



**HOLZ  
FORSCHUNG**  

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**A U S T R I A**

Member of

**ACR** AUSTRIAN COOPERATIVE RESEARCH  
*KOOPERATION MIT KOMPETENZ*

# Proposal for a modified Glaser-Method for the risk assessment of flat timber roofs

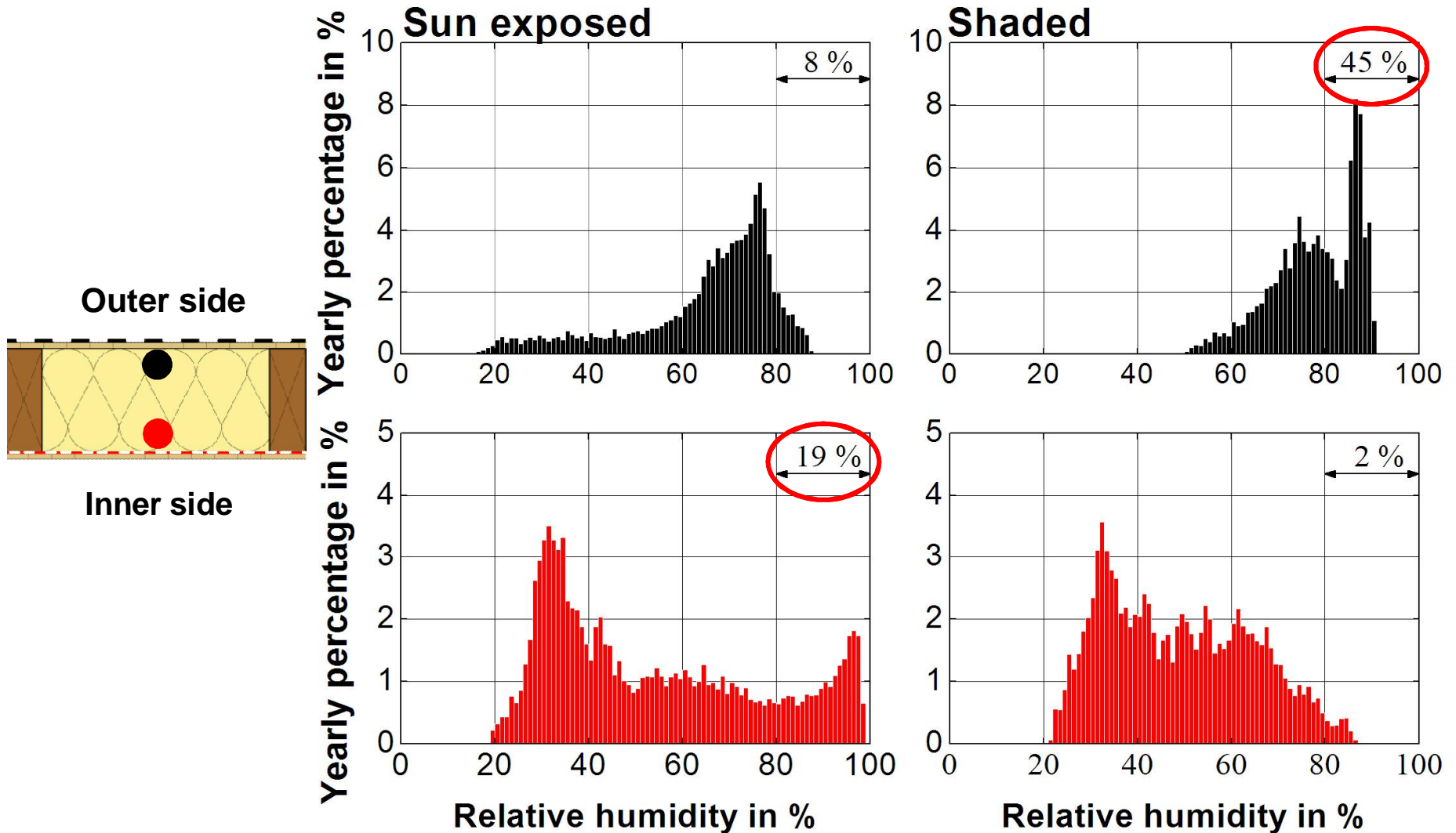
Bernd Nusser, Thomas Bednar, Martin Teibinger



# Full scale studies



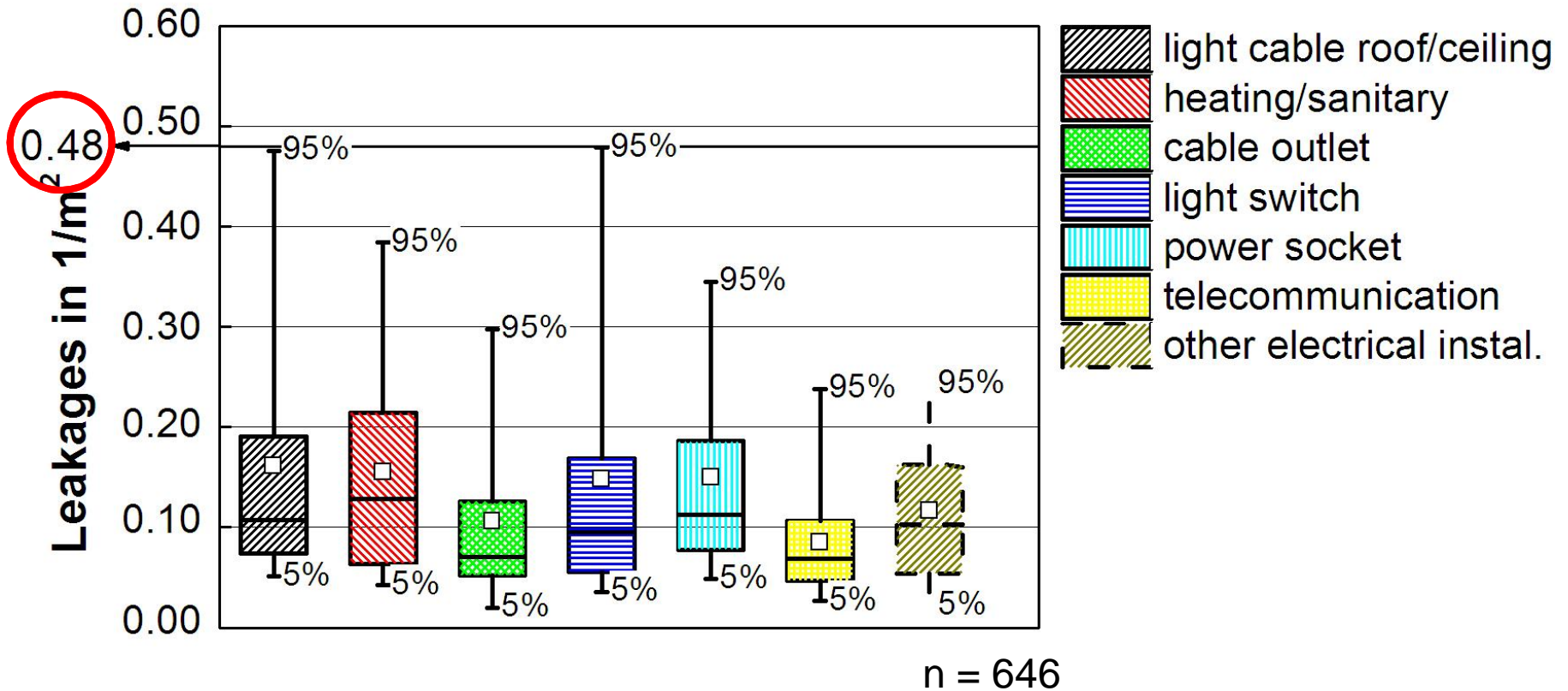
# Solar radiation



# Air exfiltration



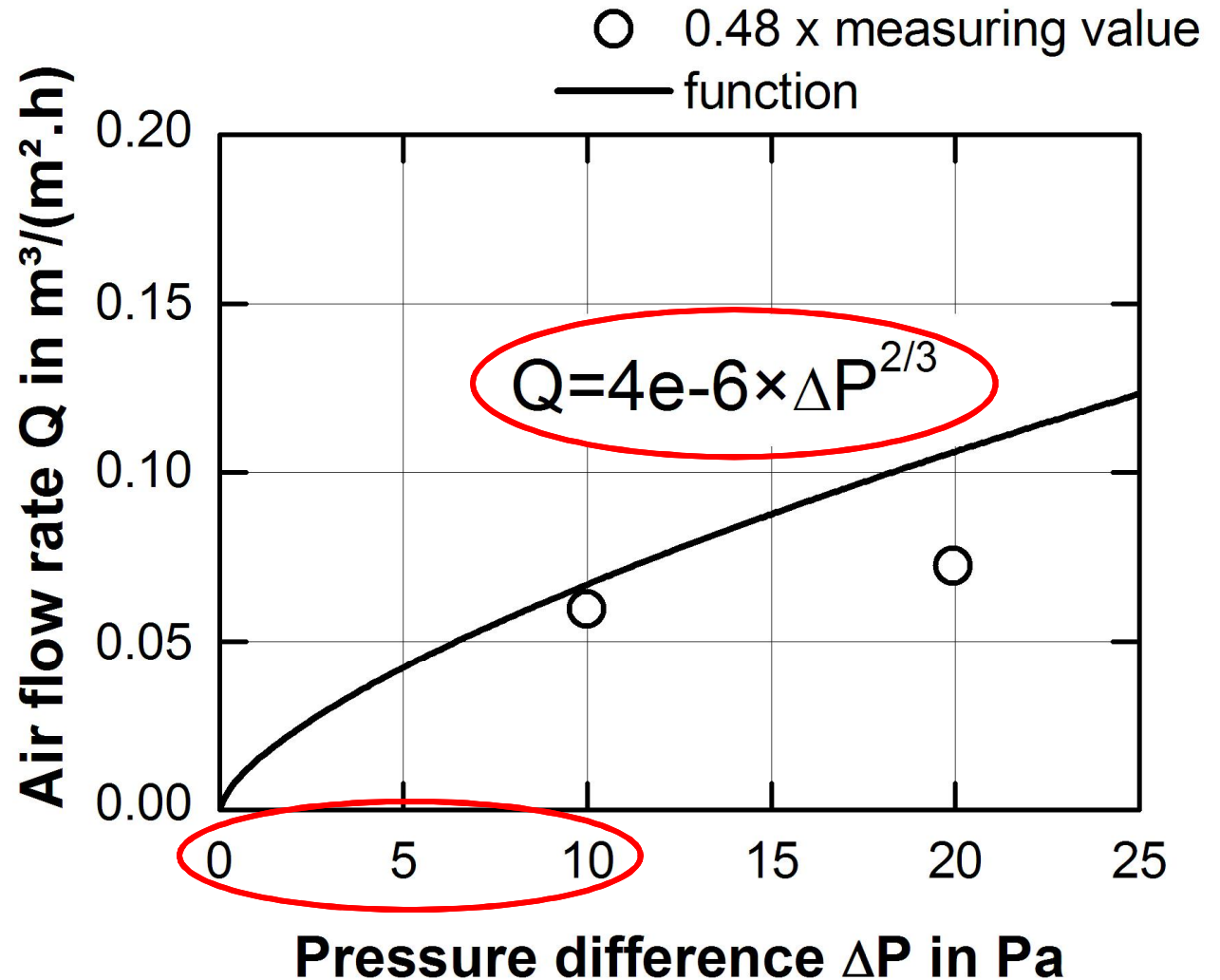
# Potential leakages in prefabricated houses



# Air flow through leakages



Hall, M.; Hauser, G. (2003)



# Building element airtightness classes

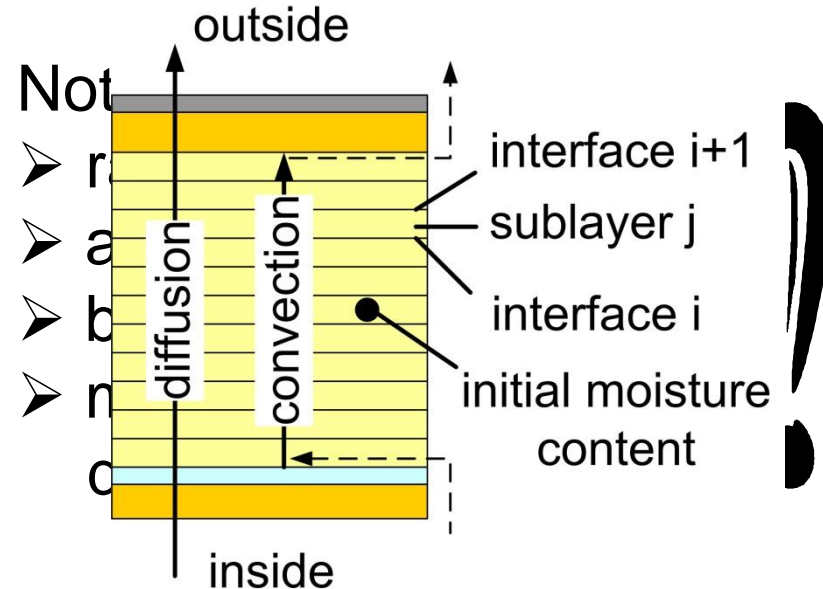
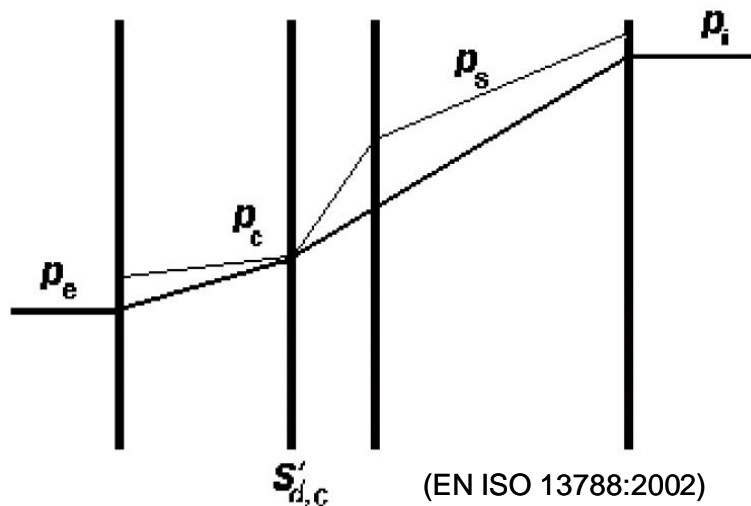
	Airtightness class			
	A+	A	B	C
<b>Requirements</b>	<ul style="list-style-type: none"> <li>- prefabricated</li> <li>- water vapour retarder membrane &amp; sheeting</li> <li>- prefabricated weather cover</li> <li>- CE mark</li> <li>- penetrations with air seal sleeves or totally enclosed</li> </ul>	<ul style="list-style-type: none"> <li>- penetrations with air seal sleeves or totally enclosed</li> <li>- leakage locating and fixing</li> </ul>	<ul style="list-style-type: none"> <li>- penetrations with air seal sleeves or totally enclosed</li> <li>- leakage locating and fixing</li> </ul>	<ul style="list-style-type: none"> <li>- up to date airtight layer</li> </ul>
$n_{50}$	not measured	$< 1.5 \text{ h}^{-1}$	$< 3.0 \text{ h}^{-1}$	not measured
$F_a$	8	4	2	1

↳ Airtightness factor    Air flow rate:  $Q=4e-6 \times \Delta P^{2/3} \times F_a^{-1}$



# Simplest calculation model?

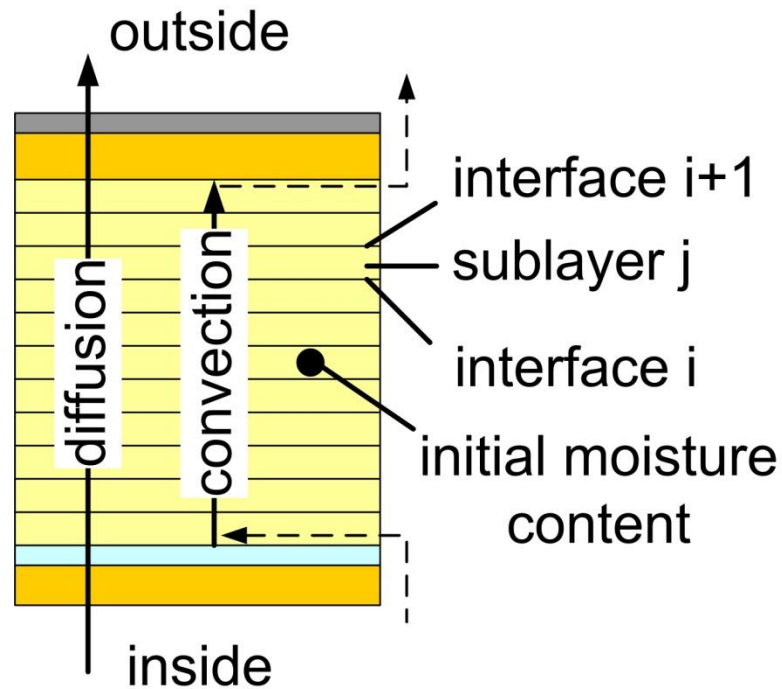
## Glaser-Method (ISO 13788)



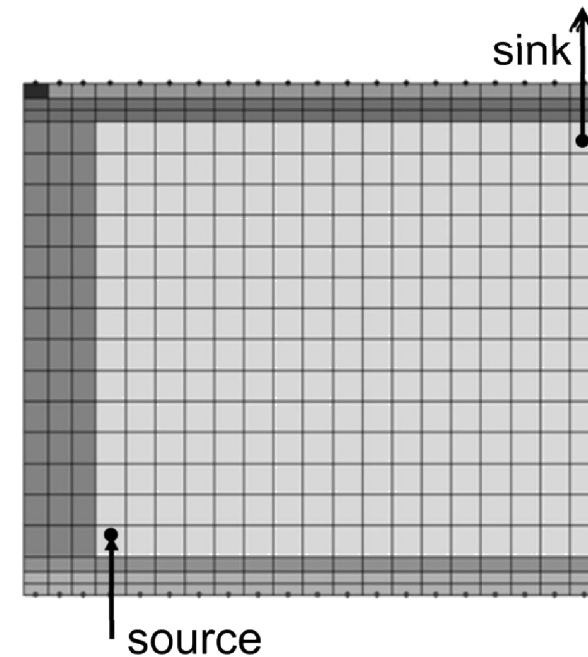
Implemented

- heat/mass transport by convection
- heat exchange by radiation
- initial moisture content of material layers
- moisture dependent diffusion resistance of material layers

## Quasi steady state 1D vs. transient 2D



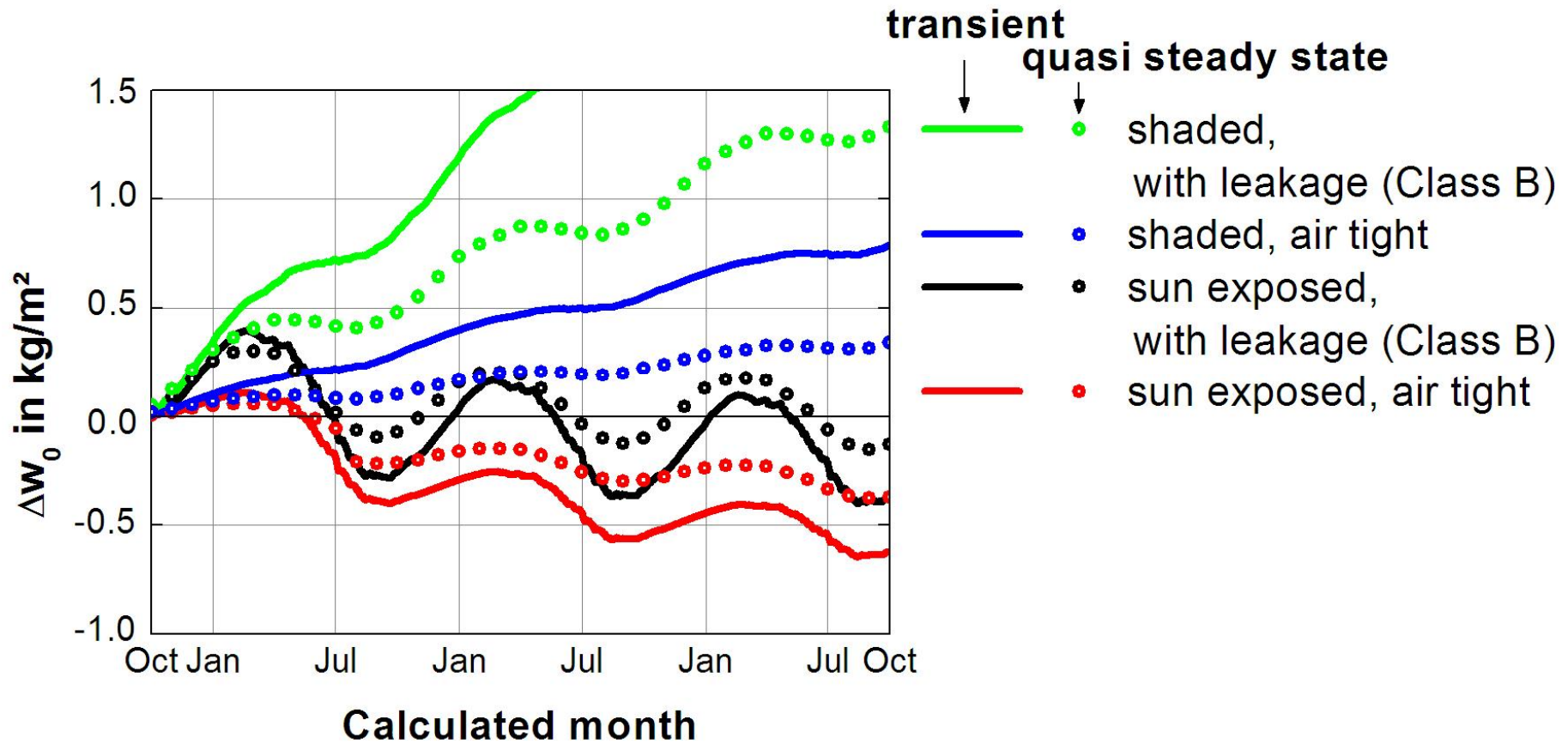
vs.



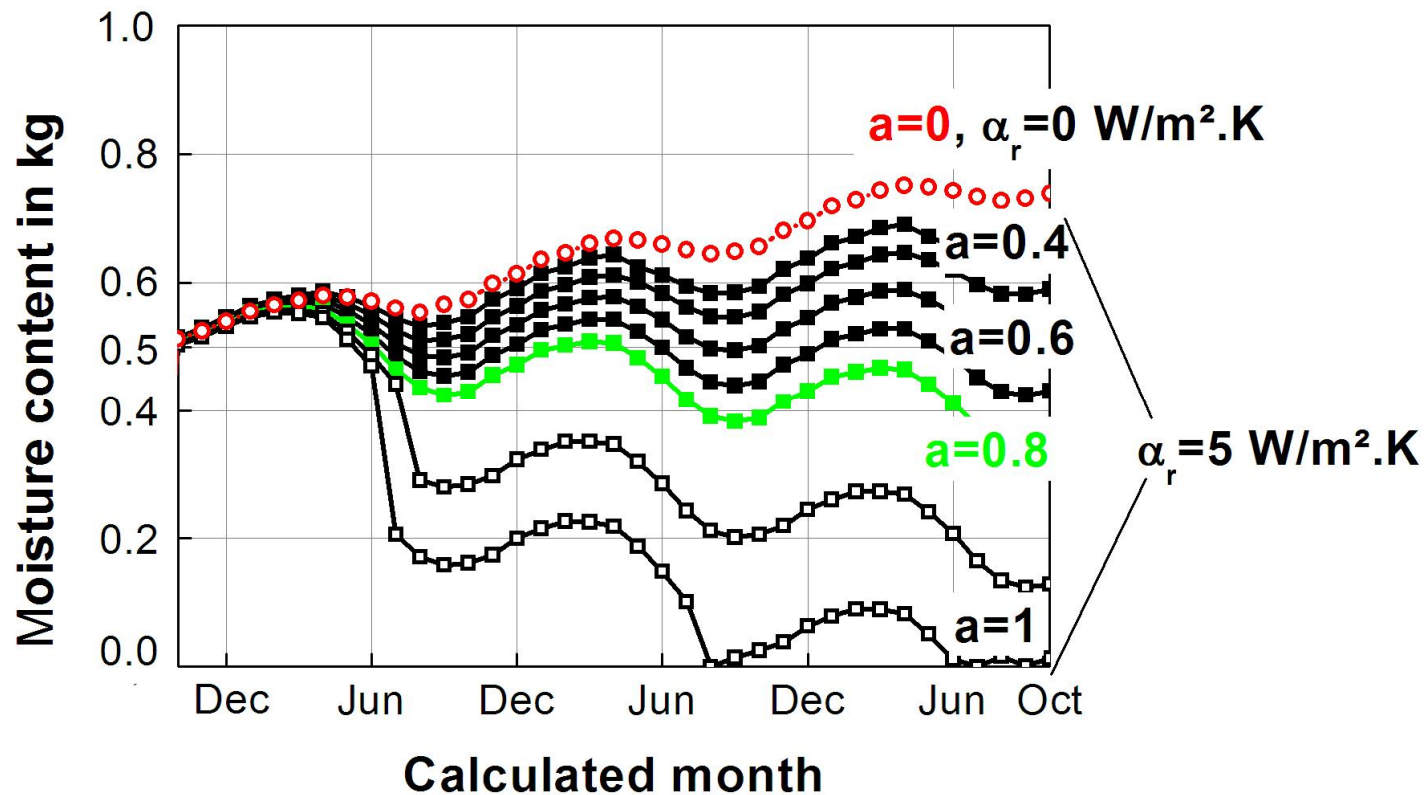
Quasi steady state (monthly mean values)

Transient (hourly values)  
HAM3D-VIE  
(validated with full scale test data)

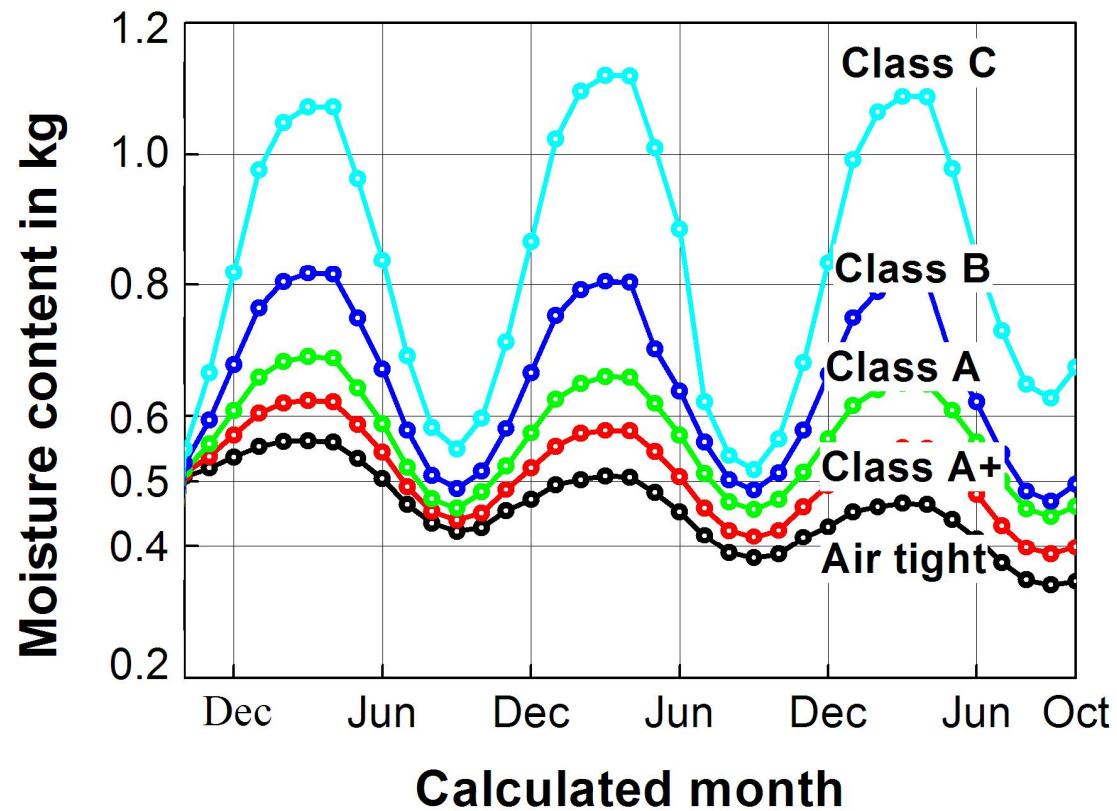
# Quasi steady state 1D vs. transient 2D



# Influence of solar absorption



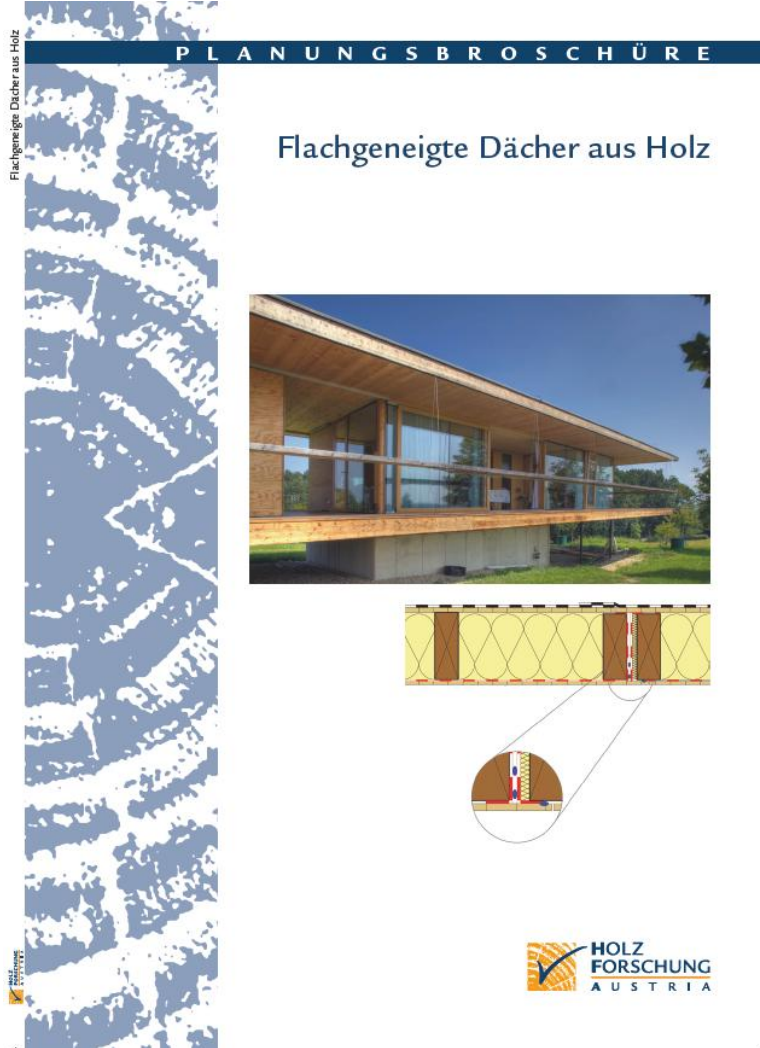
# Influence of air exfiltration



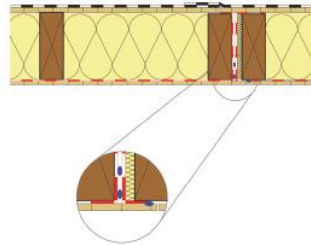
## Conclusion

- Strong influence of solar absorption/shading
- Strong influence of air exfiltration
- Influencing factors should be considered in the ISO 13788 with proposed assesment method
- Modified Glaser-Method underestimates moisture change
  
- Proper decision criteria has to be defined to evaluate the suitability of the calculated building component

# Planning Brochure



## Flachgeneigte Dächer aus Holz

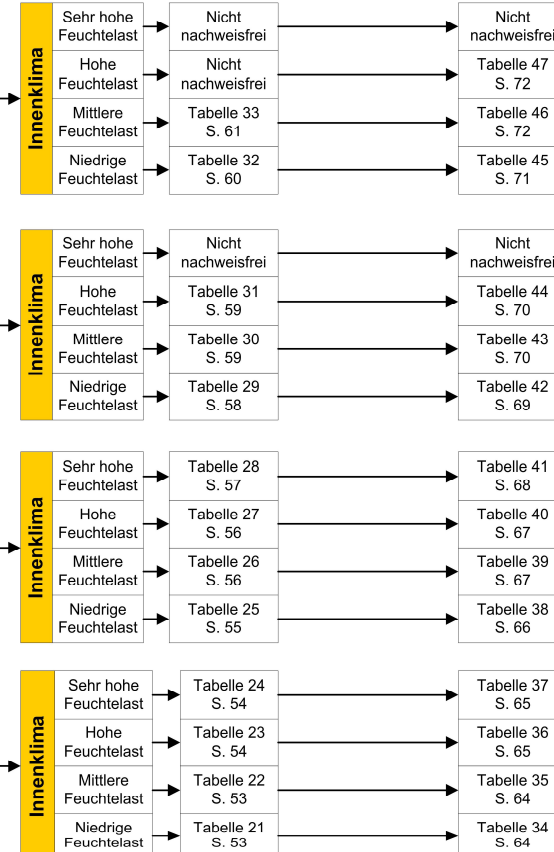


Attika		
Höhe in cm 0-50	Höhe in cm 50-80	Höhe in cm > 80
OHNE zusätzliche Beschattungsanalyse des Attikabereichs	MIT zusätzlicher Beschattungsanalyse des Attikabereichs	

Tabelle 48  
S. 74

### Luftdichtheitsklasse (LDK)

A+	A	B	C
vor-gefertigt	$n_{50} \leq 1,5$ 1/h	$n_{50} \leq 3,0$ 1/h	ohne Prüfung



**Thank you for  
your Attention!**



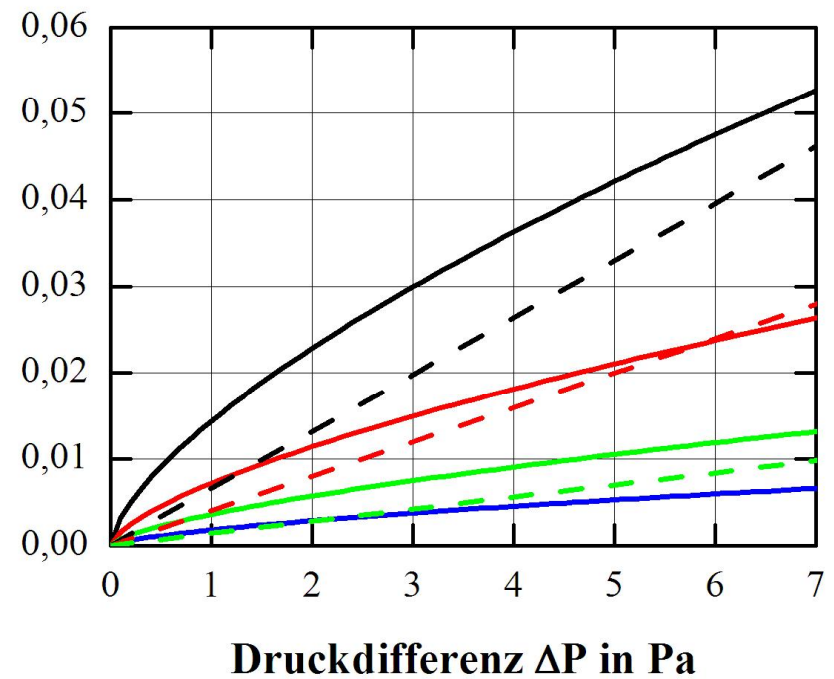
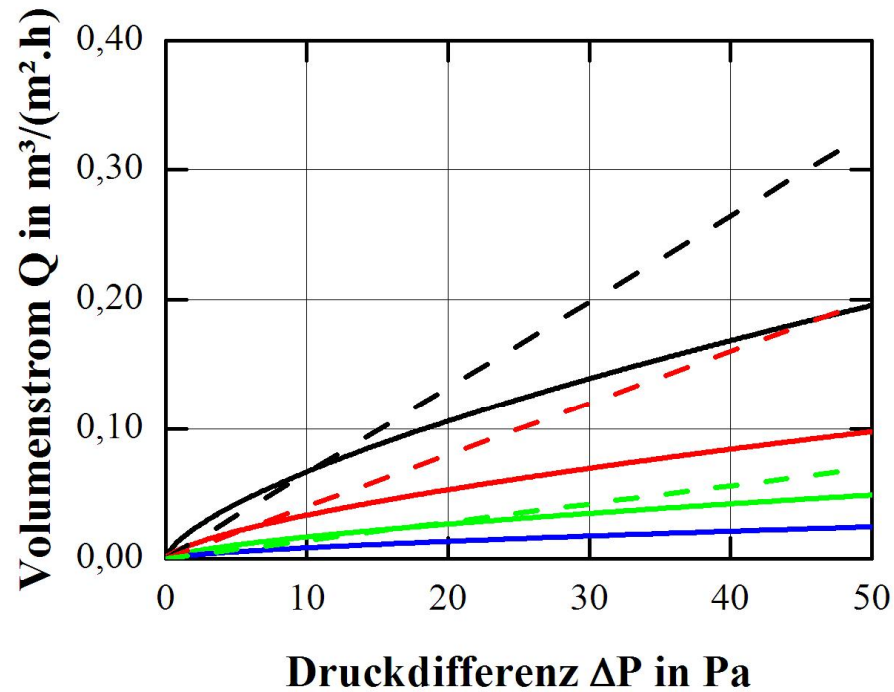
**Bernd Nusser**  
b.nusser@holzforschung.at  
Tel. +43 (1) 798 26 23-71



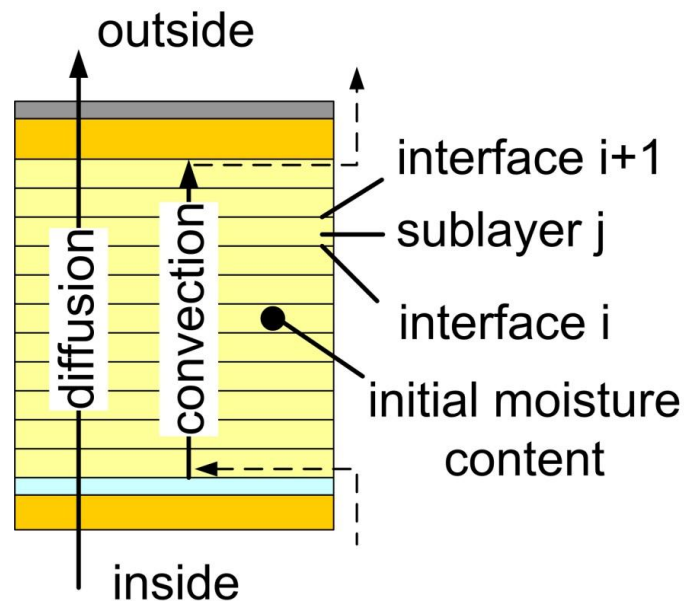


# Compared to WUFI® 5

- LDK C    - - Zirkelbach et al. Klasse C
- LDK B    - - Zirkelbach et al. Klasse B
- LDK A    - - Zirkelbach et al. Klasse A
- LDK A+    - -



# Heat transport



$$q_i = c \cdot \dot{m} \cdot \left( T_i + \frac{T_i - T_{i+1}}{e^{P_H} - 1} \right)$$

$$\text{mit } P_H = \frac{c \cdot \dot{m}}{\lambda_j / d_j}$$

$q_i$  Wärmestromdichte über die Schichtgrenze  $i$  in  $\text{W}/\text{m}^2$

$c$  Spezifische Wärmekapazität der Luft =  $1006 \text{ J}/(\text{kg} \cdot \text{K})$

$T_{i,i+1}$  Temperatur an der Schichtgrenze  $i$  bzw.  $i+1$  in  $\text{K}$

$\lambda_j$  Wärmeleitfähigkeit der Schicht  $j$  in  $\text{W}/(\text{m} \cdot \text{K})$

$d_j$  Dicke der Schicht  $j$  in  $\text{m}$

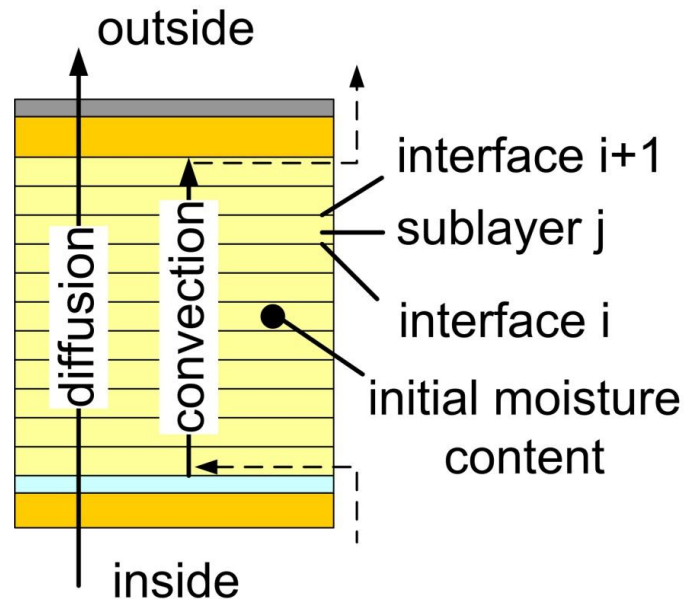
$$\dot{m} = \rho_{air} \cdot F \cdot Q$$

$\dot{m}$  Luftmassenstrom in  $\text{kg}/(\text{m}^2 \cdot \text{s})$

$\rho_{air}$  Dichte der Luft =  $1,2 \text{ kg}/\text{m}^3$

$F$  Luftdichtheitsfaktor

# Radiation



$$q_{surf,ex} = \alpha_c \cdot (T_{surf,ex} - T_{air,ex})$$

$$+ \alpha_r \cdot (T_{surf,ex} - T_{sky})$$

$$- a \cdot (1 - f_s) \cdot I_s$$

$q_{surf,ex}$  Wärmestromdichte über die Außenoberfläche in  $W/m^2$

$\alpha_{c,r}$  konvektiver bzw. radiativer Wärmeüberganskoeffizient in  $W/(m^2 \cdot K)$

$T_{surf,ex}$  Temperatur der Außenoberfläche in K

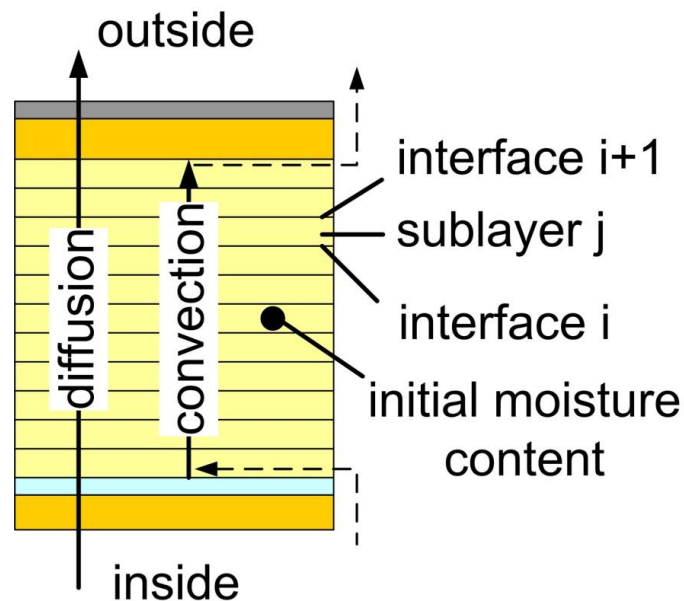
$T_{sky}$  Himmelstemperatur in K

$a$  solarer Absorptionskoeffizient der Außenoberfläche

$f_s$  Verschattung der Außenoberfläche (0-0,8)

$I_s$  mittlere monatliche Solarstrahlung in  $W/m^2$

# Mass transport



$$j_i = \frac{0,622}{p_0} \cdot \dot{m} \left( p_i + \frac{p_i - p_{i+1}}{e^{P_M} - 1} \right)$$

$$\text{mit } P_M = \frac{\dot{m} \cdot 0,622 / p_0}{\delta_0 / (\mu_j \cdot d_j)}$$

$j_i$  Massenstromdichte über die Schichtgrenze  $i$   
in  $\text{kg}/(\text{m}^2 \cdot \text{s})$

$p_0$  Luftdruck in Pa

$p_{i,i+1}$  Wasserdampfpartialdruck an Schichtgrenze  $i$   
bzw.  $i+1$  in Pa

$\delta_0$  Wasserdampfdiffusions-Leitkoeffizient der  
Luft =  $2\text{E}-10 \text{ kg}/(\text{m} \cdot \text{s} \cdot \text{Pa})$

$\mu_j$  Wasserdampfdiffusion-Widerstandszahl der  
Schicht  $j$

$$\dot{m} = \rho_{air} \cdot F \cdot Q$$

$\dot{m}$  Luftmassenstrom in  $\text{kg}/(\text{m}^2 \cdot \text{s})$

$\rho_{air}$  Dichte der Luft =  $1,2 \text{ kg}/\text{m}^3$

$F$  Luftdichtheitsfaktor