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

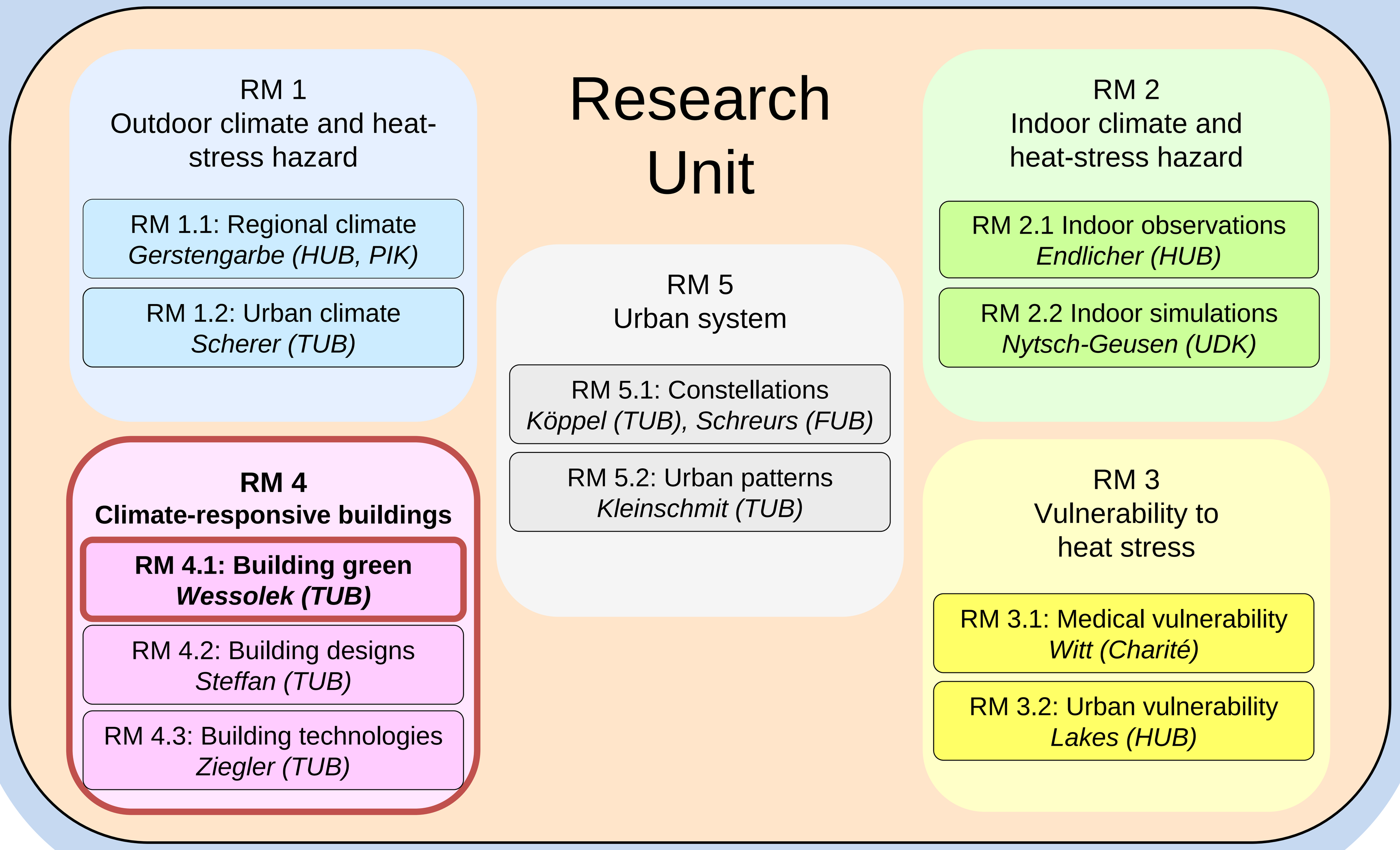
Research questions

The role of horizontal paved urban surfaces for HS mitigation (1st phase)
Lack of basic knowledge and process based models for evaporation and runoff prediction
(h1) What controls actual evaporation and cooling potential of paved urban soils?
(h2) How important is the lateral heat impact (advection) on evaporation?
(h3) Is it possible to adapted the pavement design to mitigate UHI?

The role of vertical green for HS mitigation (1st and 2nd phase)
Lack of basic knowledge on evapotranspiration of vertical green (=facade green) and the impact of "building factors" such as water supply, shading, wind, building temperature, light etc.
(v1) What controls the actual and potential evapotranspiration from vertical green?
(v2) Can the ET_{act}(vertical) be expressed following the Penman-Monteith approach?
(v3) What are the potentials of vertical green to mitigate UHI?

Synthesis
(s1) Process based model on water fluxes allowing quantification of E_{act}, run-off and percolation rate in high temporal resolution for pavements
(s2) Process based model on evapotranspiration (=cooling) and water demand for vertical green
(s3) Deriving mitigation strategies using runoff water from pavements for vertical facade green

Sub-project 4.1
Building green



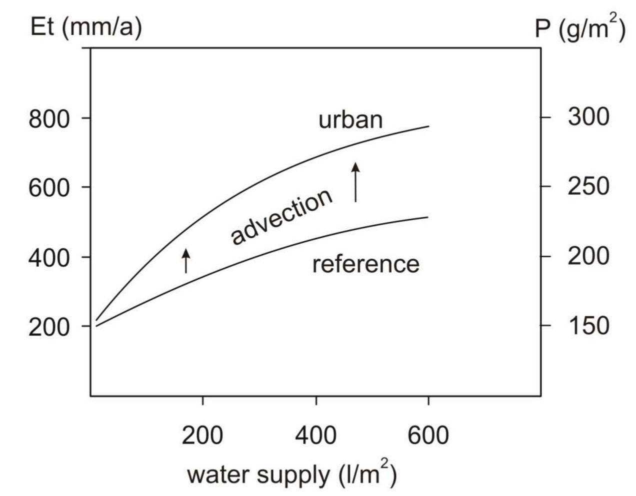
Research approach

Horizontal paved urban surfaces
- high resolution lysimeter studies at two sites: suburb in Berlin-Marienfelde (=reference site) and an inner-city climate situation highly influenced by buildings and soil sealing

Hypothesis: "urban influence" can be reduced to energy import by advection

Vertical green urban surfaces
- modeling evapotranspiration rates as a function of water supply, urban matrix, and plant structure [LAI = f(t)]
- measuring plant water uptake and biomass production

Hypothesis: ET_{act} of vertical green can be calculated using a modified Penman Monteith using a new function expressing influence of advection, water supply and plant parameter



$$\frac{Eact_{urb}}{Epot_{urb}} \approx \frac{Pact_{urb}}{Ppot_{urb}}$$

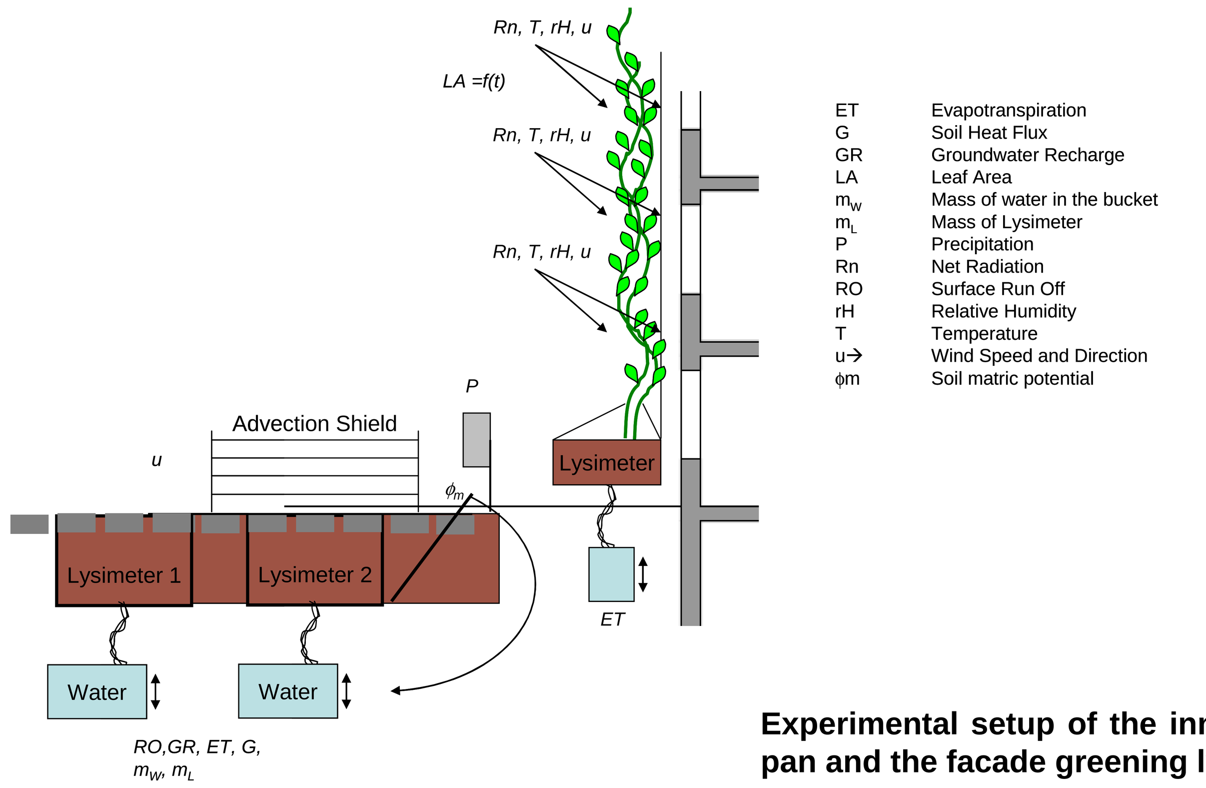
Hypothetical actual evapotranspiration rate and photosynthesis of a façade greenery under urban climate and reference climate conditions with varying water supply

Methodology

Horizontal paved urban surfaces

- high resolution lysimeter studies at two sites: suburb Berlin-Marienfelde (=reference site) and a typical inner-city climate situation heavily influenced by buildings and soil sealing

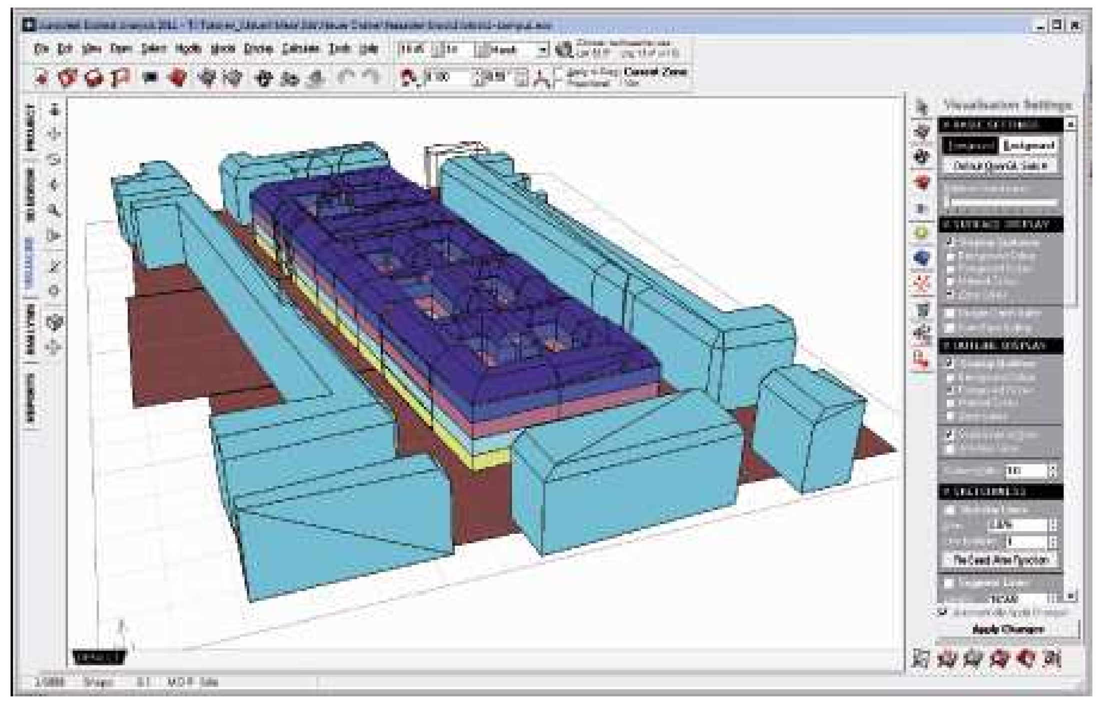
- upgrading existing lysimeters and construction of lysimeter pans for inner city sites
- coupling evaporation measurements with IR imaging



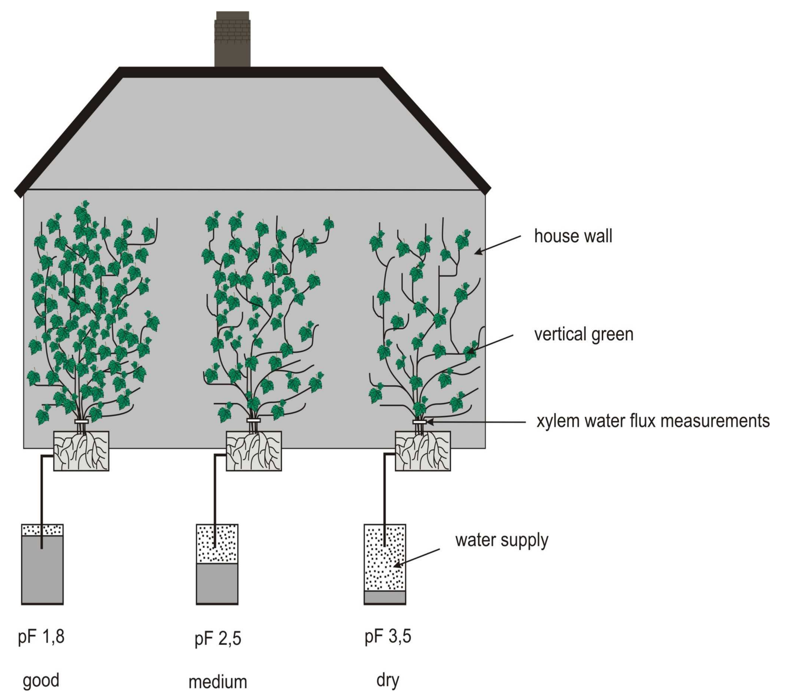
Experimental setup of the inner city lysimeter pan and the facade greening lysimeter

Vertical green

- high resolution monitoring of transpiration of facade greening using lysimeters
- monitoring LAI using time lapse photography (over six years)
- measuring LAI and biomass production in different heights at different times for calibration of LAI photography
- xylem flux and corresponding vertical climate measurements



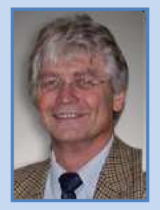
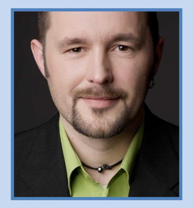
Extraction of urban factors from 3D city models: extracting net radiation as a function from height.



Setup to measure E_{pot}, E_{act}, P_{pot}, and P_{act} and xylem flux for controlled water supply conditions.

Work schedule

WP	Description	Work schedule
100	**Project management**	
110	Reporting	
120	Logistics and organisation	
200	**Individual research**	
210	**Measuring evaporation and transpiration**	
211	Measurements and experiments at a reference site in Berlin-Marienfelde using existing lysimeter technique and a new setup for façade green as shown schematically in Fig. 3.2	
212	Setup of paved lysimeters inside the city, measurements as shown schematically in Fig. 3.4	
213	Facade greening lysimeters with various water supply, setup, measurements as shown in Fig. 3.4	
220	**Model build up and validation**	
221	Deriving a model for ETa_{paved} using meteorological data Calculation of various scenarios with and without advection	
222	Up scaling the model to deriving a model $ET0_{urban}$ = f (ET0)	
223	Testing both models for other climate and site conditions, integration of literature data into the $ET0_{urban}$ concept	
230	**Modelling influence of facade greening on cooling**	
231	First simulations, scenarios, synthesis	
300	**Collaboration within the Research Module (RM)**	
310	Building energy simulations with and without vertical green	
311	We are measuring data for delivering boundary conditions for RM 4.2 and RM 4.3	
400	**Collaboration within Research Links (RL)**	
410	Atmospheric processes, urban/building green and pavements	
411	Vertical green plant parameter such as leaf area index, active leaves area and stomata resistances for various water supply conditions.	
412	Comparison between predicted (micro scale atmospheric model) and experimental data	
500	**Collaboration within Research Clusters (RC)**	
510	From regional weather and climate to indoor climates	
511	Analysing effects of urban and rural climate data on prediction actual evapotranspiration for various water supply conditions	
530	Effectiveness of actions for reducing heat-stress risks	
531	Analysing effectiveness of using vertical green for reducing heat stress	
540	Efficiency of actions for reducing heat-stress risks	
541	Cost benefit analysis of vertical greening	
600	**Collaboration within the research unit**	
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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