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Can agroforestry protect crops from cavitation / hydraulic failure ?

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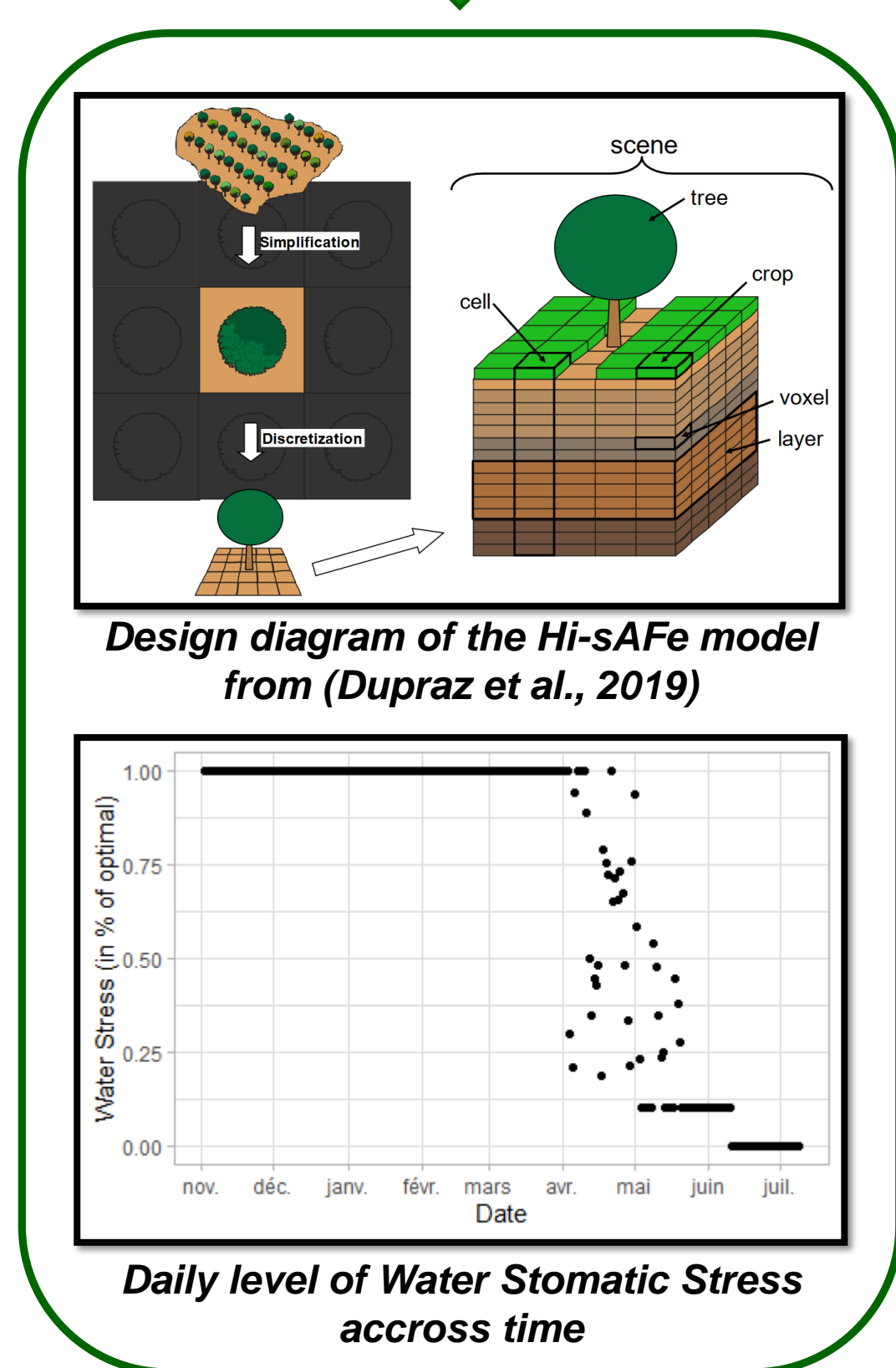
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Abstract: Agroforestry systems (AFS) are pushed as an adaptation solution of agrosystems against climate change (CC) (IPCC, 2022). Given the time constraint of tree growth, modelization and simulation are necessary. In this regard, the Hi-sAFe model (Dupraz et al., 2019) is one solution available. This model has been successfully used to assess the biophysical impact of CC on AFS (Reyes et al., 2021). However, by design, the Hi-sAFe model is not able to fully represent the physiology of plants (both crop and trees) under hydric stress and hydraulic failure situation. The SUREAU model (Cochard et al., 2021) is a mechanistic model focused on the hydraulic architecture of plants and the water resistance and water capacitances of their organs. Thanks to the SUREAU model, it is possible to represent, at plant scale, the hydraulic failure that can happen in situation of hydric stress. Here we propose a linkage of the Hi-sAFe model to the SUREAU to investigate the possibility to model hydraulic failure at plant level in agroforestry plot.

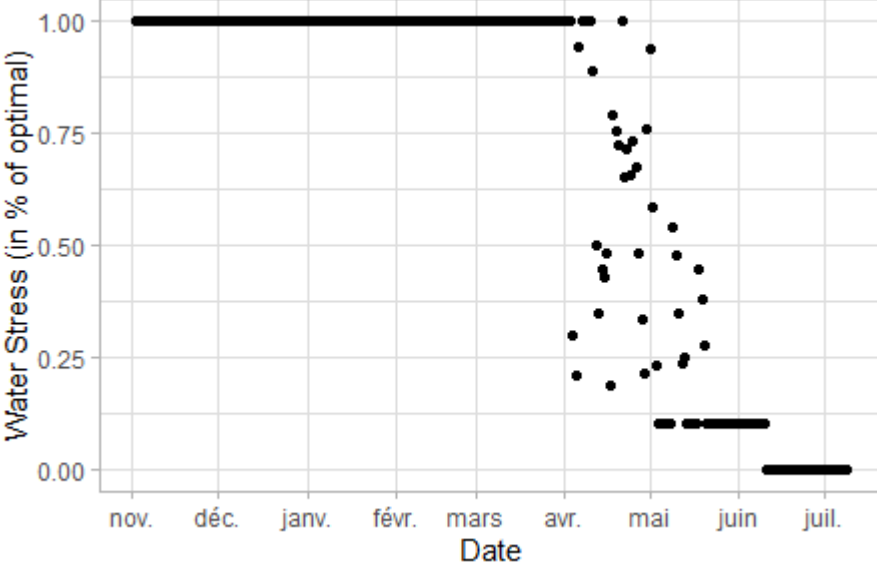
Keywords: Hi-sAFe Model; Hydraulic Failure; SUREAU Model



Example of French Agroforestry Alley-Cropping System (Credits : INRAE / Nicolas Bertrand)

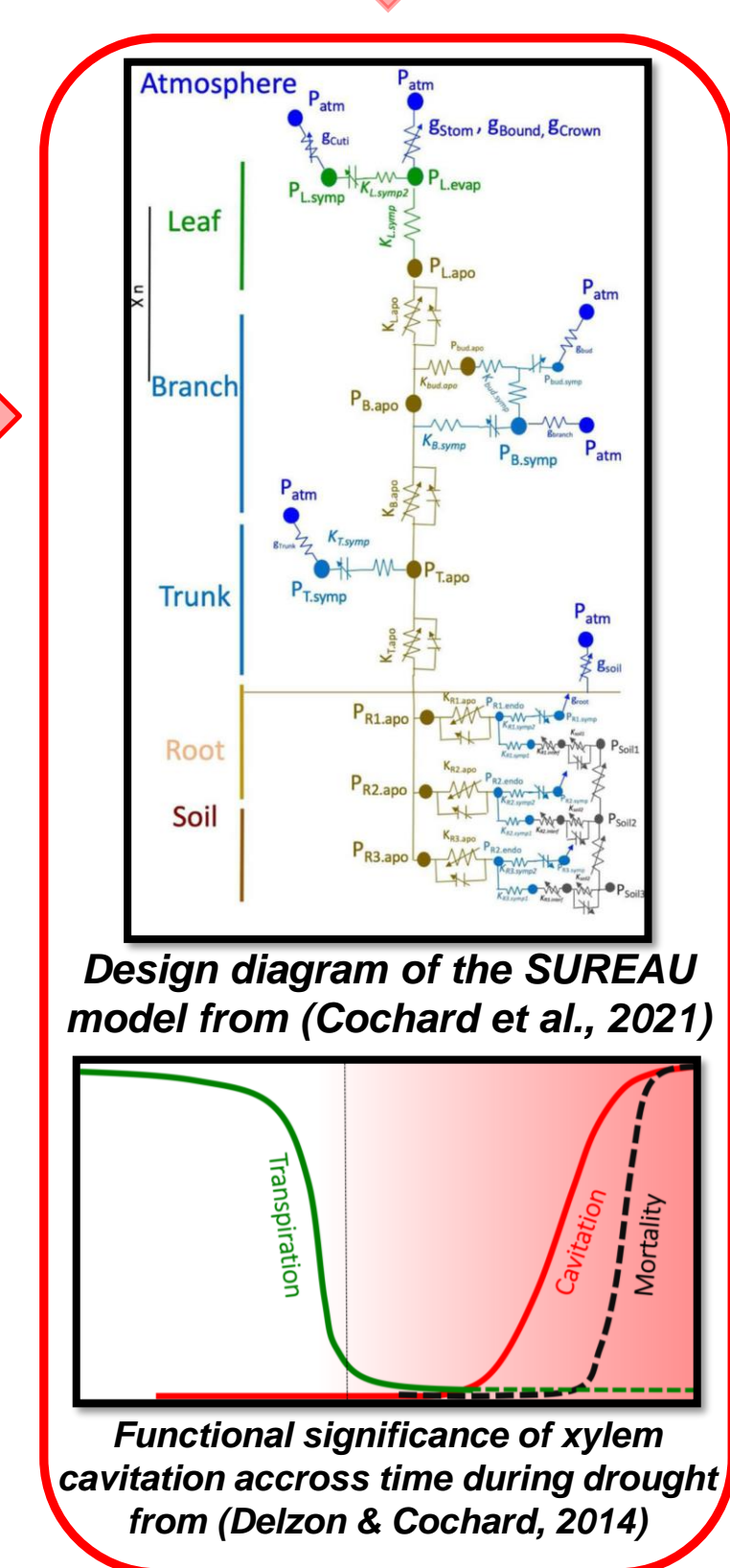


Design diagram of the Hi-sAFe model from (Dupraz et al., 2019)



Daily level of Water Stomatic Stress across time

Plot Scale



Design diagram of the SUREAU model from (Cochard et al., 2021)

Functional significance of xylem cavitation across time during drought from (Delzon & Cochard, 2014)

Individual Scale

Hypothesis: Water in Hi-sAFe represent Water through a calibrated abiotic bilinear function that represent stomatic closure effect. However :

- Reasons to believe that only stomatic stress & closure is not enough to represent physiology in Soft Wheat under drought (Corso et al., 2020)
- Reasons to believe there is a need to separate physiological response of crop between different organs for Soft Wheat (Johnson et al., 2018 ; Harrison Day et al., 2022)

There we present first approach to test :

- If AFS conditions can mitigate cavitation and/or embolia that happens on crops
- The extend and consequence of cavitation and/or embolia on yield component

Materials:

- The weather dataset and initial parameters used to operate hi-safe are those officially provided with the model and are based on the experimentation of plot A2 of the Restinclières site, Montpellier, France in a Mediterranean climate.
- Initial parameterization of SUREAU is provided alongside the model.

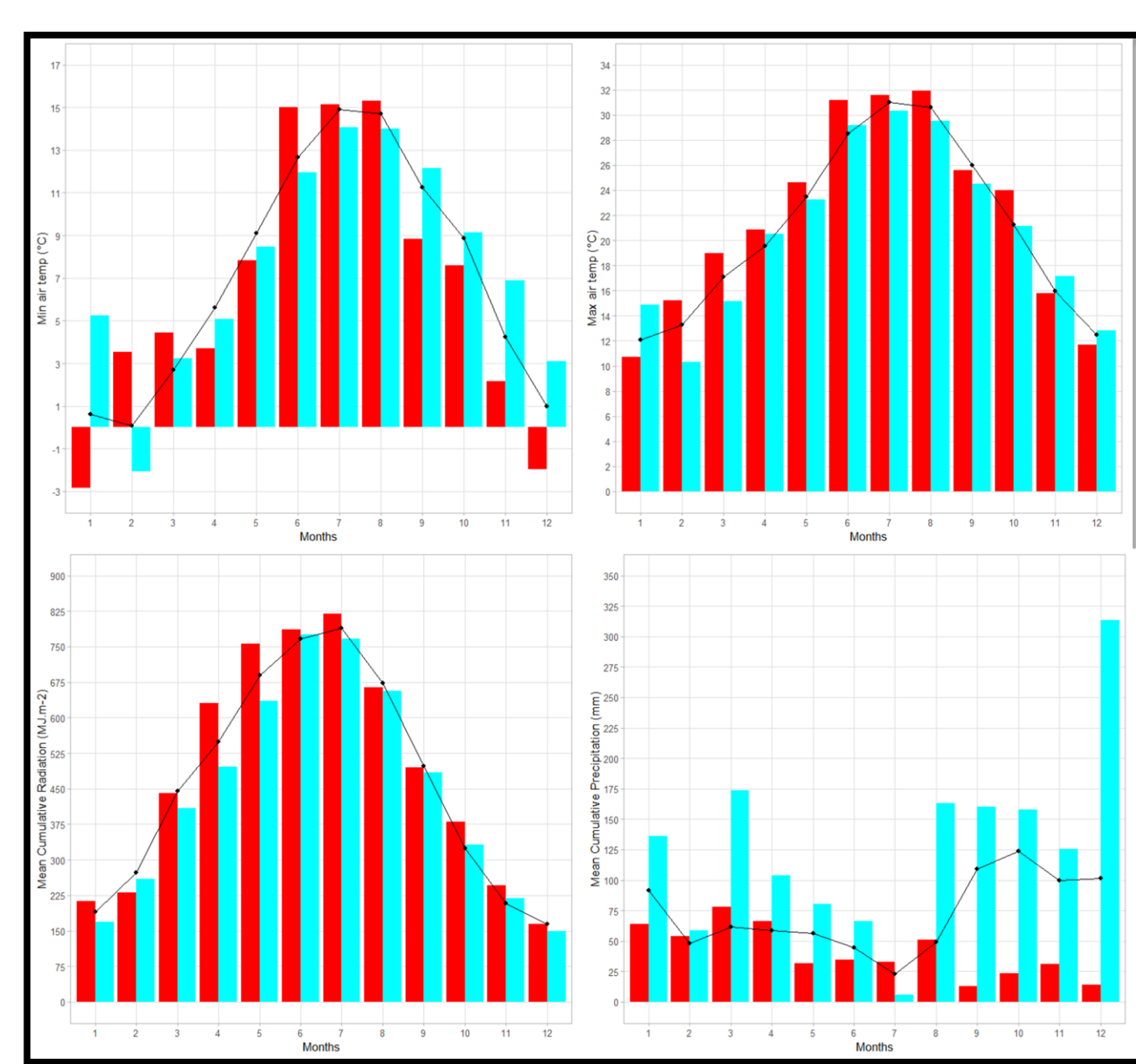
Methods:

For Hi-sAFe:

1. Computation of initial condition
2. Simulation of studied years
3. Extraction of results and initial condition

For SUREAU:

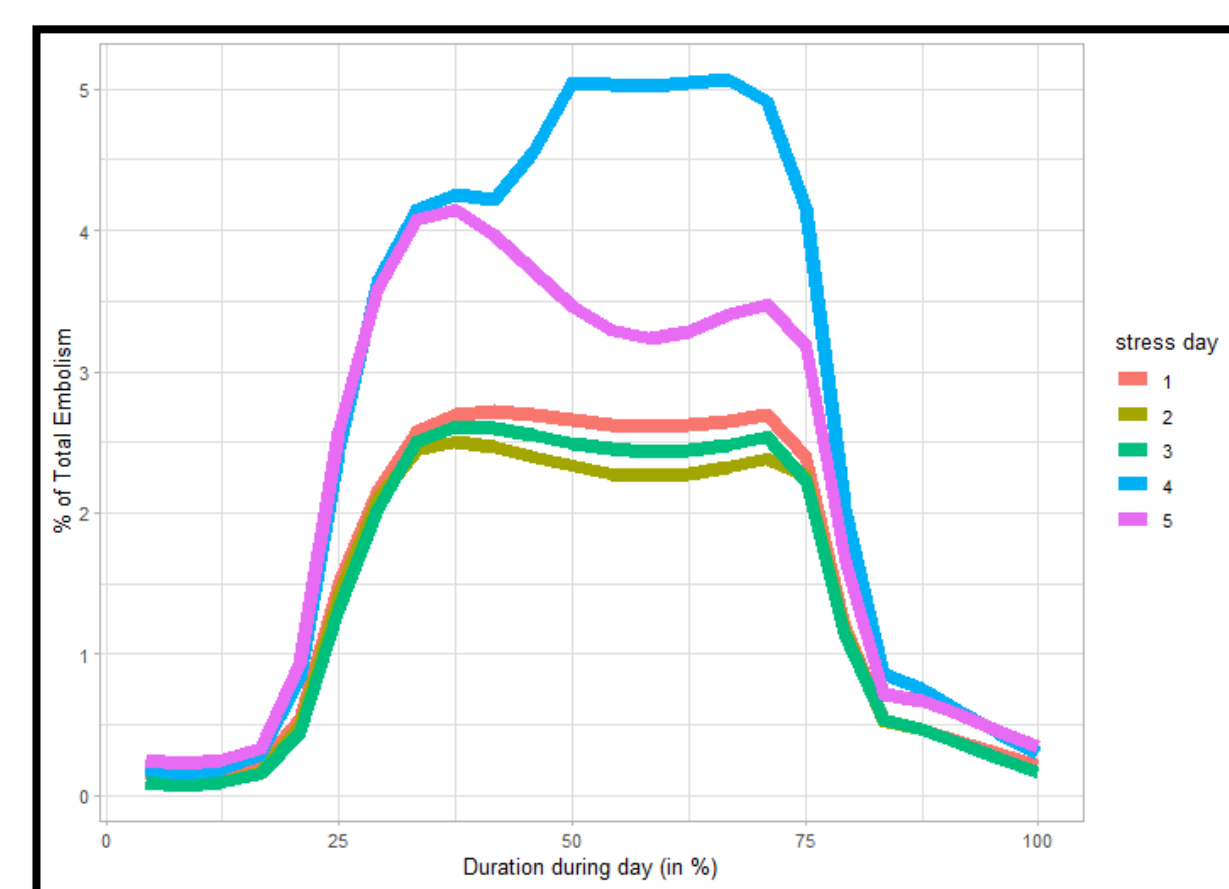
1. Formatting & Correction of inputs
2. Simulation for selected days
3. Extraction of results



Climatic data for the years modelled (red for dry year, cyan for wet year, line for average on dataset)

Year	Yield (t.ha-1)	Stress Index
dry year	max yield 3.43	0
	min yield 3.87	3.45
wet year	max yield 3.52	0
	min yield 4.68	2.50E-06

Hi-sAFe results & computation of Stress Index from (Reyes et al., 2021)



Embolism computation through day by SUREAU

Results:

- For Hi-sAFe: no stress was reported for the measure of max yield; only few days of stress were measured for min yield.
- For SUREAU: no embolism and other metrics of SUREAU to report.

Discussion:

Technical Issues:

- Need data field dataset OR better targeting campaigns with remarkable water stress
- Need additional calibration for the SUREAU modelling
- Need to correct inputs for SUREAU from Hi-sAFe

Limits to the current approach:

- SUREAU model is designed for trees architecture. Adaptation to wheat architecture instead of trees is required
- Bias of the Hi-sAFe / SUREAU model combining approach : Information transfer from Plot scale to Individual scale needs assumption and can be source of errors

Conclusion:

- Was not able to validate or invalidate both initial hypothesis

Perspective:

- Given the results of supplementary preliminary works, either hypothesis could be validated, but the full extent needs to be assessed later
- Future propositions, if the hypothesis is validated, could improve understanding microclimatic effect of AFS on crop water-related physiology
- If results prove to be correct, further improvement in the computation of water stress on the crop in STICS could be imagined

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