The use of COMSOL to explore flooding and rising water problems related to heritage

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Where innovation starts

Content

Introduction

St. Catherine's Chapel Lemiers, The Netherlands

Wall paintings

Moisture problems

HAMBase simulations indoor climate

Comsol simulations water uptake

Conclusions

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St. Catherine's Chapel Lemiers

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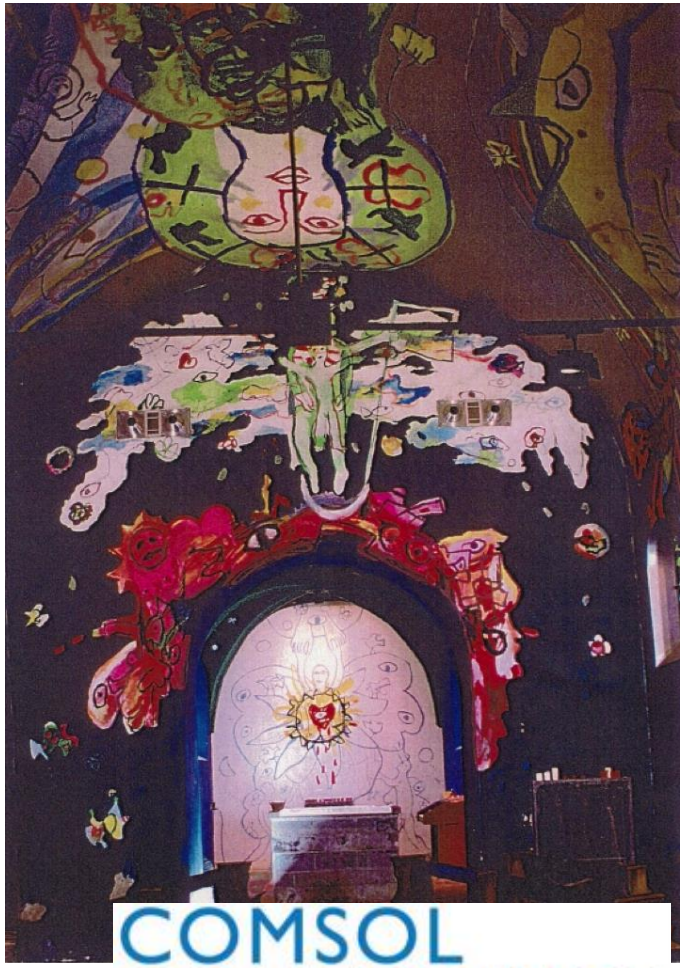
Wall paintings



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Moisture problems

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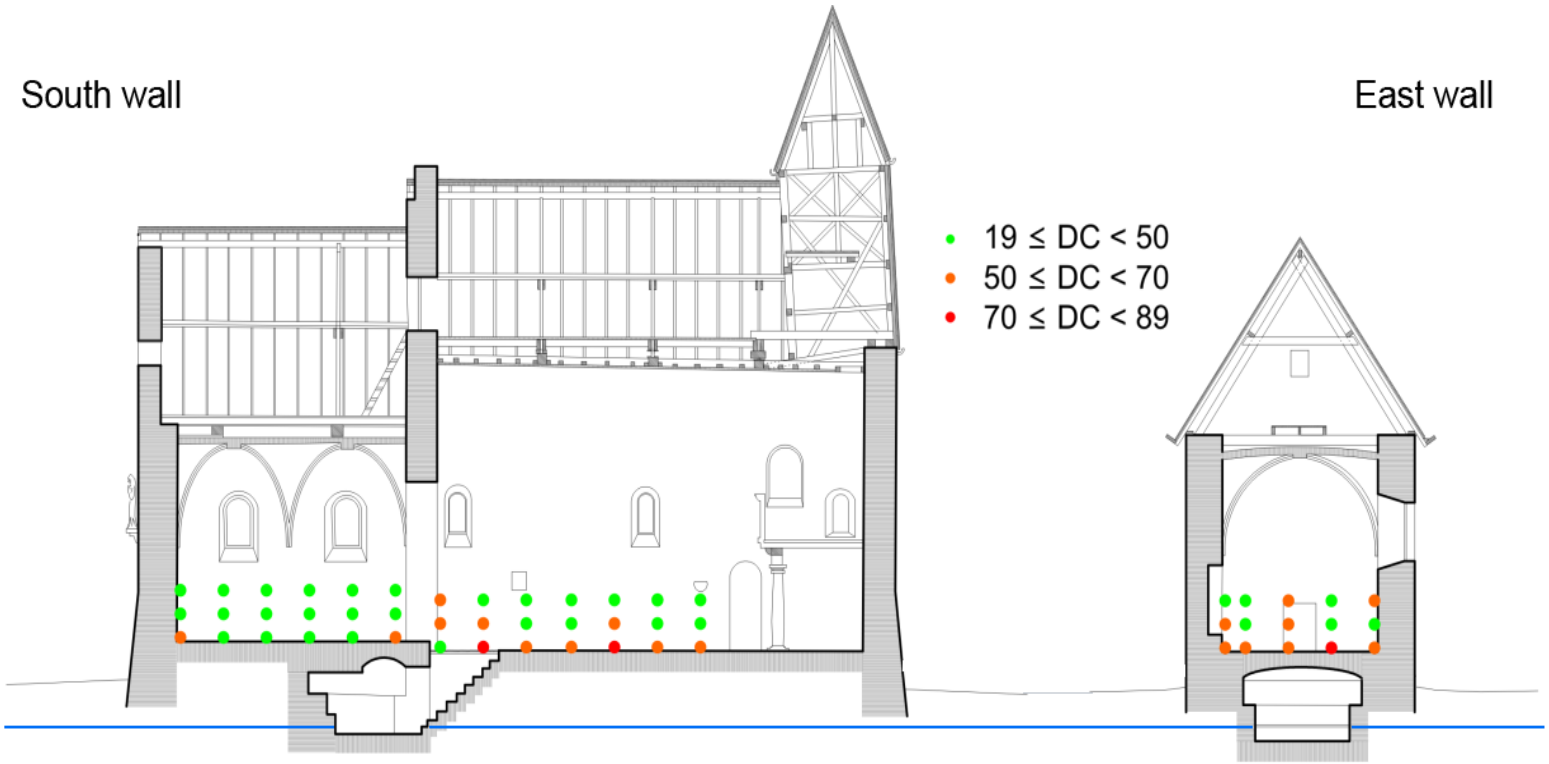
Moisture content measurements



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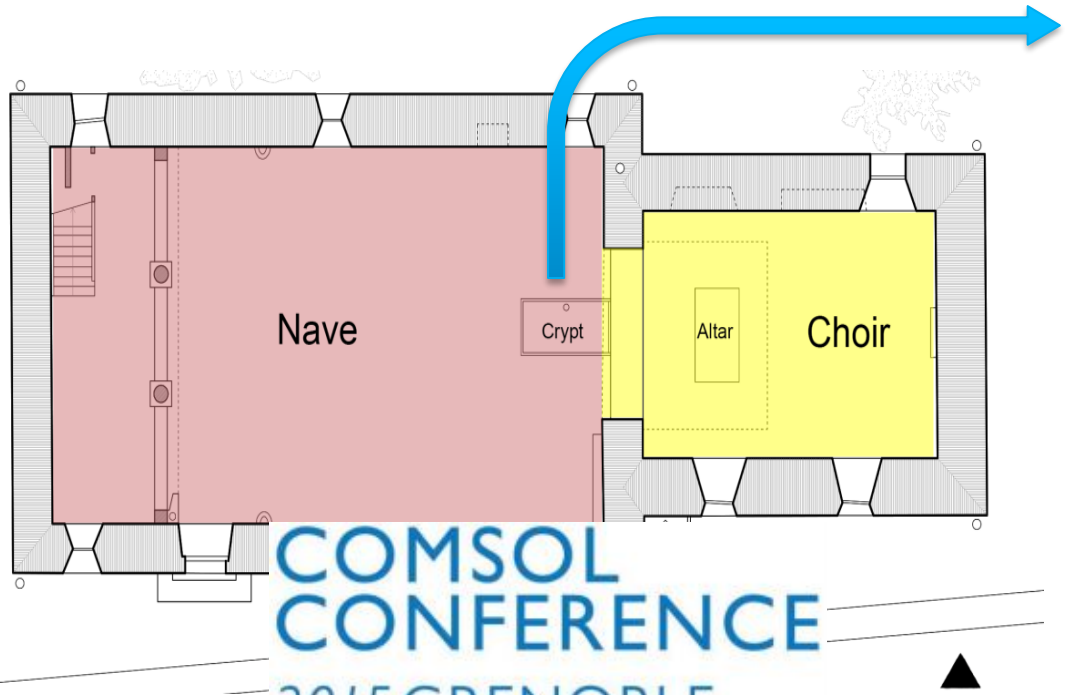
Water in crypt



Crypt

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Flooding of creeks nearby

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Restoration of the wall paintings

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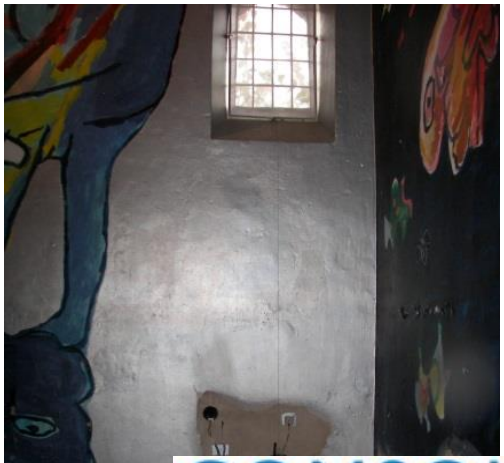
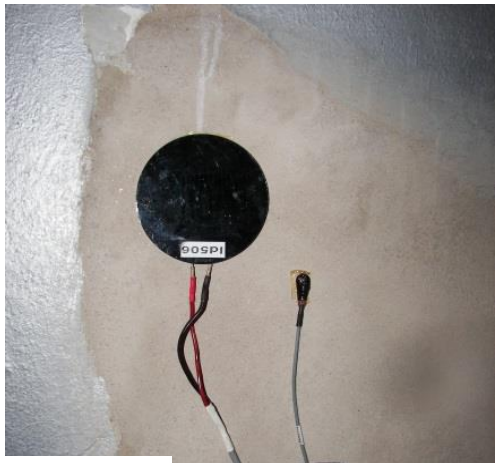
Continuous measurements





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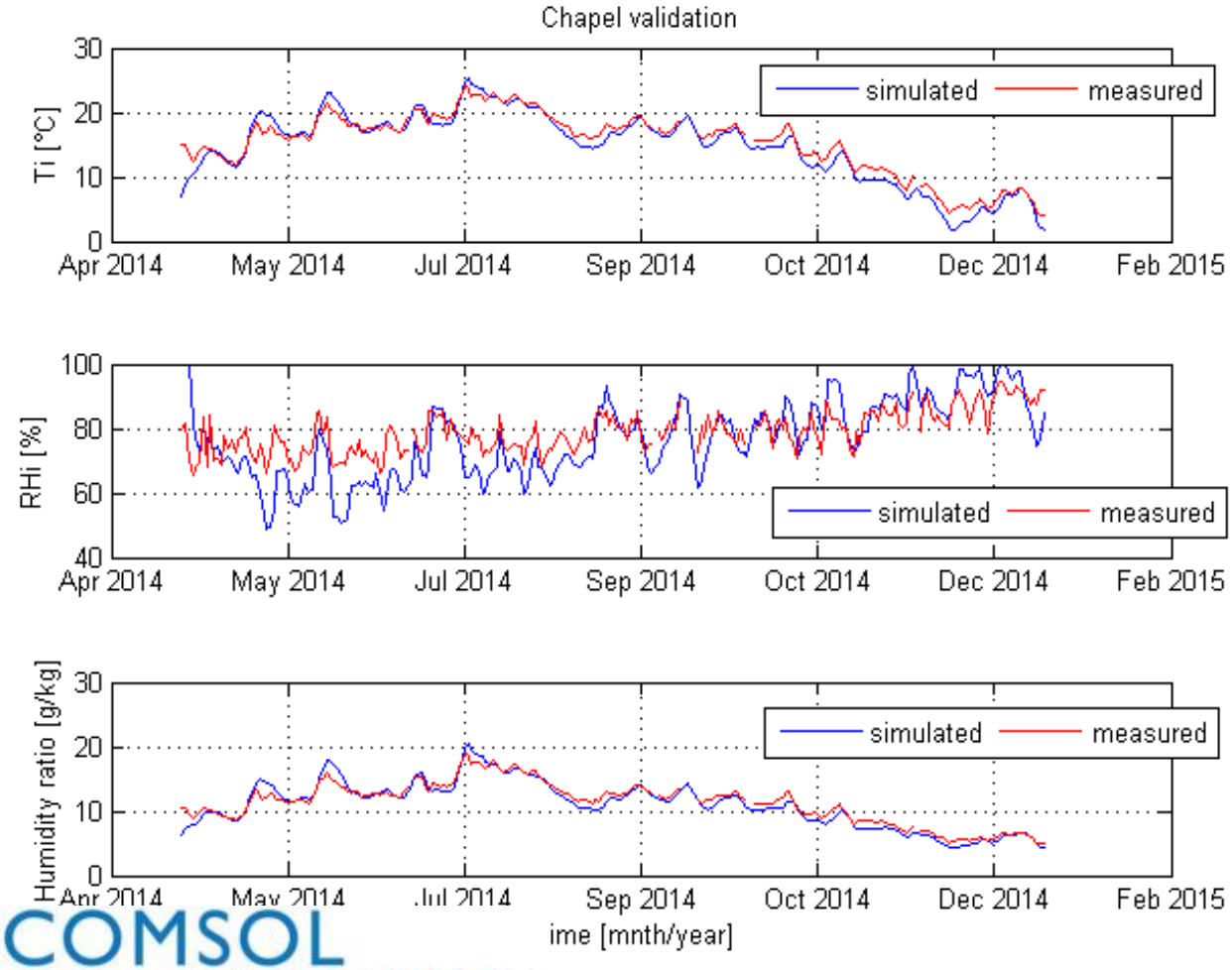
HAMBase simulations indoor climate



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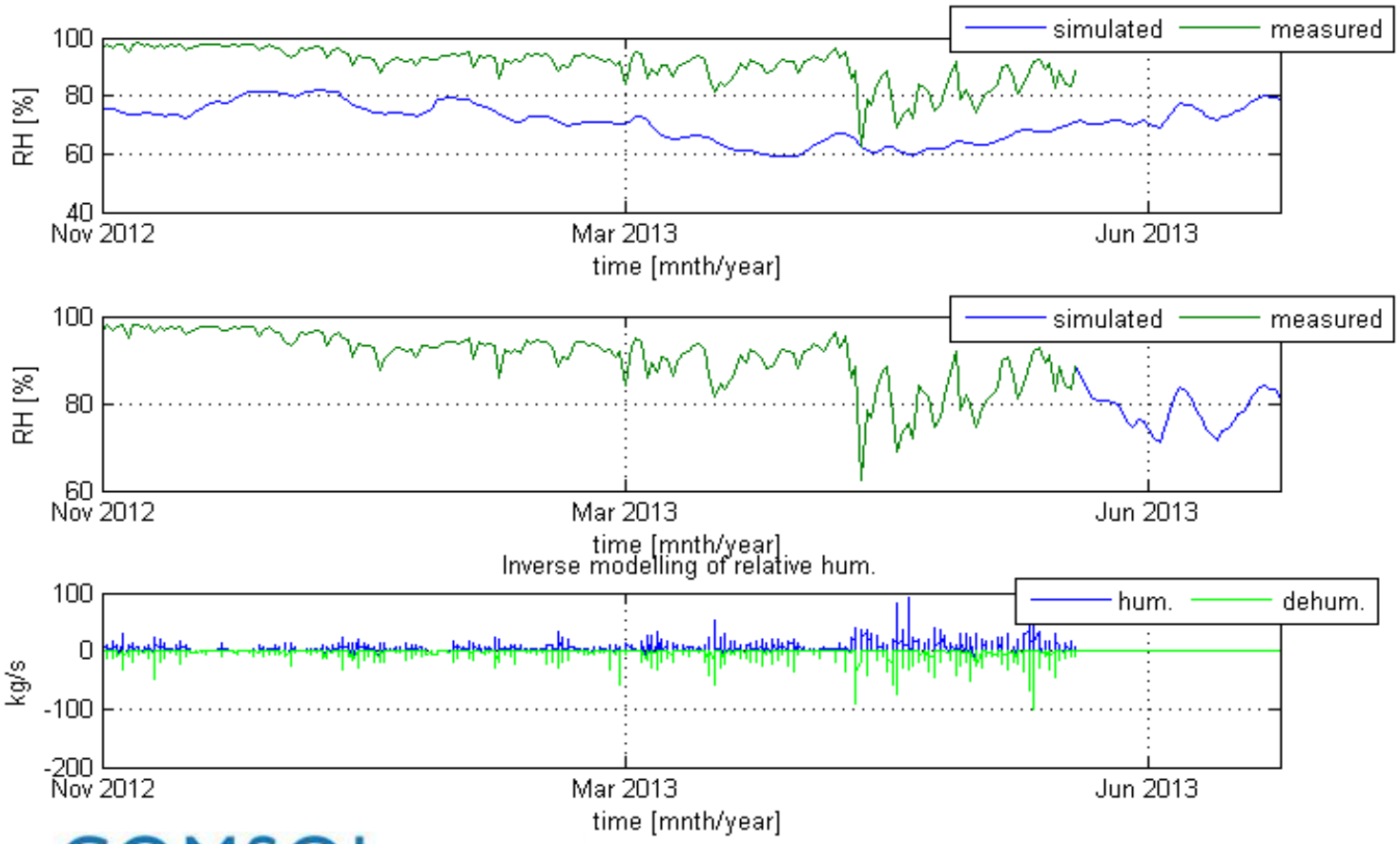
Inverse modeling



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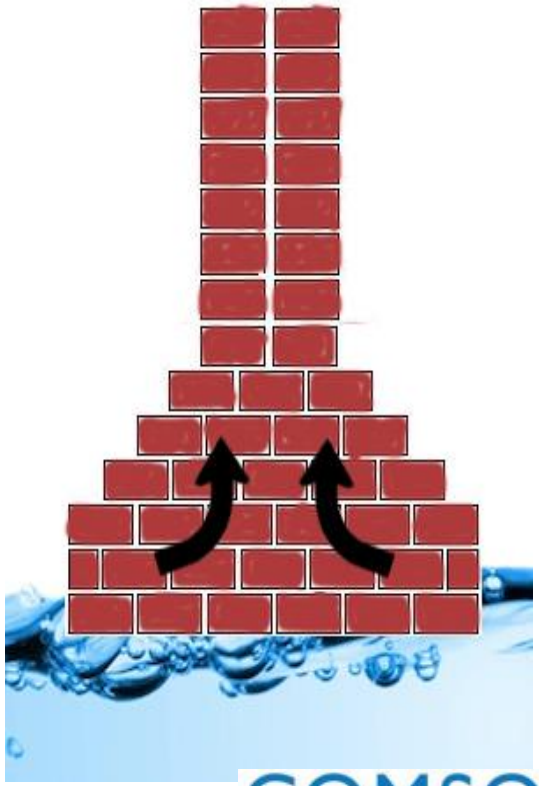
Comsol simulations water uptake



$$\frac{\partial w}{\partial t} = div\ D_w\ grad\ w$$

For which the diffusion coefficient D_w varies with the moisture content:

$$D_w = \frac{\delta_a}{\mu}\ p_{sat}\ \frac{1}{\xi}$$ for vapour transfer

$$D_w = \frac{k_m}{\Xi}$$ for liquid water transfer

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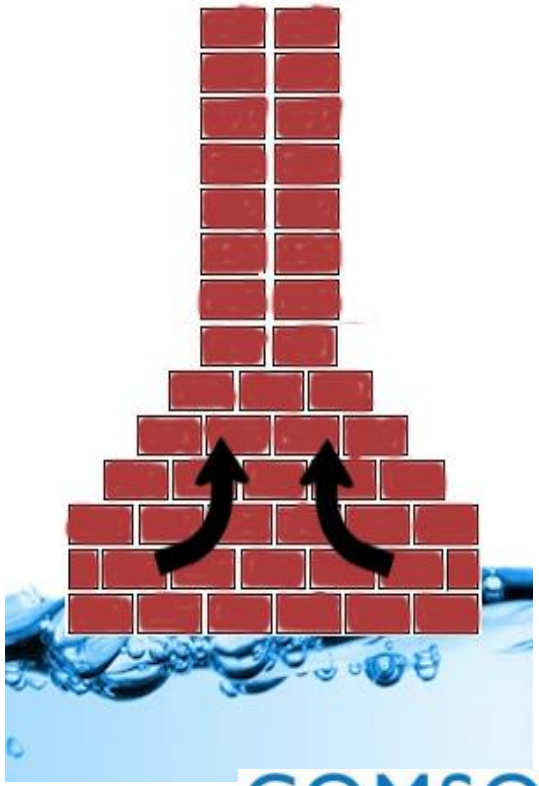
Comsol simulations water uptake



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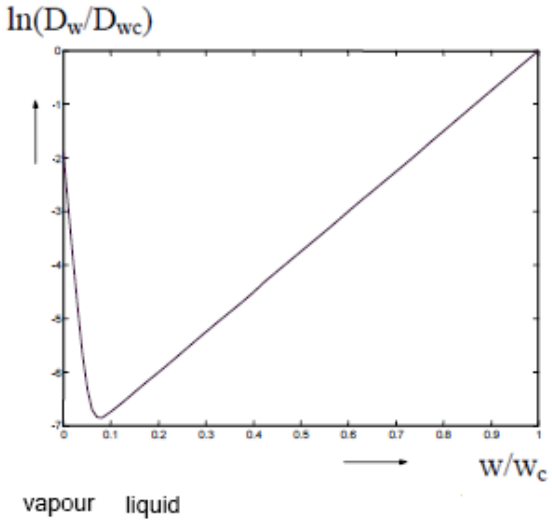

brick:

ρ_{brick} = 1529 kg/m^3

$D_w = 2.1 \cdot 10^{-9} \exp(0.0316\ w)$ m^2/s

Critical moisture content: w_{cr} = 100kg/m^3

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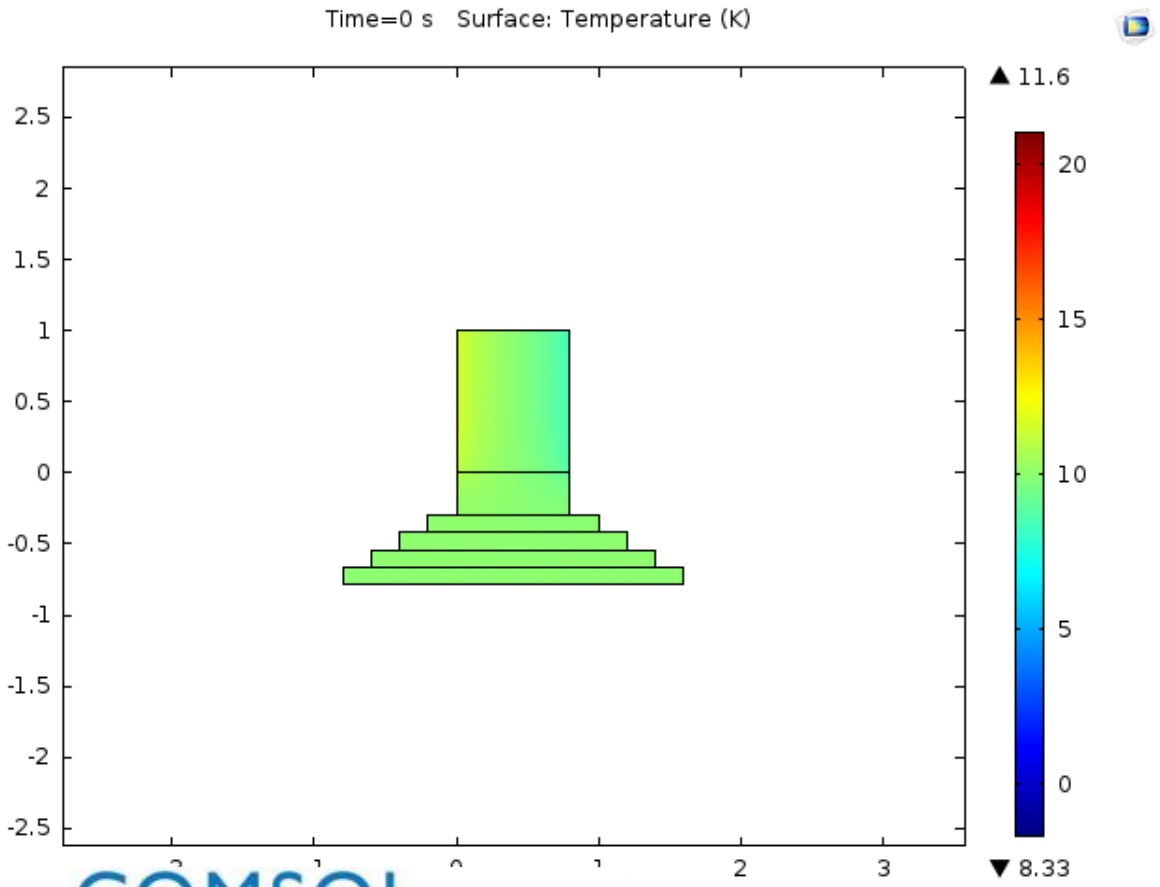
Temperature



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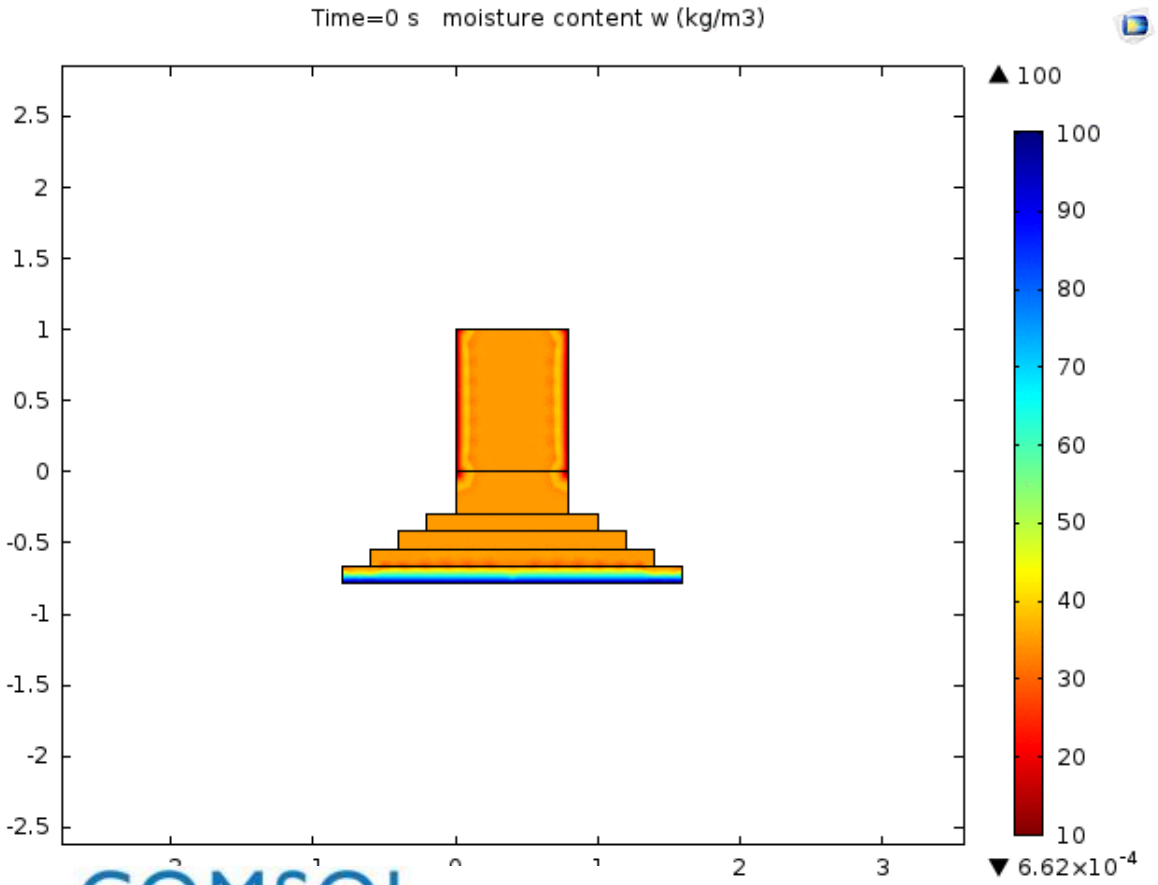
Moisture content



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Conclusions

- **Flooding of chapel by creek water**
- **High groundwater level**
- **Water in crypt**
- **Water uptake by walls**
- **Drying at internal and external surfaces of walls**
- **Relatively high vapor diffusion resistance painting**
- **Moisture source in chapel**
- **Measure:**

  Injection of foundation with water-repellent chemical liquid

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