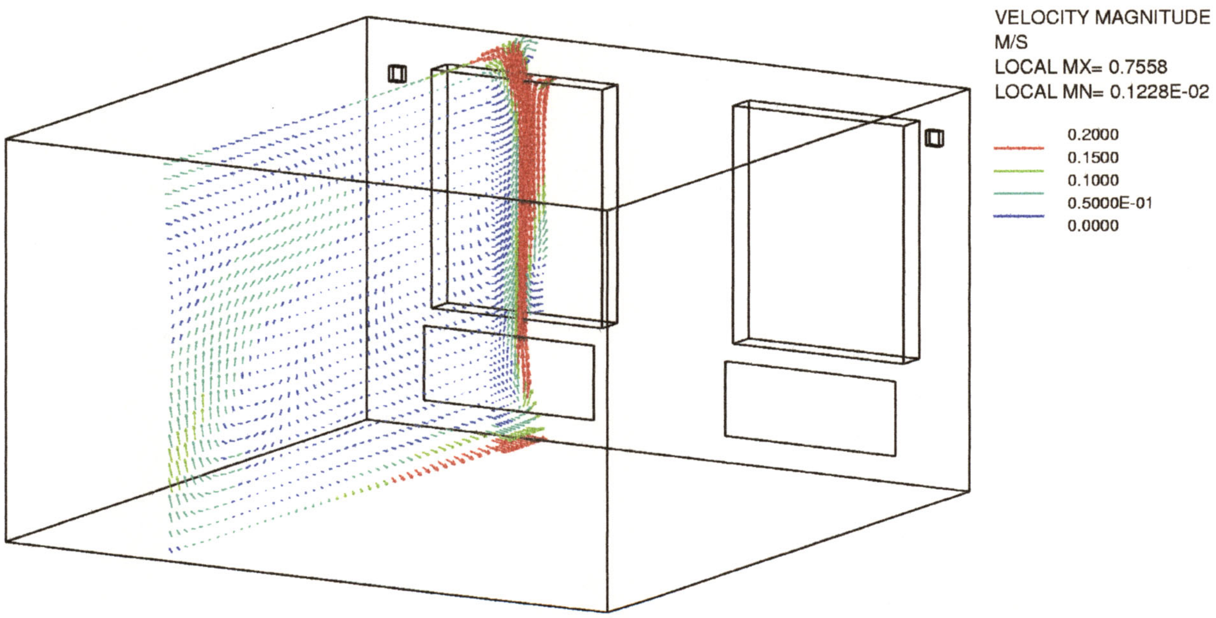

Figure 7 Air velocity

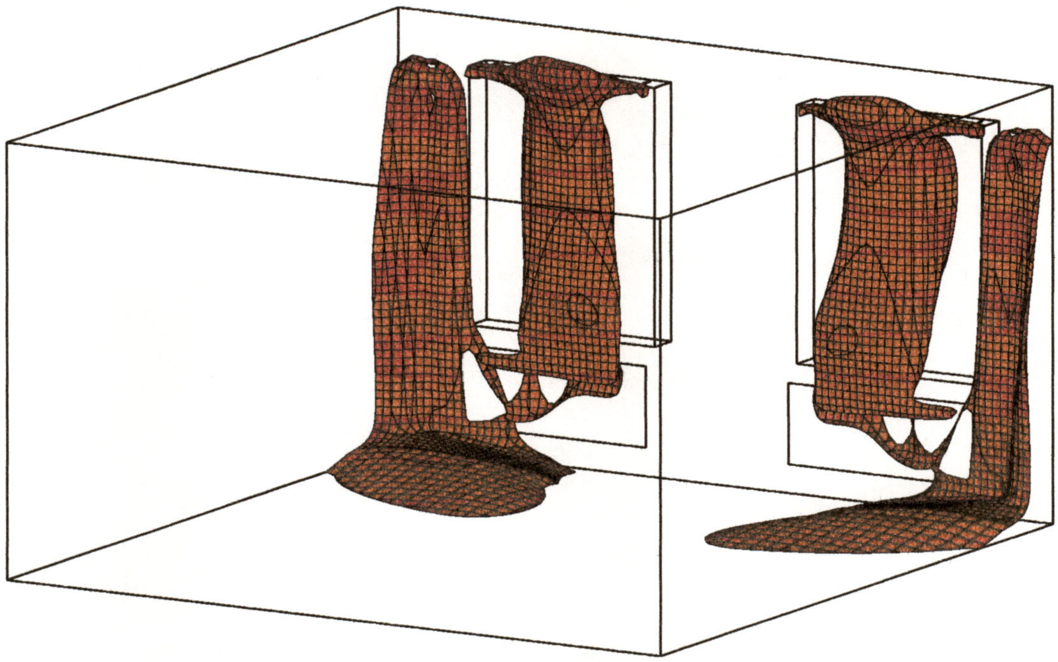

Figure 8 Isotach 0.2 m/s

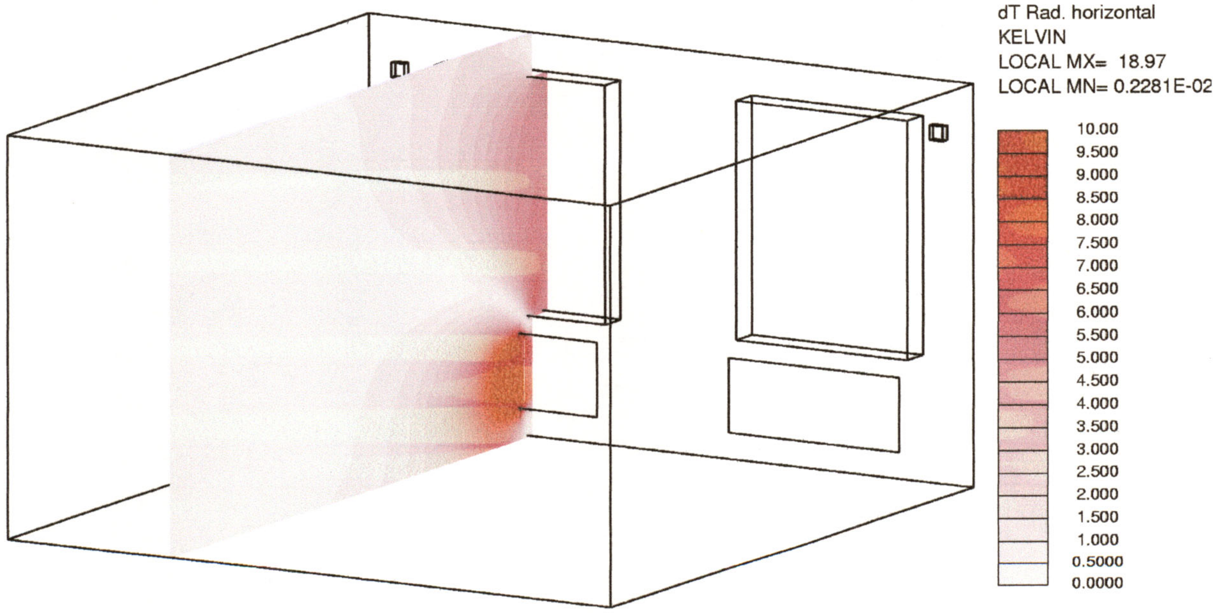

Figure 9 Horizontal radiation temperature asymmetry