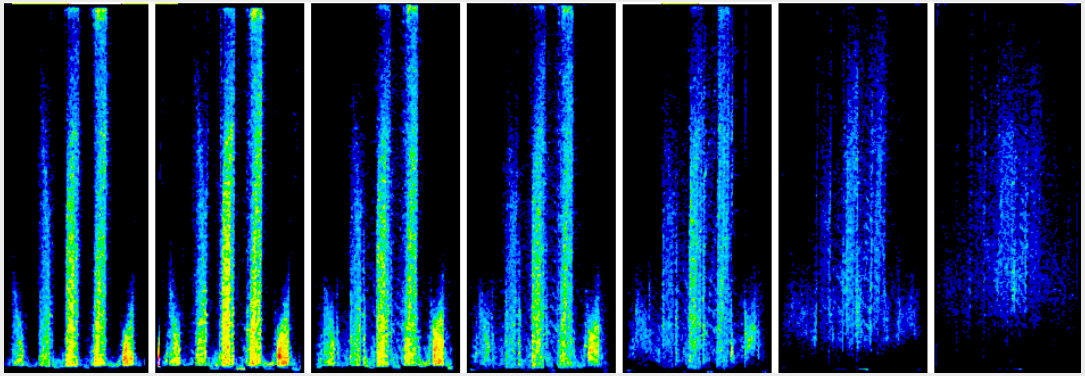
UNIVERSITEIT GENT

FACULTY OF BIOSCIENCE ENGINEERING

Time of Wetness (ToW) simulation based on testing moisture dynamics of wood



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COST FP1303
Kranjska Gora
23-24 October 2014

UGent WOODLAB

INTRODUCTION

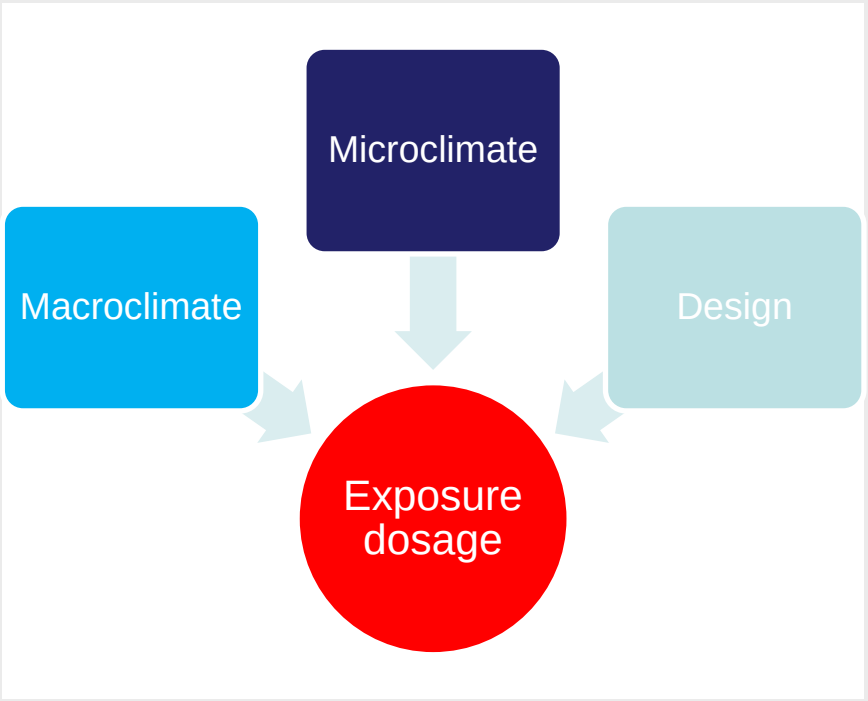
Moisture and Rot

-> Service life

-> Moisture dynamics

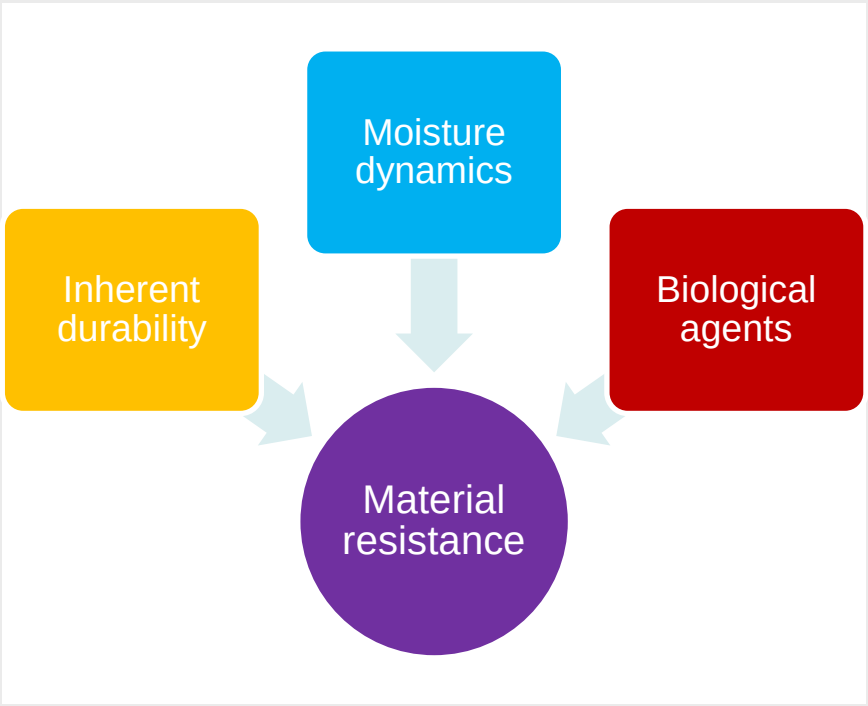
PerformWOOD
Performance standards for wood in construction - delivering customer service life needs

Exposure dosage



PerformWOOD
Performance standards for wood in construction - delivering customer service life needs

Material resistance



Material resistance

PerformWOOD
Performance standards for wood in construction - delivering customer service life needs

Biological point of view – fungal resistance

1) Organism related testing (optimal MC)
→intrinsic nutritional quality / toxicity

2) Moisture related testing (wetting ability – drying rate)
→ moisture behaviour / dynamics linked to ToW

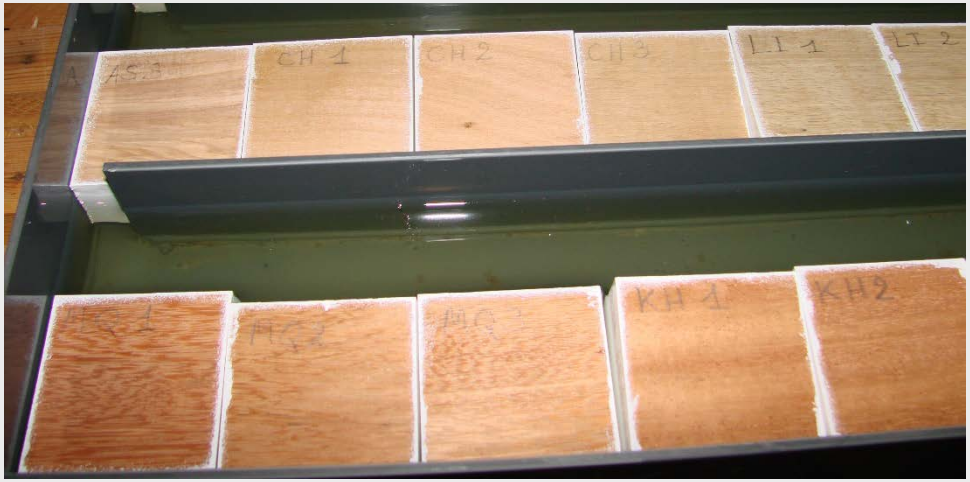
EXPERIMENTAL

Floating test

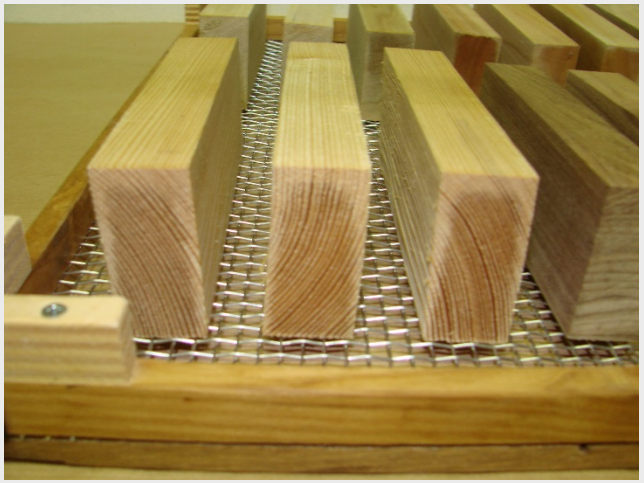
Submersion test

[Not water vapour sorption]

Floating test



Submersion test

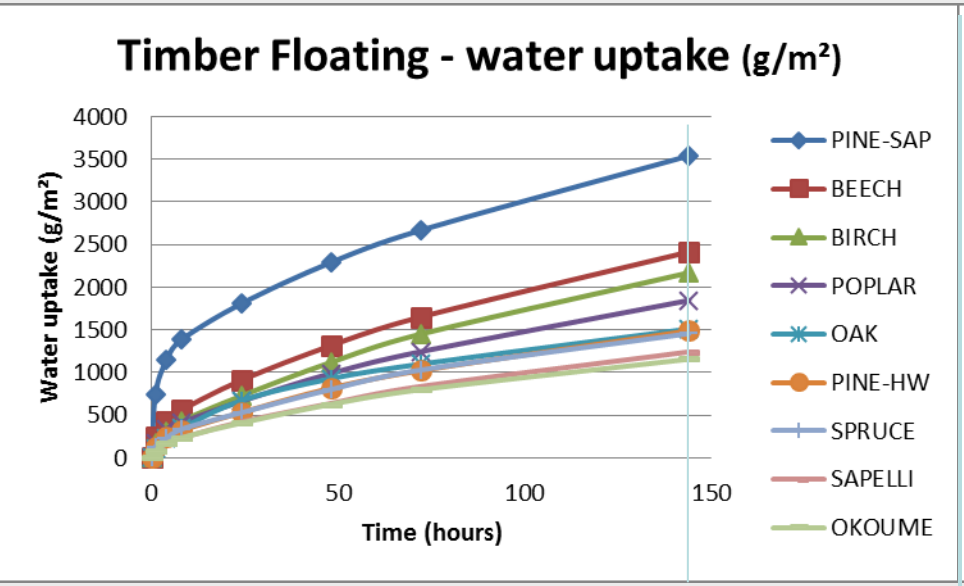


RESULTS AND DISCUSSION

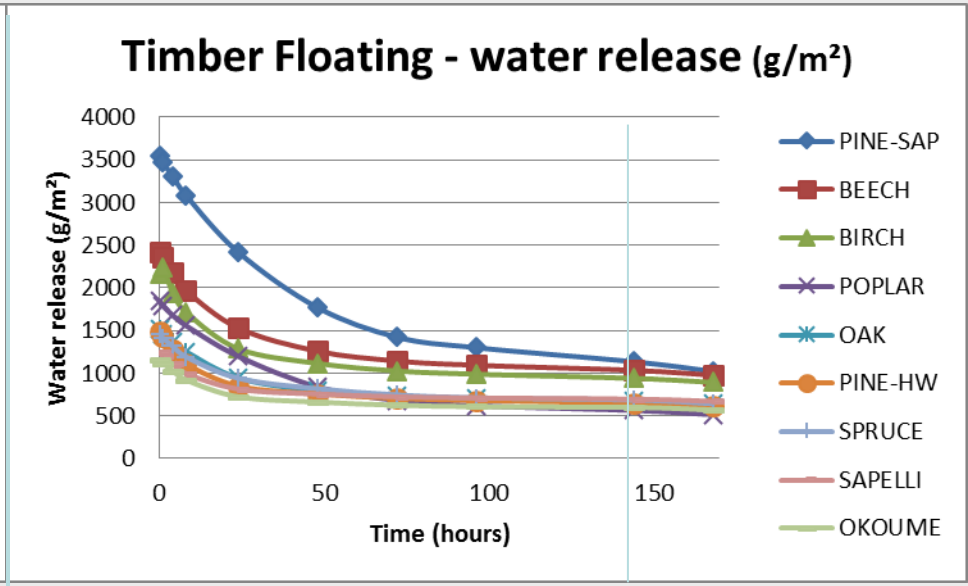
Wetting - drying

ToW concept

Water uptake – release / absorption - desorption



144 hrs



144 hrs

Classification of abs. and des. in groupings

Class upper limit	Floating test (g/m^2)		Submersion test (kg/m^3)	
	Absorption	Desorption	Absorption	Desorption
1	750	250	90	15
2	950	400	110	20
3	1150	500	130	25
4	1350	600	150	30
5	1750	750	170	40
6	2750	1000	210	55
7	5000	2000	250	70
8	∞	∞	∞	∞

Classification parameters from fitted curves

Absorption

$$f(x) = a * x^b$$

a: steepness of linear area

- absorption coefficient

b: close to 0.5, if not…

special phenomena,
capillary uptake…

Desorption

$$f(x) = a + b * e^{\left(-\frac{x}{c}\right)}$$

a: the asymptotic value after drying

b: the amount that is released

c: low c-values correspond with fast drying

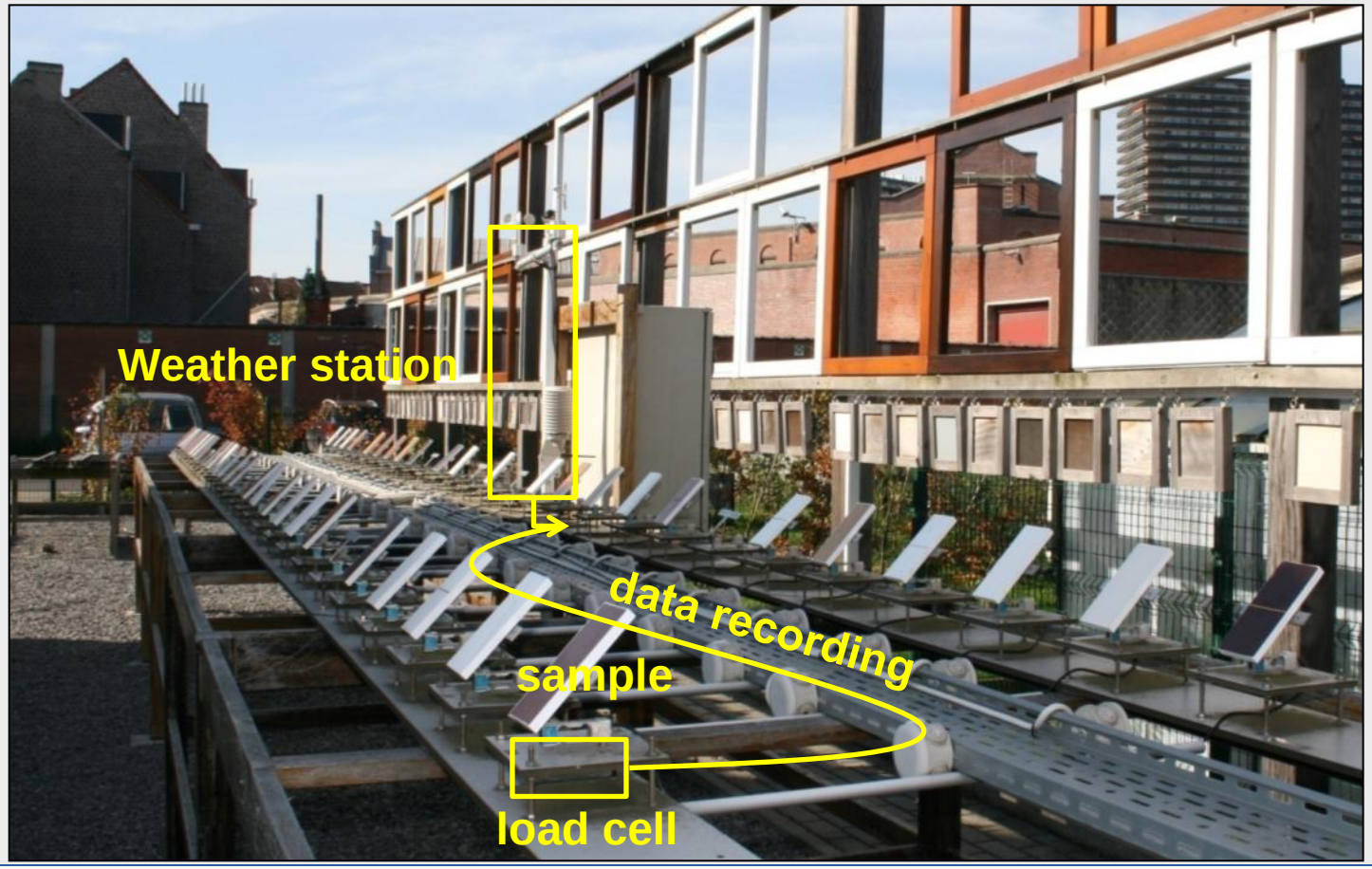
Wood species	Class F / A	Class F / D	Class S / A	Class S / D
DOUGLAS FIR	3	4	3	5
LARCH	5	5	6	6
MAR PINE	7	7	7	7
PINE-HW	4	4	5	5
PINE-HW 2	5	5		
PINE-SAP	7	7	7	6
PINE-SAP 2	7	7		
PINE-SAP 3	7	6		
RAD PINE	8	8	6	6
SIB LARCH	4	5	4	5
SIB LARCH 2	5	5	5	6
SIB LARCH 3	5	6	6	7
SPRUCE	5	5	5	5
SPRUCE 2	5	5		
W RED CEDAR	4	3	4	1

Wood species	Class F / A	Class F / D	Class S / A	Class S / D
ALDER	6	6	7	5
ASH	4	4	5	6
BEECH	6	7	8	8
BEECH 2	6	7		
BEECH 3	6	7		
BIRCH	6	6		
BIRCH 2	6	6	7	8
BLACK LOCUST	2	4	1	3
BLUE GUM	3	2	4	5
CHERRY	5	4	7	6
CHESTNUT	5	4	4	3
MAPLE	7	7	8	5
OAK	5	5	5	5
OAK 2	5	5		
OAK 3	5	5		
POPLAR	6	4	8	6
POPLAR 2	6	4		

EXPERIMENTAL

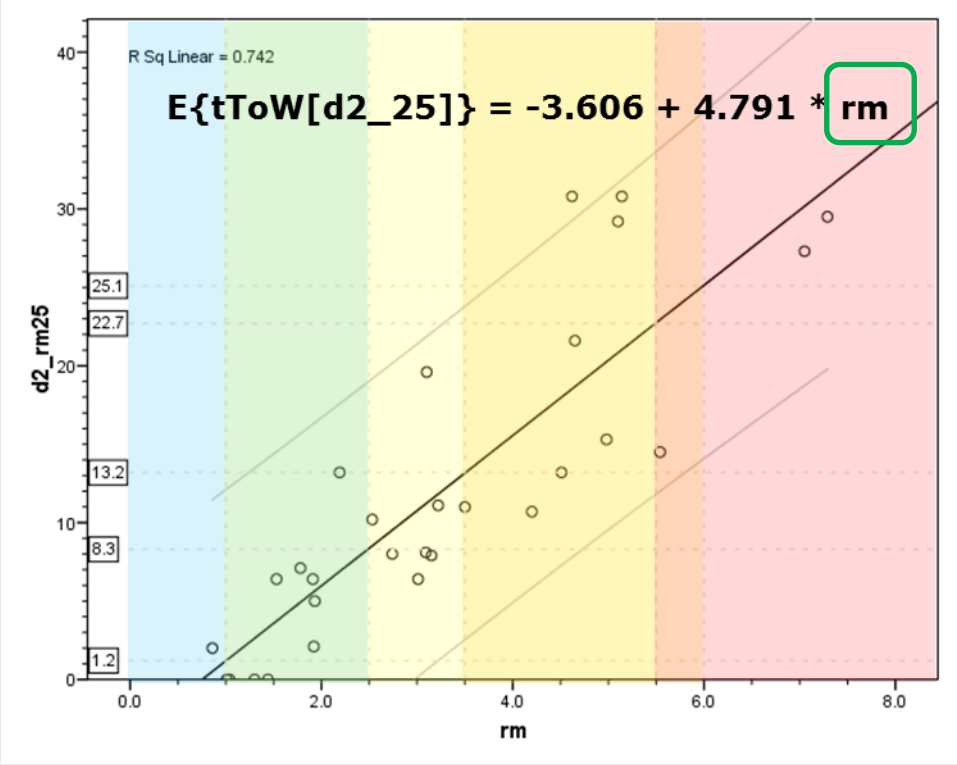
CMM

Continuous Moisture Measurements - CMM



Results from PLYWOODMOISTURE project

ToW at CMM (2d >25 % MC)



Residual moisture after floating test

Results from PLYWOODMOISTURE project

First CMM results expected in second half next year

Modelling?

Water (not water vapour!) absorption:

Important yet difficult to model in building physics (HAM):

- what kind of equations to use?
- influence of driving rain (pressure effect)
- determination of (changing) absorption coefficients / diffusivities
- redistribution of water

-> 1st & 2nd law of Fick -> not applicable > FSP

Modelling?

Theory – fitting 1D:

- Experimental equations such as Peleg and others?

$$M_t - M_0 = \frac{t}{K_1 + K_2 t}$$

$$M_t - M_0 = M_{ret}\left(1 - e^{\frac{-t}{T_{ret}}}\right) + K_{rel}t$$

Modelling?

Theory – fitting 1D:

- Hagen-Poiseuille law for absorption in capillaries?

$$M^2 = \xi \frac{\rho^2 A^2 \phi^2 \left(S_{wf} - S_{wi}\right)^2 r_{ae} \sigma cos\theta}{2\mu} t$$

Modelling?

Theory – 3D fitting:

- Conservation of mass with a Fickian like partial differential equation?

$$\frac{\delta W}{\delta t} + \nabla.(-D.\nabla W) = 0$$

with $D = \frac{\pi}{4}\left(\frac{A}{w_c}\right)^2$, $A = \frac{m}{\sqrt{t}}$

[Candanedo & Derome 2005]

Modelling?

Theory – 3D fitting:

- Percolation model of Perré for simulation water migration in wood?

-> TransPore model coupling heat and mass

Modelling?

Experimental:

1. Diffusivities change depending on the moisture content
   -> Calculation of redistribution using X-ray CT / neutron tomography

2. Diffusivities depend on the anatomy

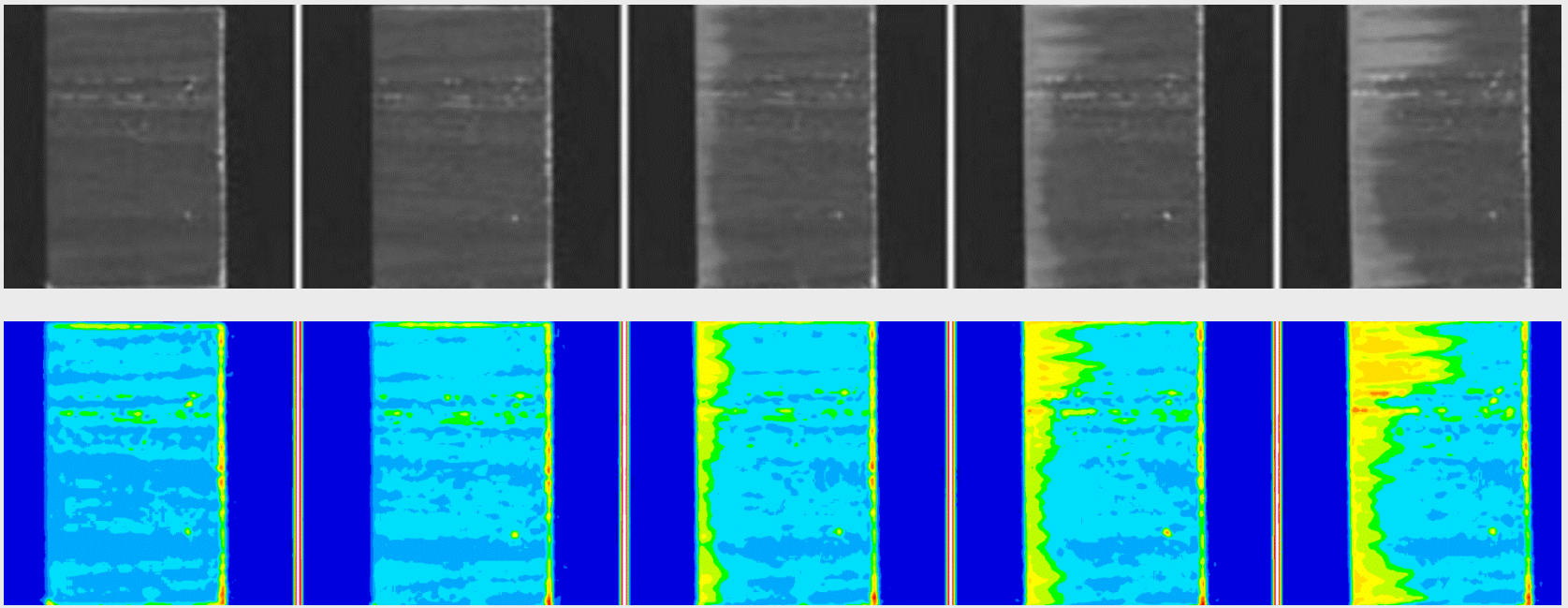
Modelling?

Input:

- Determine absorption coefficients based on the moisture front
- Characterize diffusivities taking into account anatomical parameters
- Determine redistribution of water
- Deviations from average behaviour

Modelling?

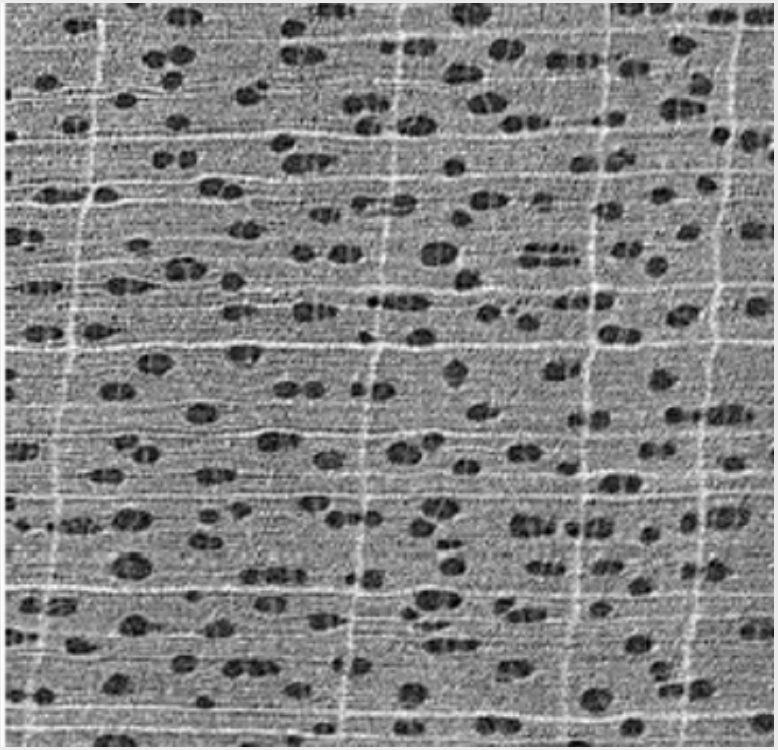
Input: **solid wood (X-ray CT)**



[Li et al. 2013]

Modelling?

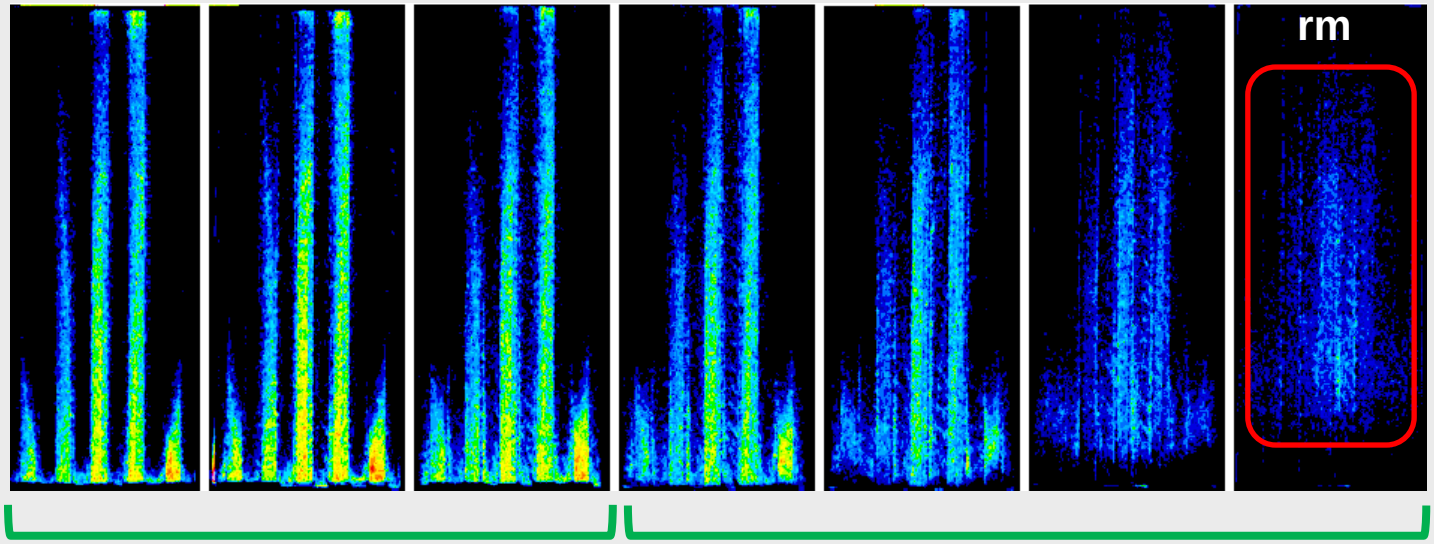
Input:



[Li et al. 2014]

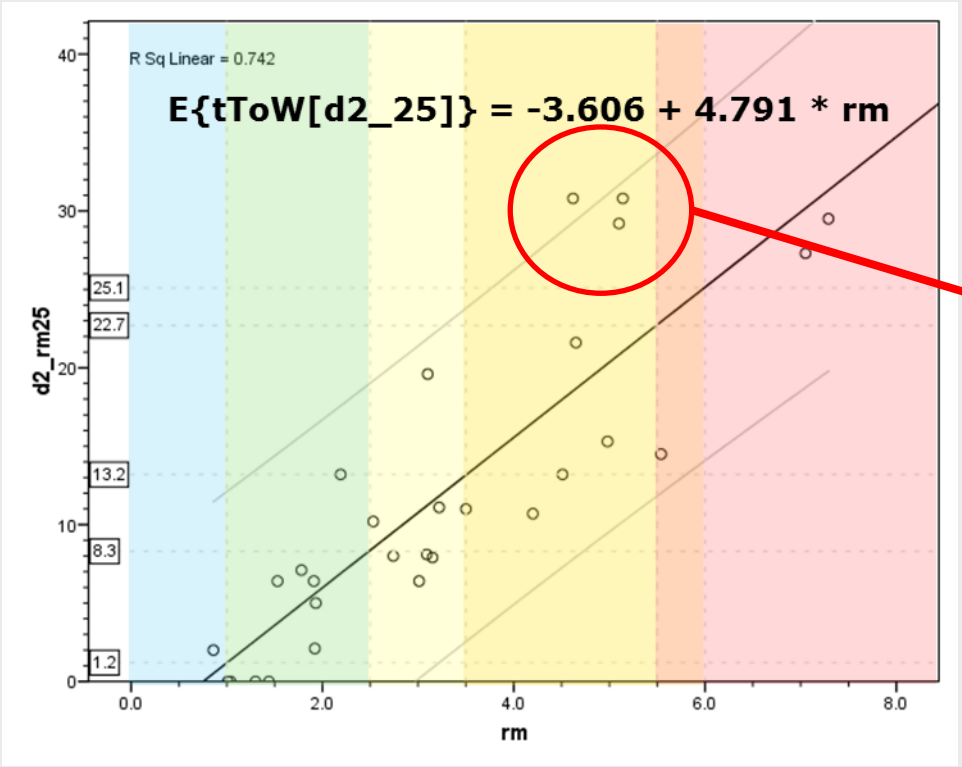
Modelling?

Input: plywood (neutron radiography)



[Li et al. 2014]

Results from PLYWOODMOISTURE project



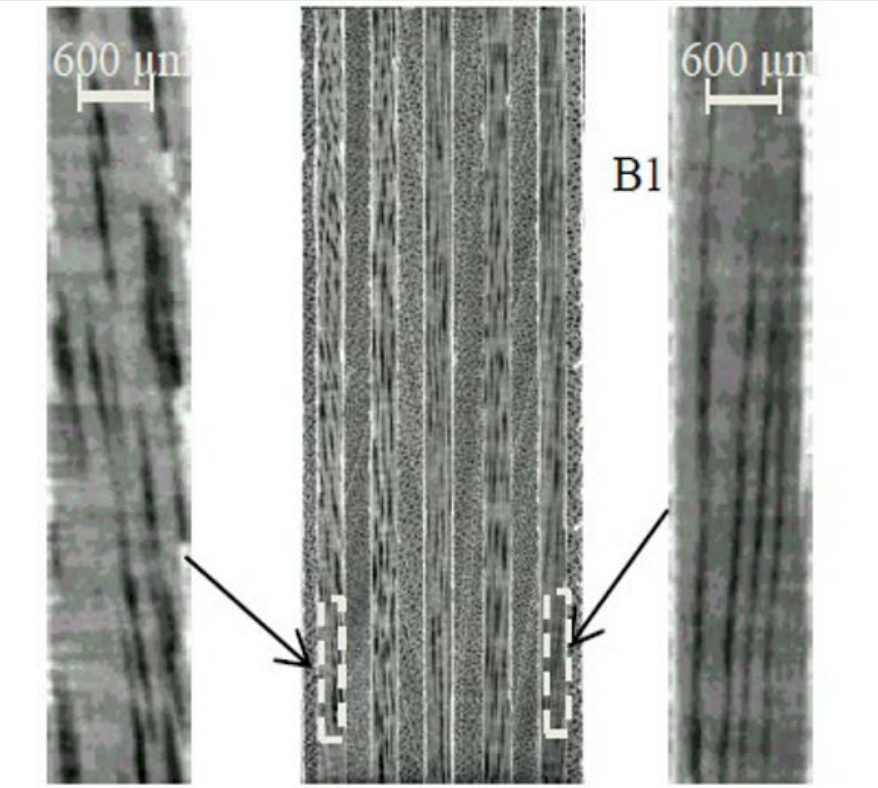
ToW at CMM (2d >25 % MC)

- Weathering
- Structure

Residual moisture after floating test

Modelling?

Input:



[Li et al. 2014]

CONCLUSION

- Work to do in collaboration building & drying physicists
- Preservative treated wood?
- Collaboration outreach

THANK YOU

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