Coupled Heat and Moisture Transfer in Building Components - Implementing WUFI® Approaches in COMSOL Multiphysics®

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Introduction: A well known and worldwide used commercial software for calculating the coupled heat and moisture transfer in building components is WUFI® [1]. From the scientific point of view the restricted access to governing equations is nevertheless a drawback of this software.

Computational Methods: We use the PDE (c) application mode

$$d_a \frac{\partial u}{\partial t} - c\nabla^2 u = 0 \qquad u = [T, RH]^T$$

to implement the governing equations of WUFI

$$\begin{bmatrix} \lambda + h_v \delta_p \varphi \frac{\mathrm{dp_{sat}}}{\mathrm{dT}} & h_v \delta_p p_{sat} \\ \delta_p \varphi \frac{\mathrm{dp_{sat}}}{\mathrm{dT}} & D_\varphi + \delta_p p_{sat} \end{bmatrix} \begin{bmatrix} \nabla^2 T \\ \nabla^2 \varphi \end{bmatrix} = \begin{bmatrix} \left(c_s + \frac{1}{\rho_s} c_w w\right) \rho_s & 0 \\ 0 & \xi \end{bmatrix} \begin{bmatrix} \frac{\partial T}{\partial t} \\ \frac{\partial \varphi}{\partial t} \end{bmatrix}$$

$$\begin{bmatrix} c11 & c12 \\ c21 & c22 \end{bmatrix} \begin{bmatrix} \nabla^2 T \\ \nabla^2 RH \end{bmatrix} = \begin{bmatrix} d_a 11 & d_a 12 \\ d_a 21 & d_a 22 \end{bmatrix} \begin{bmatrix} \frac{\partial T}{\partial t} \\ \frac{\partial RH}{\partial t} \end{bmatrix}$$

in COMSOL Multiphysics®.

Results: To evaluate the model, we compare the COMSOL results with different benchmarks [2,3] and with WUFI results. Figure 1 and Figure 2 show some comparisons of those simulations.

Conclusion: It is shown, that the COMSOL model delivers good results in accordance with the benchmarks.
The accordance of COMSOL and WUFI results is good as well. However, slight deviations between COMSOL and WUFI results can occur if the moisture load on the construction is very high.

References:

[1] Künzel, H. M.: *Simultaneous Heat and Moisture Transport in Building Components. One- and two-dimensional calculation using simple parameters.* Dissertation, University Stuttgart, Germany. (1994)
[2] EN 15026: *Hygrothermal performance of building components and building elements - Assessment of moisture transfer by numerical simulation. (*2007-06-01)
[3] Hagentoft, C.-E.; et al.: *Assessment Method of Numerical Prediction Models for Combined Heat, Air and Moisture Transfer in Building Components: Benchmarks for One-dimensional Cases.* In: Journal of Thermal Envelope and Building Science, Vol. 27, No. 4, P. 327–352. (2004)

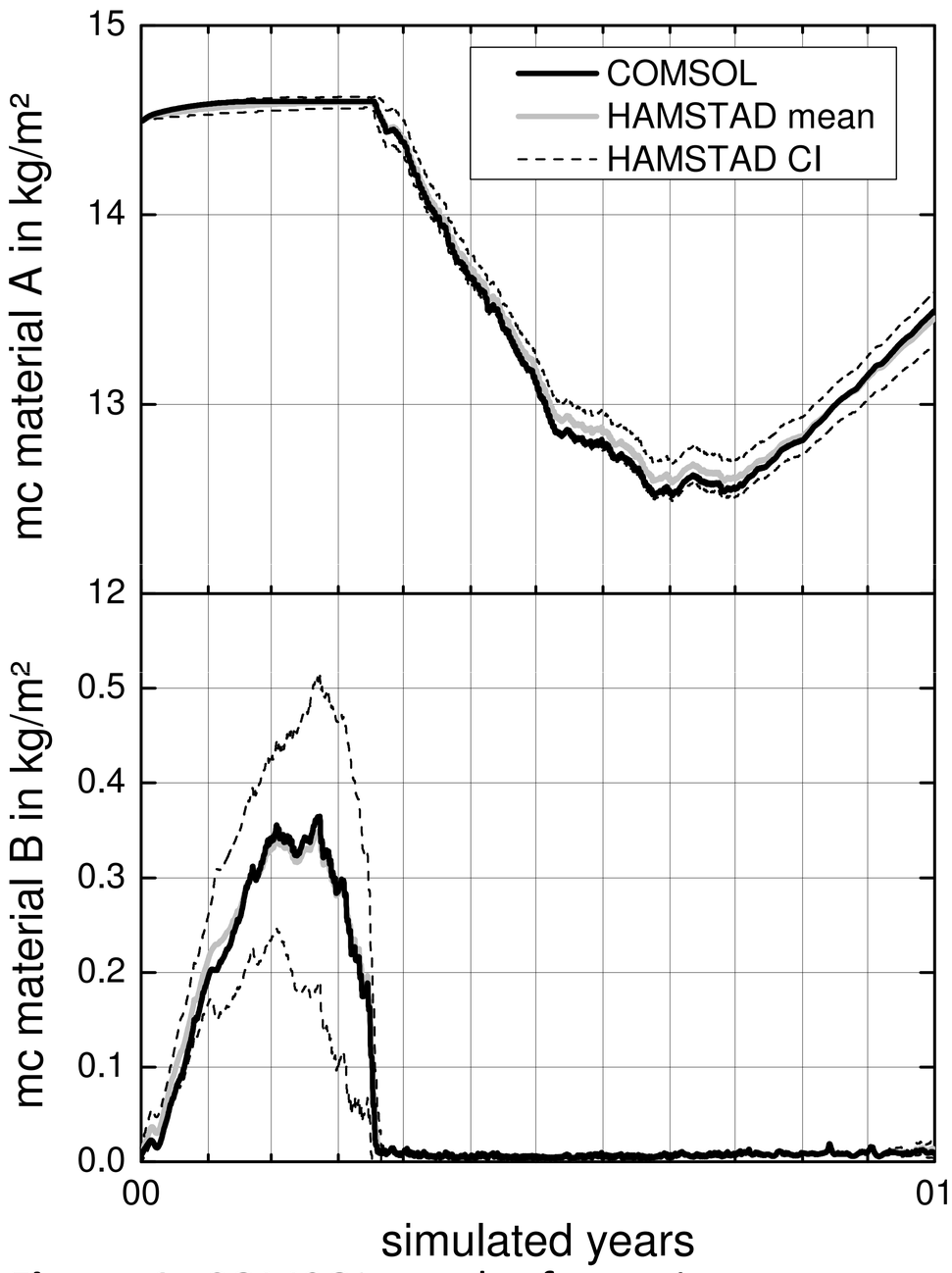

Figure 1. COMSOL results for moisture content (mc) of material A and B as well as mean value and confidence interval (CI) of the HAMSTAD benchmark [3]

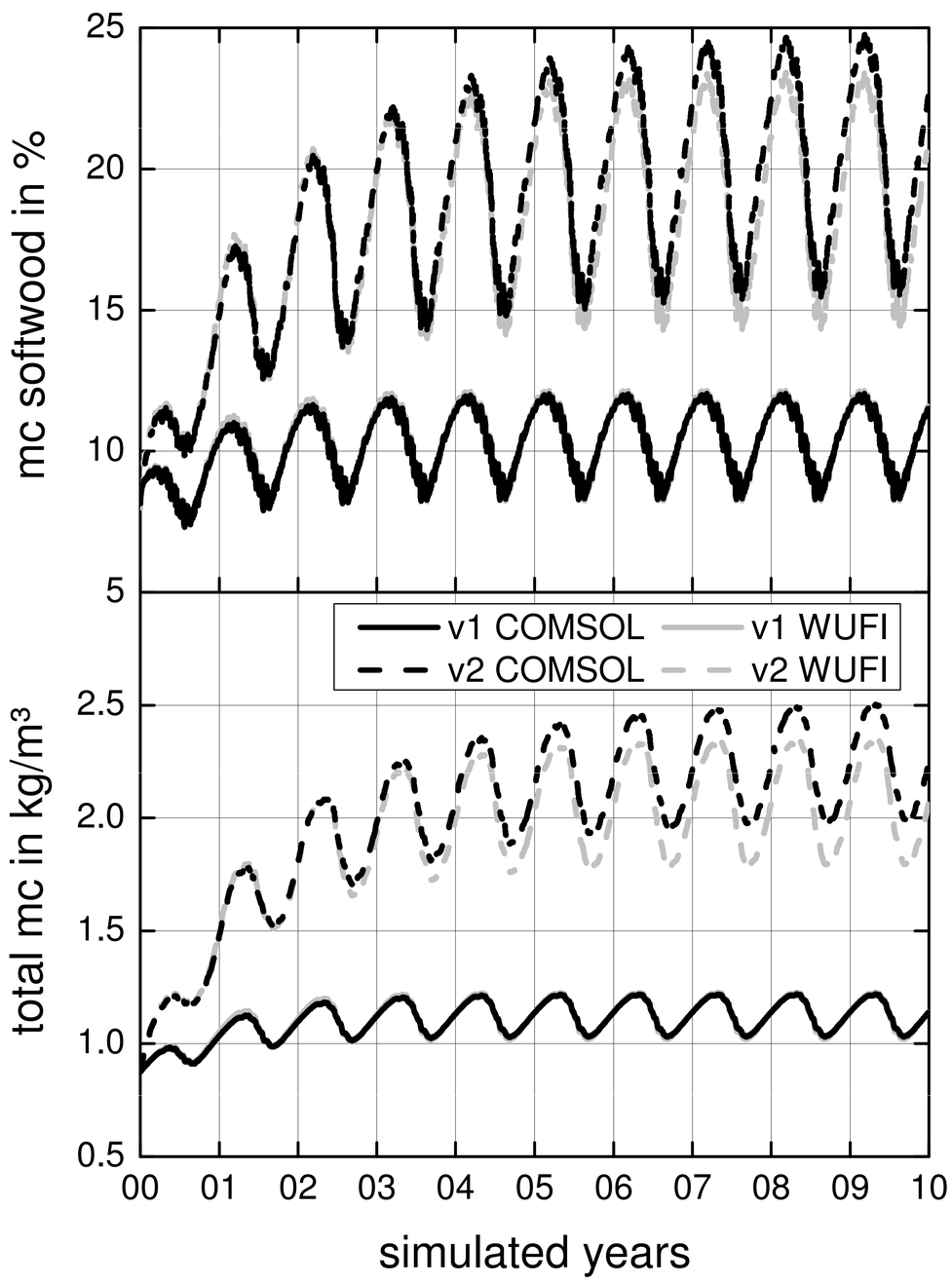

Figure 2. COMSOL and WUFI results for the moisture content (mc) of the exterior softwood and of the total construction for two investigated versions of a timber flat roof