UCaHS - Urban Climate and Heat Stress in mid-latitude cities in view of climate change

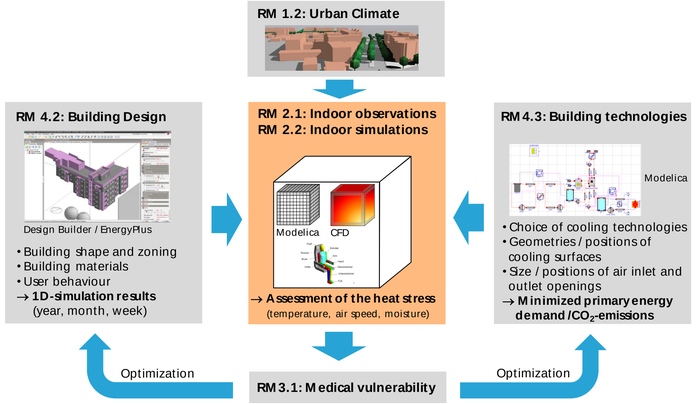
Research questions

A differentiated assessment of the heat stress risk in indoor environments needs different spatially resolved thermal room models in combination with suitable segmented physiological models of the human body and psychological voting models for the thermal comfort and heat stress. These three sub-models will be integrated in RM 2.2 into a common **I**ndoor **C**limate **S**ystem **M**odel (ICSM). Based on the ICSM, following research questions shall be answered:

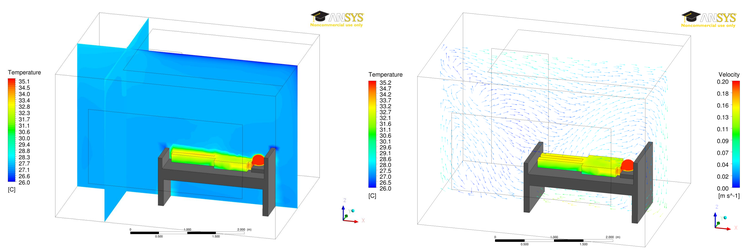
- How far measured indoor heat stress events can be reproduced with a ICSM or can be predict for future scenarios of a modified urban climate ?
- How much the assessment of heat stress events by a high detailed ICSM differs from the assessment by a simplified ICSM?
- Which time periods of transient heat stress scenarios can be simulated with the help of a simplified ICSM with a reasonable calculation effort ?
- Which reduction of the heat stress in inner spaces can be proved by a ICSM under inclusion of an appropriate architectural design, an improved building construction and an energy efficient building technology ?

Research approach

The ICSM shall form the evaluation basis for room configurations, which use the optimization potential of a suitable architectural design (RM 4.2) and air conditioning technologies (RM 4.3) under consideration of the urban climate (RM 1.2) for a significant reduction of the heat stress risk.

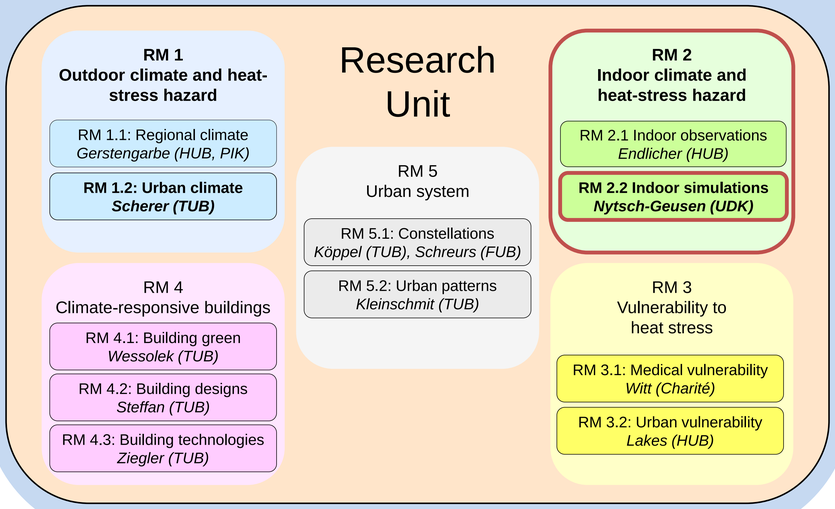


One important subproject, together with the Humboldt University Berlin, will be the common experimental and simulation-based analysis of the heat risk within hospitals, which consists in a systematical comparison of air-conditioned and not air-conditioned patient rooms of the University clinic Charité:



Temperature and velocity distribution around a patient bed within an air-conditioned room with a cooling ceiling during a hot outside climate situation, calculated by a steady-state CFD model

Sub-project 2.2
Indoor simulations

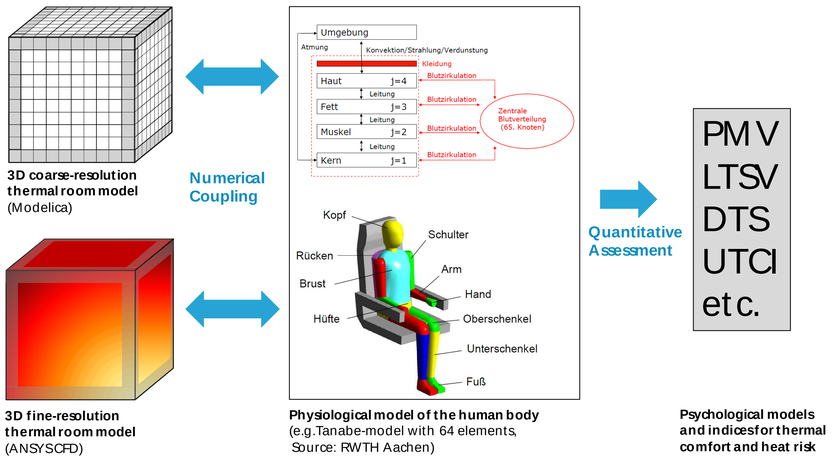


- **Simplified model for long time periods**: A strong simplified three-dimensional thermal room model (1,000 to 100,000 balance elements), based on the modeling language Modelica, should be developed and integrated with a segmented physiological model of the human body (up to 64 balance elements) and a psychological voting model for the heat stress to the numerically fast **ICSM_coarse**. This system model can calculate transient heat stress scenarios of the indoor climate, even over several days up to two weeks.

- **Complex model for short time periods**: A high-resolution three-dimensional CFD model of the indoor air and a finite volume model of the building construction (up to several million balance elements) is combined with a similar human body model and voting model to the detailed, but numerically expensive **ICSM_fine.** The ICSM_fine shall be used for in-depth analysis of steady state or transient short-time heat stress scenarios of the indoor climate.

Methodology

Two three-dimensional thermal room modeling approaches should be pursued, which differ greatly in the spatial resolution and the performance during the simulation experiment :



Work schedule

Table 3.1: *Work packages (WP) and associated work schedule (in half-yearly intervals).*

WP	Description	Work schedule
100	**Project management**	
110	Reporting	
120	Logistics and organisation	
200	**Individual research**	
210	Development of a high-resolution CFD room model	
220	Development of a coarse-resolution Modelica room model	
230	Development of a physiological human body model and psycho-logical assessment models for thermal comfort and heat stress	
240	Integration of the room models with the human body and assessment models to two indoor climate system models (ICSM_fine and ICSM_coarse)	
250	Validation of the ICSMs with benchmarks and measurement data from external project partners	
300	**Collaboration within the Research Module (RM)**	
310	Validation of the ICSMs, based on indoor observations	
400	**Collaboration within Research Links (RL)**	
430	Simulation-based design for rooms and buildings for reducing heat-stress risks	
440	Prospective active A/C-solutions and building design	
500	**Collaboration within Research Clusters (RC)**	
510	From regional weather and climate to indoor climates	
520	Present-day heat-stress hazards, vulnerabilities and risks	
530	Effectiveness of actions for reducing heat-stress risks	
540	Efficiency of actions for reducing heat-stress risks	
600	**Collaboration within the Research Unit (RU)**	
610	Projected heat-stress hazards, vulnerabilities and risks	
620	Transferability of the methodology to other mid-latitude cities	
630	Identification of future research and development activities	
640	Preparation of the follow-up proposal	

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