COMFORT – Data-Driven Analysis and Simulations of Human Comfort in Office Rooms

G. Feichtinger, H. Gursch, E. Schlager, D. Brandl, M. Gratzl

Symposium Energieinnovation, 13.2.2020

Consortium

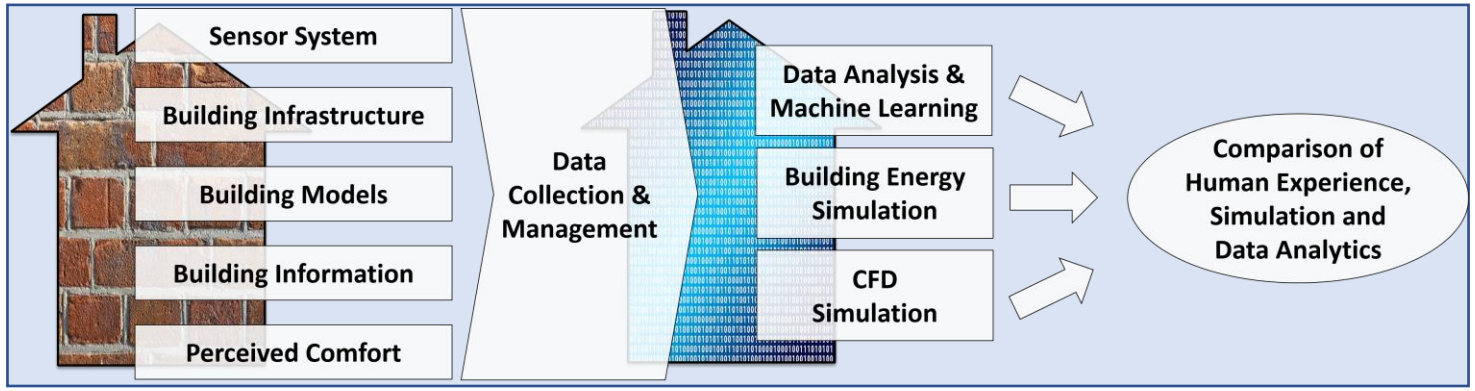
Associate Partner

Funding

Agenda

- Project Scope
- Data Management
- Modeling Approach
- (Main) Results
- Outlook

Project „COMFORT“ – Facts

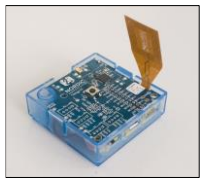


- Understand, predict and simulate perceived human comfort with operational constraints
  - Develop a wireless measurement system
  - Apply coupled data analysis and building simulation approaches

- 8 partners, run time 10/2018 – 03/2021, budget approx. €1mio.

Data Management

- Main challenges
  - Sensor vs. meta data
  - Heterogeneous data sources (protocols, formats)
- WebService for all partners
  - Download „pre-processed“ data sets
- „Integration“ of *FEELings*

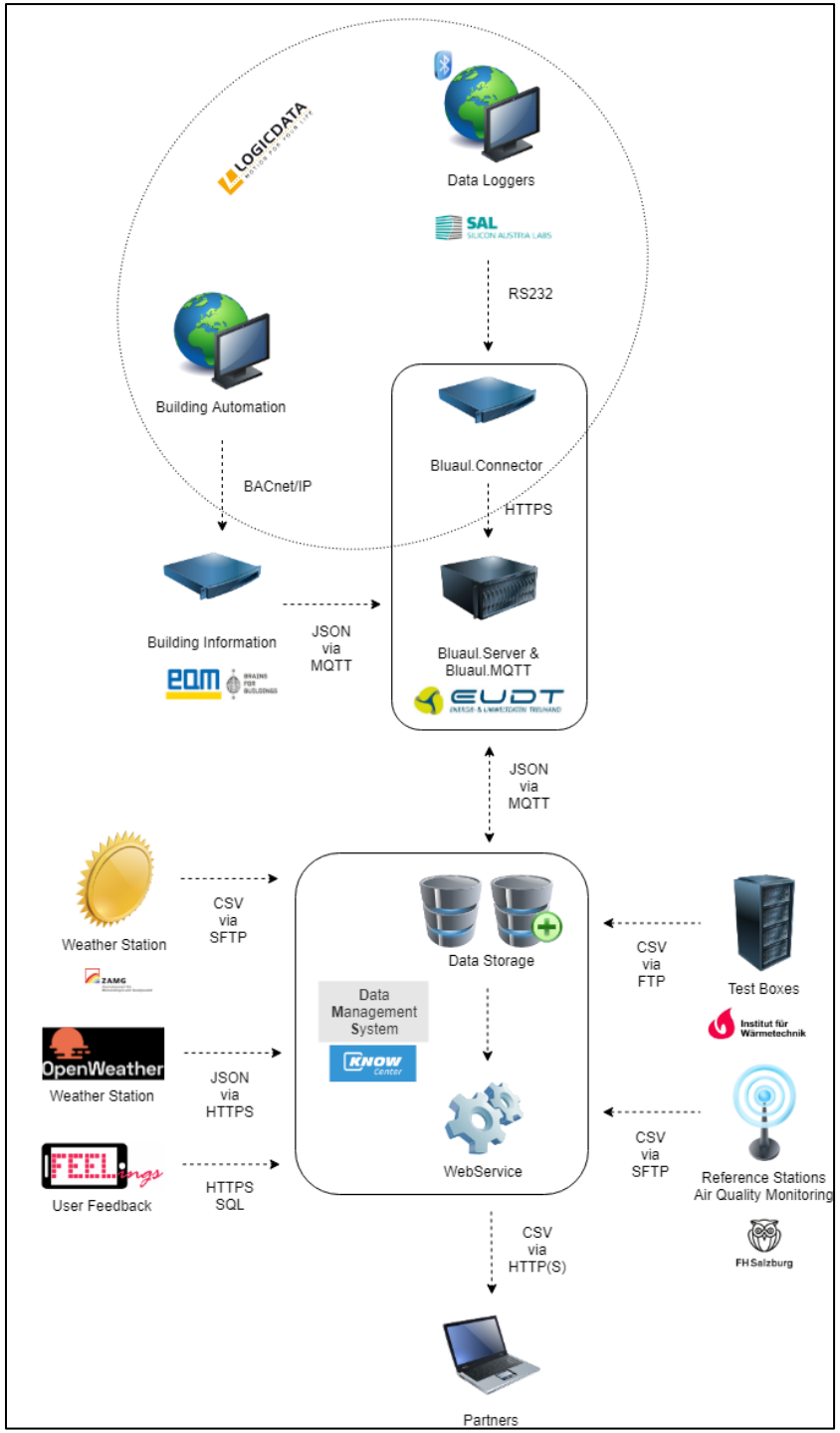

Data Logger
[Source: Know-Center / SAL]


Building Automation
[Source: EAM Systems]


Reference Station
[Source: FH Salzburg]


Test Box
[Source: TUG-IWT]


Weather Station
[Source: ZAMG]



Solar Radiation

- Solar radiation has significant impact on simulation models
  - i.e. to quantify heat gains via windows (absorption/reflection)
  - Distinction between „direct“ and „diffuse“ radiation required

- Problem
  - Only global radiation available for Deutschlandsberg (@LogicData)
  - Measuring direct/diffuse radiation is costly (special instruments, i.e. Graz)

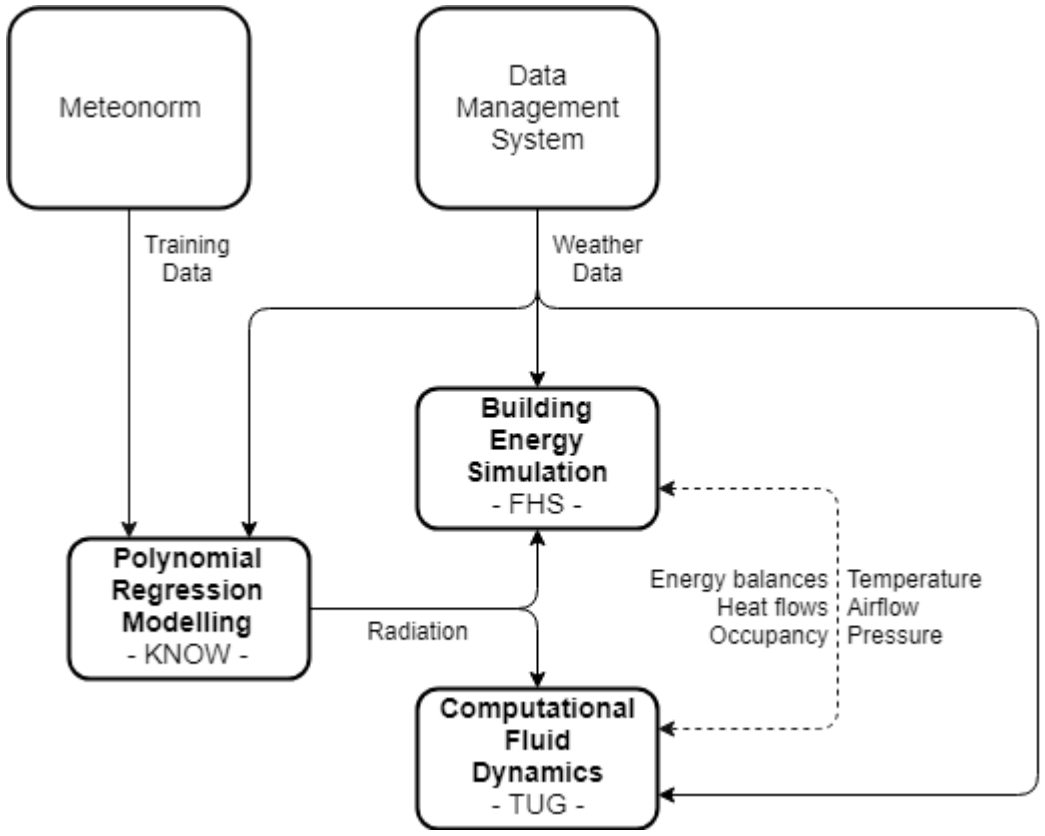
- Task
  - Find appropriate estimation approaches based on available weather data

Weather Data

COMFORT

- Which parameters to consider?
  - Global radiation, cloudiness, precipitation (rain, snow), sunshine, temperature, sea level pressure, sun altitude, time of the year, air pollution, location, …
- Restriction via available data sources (for Deutschlandsberg)
  - ZAMG (i.e. global radiation, precipitation, temperature, air pressure)
  - OpenWeatherMaps (i.e. cloudiness, precipitation)
  - Computable from data (i.e. sun altitude using location and time)

Modeling Approach

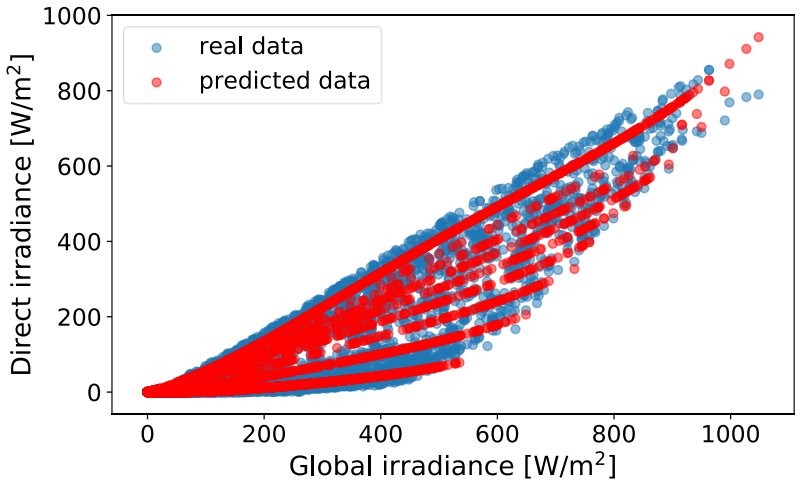


Estimation Approach

- (Virtual) Training data set
  - Meteonorm (global/direct/diffuse radiation, cloudiness, temperature, sunshine) for Deutschlandsberg
  - 5 years for training and 1 year for testing, hourly based

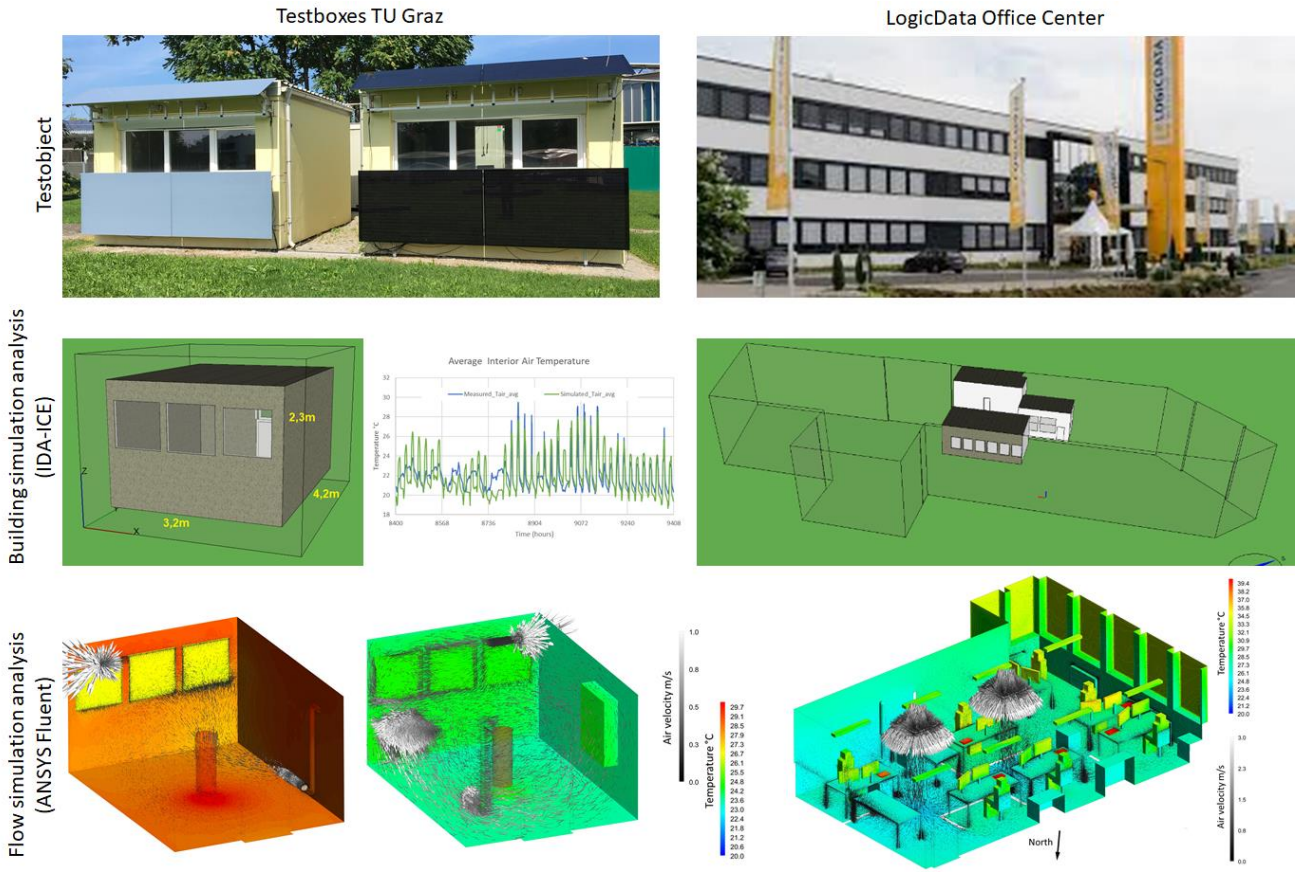
- Polynomial regression of degree *n* (= 3, 4)
  - Direct radiation as dependent variable
  - Global radiation, cloudiness, season (wi/su solstice, sp/fa equinox) as features

$$R_{dir} = \sum_{i_1=0}^{n} \sum_{i_2=0}^{n-1} \dots \sum_{i_k=0}^{n-i_{k-1}} \alpha_{i_{1,\dots},i_k} \prod_{i=1}^{k} x_i^{i_k}$$



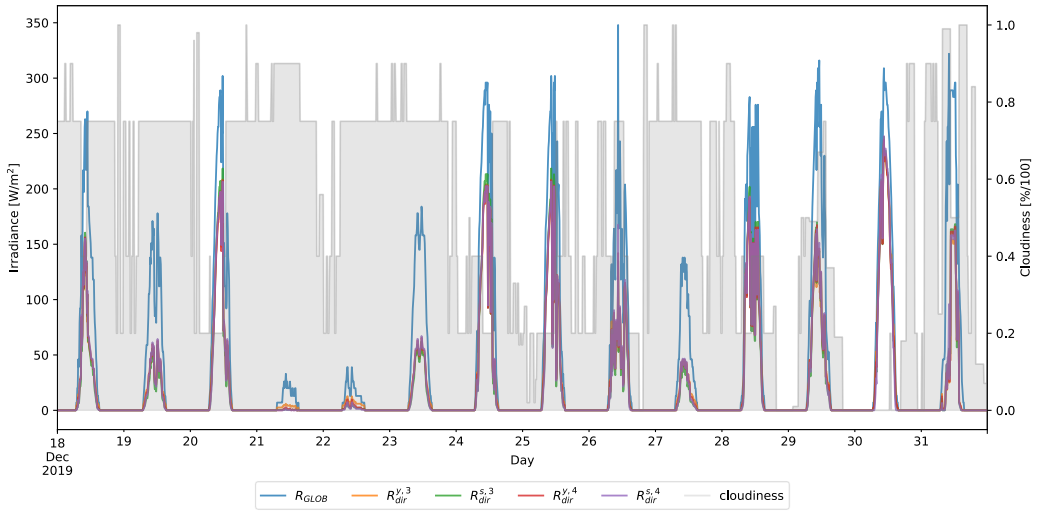
Building Simulation Models

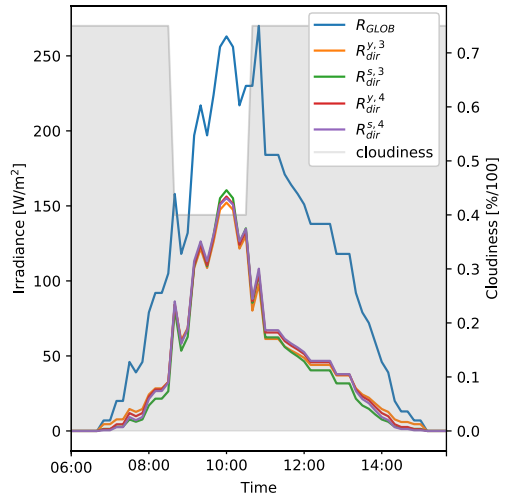
- Building Energy Simulation
  - Average thermal comfort in zones (i.e. offices)
  - Fast and time-efficient
- CFD simulation
  - Detection of local discomfort (i.e. hot/cold spots)
  - Simulations in real time
  - Calibration via *Test Boxes*

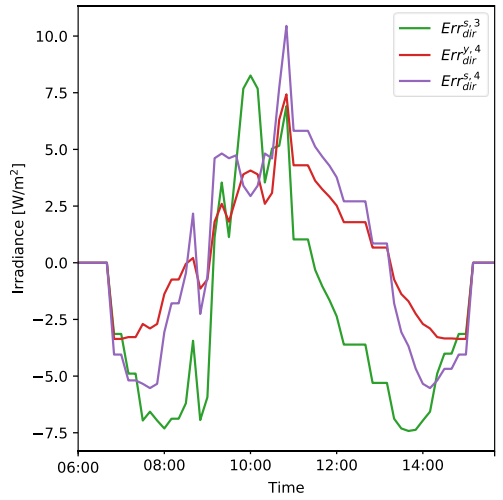


Results: Estimation

- Test/Calibration period
  - 18.12.-31.12.2019
  - Based on real weather information
- Several estimators to be validated
  - Polynomials of 3rd and 4th degree
  - Seasonal effects (winter solstice)
- Different approaches vary in performance dependent on error measurement (R^2, MSE, MBE, …)

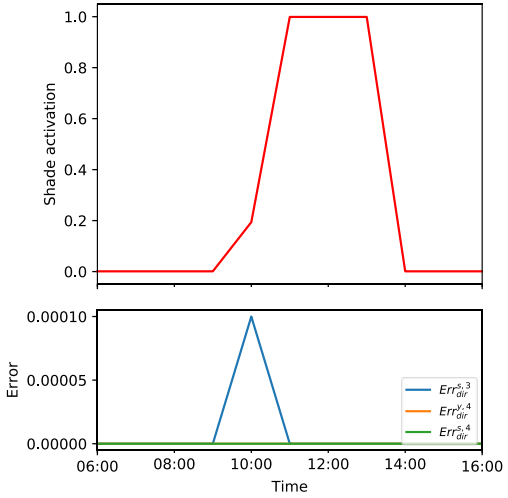


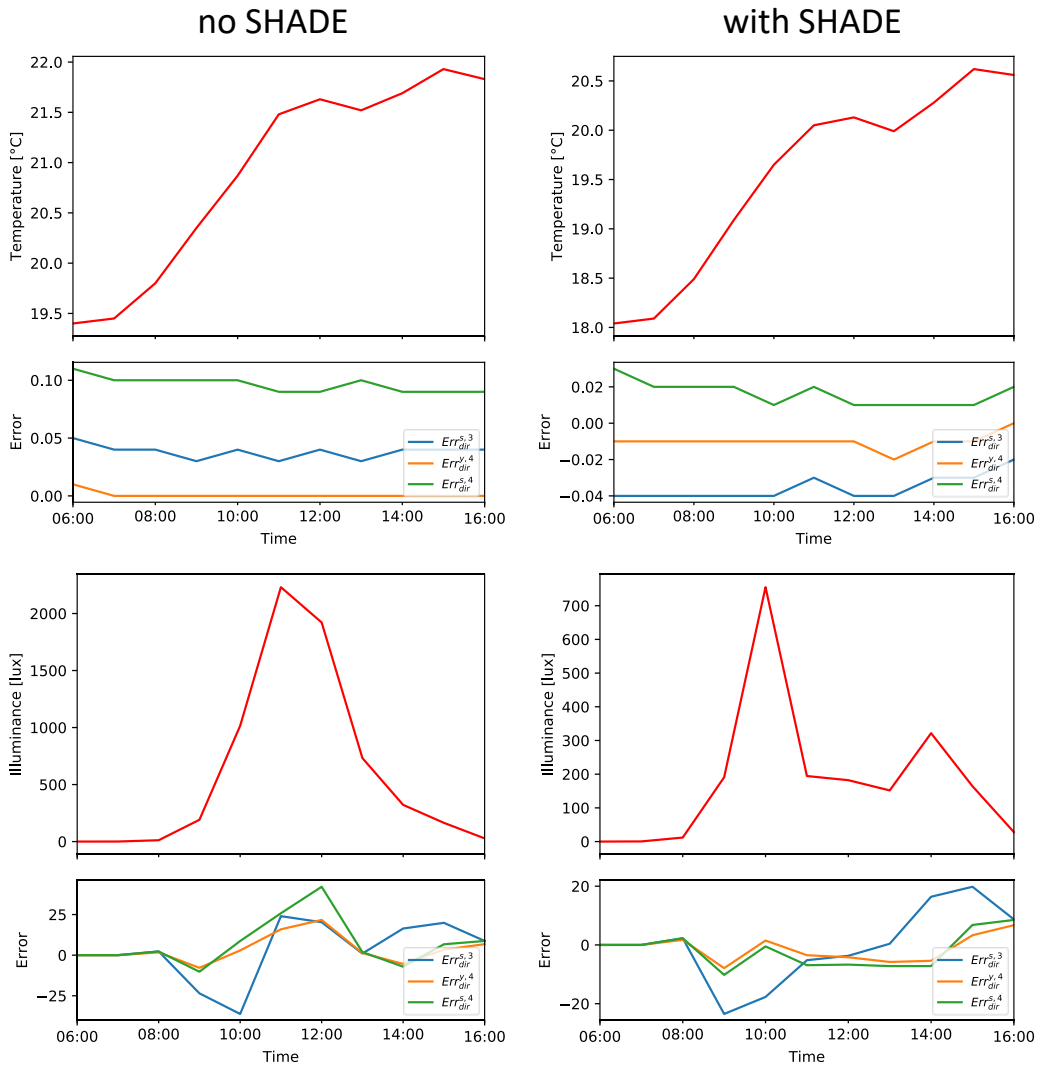




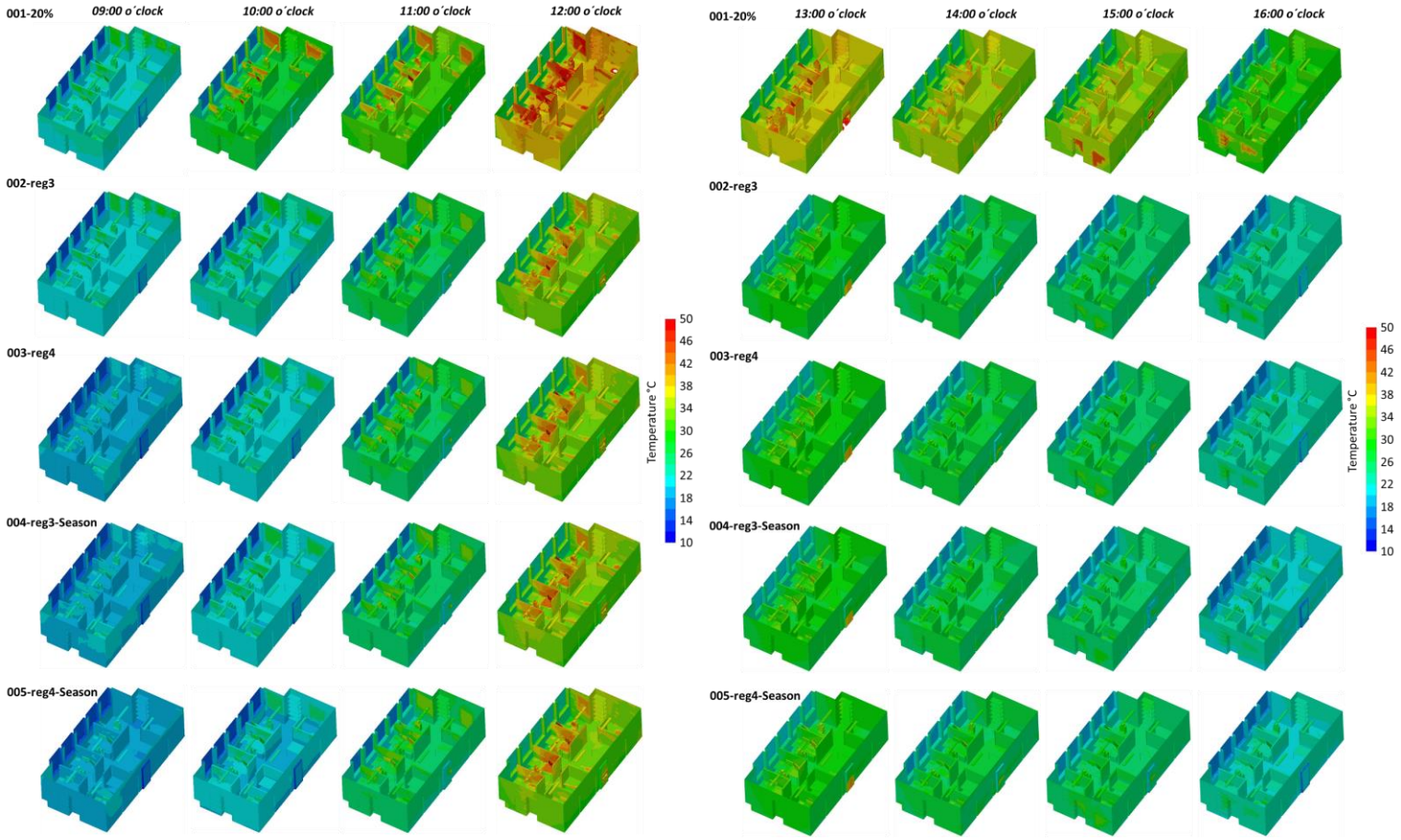
Results: Building Simulation

- Differences in estimators with minor impacts
- Effects due to shade activation



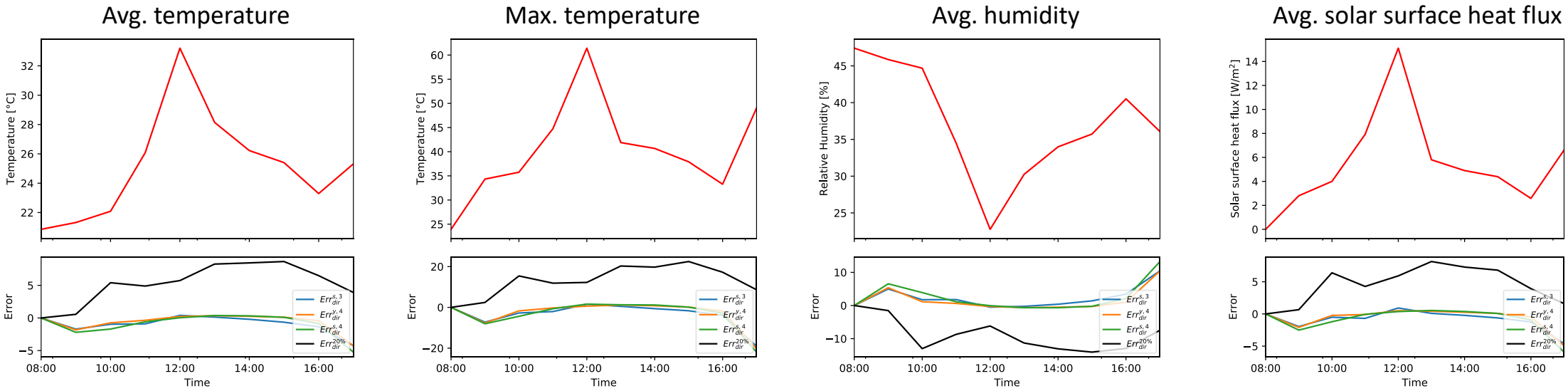


Results: CFD Simulation (I)



Results: CFD Simulation (II)

- Differences in estimators with minor impacts
- Assumption of 20% diffuse radiation might be misleading
- Hot spots (max. temperature of 60°C)



Outlook

COMFORT

- Improvement of estimation approaches
  - New features to be included/tested (i.e. clearness index, sun altitude, etc.)
  - Residual analysis
  - Validation
- Finalisation of (simulation) model coupling
- Other goals
  - Develop „Machine Learning“ based approaches to estimate comfort
  - Final development of the (wireless) measuring plattform