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

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## Abstract

Introduction: Calculating time-dependent heat and moisture transports trough building components are important tasks in the area of building physics. Different approaches can be used to investigate the long time behavior of building elements under fluctuating conditions. Beside calculation programs, which are used only by scientists for research purposes, there are also commercial programs available. A well known and worldwide used commercial software for calculating the coupled heat and moisture transfer in building components is WUFI®, developed at the Fraunhofer-Institute for Building Physics [1]. It is used for research purposes and also by designers for commercial tasks. From the scientific point of view the restricted access to governing equations is nevertheless a drawback of WUFI. Use of COMSOL Multiphysics: In this paper it is shown how the physical approaches used in WUFI are implemented in COMSOL Multiphysics using the Partial Differential Equation interface for a 1-D model. The COMSOL results are evaluated with different benchmarks [2,3] and WUFI results itself. Results: Figure 1 shows the COMSOL results and the confidence intervals of the benchmark according to the European Standard EN 15026 [2]. As can be seen from the graphs, the COMSOL results are within the confidence intervals of the analytical solutions for all time steps investigated. Figure 2 shows the COMSOL results and the corresponding mean value and confidence intervals of a benchmark from the international HAMSTAD project [3]. It is shown, that the COMSOL results are within the confidence intervals and close to the mean values.

To compare COMSOL results with WUFI results, we calculated two versions of a flat roof with vapor tight sealing and wooden cladding at the exterior side. Figure 3 indicates the moisture content of the softwood and the whole roof element during the simulated years. As one can see, the COMSOL results and the WUFI results are nearly identical in version 1. In version 2 where the moisture content of the softwood exceeds the critical value of 20 %, slight deviations between COMSOL and WUFI results occur. Conclusion: This paper describes the governing equations which are necessary to implement the WUFI approaches in COMSOL Multiphysics and evaluate the so created model. It is shown, that the COMSOL model delivers good results in accordance with two different benchmarks for heat and moisture simulations. 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.

## Reference

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)

## Figures used in the abstract

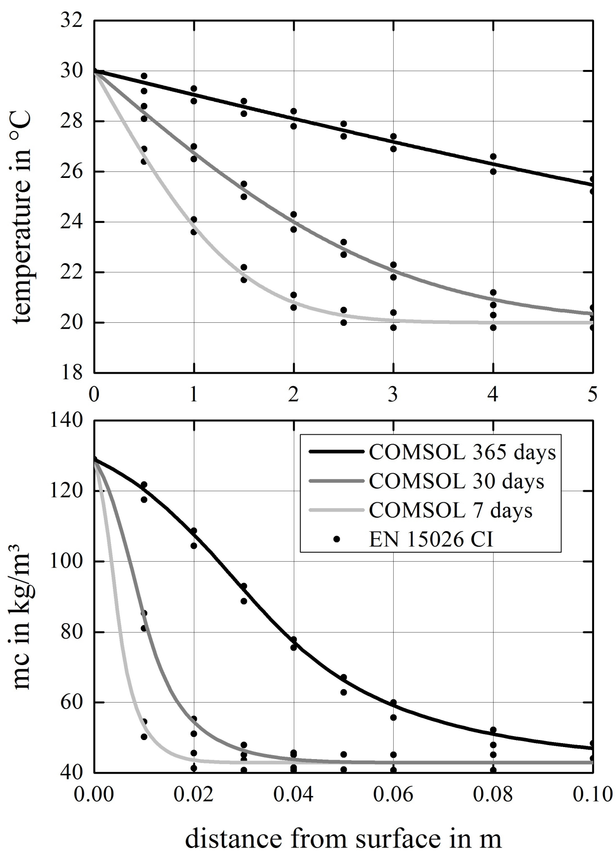


**Figure 1**: COMSOL results for temperature and moisture content (mc) of the building material as well as associated confidence interval (CI) of the analytic solution according to the EN 15026 benchmark [2] for certain time steps.

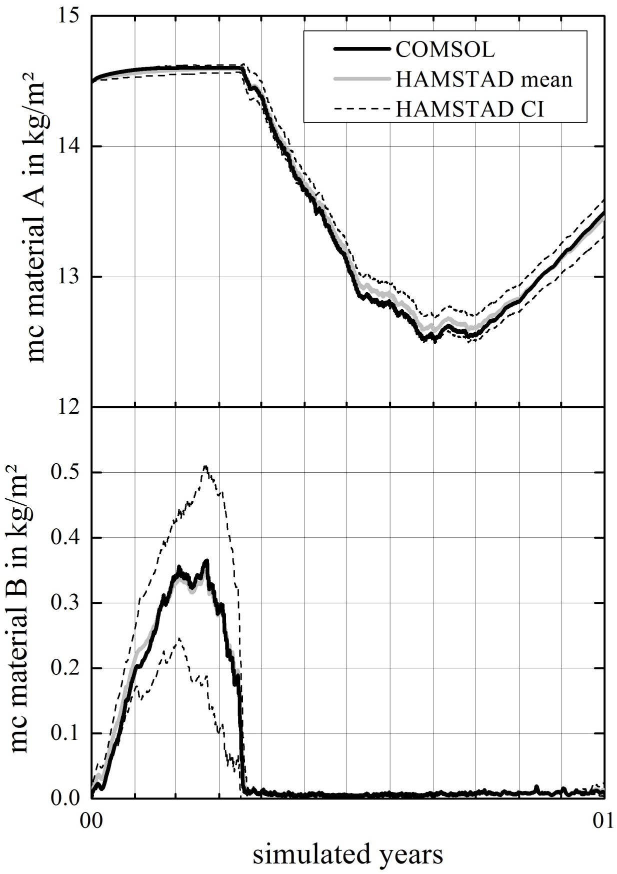


**Figure 2**: COMSOL results for moisture content (mc) of material A and B as well as mean value and confidence interval (CI) of the HAMSTAD benchmark [3] in the first simulated year.

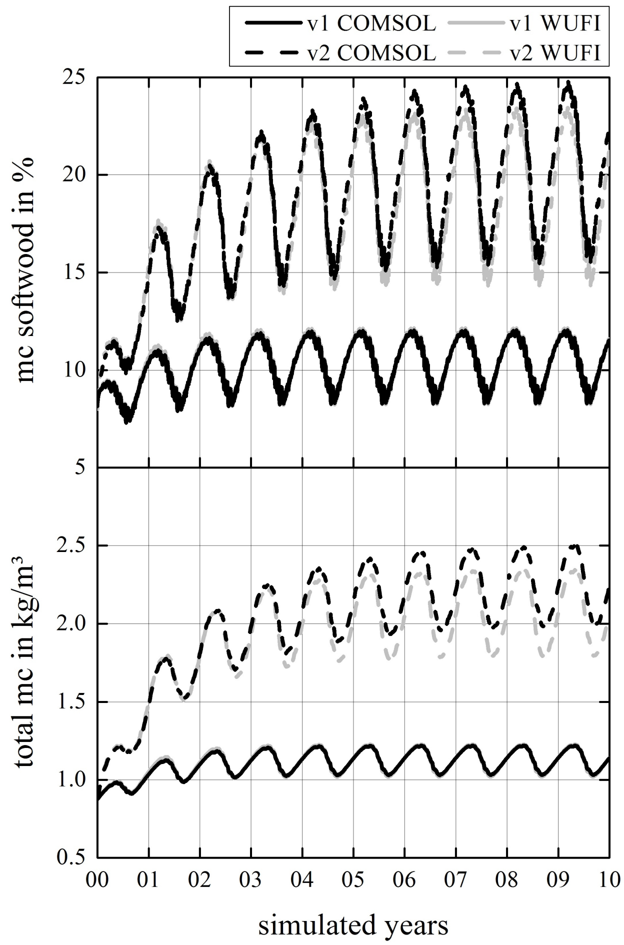


**Figure 3**: COMSOL and WUFI results for the moisture content (mc) of the softwood and of the total roof construction for both calculated versions.