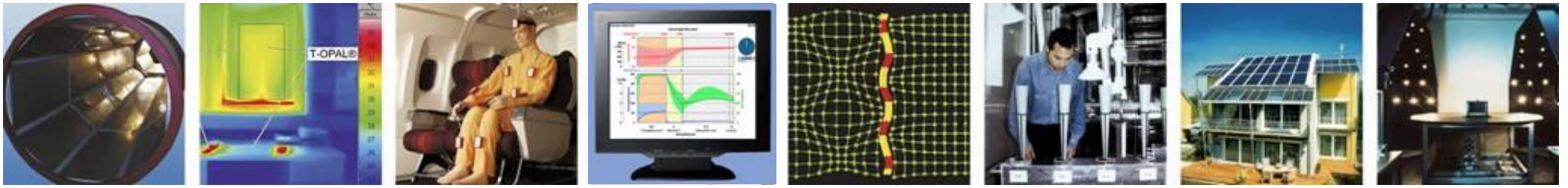

Mold growth risk evaluation using the mold index MI

Fraunhofer IBP

Mold risk evaluation

Contents:

Mold problems in practice

Example Case

Evaluation with WUFI®-Bio

Evaluation with WUFI®-VTT

Common traffic light classification

Mold problems in building practice

Mould growth occurs at the surface as well as inside building assemblies

… in old and new buildings
… in cold (winter) and warm countries (summer)
and leads to significant renovation costs


Behind interior insulation *(Germany)*


Cold surface behind cupboard *(Germany)*


Behind vapour retard. vinyl paper *(Florida)*

© J. Lstiburek


Façade in warm-humid climate *(Thailand)*


Due to summer condensation *(Japan)*

© T. Tanaka

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Mold problems in building practice

- Higher insulation level reduces risk on the interior surface
  …but also lowers the drying potential of the assembly
- Air tight construction / high performance AC increase risk due to higher indoor RH
- Lower tolerance of inhabitants versus mold

Mould growth risk evaluation continues to be important!

Main question in practice:
Who is to blame - the user or the building design??

Mold growth prediction models

Numerical hygrothermal simulations allow the prediction of temperature and RH on the surfaces as well as at the interfaces between different materials inside the assemblies.

The mould growth risk can be predicted by numerical models on basis of Temperature, RH (normal or extreme indoor climate) and the nutrient quality of the substrate.

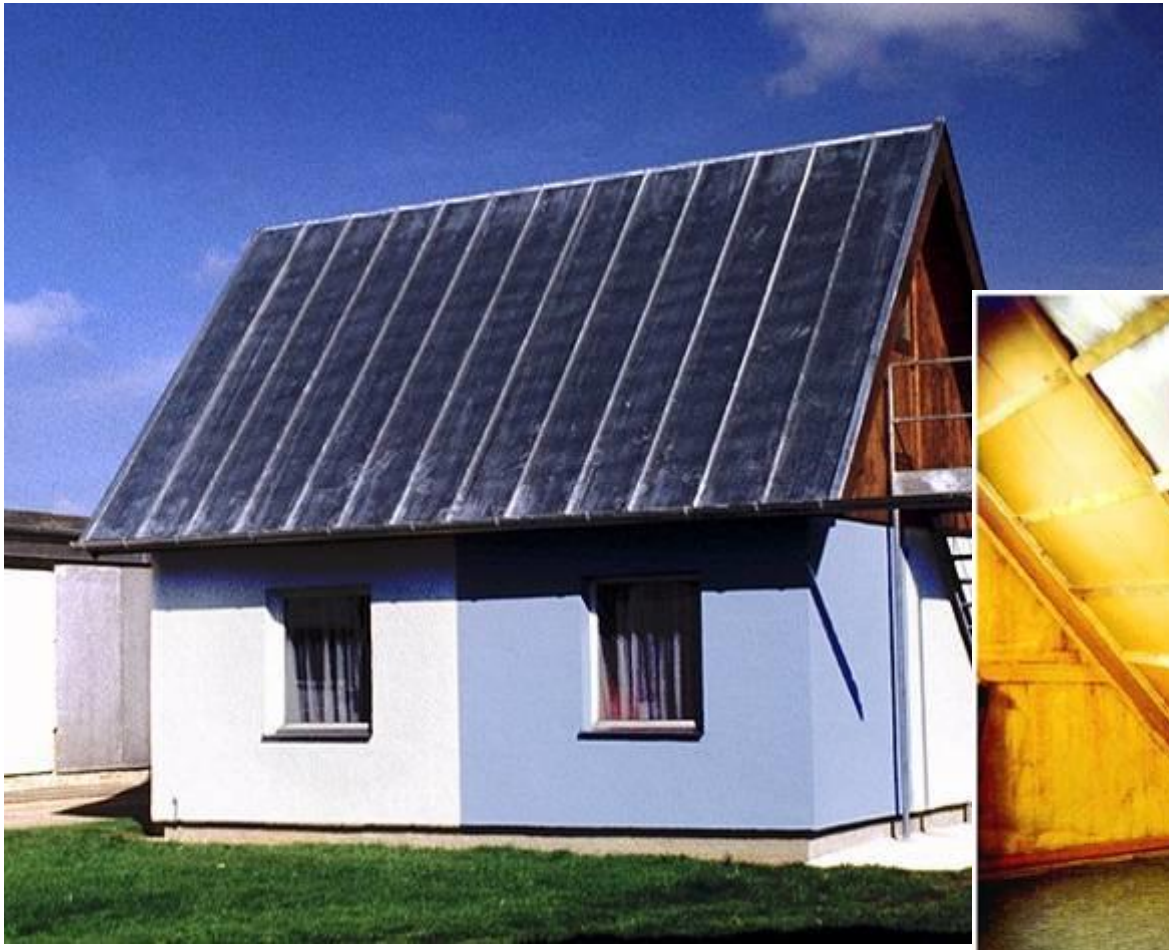
Amongst others two numerical prediction models are available, well established and used worldwide for this purpose:

Biohygrothermal IBP model

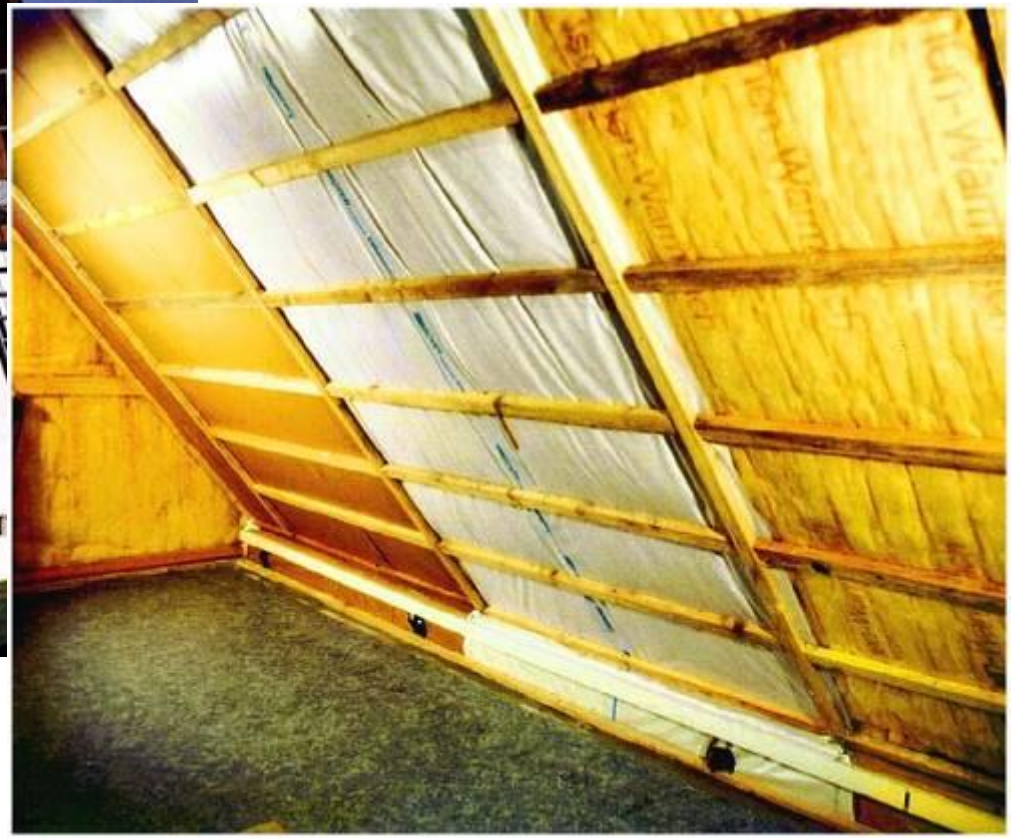
VTT / Viitanen model

Example Case

Conditions in a building assembly



Cathedral ceiling insulation of pitched metal roof



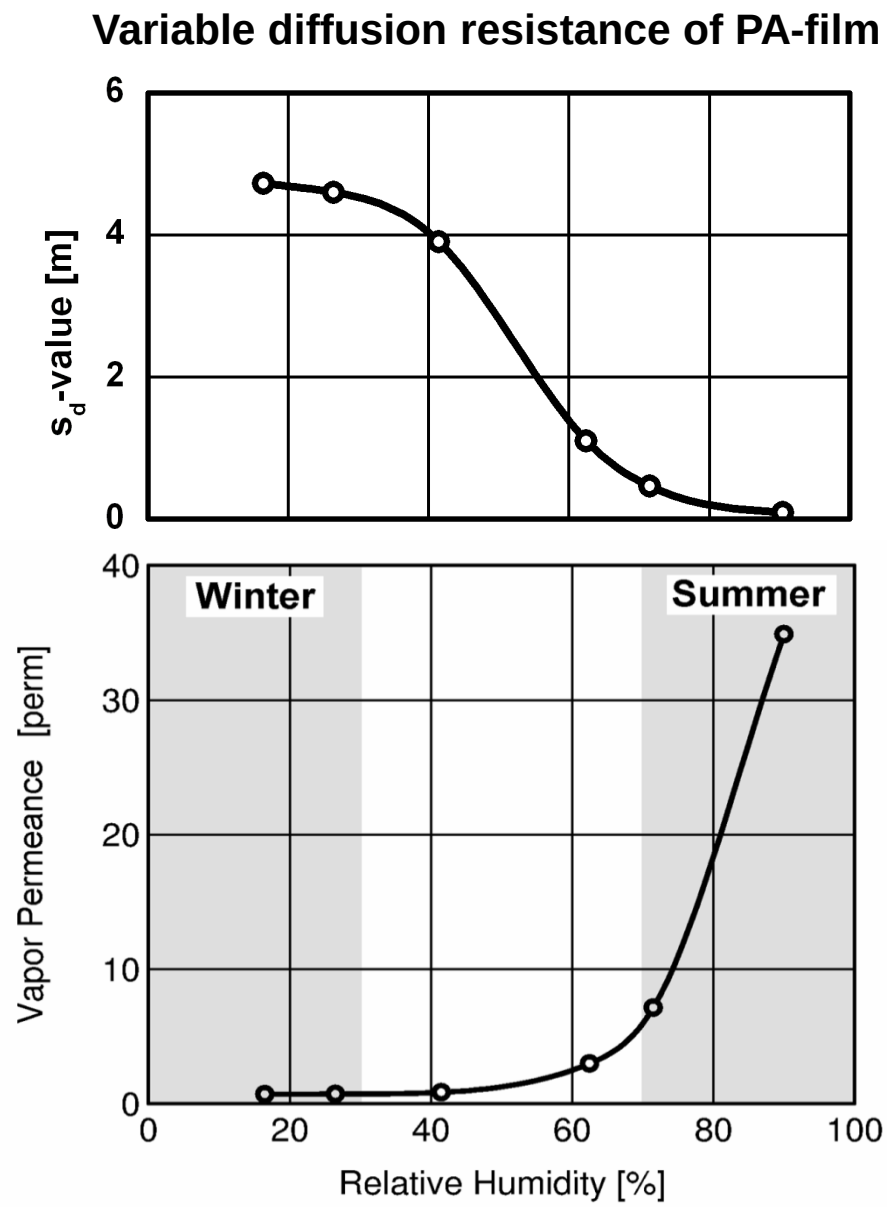
Example Case

Mould growth caused by solar vapor drive

Fraunhofer IBP

Example Case

No mould growth on PA-film



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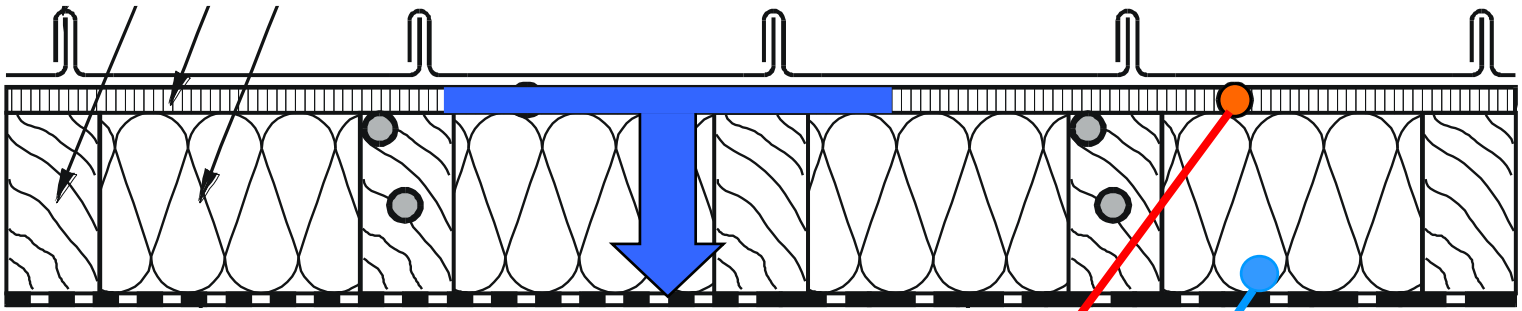
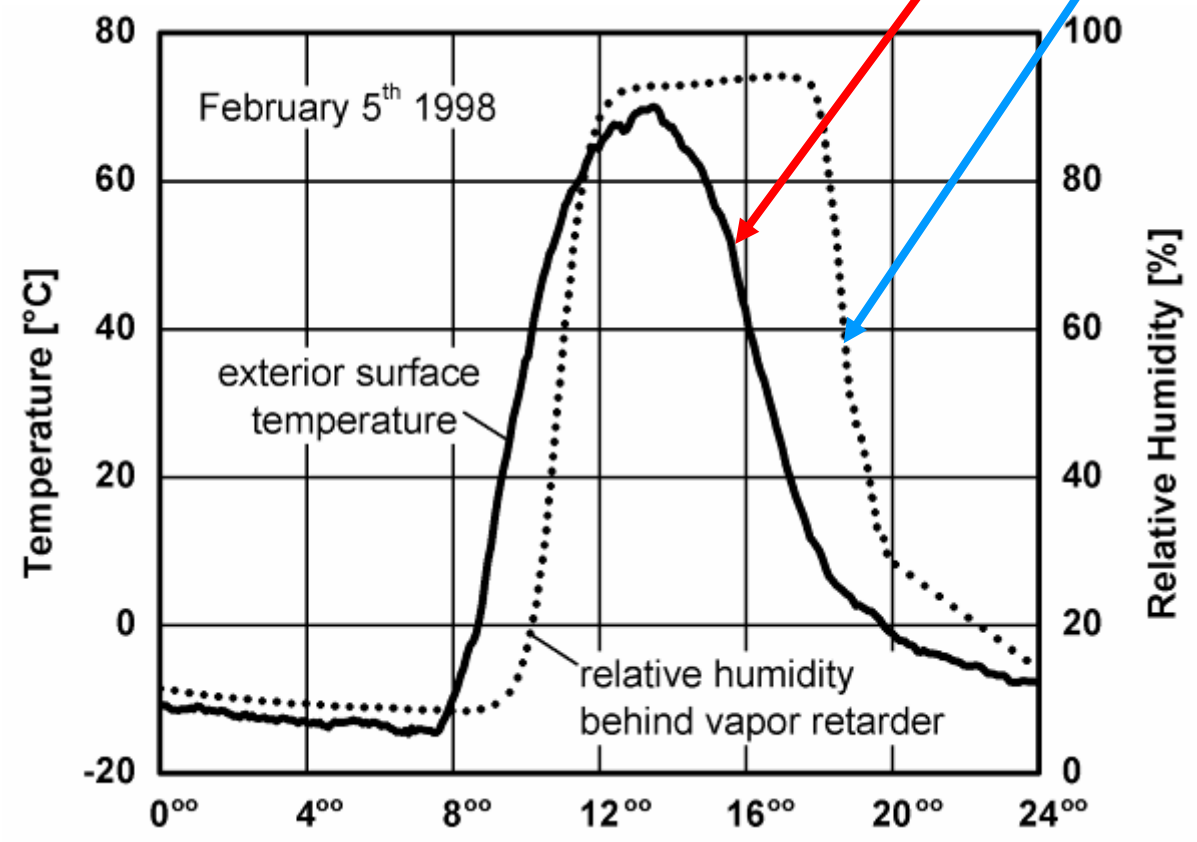
Example Case





Measurements

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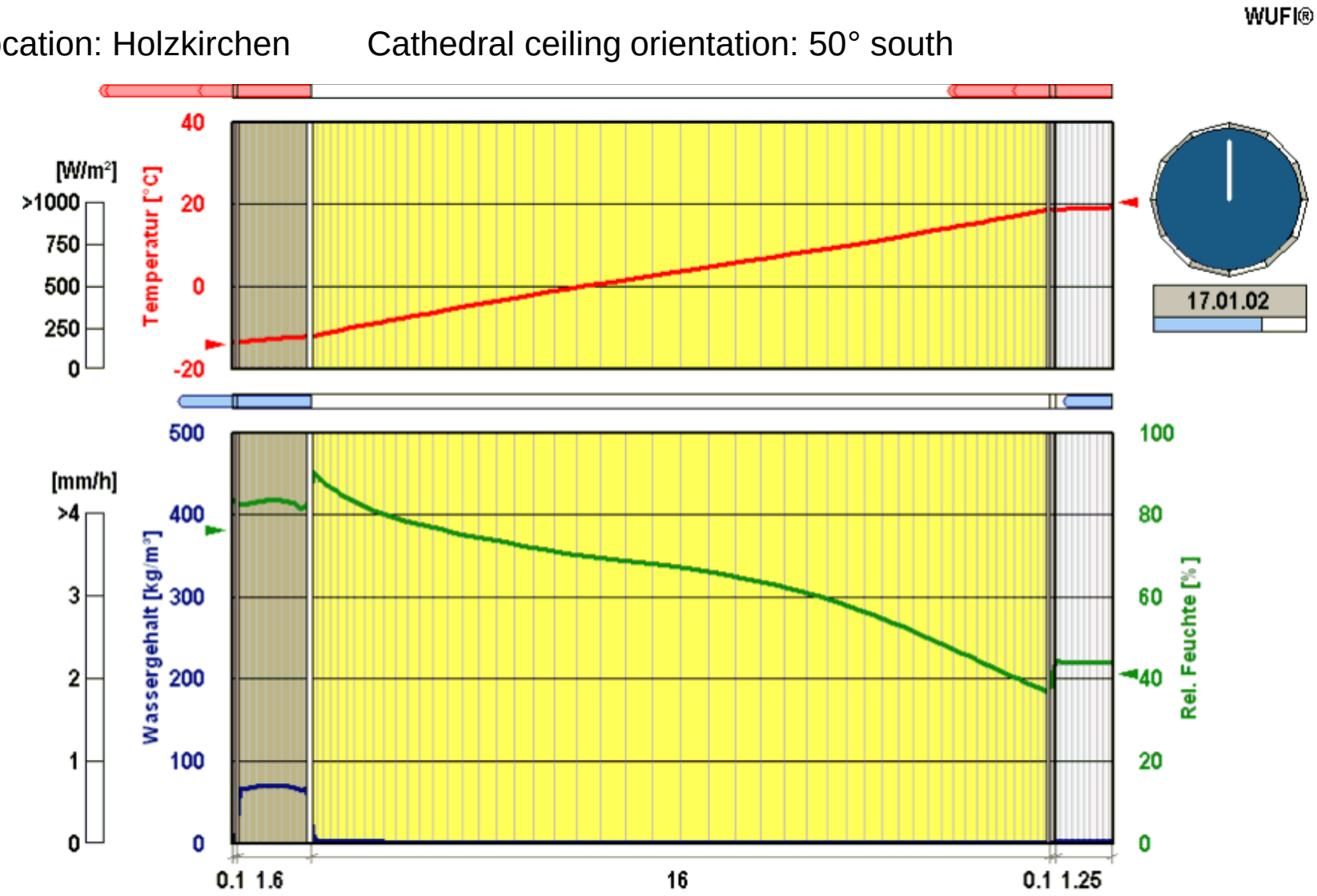
Example Case

WUFI®
simu-
lation

Location: Holzkirchen Cathedral ceiling orientation: 50° south



zinc on wooden sheathing fiber glass insulation v.r. & gypsum board

cross section [cm]

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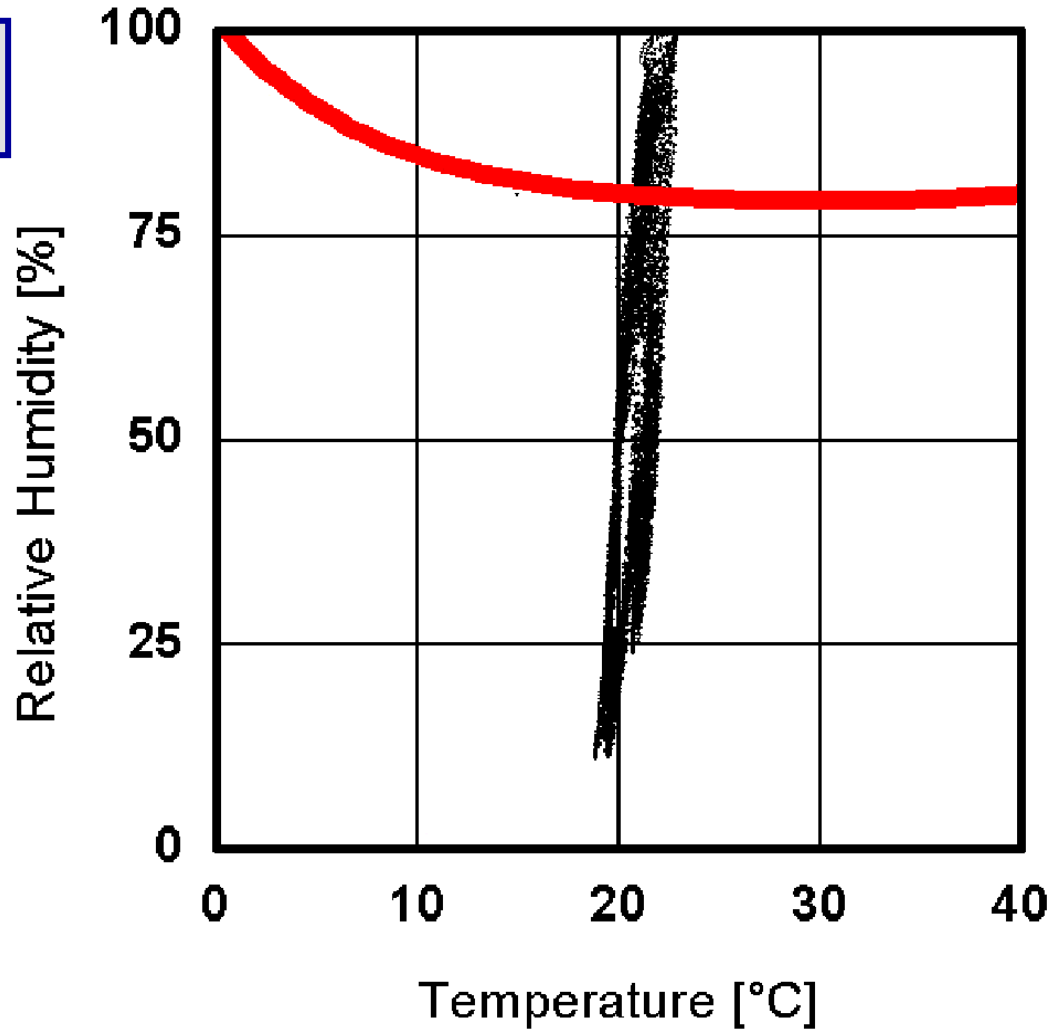
Evaluation with WUFI®-Bio

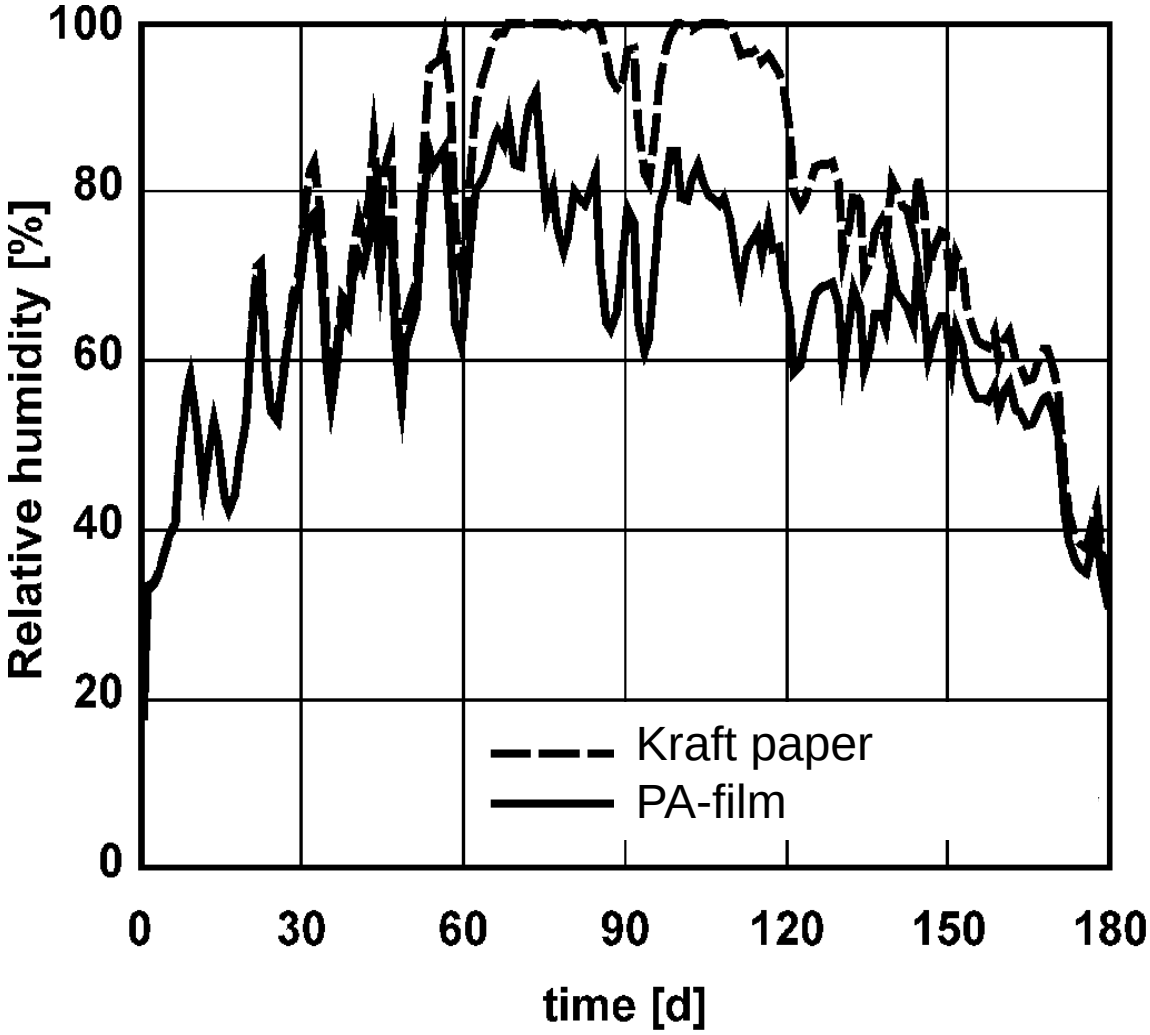
WUFI® simulation



Hygrothermal conditions between vapor retarder and insulation

Fraunhofer IBP

Evaluation with WUFI®-Bio

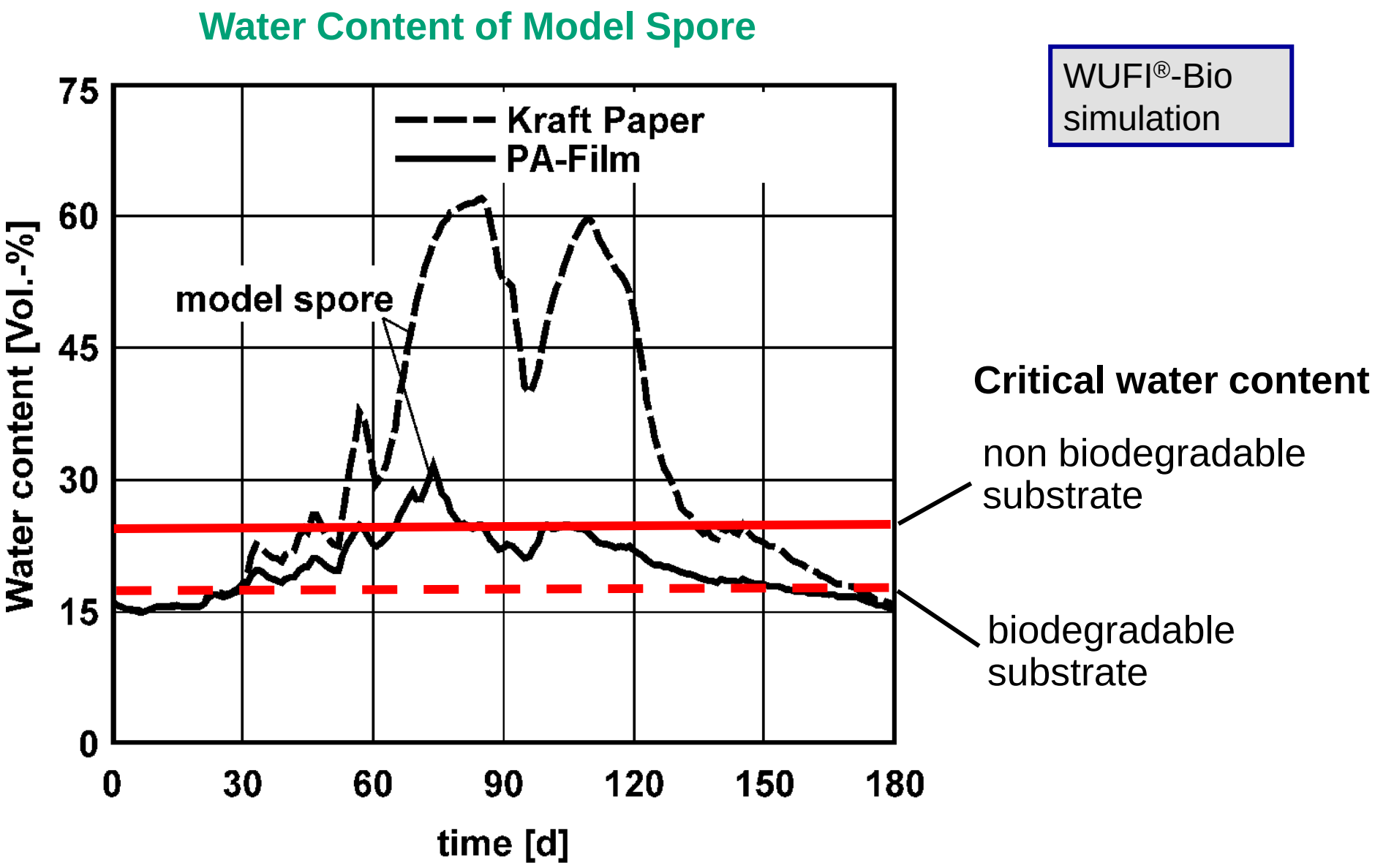


WUFI® simulation

Humidity fluctuations between vapor retarder and insulation

Fraunhofer IBP

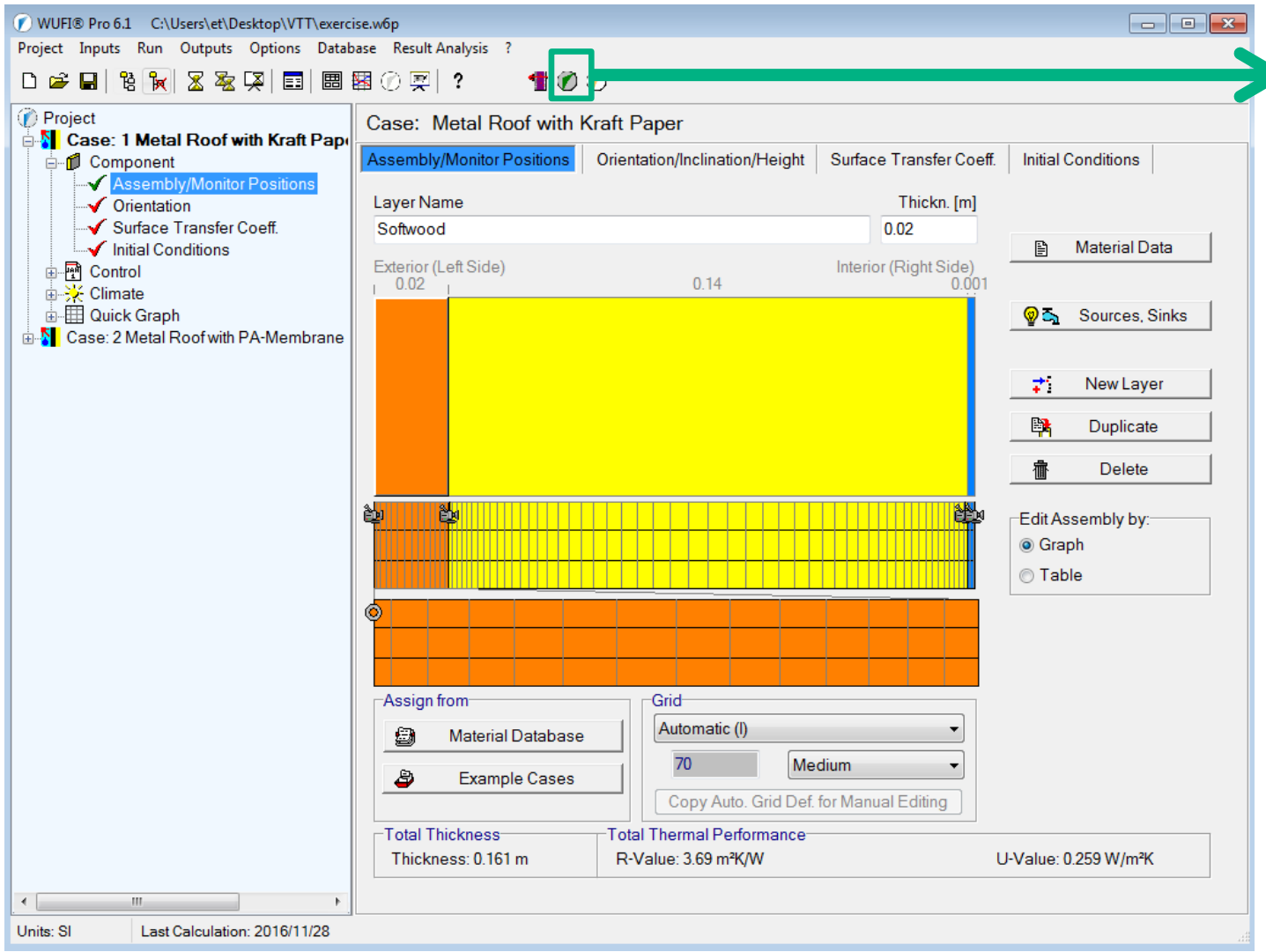
Evaluation with WUFI®-Bio



Fraunhofer IBP

Evaluation with WUFI®-Bio

WUFI®-Bio: As a PostProcessor combined with WUFI®-Pro



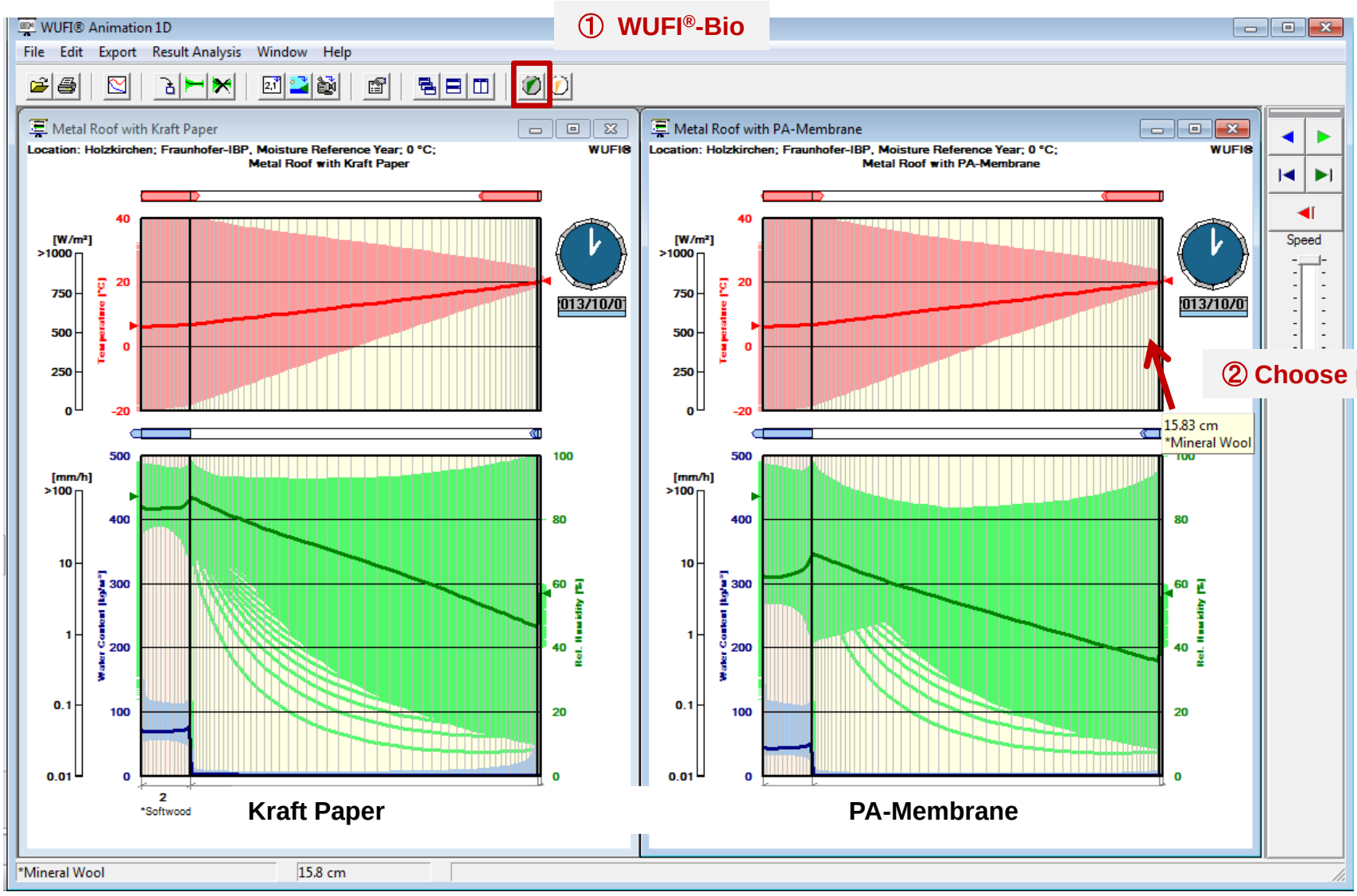
WUFI®-Bio

Here only an assessment of the interior surface is possible

Fraunhofer IBP

Evaluation with WUFI®-Bio

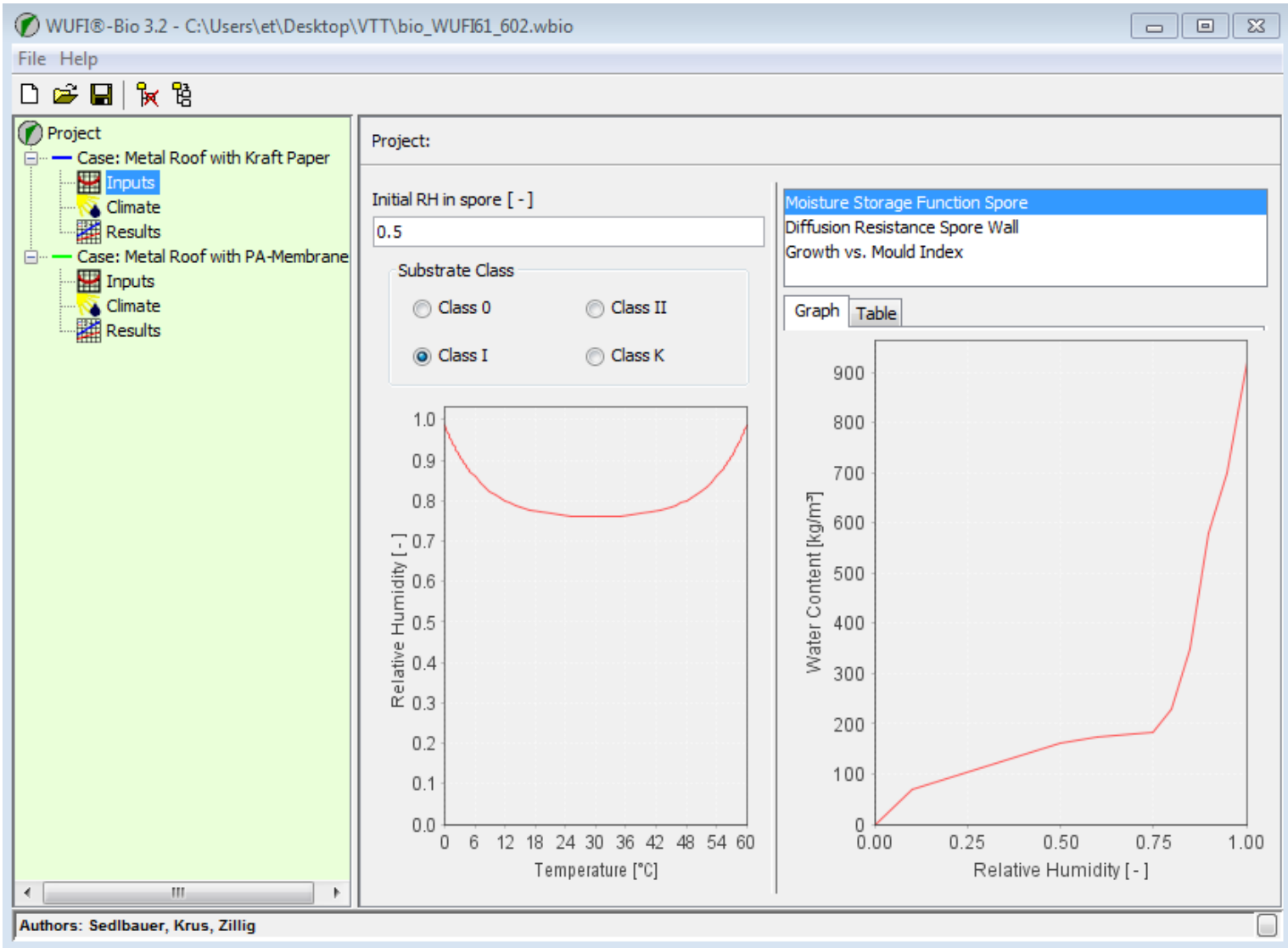
WUFI®-Bio: As a PostProcessor combined with WUFI®-Pro (Animation)



Fraunhofer IBP

Evaluation with WUFI®-Bio

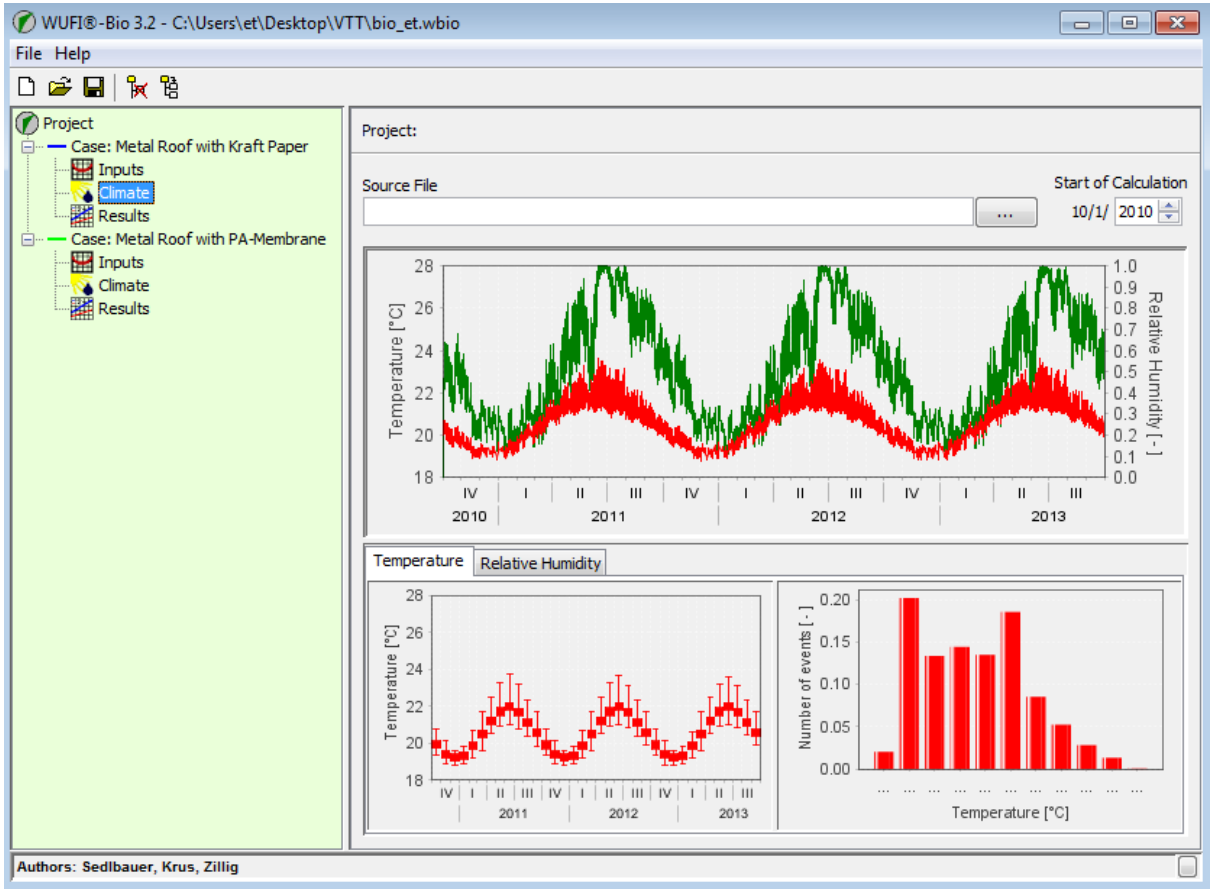
Inputs : Initial RH in spore & Substrate Class



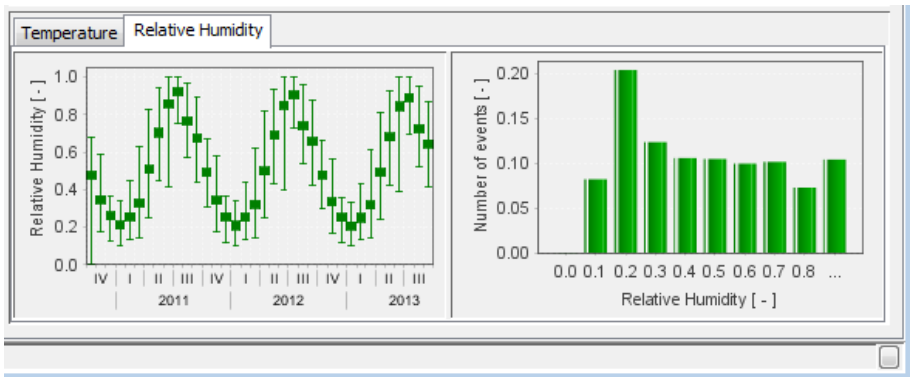
Fraunhofer IBP

Evaluation with WUFI®-Bio

Climate: Temperature and Relative Humidity used for the Assesment



Temperature

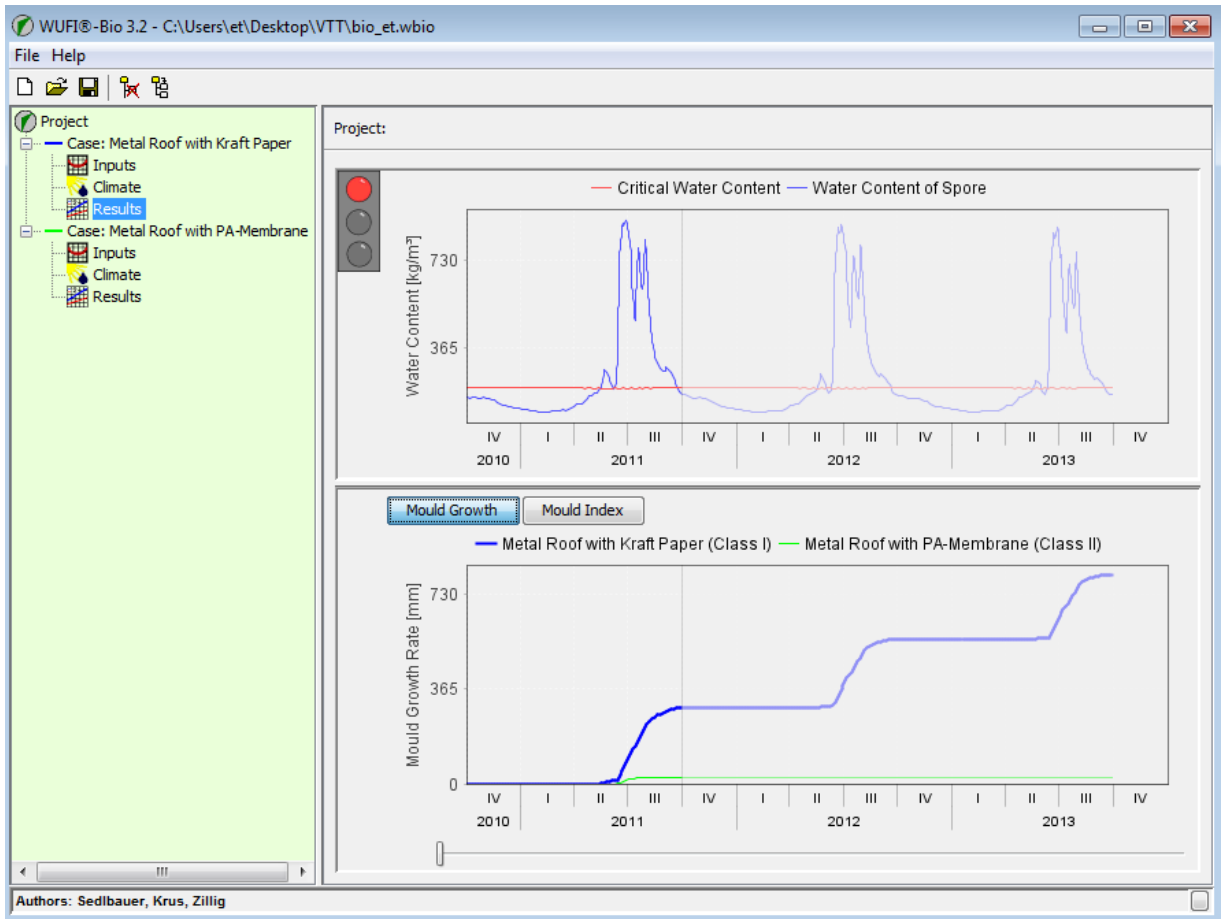


Relative Humidity

Fraunhofer IBP

Evaluation with WUFI®-Bio

Kraft Paper



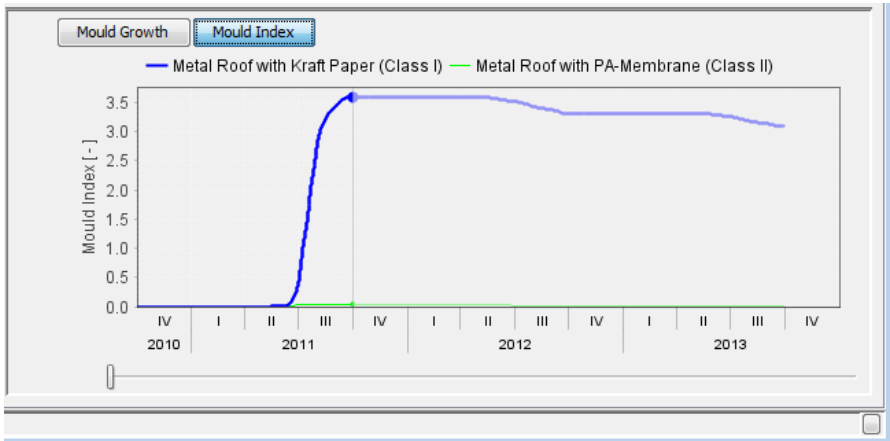
Mould Growth [mm]

Calculation period is less than 1 year. No assessment possible.

Mould growth exceeds 200 mm/year, which corresponds to a mould index of approximately 2.
Usually not acceptable.

Mould growth is between 50 mm/year and 200 mm/year.
Additional criteria or investigations are needed for assessing acceptability.

Mould growth is below 50 mm/year, which corresponds to a mould index of approximately 0.5.
Usually acceptable.

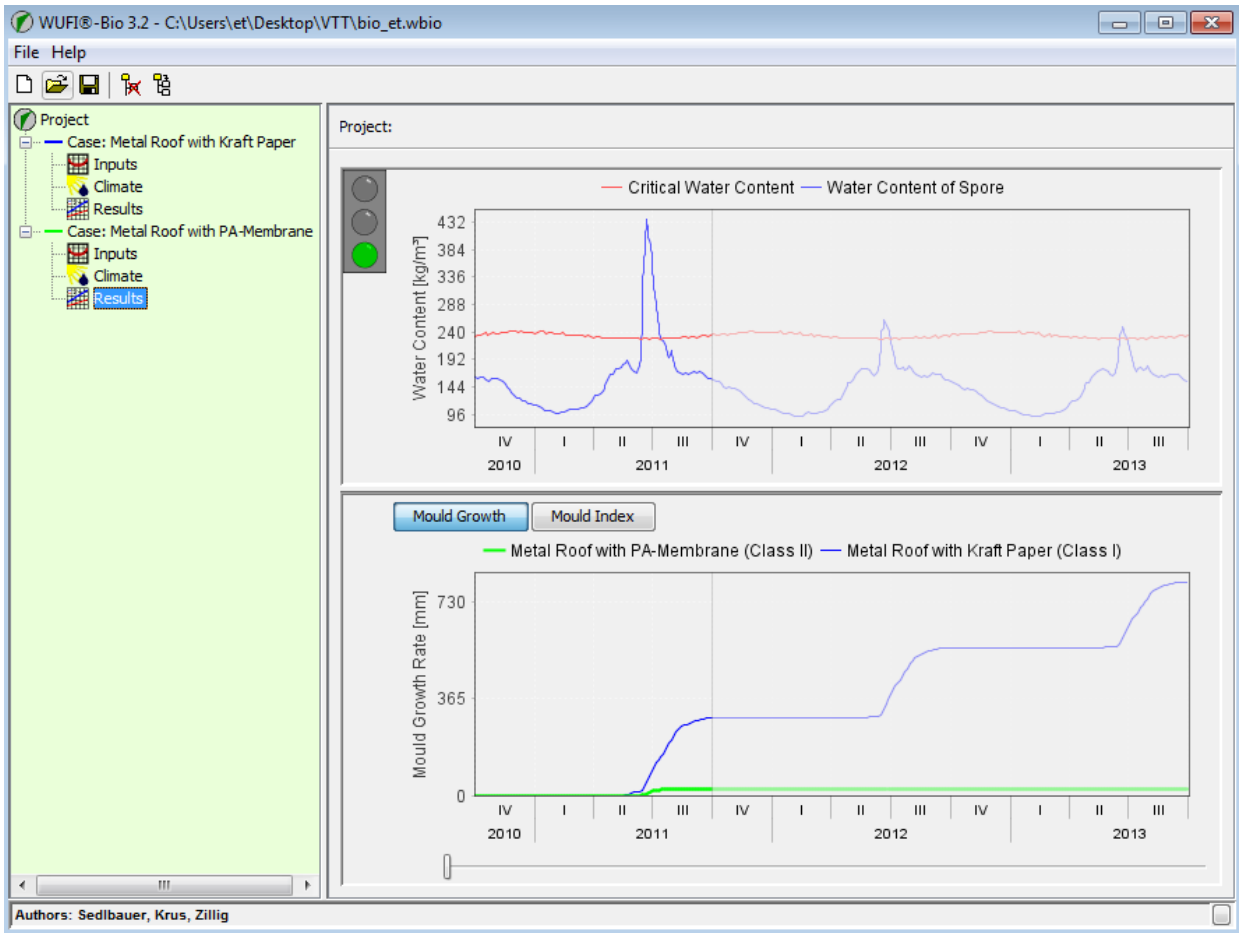


Mould Index [-]

Fraunhofer IBP

Evaluation with WUFI®-Bio

PA-Membrane



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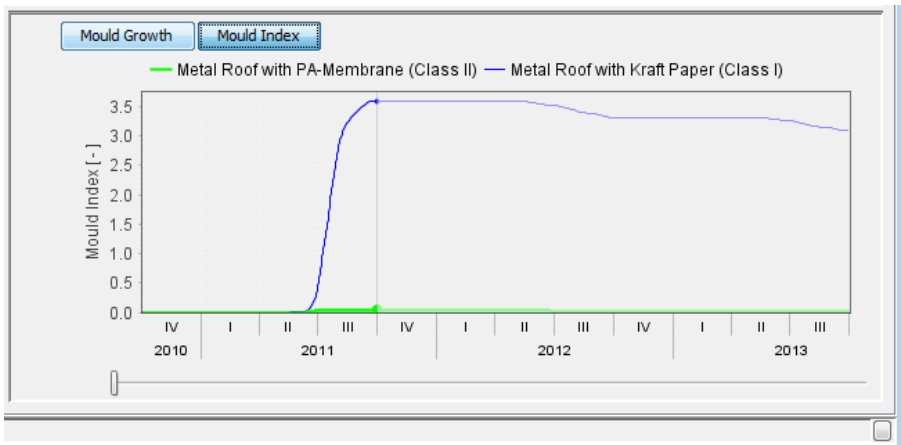
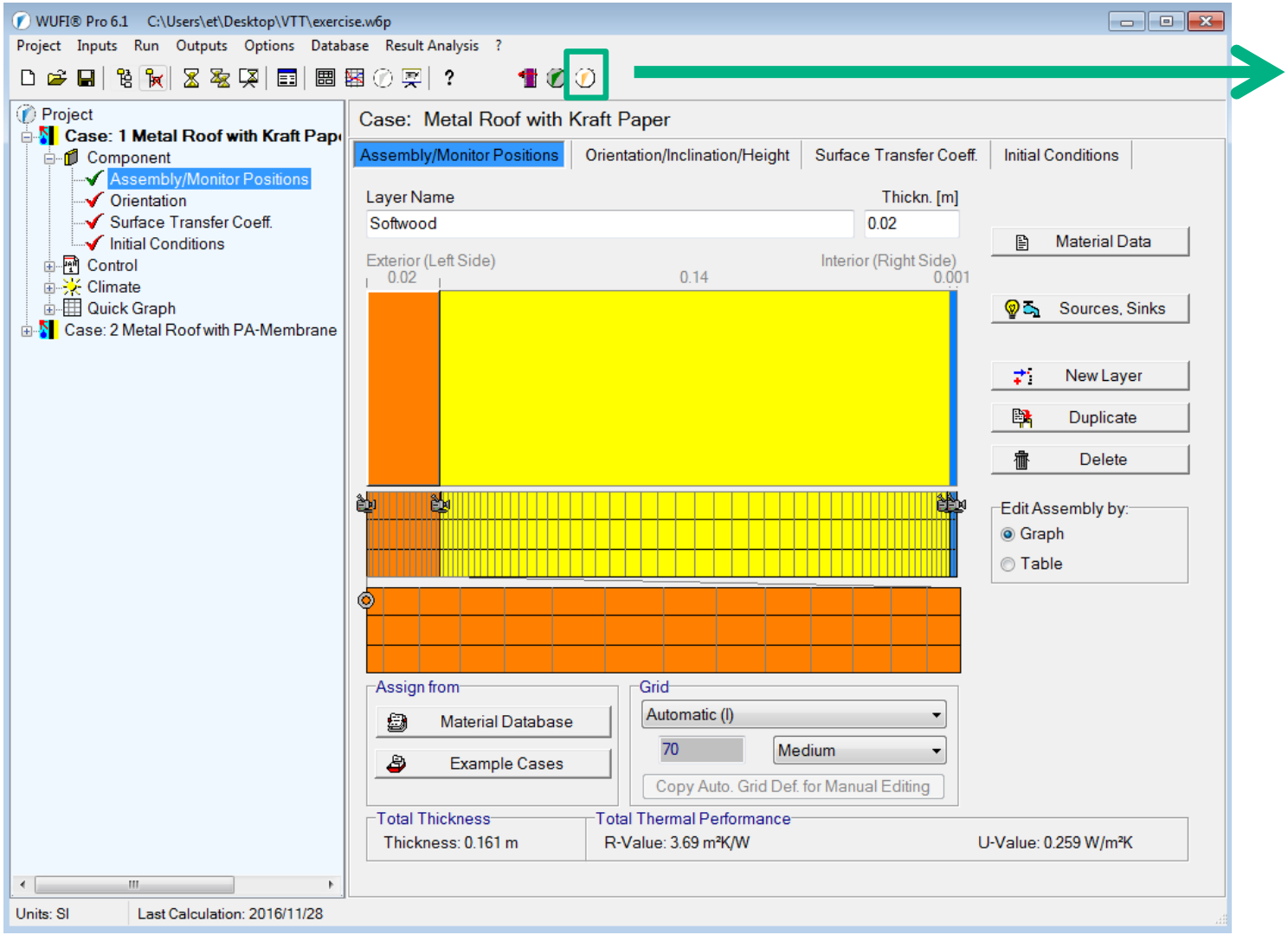


Mould Index [-]

Fraunhofer IBP

Evaluation with WUFI®-VTT

As a PostProcessor combined with WUFI®-Pro



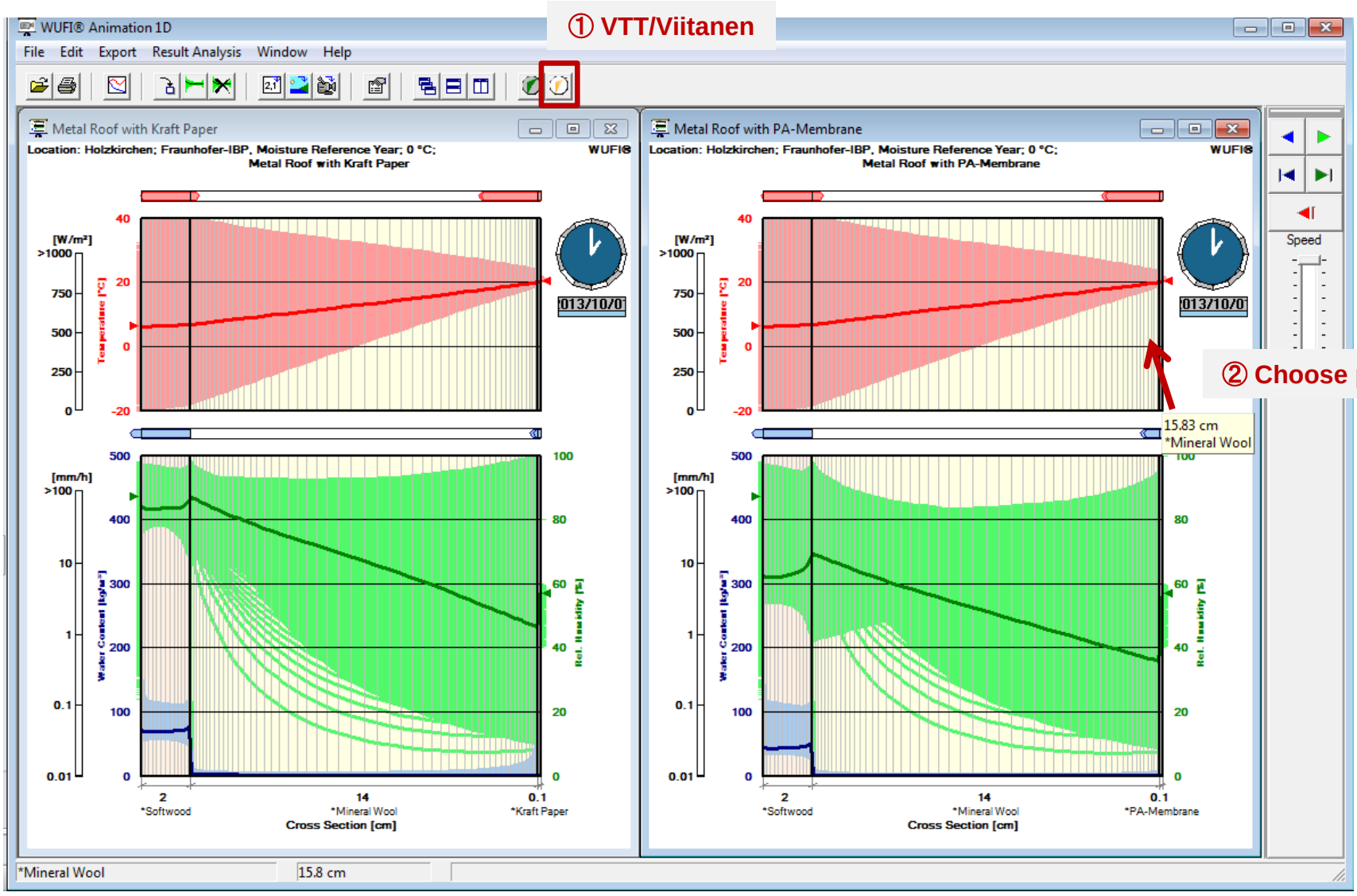
VTT/Viitanen

Here only an assessment of the interior surface is possible

Fraunhofer IBP

Evaluation with WUFI®-VTT

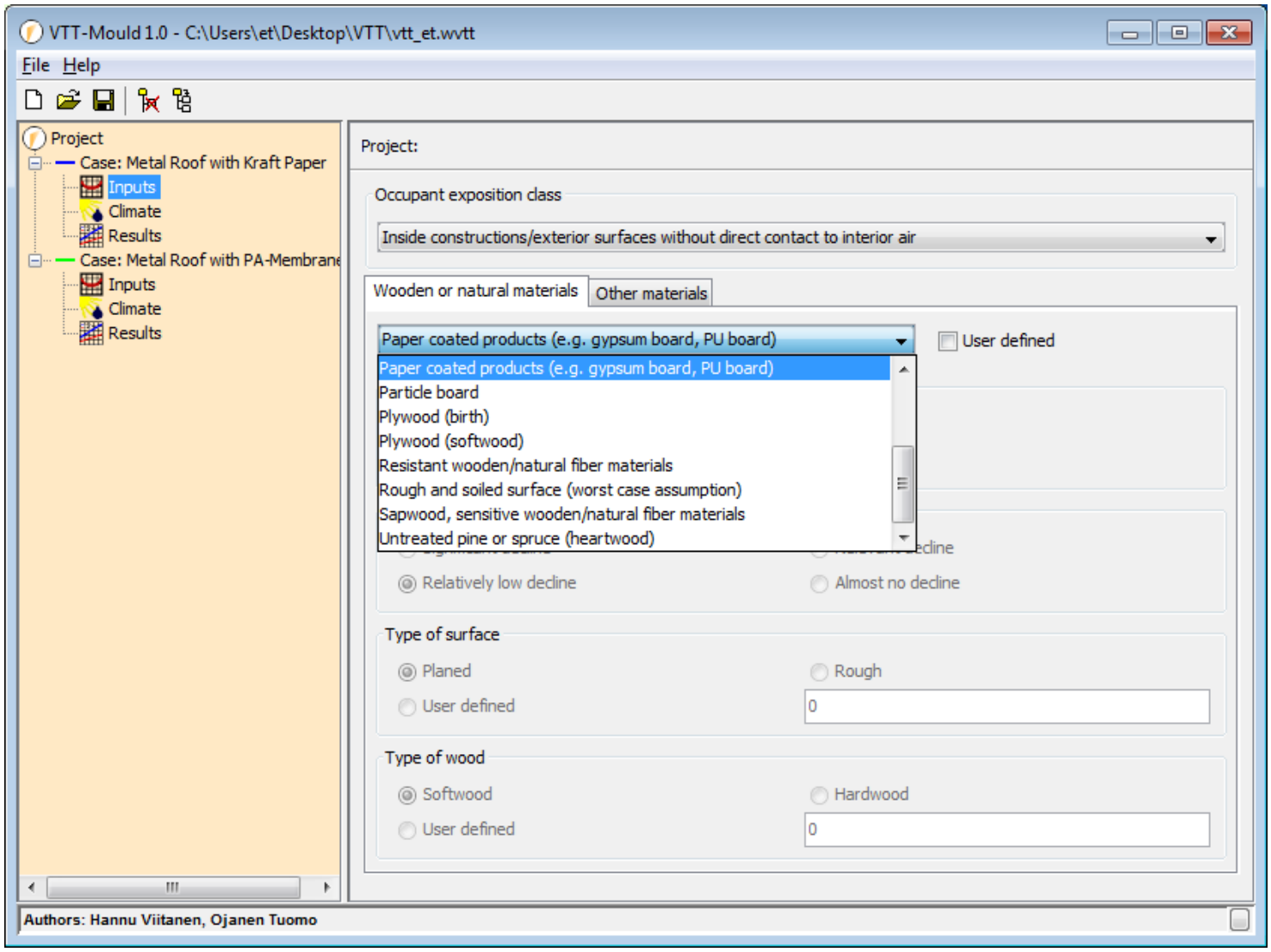
As a PostProcessor combined with WUFI®-Pro (Animation)



Fraunhofer IBP

Evaluation with WUFI®-VTT

Input: Exposition class of surface



Occupant exposition class → criterium of traffic light

Choice of Material
- Wooden materials x 14
- Other materials x 16

Setting the factors
Factors are for each material predefined:
- Sensitivity Class
- Material Class
- Type of surface
- Type of wood

User defined also possible

Fraunhofer IBP

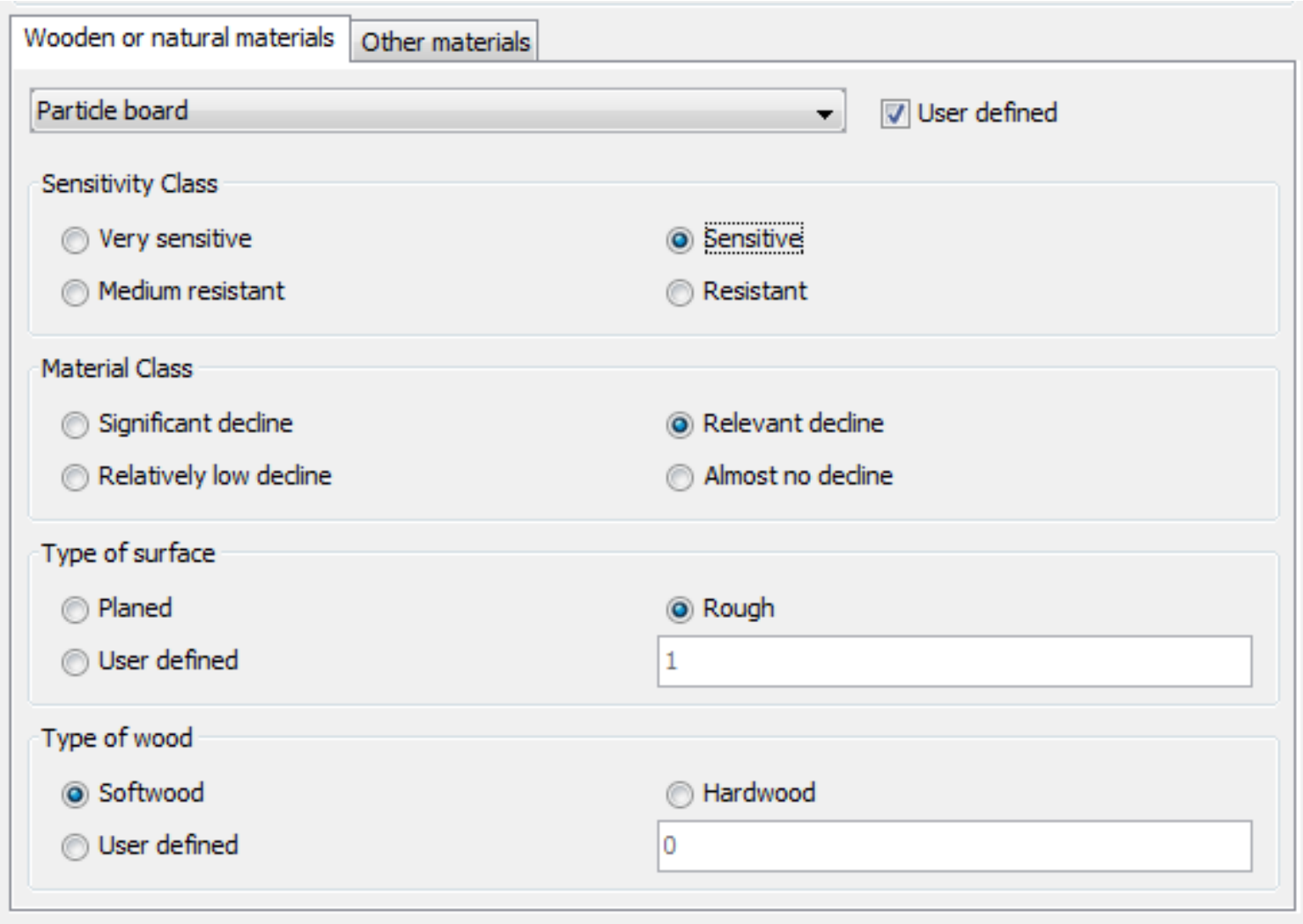
Evaluation with WUFI®-VTT

Input: Available materials in the lists

Wooden and natural materials	Other materials
Coated wooden materials for outdoor use	„worst case“
Hardwood resistant (e.g., oak, larch, western red cedar) (heartwood)	Aerated autoclaved concrete
Hardwood sensitive (e.g. birch, maple, beech) (heartwood)	Brick
Mineral fibers	Cement based materials
Moisture resistant Particle board	Concrete
OSB	EPS
paper coated products (e.g. gypsum board, PU board)	Glass / Metal / Metal coated surface
Particle board	Gypsum render with organic compounds
plywood (birch)	Light weight concrete
plywood (softwood)	PU-insulation with Al-foil
Resistant wooden / natural fibre materials	PUR-products
Rough and solied surface (worst case assumption)	Prastic surfaces (smooth)
Sapwood, sensitive wooden/natural fiber materials	Prastic wool
Untreated pine or spruce (heartwood)	Pure gypsum or lime render
	Silicate wall painting
	Wall paints for indoor use

Evaluation with WUFI®-VTT

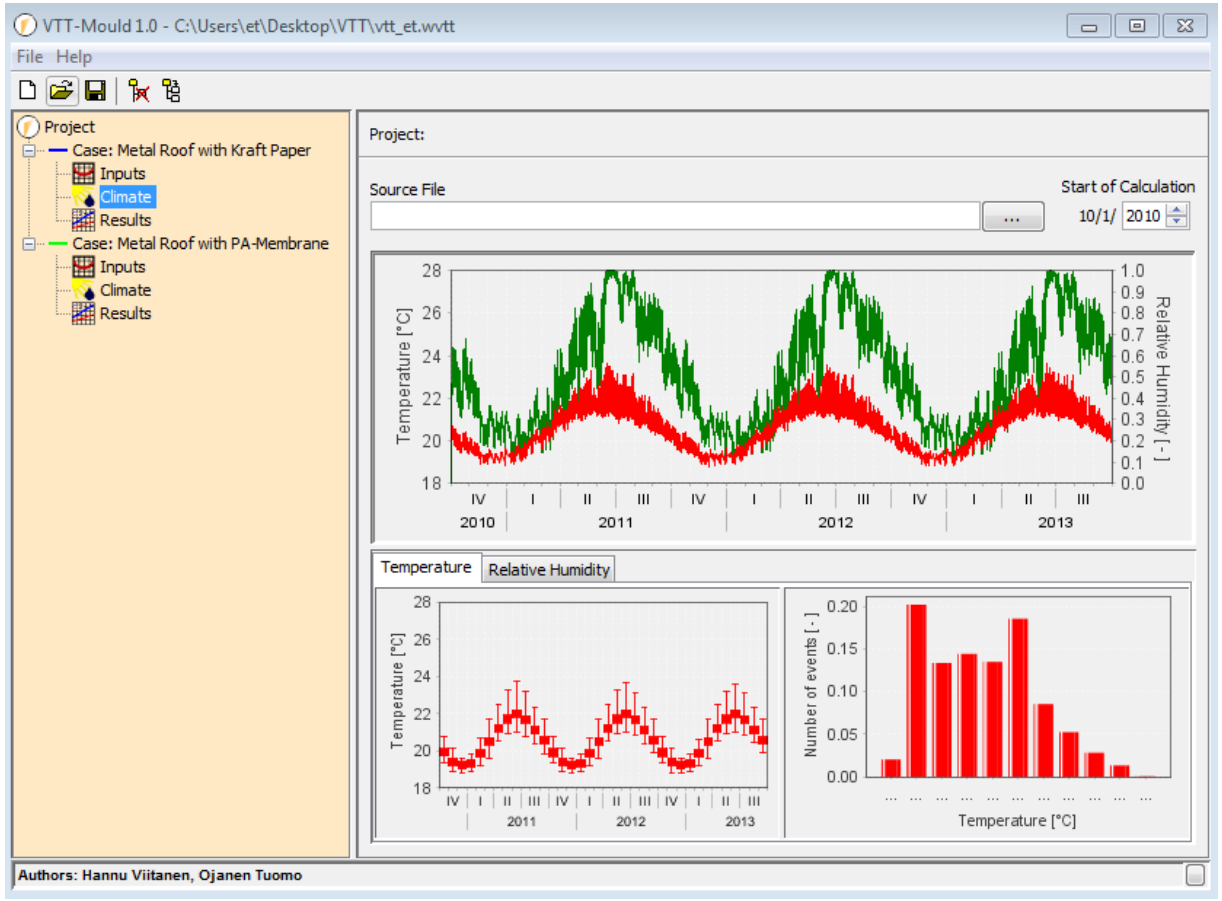
Input: User defined seetings

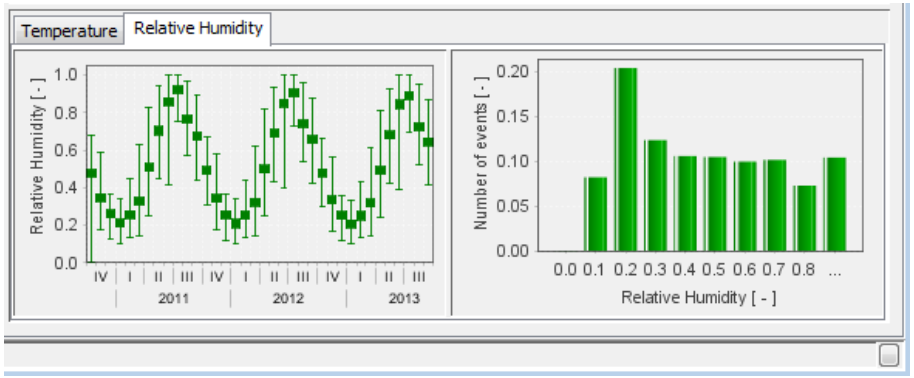


Fraunhofer IBP

Evaluation with WUFI®-VTT

Climate: Temperature and Relative Humidity used for the Assessment Input from WUFI®

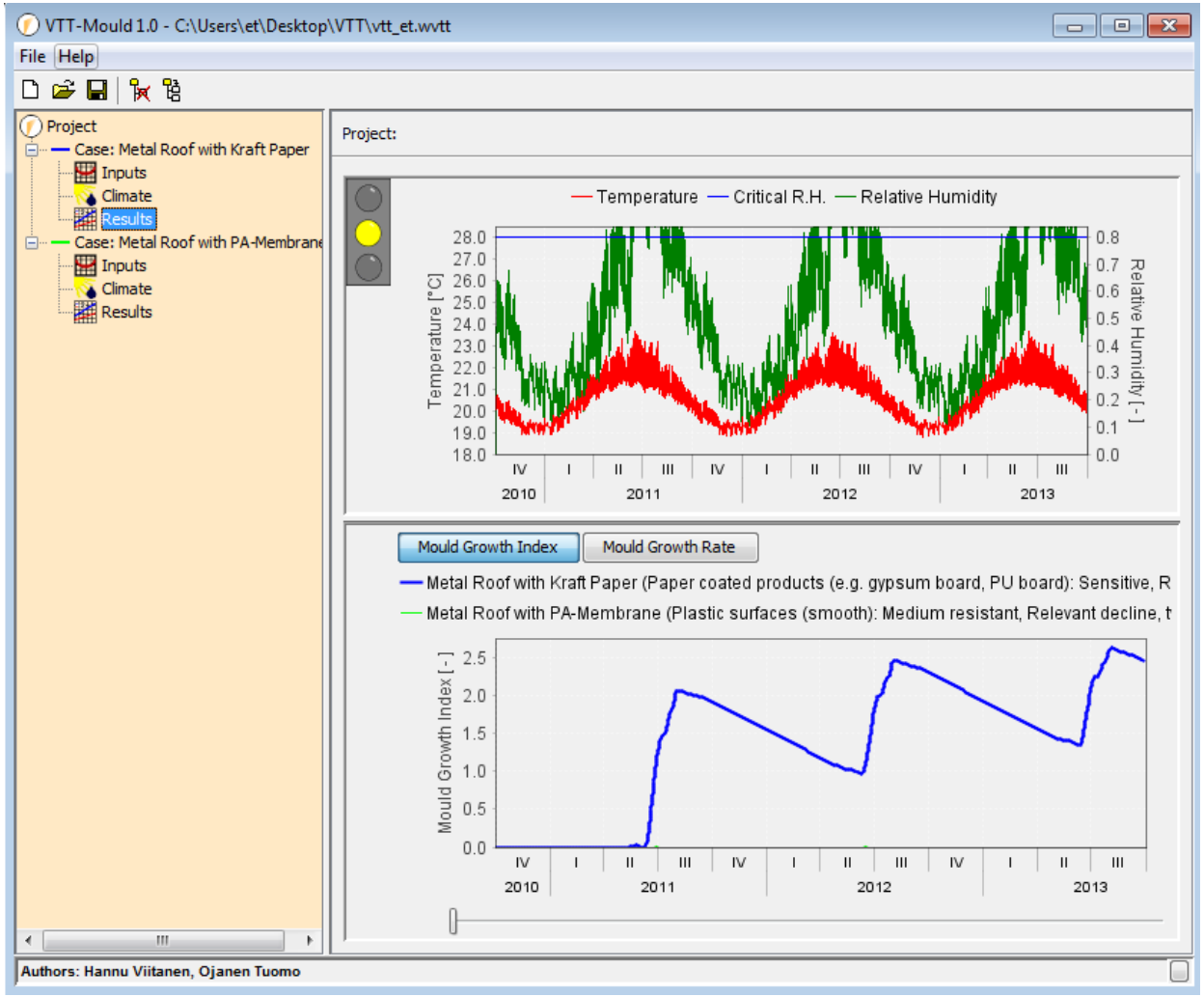




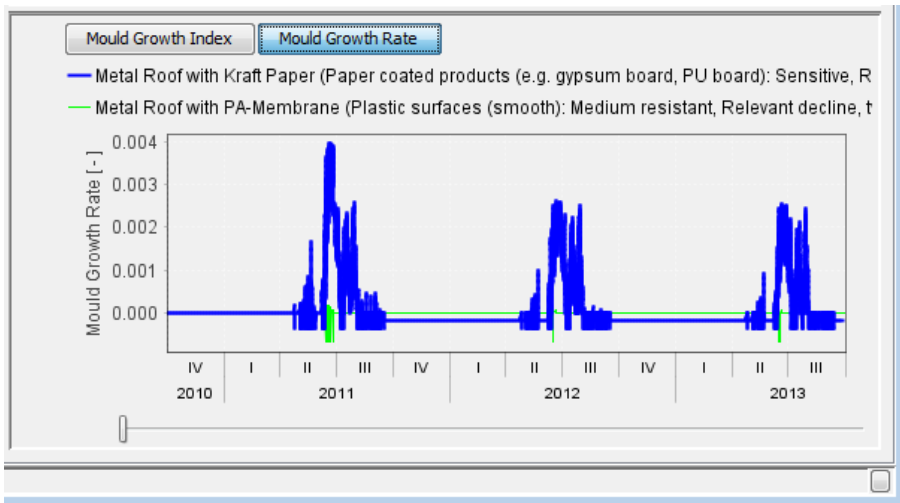
Fraunhofer IBP

Evaluation with WUFI®-VTT

Kraft Paper



Mould Growth Index

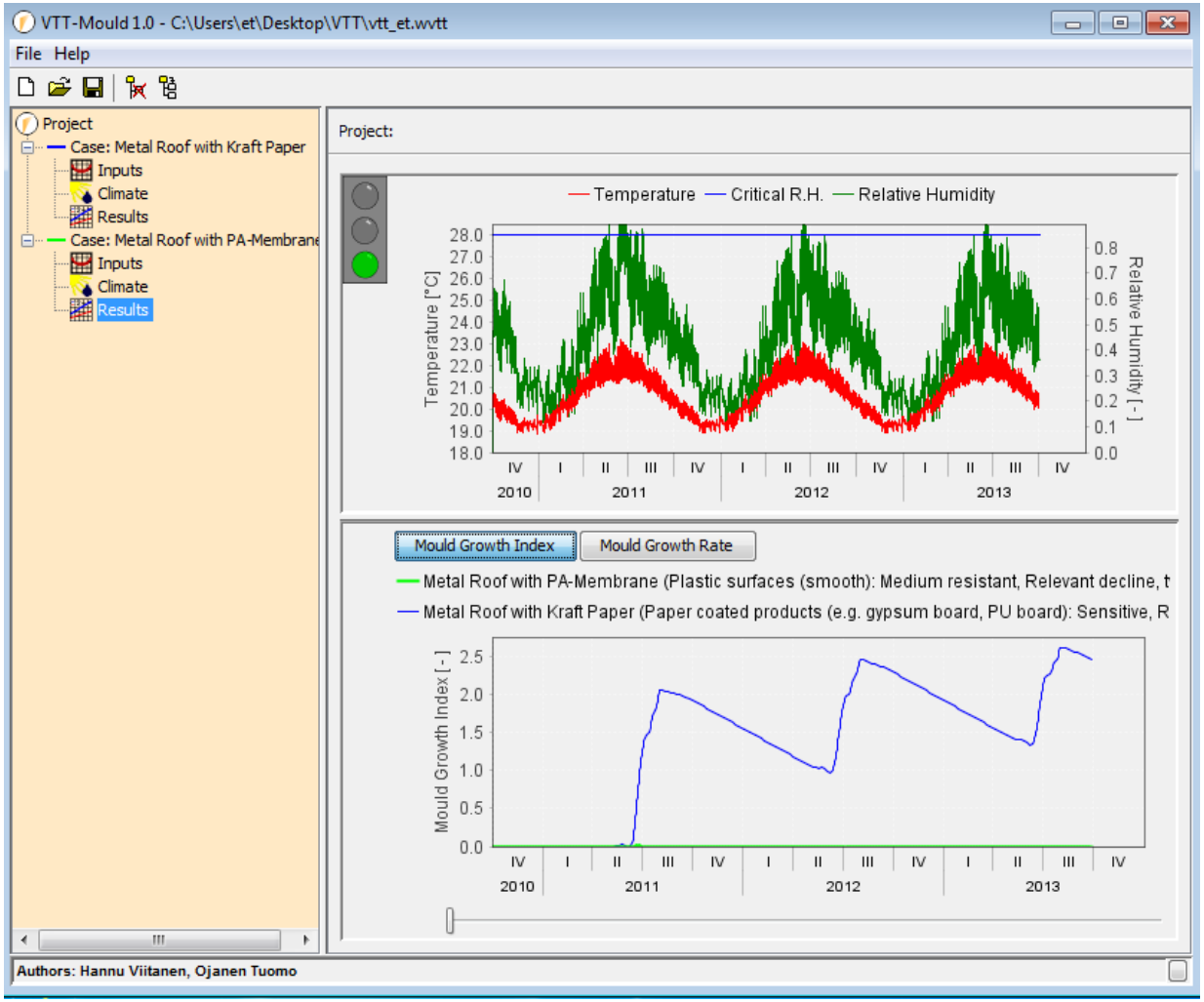


Mould Growth Rate

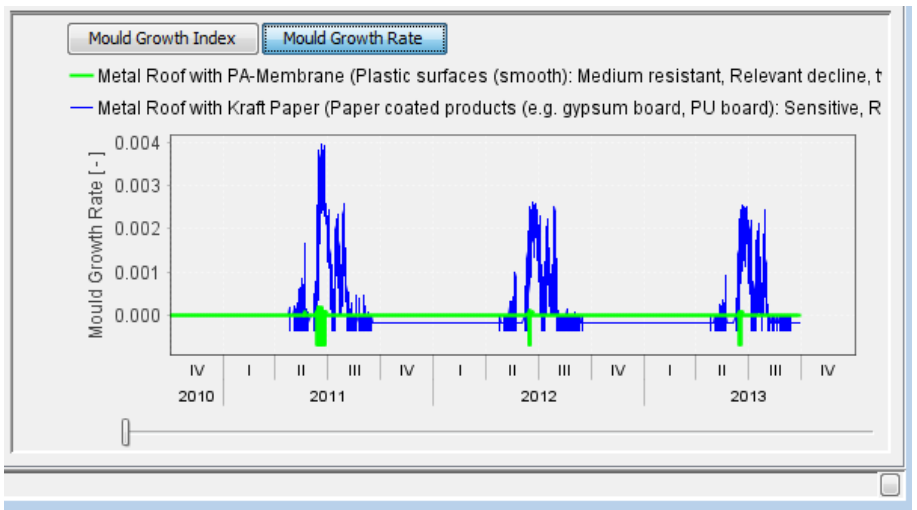
Fraunhofer IBP

Evaluation with WUFI®-VTT

PA-Membrane (compared to Kraft Paper)



Mould Growth Index



Mould Growth Rate

Fraunhofer IBP

Common traffic light classification

Comparison of mould growth prediction from the two models to develop a transfer function for hyphen growth in mm to Mould Index MI

Outdoor climate: 32 different locations in Europe and USA representing regions with cold winters, moderate climate, warm summer etc.

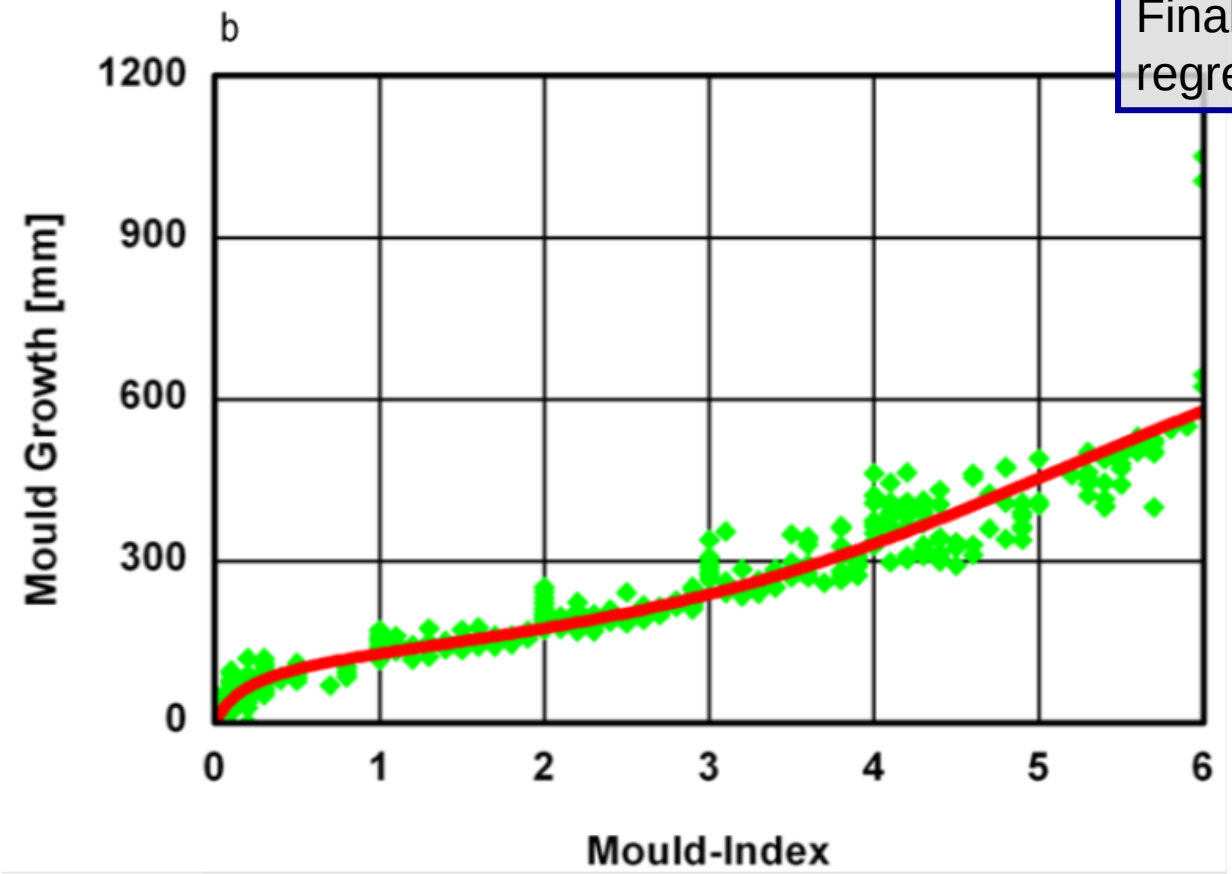
Indoor climate: 14 different cases varying indoor climate according to different European and US standards and guidelines

Lightweight and massive assemblies with U-values from 0,3 W/m²K (well insulated new walls) to 1,9 W/m²K (thermal bridge situation)

→ In total about 350 simulation cases

Common traffic light classification

Comparison of mould growth prediction from the two models to develop a transfer function for hyphen growth in mm to Mould Index MI



Finally good correlation with polynomial regression fit (red curve)

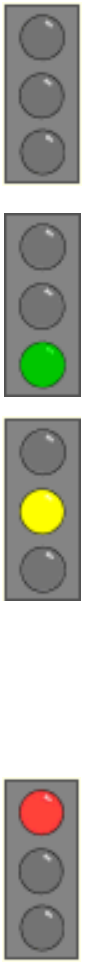
Periods with growth reduction (only VTT model) and growth rates above MI 6 (only IBP model) were excluded

A Brunauer–Emmett–Teller (BET) adsorption was chosen as regression curve

Transfer Function allows to compare the results of the two models and to express them commonly in the clear six-steps Mould-Index scale

Fraunhofer IBP

Common traffic light classification for VTT and Bio



Interior surface / direct contact to the indoor air	Surfaces inside the assembly / no contact to the indoor air	Contact with users / inhabitants excluded
Period too short (< 1 year) ⇨ Evaluation not possible or not meaningful		
MI < 1 : no or just starting invisible growth acceptable in indoor spaces (plants, food)	MI < 2 : no or only invisible growth, recognizable only by microscope	MI < 3 : growth starts to become visible to the naked eye
1 ≤ MI < 2: invisible growth, recognizable only by microscope	2 ≤ MI < 3: growth starts to become visible to the naked eye	MI ≥ 3 In most cases no damage of the material due to mold! Stricter limits may be necessary to avoid damage caused by metabolites or to exclude growth of toxic mold species! Topic of further research!
MI ≥ 2: growth starts to become visible to the naked eye	MI ≥ 3: growth is visible to the naked eye and starts covering the surface	

Model limitations

1. **No evaluation of exterior surfaces!**
   ⇨ UV radiation, frost, rain water impact may be lethal for many species considered by the model.

2. **Reduced growth risk in isolated air gaps inside the assemblies!**
   ⇨ No new spores and nutrients are provided during operation.

3. **Reduced growth risk on fresh concrete, renders or cementitious materials**
   ⇨ alkaline conditions prohibit mold formation and the predicted MI values are not valid until complete carbonation of the considered surface

4. **Reduced or eliminated growth risk at interfaces exposed to high temperatures (like e.g. dark flat roofs**)
   ⇨ high temperatures can become lethal for most mold species. If hyphen die before sporolation, the interface is sterilized

Conclusions

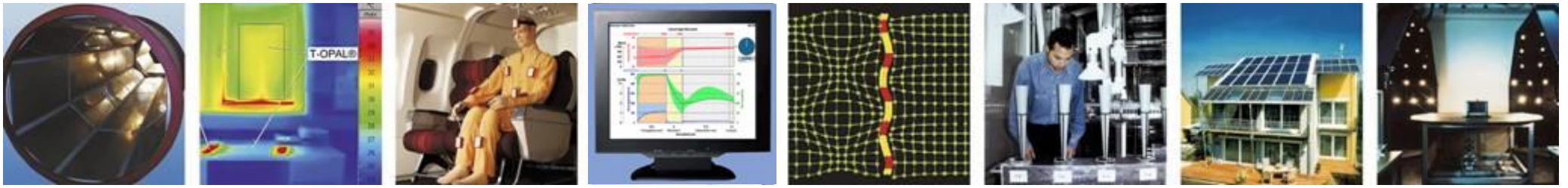
Transfer function allows to compare the results of VTT / Viitanen and the Biohygrothermal IBP model.

Apart from minor deviations both models provide similar risk predictions.

Therefore also a common risk classification becomes possible. The traffic light classification helps to interpret the results depending on exposure and to avoid misevaluation!

Green: no or negligible growth / acceptable conditions
Red: significant growth / inacceptable conditions
Yellow: remaining uncertain range / evaluation of growth risk depends on specific operation and requirements

A new software tool for the **VTT / Viitanen model** as well as a new version of the **Biohygrothermal IBP model** will be **available for free** on the homepages of VTT and IBP!
The tools can evaluate both: simulation results and measured data!



Mold growth risk evaluation with the mold index MI

Fraunhofer IBP