TECHNISCHE UNIVERSITÄT DRESDEN

Fakultät Maschinenwesen Institut für Thermodynamik und Technische Gebäudeausrüstung
Professur für Heizungs- und Raumlufttechnik

Thermal comfort under summer conditions in consideration of several cooling methods for a room

- short report -

The research project was sponsored by Bundesamt für Bauwesen und Raumordnung (project id: Z 6 – 10.07.03 – 05.16 / II 13 – 80 01 05 - 16). The authors are responsible for the content of the report.

Project leader: Prof. Dr.-Ing. habil. W. Richter

Researchers: Dr.-Ing. R. Gritzki
Dipl.-Ing. M. Knorr
Dipl.-Ing. I. Müller
Dr.-Ing. A. Perschk
Dr.-Ing. M. Rösler

Dresden, June 2006

1 Objective of the research project

Technical equipment for cooling a room is installed to ensure the thermal comfort for residential and office buildings and comparable rooms as for residential and working purposes. Therefore it is not surprising that considerations about quantifying comfort criteria are very old. Many years the

operative temperature

was regarded as a sufficient measure. However, the influence of the indoor air flow is insufficiently taken into account. As recently as with the investigations by FANGER comprehensive calculation equations for evaluating the thermal comfort are available. Meanwhile, these equations are established in the relevant European standard

DIN EN 7730.

However for the user there is still a problem, because it is impossible to check the thermal comfort for the considered situation by means of usual planning tools, for instance in order to change building conditions or technical equipment. Especially the estimation of the resulting indoor air flow as main factor for the comfort criterion “draught risk” is restricted to be done by some scientific institutions or manufactures.

This unsatisfactory situation has not been improved in recent time. Is thermal comfort decreasing with increasing part of window area? Is there a “degree of freedom“ by selecting or positioning solar shading? These and other controversial questions require an explicit clarification, because thermal comfort under cooling conditions seem to become a crucial criterion for renting or for the sale of buildings.

2 Implementation of the research task

The investigation is carried out by using an established coupled simulation method taking into account

- indoor air flow,
- thermal behaviour of room enclosure and

- operating performance of the room cooling system.

By evaluating thermal comfort the specifications according to DIN EN 7730 are applied. According to this a graphical presentation of the results is carried out for the following criteria

- PMV (predicted mean vote),
- PPD (predicted percentage of dissatisfied),
- air temperature over height,
- radiation asymmetry,
- draught risk,
- surface temperature

and for additional data concerning air velocitiy profiles, operative temperature and a so called „Total thermal comfort“ criterion (an appropriate summary of all comfort criteria). Important parameters are constructive data as thermal mass, glazing area and solar shading as well as properties of the technical equipment like cooling method for the room.

3 Summary of results

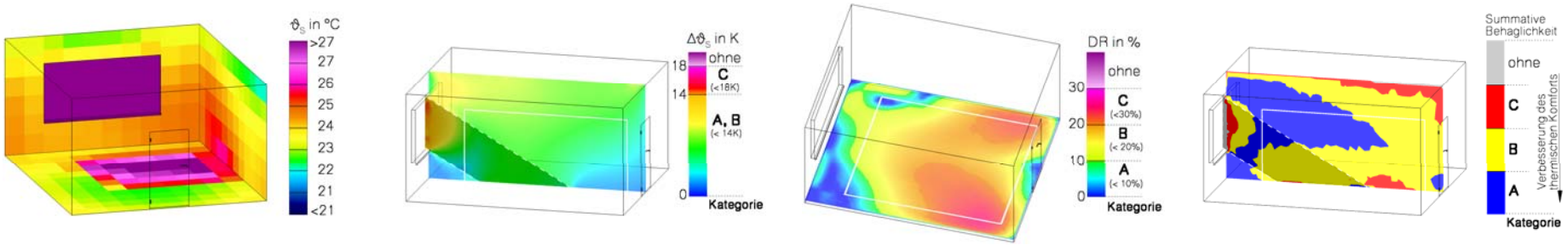
- Compared to the heating in winter time cooling in summer generally causes considerably more differences concerning thermal comfort.
- Therefore more building and technical measures must be undertaken to ensure thermal comfort in the occupied zone in a sufficient way.
- In addition, it can been seen that contrary to the heating season some global and local criteria (e. g. PMV and vertical temperature gradient) get more importance.
- Concerning the mainly investigated parameters of practical relevance
  - time of evaluation
  - thermal mass
  - solar shading
  - glazing area
  - cooling method

the solar shading is of prime importance from the building point of view. In case of sufficient solar shading the other parameters are of lower importance.

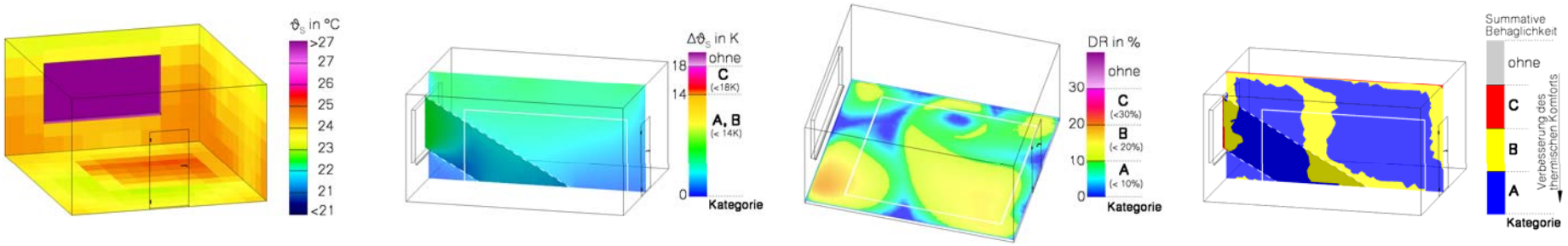
- There are of course substantial differences between the methods of room cooling. Concerning the investigated systems integrated in the building envelope (surface cooling) the cooling ceiling shows some advantages. By using a cooling floor good results are also achievable.

By this investigation results concerning thermal comfort under cooling conditions are available in very simple form and for practical use for the first time. Using these results within design and planning manuals the whole process of design and planning could reach a completely new quality.

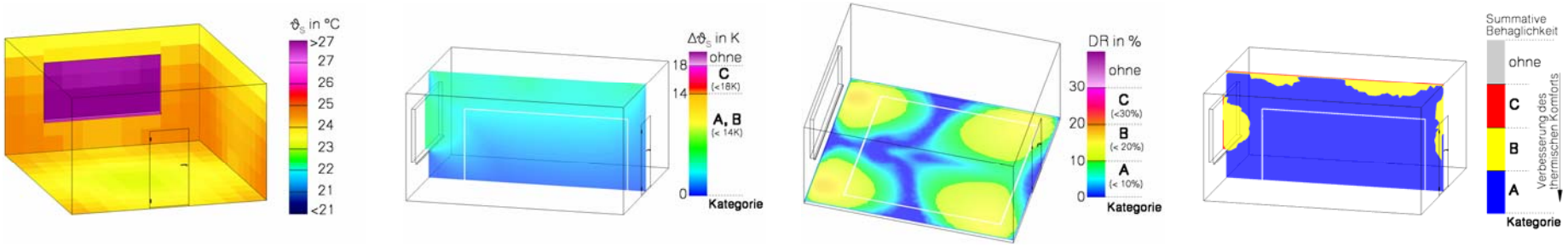
surface temperatures	max. radiation asymmetry	draught risk	total therm. comfort



without solar shading - FK 11 (16)



sun-blind - FK 10 (16)

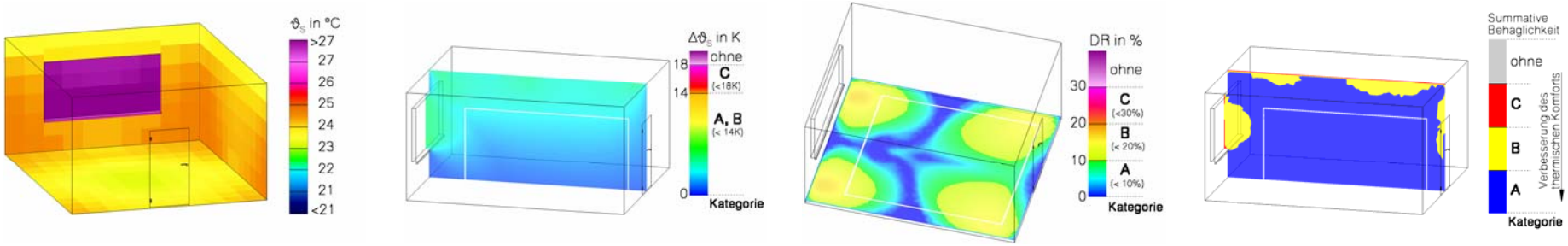


overhang (100%) - FK 9 (16)

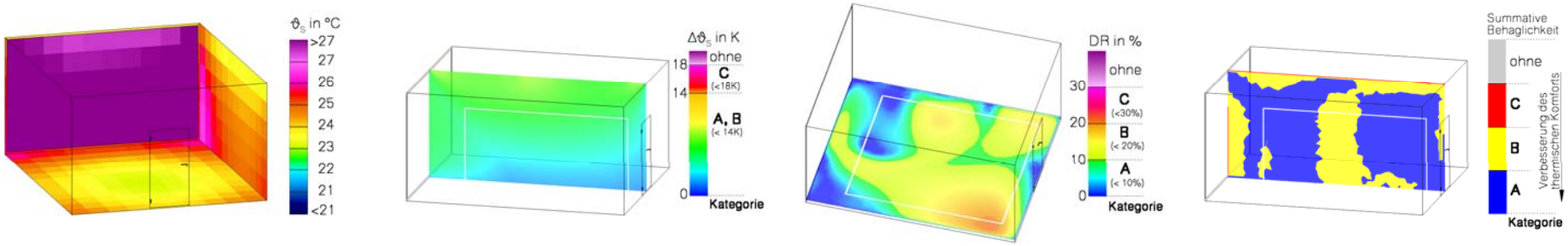
influence of solar shading

- cooling ceiling; 30% glazing area; lightweight construction; time of evaluation 4.00 p.m. -

surface temperatures	max. radiation asymmetry	draught risk	total therm. comfort



30% glazing area - FK 9 (16)

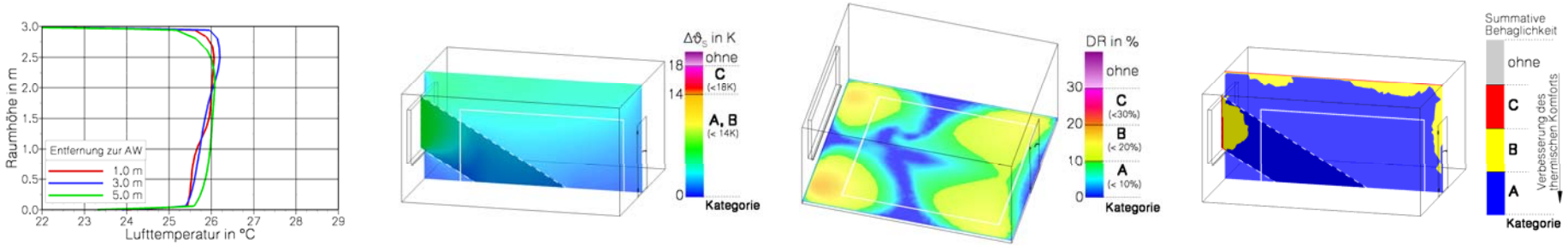


100% glazing area - FK 33 (16)

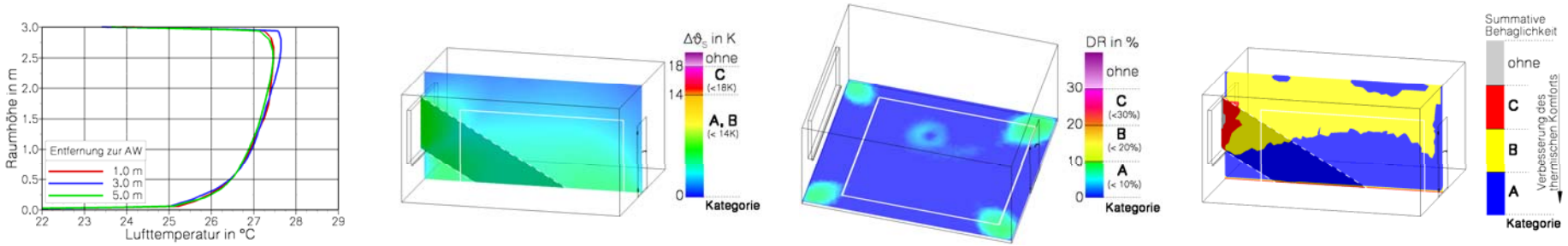
influence of glazing area

- cooling ceiling; lightweight construction; overhang (100%); time of evaluation 4.00 p.m. -

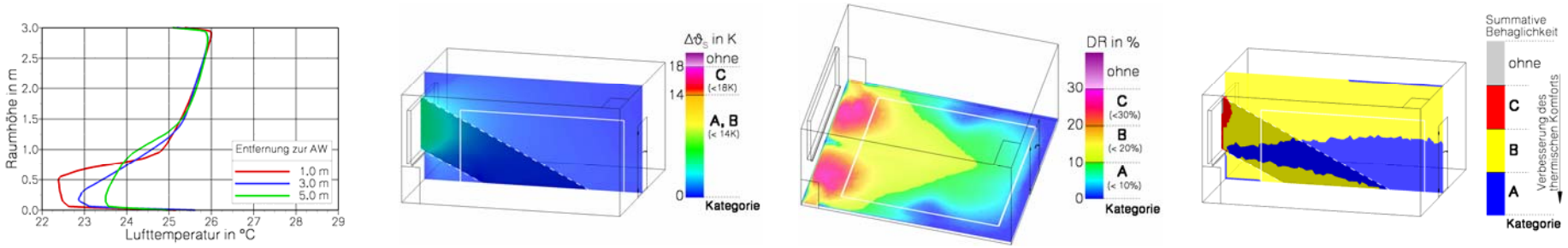
profiles of air temperature	max. radiation asymmetry	draught risk	total therm. comfort



cooling ceiling - FK 3 (16)



cooling floor - FK 22 (16)



displacement ventilation - LK 11 (16)

influence of cooling method

- middle-heavy weight construction; 30% glazing area; sun-blind; time of evaluation 4.00 p.m. -