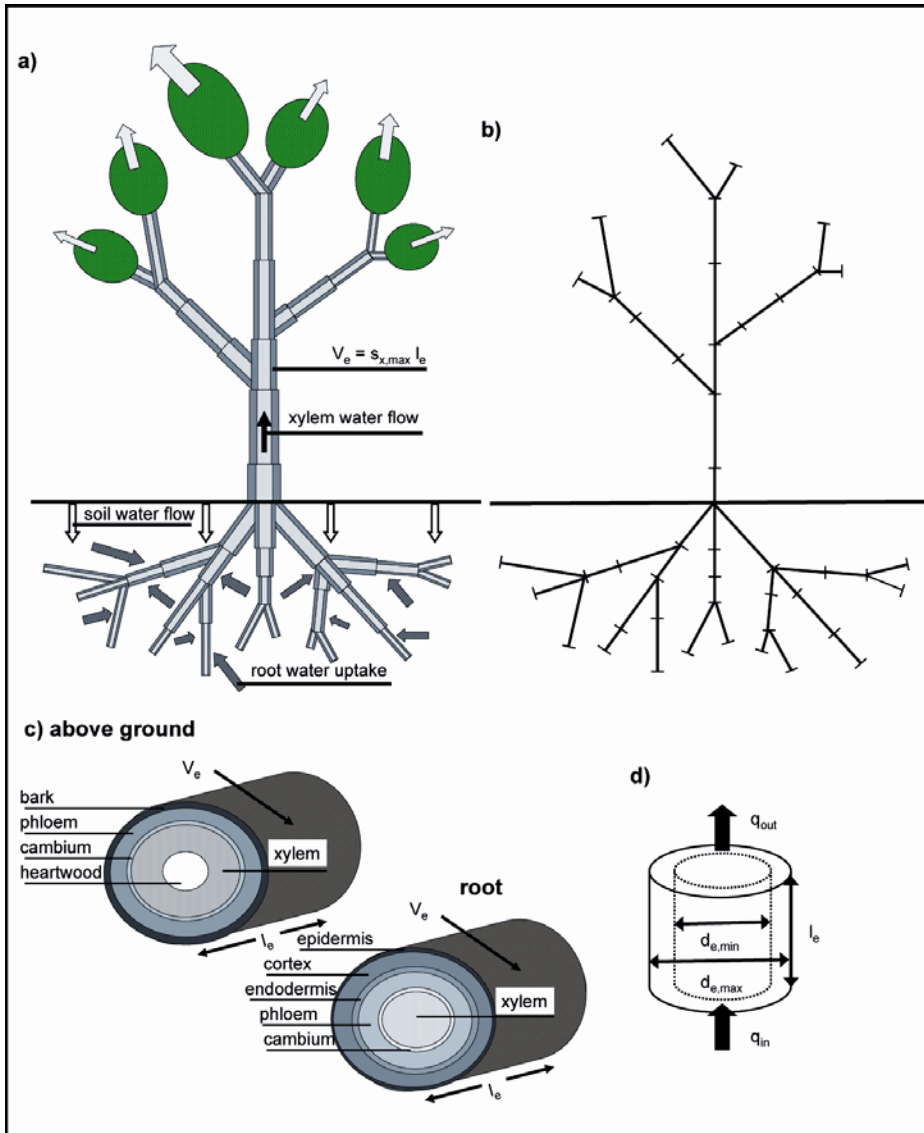


Modelling tree sap flow based on 3D tree architectures and forest canopy structure obtained from terrestrial LiDAR measurements

Rainer Hentschel, Sebastian Bittner, Daniel Ritter and **Eckart Priesack**

Soil-Plant Continuum Water Flow Model



We assume:

- Long distant water flow in plants is determined by xylem water flow
- Darcy flow
- Mass conservation, defining xylem water content in relation to the maximal possible xylem volume in a cylindrical unit.
- Homogeneity of xylem hydraulic characteristics in a cylindrical unit

Janott et al. (2011), *Plant and Soil* 341:233-256

Xylem water flow equation

$$\frac{\partial \theta_x}{\partial t} = \frac{\partial}{\partial l} \left(k_x(\psi_x) \cdot \frac{\partial \psi_x}{\partial l} + \cos \alpha_x \right) - S_x$$

θ_x xylem water content [$\text{mm}^3 \text{mm}^{-3}$]

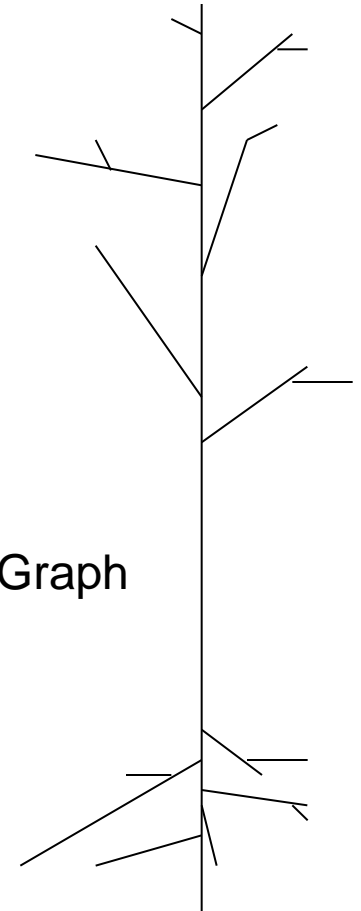
ψ_x xylem water potential [mm]

k_x xylem hydraulic conductivity [mm s^{-1}]

l length of tree element [mm]

S_x sink or source term [s^{-1}]

Plant Graph



Lysimeter Scenario

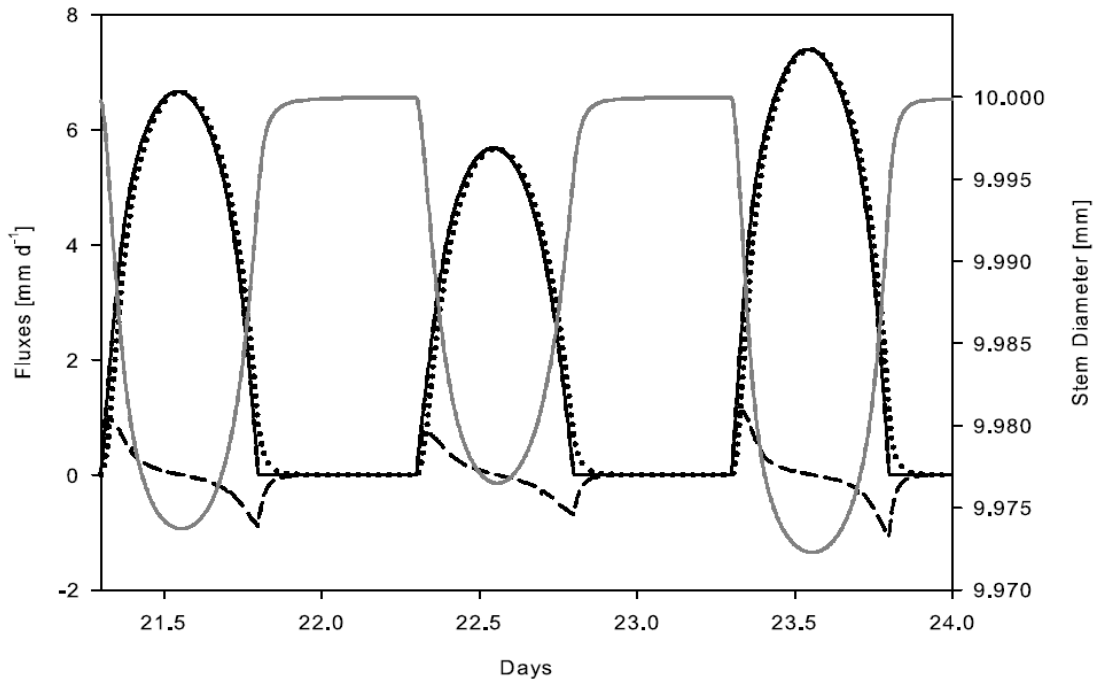
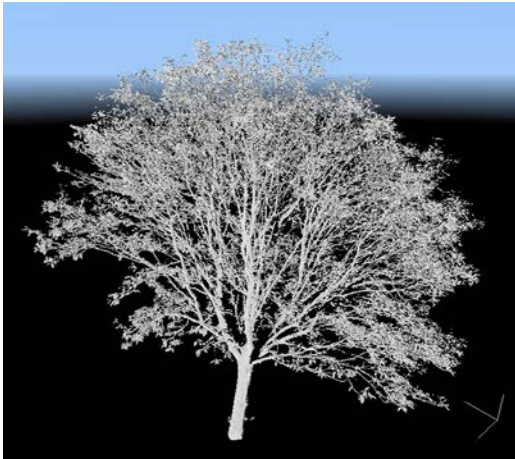


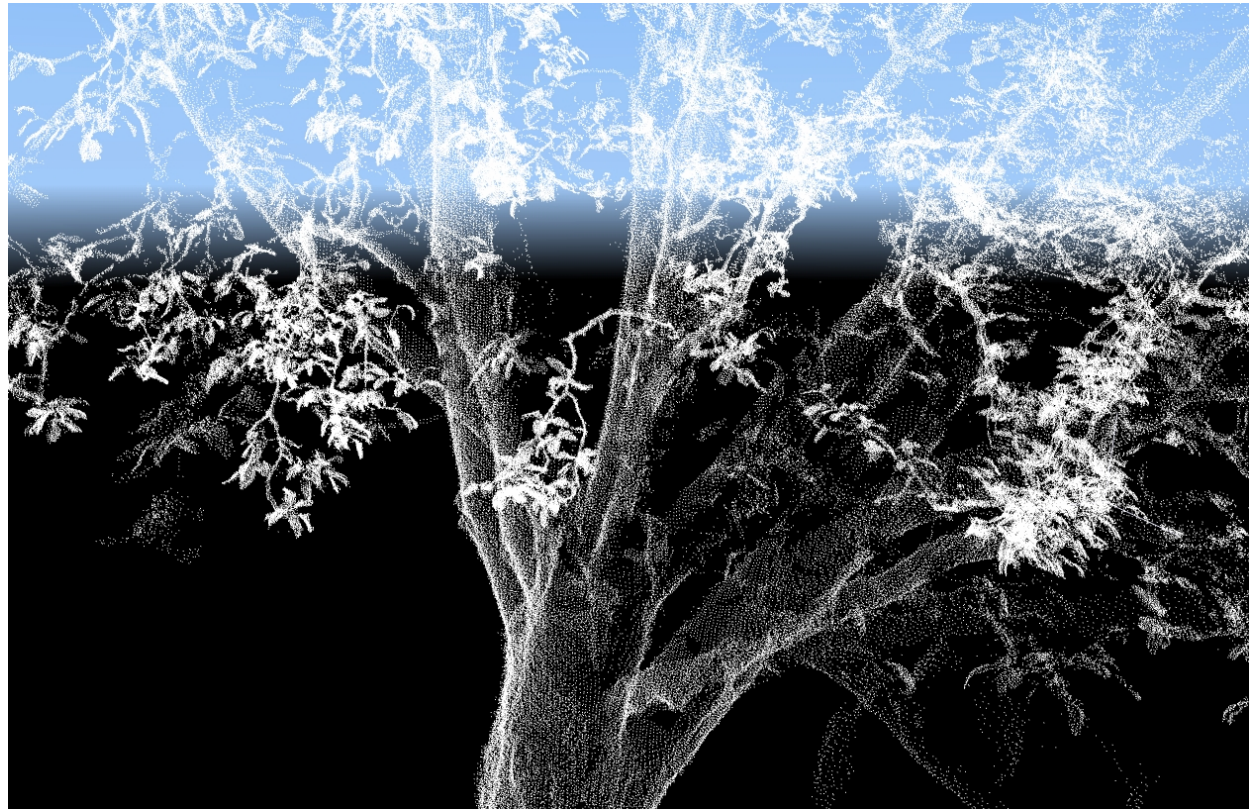
Fig. 8 Lysimeter scenario: Simulated diurnal course of transpiration [$mm\ d^{-1}$] (solid line), of xylem water flux at the root collar [$mm\ d^{-1}$] (dotted line), of change rate of xylem water content [$mm\ d^{-1}$] (dashed line) and of stem diameter [mm] (grey line) during three days.

Terrestrial Laser Scanner

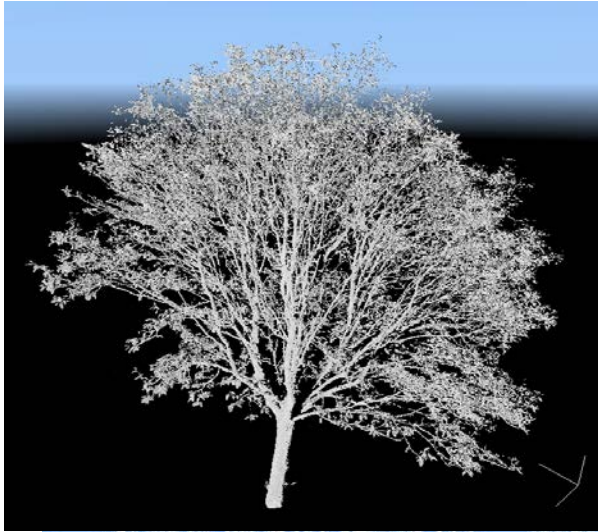


Aboveground:

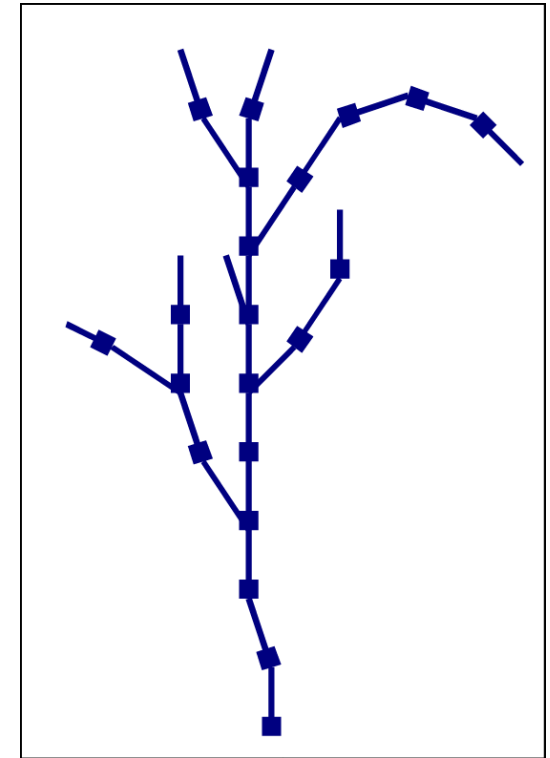
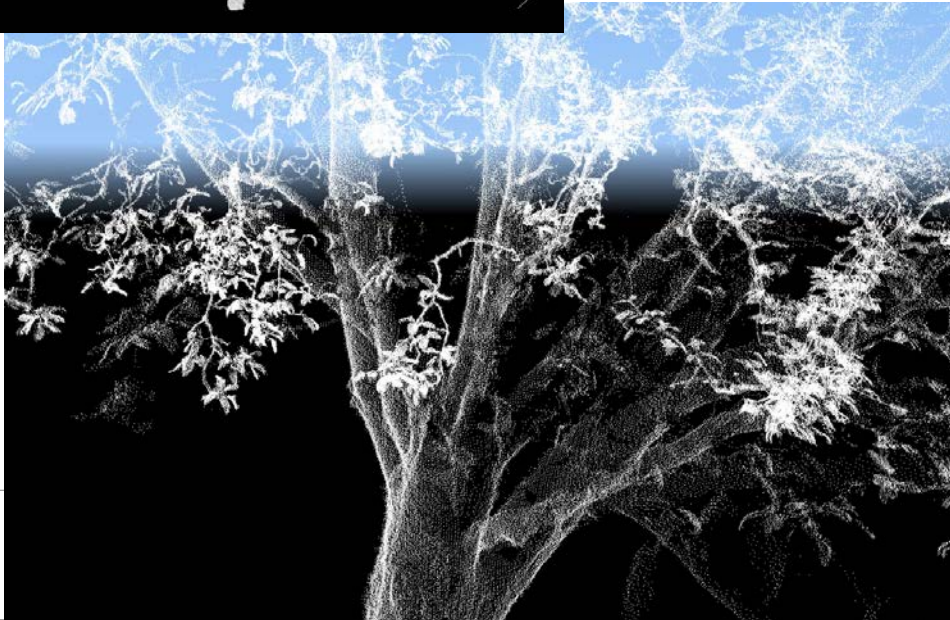
Terrestrial Laser
Scanning



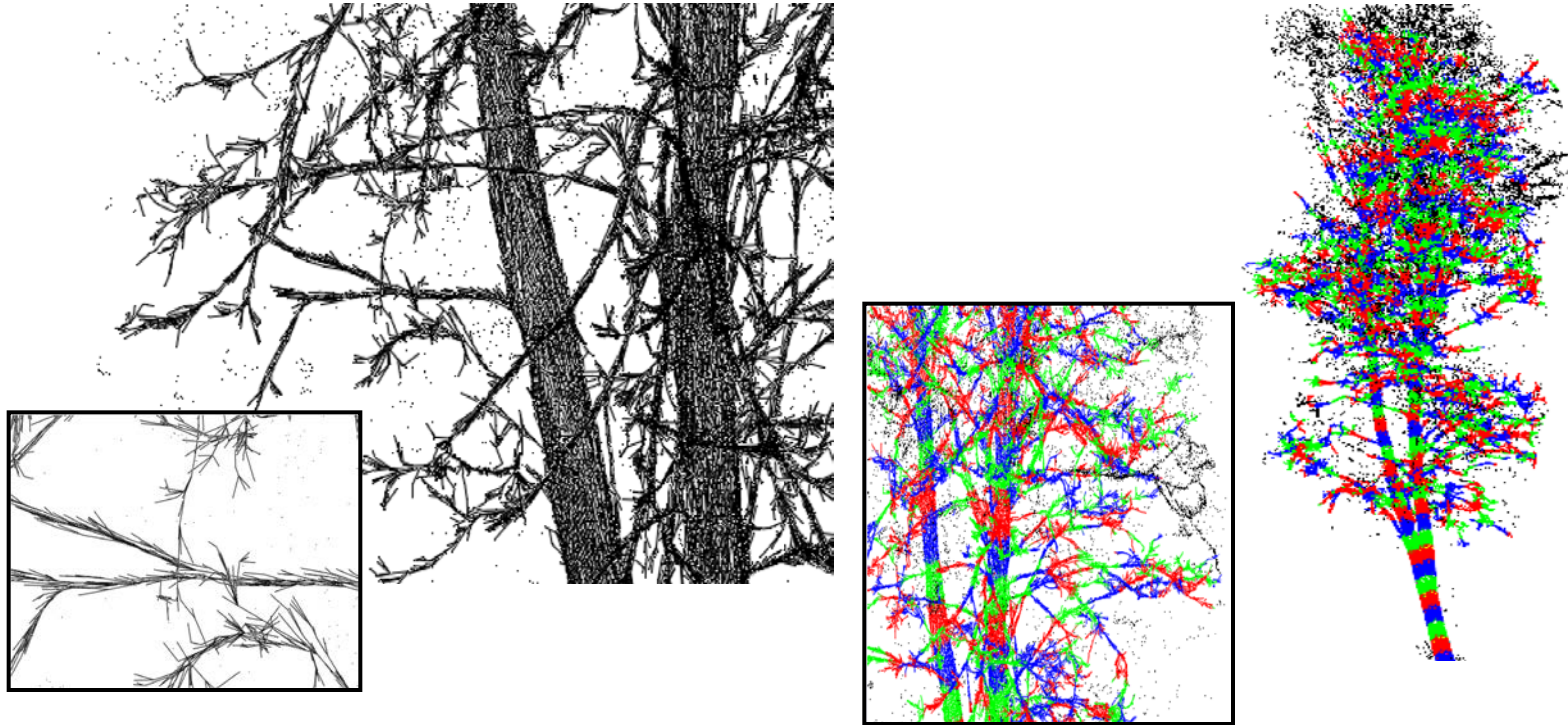
Terrestrial laser scanner



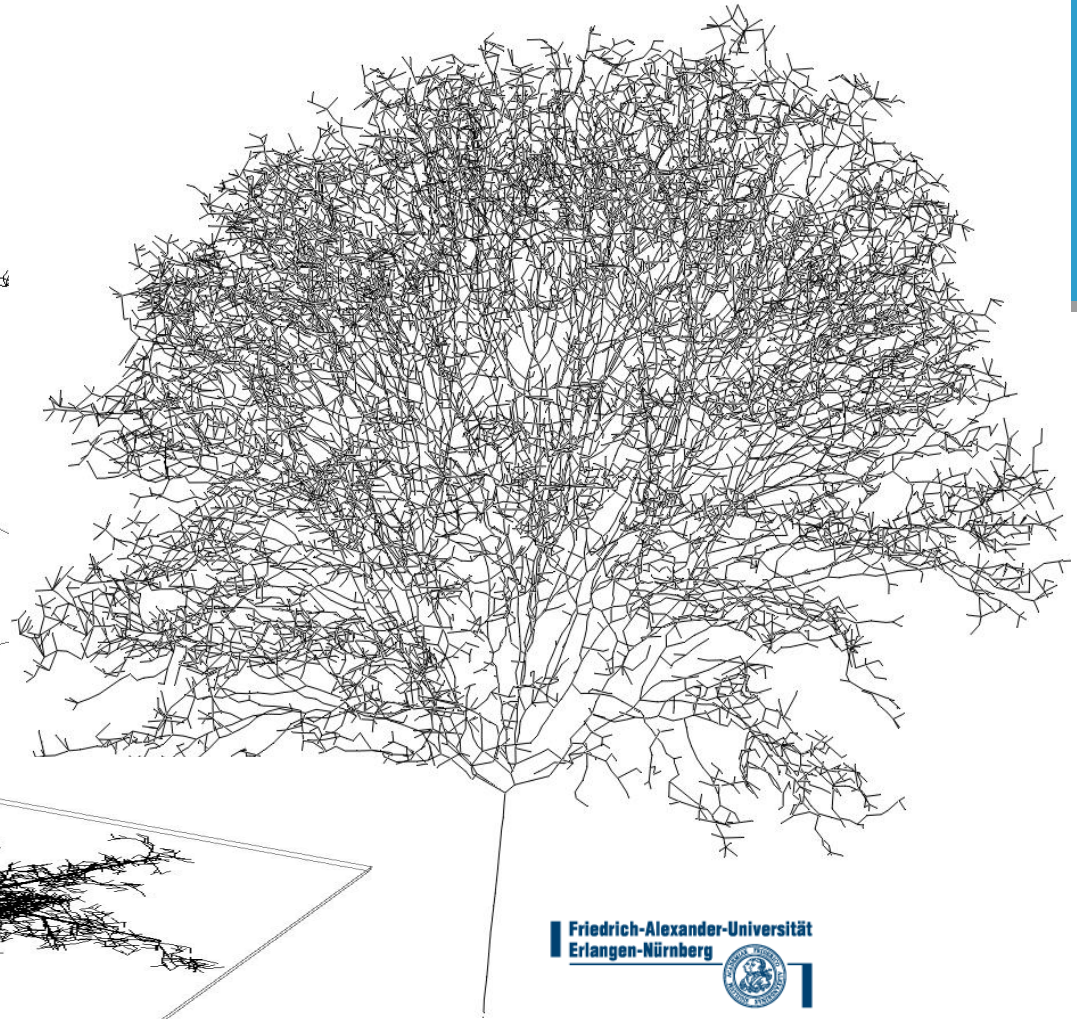
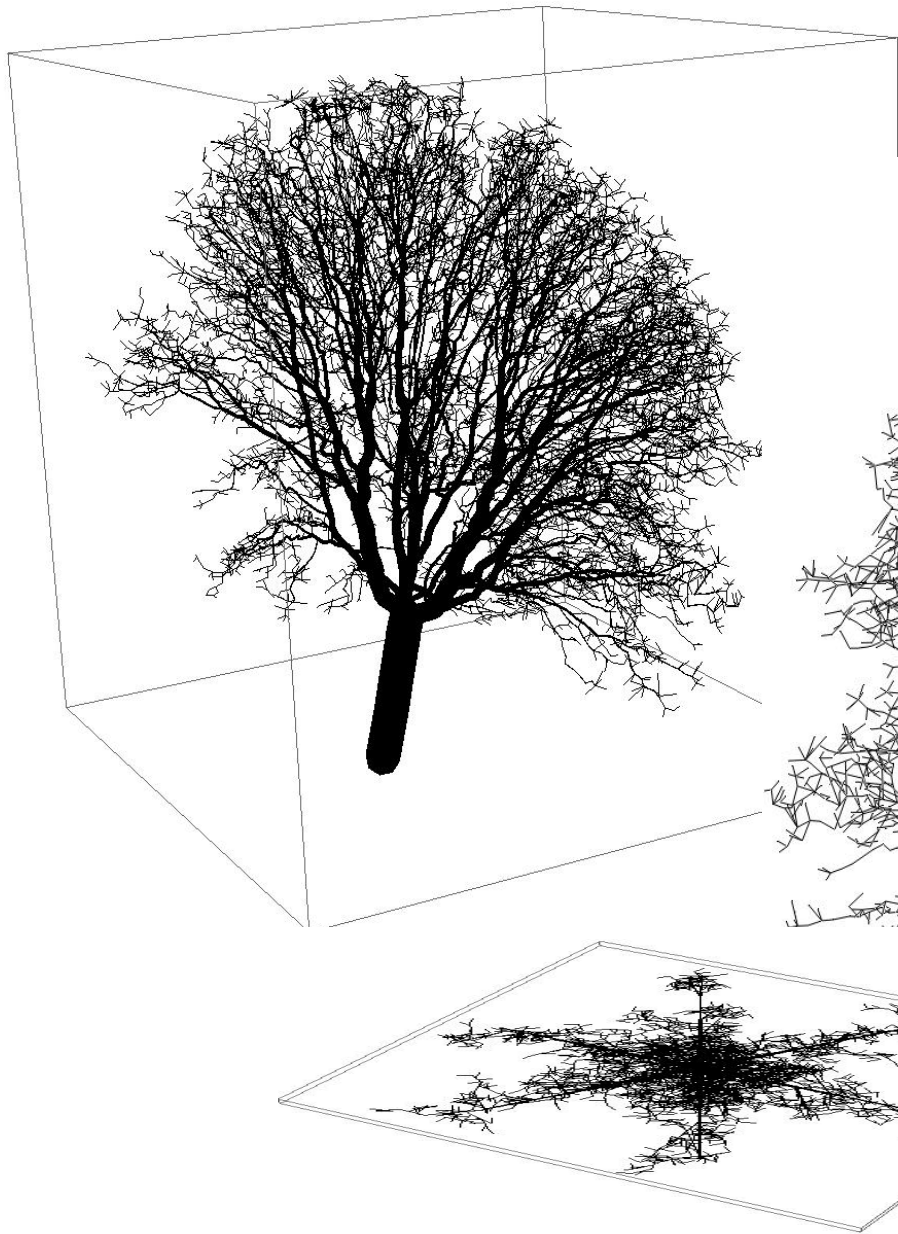
Tree skeleton has to be extracted from point clouds



Terrestrial laser scanner



Automatic skeleton extraction algorithm acc. To (Verroust and Lazarus, 2000; Xu et al., 2007)



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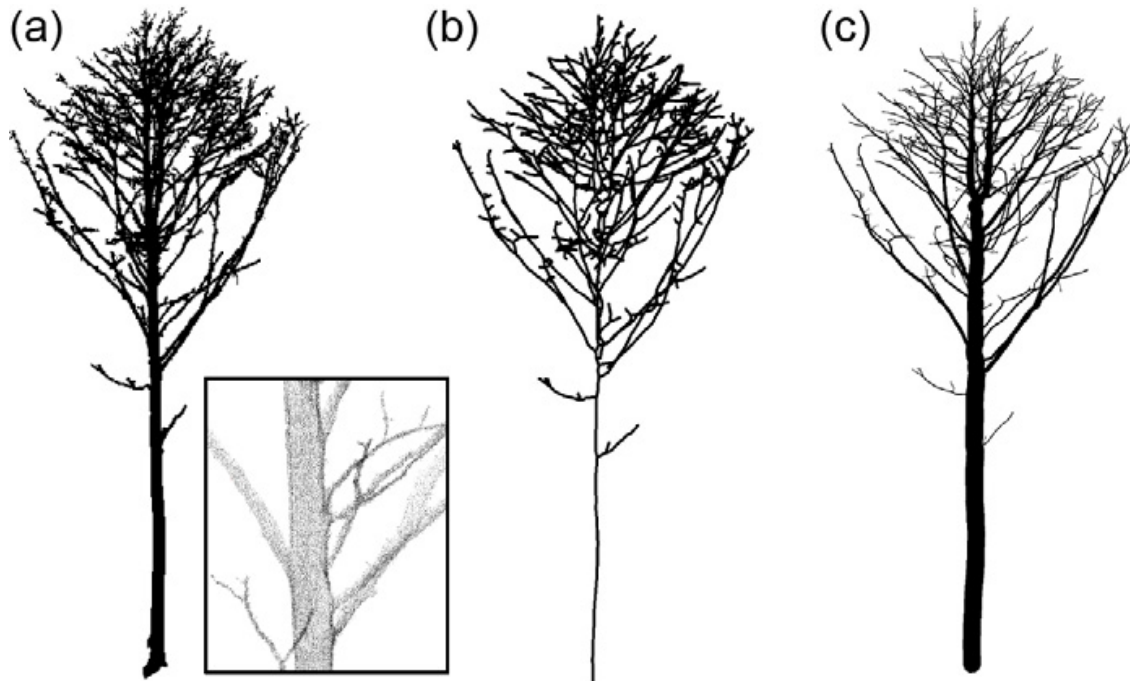


 HELMHOLTZ
ASSOCIATION

Tree - Architecture

Aboveground:

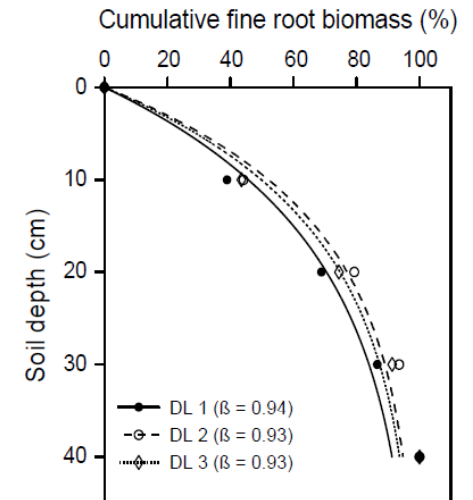
Tree architecture model, based on 3D laser scans



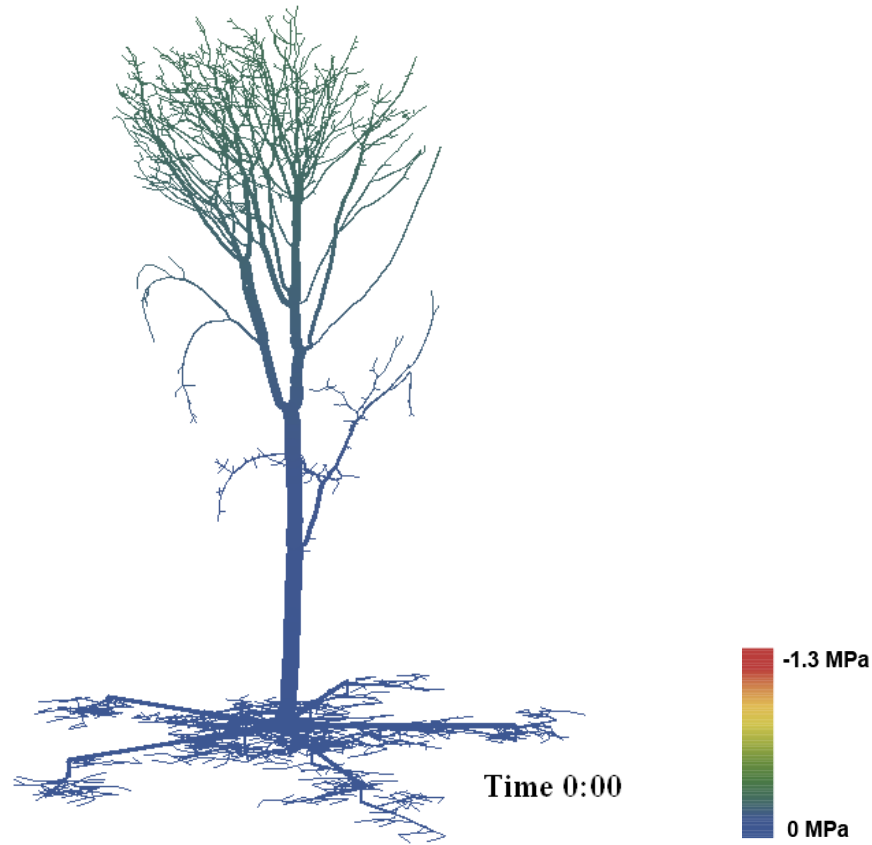
- (a) Point cloud obtained by 3D laser scans
- (b) Tree graph obtained by skeleton extraction
- (c) Virtual canopy represented by cylinder elements

Belowground:

Root architecture model, based on measurements of the spatial fine root distribution



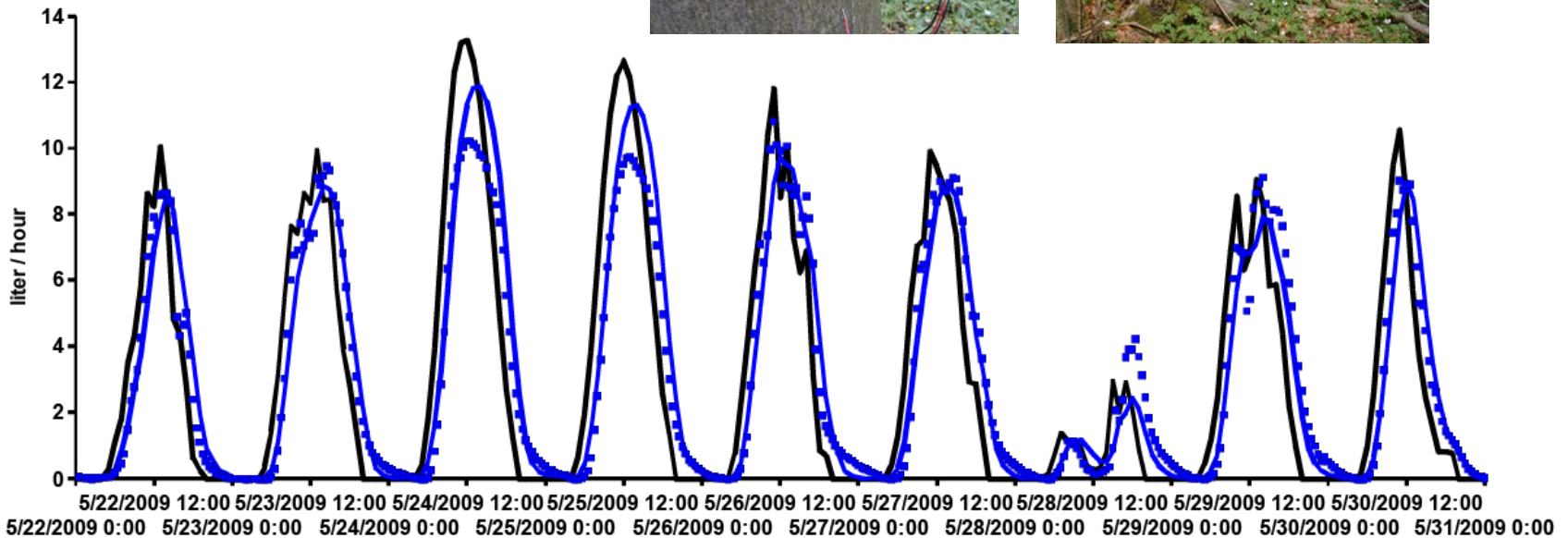
Results – Xylem Water Potential



Results – Stem Water Flux

Measurement: Granier-type heat flux sensors

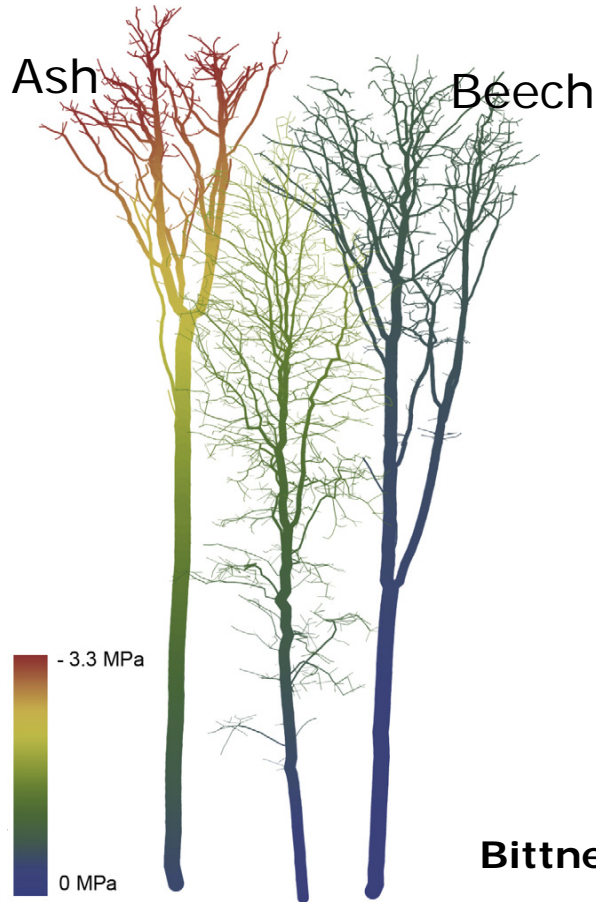
- Simulated transpiration
- Simulated stem sap flux
- Measured stem sap flux



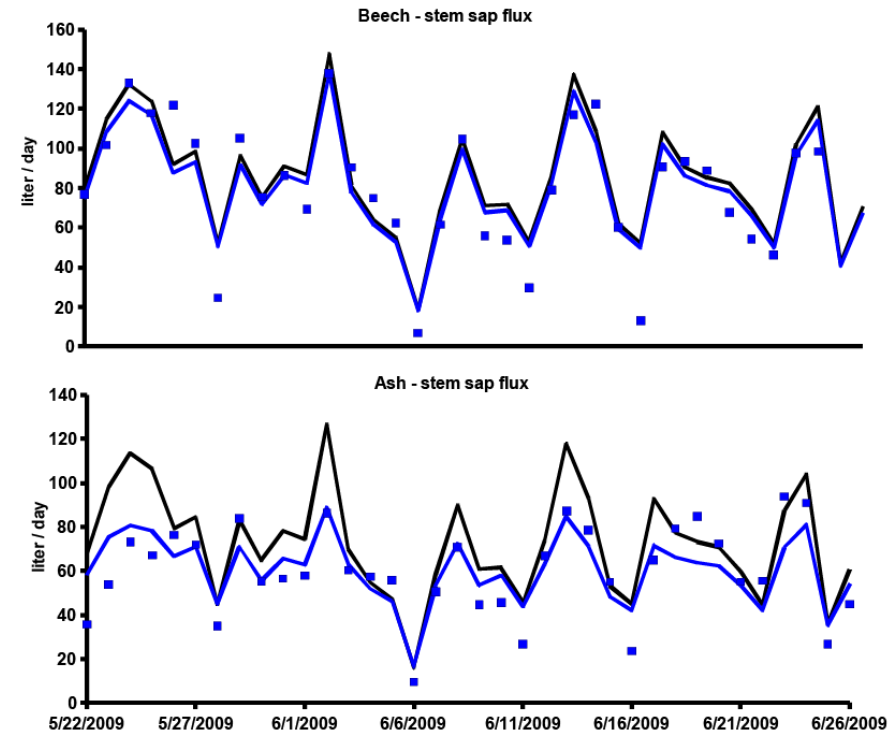
Results – Differences between Tree Species

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Xylem Water Potential

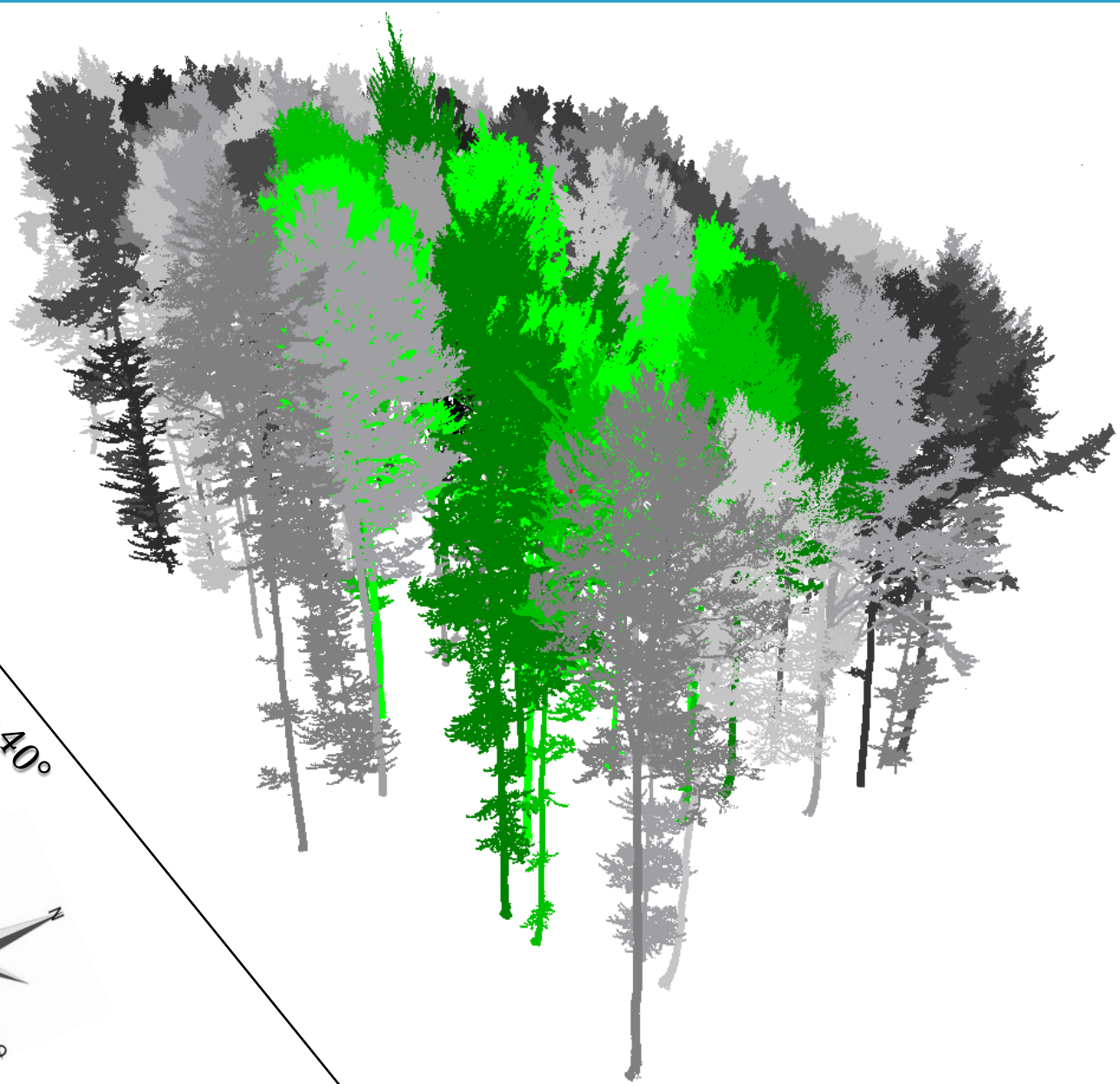


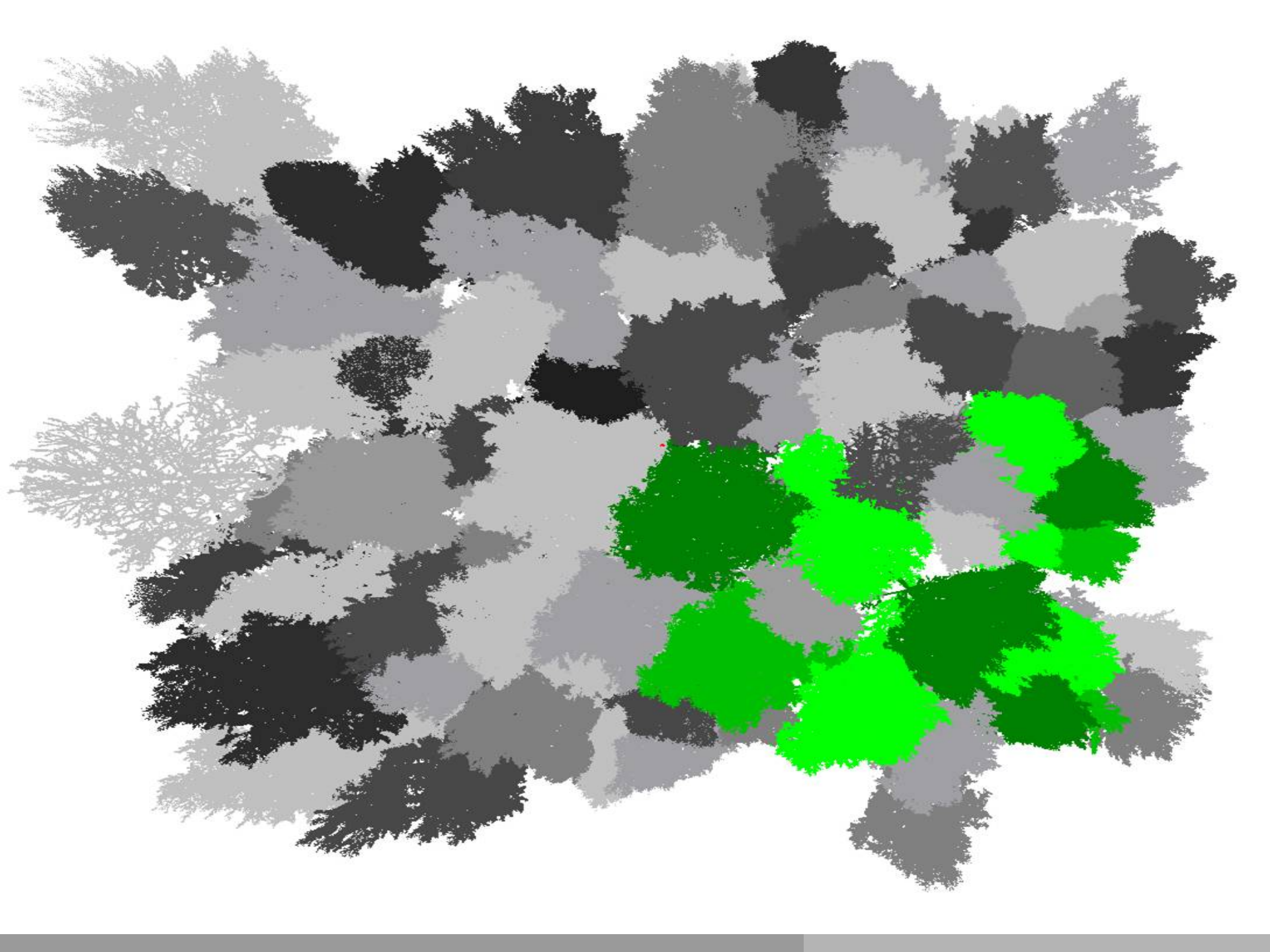
Daily Stem Sap Flux

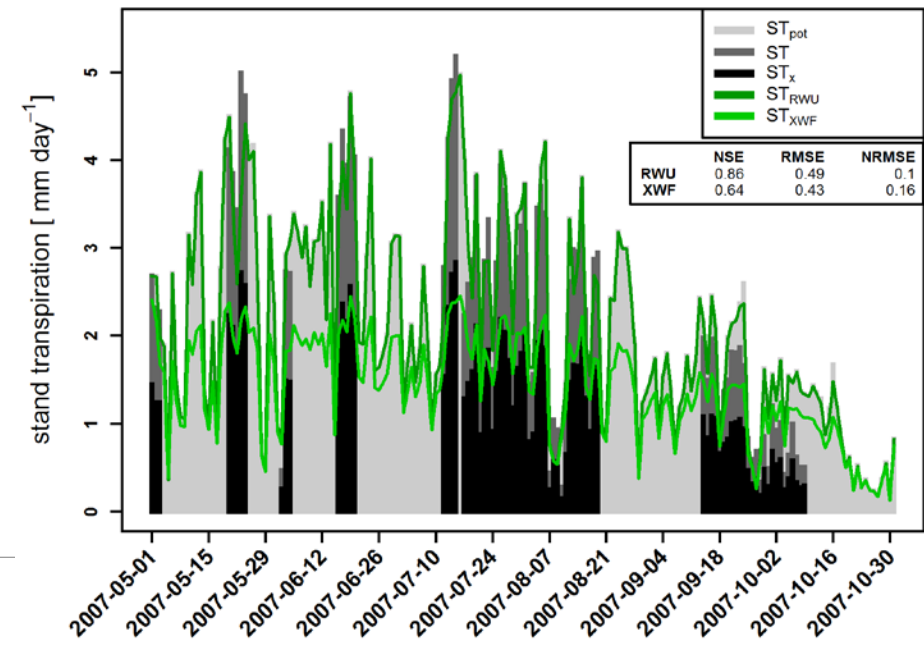
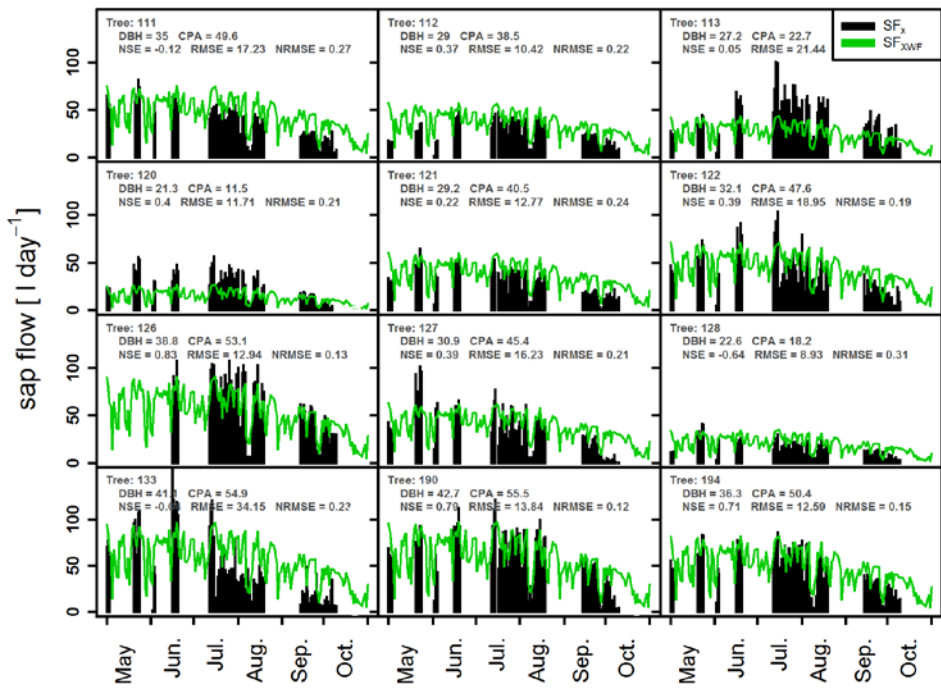
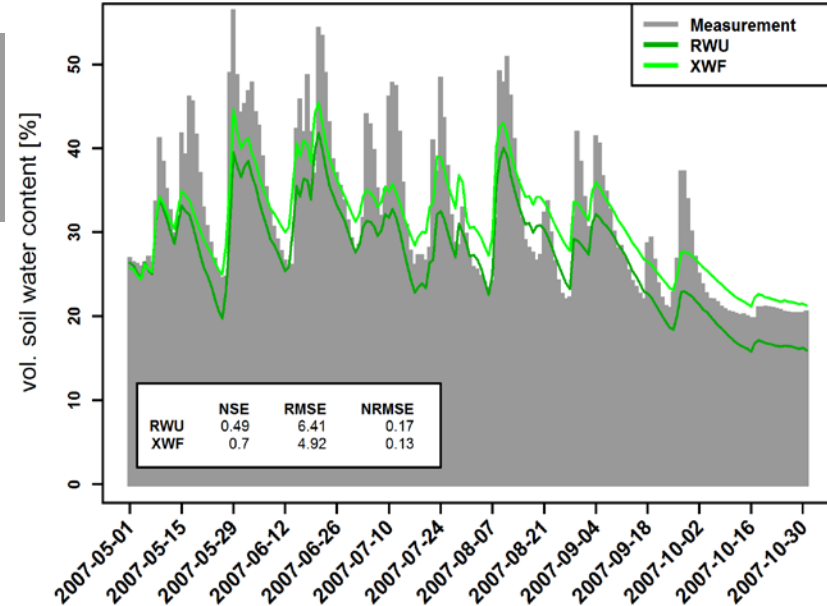
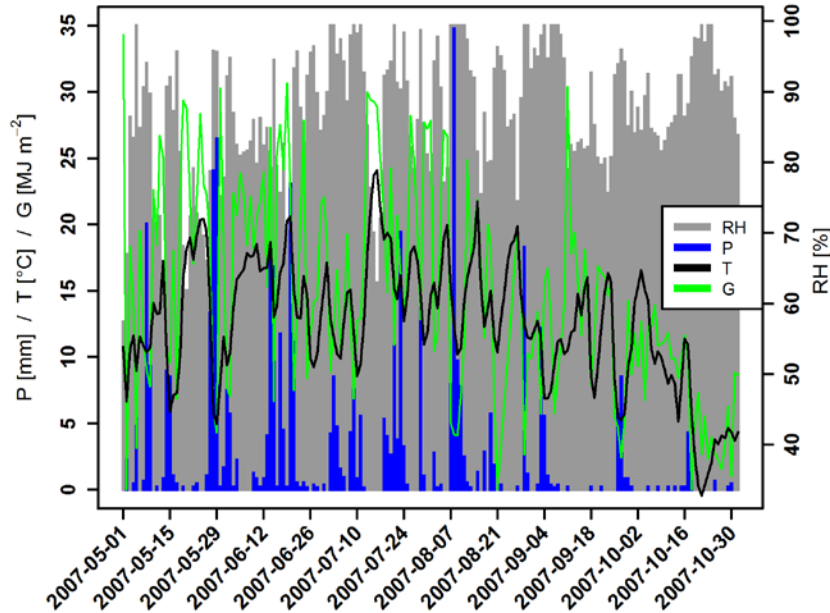


Bittner et al. (2012), Agric Forest Met 158– 159 (2012) 80– 89

Inclination = 40°







Thank you for your interest

Thanks to



DFG GK1086



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Chair of System Simulation, University Erlangen-Nürnberg
Janakan Sivagnanasanduram, Ulrich Rüde



Publications

Janott et al. (2011), *Plant and Soil* 341: 233-256

Bittner et al. (2012), *Agric Forest Met* 158–159: 80–89

Bittner et al. (2012), *J Geophys Res* 117, G01037,

Hentschel et al. (2013), *Agric Forest Met*, accepted.