Indoor Climate and Humidity Loads in Old Rural Houses with Different Usage Profiles

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INTRODUCTION

Rural house

New requirements
– comfort
– function
– energy-efficiency

Information
– current situation
– hygrothermal loads
– indoor climate

Major renovation
– continuous use
– periodical use
– unheated houses

INTRODUCTION

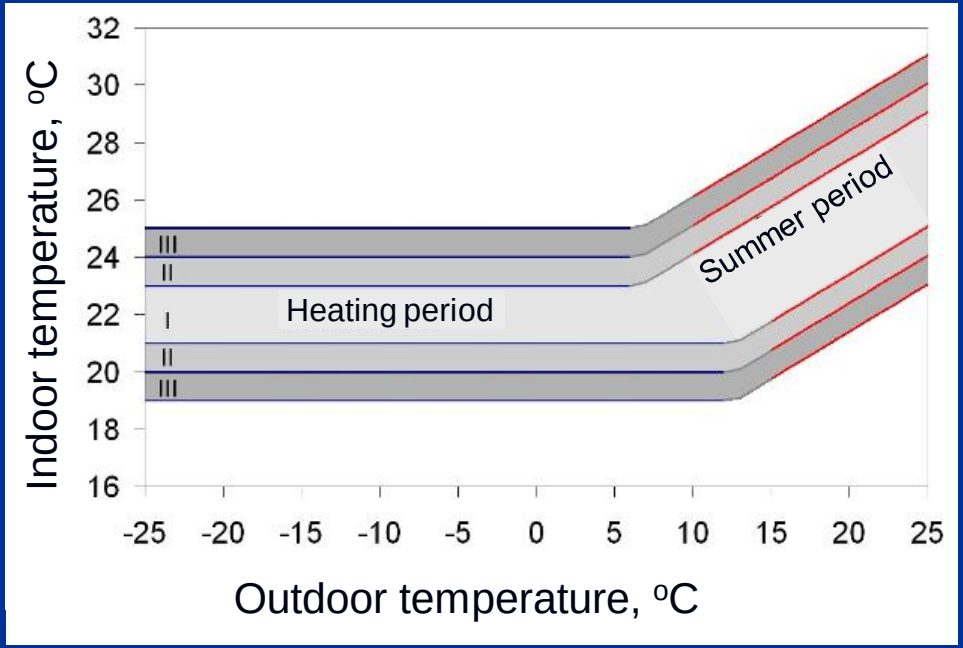
- Selection of buildings
  - indoor climate was studied in 29 houses, equal number of
    - continuously used houses,
    - periodically used houses,
    - unheated houses (summer houses);
  - average age 94 years (1856...1950);
  - external walls made of logs;
  - natural, passive stack ventilation;
  - majority were heated with wooden oven.

METHODS

- Temperature and RH measurements
  - Hobo U-12 011 loggers at one-hour interval over one year period
  - from master bedroom or living room
  - on inner surface of first log
  - from crawl space
  - outdoor climate data from nearest weather station
- The air tightness with fan pressuration method
  - mean air leakage - q_{50}=15 $m^3/(h \cdot m^2)$
  - mean air change rate - n_{50}=22 h^{-1}

METHODS

- Indoor thermal conditions
  - target values from CR 1752 and EN 15251
  - lowest indoor climate category was selected

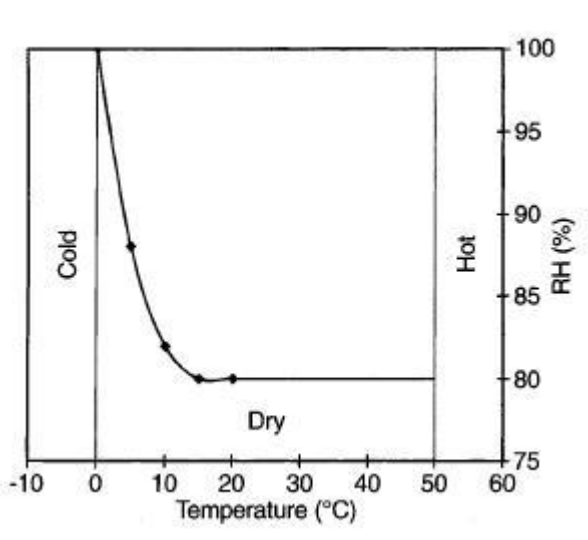


METHODS

- Indoor thermal conditions
  - target values from CR 1752 and EN 15251
  - lowest indoor climate category was selected
- Internal moisture excess
  - maximum values of one-week period
  - the higher 10% level was calculated
- Risk for mould growth:
  - indoor air (furniture, separating walls), crawl space, thermal bridges (lower log)
  - the time of the temperature and RH conditions favourable for mould growth

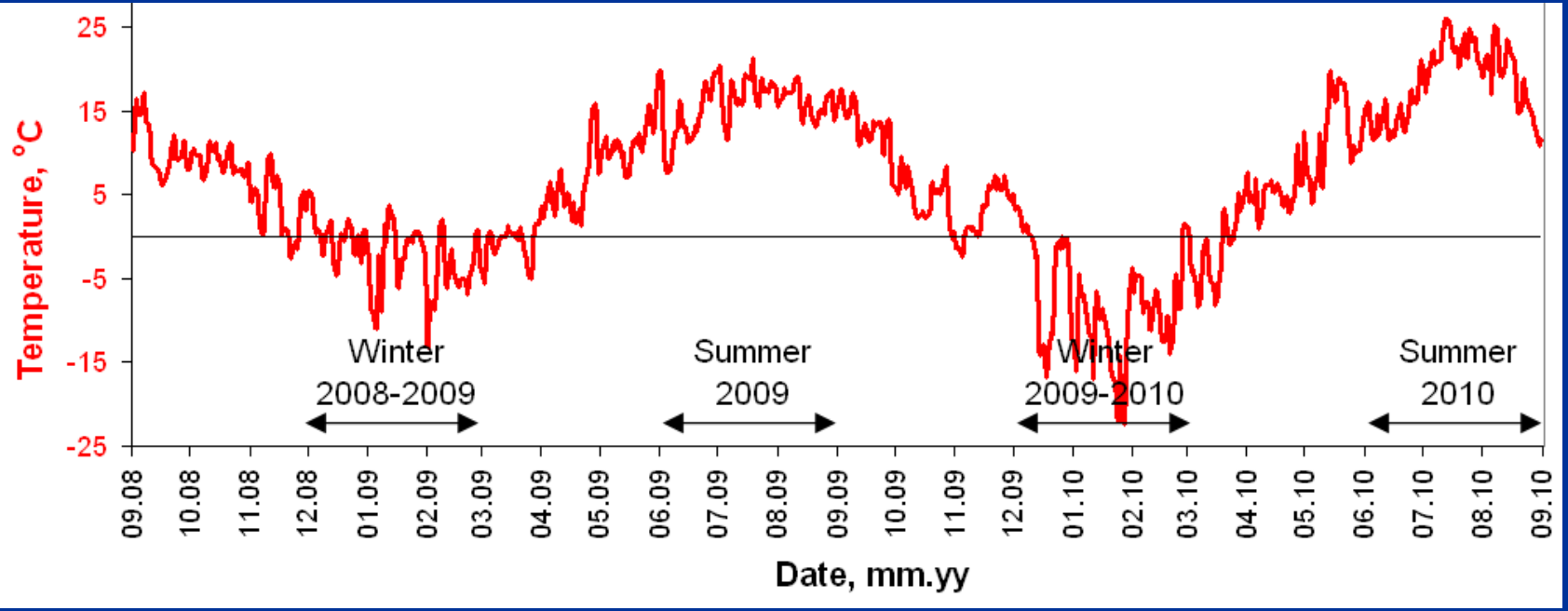
$$\Delta\nu = \nu_i - \nu_e$$

$$RH_{crit} = \begin{cases} -0.00267 \cdot t^3 + 0.160 \cdot t^2 - 3.13 \cdot t + 100 & ,when\ t \le 20°C \\ 80\% & ,when\ t > 20°C \end{cases}$$



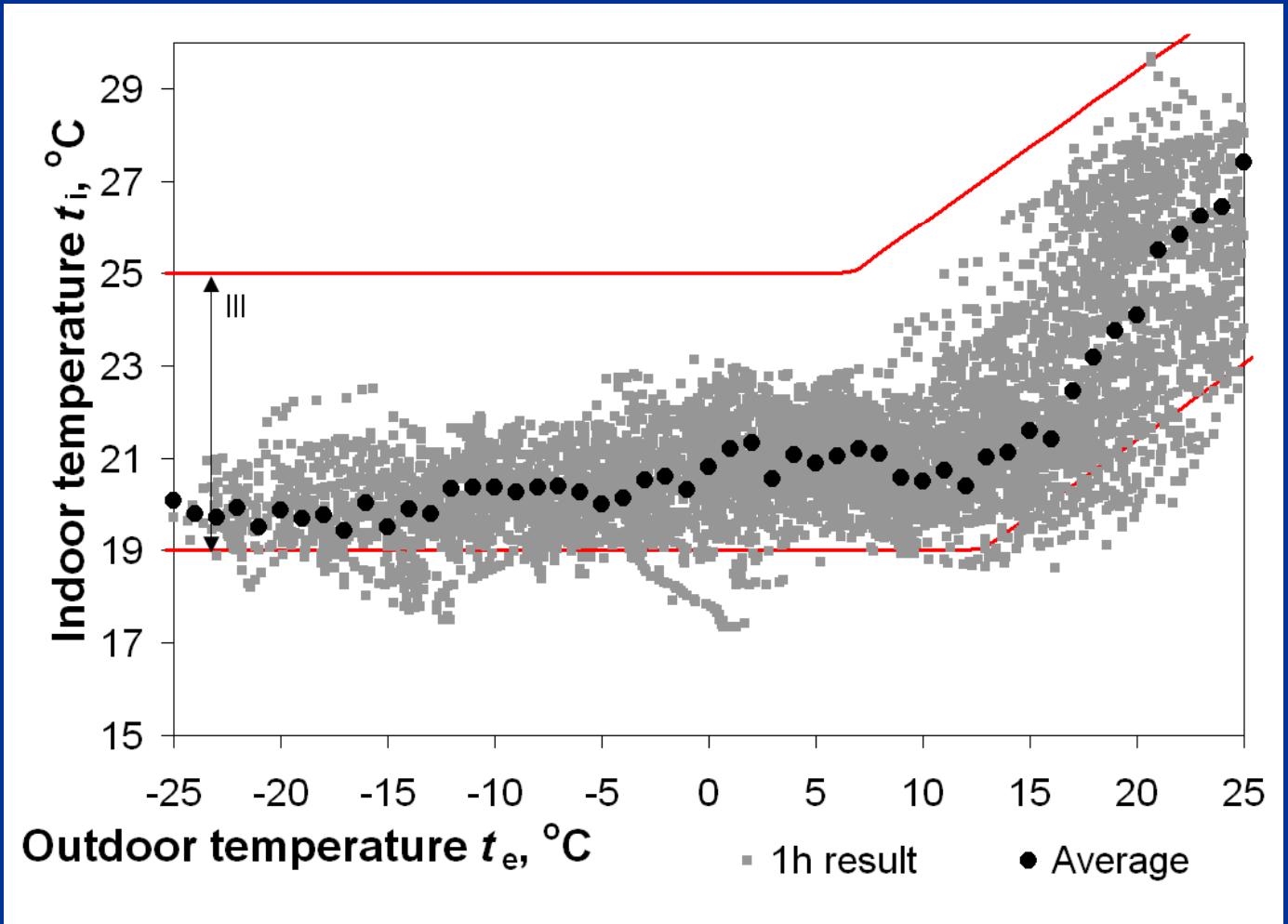
RESULTS

- Outdoor temperature
  - Average of winter months -5°C (min. -31°C)
  - Coldest monthly average -12°C
  - Average of summer months +17°C
  - Warmest monthly average +22°C



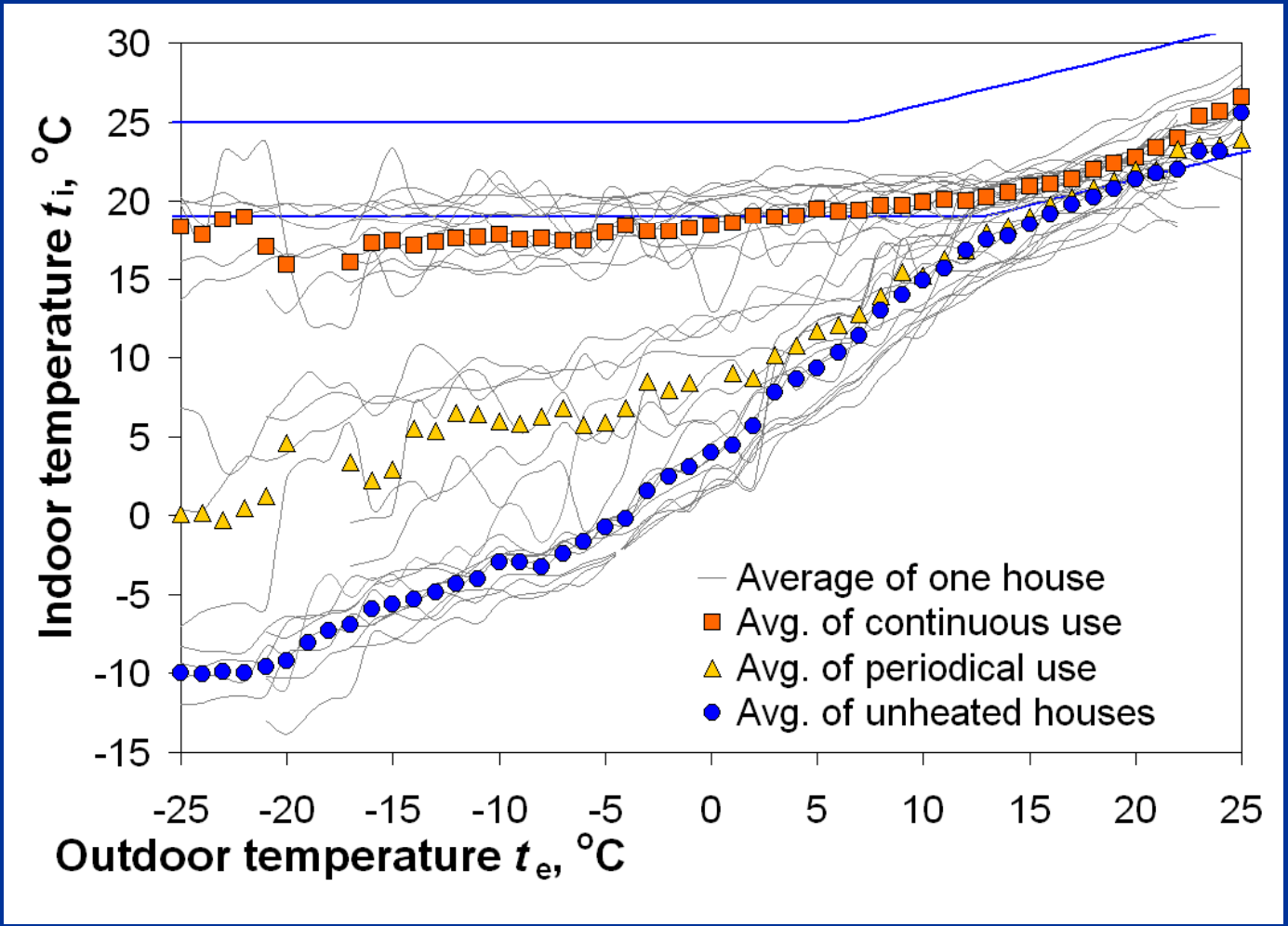
RESULTS

- Indoor temperature in continuously heated house



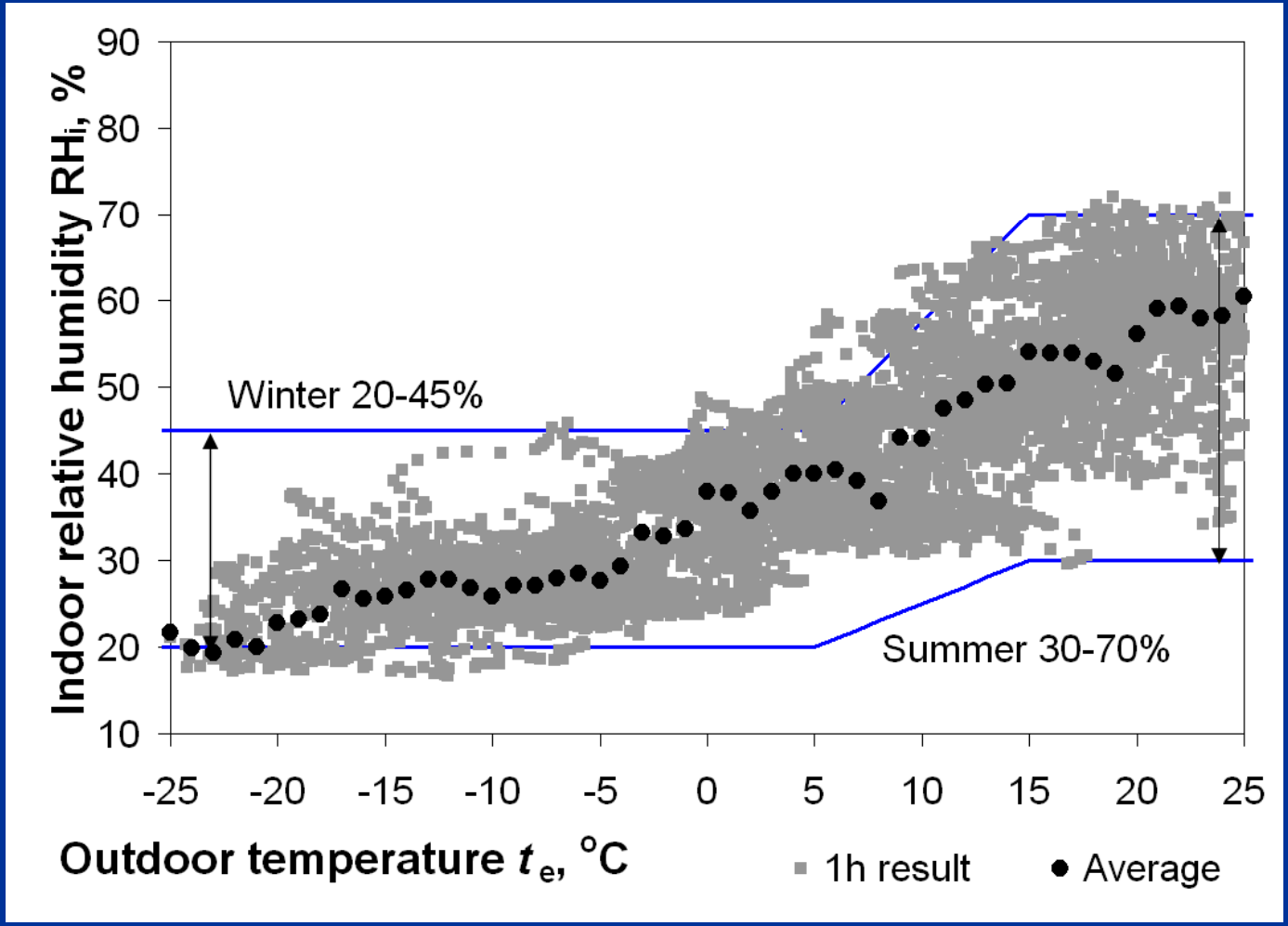
RESULTS

- Indoor temperature in all houses



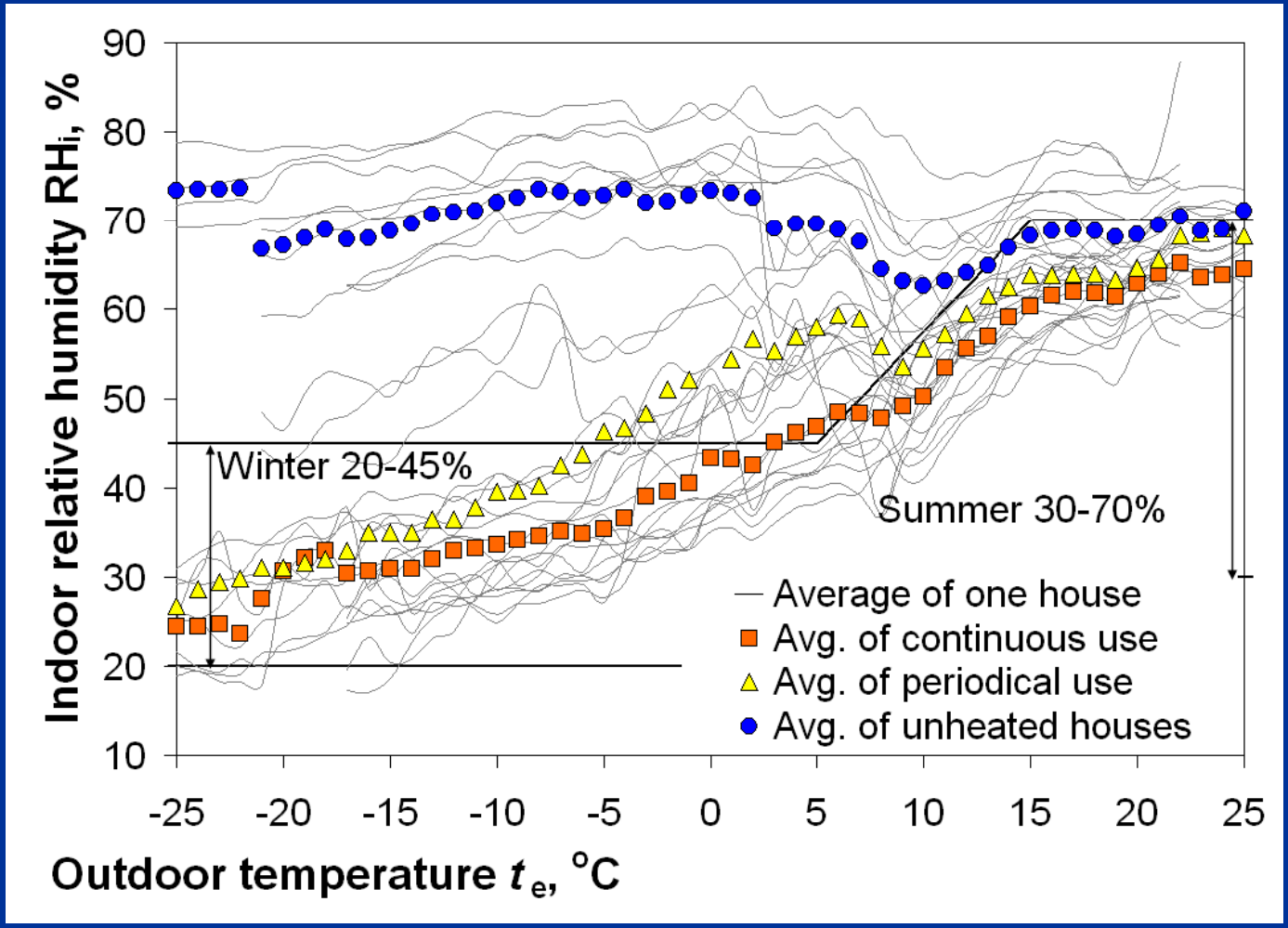
RESULTS

- Indoor relative humidity in continuously heated house



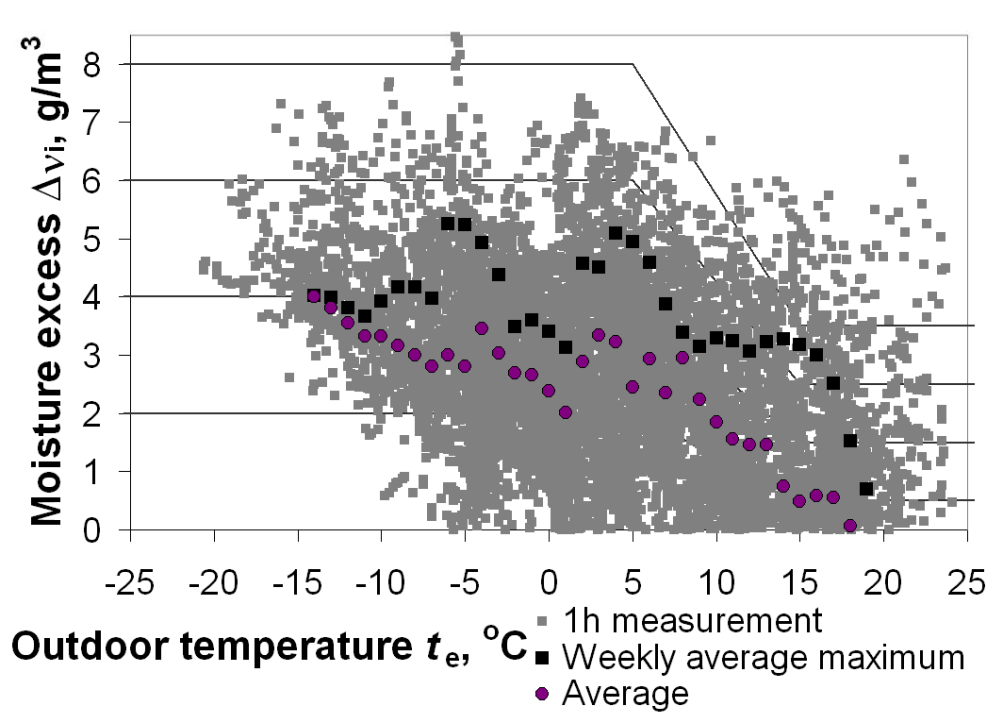
RESULTS

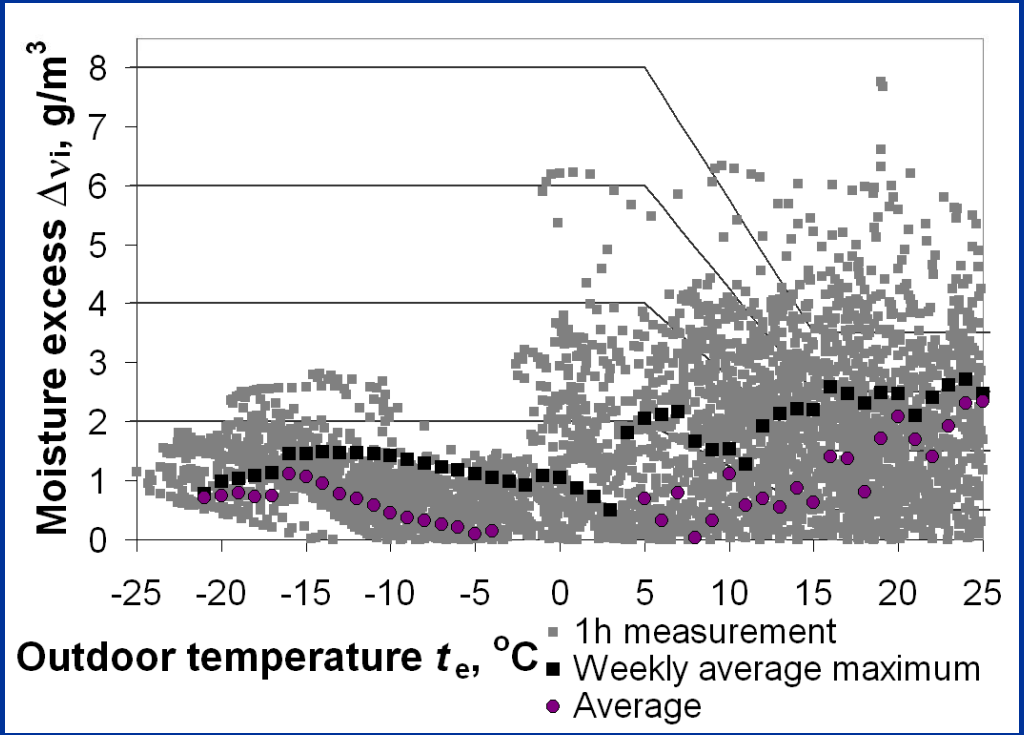
- Indoor relative humidity in all houses



RESULTS

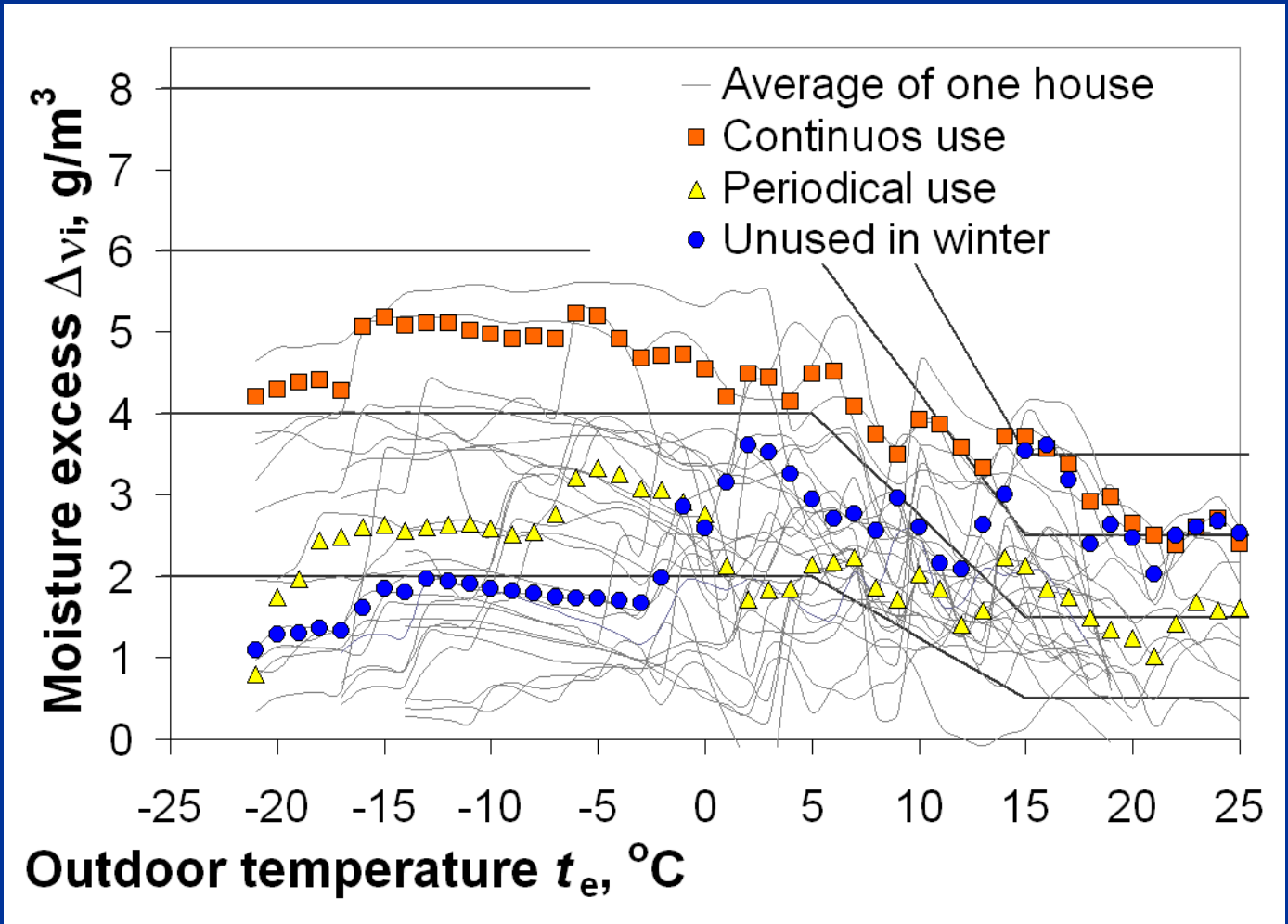
- Moisture excess in:
  - continuously used and heated house
  - in winter unheated-unused house





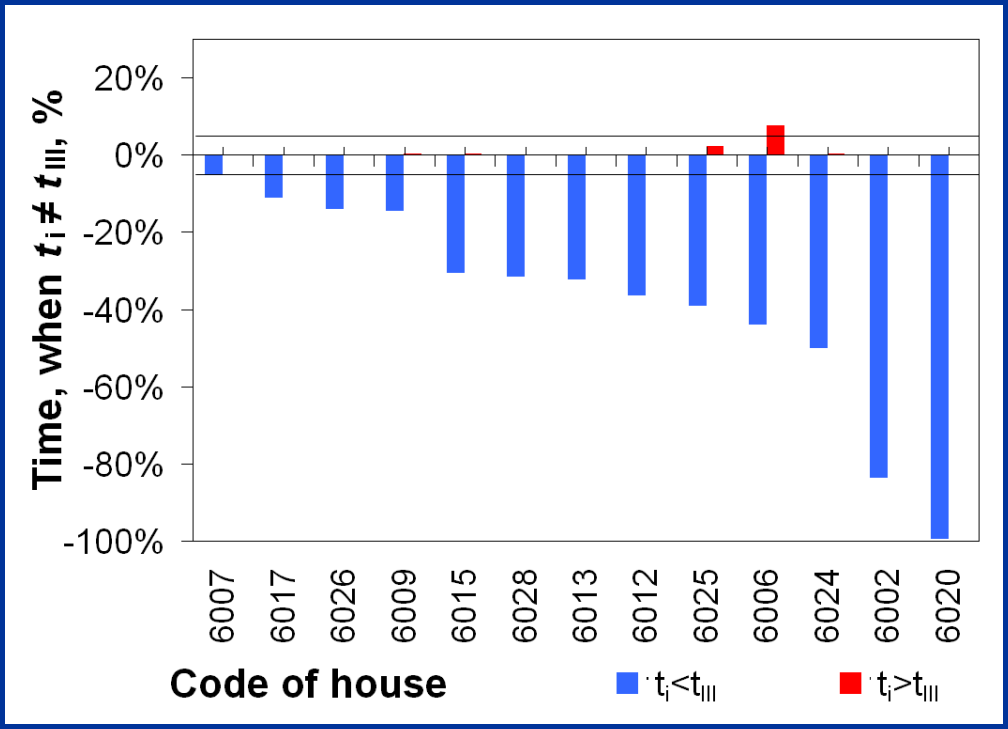
RESULTS

- The maximum weekly average moisture excess: ~5g/m³



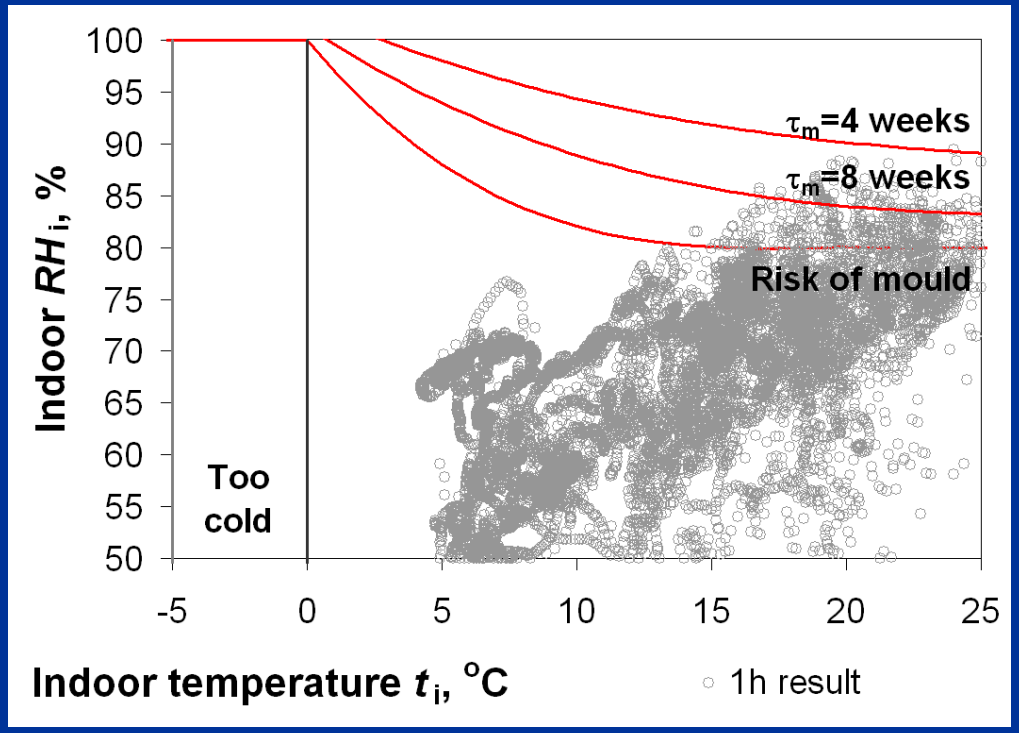
RESULTS

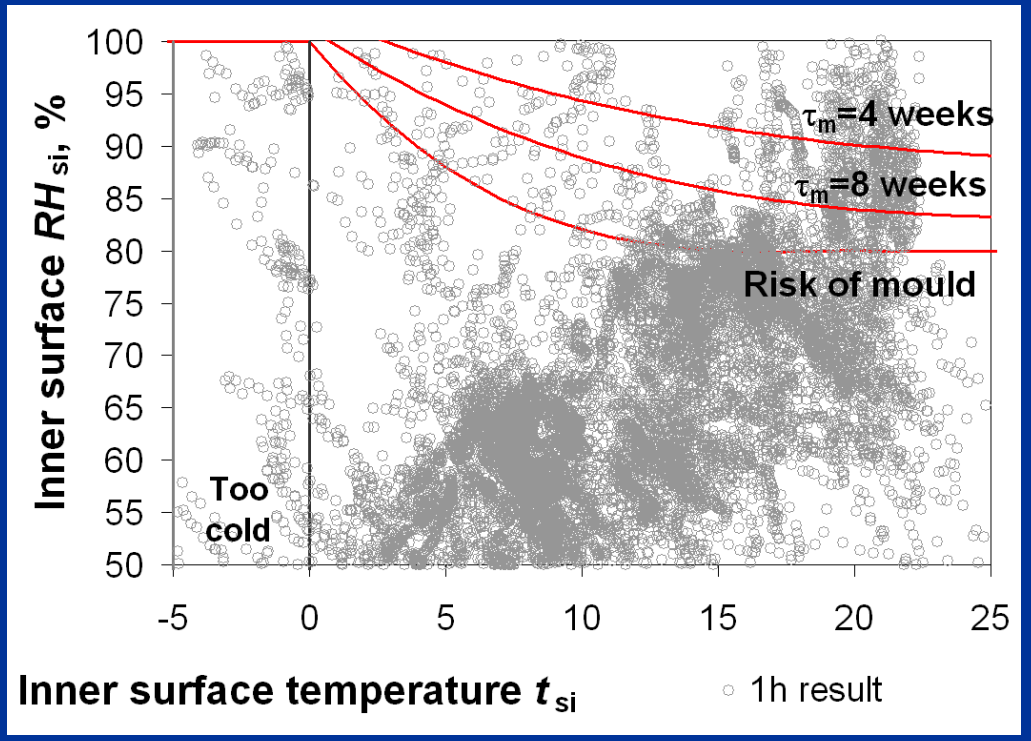
- Cool temperatures
- Reasons of cool temperatures:
  - large heat losses of the house envelope;
  - problems connected with ovens
    - low heating capacity;
    - limited heating time due to ovens' condition;
    - heating is not done properly;
  - residents accept lower indoor temperatures.



RESULTS

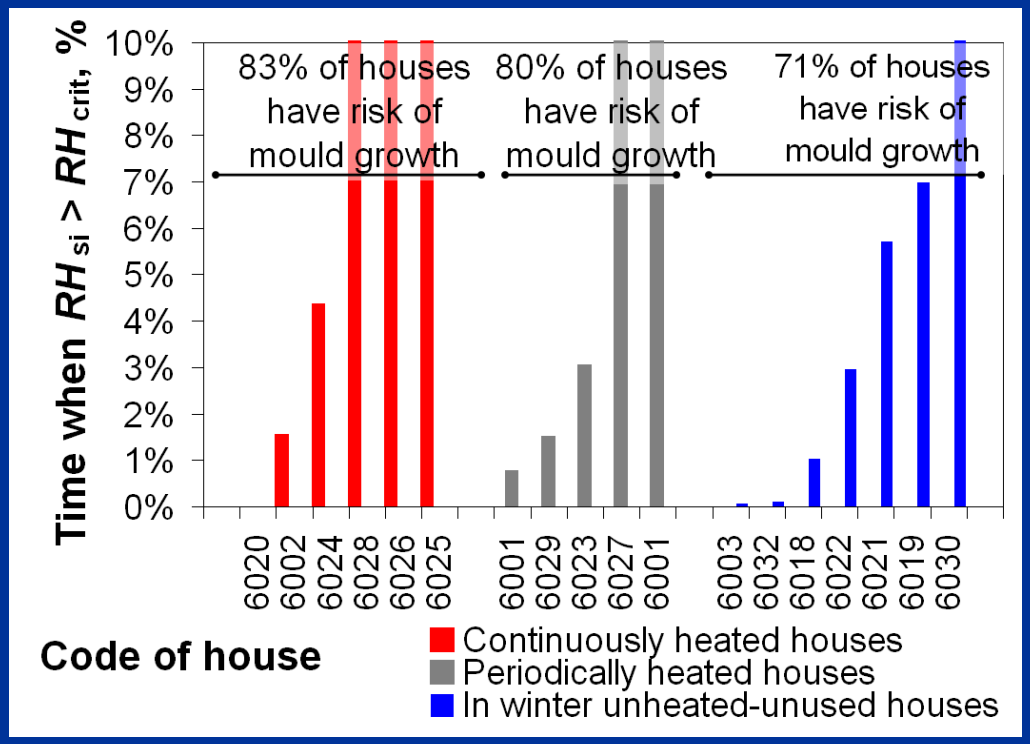
- Risk of mould growth
  - in indoor air
  - on inner surface of first log

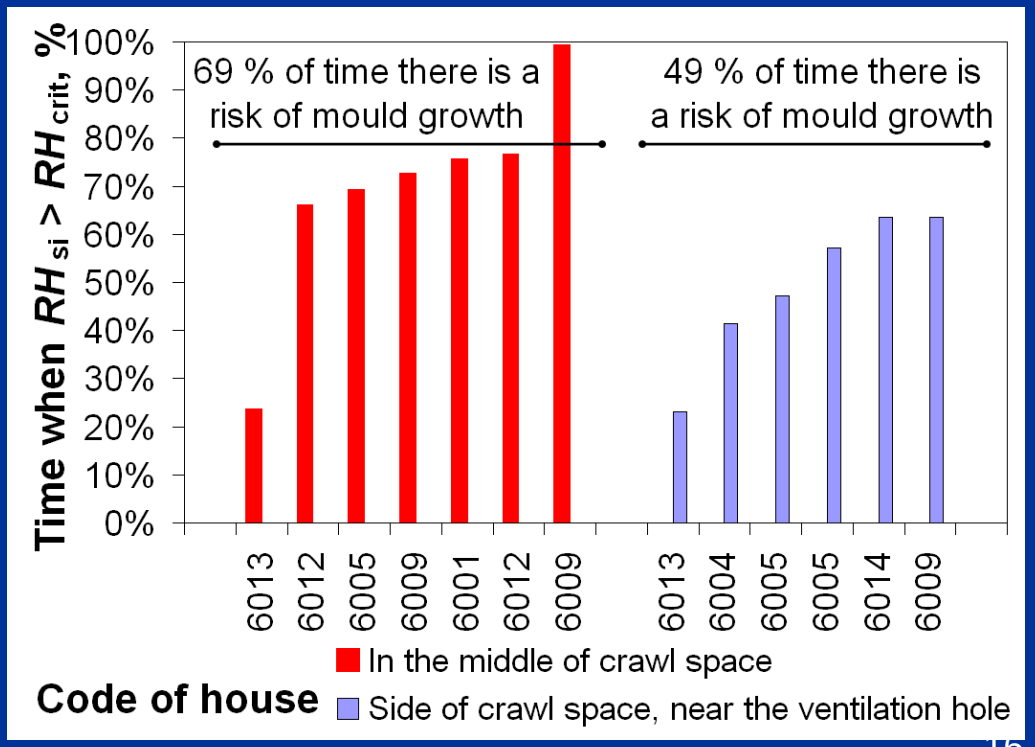




RESULTS

- Time when there is a mould growth risk
  - on inner surface of first log
  - in the crawl space
    - in the middle of crawl space
    - side of crawl space, near the ventilation hole





Conclusion I

- The measured indoor temperatures in continuously heated houses are slightly lower in wintertime when compared to indoor climate standard III category limits.
- RH in continuously and periodically used houses is in the range of target values
- RH in winter unheated-unused houses is significantly higher than target values
  - RH levels also high in periodically used houses when not used
  - Option to heat the house througout the winter based on humidistat
  - Studies needed in houses which are unused during wintertime, but continuously heated to the desired humidity level

Conclusion II

- Weekly maximum moisture excess in wintertime
  - in continuously heated houses 2.5-5.7 g/m^3
  - in periodically heated houses 0.5-2.5 g/m^3
  - in winter unheated-unused houses 0.5-2.0 g/m^3
- Design value of moisture excess in wintertime ~4…5g/m^3, similar in continuously and periodically used houses
- Risk for mould growth:
  - Indoor air in >80% of unheated and periodically heated houses.
  - >80% on inner surface of the first log because of the high RH wall surface.
  - In every crawl space because of a lack of air change.