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The m-model: a method to assess the risk for mould growth in wood structures with fluctuating hygrothermal conditions

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Åse Togerö, Charlotte Svensson Tengberg, Bengt Bengtsson
Skanska Sweden

It started 2008…

… when Building Physics at Skanska Teknik decided to start working with moisture safety design in the way that the Swedish building regulations (BBR) stated –

1. Define well researched critical moisture levels for sensitive materials, and
2. compare these with actual conditions from measurements and moisture calculations to find good design solutions.

We interpreted the BBR regulations as: – The climate conditions in wood structures must not be such that the Viitanen mould index 1 is optained, i.e. that mould growth is initiated.

Table 1: Mould growth index for the experiments and modelling

Index	Growth rate	Description
0	No growth	Spores not activated
1	Small amounts of mould on surface (microscope)	Initial stages of growth
2	<10% coverage of mould on surface (microscope)	
3	10-30% coverage mould on surface (visual)	New spores produced
4	30-70% coverage mould on surface (visual)	Moderate growth
5	> 70% coverage mould on surface (visual)	Plenty of growth
6	Very heavy and tight growth	Coverage around 100%

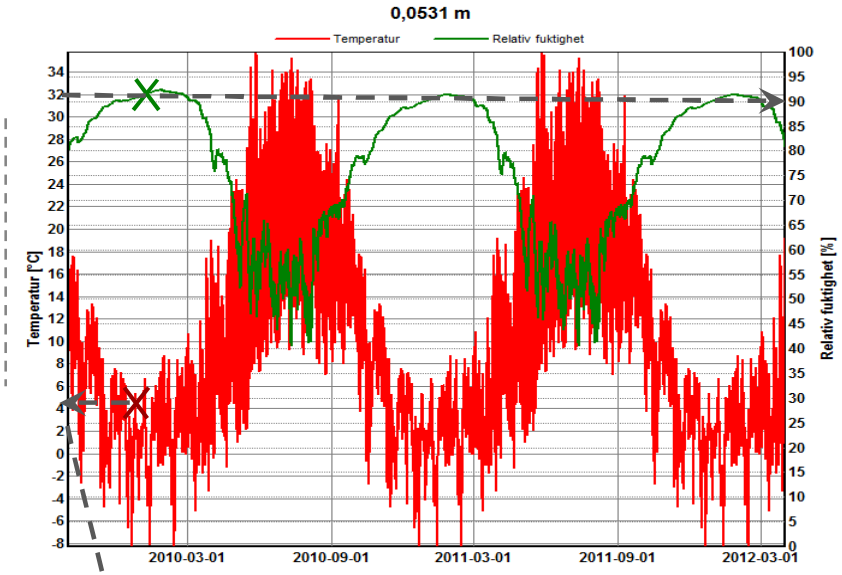
We developed a tool for being able to tell if and when the risk is high for mould initiation, from hygrothermal indata on an hourly basis: the m-model.

WoodBuild:

Mould growth index 1 should not occur, i.e. mould growth must not be initiated.

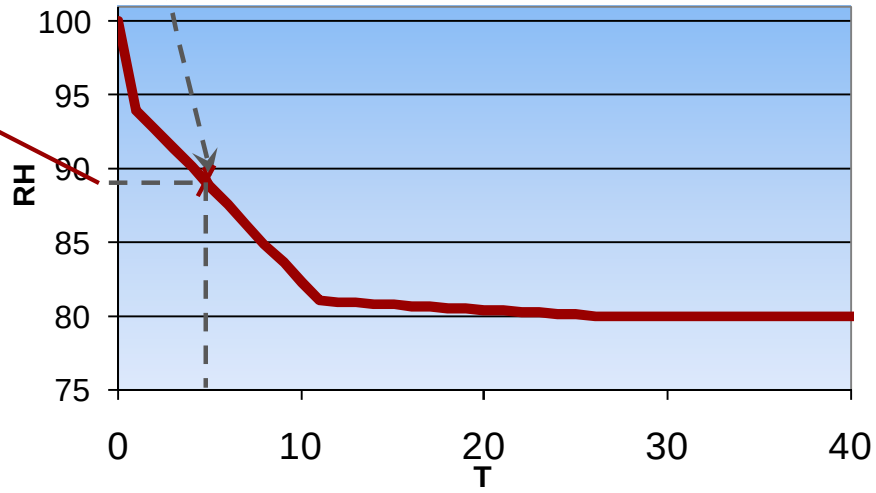
the first step in the m-model:

$$m = \frac{RH_{act}(t)}{RH_{crit}(T(t))}$$



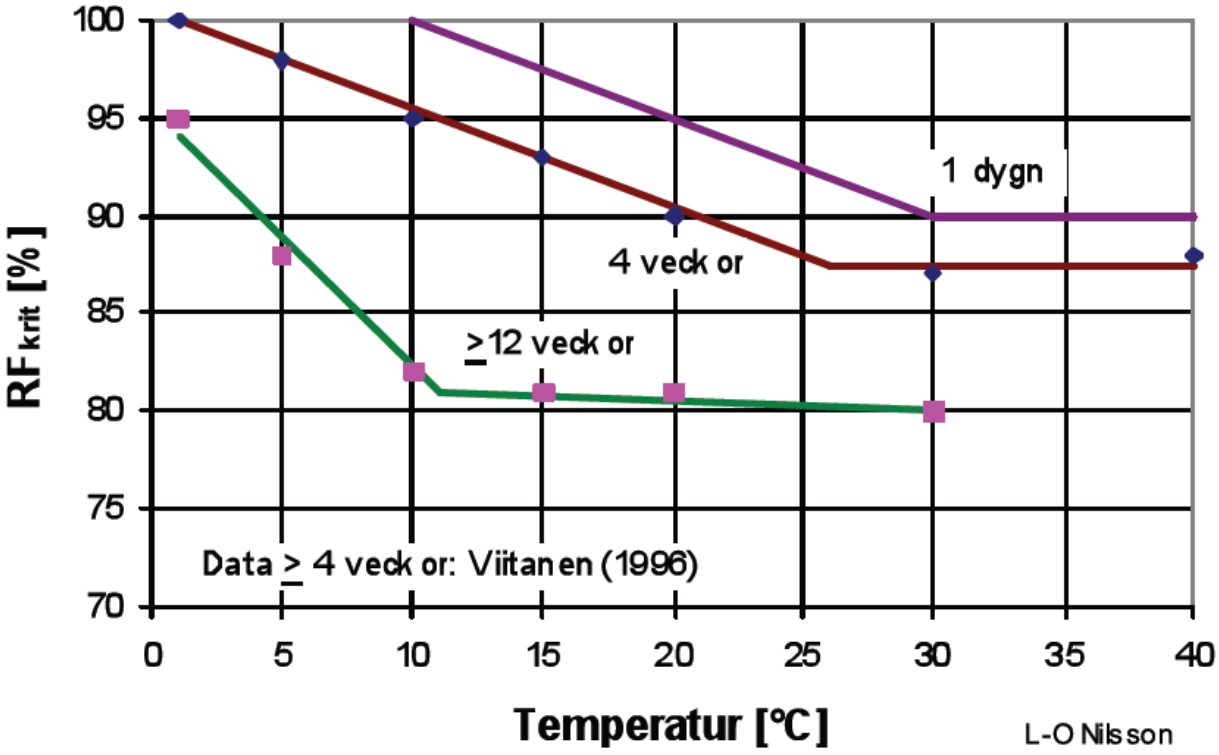
We thouht we invented this m, but no! In 2008, Hagentoft et al published a paper and introducing the mould growth potential!

One small difference: definition of RH_{crit}

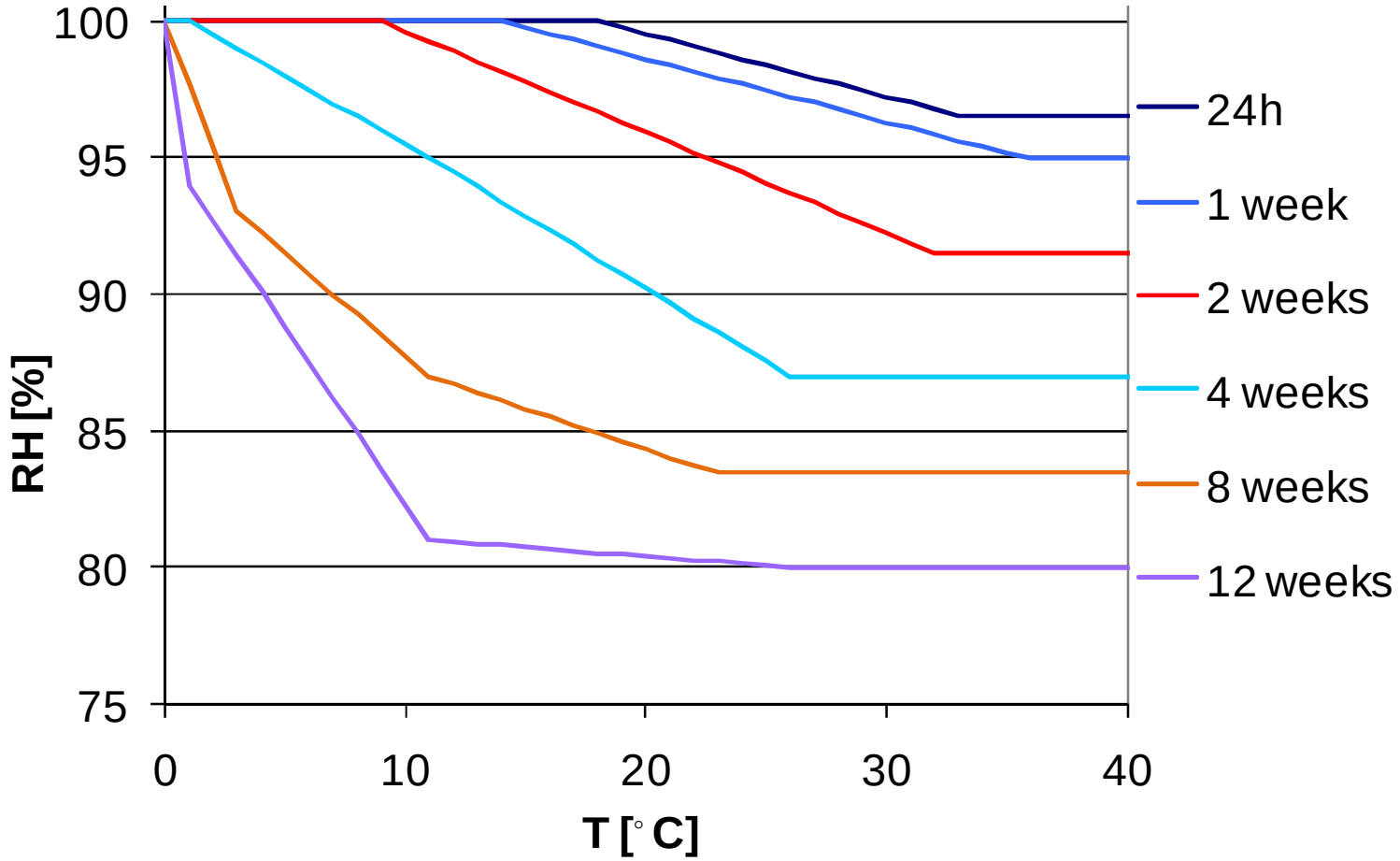


Advice from WoodBuild

- Use relations for critical moisture levels/ durations from the work of Dr Hannu Viitanen:



Laboratory data from Viitanen (1996) gave six critical relations RH_{crit} (T) for six durations, i.e. six mathematical expressions



The m-model

- Calculates the accumulated risk time and the time with unfavourable conditions in parallell, on an hourly basis, during max. 4 years
- Models the behaviour and the process of mould initiation
- When conditions change from favourable to unfavourable:
  - Stand-by behaviour meanwhile ”waiting” for better conditions
  - Regression in case the unfavourable condition continues
  - Total reset of the initiation process if the conditions do not get favourable within a certain time
- The regression rules are different depending on the conditions: i.e. a rapid initiation process will have a specific regression imitating what can be observed in Viitanen (1995)
- The regression is not a constant but depending on how unfavourable the new conditions are.

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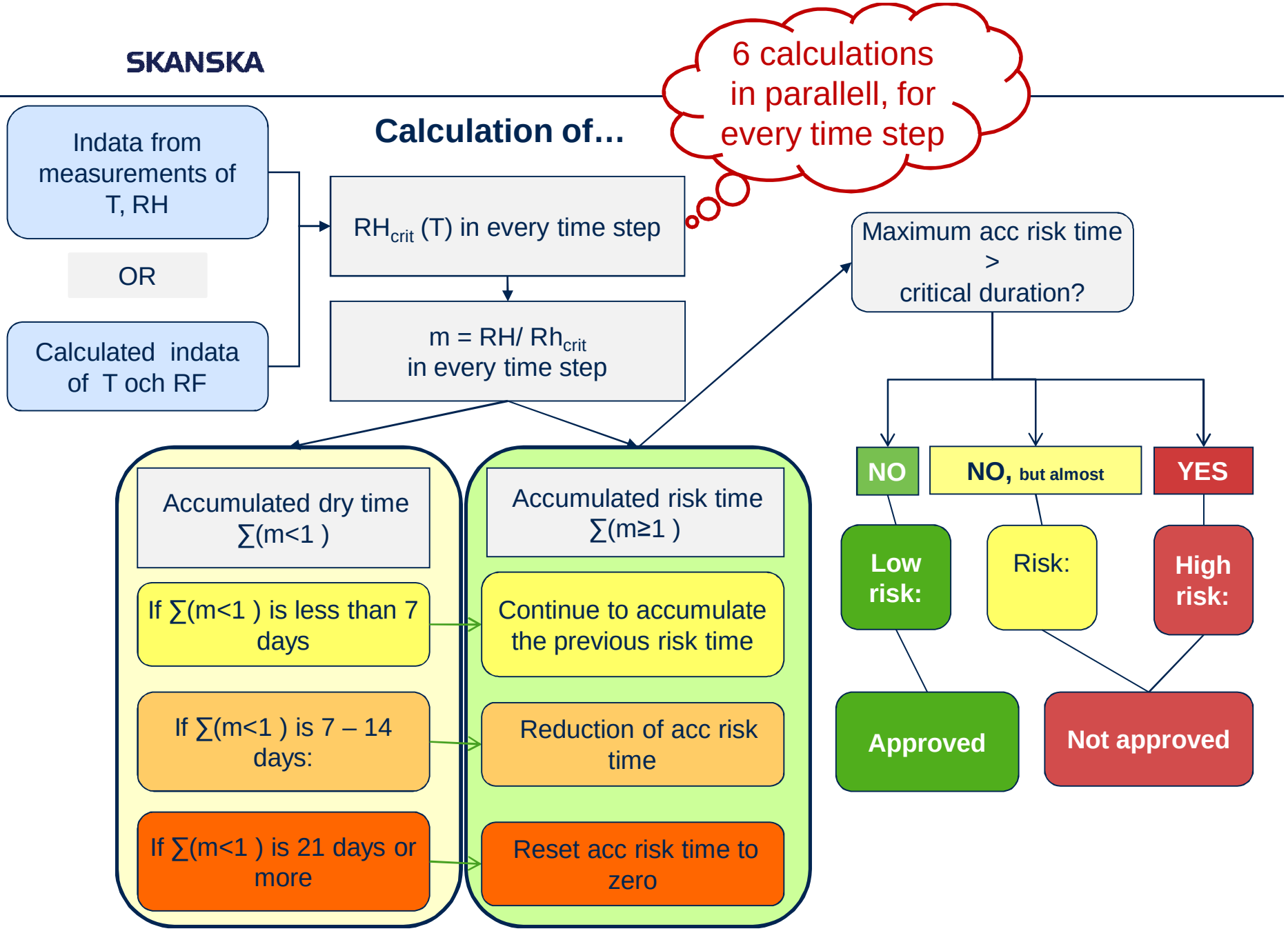
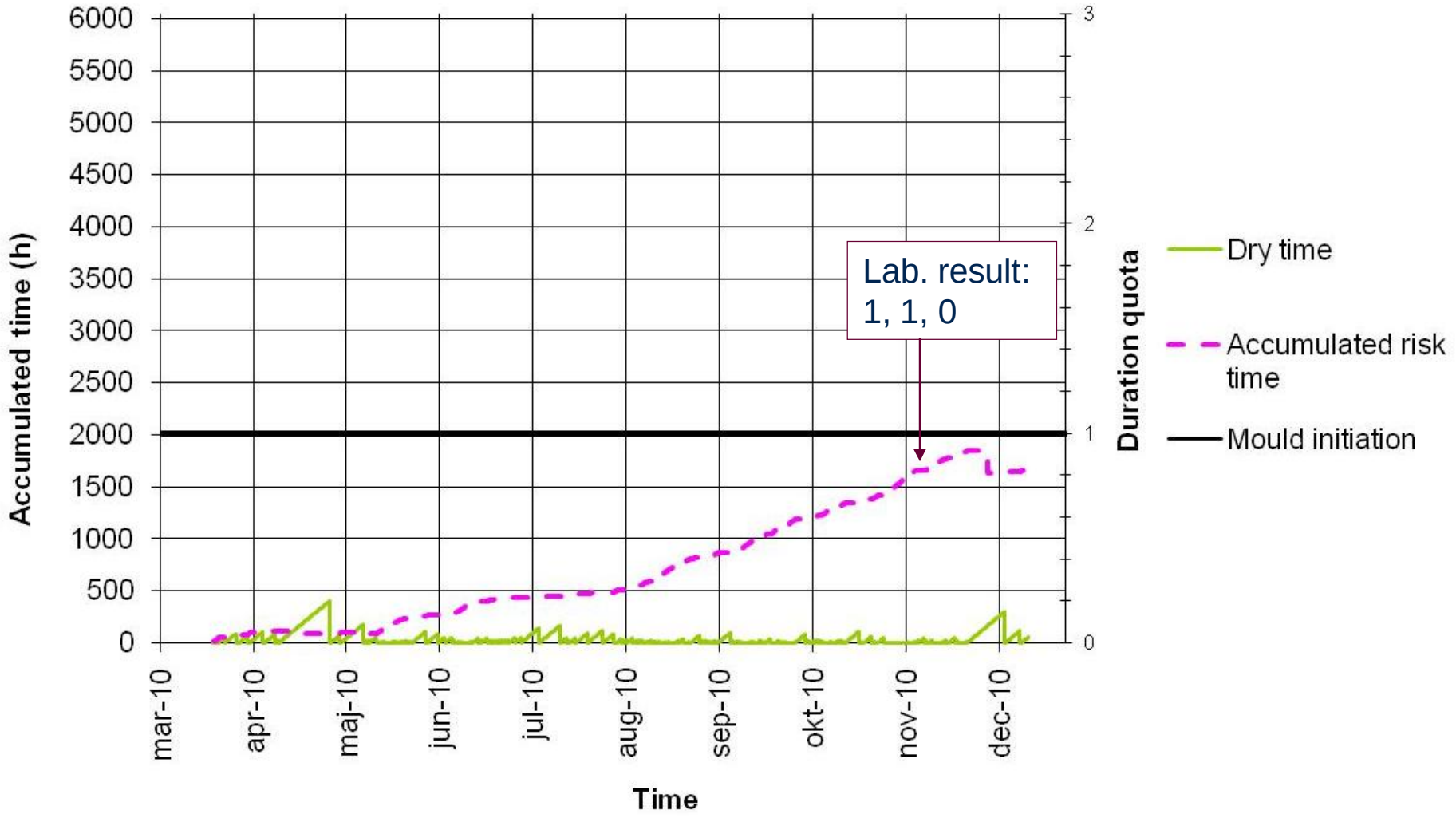

6 calculations in parallell, for every time step
Calculation of…
Indata from measurements of T, RH
OR
Calculated indata of T och RF
RHcrit (T) in every time step
m = RH/ Rhcrit in every time step
Maximum acc risk time > critical duration?
NO
NO, but almost
YES
Low risk:
Risk:
High risk:
Approved
Not approved
Accumulated dry time ∑(m<1)
If ∑(m<1) is less than 7 days
If ∑(m<1) is 7 – 14 days:
If ∑(m<1) is 21 days or more
Accumulated risk time ∑(m≥1)
Continue to accumulate the previous risk time
Reduction of acc risk time
Reset acc risk time to zero

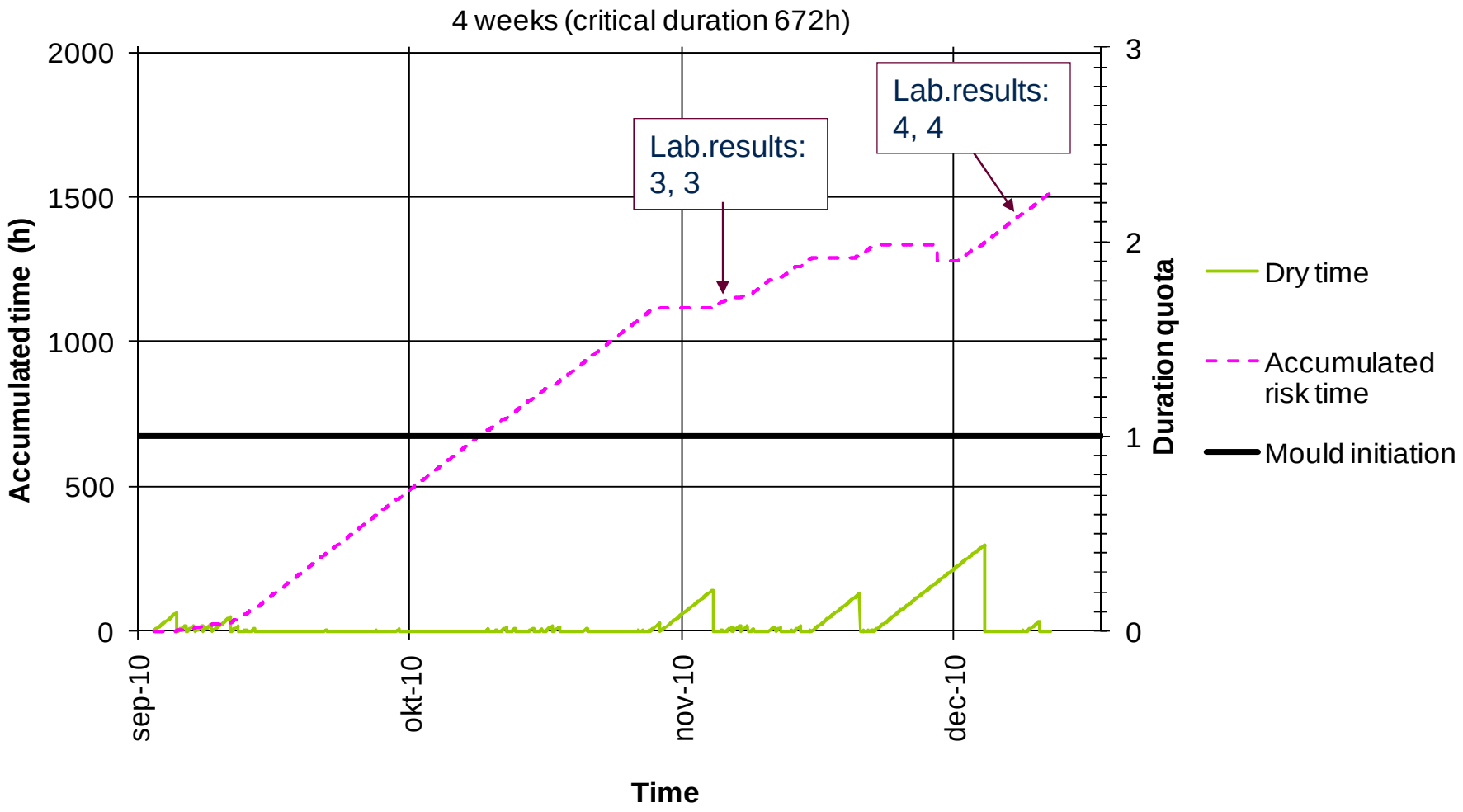
Evaluation of the m-model

- Planed pieces of pine (sapwood) mounted in 8 attics, one carport and in one mini-house. Start in March 2010 / September 2010 (mini-house)
- Measued climate with calibrated Testo loggers.
- Mould analyses carried out by SP in June, November and for the mini-house also in December 2010.
- The mini-house was intended to give us a guaranteed mould growth: not heated, no floor, humid grounds, no condensate.

Calculations and lab results from carport



m-model calculation of ”mini house”

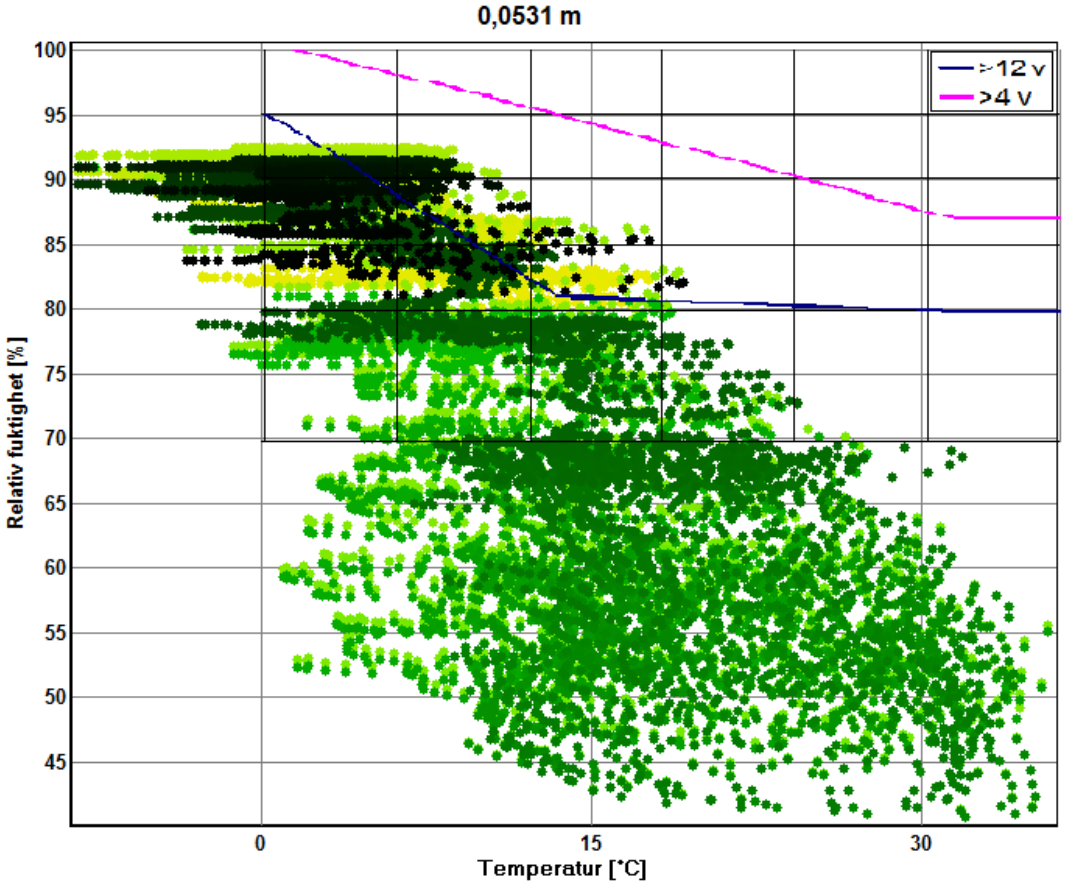


Version 4 – effects of low temperatures

- New version has the possibility to specify a regression behaviour during low temperatures
  - for example longer stand-by and regression times with unfavourable (cold) conditions before the initiation totally stops.
- Data is much appreciated!

The same results viewed as RH/temp-isoplets in relation to critical moisture limits according to WoodBuild/Viitanen

Duration?
Fluctuations?
Cold weather?
”Stand-by”?
”Reset”?



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Thank you for listening!

m = RH/RH$_{crit}$ over time

back