Webinar

How to determine the real performances of buildings?

Building characterisation by co-heating

January 22, 2014

State-of-the-art on the co-heating test methodology

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1

Introduction

Energy performance of buildings: predicted vs actual

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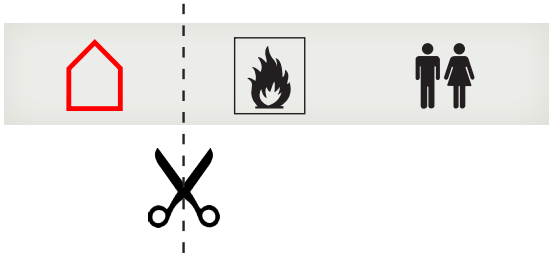
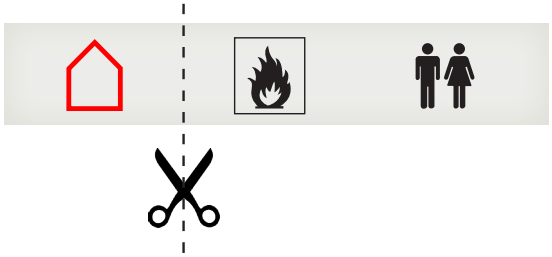


thermal performance characterisation building fabric

Energy performance of buildings: predicted vs actual



thermal performance characterisation building fabric

co-heating test

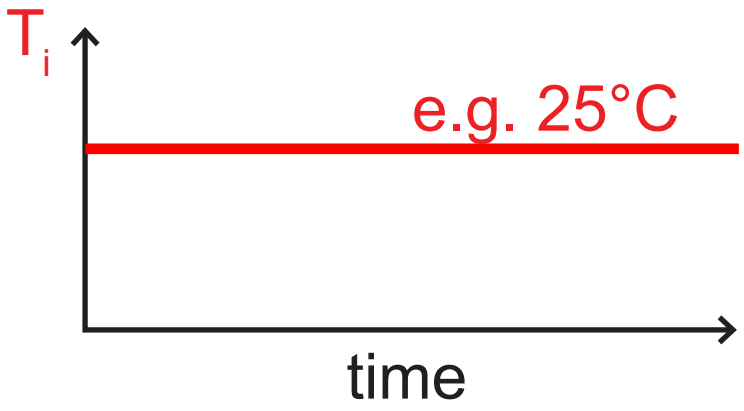

heaters
thermostat
heaters


ventilators
heaters
thermostat
heaters
ventilators


sensors
ventilators
thermostat
heaters
heaters
ventilators
sensors

Co-heating test

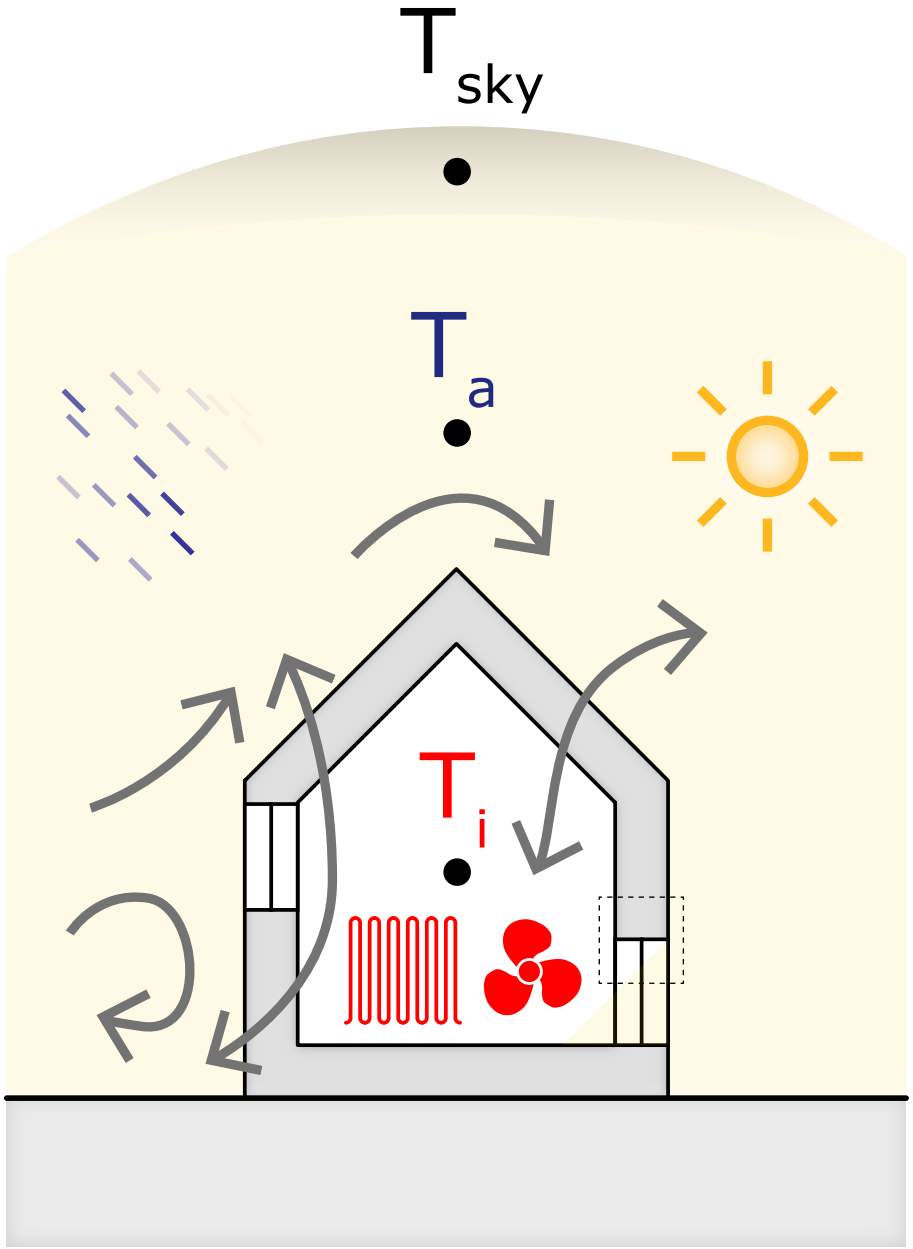
quasi-stationary test



monitored throughout test:

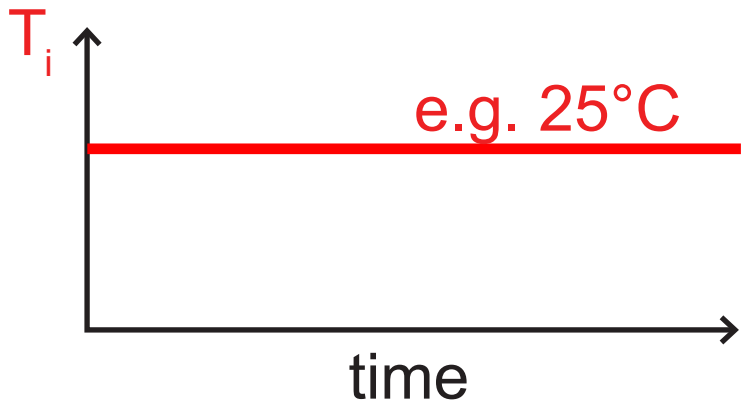
$T_i - T_a$

aggregated data (e.g. daily)



Co-heating test

quasi-stationary test



monitored throughout test:

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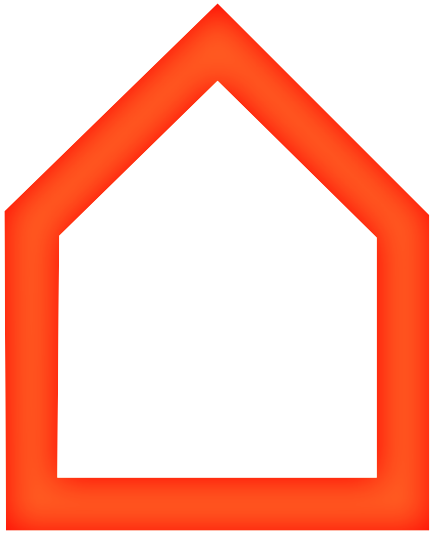
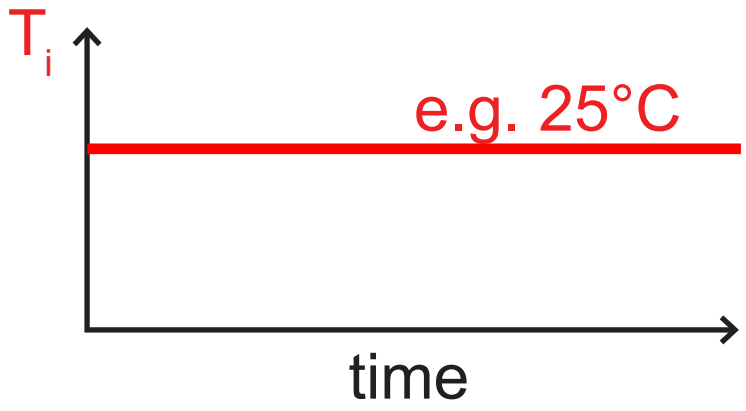
aggregated data (e.g. daily)

HLC



Co-heating test

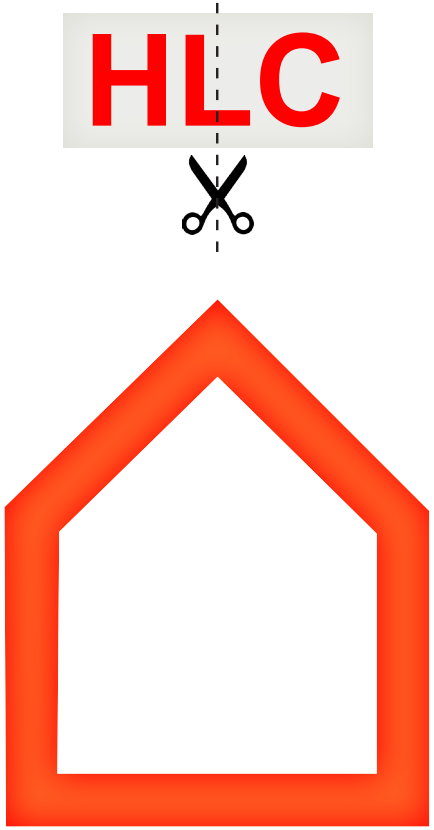
quasi-stationary test



monitored throughout test:

aggregated data (e.g. daily)

transmission ventilation



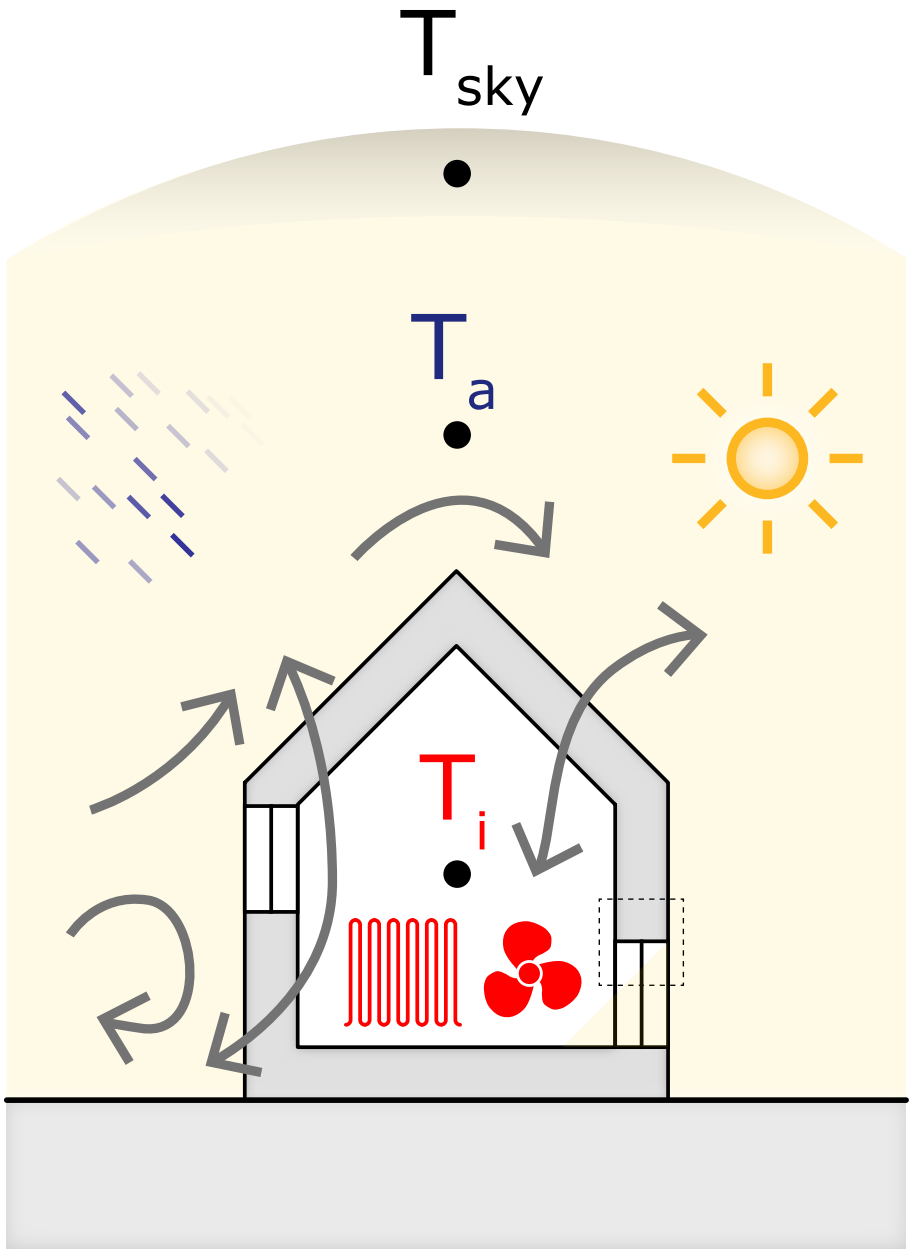
2

State-of-the-art

Simplified heat balance

$T_i - T_a$

$$Q_h = HLC\Delta T - A_{sw,*}q_{sw,*} + c$$



2.1

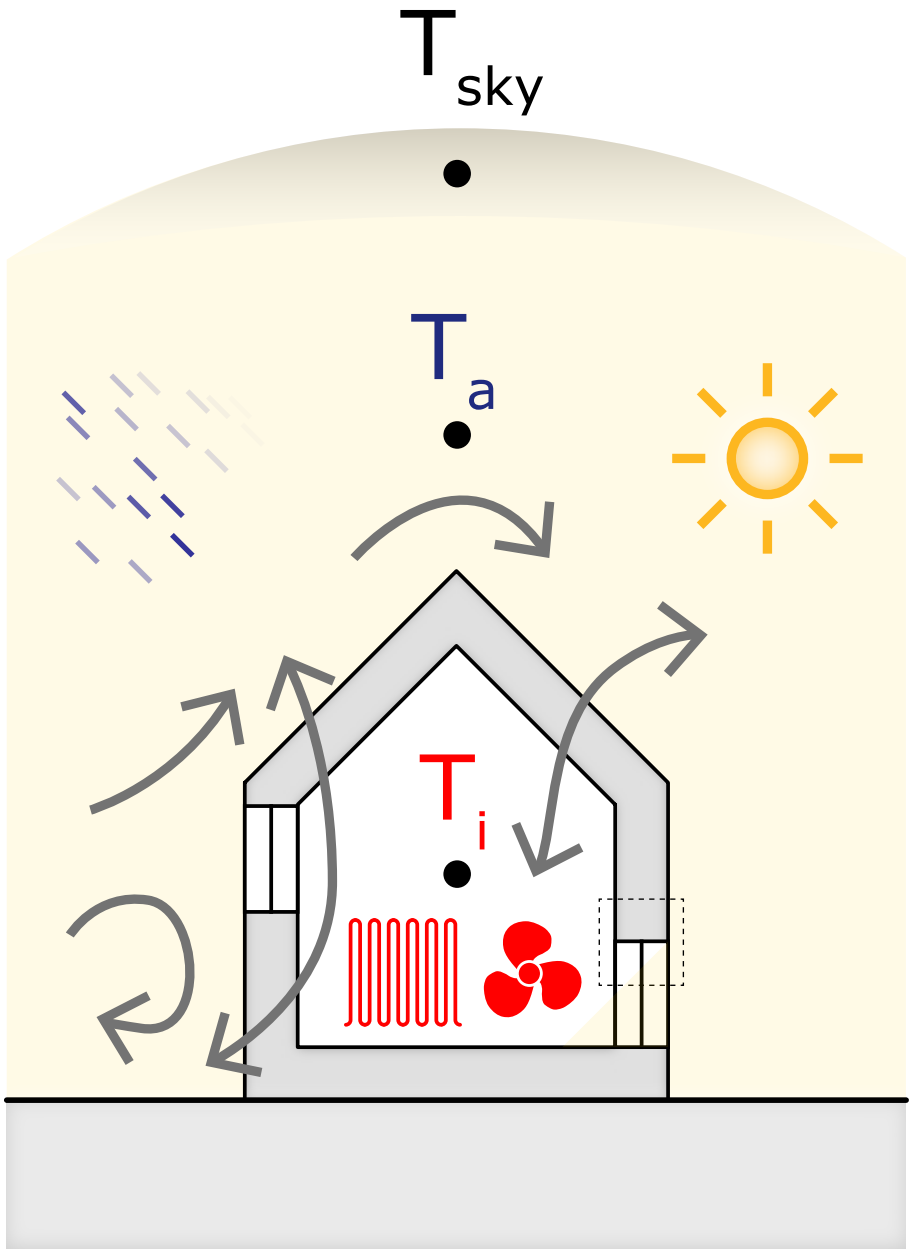
Basic heat balance

- building acts as one zone

- thermostatically controlled Ti

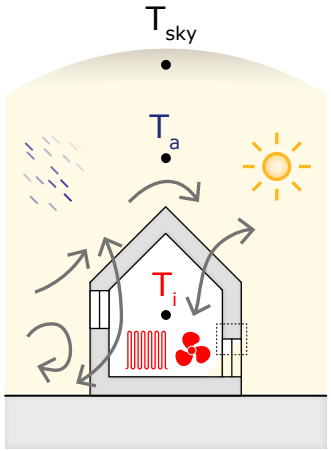
- aggregated performance data

- thermal mass in equilibrium



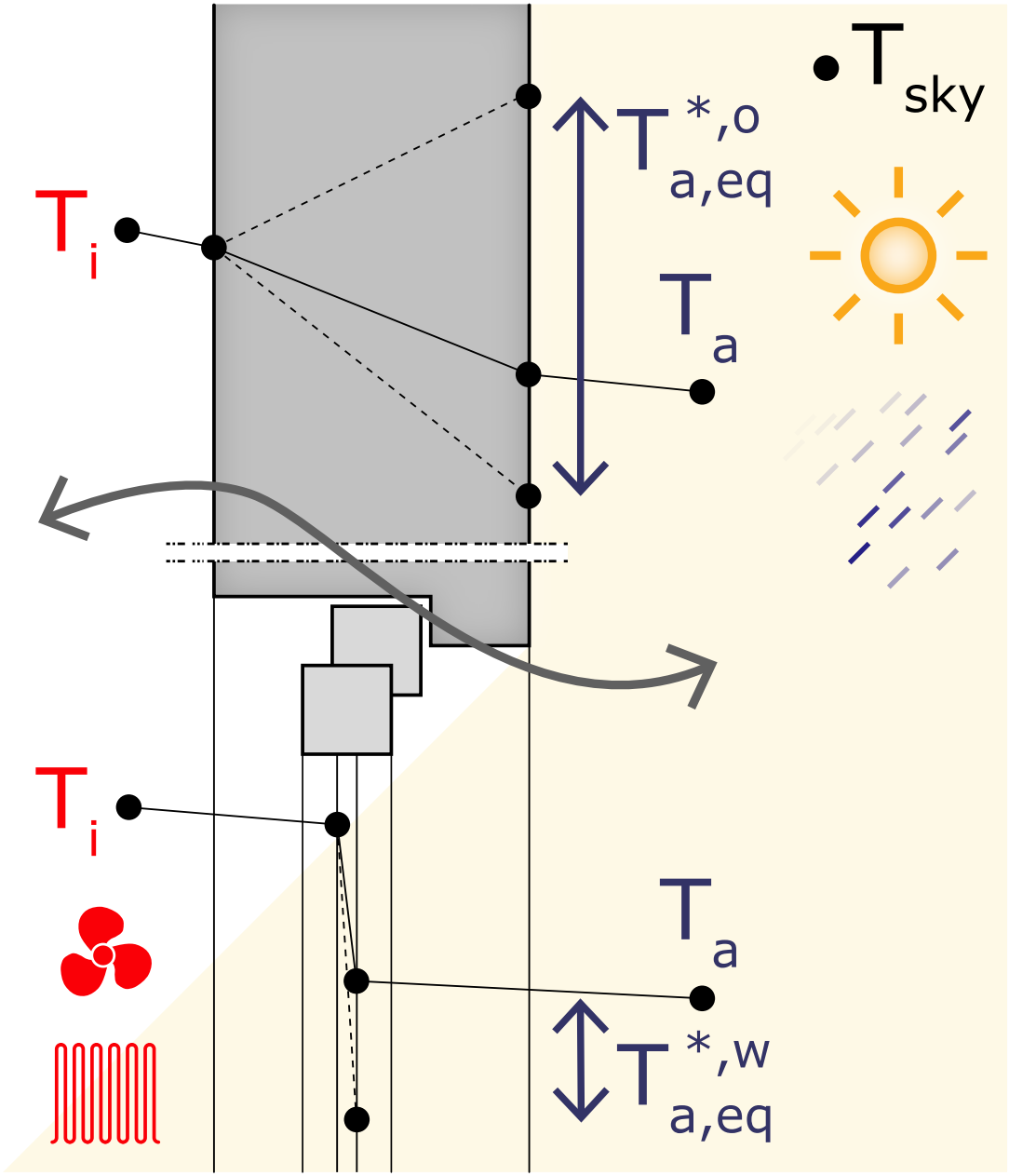
Stationary heat balance T_i

$$\sum Q_i + c = 0$$



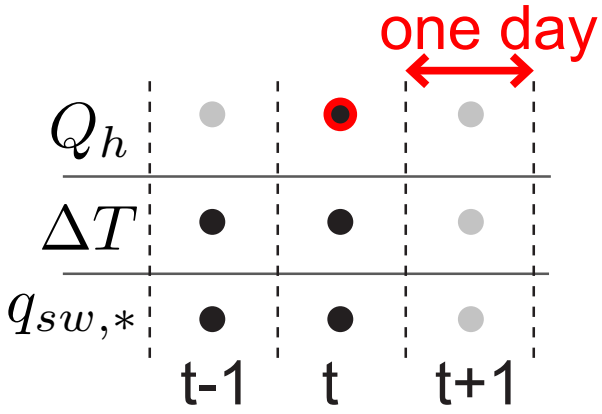
$$Q_h + Q_{sw} - (Q_{tr} - Q_{s,sw} + Q_{s,lw}) - Q_v - Q_{latent} + c = 0$$

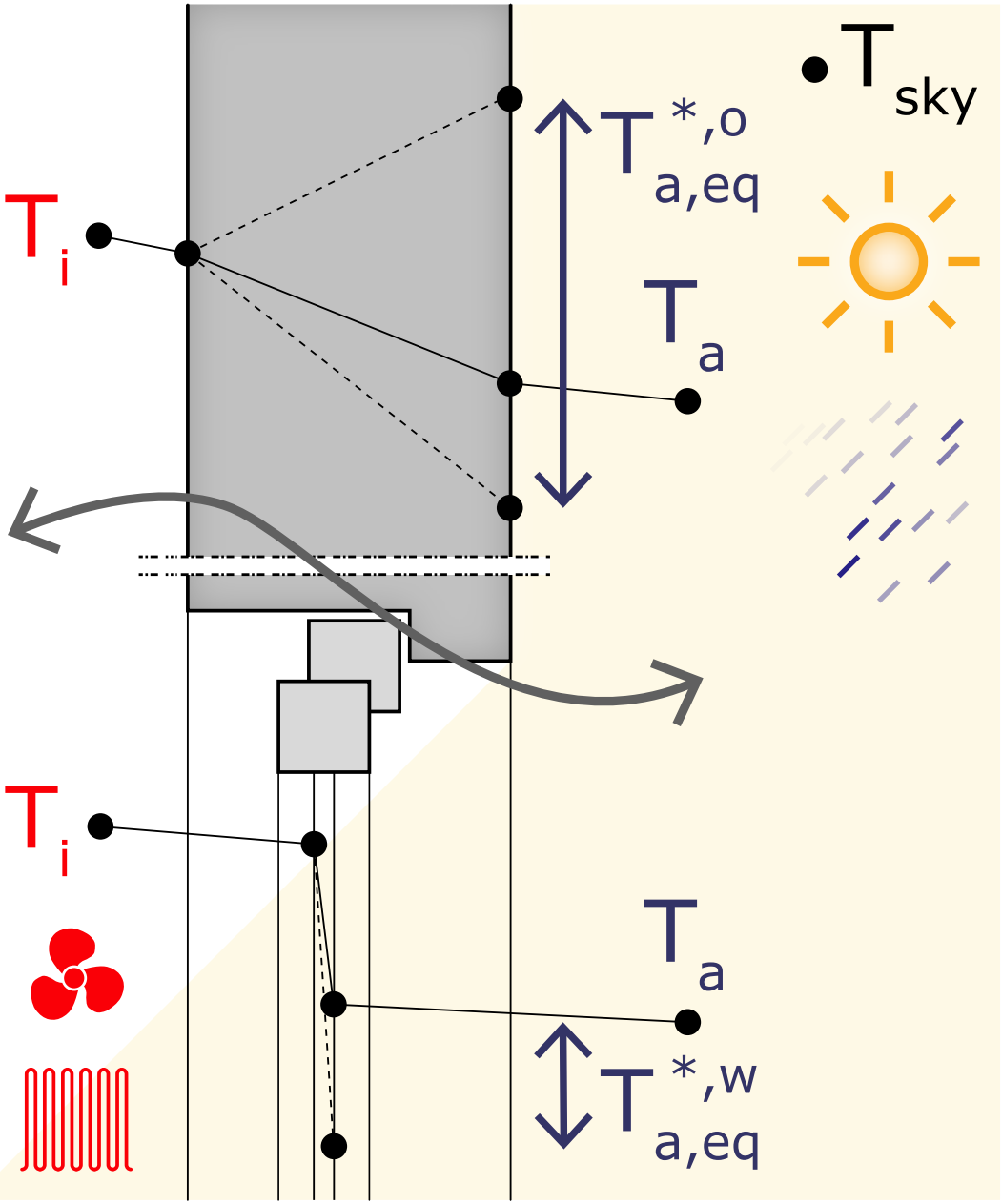
- equivalent outdoor temperature



- equivalent outdoor temperature

- thermal lags





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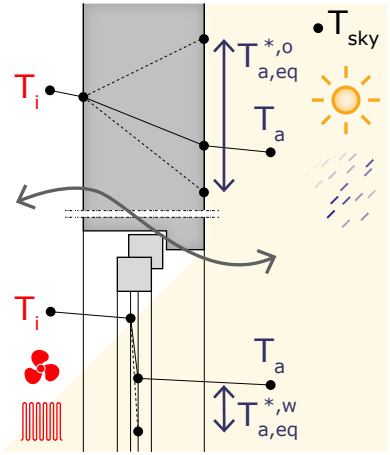

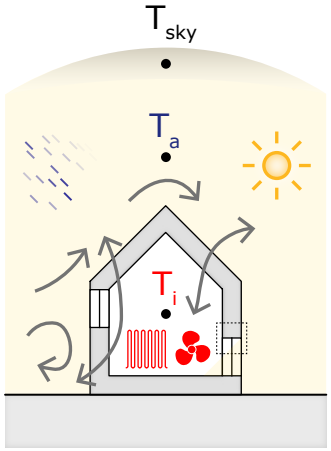

$$Q_h + \sum_{*,w} A_{sw,*,w} q_{sw,*,avg} + \sum_{*,o} U_o A_{*,o} \alpha_{sw,*,o} q_{sw,*,avg}$$

$$= \sum_{*,o} U_o A_{*,o} \Delta T_{avg} + \sum_{*,w} U_w A_{*,w} \Delta T \qquad T_i - T_a$$

$$+ \sum_{*,o} U_o A_{*,o} c_{lw,*,o} + \sum_{*,w} U_w A_{*,w} c_{lw,*,w} + c_a G_a \Delta T + c_{vP} + c$$

T_{sky} T_{sky}

2.2

Linear regression

Simplified heat balance

- stationary heat balance

$T_i - T_a$

- aggregated performance data

$$Q_h = HLC\Delta T - A_{sw,*}q_{sw,*} + c$$

Simplified heat balance - stationary heat balance

$T_i - T_a$ - aggregated performance data

$$Q_h = HLC\Delta T - A_{sw,*}q_{sw,*} + c$$

simplifications:

$$Q_h + \sum_{*,w} A_{sw,*,w}q_{sw,*,avg} + \sum_{*,o} U_o A_{*,o}\alpha_{sw,*,o}q_{sw,*,avg}$$

$$= \sum_{*,o} U_o A_{*,o}\Delta T_{avg} + \sum_{*,w} U_w A_{*,w}\Delta T \qquad T_i - T_a$$

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T_{sky} T_{sky}

Simplified heat balance

 $T_i - T_a$ 

$$Q_h = HLC\Delta T - A_{sw,*}q_{sw,*} + c$$

simplifications:

- # independent variables = # parameters
-  's correlated
- ΔT and ΔT_{avg} correlated
- influence T_{sky}  assumed constant

  (ground floor heat loss)

Simplified heat balance


$T_i - T_a$

$$Q_h = HLC\Delta T - A_{sw,*}q_{sw,*} + c$$

Linear regression analysis:

- simple linear regression (solar corrected Q_h)

- simple linear regression (transformed equation)

- multiple linear regression

Simplified heat balance

$T_i - T_a$


$$Q_h = HLC\Delta T - A_{sw,*}q_{sw,*} + c$$

$$Q_h + A_{sw,*}\,q_{sw,*} = HLC\Delta T + c$$

Linear regression analysis:

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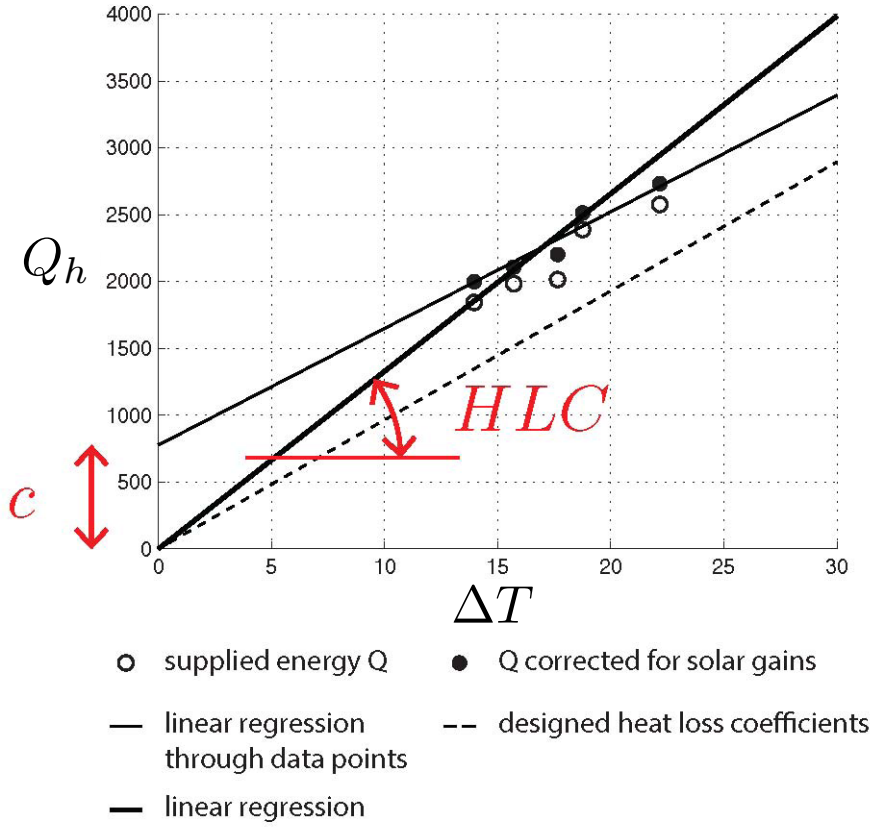

Simplified heat balance

$T_i - T_a$

$$Q_h = HLC\Delta T - A_{sw,*}q_{sw,*} + c$$

$$\frac{Q_h}{\Delta T} = HLC - A_{sw,*}\frac{q_{sw,*}}{\Delta T}$$

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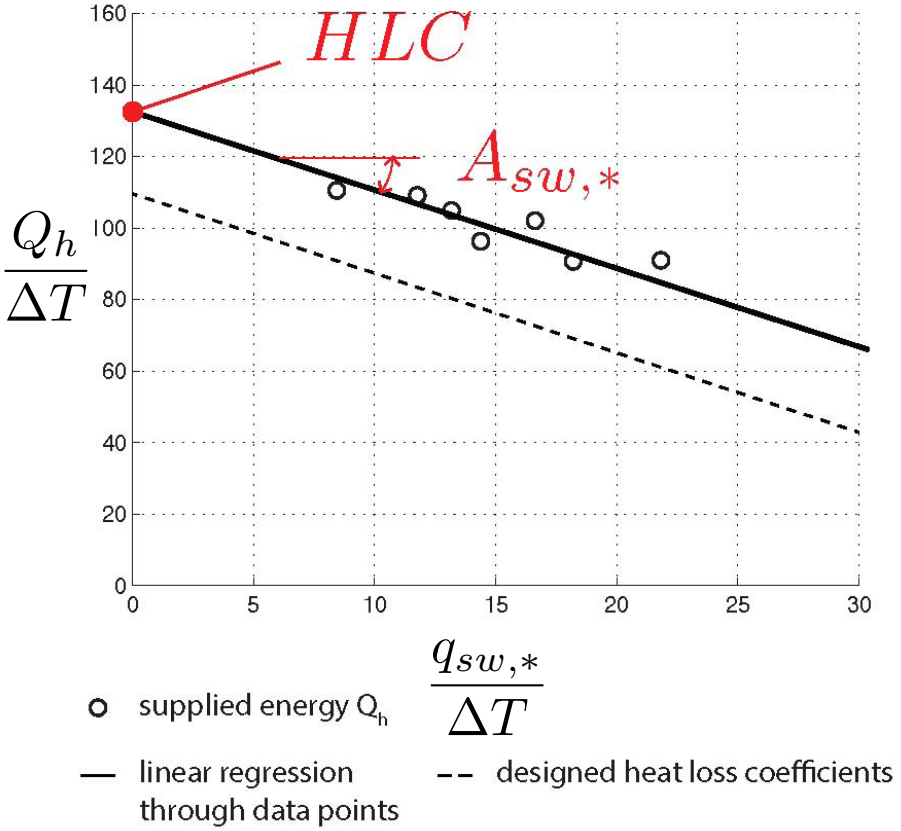

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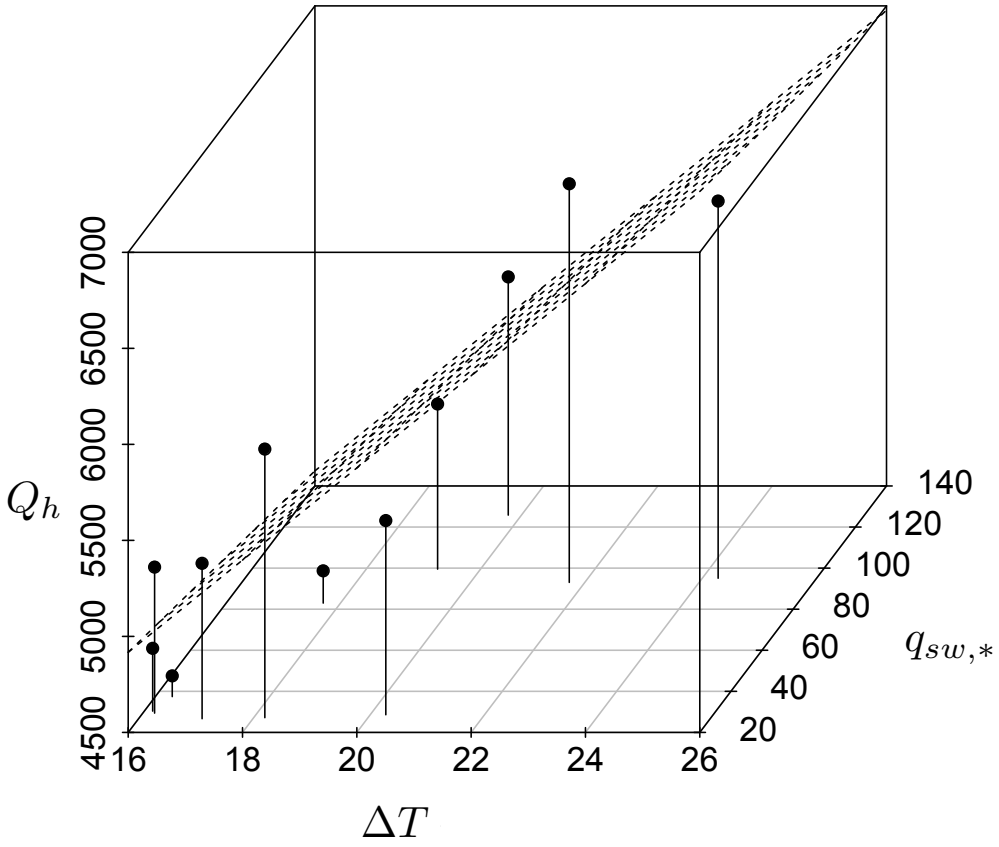
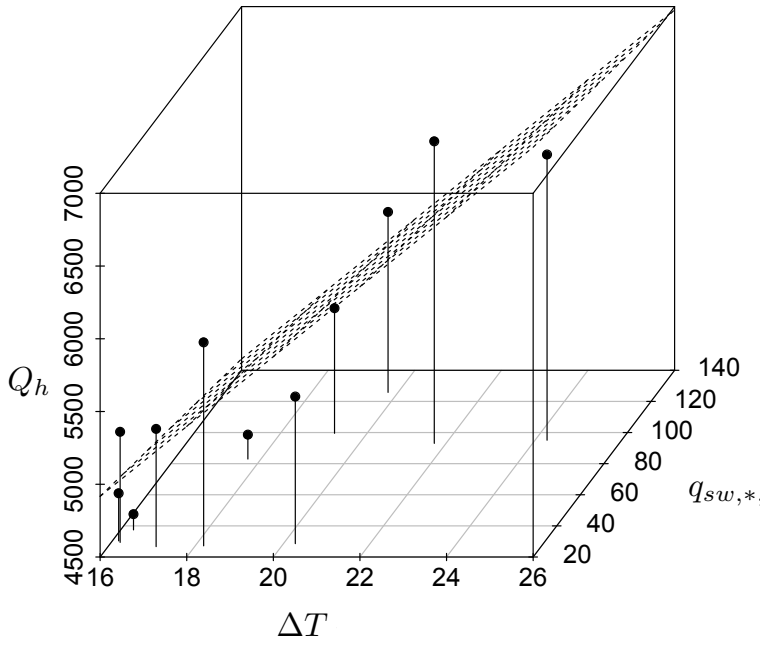


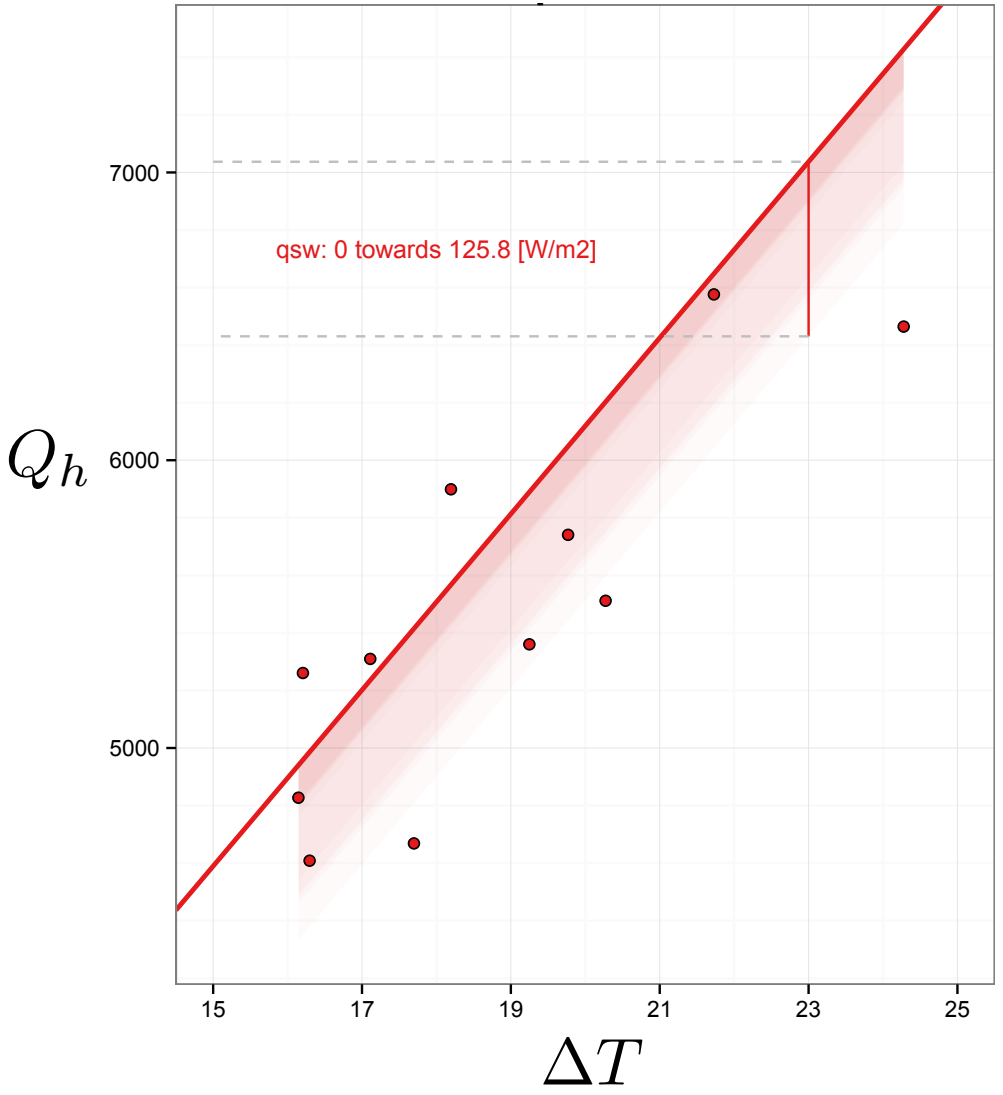
2.3

Visualisation

Multiple linear regression

$$Q_h = HLC\Delta T - A_{sw,*}q_{sw,*} + c$$





Multiple linear regression

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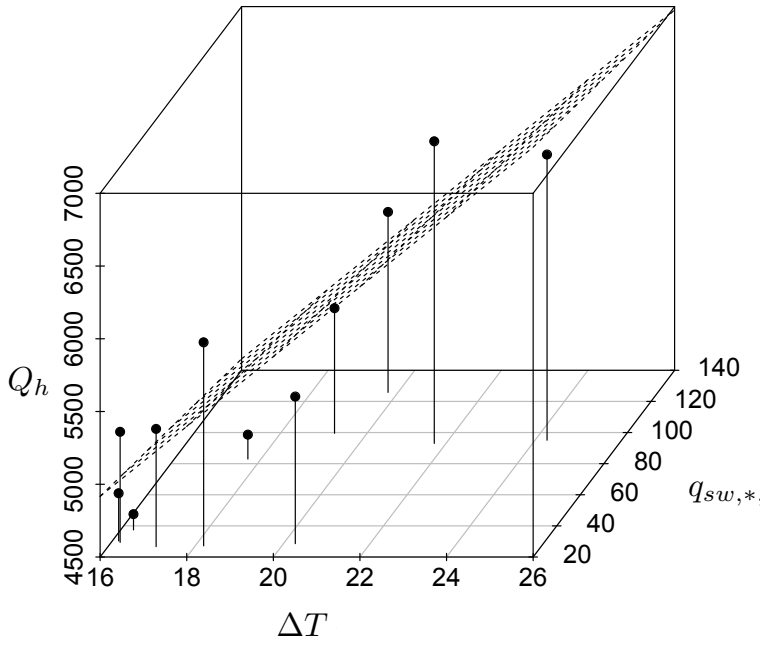

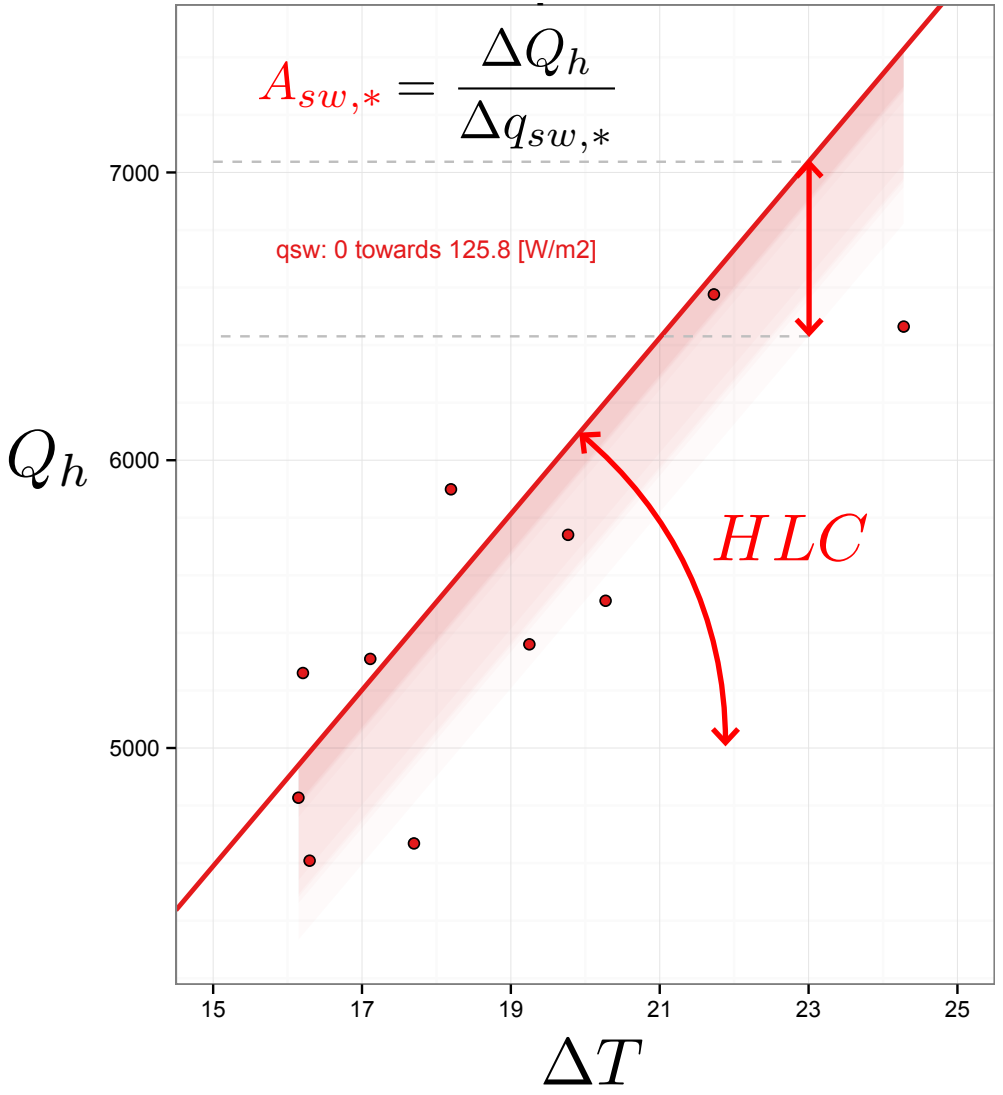

3

Reliability

4 factors influence co-heating test reliability

- duration of experiment

- weather conditions

- test case

- analysis method

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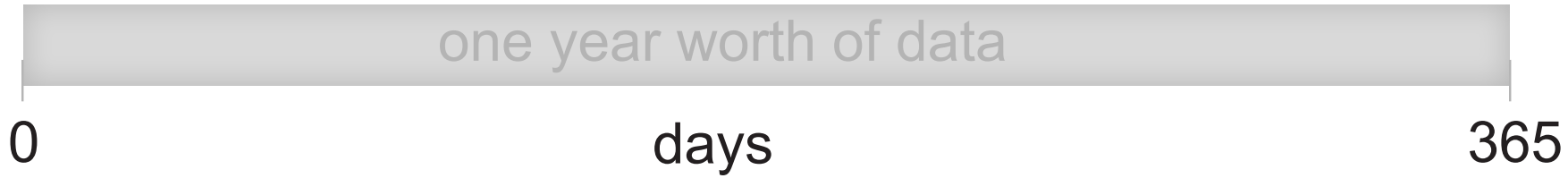

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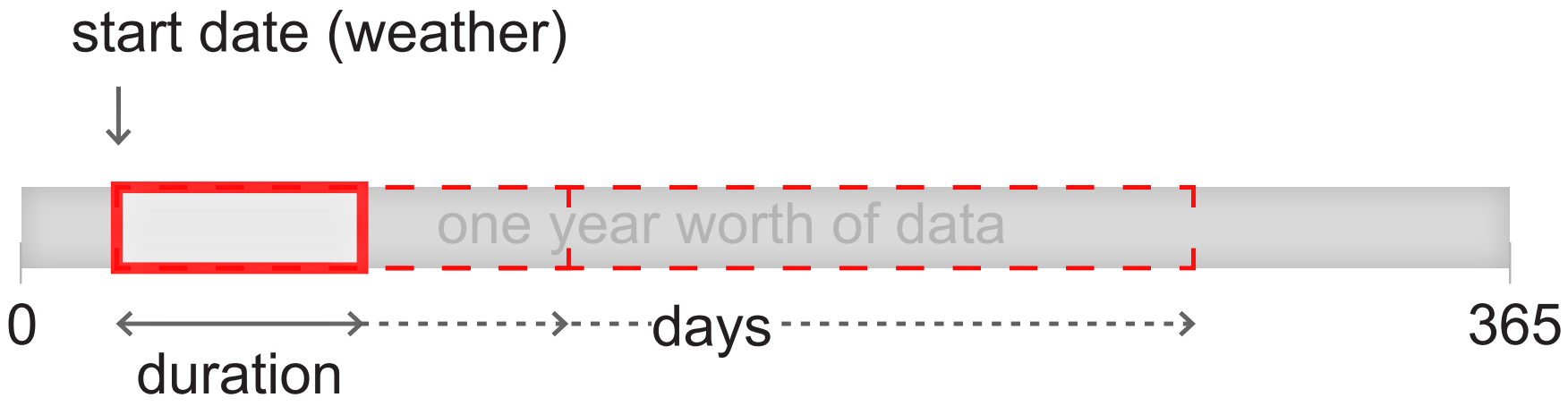

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- duration of experiment

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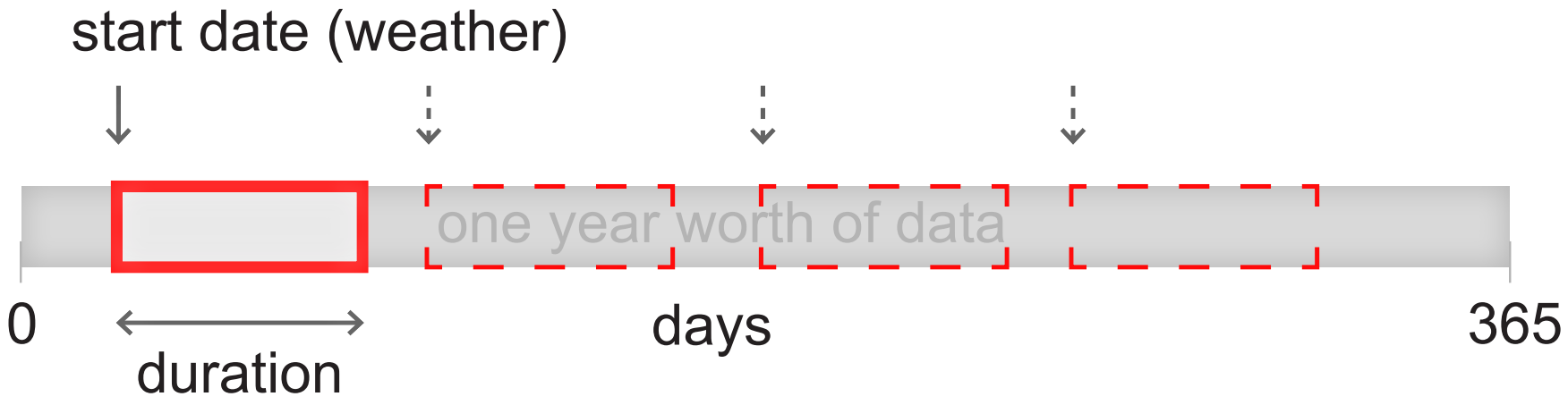
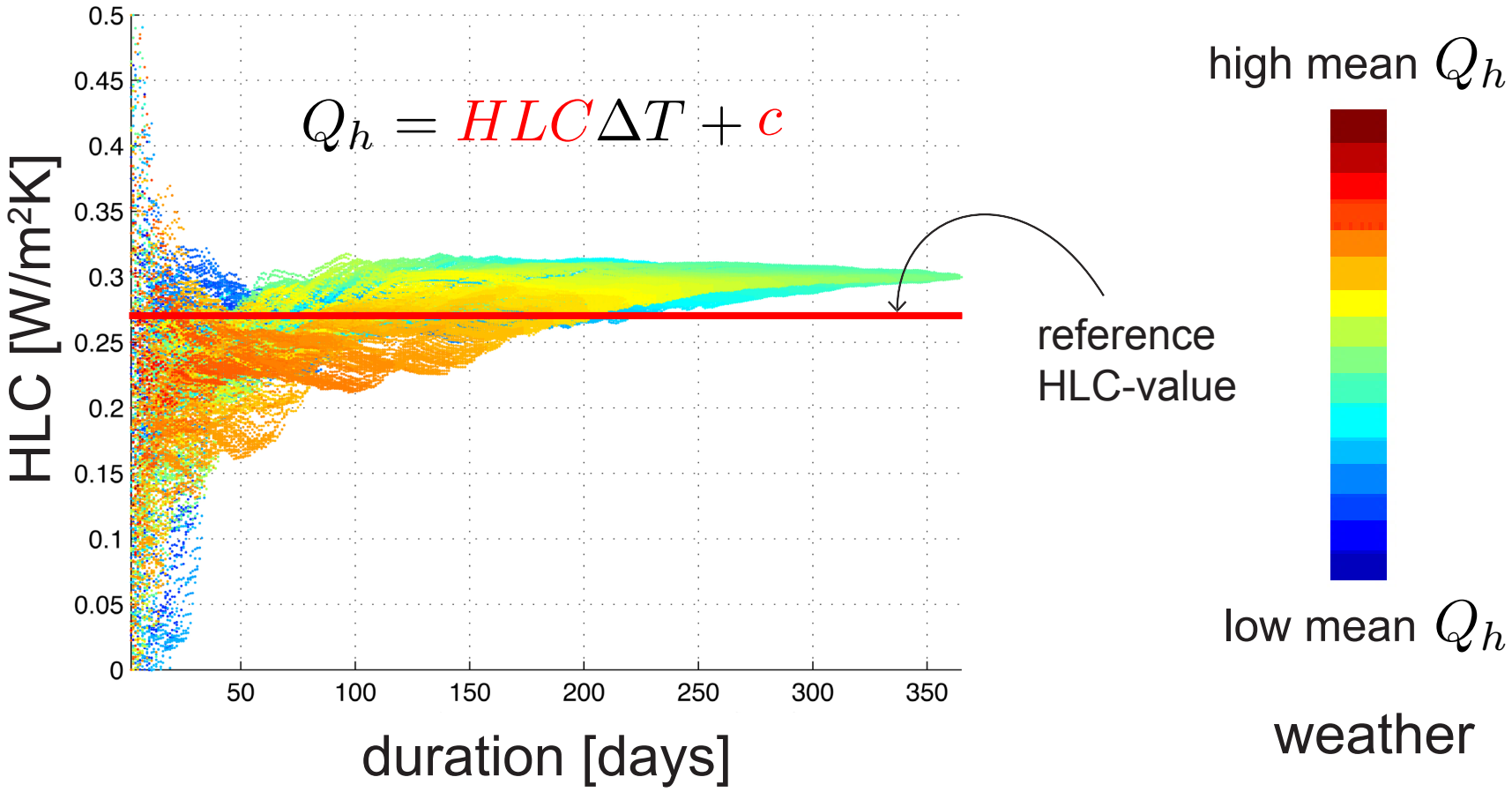
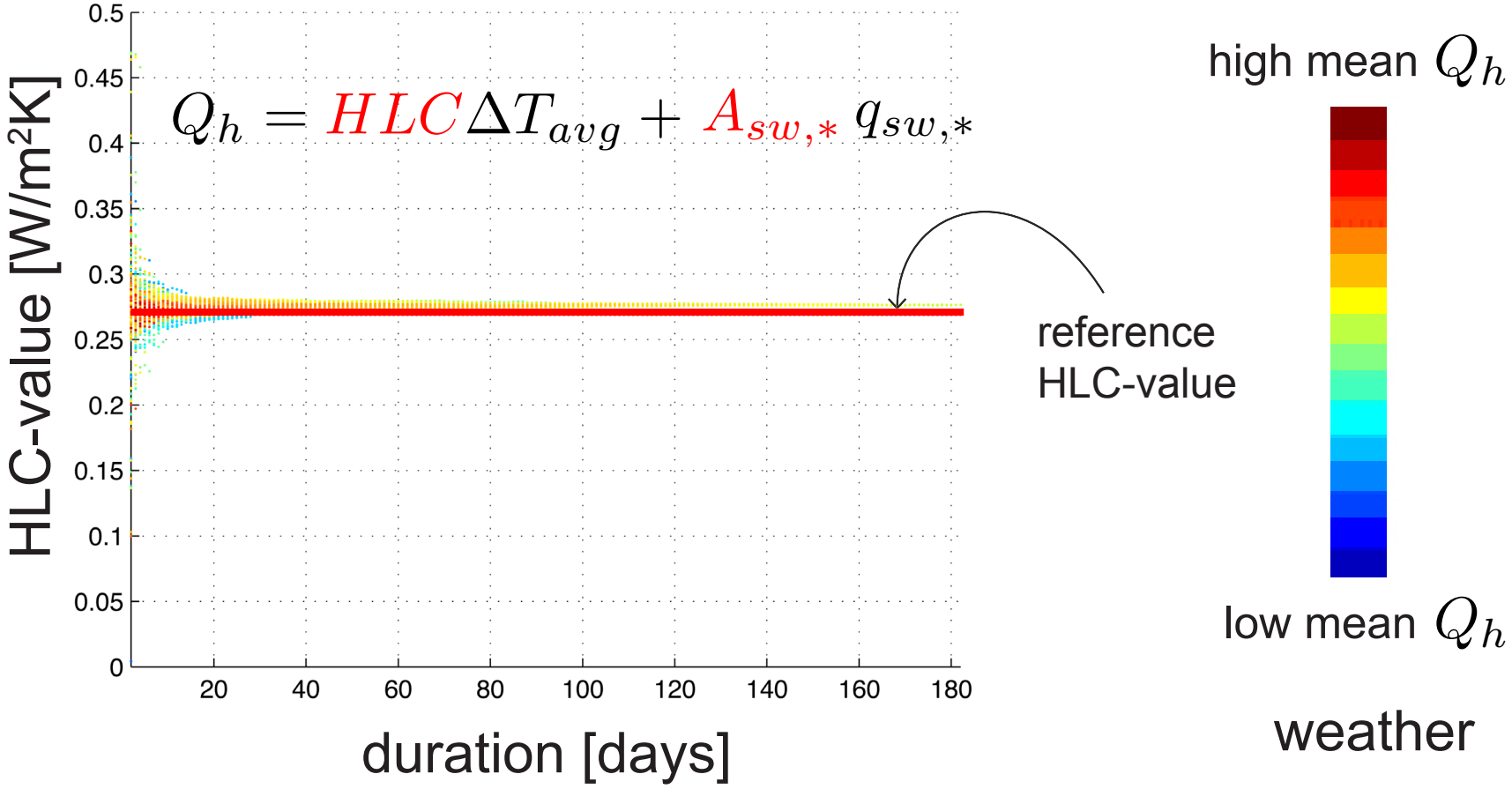


Fixed test case & analysis methodology:



Fixed test case & analysis methodology:

Zero intercept, winter data, solar radiation, thermal lag



Reliable results:

- appropriate analysis method

- sufficient duration

- winter measurements (high mean Q_h)

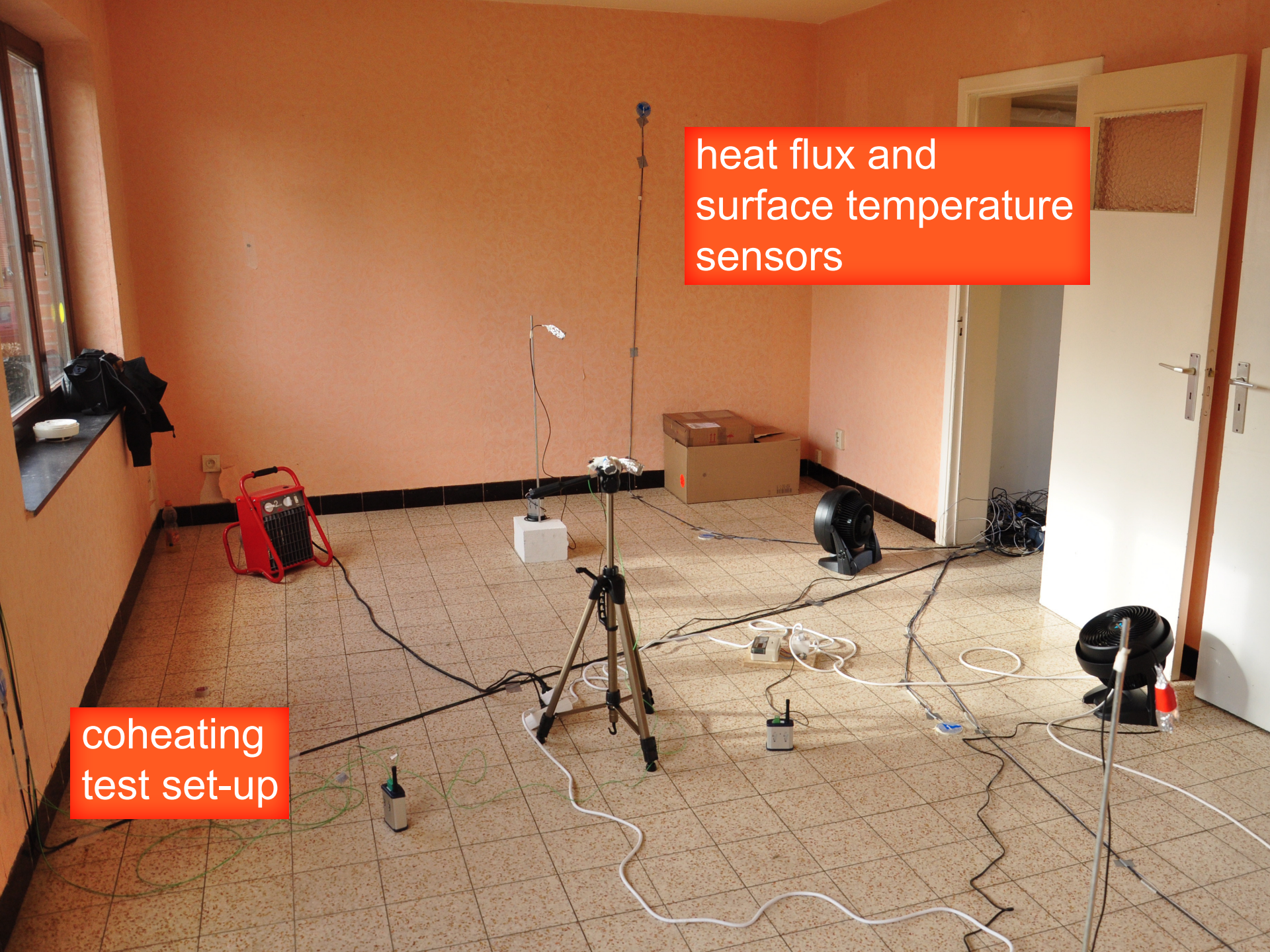
4

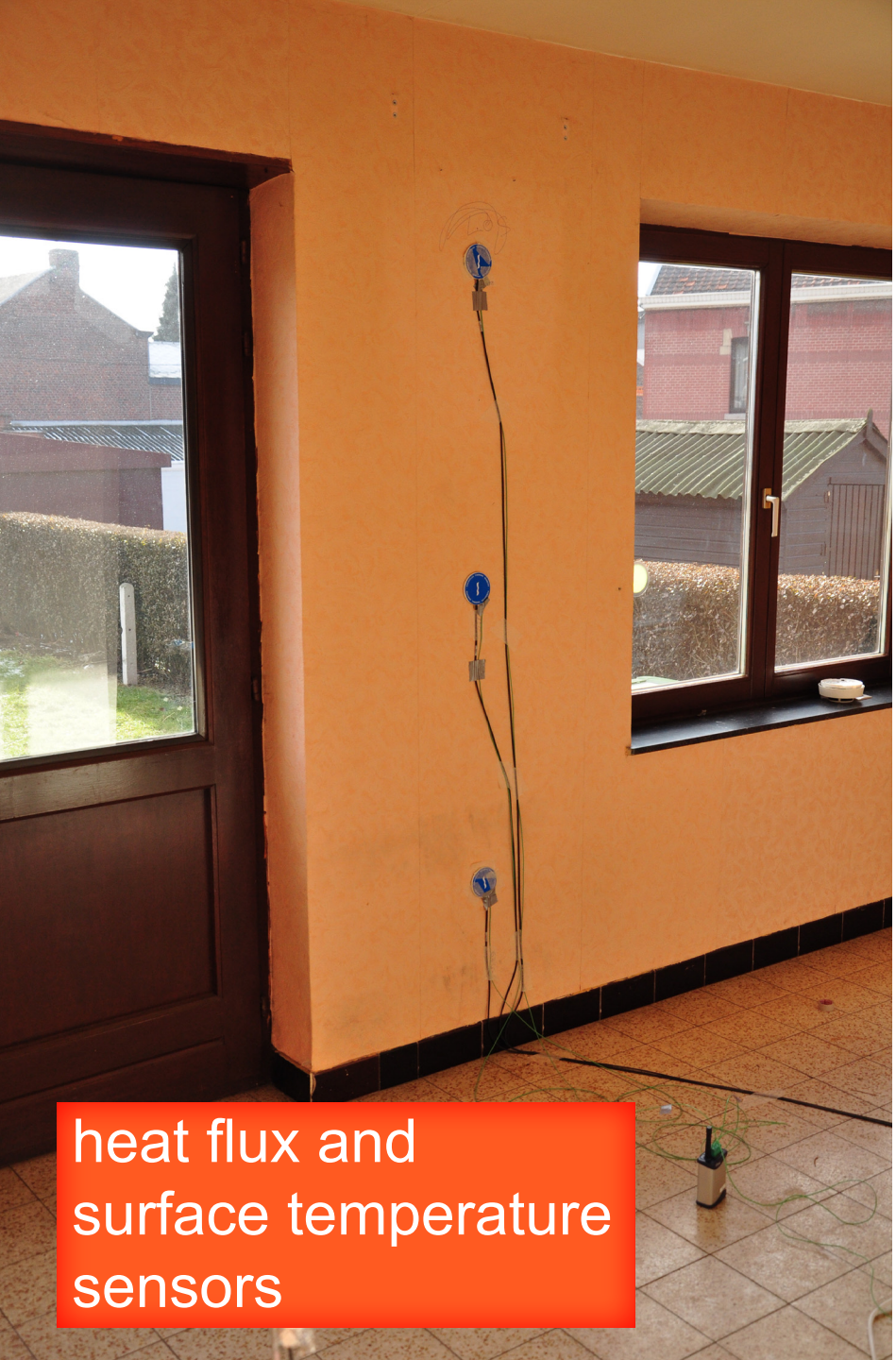
Test Case: Terraced house in Herstal, Belgium


VANDORMAEL
ROCOURT

- extended co-heating test: February - May


coheating
test set-up


heat flux and surface temperature sensors
coheating test set-up


heat flux and
surface temperature
sensors


blowerdoor
measurements


air change rate
measurements
BBRI

- extended co-heating test: February - May

- 2 renovation steps:

STEP 1

- blowing in insulation in façade and party wall cavities

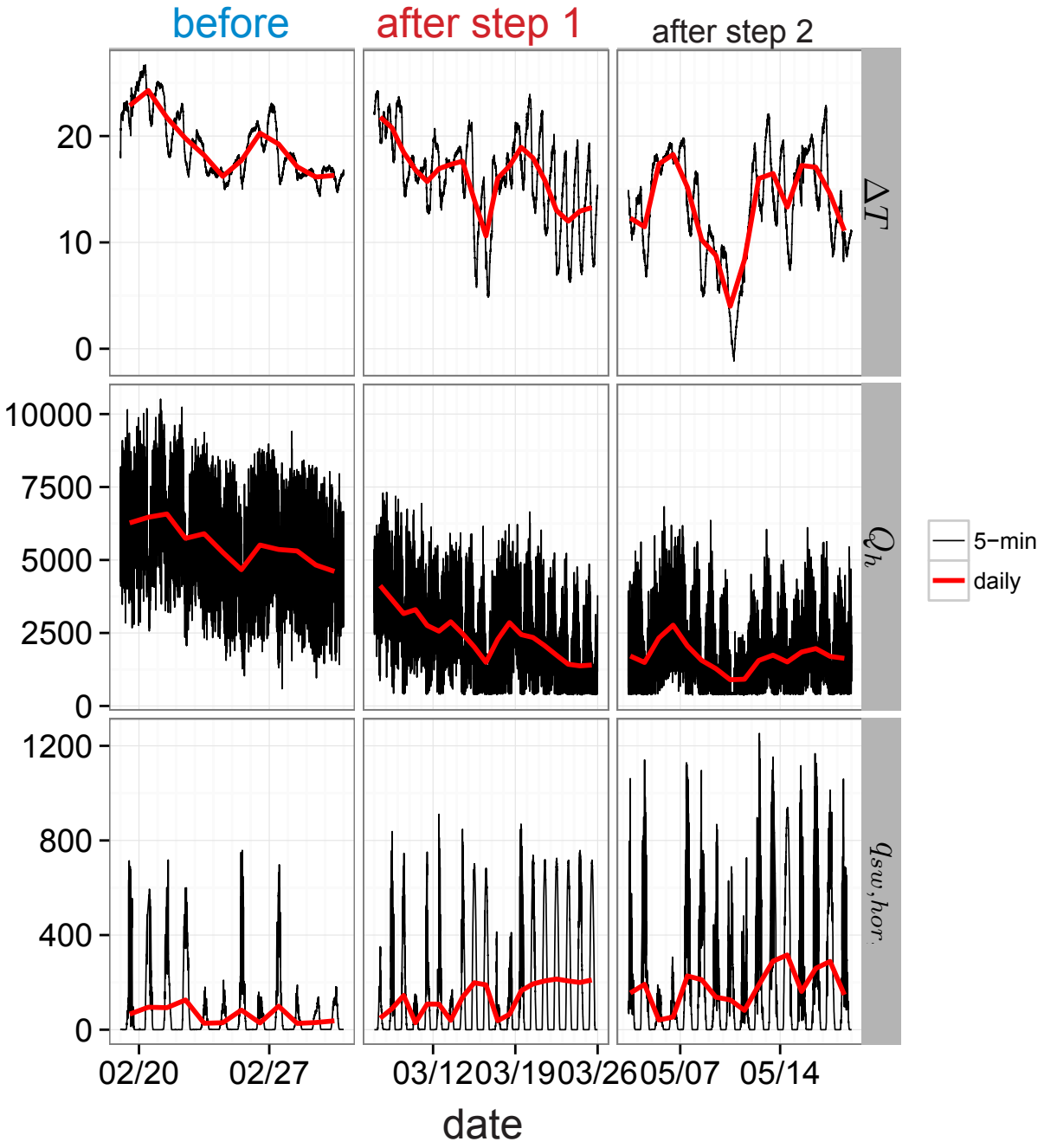
- insulating the attic floor slab

STEP 2

- insulating floor above basement

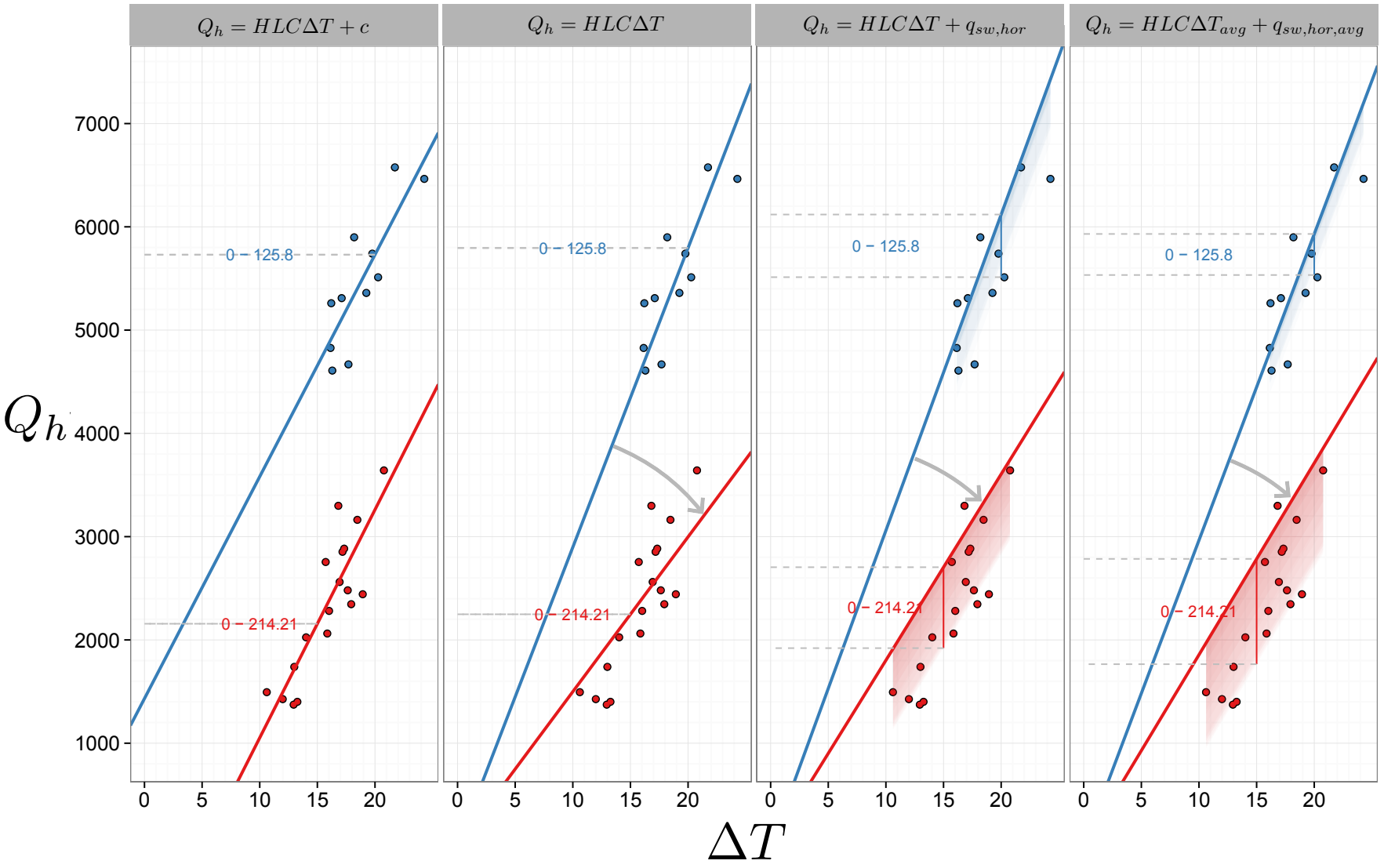

KNAUF INSULATION

Co-heating measurement data



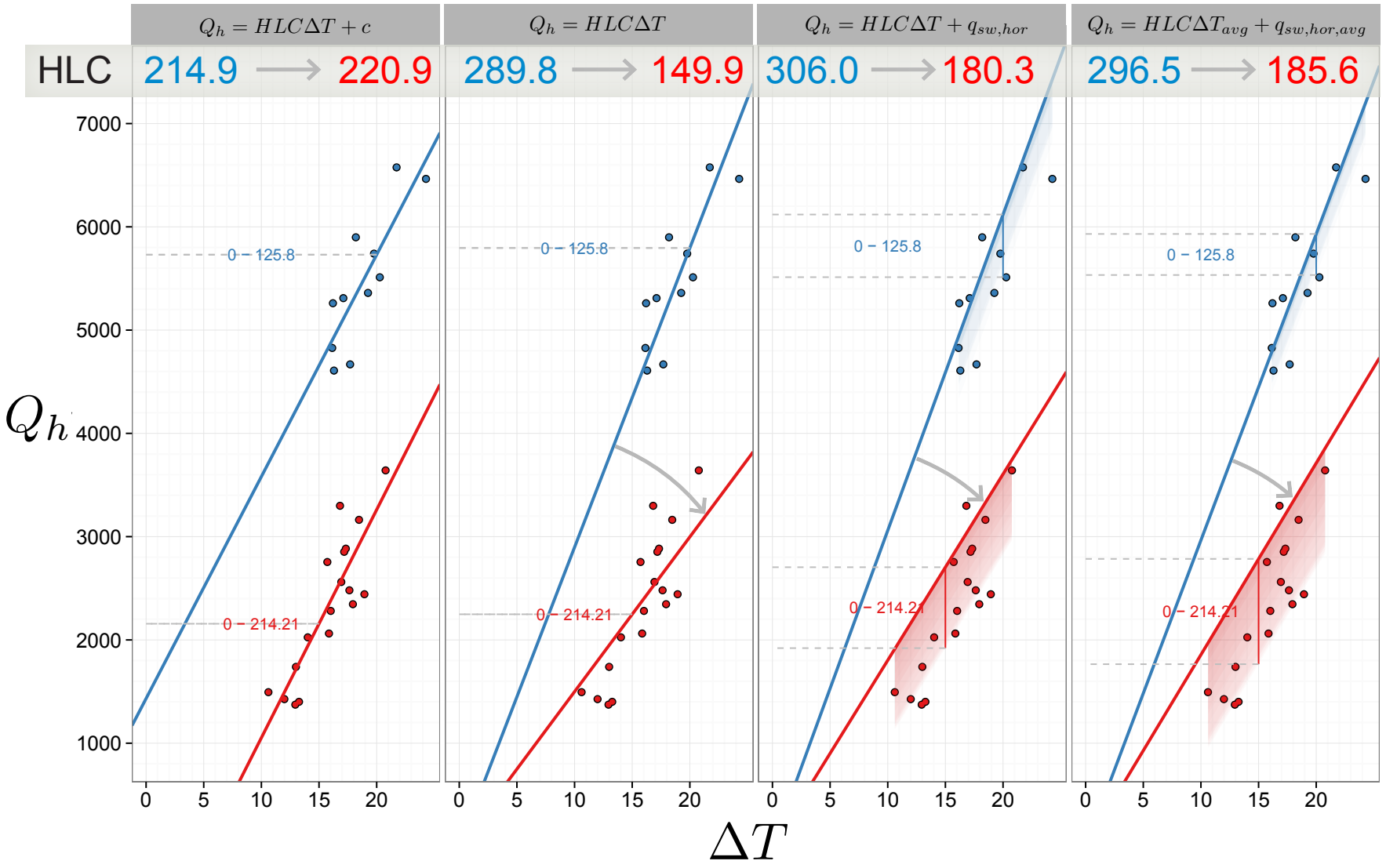
Co-heating analysis result

before → after step 1



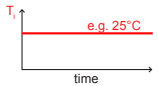
Co-heating analysis result

before → after step 1



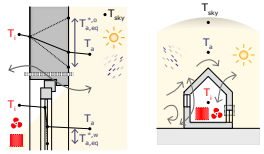
5
Conclusions

Co-heating test to assess thermal performance of buildings

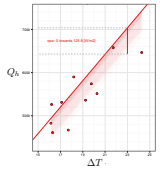


Stationary analysis of quasi-stationary test

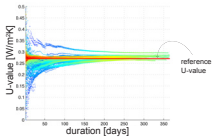
Limited model complexity



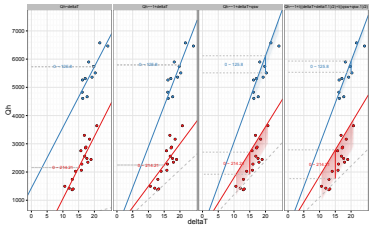
Underlying physical phenomena identified



Multiple linear regression and visualisation



Reliability



Renovation induced performance improvement: co-heating test

Webinar

How to determine the real performances of buildings?

Building characterisation by co-heating

January 22, 2014

State-of-the-art on the co-heating test methodology

Thank you.

Geert Bauwens, Staf Roels
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