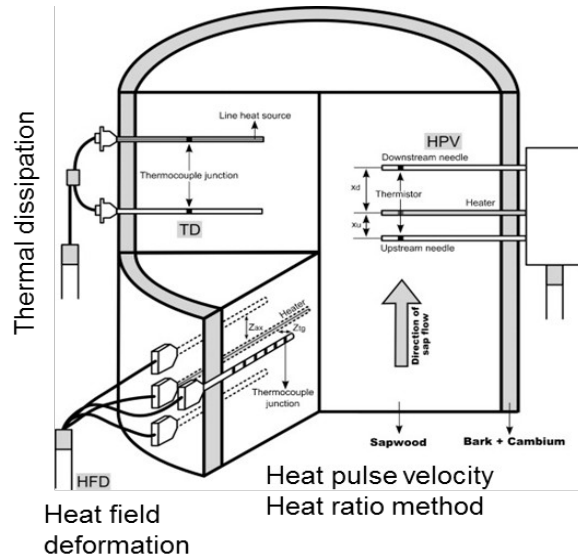


Towards a consistent quantification of ecosystem transpiration and its uncertainty from the SAPFLUXNET database

Rafael Poyatos (r.poyatos@creaf.uab.cat),
Víctor Granda, Víctor Flo, Maurizio Mencuccini, Jordi Martínez-Vilalta

Uncertainty in sap flow measurements

- Methodological
- Whole-plant integration
- Sampling and upscaling to ecosystem level.

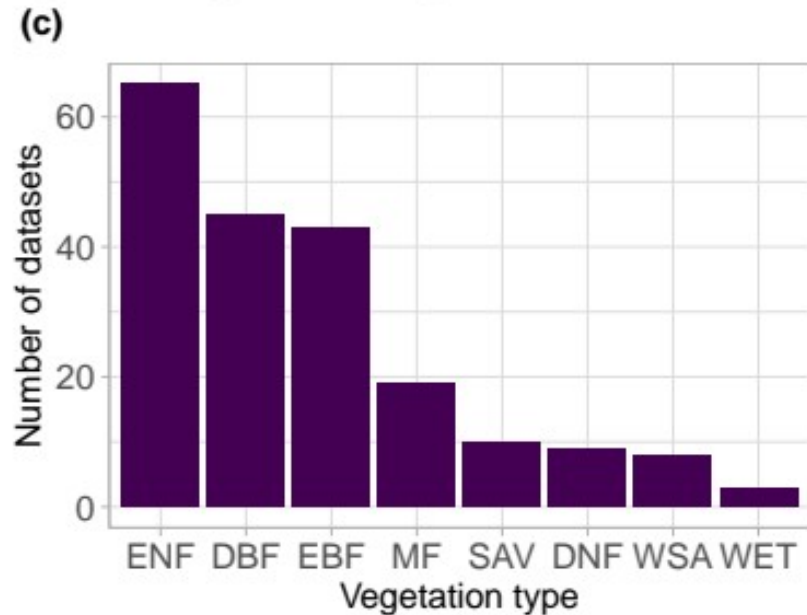
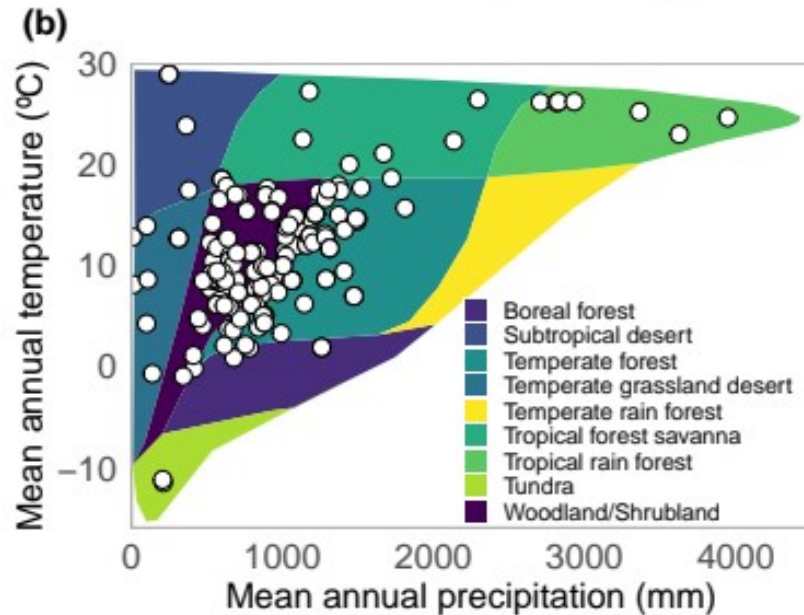
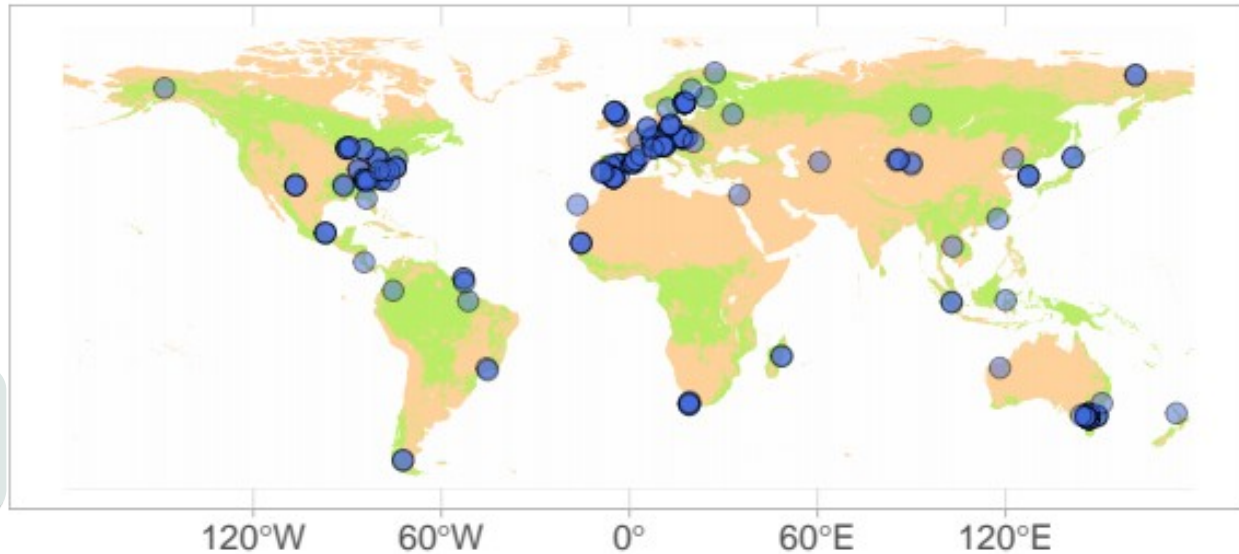


SAPFLUXNET, global sap flow data at the plant level

Poyatos et al. 2020. Earth System Science Data Discussions



202
datasets

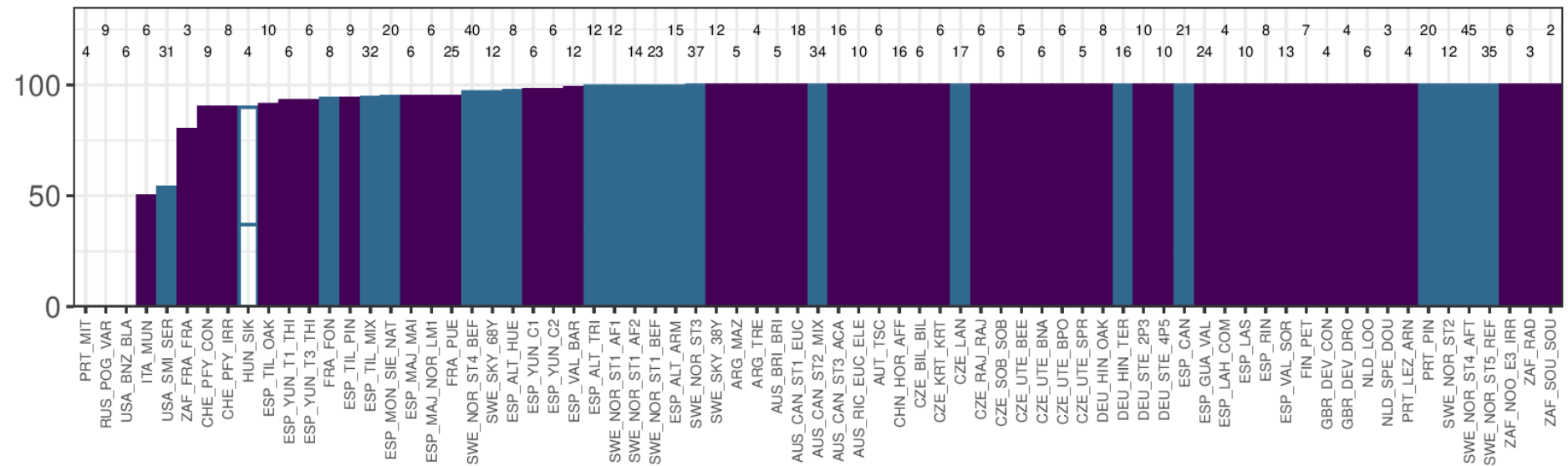


Potential for ecosystem-level scaling

Poyatos et al. 2020. Earth System Science Data Discussions

- Datasets often include species comprising most of plot basal area.
- Stand metadata available in SAPFLUXNET: tree DBH, total stand basal area and species fractional basal area.

(c) Woodland/Shrubland



Methodological uncertainty

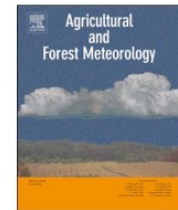
- Inherent methodological uncertainty.
- Installation and data processing.
- Conversion of sapwood temperatures into sap flux.



Contents lists available at [ScienceDirect](#)

Agricultural and Forest Meteorology

journal homepage: www.elsevier.com/locate/agrformet



A synthesis of bias and uncertainty in sap flow methods

Víctor Flo^{a,*}, Jordi Martinez-Vilalta^{a,b}, Kathy Steppe^c, Bernhard Schuldt^d, Rafael Poyatos^{a,b,c}

^a CREAM, Cerdanyola del Vallès 08193, Spain

^b Univ Autònoma de Barcelona, Cerdanyola del Vallès 08193, Spain

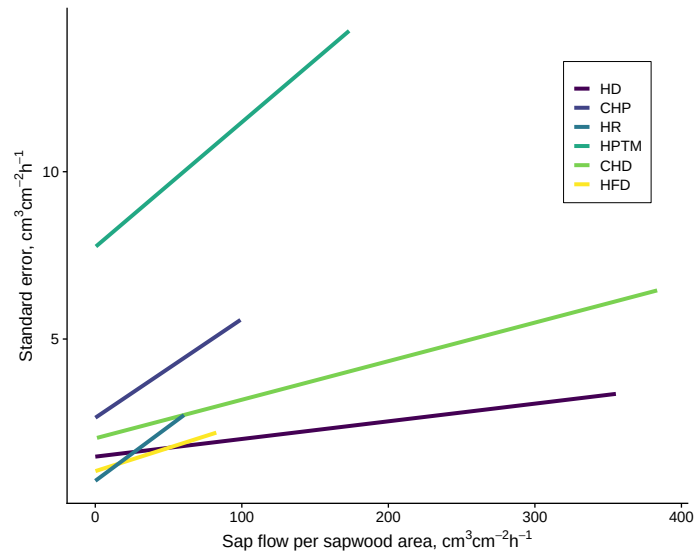
^c Laboratory of Plant Ecology, Department of Plants and Crops, Faculty of Bioscience Engineering, Ghent University, Coupure links 653, 9000 Gent, Belgium

^d University of Würzburg, Julius-von-Sachs-Institute of Biological Sciences, Ecophysiology and Vegetation Ecology, Julius-von-Sachs-Platz 3, 97082 Würzburg, Germany

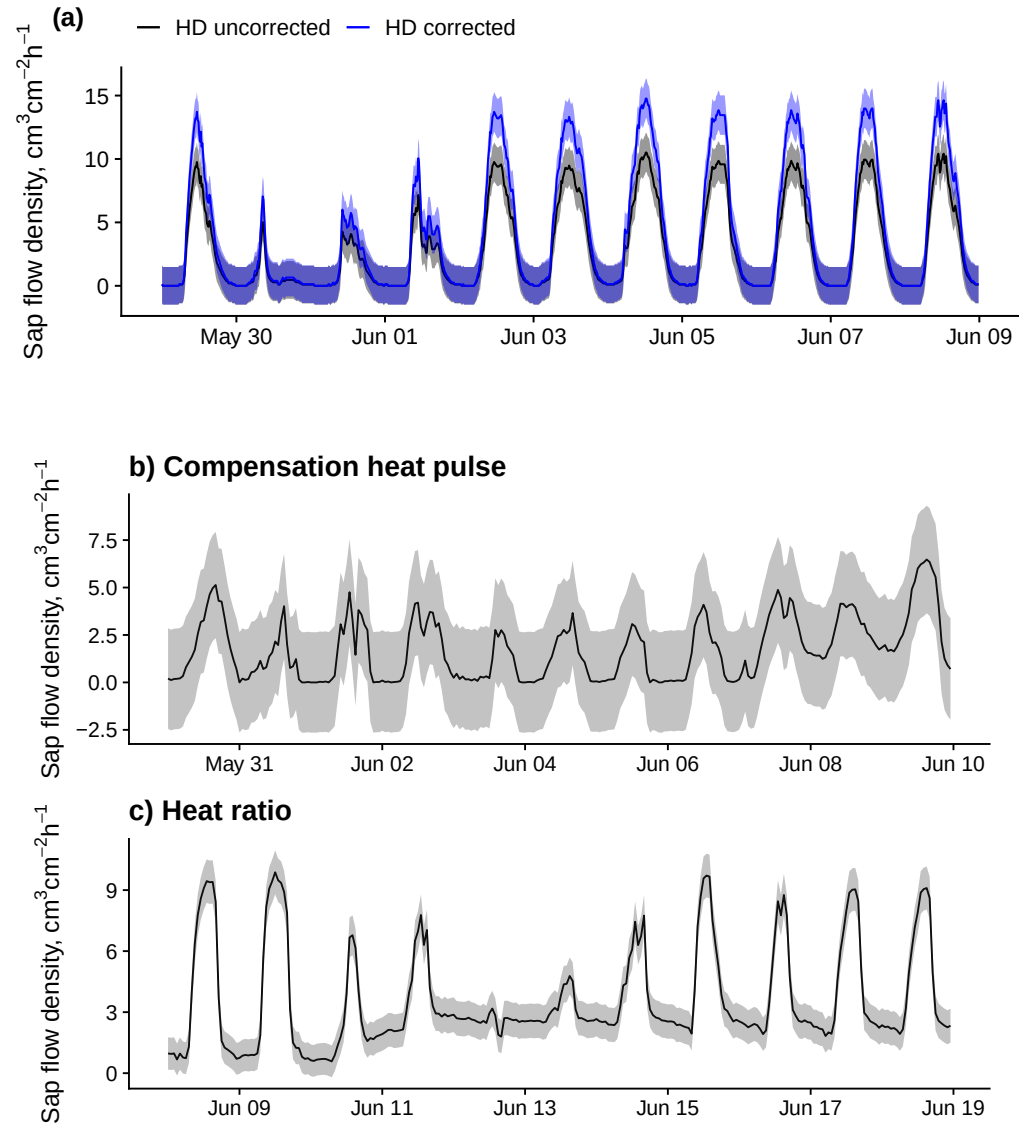


<https://doi.org/10.1016/j.agrformet.2019.03.012>

Methodological uncertainty from sap flow calibrations

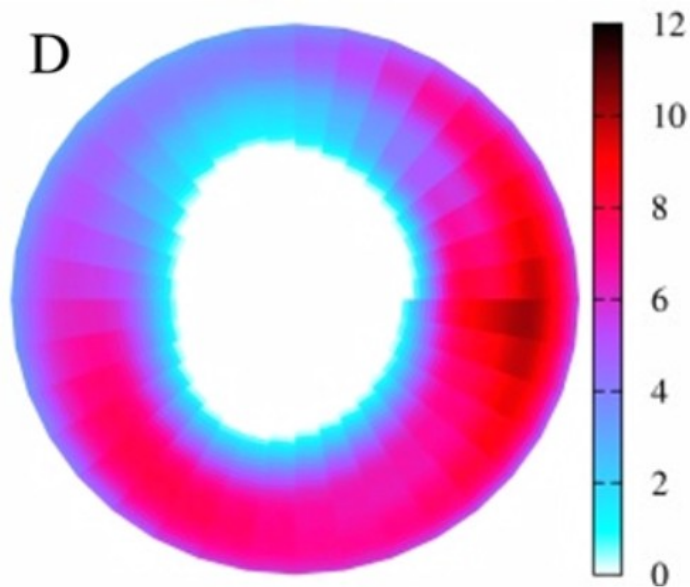


Sap flow calibrations meta-analysis used to apply bias correction of uncalibrated HD data and to estimate standard error of sap flux $\sim f(\text{method, flux rate})$.



Whole-plant integration

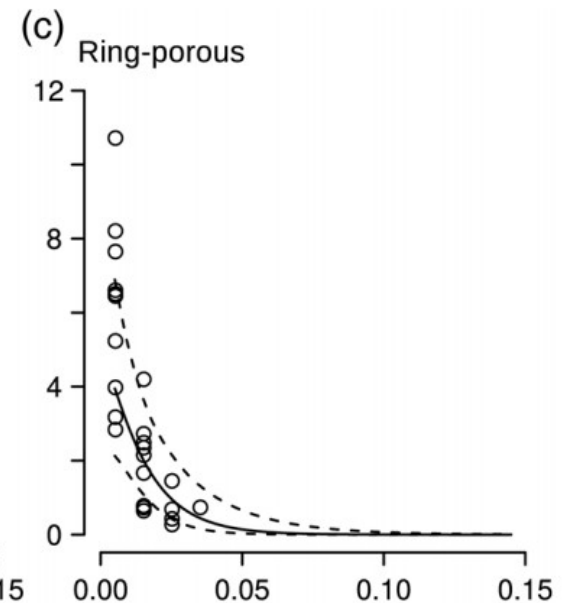
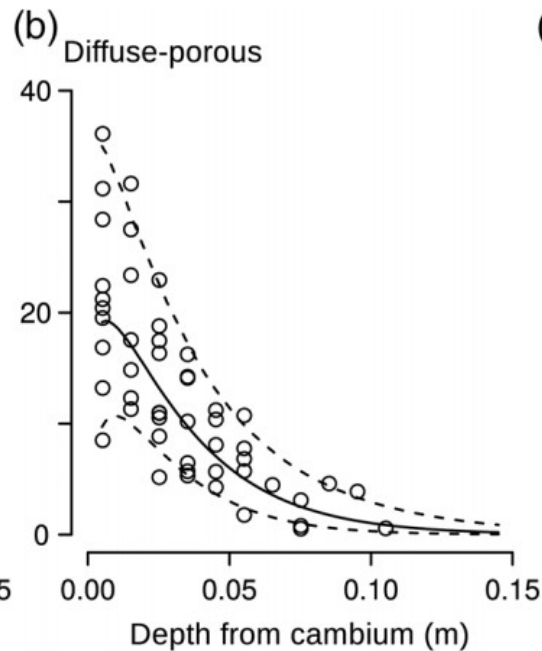
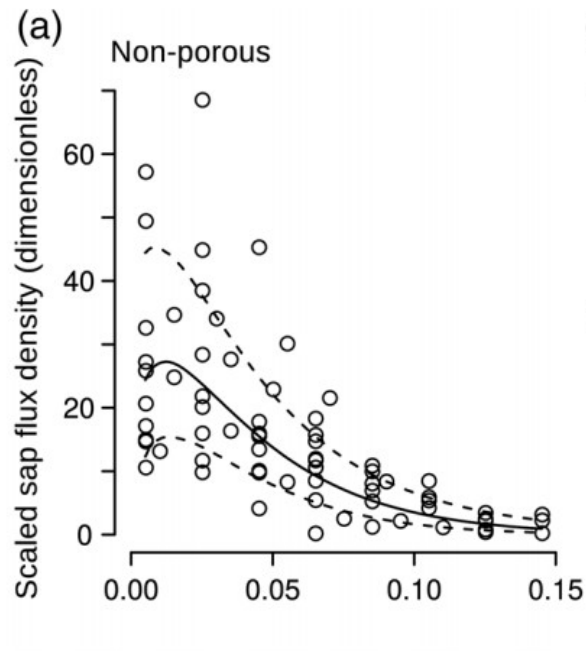
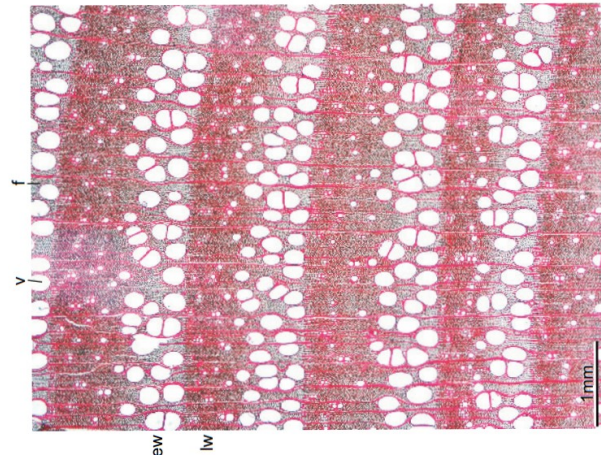
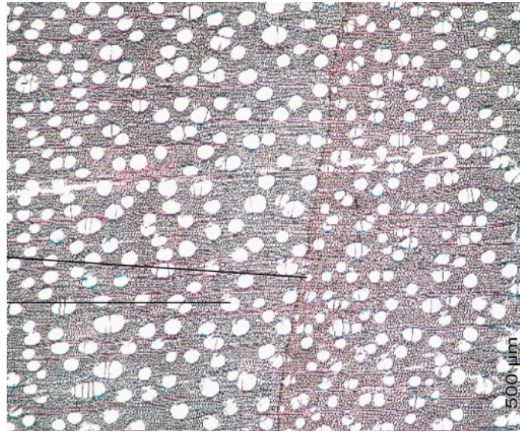
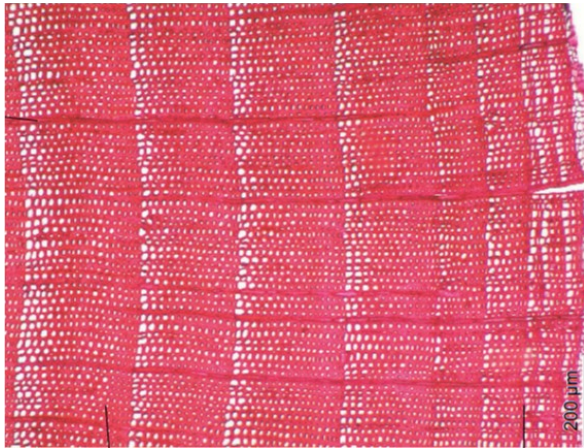
- Radial variability.
- Azimuthal variability.
- Sapwood area estimation.



Schweingruber et al 2008, Atlas of Woody Plant Stems

Wood type-specific radial profiles of sap flow

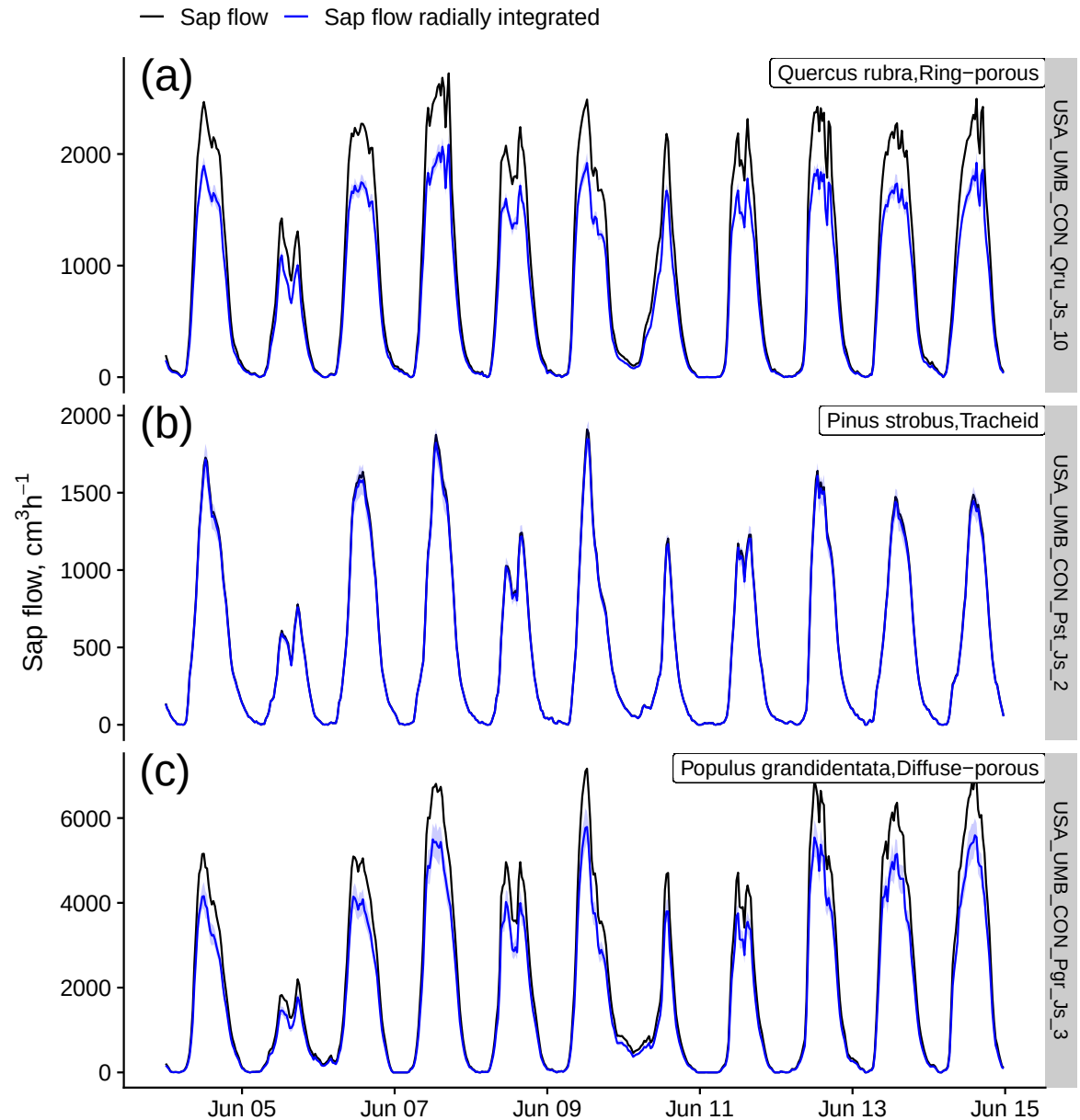
Schweingruber et al 2008, Atlas of Woody Plant Stems



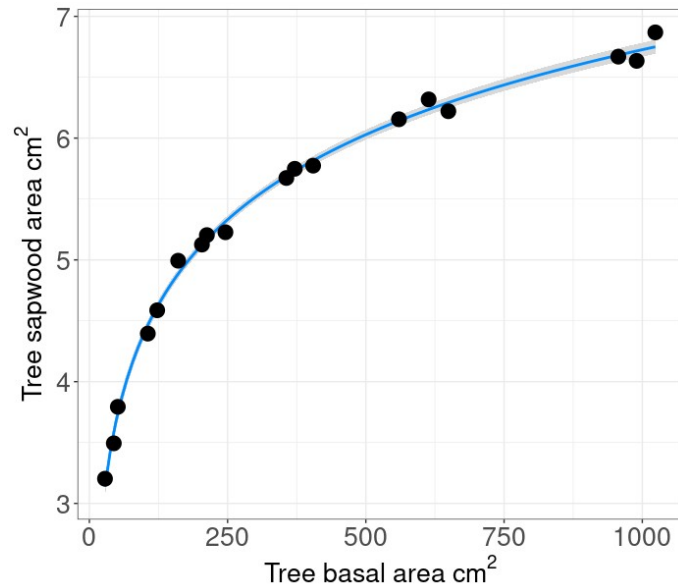
Berdanier et al. 2016, <https://doi.org/10.1093/treephys/tpw027>

Accounting for radial variation in sap flow

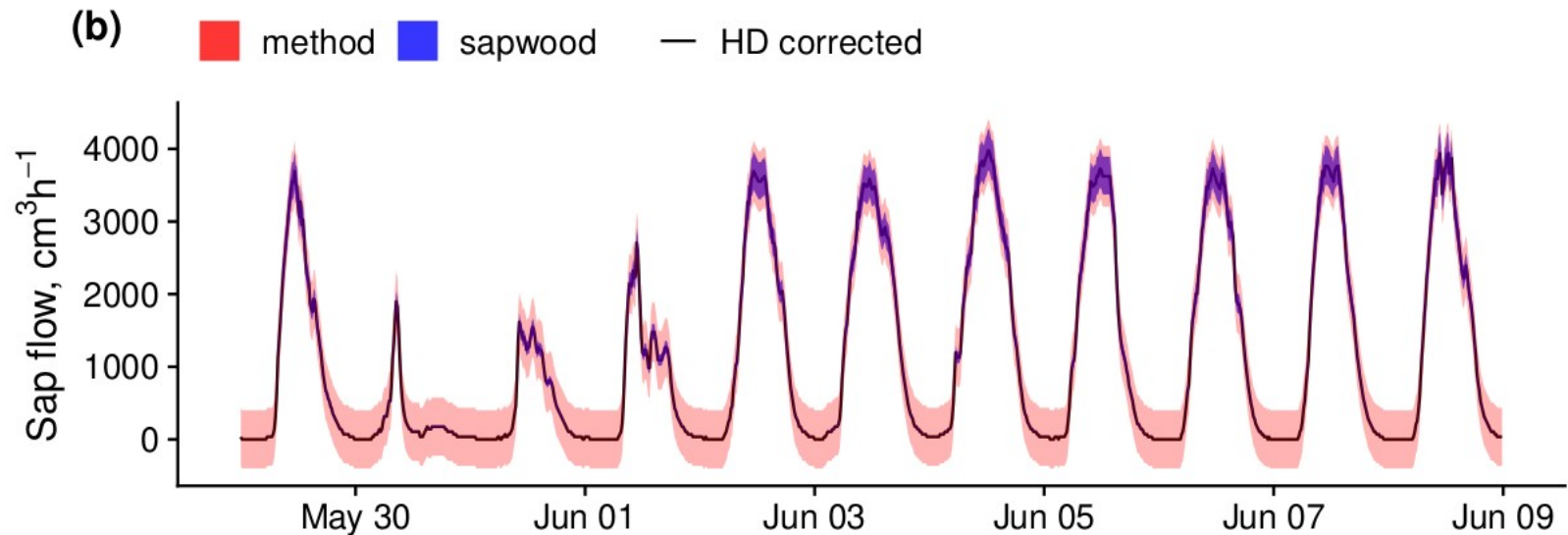
Wood type-specific radial profiles of sap flow applied to SAPFLUXNET data where radial variation was not considered.



Accounting for uncertainty in sapwood area estimation



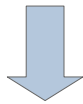
Tight relationship between basal area and sapwood area results in lower uncertainty, when compared with methodological uncertainty.



Simple species-level ecosystem scaling

- Estimate ecosystem transpiration (T) using data and metadata from SAPFLUXNET.

$$J_{Ab,i} = \frac{J_i}{A_{b,i}}$$



$$T = 1000 \cdot \sum_{m=1}^M \overline{J_{Ab,j}} \cdot f_{Ab,j} \cdot A_B$$

J_i Tree-level sap flow [$\text{cm}^3 \text{h}^{-1}$]

$A_{b,i}$ Tree cross-sectional basal area [cm^2]

$\overline{J_{Ab,j}}$ Mean species sap flow per basal area [$\text{cm}^3 \text{cm}^{-2} \text{h}^{-1}$]

$f_{Ab,j}$ Fraction of stand basal area occupied by species j

A_B Total stand basal area [$\text{cm}^2 \text{m}^{-2}$]

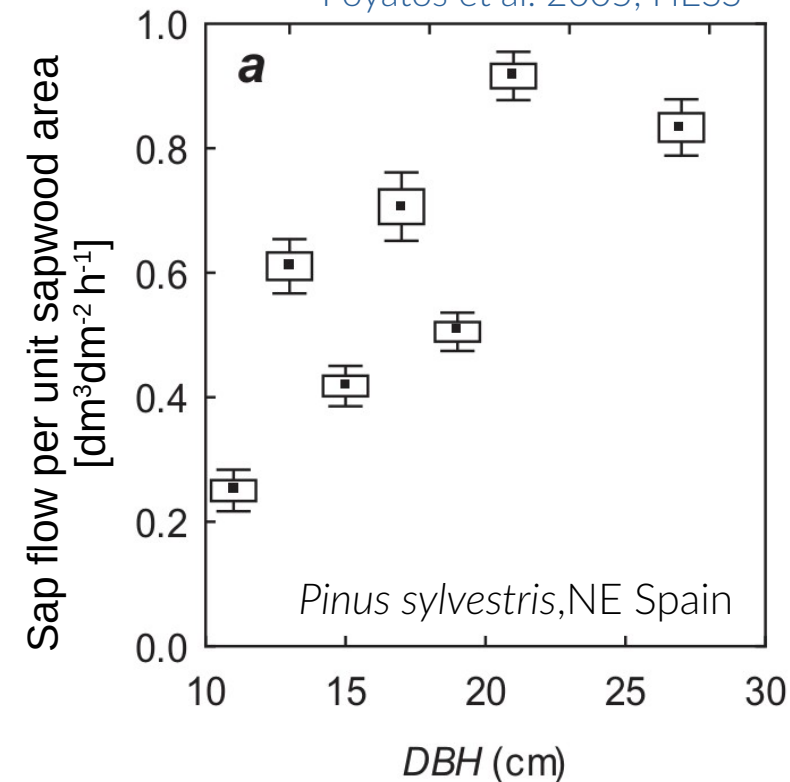
Quantify tree sap flow
per unit basal area



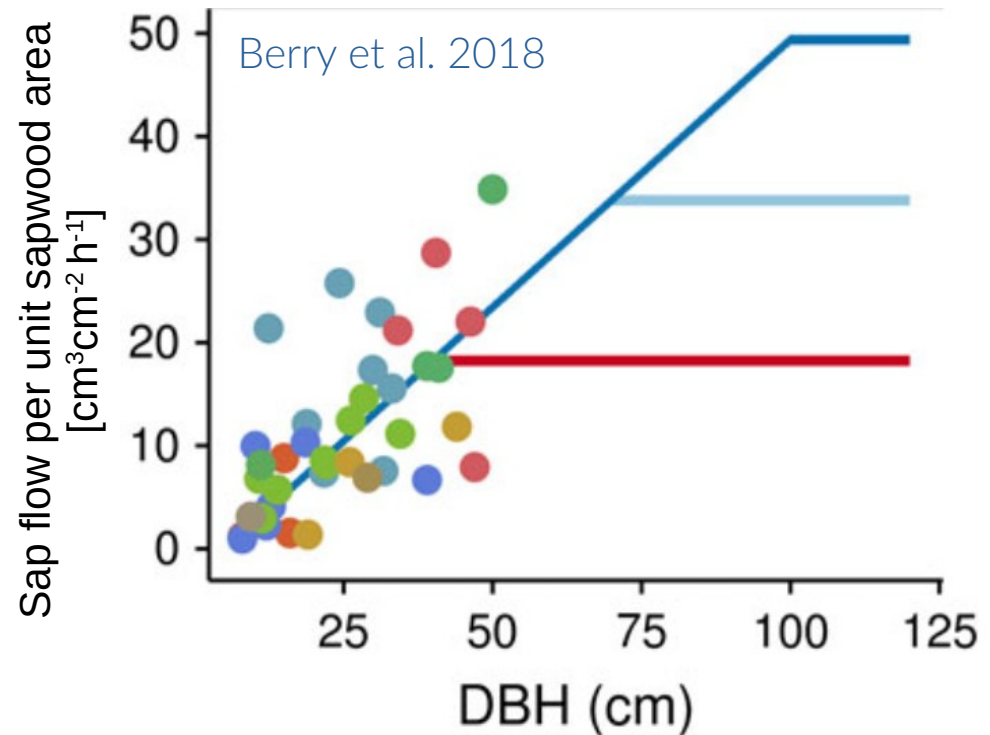
Multiply species-mean sap flow
per basal area by species
basal area in the plot and
add up to obtain ecosystem T [mm h^{-1}]

Tree size influences on sap flow upscaling

Poyatos et al. 2005, HESS



Berry et al. 2018



- Increasing tree water use with size co-driven by larger sapwood areas and potentially larger sap flow per sapwood area (left).
- How to consider the potential diversity of relationships between sap flux density and tree size?

Data-driven size-dependent scaling framework



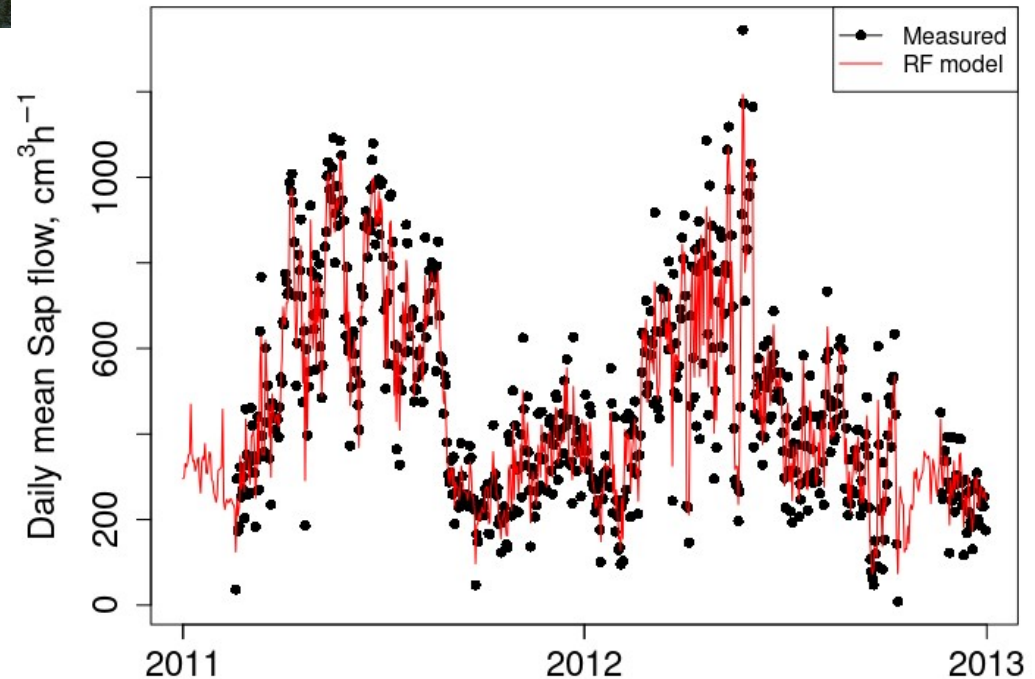
ESP_CAN site,
Mediterranean forest
Arbutus unedo (4)
Pinus halepensis (3)
Quercus ilex (7)
Quercus pubescens (7)

Daily means of tree-level sap flow J_i



Train Random Forest model

$J_i \sim \text{RF}[\text{VPD}, \text{DBH}, \text{species}, \sin(\text{DOY}), \cos(\text{DOY})]$



Data-driven size-dependent scaling framework



SAPFLUXNET dataset [ESP_CAN]

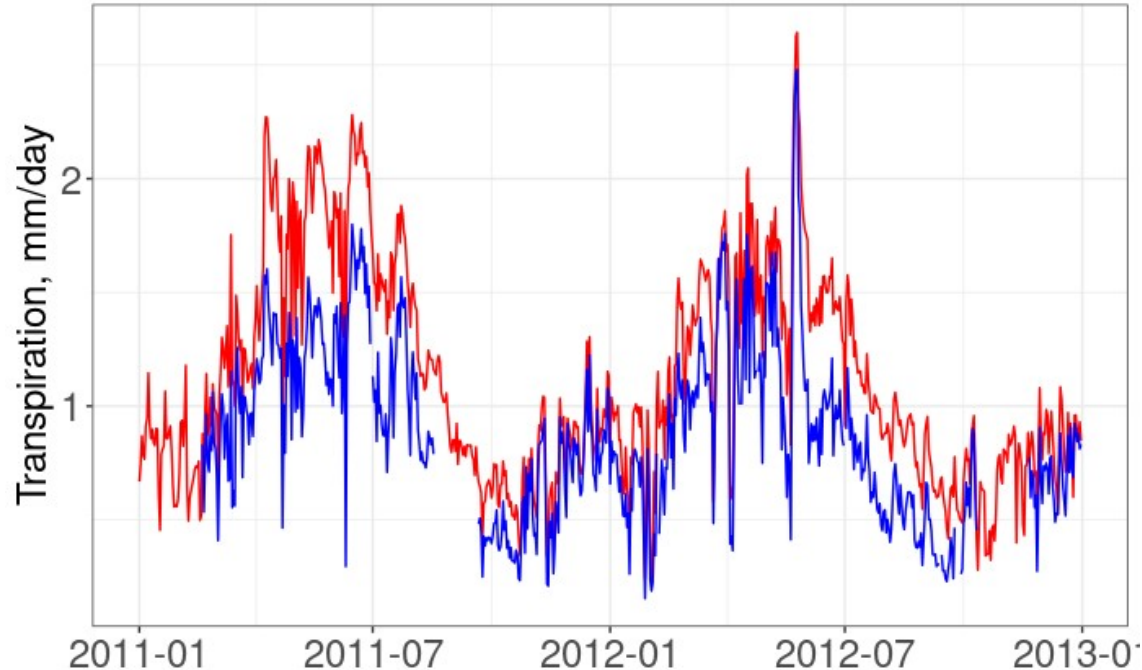


RF model of tree-level sap flow J_i

Forest inventory [0.7 ha plot]
Species identity + DBH
of 1000 trees

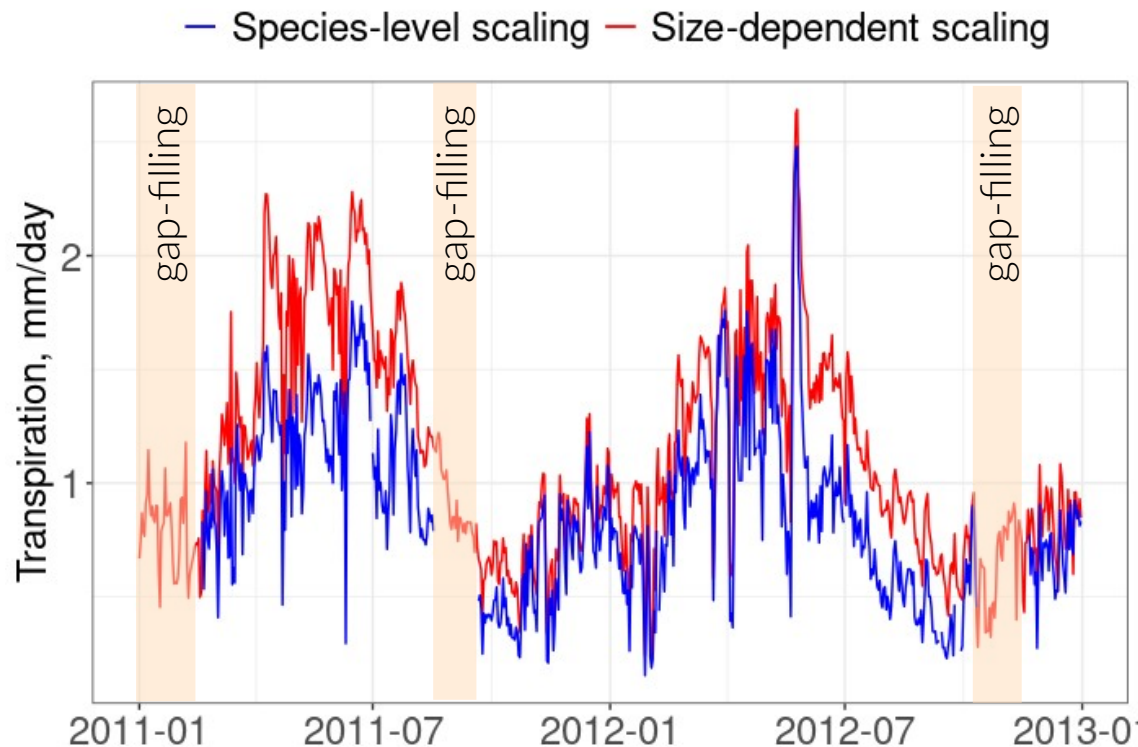
RF predictions of daily sap flow for 1000 trees

— Species-level scaling — Size-dependent scaling



Advantages of RF-based scaling

- No a priori functional form between tree sap flow and tree size.
- Improve plot representativity and consider size influences by using measured tree size distributions..
- Gap-filling of missing data at the tree level.



Challenges – sensor to tree upscaling

- How to estimate methodological uncertainty for methods not assessed in the calibrations meta-analysis by Flo et al. 2019?
- Radial upscaling could be improved using species-specific, not wood type-specific, radial profiles.
- Raw data for allometric relationships between basal area and sapwood area not available in SAPFLUXNET.
- Incorporate these estimations in operative R code to enable better characterisation of uncertainty.

Challenges – tree to ecosystem upscaling

- Optimize Random Forest model training (hyperparameters, computing efficiency) within the data-driven size-dependent upscaling.
- Data inventories to augment sap flow datasets are not available in SAPFLUXNET.
- Compare different upscaling approaches with other transpiration products (e.g. T estimated from eddy flux data).