Drought monitoring and modelling: the case of 2022 in a mid-mountain forested catchment

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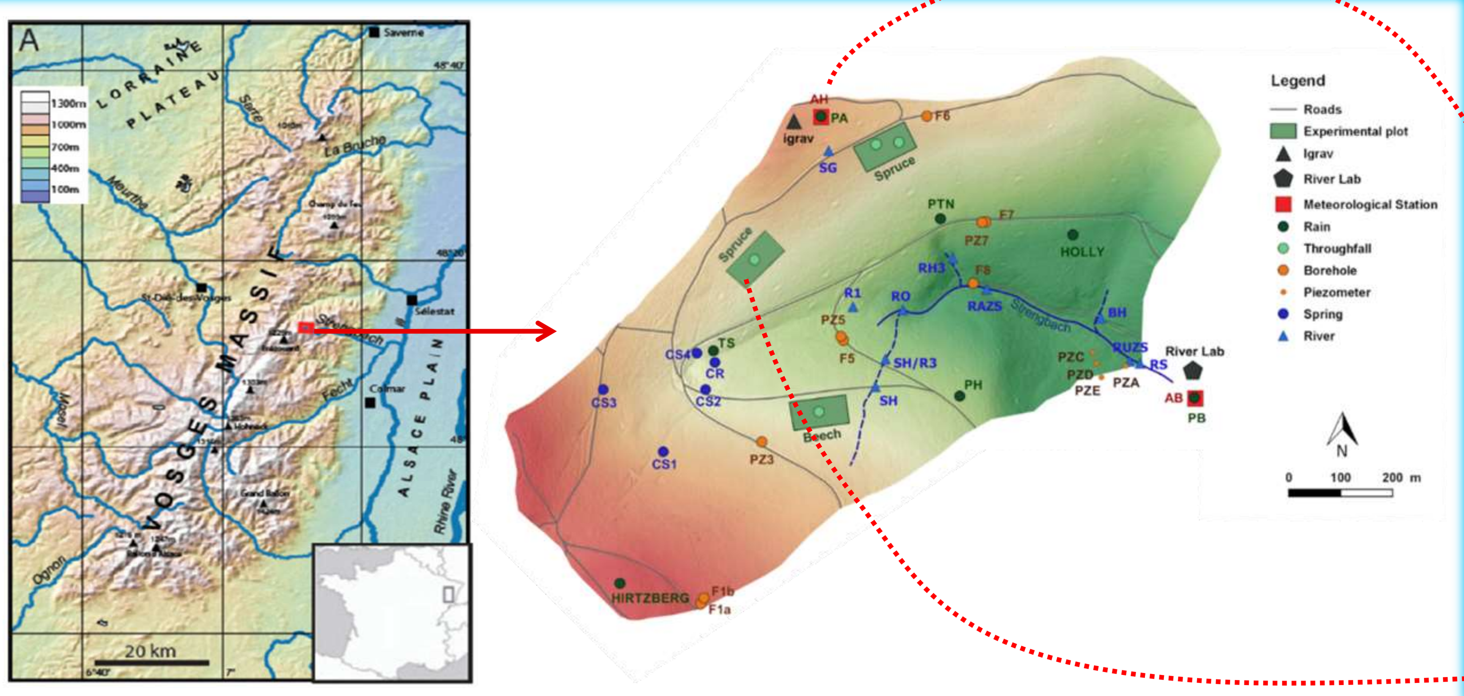
Introduction and objectives

The Strengbach catchment is a small **mid-mountain forested observatory** monitored since 1986 to characterize the amount and the chemistry of water coming from rainfall, throughfall, soil solutions, discharge of the main stream and sources. If the issue of forest dieback and its possible link with acid rain motivated the first observations, **forest vulnerability due to climate change** has become a major concern today. A recent work suggests that climate change, through its influence on vegetation, evaporation, and snow mantle dynamics can influence the catchment's hydrological behavior (more details [1]).

This poster briefly describes the catchment, the observed data and shows that periods of water stress are becoming increasingly frequent over the 35 years of chronicles. A weak point in the reliable estimation of water mass balances was the **poor characterization of evapotranspiration** over the watershed. Also, a **sap flow campaign** was carried out in **2022**. The results presented in this poster allow us to better characterize the consequences of **drought** and will serve to **constrain our soil-vegetation-atmosphere model** currently being developed.

Overview of the Strengbach catchment



This watershed belongs to the French and European networks of Critical Zone observatories

Brief description:

Name: Observatoire Hydro-Géochimique de l'Environnement (OHGE, http://ohge.unistra.fr)

Location: Vosges Mountains — Surface: 0.8 km^2

Altitudes: from 883 to 1146 m — Climate: mountainous-oceanic

Mean annual rainfall: 1400 mm — Average temperature: 6°C

Permanent sampling and measuring stations since 1986

Experimental stand: ALT: 1079 m; COORD: 48°12.963' N and 7°11.928' E

In-situ measurements: meteorology and vadose zone

Video with chapters

Meteorological station: T°, Rain, Wind, Rad. (freq: 10 min)

Estimation of PET with Penman model ←

Estimation of AET and REW with BILHDAY model ←

Inputs: rain, PET, vegetation and soil properties

Vadose zone monitoring devices

5 TDR sensors for water content

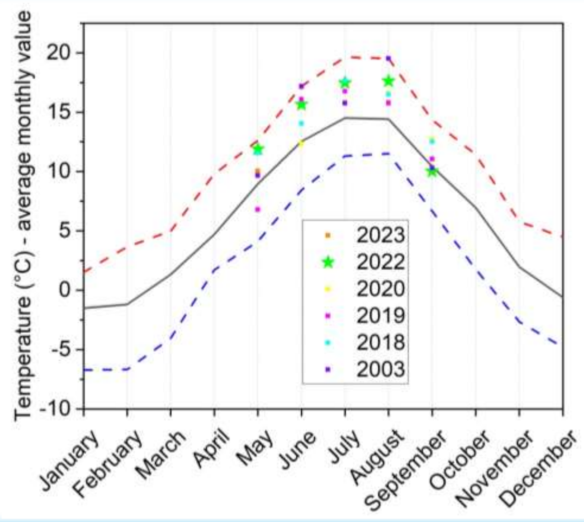
5 Watermark sensors for matric potential,

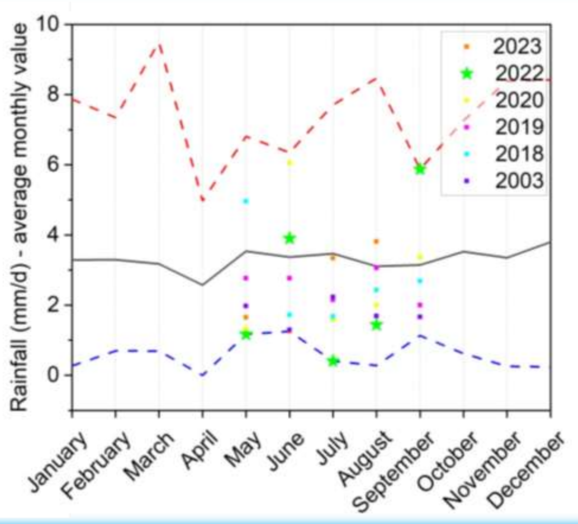
4 Campbell 107 probes for temperature

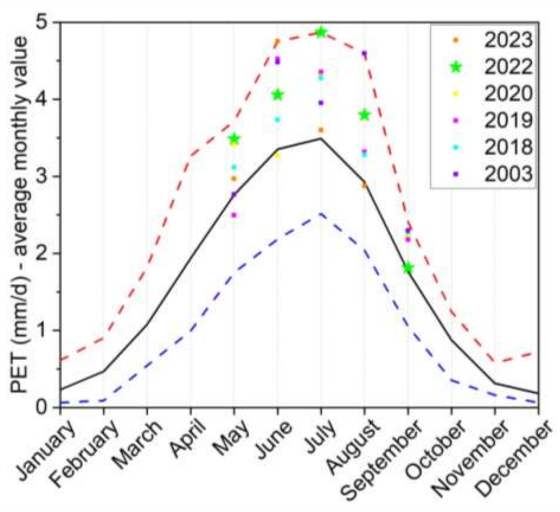
inserted at five different depths (10, 30, 50, 70, and 100 cm)

(Campbell Scientific® CR1000 datalogger / freq: 10 min)

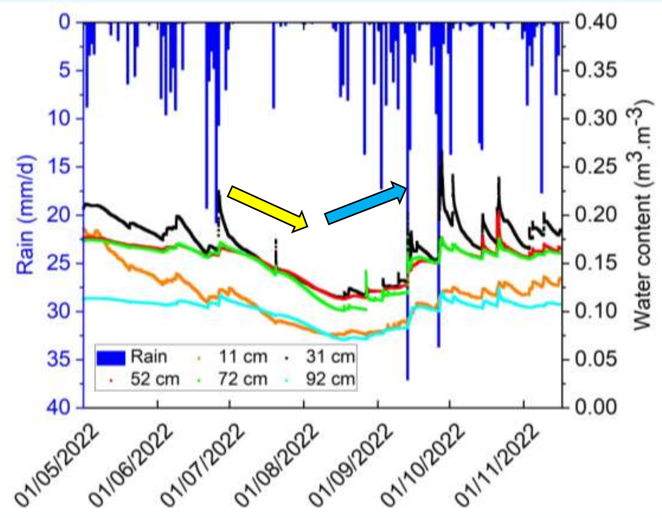
Treatment of daily measurements between 1/01/1987 and 31/08/2023







Focus on summer 2022



Conceptual modeling approach

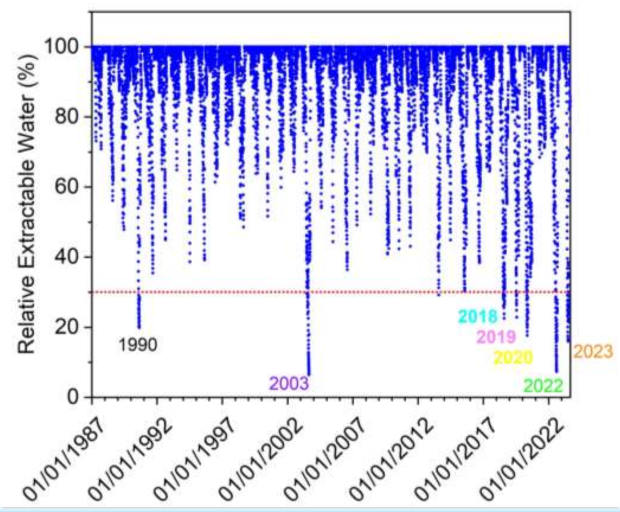
Relative extractable water

$$REW = \frac{\theta_d - \theta_{wp}}{\theta_{fc} - \theta_{wp}}$$

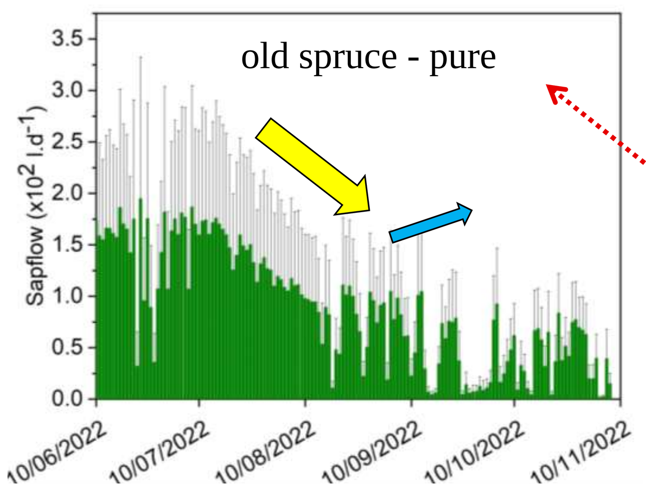
θ_d soil water content on a given day

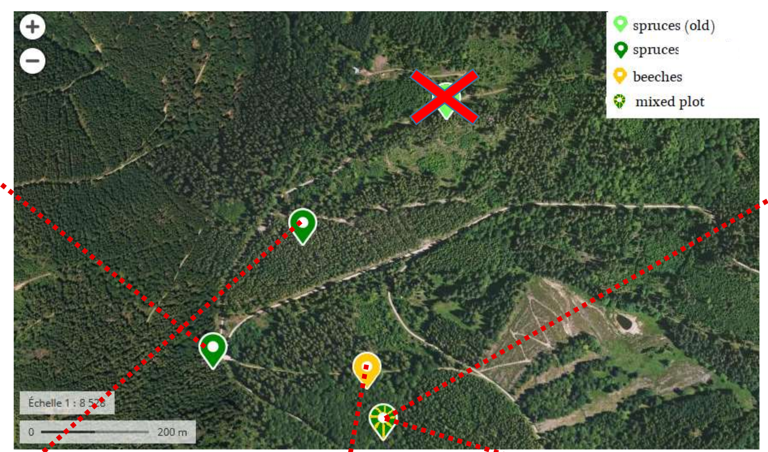
θ_{wp} soil water content observed at the permanent wilting point

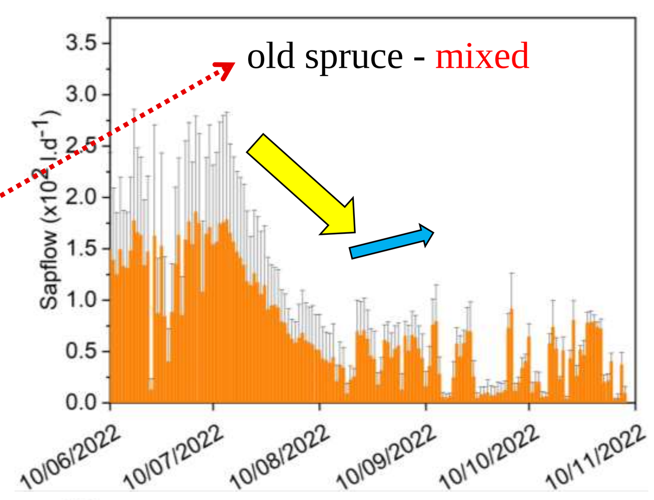
θ_{fc} soil water content observed at the field capacity

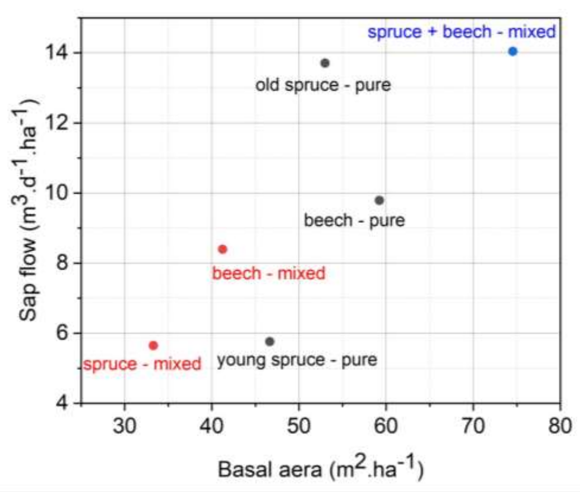


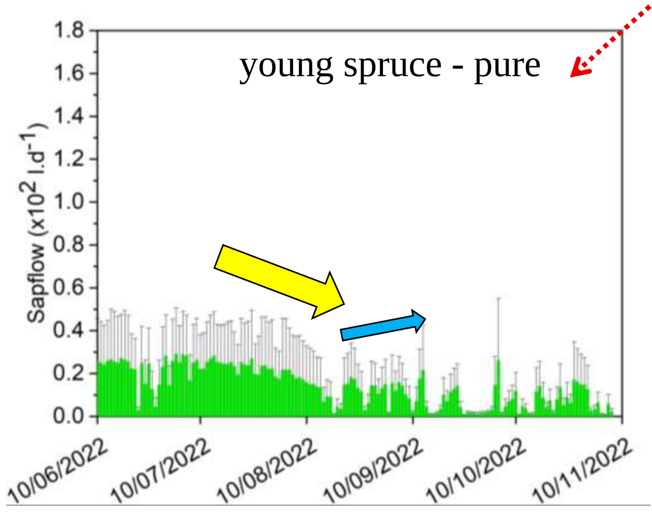
Results of the sap flow campaign 2022 (mean flux - per tree & plots– per day & period)

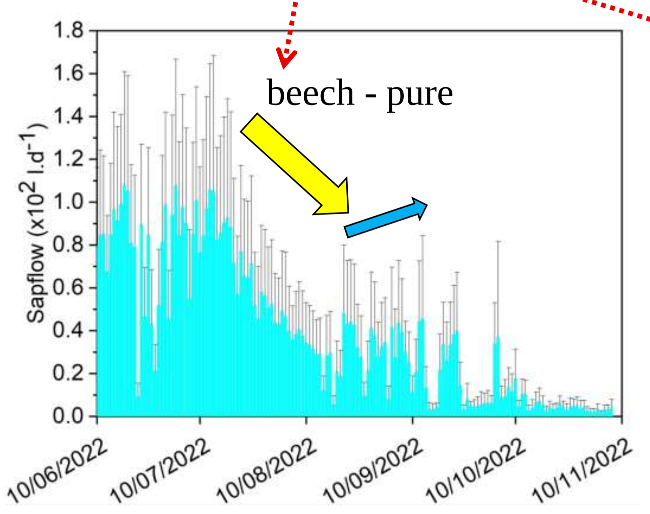


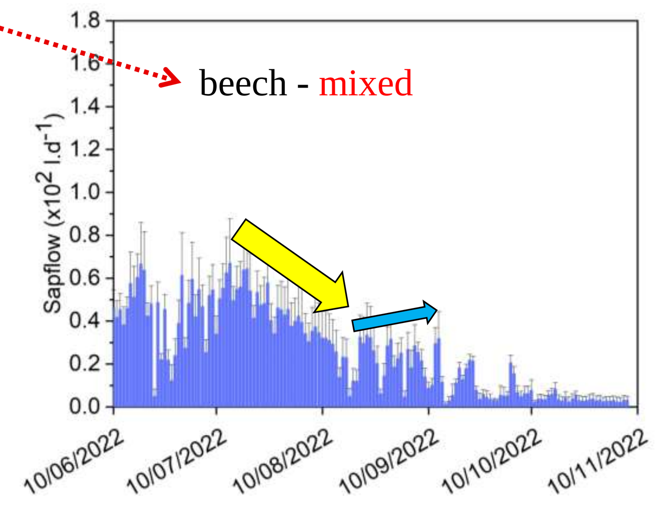




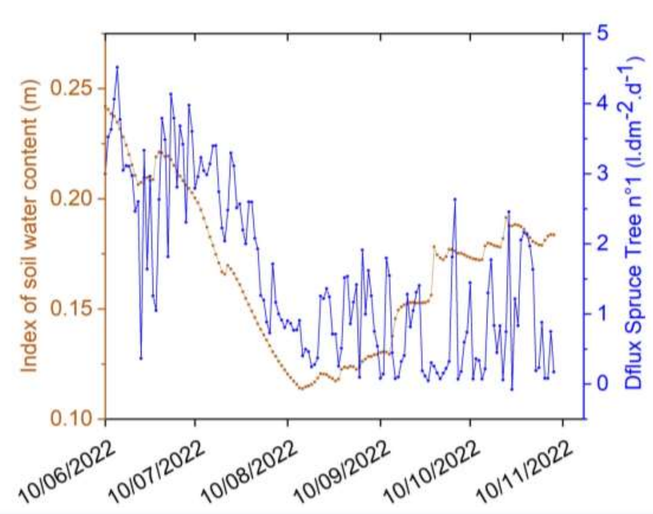


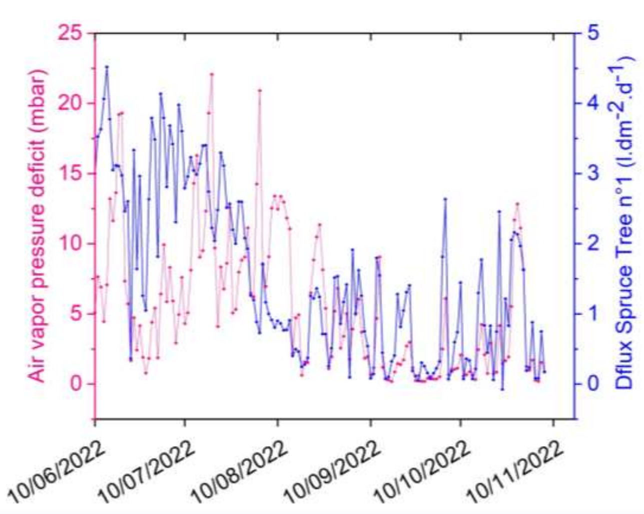


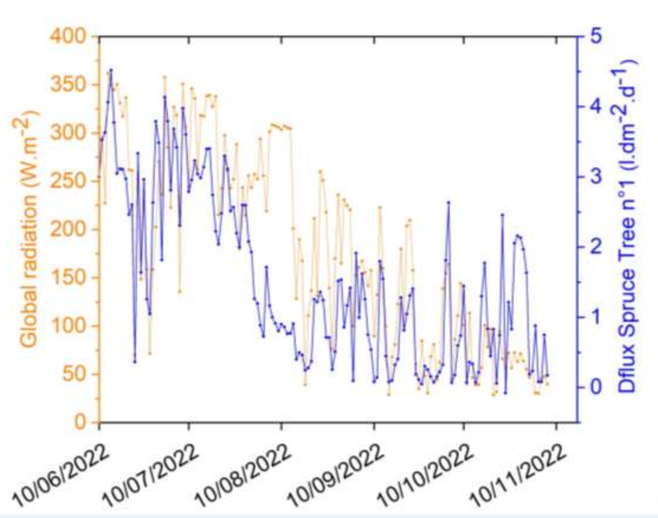


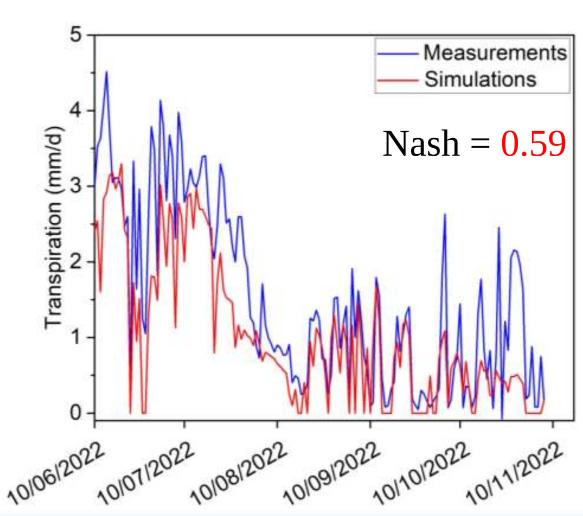


Correlation with Sapflow density	
Humidity (%)	-0,61
Rainfal (mm.d^{-1})	-0,32
Wind speed (m.s^{-1})	-0,16
Tsoil (°C)	0,39
ISWC (m)	0,54
Vapor pressure deficit (mbar)	0,53
Temperature (°C)	0,56
Solar radiation (W.m^{-2})	0,72
PET (mm.d^{-1})	0,72

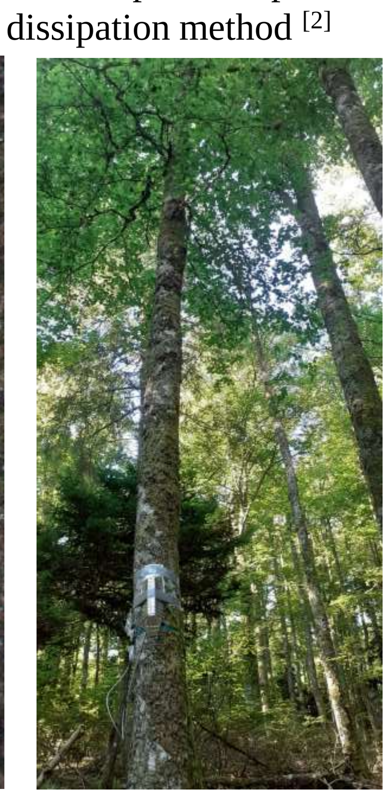








36 trees equipped (pure and mixed plots of spruce & beech trees) – thermal dissipation method [2]



Drought & bark beetle attack

→ old spruces stand decimated

Conclusion

28 trees were monitored with sap flow sensors – A high variability between trees of a given species is observed.

Transpiration is highly affected by drought period ⇨ Sap flux densities increase again with water availability and PET and solar radiation ⇨

Transpiration of spruce trees is greater than beech trees (with an influence of tree diameter)

Comparing wet and dry periods (mid-june vs end-july): transpiration loss is similar for both species in pure stands. For each species, transpiration loss is greater in the mixed stand than in the pure stands.

Characterizing in detail the abiotic factors that control tree transpiration is a complex task. Modeling transpiration throughout mechanical approach will be tricky but interesting !

References

[1] Strohmenger L., Ackerer P., Belfort B., & Pierret M. C. 2022. Local and seasonal climate change and its influence on the hydrological cycle in a mountainous forested catchment. Journal of Hydrology, 610, 127914.

[2] Lu P., Urban L., Zhao P. 2004. Granier's thermal dissipation probe (TDP) method for measuring sap flow in trees: theory and practice. Acta Botanica. 46.6: 631-646.

[3] Bonal D., et al. 2008. Impact of severe dry season on net ecosystem exchange in the Neotropical rainforest of French Guiana. Global Change Biology. 14.8: 1917-1933.

Acknowledgements

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