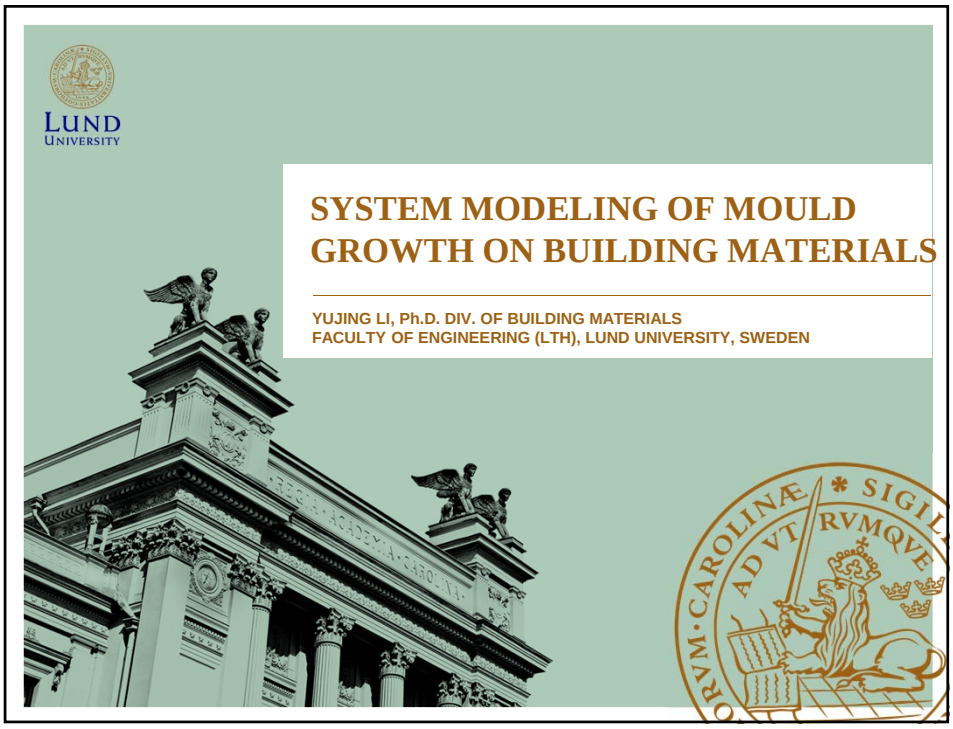

Major challenge

Modelling **HOW**

MOULD grown on

building **MATERIALS**

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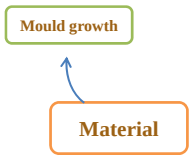
Fundamentals behind: How does mould grow?



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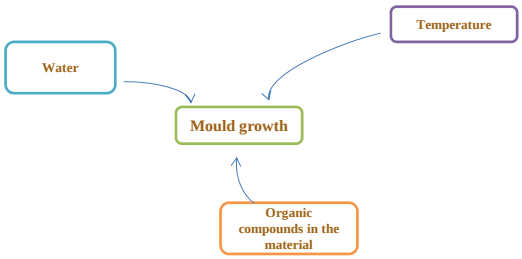
Fundamentals behind: How does mould grow



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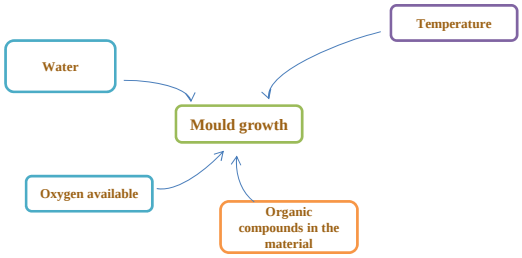
Fundalmentals behind: How does mould grow



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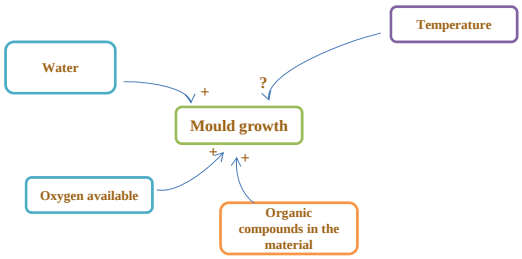
A Causal Loop Diagram (CLD)



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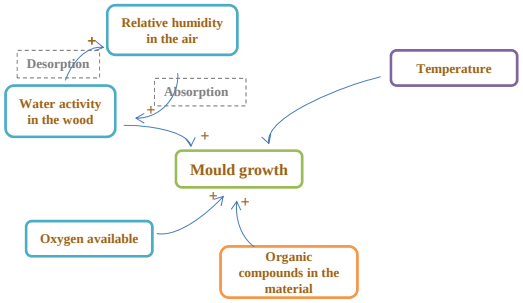
A Causal Loop Diagram (CLD)



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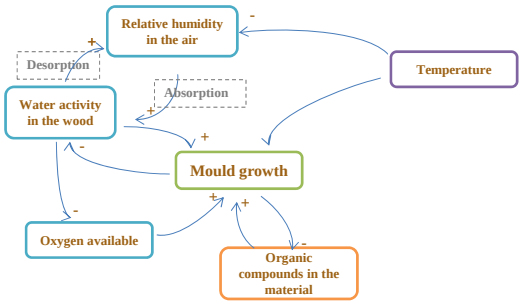

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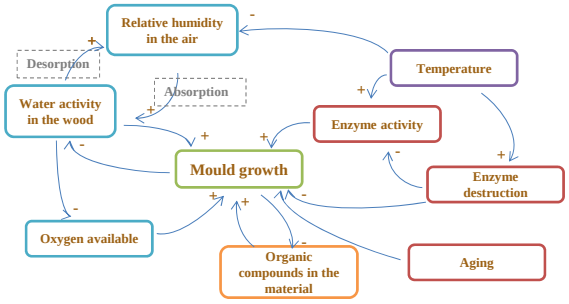
A Causal Loop Diagram (CLD)



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Modelling...

Can we put **ALL** together?

System analysis &
System dynamic modelling

- Building Biology Group, LTH, Lund University
  www.byggnadsmaterial.lth.se
- Applied Systems Analysis & System Dynamics (ASASD) Group, Lund University
  www.lth.se/asasd

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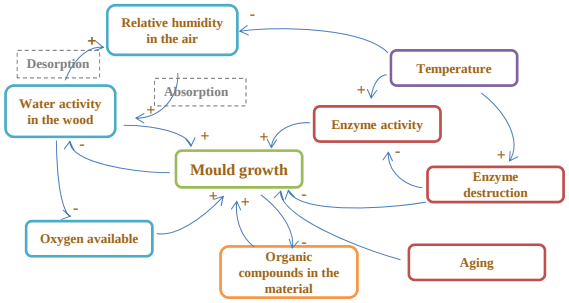

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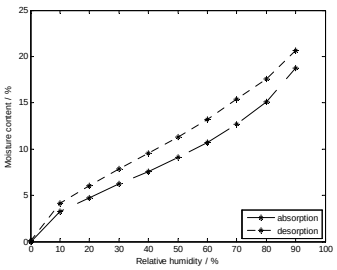
Materal's moisture simulation

Desorption and Adsorption

$$m_{wv,s} = \frac{hD}{R \times T}\left(P_{wv,w} - P_{wv,a}\right)$$

$m_{wv,s}$:	water vapour mass flow rate (kg/m2s)
h_D:	diffusion coefficient
R:	gas constant
T:	temperature
$P_{wv,w}$:	water vapour pressure of the wood
$P_{wv,a}$:	water vapour pressure in the air



The sorption isotherm of wood (air dried spruce sapwood).

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Desorption and Adsorption

$$m_{wv,s} = \frac{hD}{R \times T}\left(P_{wv,w} - P_{wv,a}\right)$$

$m_{wv,s}$:	water vapour mass flow rate (kg/m2s)
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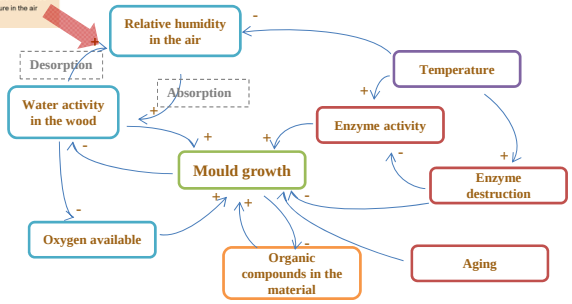

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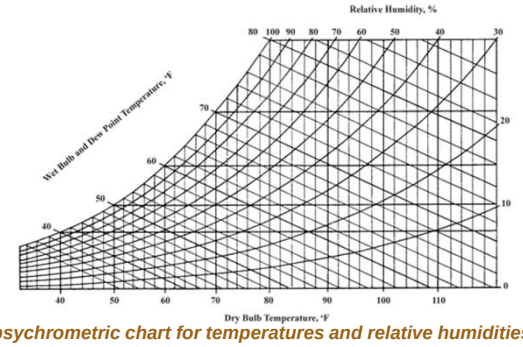
Relative humidity and temperature

$$P_{wv,s} = (1.0007 + 3.46 \times 10^{-6} \times P_a) \times 6.1121 \times e^{\frac{17.502 \times T}{240.97 + T}}$$



Simplified psychrometric chart for temperatures and relative humidities.

Source: University of Nebraska 2008, http://www.ianrpubs.unl.edu/pages/publicationD.jsp?publicationId=1000

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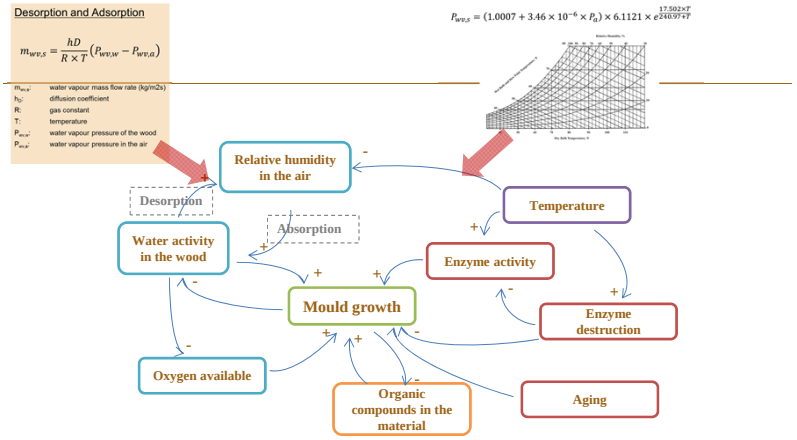


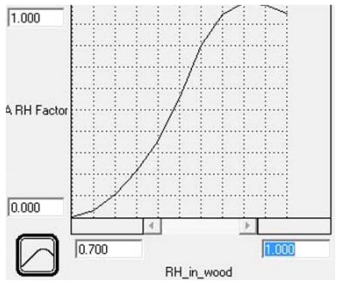


Fig. 3. The factor by relative humidity on mould activity. (Ayerst 1969)

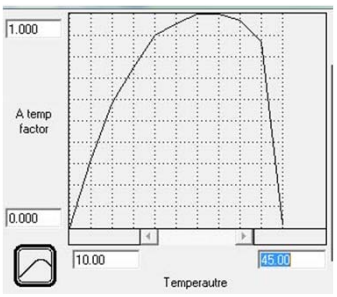
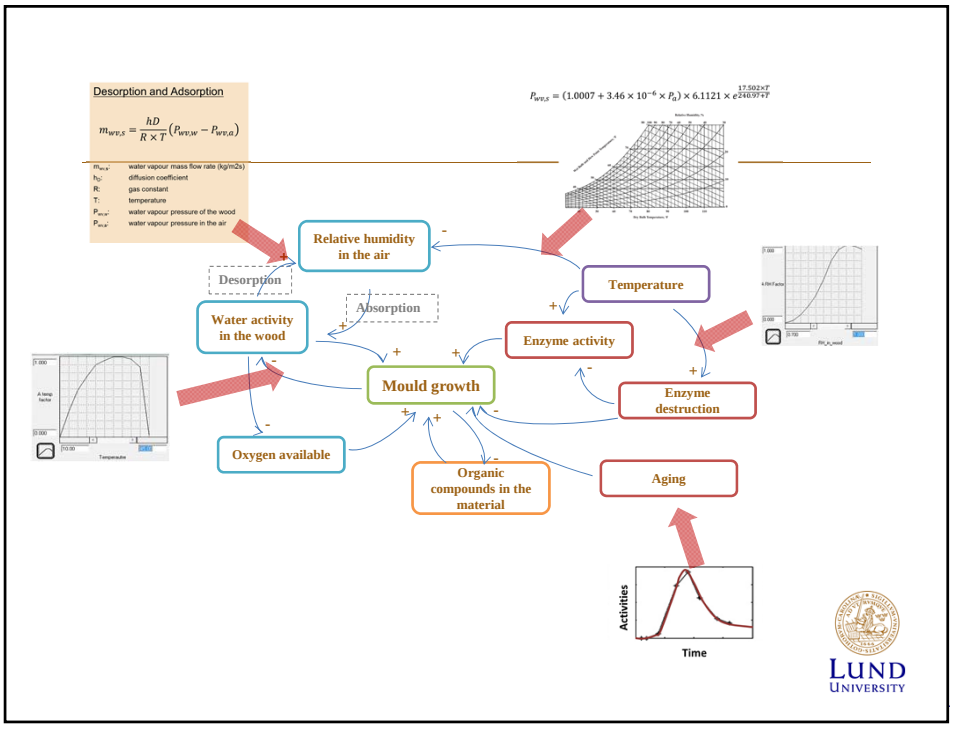
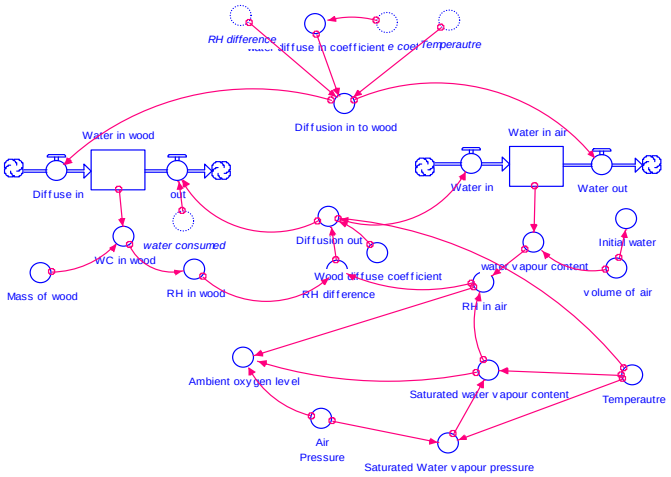


Fig. 4. The temperature factor (Ayerst 1969



Modelling: moisture – material properties



model of water vapour exchange between wood and air, STELLATM V 9.0 (isee systems, inc.)

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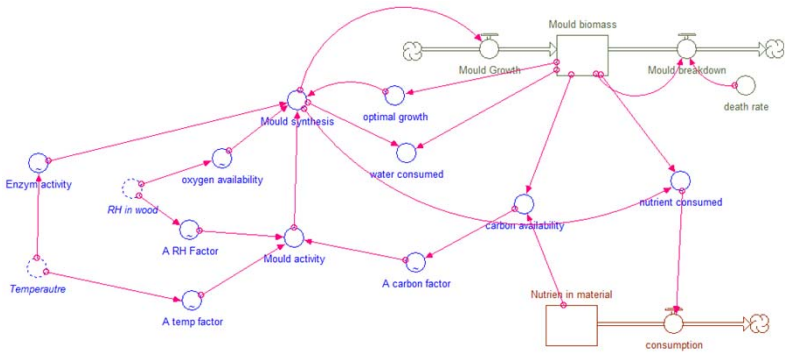
Modelling: mould growing behaviour



model of mould growth with influencing factors, STELLATM V 9.0 (isee systems, inc.)

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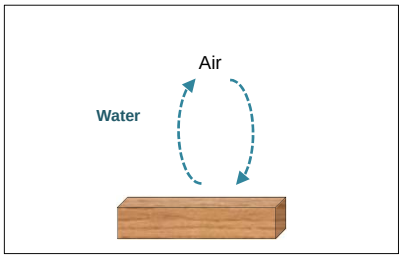
Some simulaiton results – start with...

Mould grown on wood in a closed environment



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Results: Scenario 1 - drying

Initial conditions:

- **RH in the air: 70%**
- **Water content in wood: 0.3**
- **Temperature: 20° C (constant)**

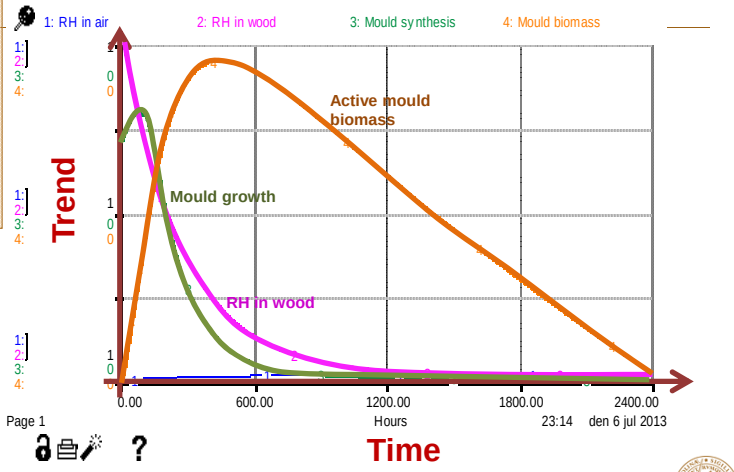

Fig. 5-1. The development of mould growth on wood during wood drying

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Results: Scenario 1 - drying

Initial conditions:

- **RH in the air: 70%**
- **Water content in wood: 0.3**
- **Temperature: 20° C (constant)**

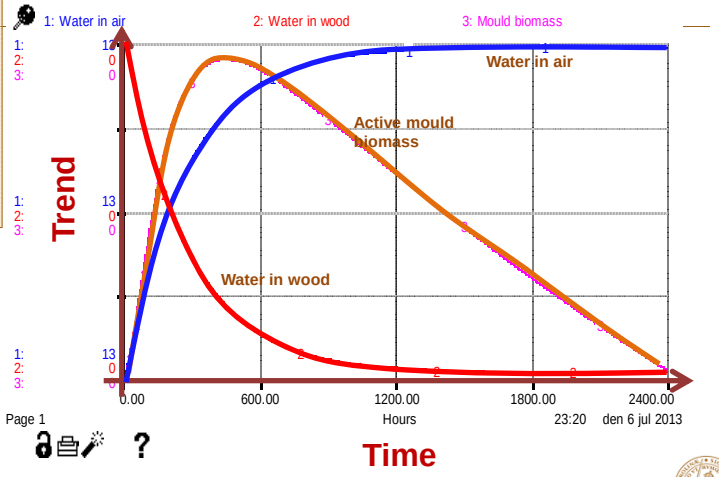

Fig. 5-2. The development of mould growth with moisture content changes

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Scenario 2 - wetting

Initial conditions:

- **RH in the air: 90%**
- **Water content in wood: 0.16**
- **Temperature: 20° C (constant)**

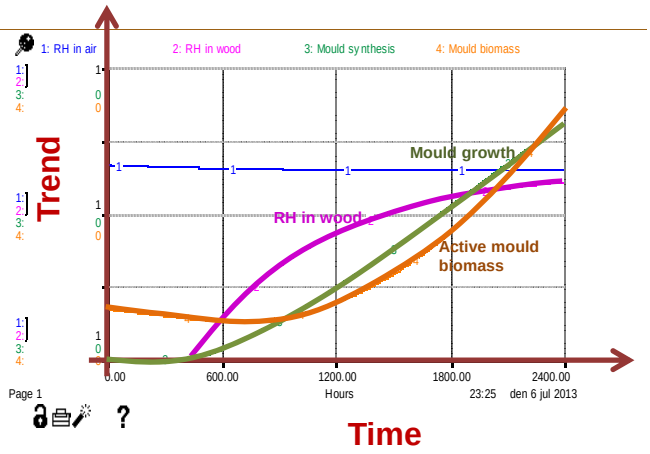

Fig. 6. The development of mould growth on wood during wood wetting

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Scenario 3 – fluctuating temperature

Initial conditions:

- **RH in the air: 70%**
- **Water content in the wood: 0.3**
- **Temperature varying between 20° C (noon time) and 10° C (night)**

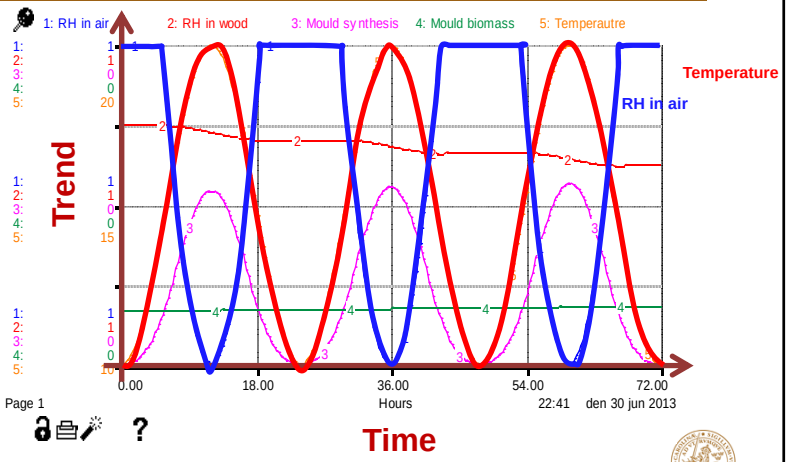

Fig. 5. The development of mould synthesis with varying temperature changes

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Scenario 3 – fluctuating temperature

Initial conditions:

- **RH in the air: 70%**
- **Water content in the wood: 0.3**
- **Temperature varying between 20° C (noon time) and 10° C (night)**

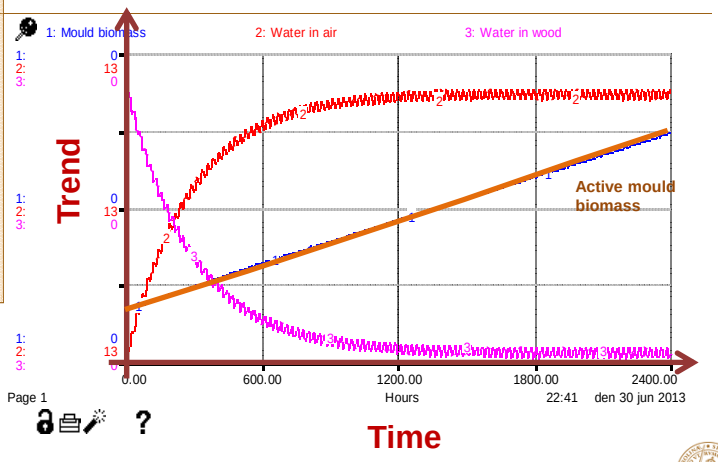
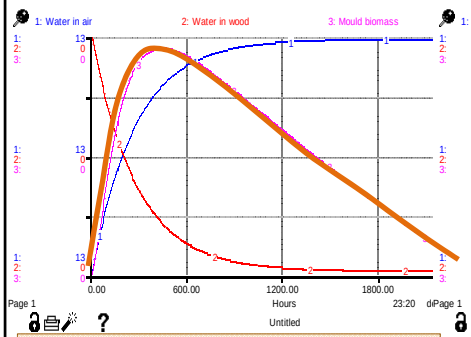
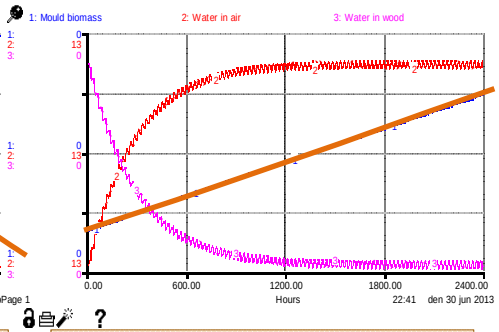


Fig. 6. The development of mould biomass with varying temperature changes



Initial conditions:

- **RH in the air: 70%**
- **Water content in wood: 0.3**
- **Temperature: 20° C (constant)**



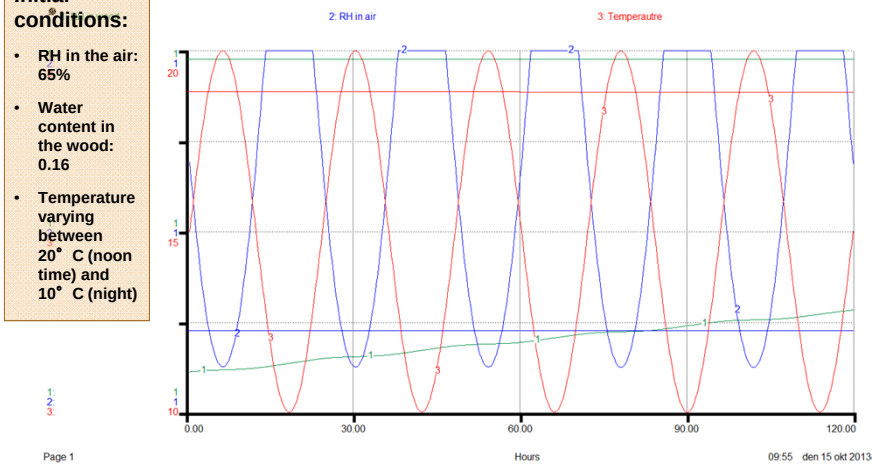
Initial conditions:

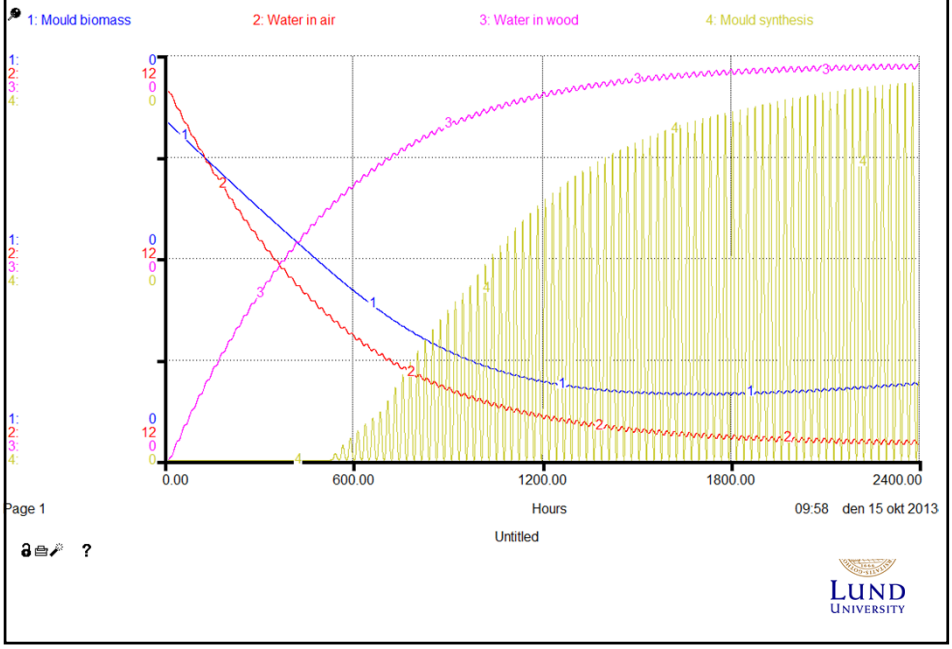
- **RH in the air: 70%**
- **Water content in the wood: 0.3**
- **Temperaturevarying between 20° C (noon time) and 10° C (night)**

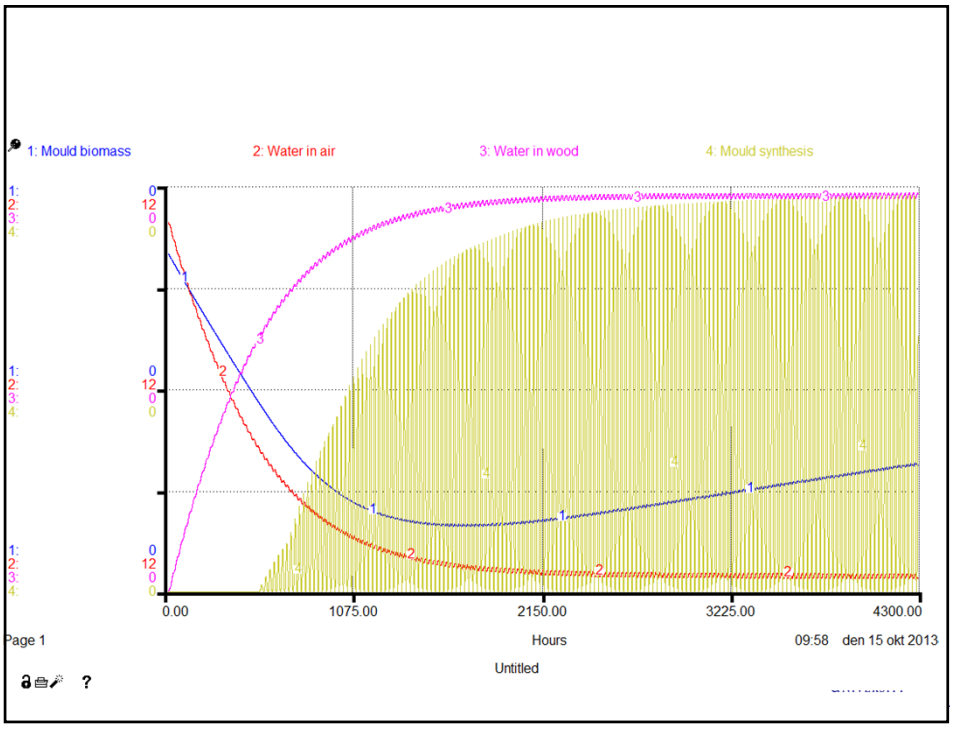
Scenario 4 – longer period

Initial conditions:

- **RH in the air: 65%**
- **Water content in the wood: 0.16**
- **Temperature varying between 20° C (noon time) and 10° C (night)**







Conclusion

- it is called a conceptual model for the moment
- It is possible to combine the material properties and the mould behaviour into modelling
- The temperature variation has significant impact on mould growth

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Thank you for your attention!

Fundamental reasons behind

Physical parameters
(temp. RH, etc.)

Materials

Mould on material

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