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Using tracheid isometry to upscale water transport from pit to tree-rings

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Assessing the characteristic of water transport in wood is challenged by the complexity of its tissue composed by numerous different-sized and interconnected conduits. Current methods for measuring conductivity or flow resistance performed on a piece of wood usually have no direct link to the anatomy of the single conduits. Thus, despite the large application of these assessment for ecological studies, this integrated tissue-level approach hampers the possibility to extend the hydraulic assessment across time by using dated series of tree rings.

In this contribution we make use of tracheid versus pit isometry to propose a new hydraulic model merging existing morphological-based components of tracheid hydraulic to upscale water transport properties across time and environments. By using linear relations between tracheid dimeter and pit size as described in the literature, we applied our model to tracheids of increasing size to show that our assessments of the pit and tracheid resistances match with estimations performed in independent studies. We then apply the model to tracheid anatomical measurements from Larix sibirica tree-rings (from 1986 to 2015) formed under harsh conditions in southern Siberia to show the potential to reconstruct hydraulic properties across tree-rings and to quantify their intra- and inter-annual variability.

The proposed model (see 10.1093/jxb/eraa595 for more details on the performed study) not only provide means to derive realistic conduits hydraulic properties via accessible measures of cross-sectional tracheid size, but it also allows assessing how different-sized tracheid's components contribute to the overall hydraulic properties. In particular, our up-scaled results from the study case with trees from Southern Siberia showed that the natural inter- and intra-ring anatomical variations had a substantial impact on the ring hydraulic properties and can consequently be applied to assess the impact of cell structural characteristics on the hydraulic functioning of trees.

We therefore conclude that this model, despite its early developmental stage, has the potential to provides a novel basis to investigate xylem structure-function relations across time and environmental conditions.