ALTERNATIVE PLANTS

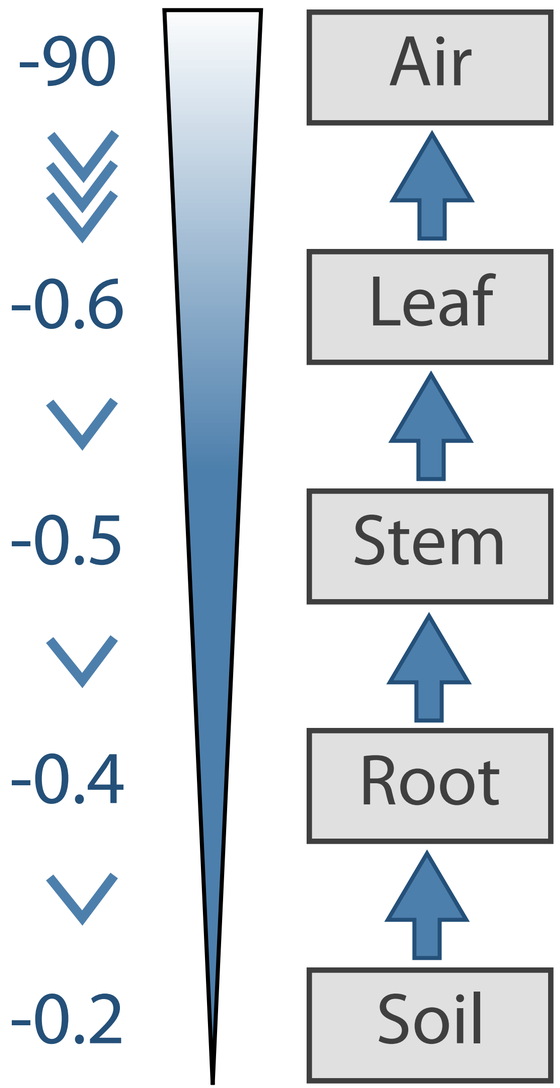
WHY DO WE NEED **MODELS** TO UNDERSTAND THE **COMPLEXITY** OF PLANTS.

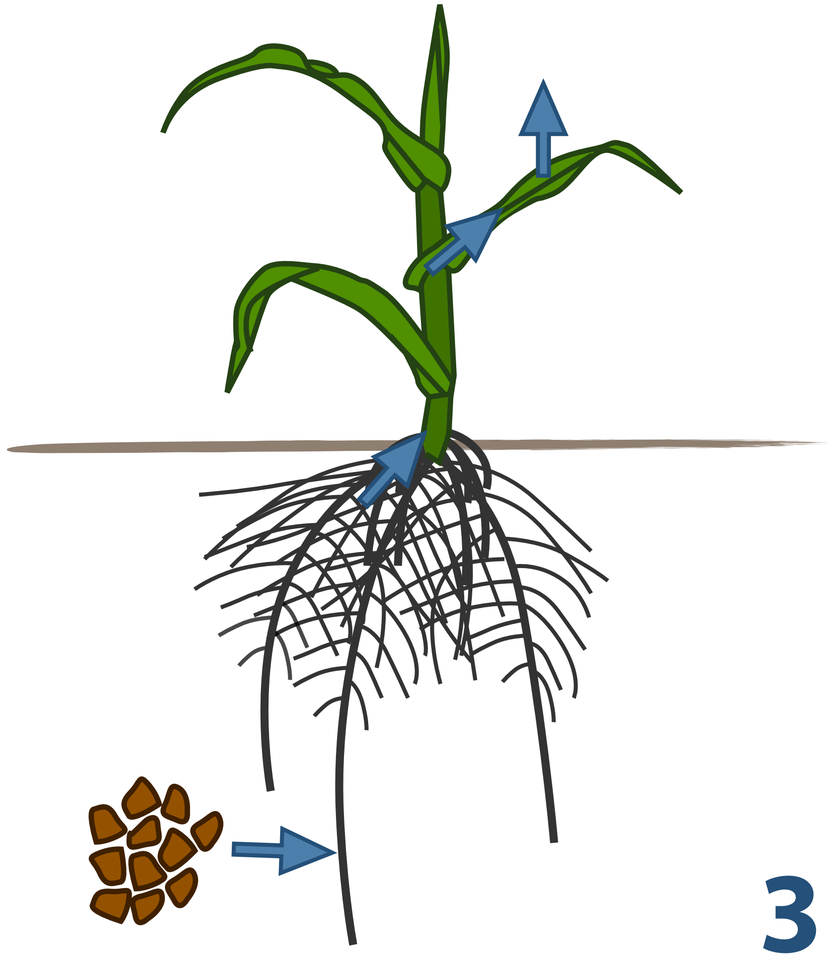
Guillaume Lobet, Valentin Couvreur, Xavier Draye, Mathieu Javaux, Félicien Meunier

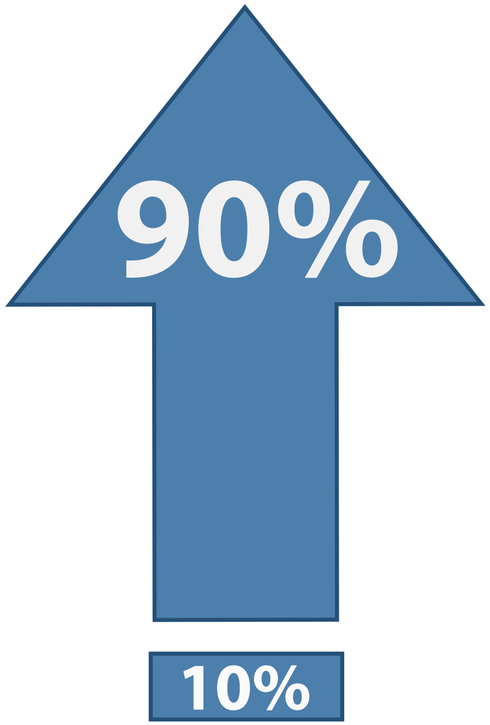
@guillaumelobet

IPG MEETING 2017 – MISSOURI – 08 JUNE 2017

WATER FLOW IN THE SOIL–PLANT–ATMOSPHERE





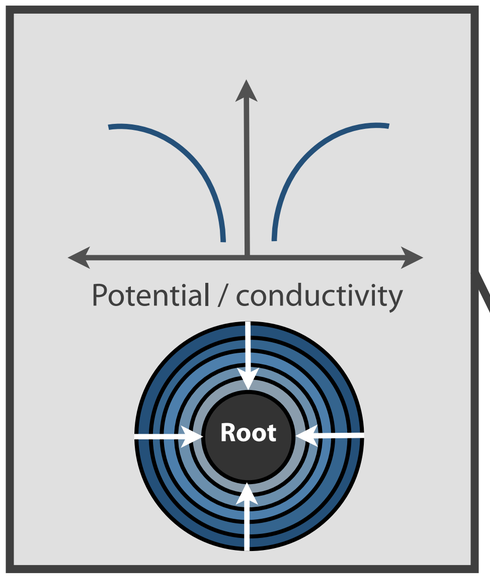


3 x 10^{14} l/year

Lobet et al. 2014
PMID: 24515834

REGULATION OF WATER FLOW

SOIL



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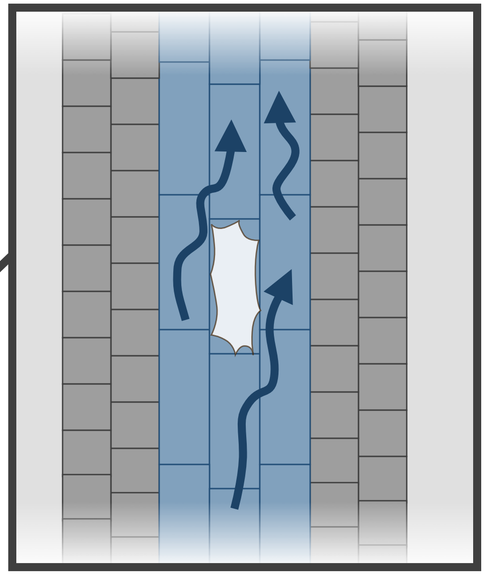
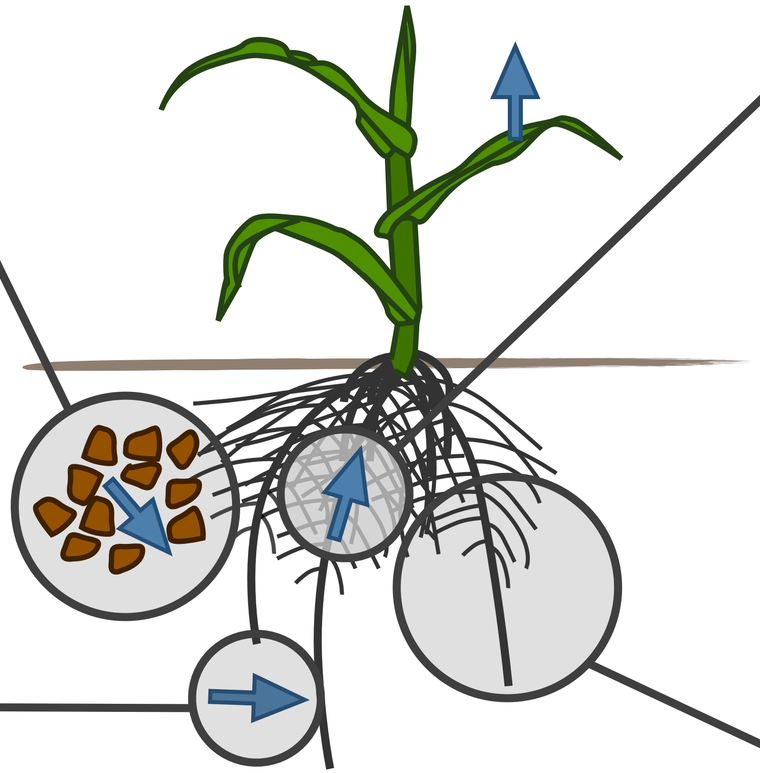
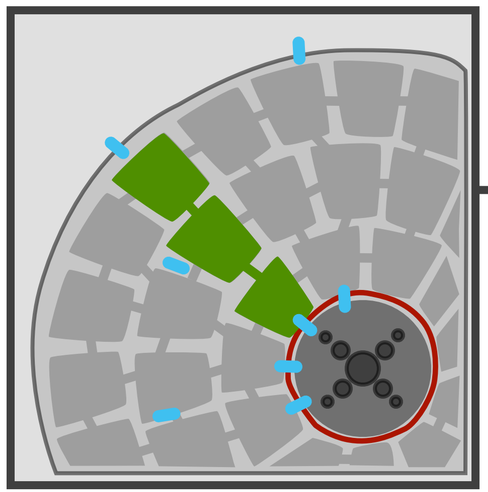
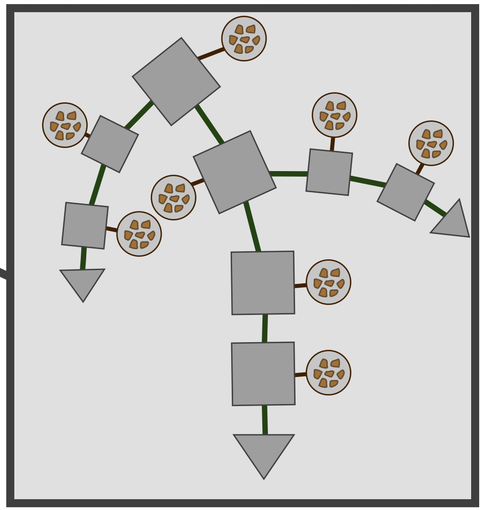




RADIAL

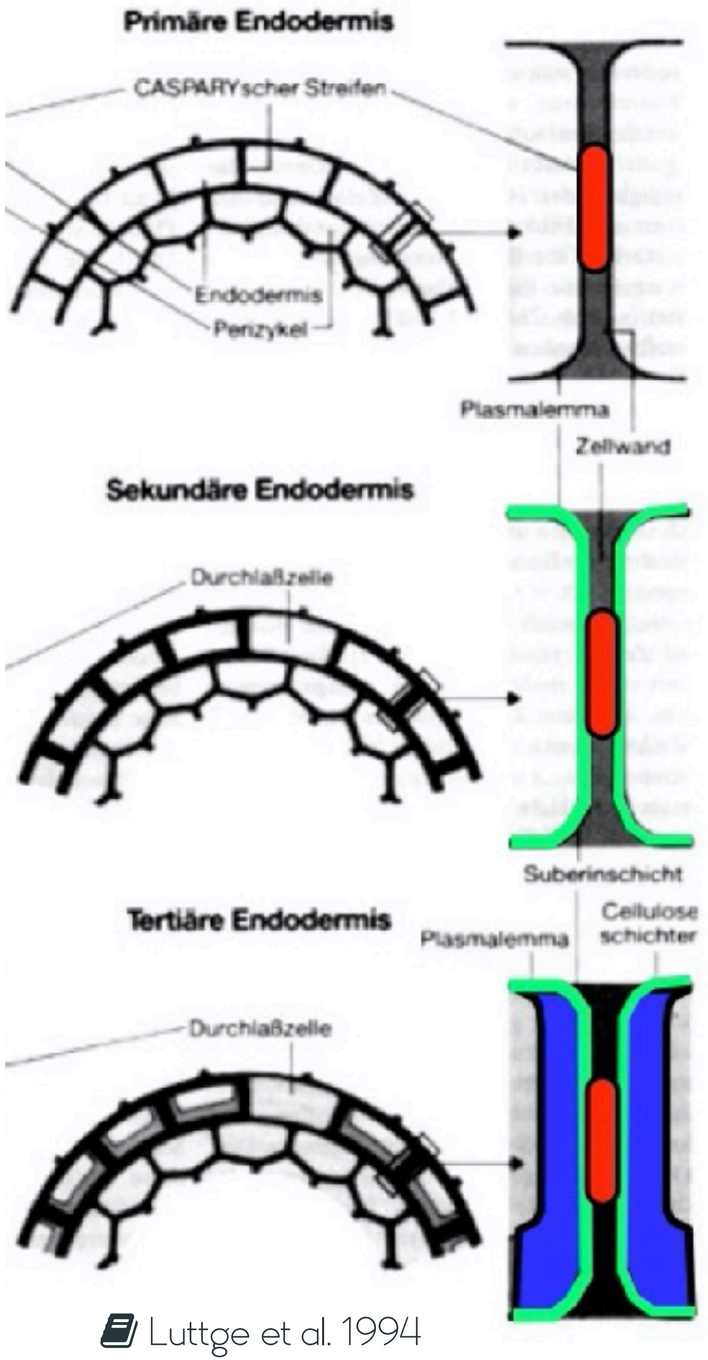


ARCHITECTURE

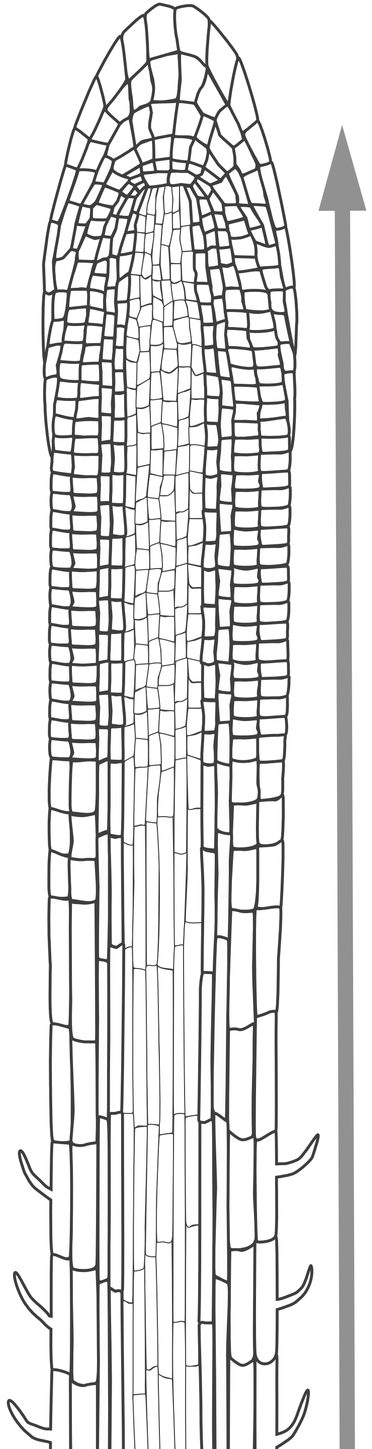


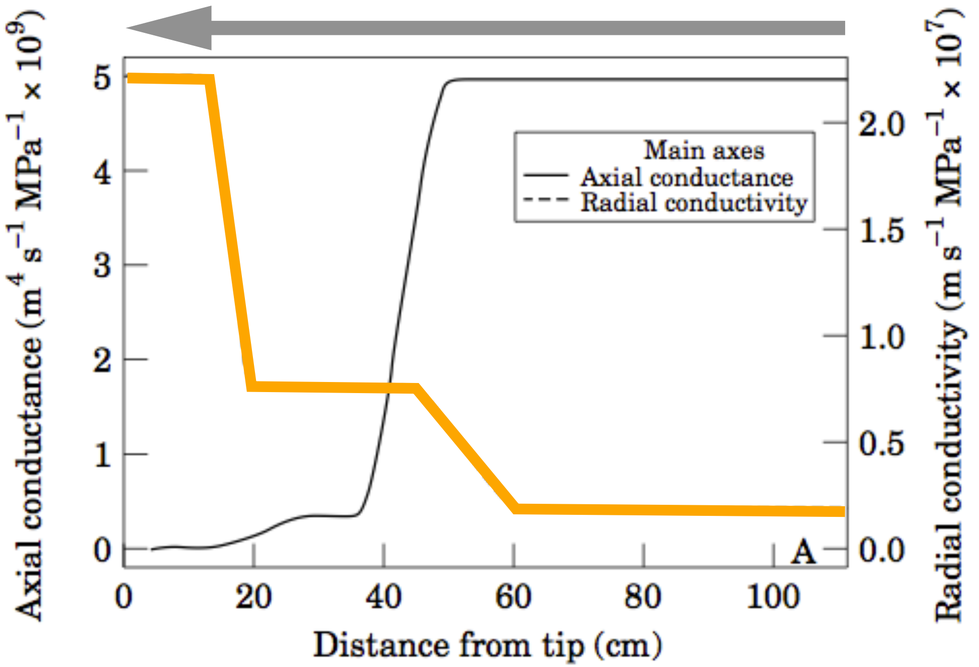
Lobet et al. 2014
PMID: 24515834

APOPLASTIC BARRIERS DEVELOPMENT



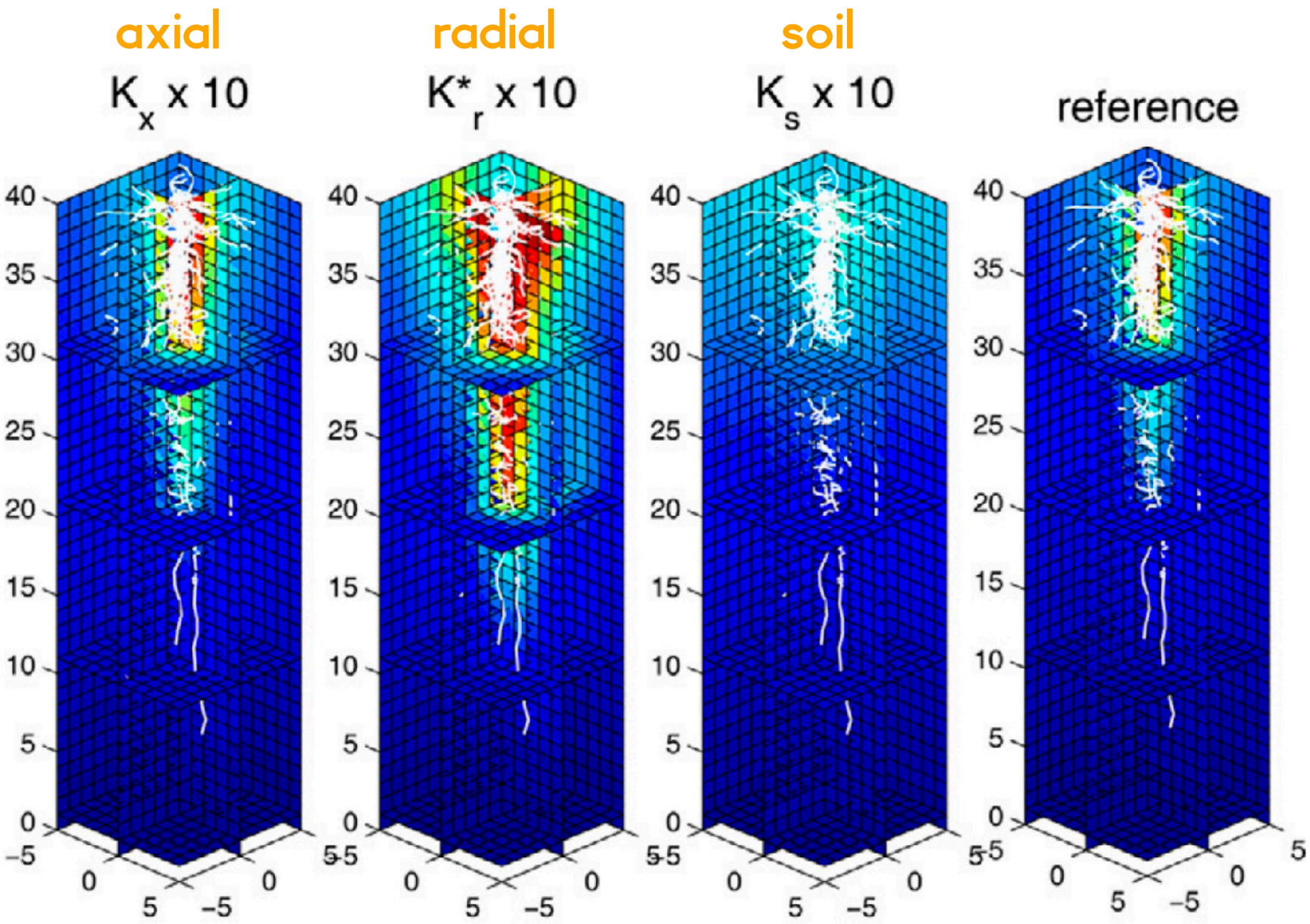
Luttge et al. 1994





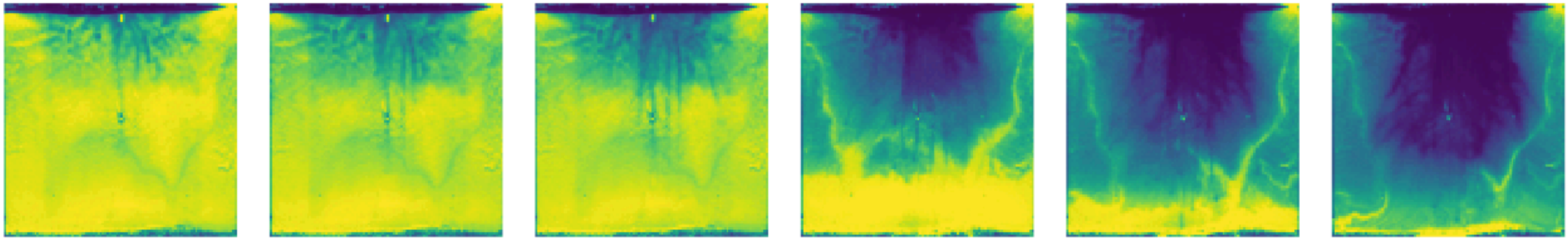
Doussan et al. 2006, Plant and Soil

SYSTEM SENSITIVITIES TO CONDUCTIVITIES

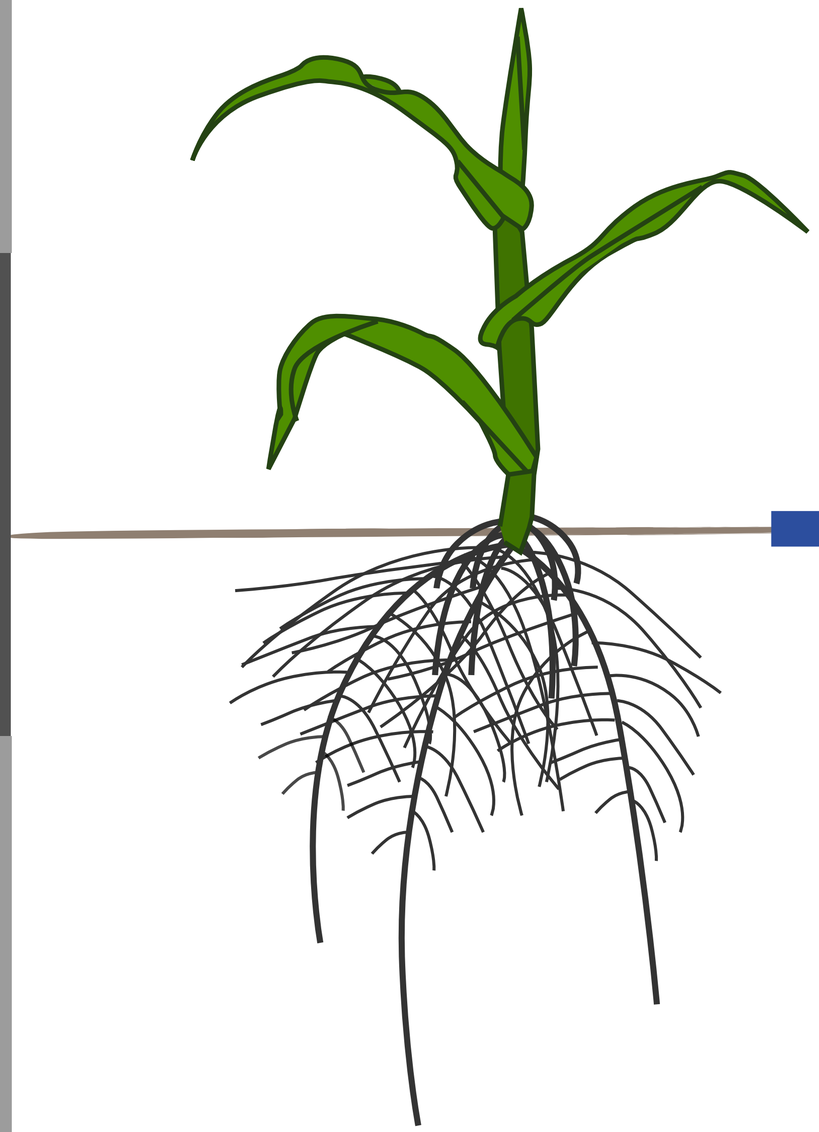


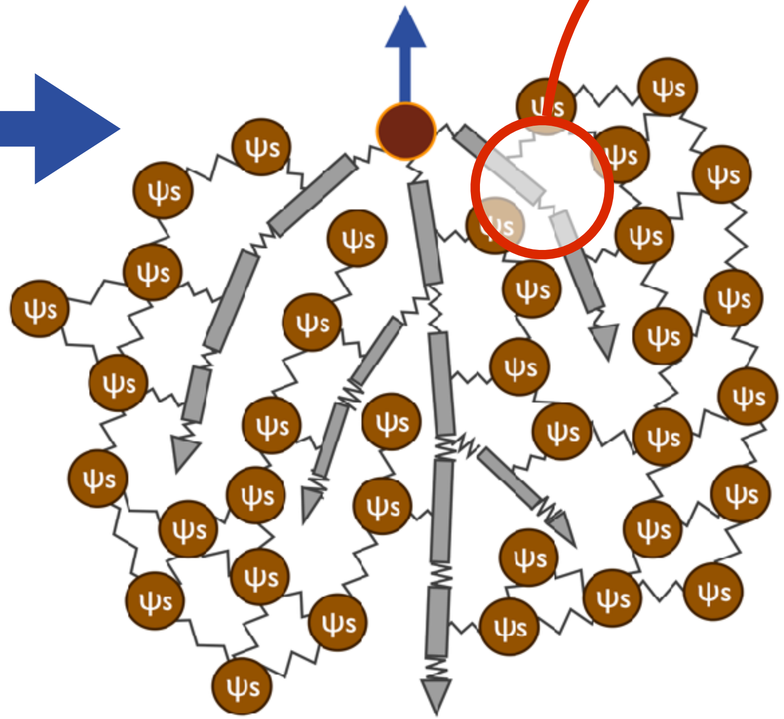
JÜLICH
FORSCHUNGSZENTRUM

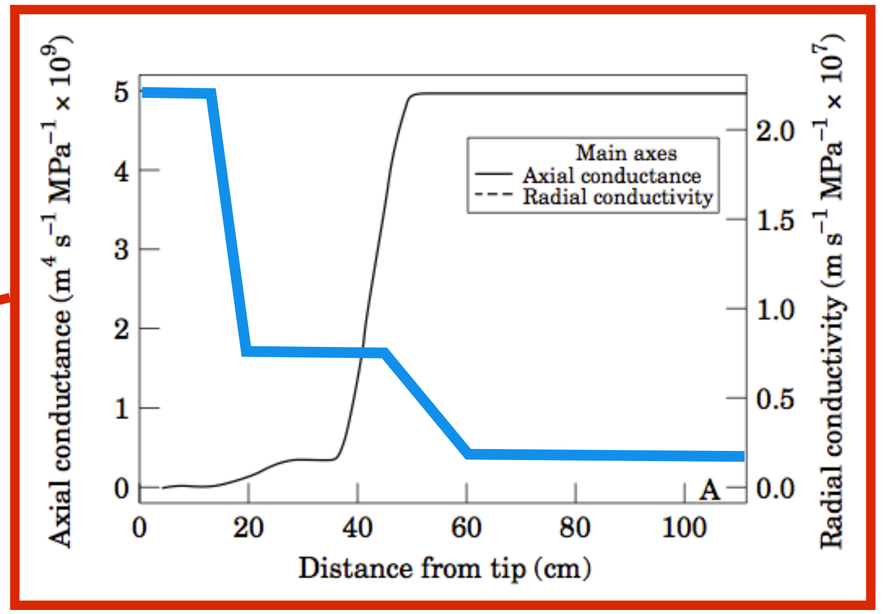
1 USING **FSPM** TO **ANALYSE** EXPERIMENTAL **DATA**



MODELLING **SOIL–PLANT** WATER MOUVEMENT





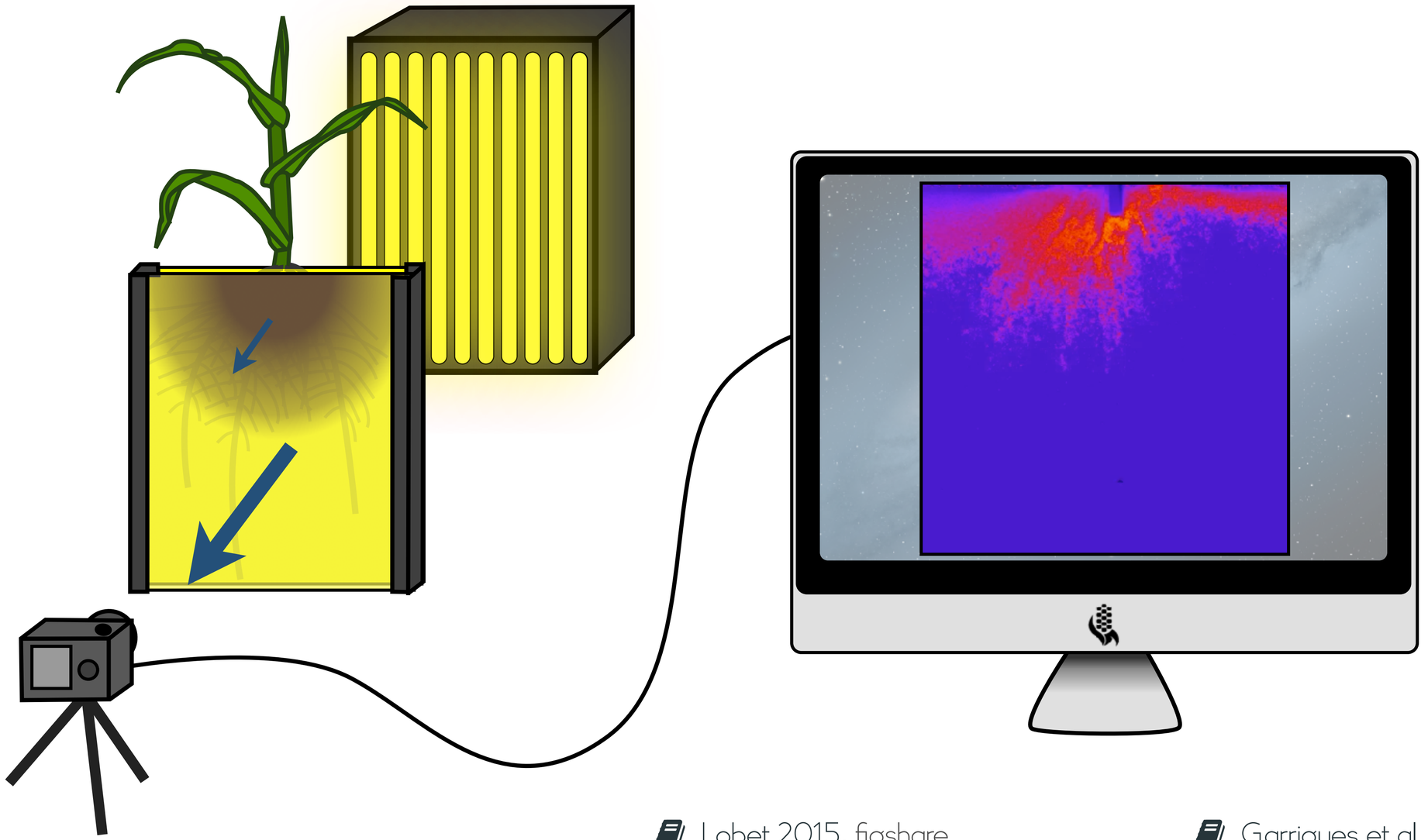


R-SWMS

bit.ly/rswms

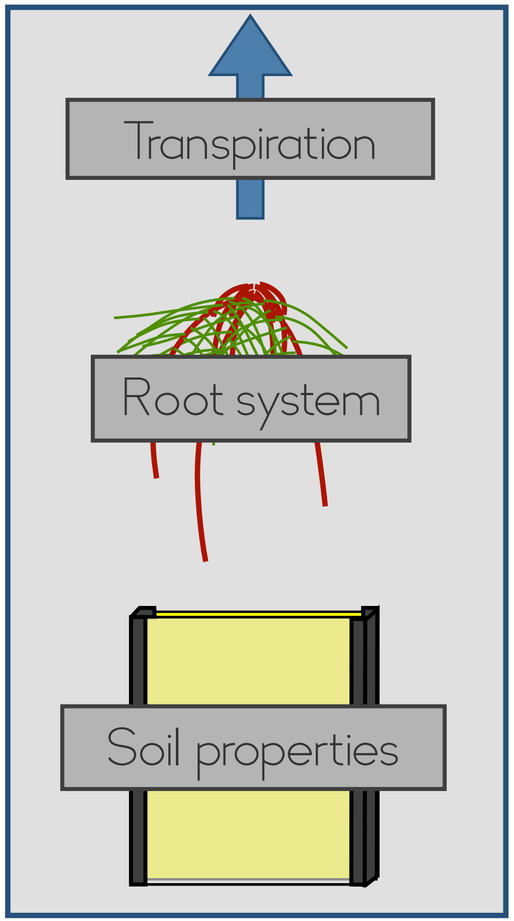
Javaux et al. 2008, Vadoze Zone J.

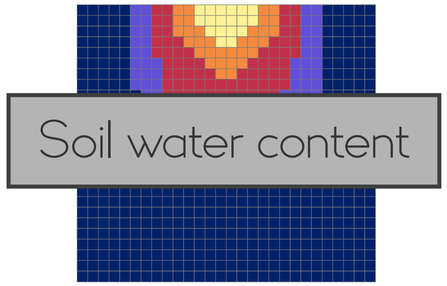
LIGHT TRANSMISSION IMAGING

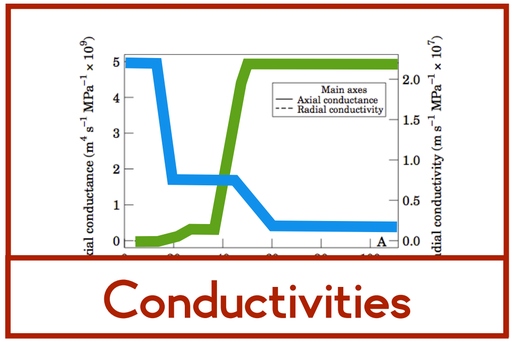


Lobet 2015, figshare

Garrigues et al. 2006, Plant and Soil







Conductivities

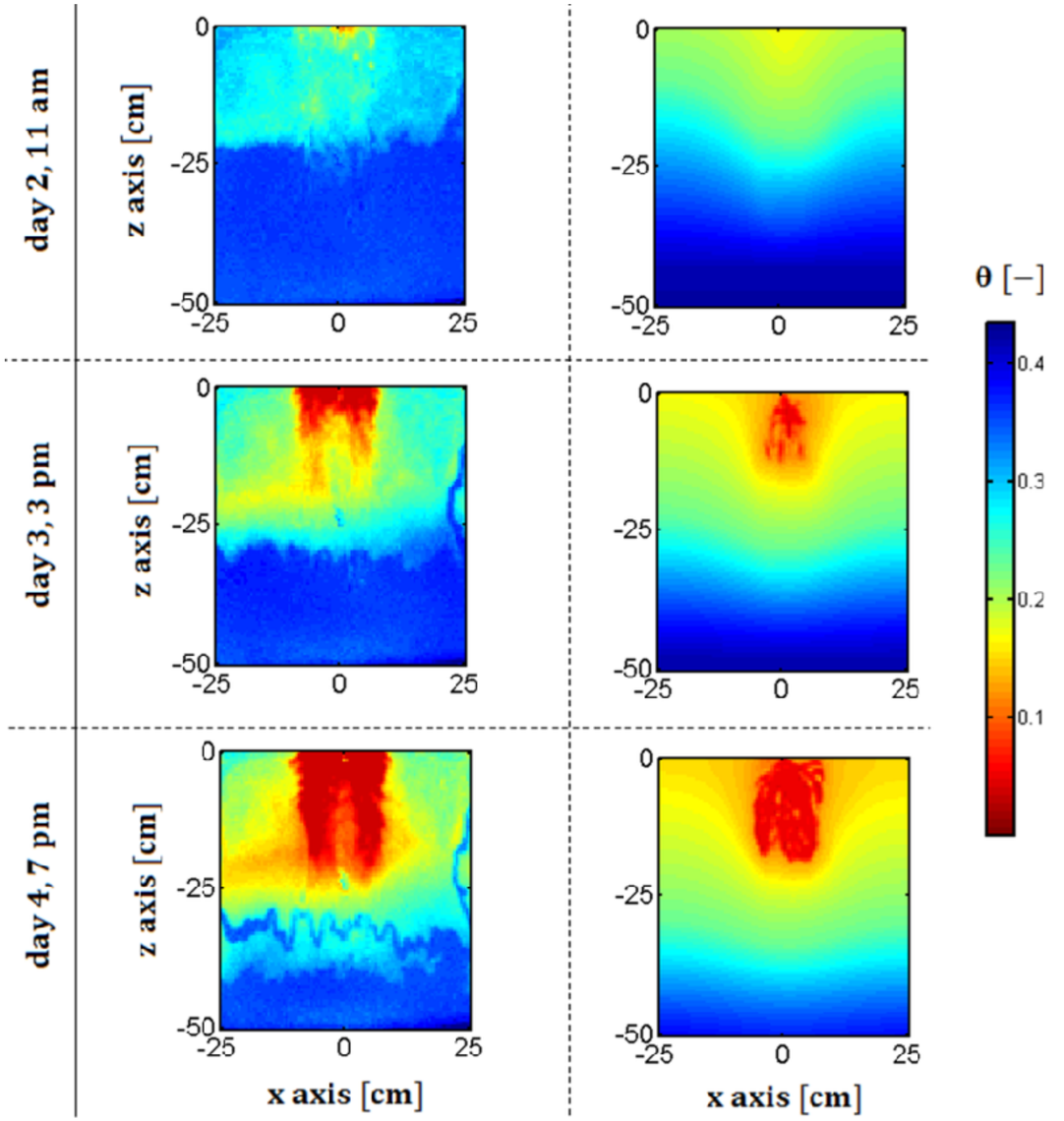
R-SWMS

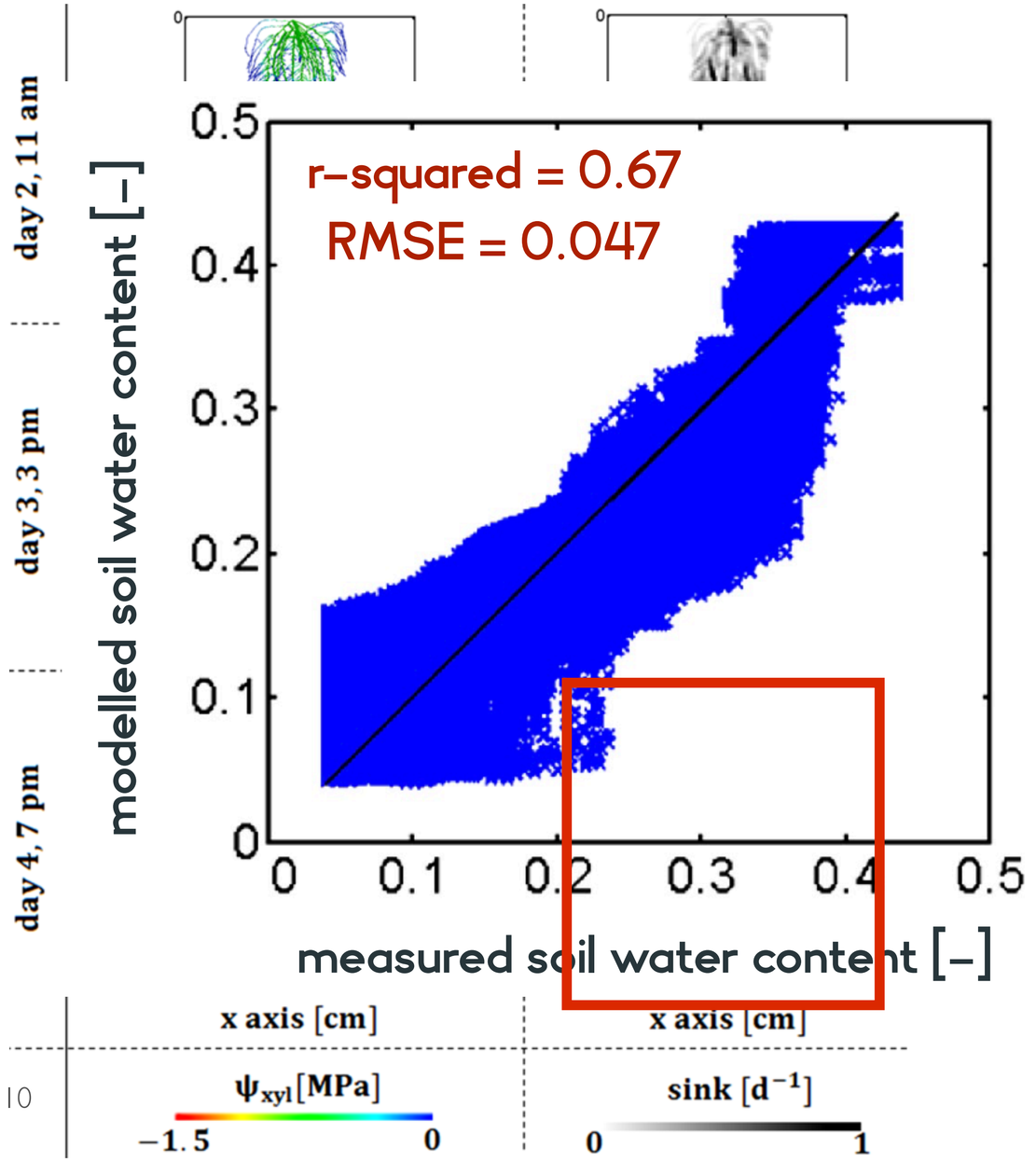
3D water flow
soil-root domain

VALIDATION

New variables

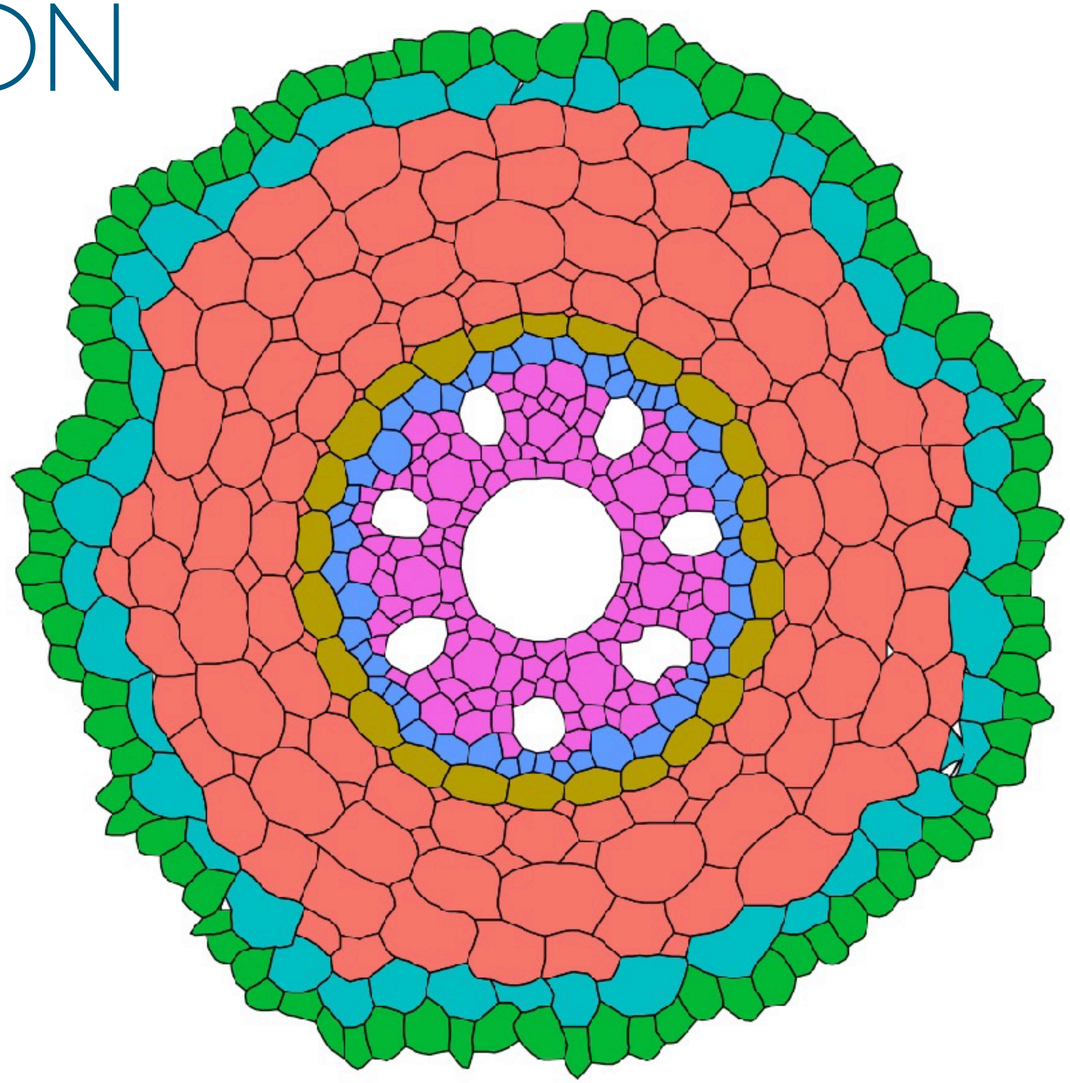
USING **FSPM** TO **ANALYSE** EXPERIMENTAL **DATA**





JÜLICH
FORSCHUNGSZENTRUM

2 / MODEL OF EXPLICIT CROSS-SECTION HYDRAULIC ANATOMY



MECHA

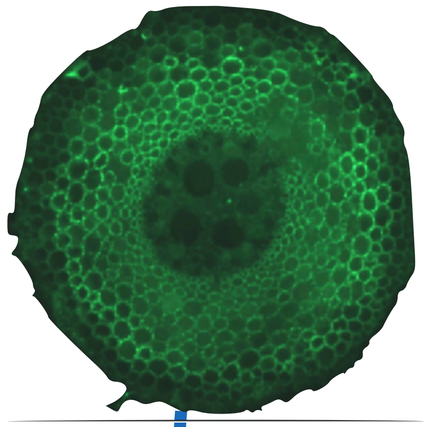
Couvreur et al 2017, biorXiv

BIT.LY/MECHA-PAPER

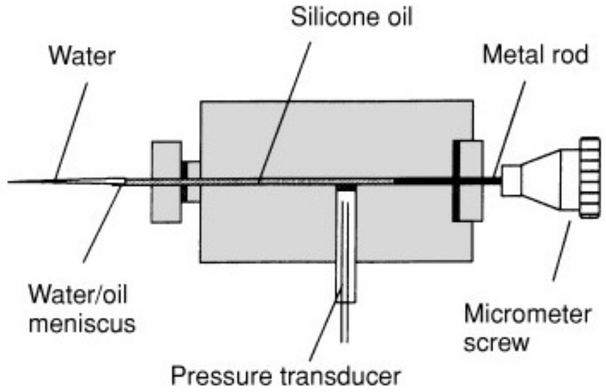
MECHA USES **REAL** EXPERIMENTAL DATA

JÜLICH FORSCHUNGSZENTRUM

Image of **root cross section**



Cell scale **hydraulic measurements**



WATER POTENTIAL IN CELLS

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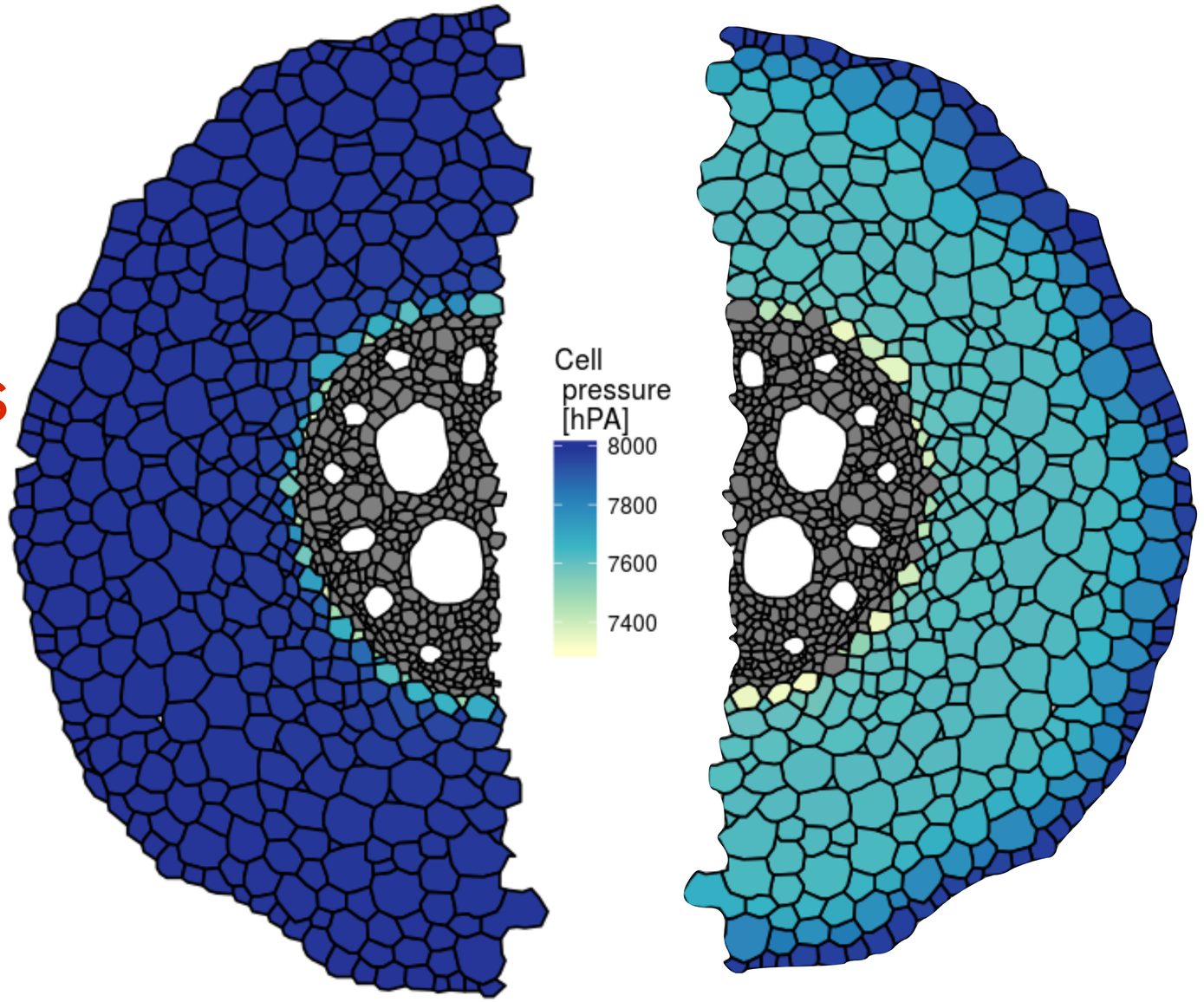
– ENDODERMIS
– EXODERMIS

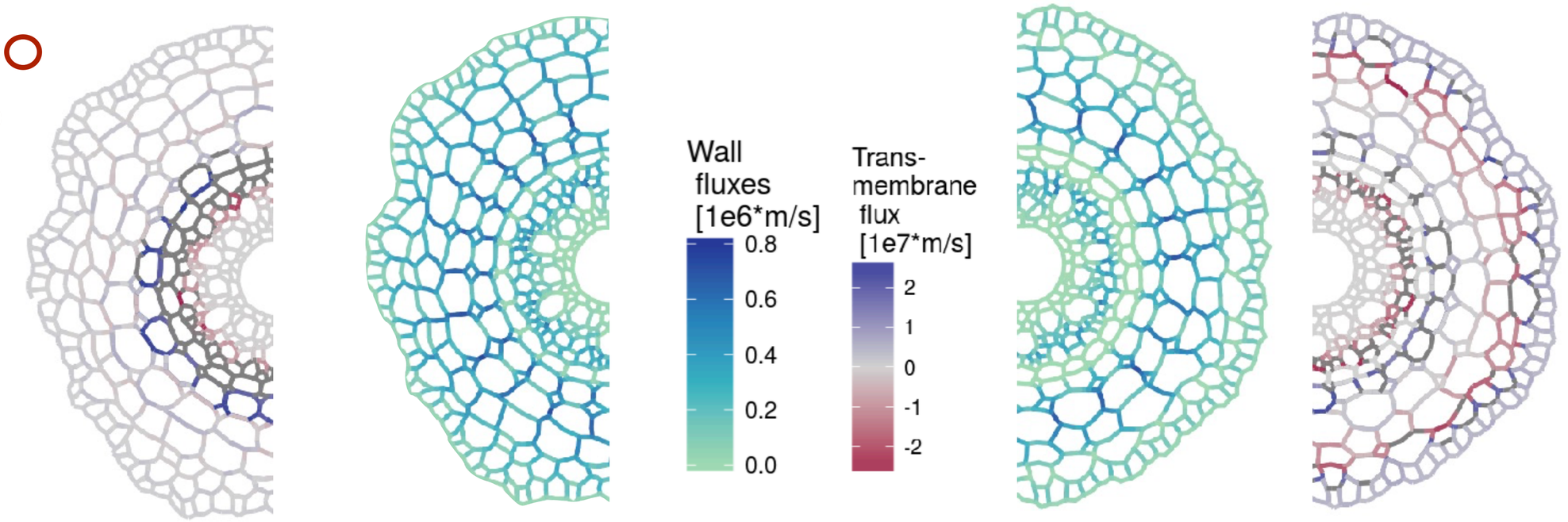


+ ENDODERMIS
+ EXODERMIS

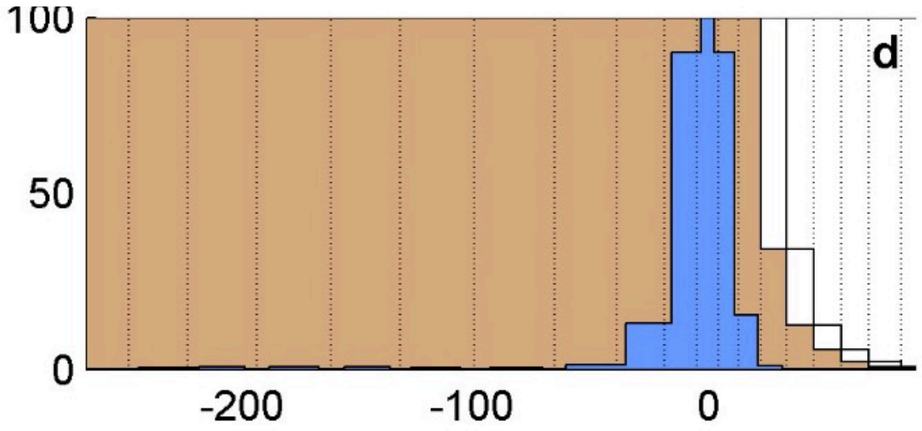
FLUXES IN WALLS AND MEMBRANES

JÜLICH FORSCHUNGSZENTRUM

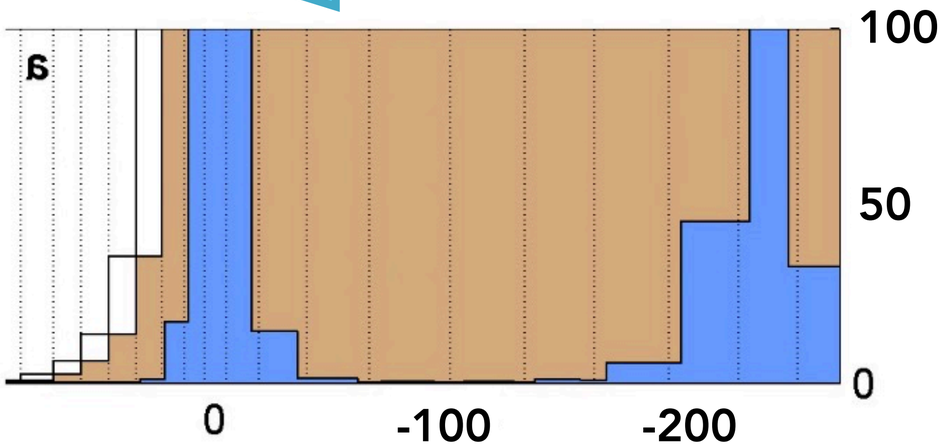
– ENDO
– EXO



+ ENDO
+ EXO

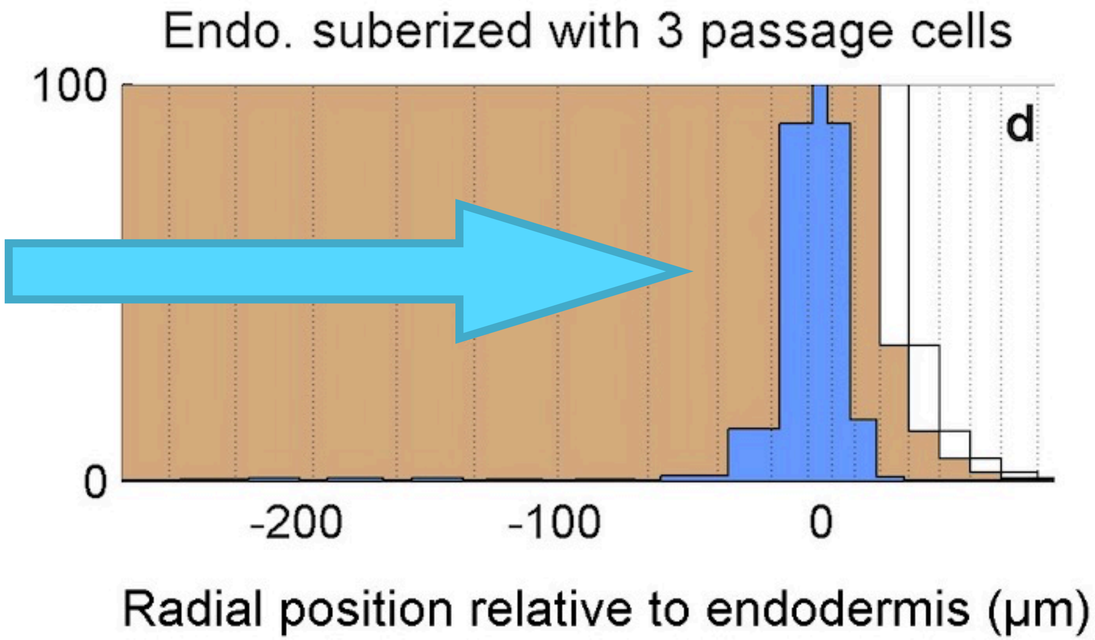


Apoplastic
Symplastic
Xylem



SENSITIVITY TO CELL-SCALE PROPERTIES

High kw || Low Kpd



Low kw || High Kpd

Apoplastic

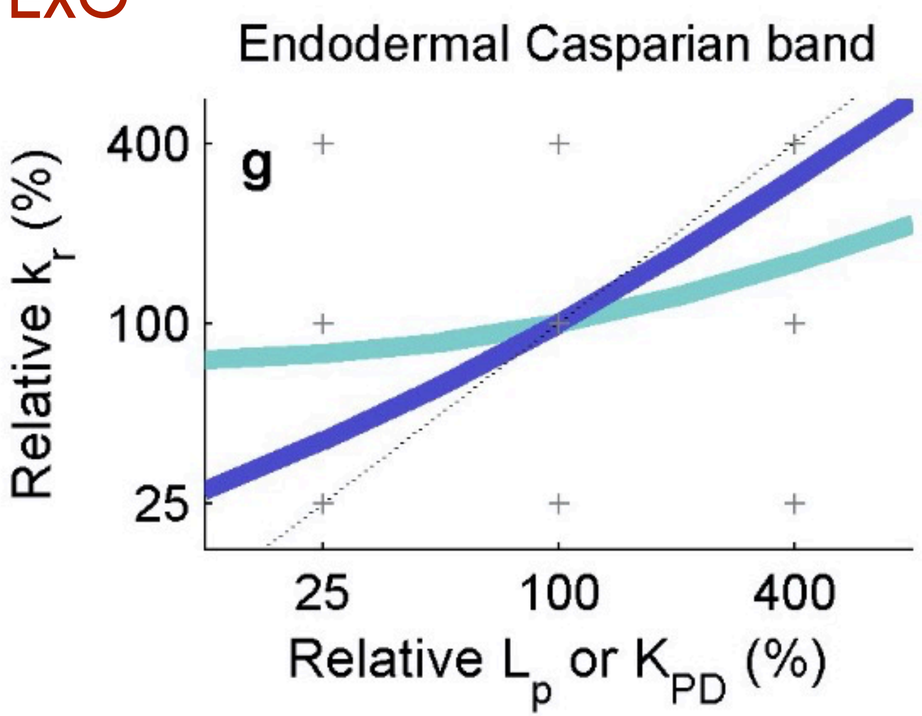
Symplastic

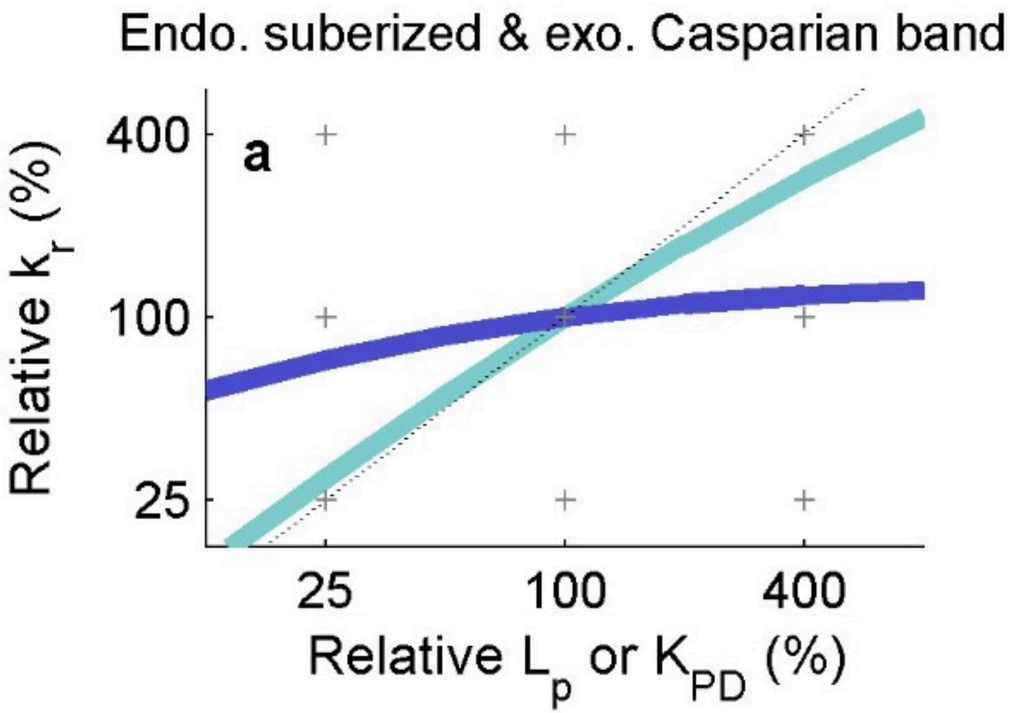
Xylem

SENSITIVITY TO CELL-SCALE PROPERTIES

– ENDO
– EXO

+ ENDO
+ EXO

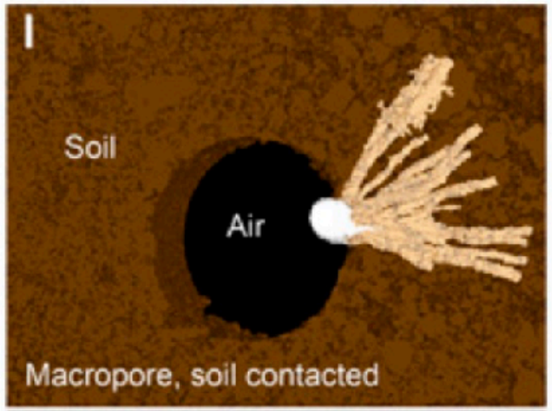


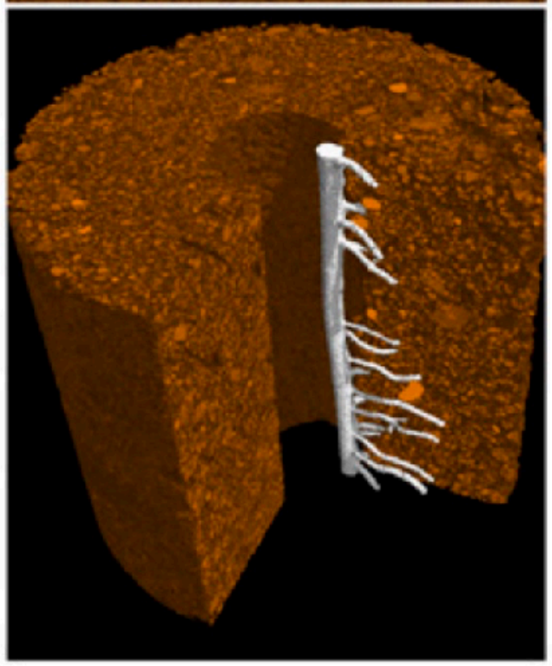


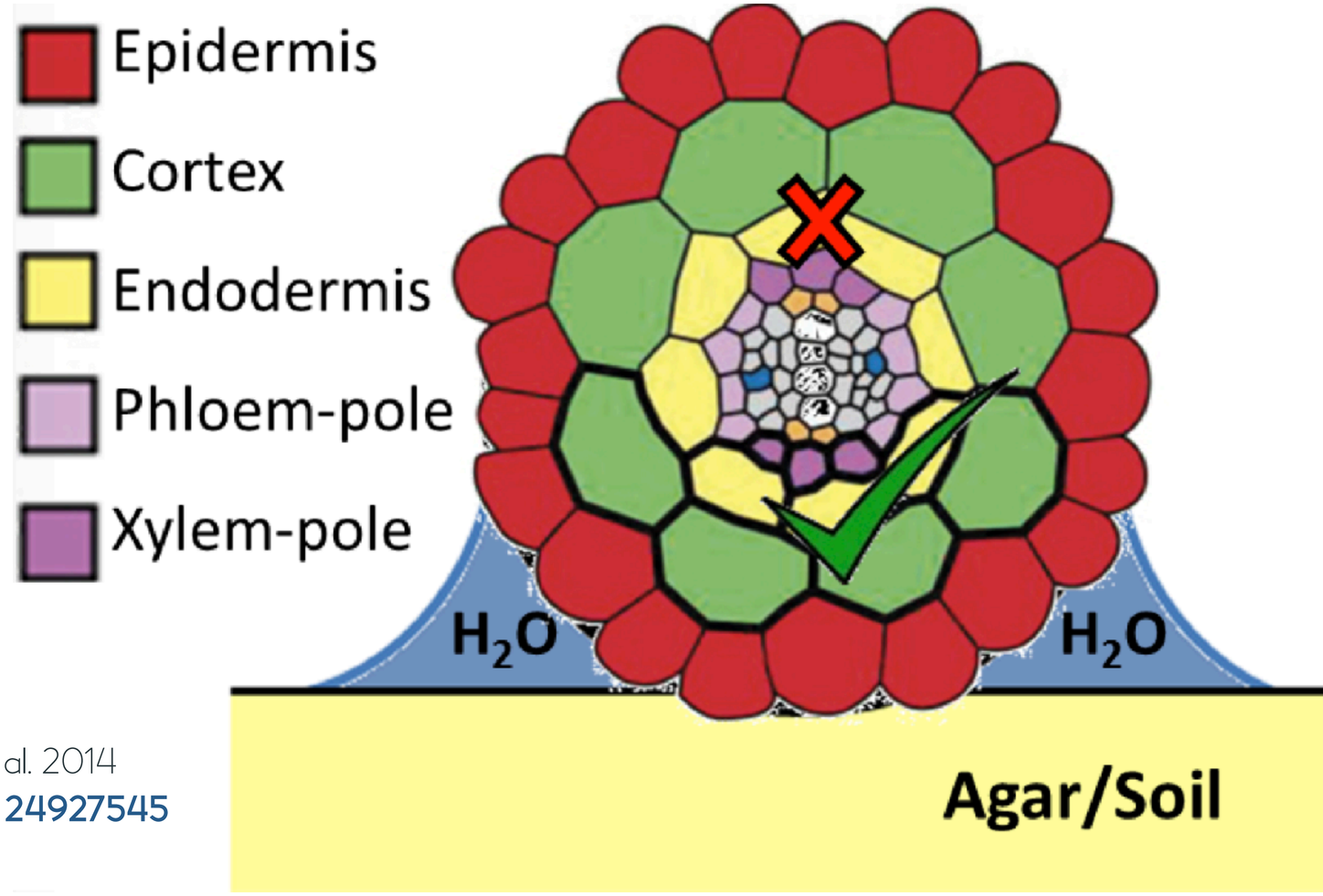
Plasmodesmata conductivity

Cell membrane conductivity

HYDROPATTERNING ARISES FROM HETEROGENEITY

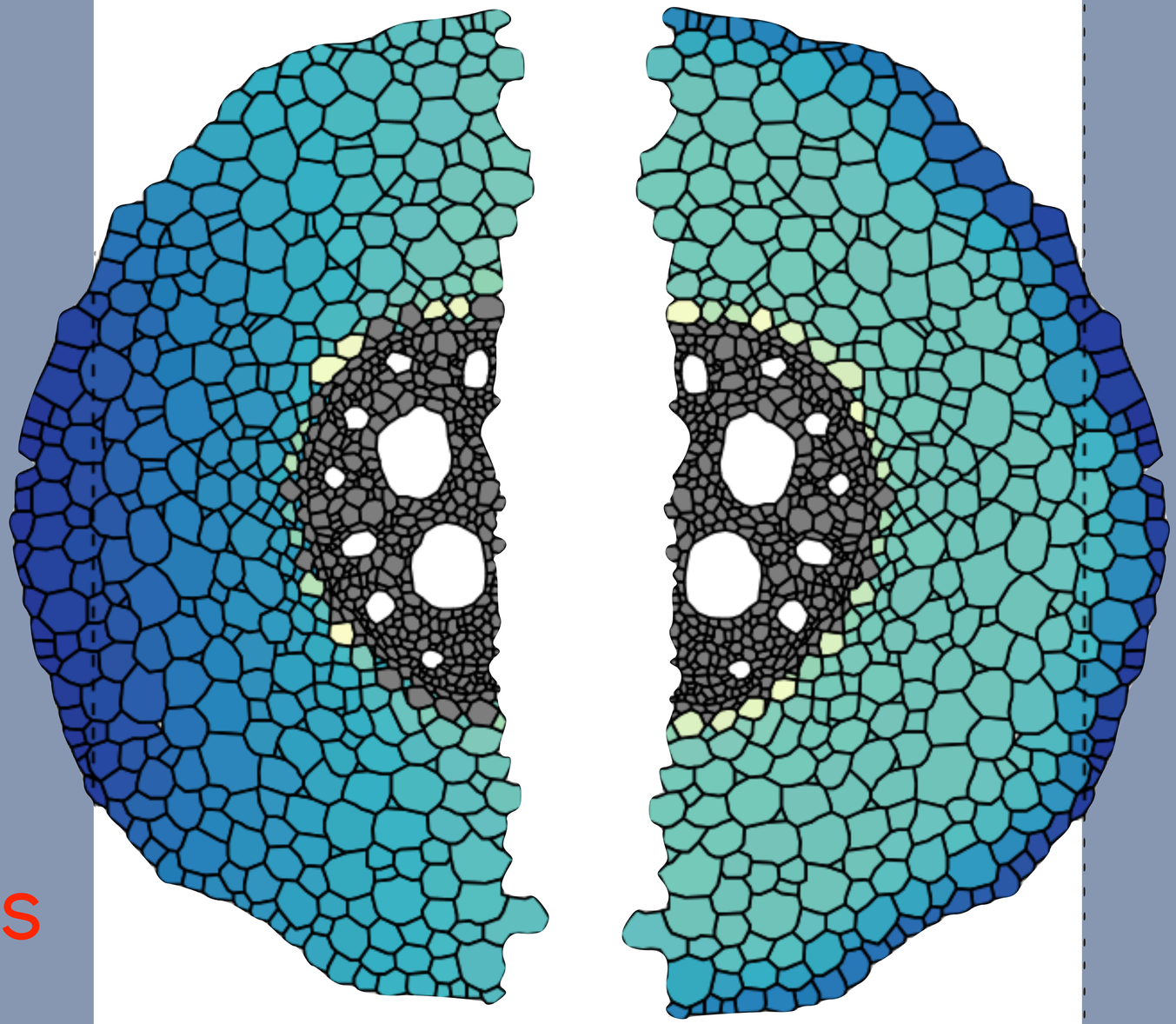






Bao et al. 2014
PMID: 24927545

PARTIAL SOIL CONTACT



– ENDODERMIS
– EXODERMIS

+ ENDODERMIS
+ EXODERMIS

TRY OUT THE MODEL

BIT.LY/ROOTMECHA

JÜLICH FORSCHUNGSZENTRUM

MECHA - Model of Explicit Cro

Guillaume

Secure https://plantmodelling.shinyapps.io/mecha/

MECHA - Model of Explicit Cross-section Hydraulic Anatomy

Valentin Couvreur, Marc Paget, Guillaume Lobet, Mathieu Javaux, François Chaumont and Xavier Draye

Université catholique de Louvain, Forschungszentrum Juelich GmbH

Choose plant | Change parameters | About

Choose developmental stage

Maturity level: 1 (1 2 3 4)

the maturity level indicates which and where the apoplastic barriers are developped.

Endodermis: casparian strip

Exodermis:

Choose plant parameters

Update the simulation parameters

Soil contact: complete

Aquaporins : yes

Wall conductivity: high

Plasmodesm conductance: high

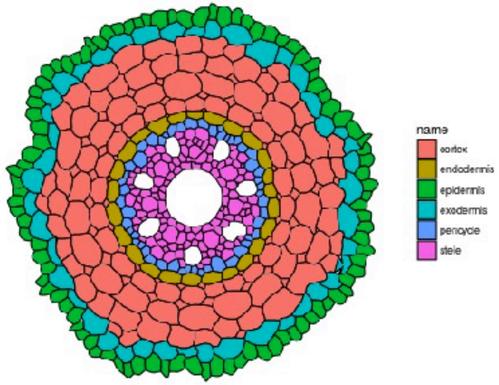
Choose boundary conditions

Soil pressure: dry

Xylem pressure: day

Tissue layers

Visualisation of the different cell layers used in the simulation



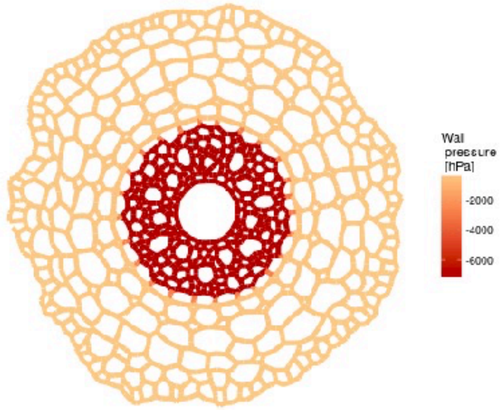
Select the information to visualize: potentials

Synthetic information about the simulation

param	value	unit
Cross-section height	0.02	cm
Cross-section perimeter	0.345	cm
Cross-section radial conductivity	1.76e-04	cm/hPa/d
Xylem pressure potential	-7000	hPa
Soil pressure potential	-100	hPa
Xylem osmotic potential	-1500	hPa
Soil osmotic potential	-3000	to
Soil contact	9999999	microns

Cell walls pressure

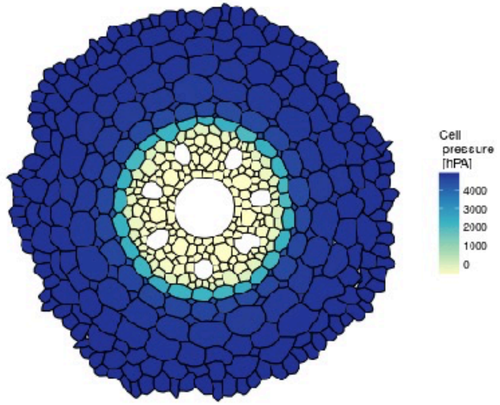
Pressure within the cell walls of the cross section



Display range: -7,000 (-7,000 -5,820 -4,640 -2,860 -1,480 -760 -100) -100

Cells potentials

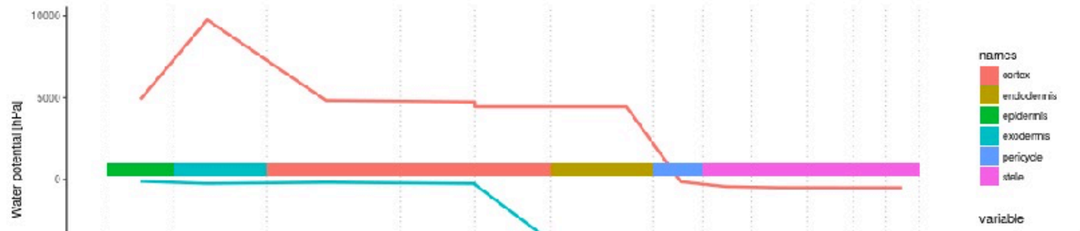
Pressure within the cell of the cross section



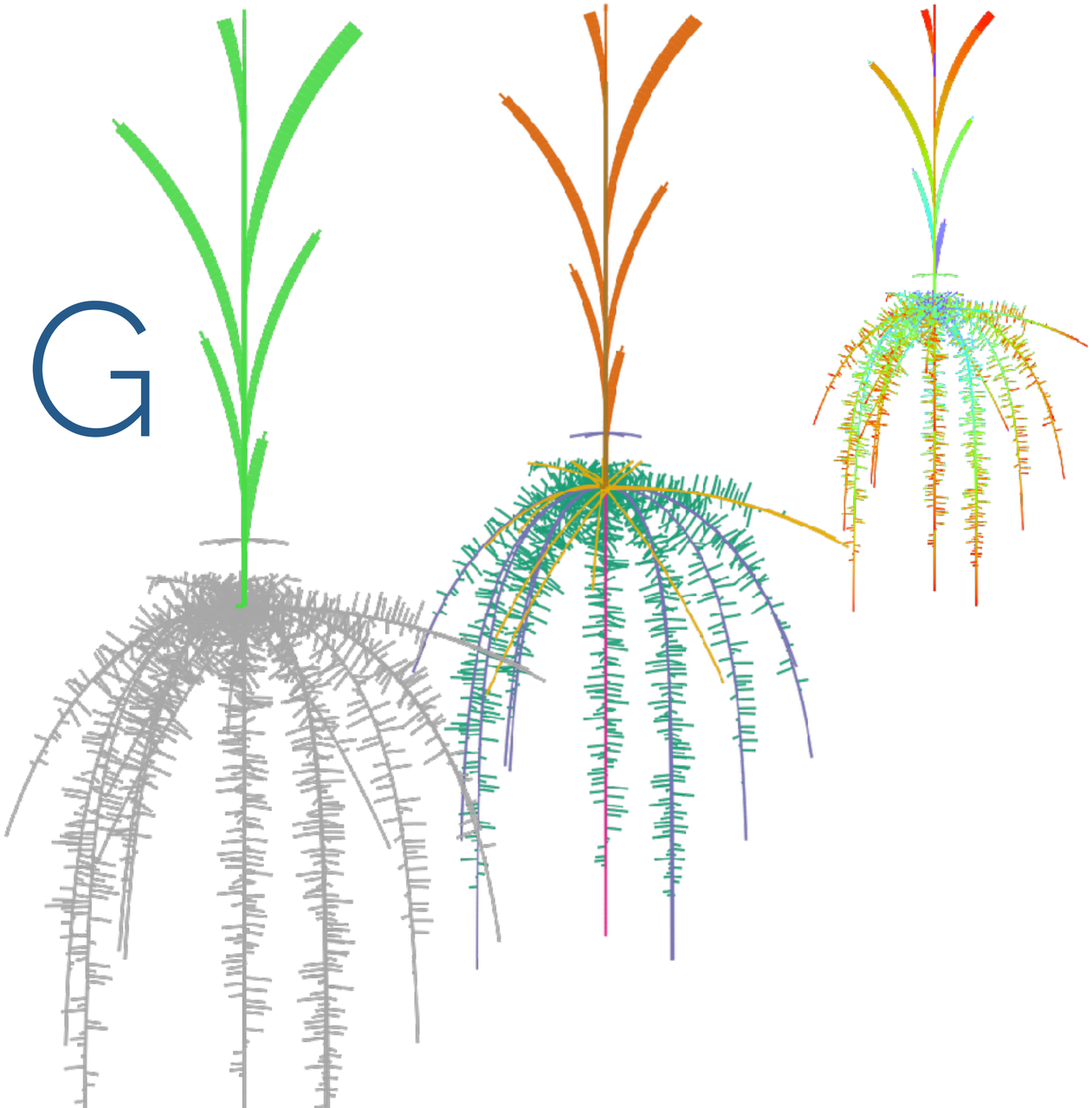
Display range: -500 (-500 39.7 579.4 1,659.3 3,238.2 3,817.6 4,697) 4,697

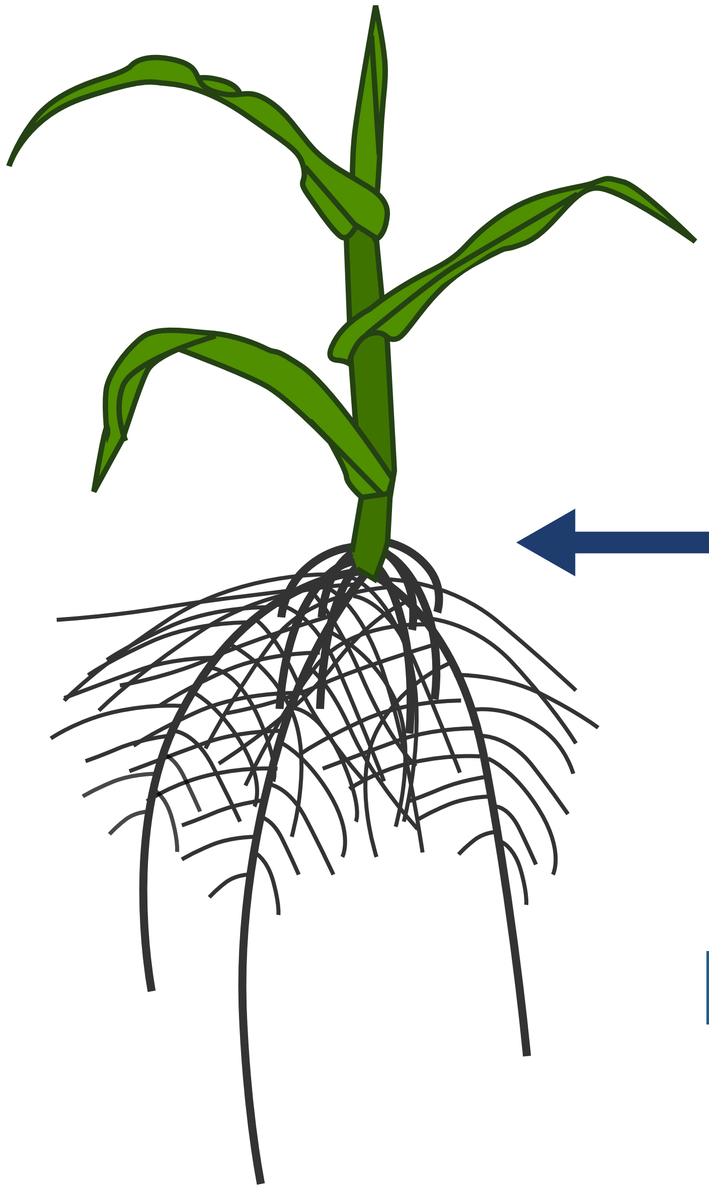
Average cell and wall pressure

Visualisation of the average cell and wall pressure across the cross-section



WRAPPING UP





WE CAN LINK

MODELS

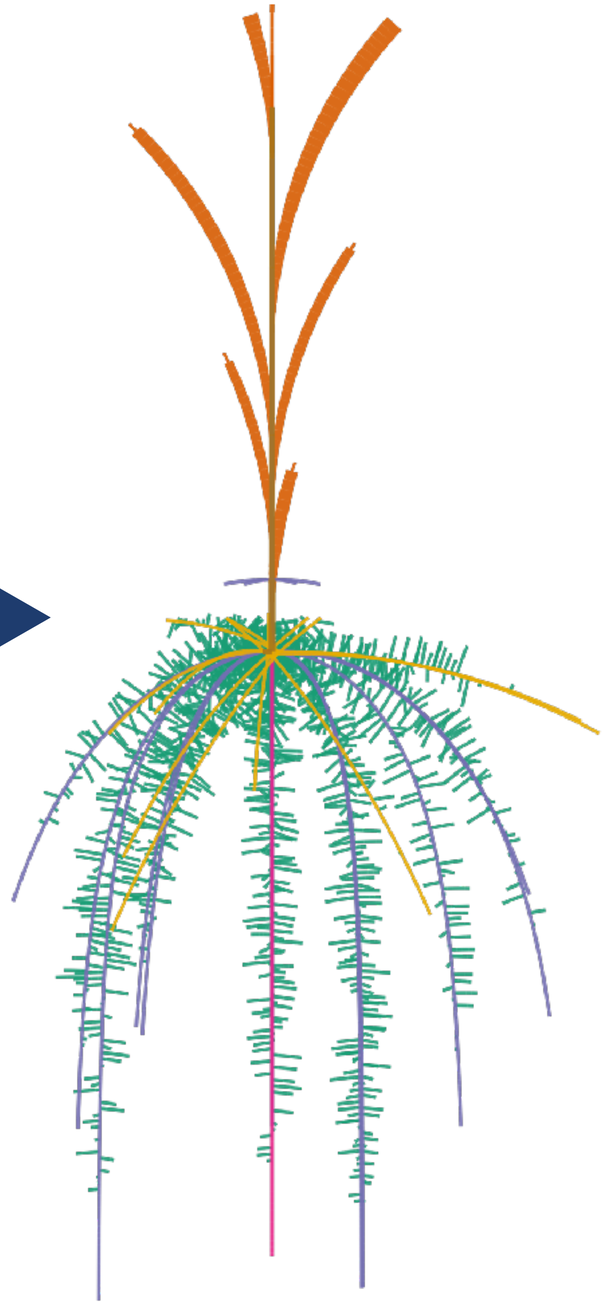
AND

EXPERIMENTS

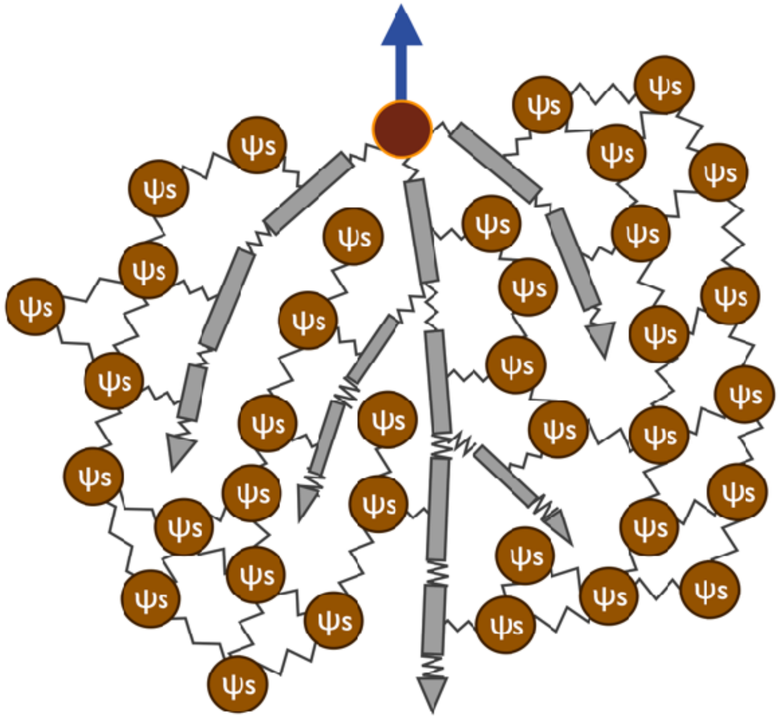
TO GET MORE

FUNCTIONAL

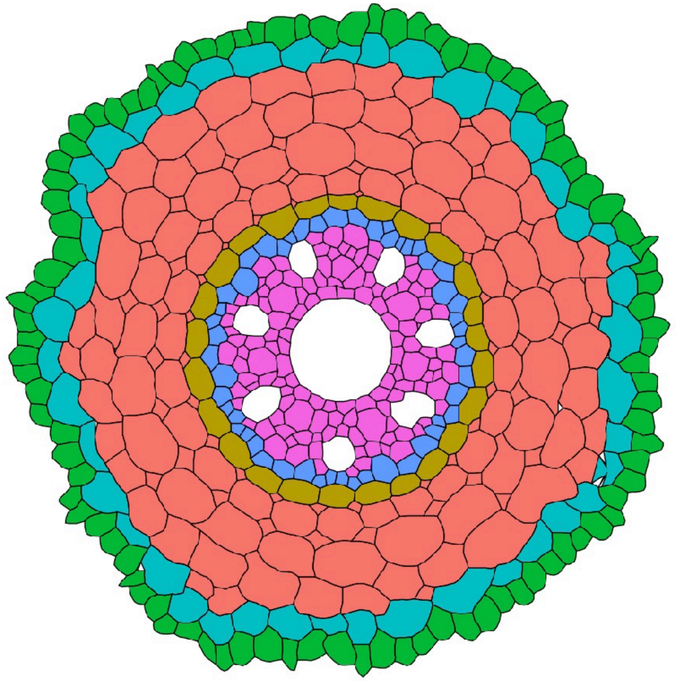
INFORMATIONS



DIFFERENT MODELLING STRATEGIES FOR **SIMILAR** QUESTIONS



TOP–DOWN



BOTTOM–UP

ACKNOWLEDGEMENTS

Xavier Draye

Mathieu Javaux

Valentin Couvreur

Félicien Meunier

UCL Université catholique de Louvain

JÜLICH FORSCHUNGSZENTRUM

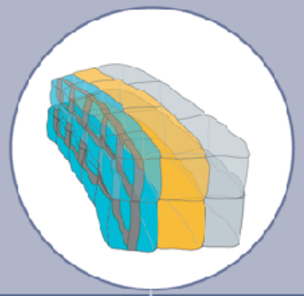
DROPS

fnrs LA LIBERTÉ DE CHERCHER

#PLANTILLUSTRATIONS

A COMMUNITY REPOSITORY OF PLANT VECTOR-GRAPHICS

Available at http://bit.do/plant-illustrations



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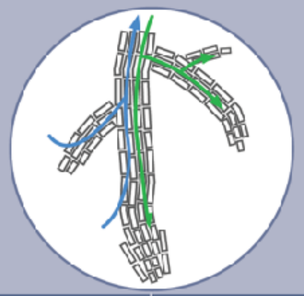
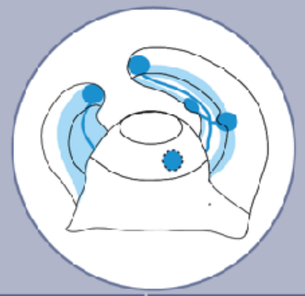


CREDITS GUILLAUME LOBET



CREDITS CIERA MARTINEZ

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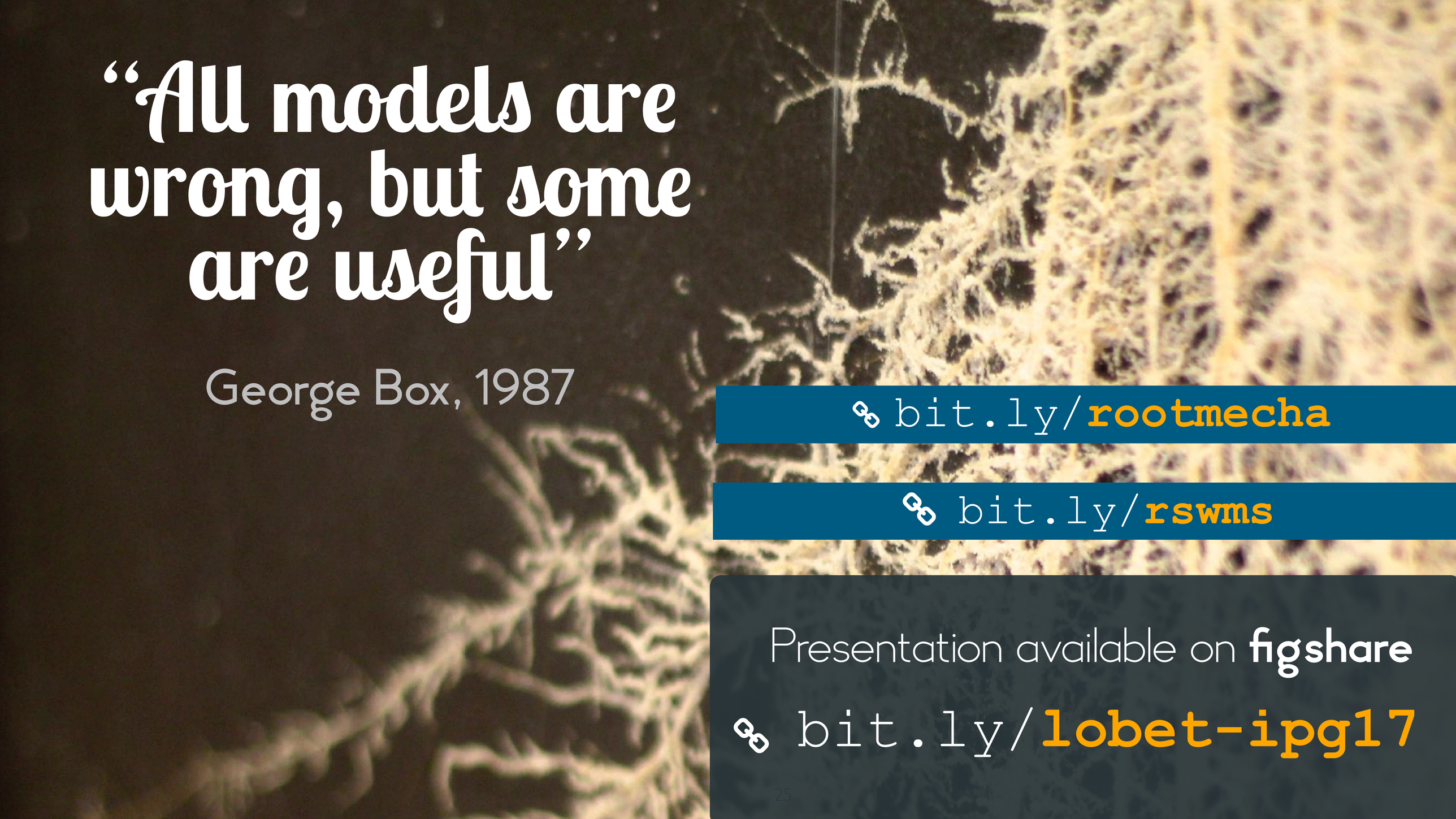
CONTRIBUTE



“All models are wrong, but some are useful”

George Box, 1987

bit.ly/**rootmecha**

bit.ly/**rswms**

Presentation available on **figshare**

bit.ly/**lobet-ipg17**

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