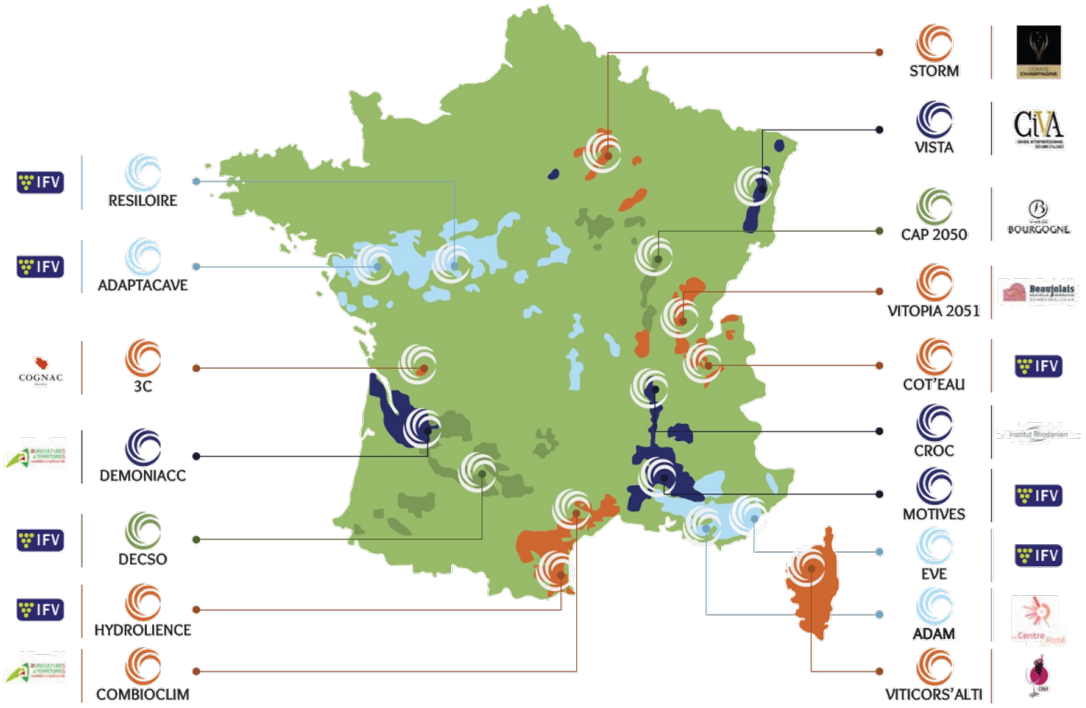
XIVth STICS seminar, 17-19 March 2026, organized by ULiege-GxABT & INRAE

Evaluating the STICS model for simulating grapevine development and new formalisms across contrasting soil types at a local scale in Saint-Émilion – **Preliminary results**

Authors : Martin Pardon, Nathalie Ollat, Clément Saint-Cast, Cornelis van Leeuwen, Loïc Strullu, Iñaki Garcia de Cortázar Atauri, Jean-Pascal Goutouly, Sébastien Zito and Laure de Rességuier

Vitilience project

Network of 17 demonstrators



- **Mobilize** stakeholders in the wine sector around concrete solutions to accelerate their adoption ;

- **Develop** new methods, organizational approaches, and solutions to move toward more climate-resilient systems ;

- **Co-create and experiment** with these solutions according to the specificities of each wine-growing region ;

- **Share solutions** and raise awareness among winegrowers

Vitilience project

Agro-eco-climatic projections

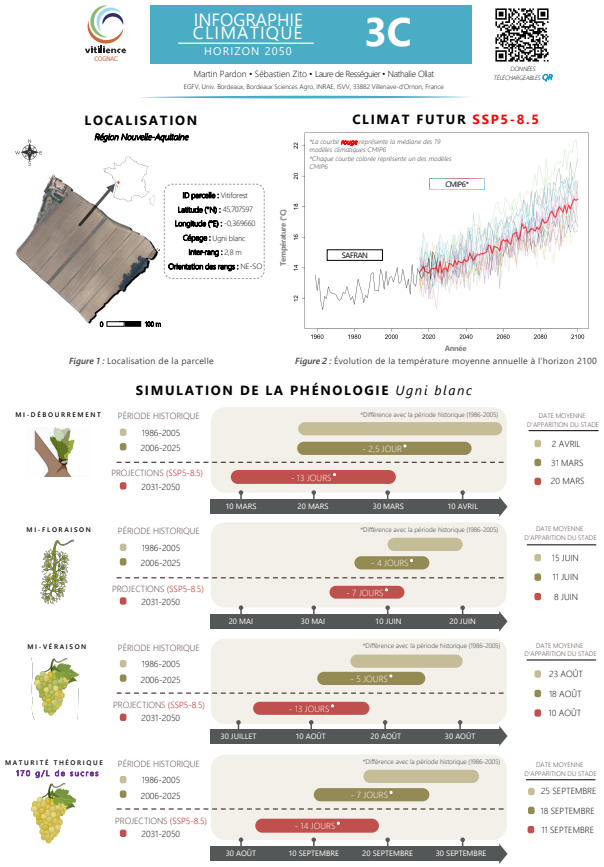
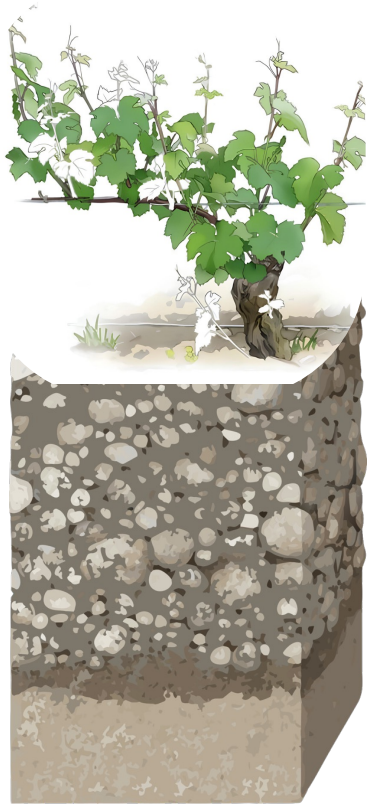


Figure 1 : Localisation de la parcelle

Figure 2 : Évolution de la température moyenne annuelle à l'horizon 2100

- Phenological modeling
- Ecoclimatic indicators
- Water balance

System Modeling



- Vineyard Management
- Varietal choice
- Lever Combinations
- Mid-term projections (2050)

Objectives

Influence of Climate, Soil, and Cultivar on Terroir

Cornelis van Leeuwen,[1,2]* Philippe Friant,[1] Xavier Choné,[1,2]
Olivier Tregoat,[1,2] Stephanos Koundouras,[2] and Denis Dubourdieu[2]

Abstract: The three main components of terroir—soil, climate, and cultivar—were studied simultaneously. Vine development and berry composition of nonirrigated *Vitis vinifera* L. cv. Merlot, Cabernet franc, and Cabernet Sauvignon were compared on a gravelly soil, a soil with a heavy clay subsoil, and a sandy soil with a water table within the reach of the roots. The influence of climate was assessed with year-to-year variations of maximum and minimum temperatures, degree days (base of 10°C), sunshine hours, ET_o, rainfall, and water balance for the period 1996 to 2000. The effects of climate, soil, and cultivar were found to be highly significant with regard to vine behavior and berry composition (an example being anthocyanin concentration). The impacts of climate and soil were greater than that of cultivar. Many of the variables correlated with the intensity of vine water stress. It is likely that the effects of climate and soil on fruit quality are mediated through their influence on vine water status.

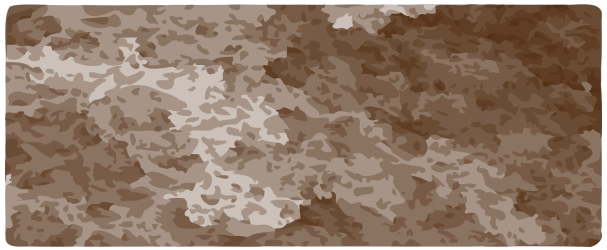
Key words: terroir, soil, climate, cultivar, vine, water deficit

DOI:10.5344/ajev.2004.55.3.207

- **Use** STICS on a multi-year dataset from Saint-Émilion (from 2003 to 2016)
- **Retrieve** the same conclusion (*van Leeuwen et al. 2004)*
- **Explore** new options or formalisms
- **Identify** some limits
- **Guide** methodology and objectives for future STICS use in the context of Vitilience project

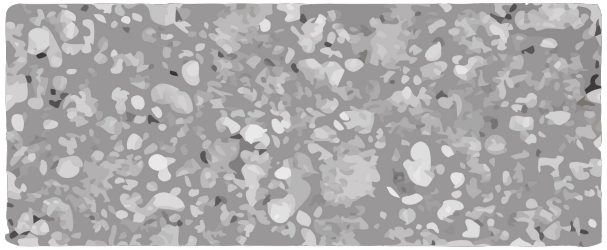
Saint-Émilion Dataset

Clayey - Albaquic Hapludalf



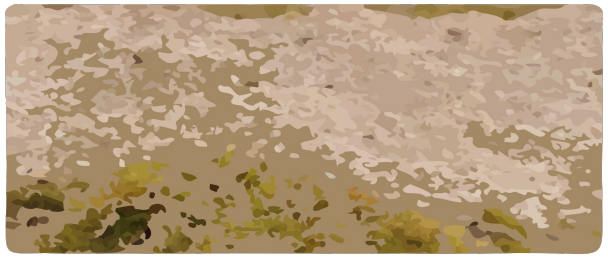
A

Gravelly - Arenic Eutrudept



G

Sandy - Typic Psammaquent



S

Merlot (clone 181)

PlantGrape

Cabernet franc (clone 326)

PlantGrape

Grafted onto **3309C** rootstock

Characteristics

- 6000 vines per hectare
- 1.2 m x 1.4 m (vine x row spacing)
- North-south row orientation
- Simple - Guyot pruned

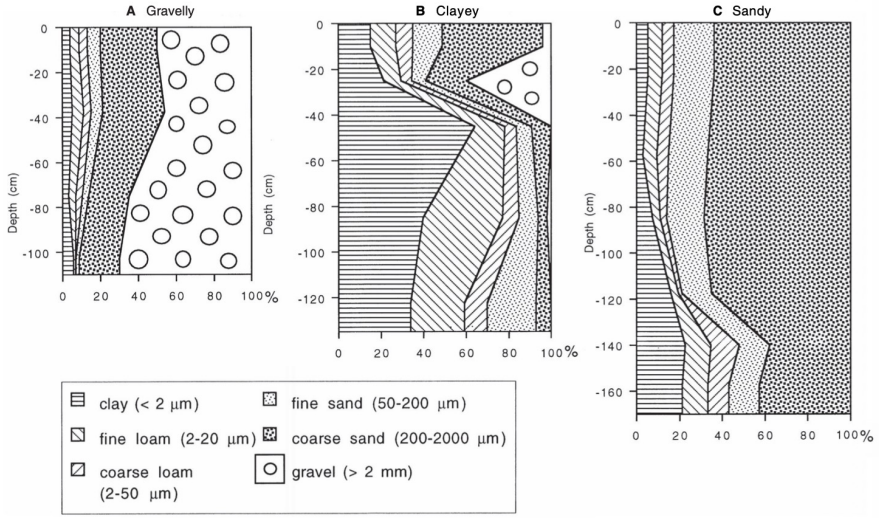
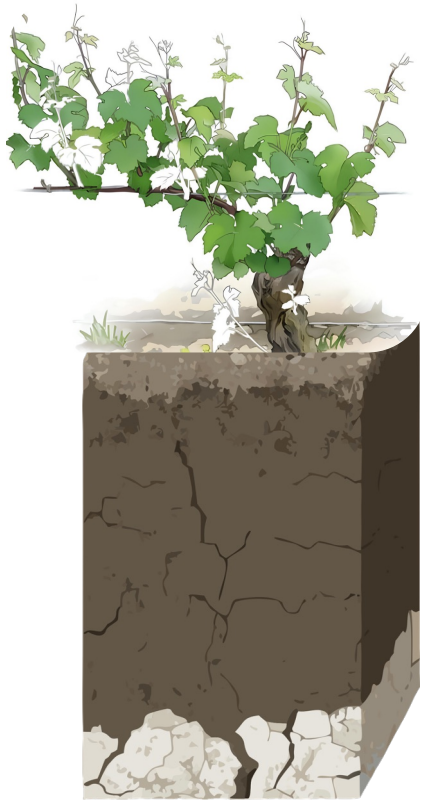


Figure 1 Percentage of clay, loam, sand, and gravel in the root zone of (**A**) gravelly soil, (**B**) clayey soil, and (**C**) sandy soil.

van Leeuwen et al. 2004



A

+

Characteristics

- 6000 vines per hectare
- 1.2 m x 1.4 m (vine x row spacing)
- North-south row orientation
- Simple - Guyot pruned

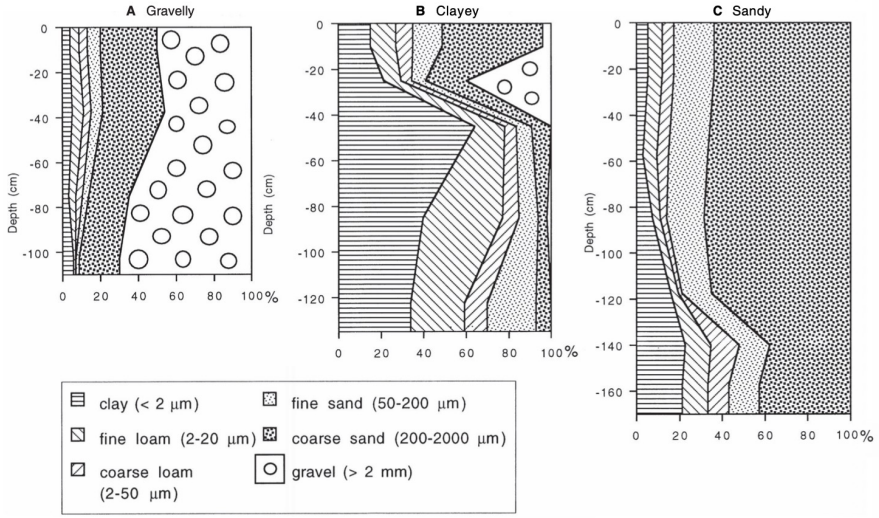
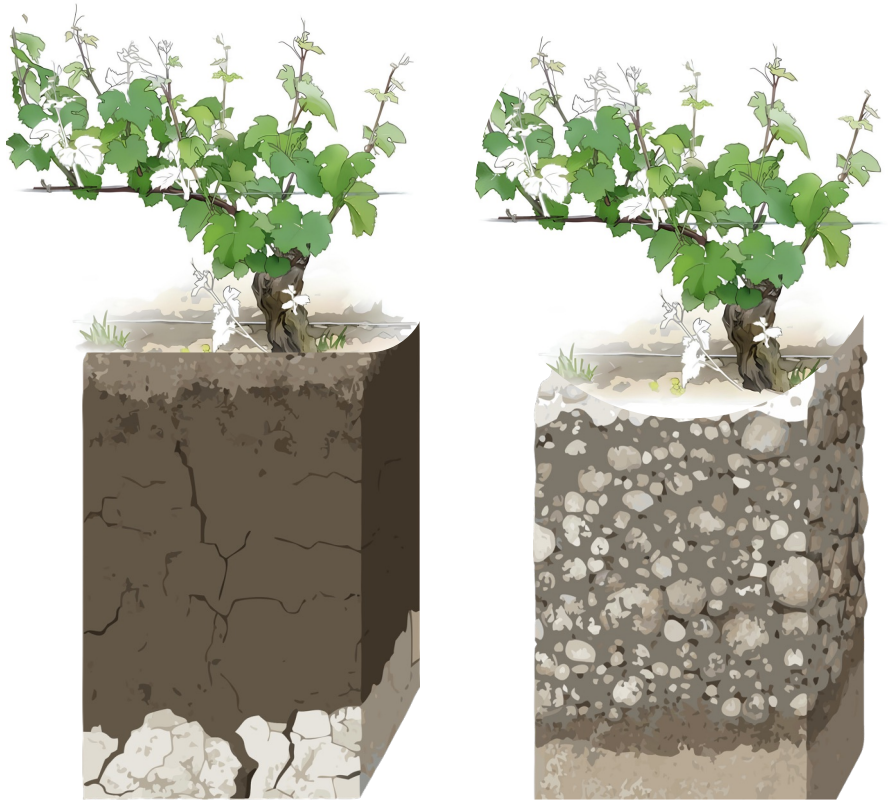


Figure 1 Percentage of clay, loam, sand, and gravel in the root zone of (**A**) gravelly soil, (**B**) clayey soil, and (**C**) sandy soil.

van Leeuwen et al. 2004



A

+

G

-

Characteristics

- 6000 vines per hectare
- 1.2 m x 1.4 m (vine x row spacing)
- North-south row orientation
- Simple - Guyot pruned

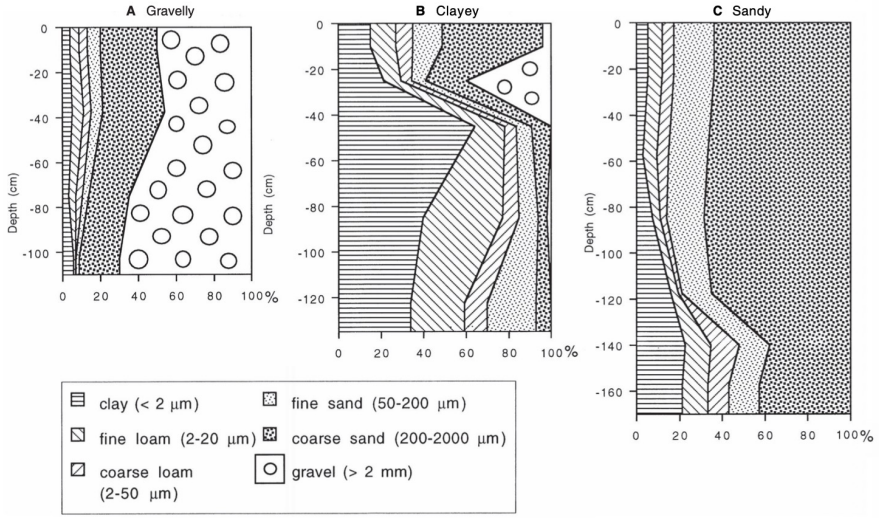
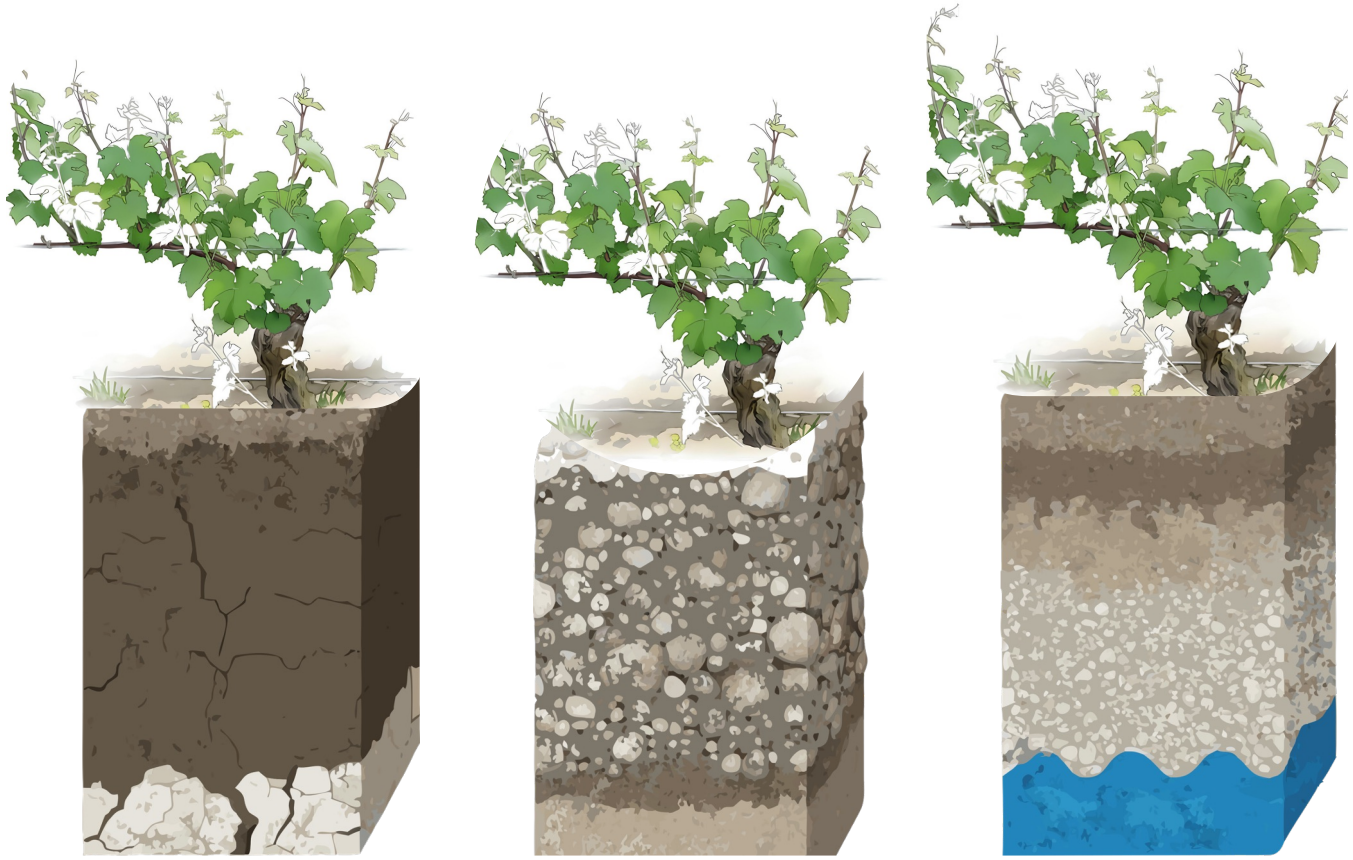


Figure 1 Percentage of clay, loam, sand, and gravel in the root zone of (**A**) gravelly soil, (**B**) clayey soil, and (**C**) sandy soil.

van Leeuwen et al. 2004



A

+

G

-

S

+++

Measurements / Observations

STICS	Definition	Unit
psibase	predawn leaf water potential	MPa

A — n = **82** / 2004 à 2016

G — n = **58** / 2004 à 2013

S — n = **75** / 2004 à 2015

Measurements taken every two weeks from ~3 weeks after **flowering until harvest**.

Measurements / Observations

STICS	Definition	Unit
psibase	predawn leaf water potential	MPa
lai(n)	Leaf area index	m^2/m^2

Total leaf area per vine was determined for each year just before harvest

Leaf area measured using a **planimeter**

Measurements / Observations

STICS	Definition	Unit
psibase	predawn leaf water potential	MPa
lai(n)	Leaf area index	m^2/m^2
pdsfruitfrais	weight of fresh fruits	$t.ha^{-1}$

Measurements / Observations

STICS	Definition	Unit
psibase	predawn leaf water potential	MPa
lai(n)	Leaf area index	m^2/m^2
pdsfruitfrais	weight of fresh fruits	$t.ha^{-1}$
ilevs	Date of emergence	julian day
iflos	Date of flowering	julian day
ilaxs	Date of lax stage (leaf index maximum)	julian day
irecs	Date of harvest	julian day



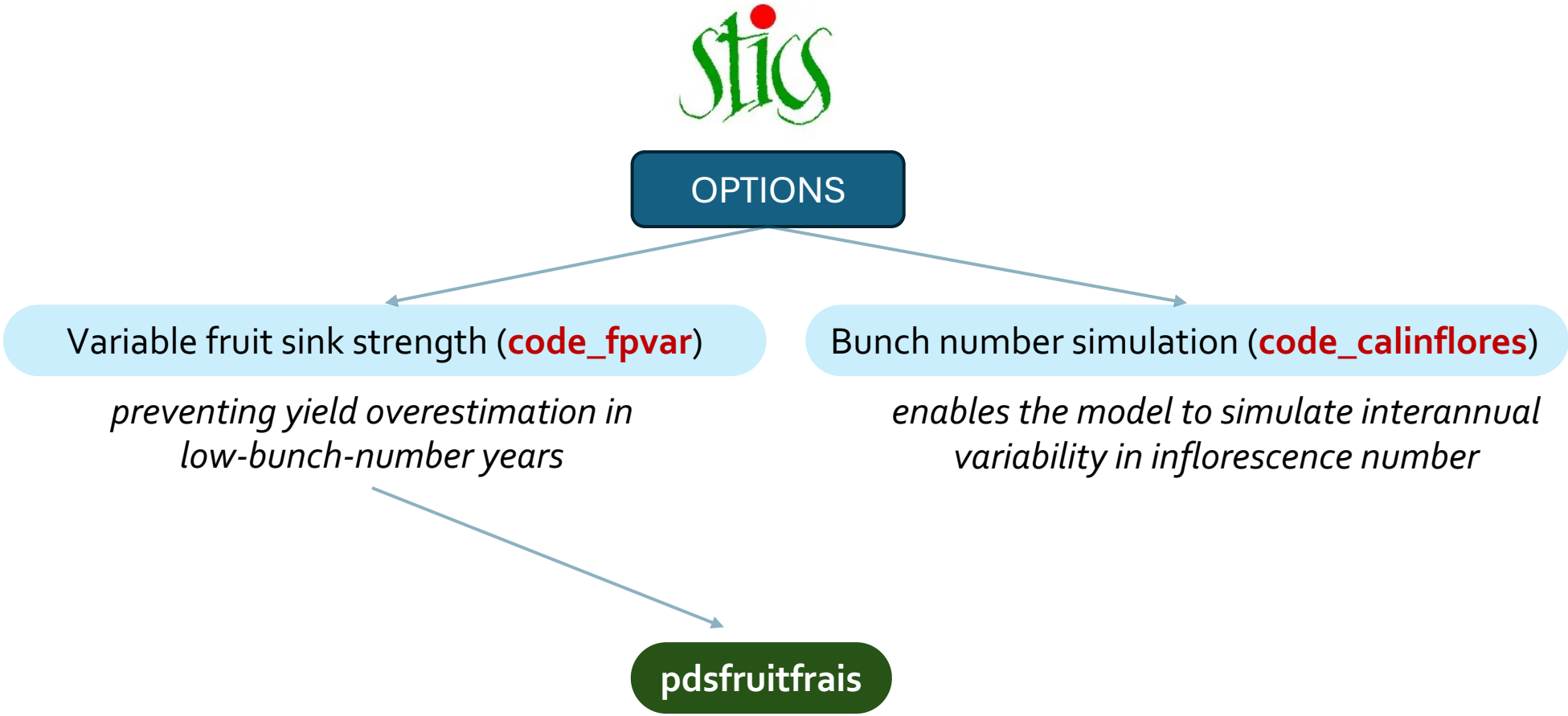

Measurements / Observations

STICS	Definition	Unit
psibase	predawn leaf water potential	MPa
lai(n)	Leaf area index	m^2/m^2
pdsfruitfrais	weight of fresh fruits	$t.ha^{-1}$
ilevs	Date of emergence	julian day
iflos	Date of flowering	julian day
ilaxs	Date of lax stage (leaf index maximum)	julian day
irecs	Date of harvest	julian day

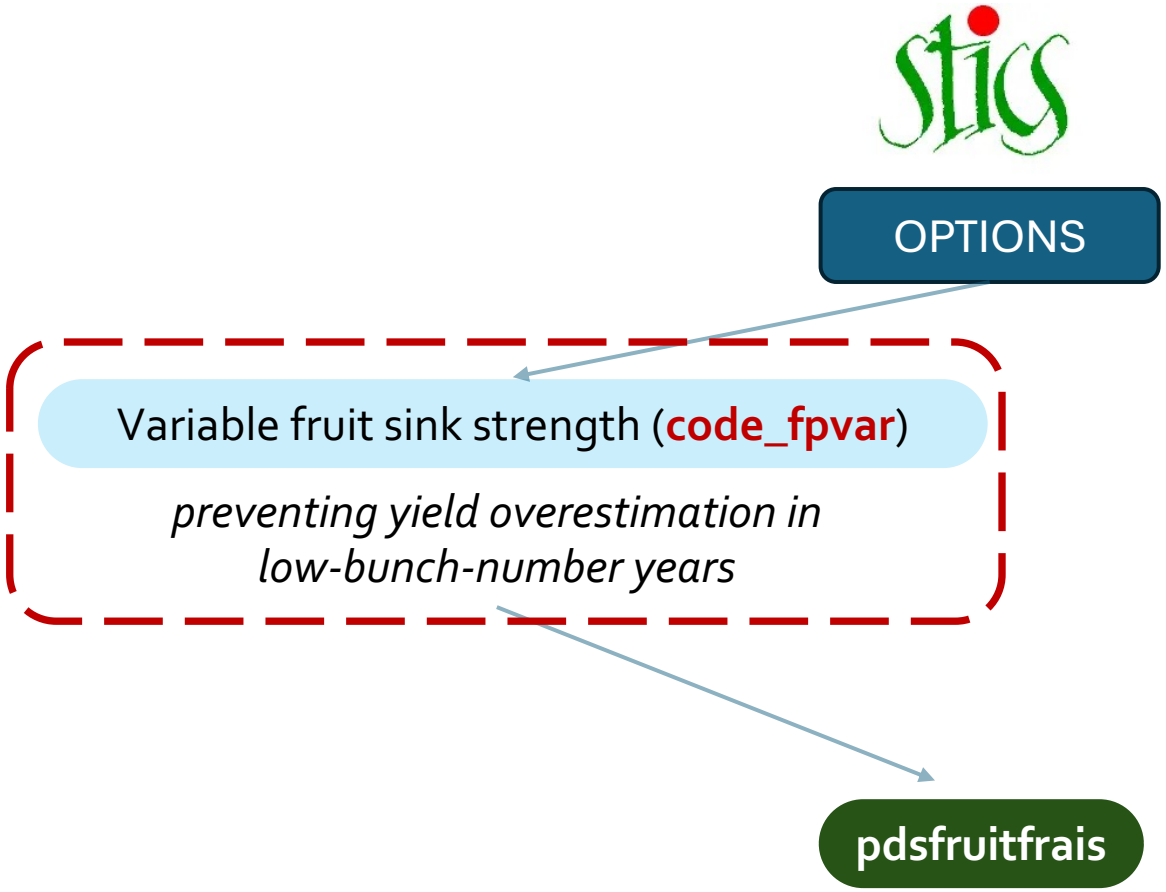
STICS v10.4.1

development branch

STICS development version



STICS development version



Nbinflo imposed number of inflorescences per plant

$pf\max = P\_pgrainmaxi$

Previous : constant sink strength (fewer number of inflorescences led to **overly large berries)**

$$pfmax = pfmax \,.\, \frac{P\_nbinflo}{P\_inflomax}$$

New : sink strength scaled by number of inflorescences = **realistic berry size**

better capturing interannual yield variability

Adjustment

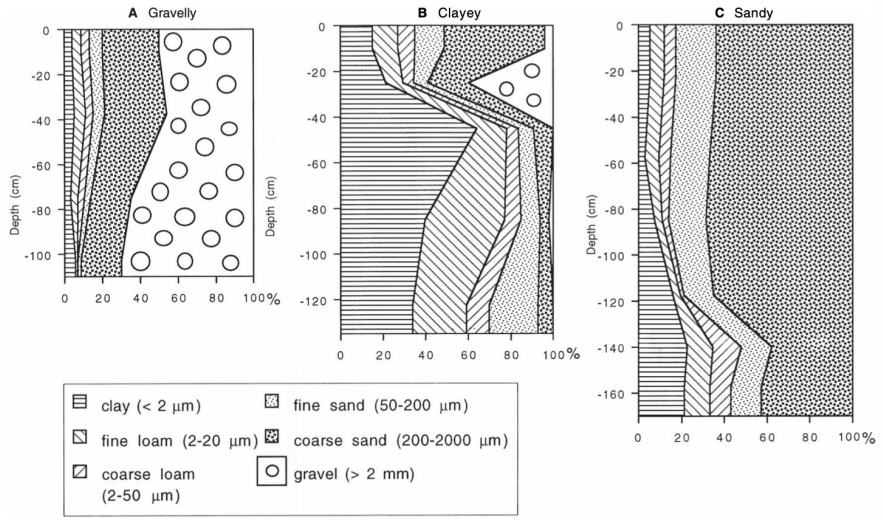
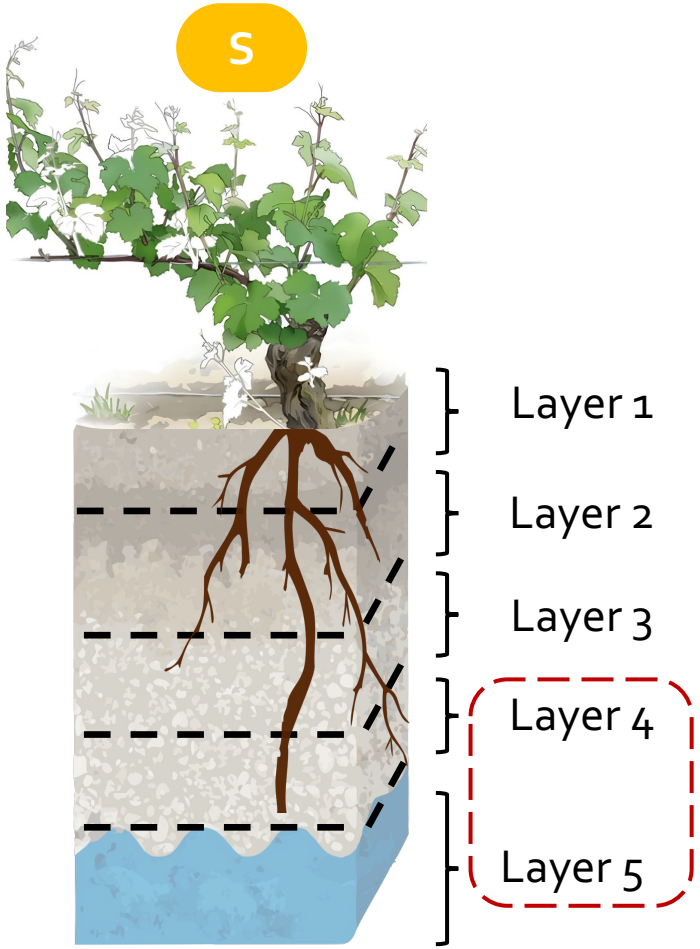


Figure 1 Percentage of clay, loam, sand, and gravel in the root zone of (**A**) gravelly soil, (**B**) clayey soil, and (**C**) sandy soil.

van Leeuwen et al. 2004



Ensures that the model reflects unlimited available water throughout the growing season

HCCF*

gravimetric water content at field capacity

HMINF*

gravimetric water content at witling point

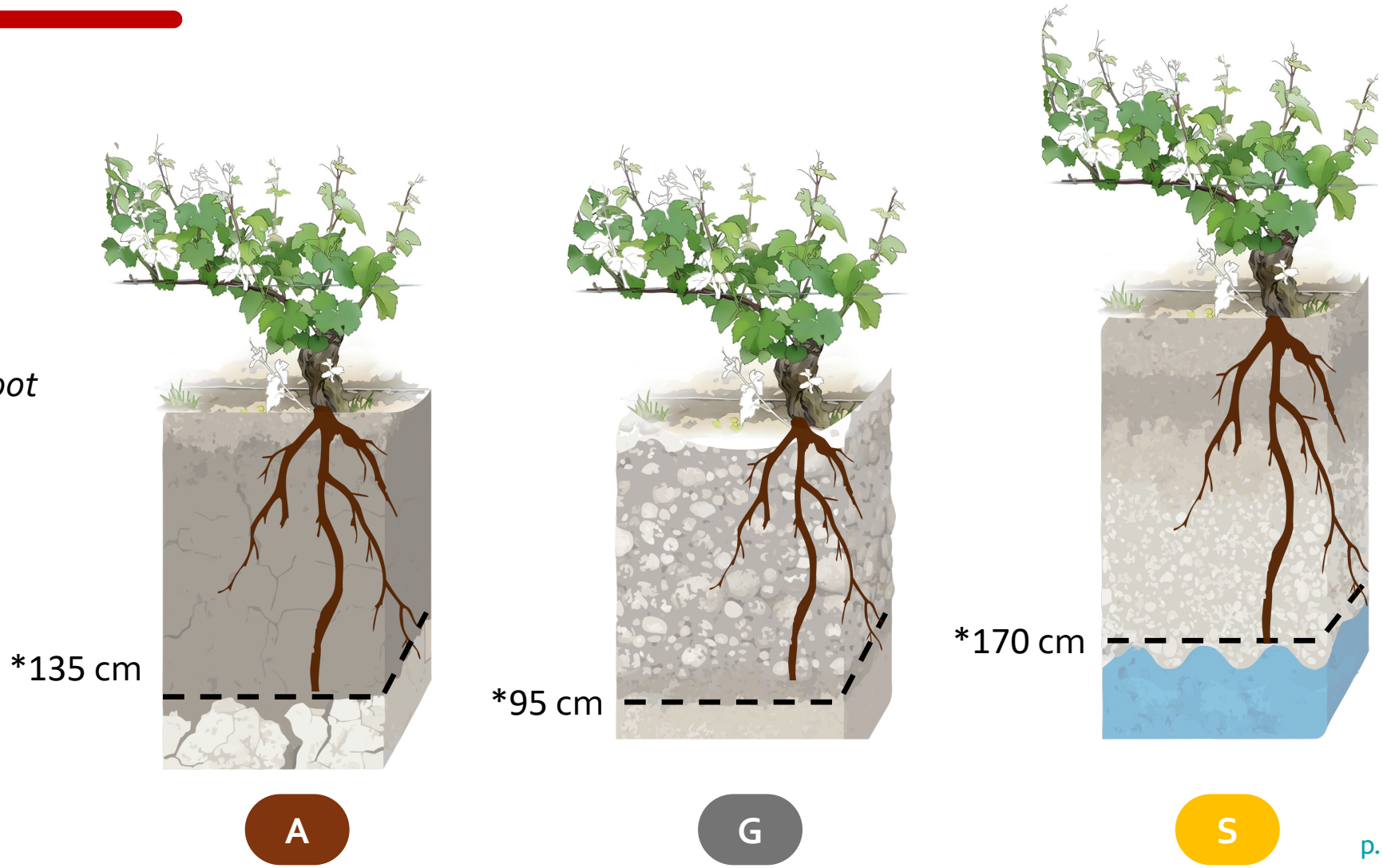
Parametrization

- From **observations data**
- **literature**
- **optimization**

Parametrization

- From **observations data**
- **literature**
- **optimization**

obstarac* : *soil depth at which root growth is stopped due to physical constraints (cm)*



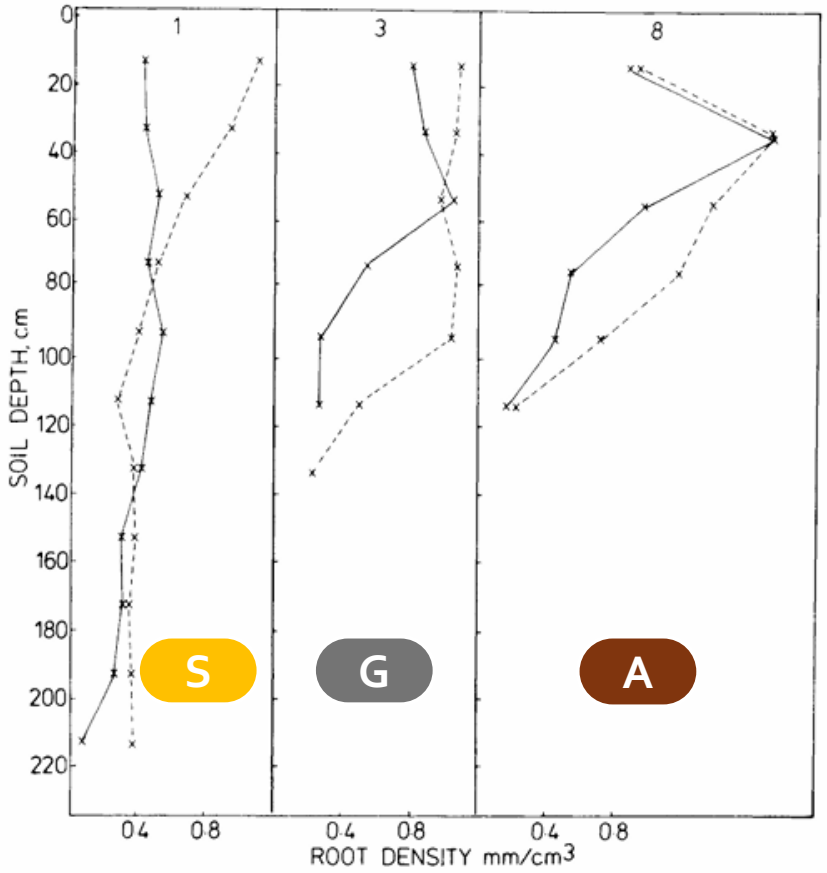
Parametrization - psibase

$$\Psi_{base} = \sum_{couche} \frac{\left(d_{racinaire(i)} \times \Psi_{sol(i)}\right)}{\sum d_{racinaire}} , \qquad avec\ \Psi_{sol} > pFp$$

Parametrization - psibase

$$\Psi_{base} = \sum_{couche} \frac{\left(d_{racinaire(i)} \times \Psi_{sol(i)}\right)}{\sum d_{racinaire}}, \qquad avec\ \Psi_{sol} > pFp$$

1 Literature



Nagarajah (1987)

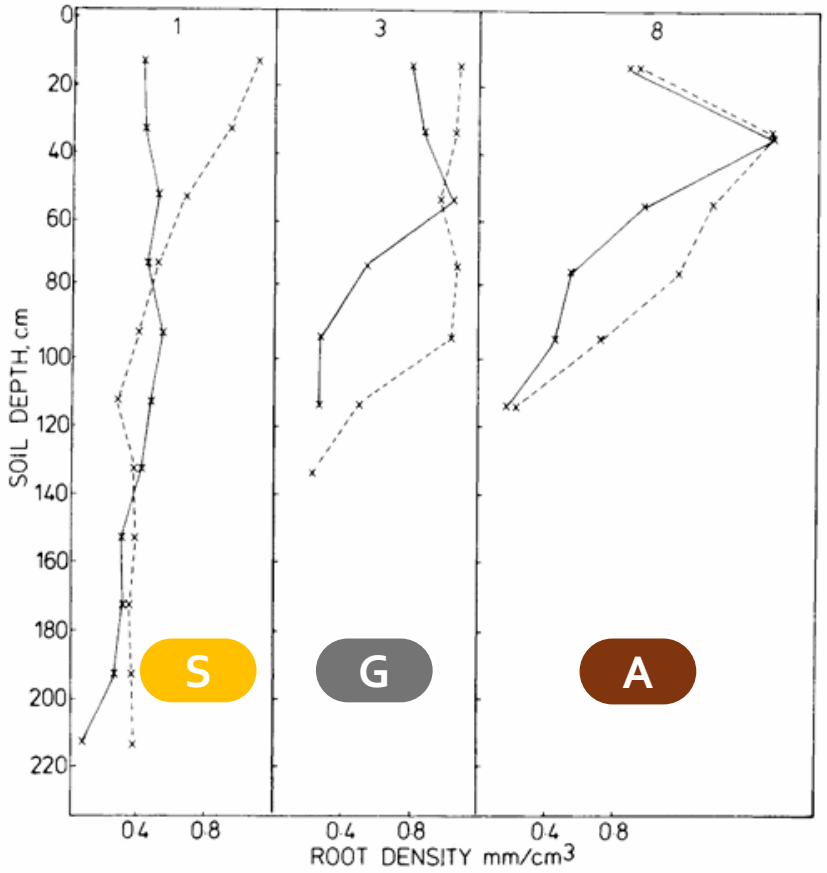
Fig. 2. Root density of Thompson Seedless vines on own roots (_) or on Ramsey rootstock (_ _) with soil depth and at 30 cm from the vine trunk. 1 - coarse soil, 3 - moderately coarse soil, and 8 - fine soil.

DOI: 10.5344/ajev.1987.38.1.54

Parametrization - psibase

$$\Psi_{base} = \sum_{couche} \frac{\left(d_{racinaire(i)} \times \Psi_{sol(i)}\right)}{\sum d_{racinaire}}, \qquad avec\ \Psi_{sol} > pFp$$

1 Literature



Nagarajah (1987)

Fig. 2. Root density of Thompson Seedless vines on own roots (_) or on Ramsey rootstock (_ _) with soil depth and at 30 cm from the vine trunk. 1 - coarse soil, 3 - moderately coarse soil, and 8 - fine soil.

2 Optimization

Assimilation des caractéristiques du sytème sol-racines par simulation du potentiel de base en parcelle viticole

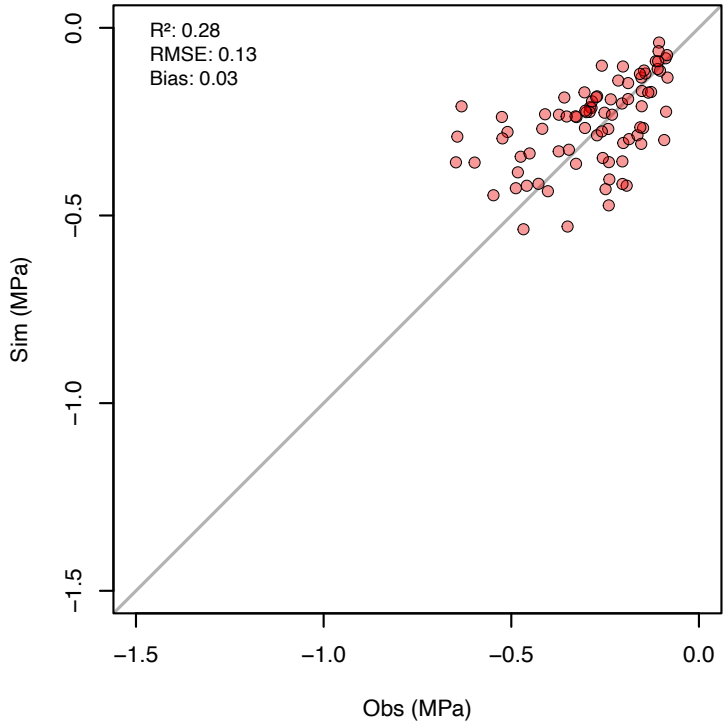
Jean-Christophe PAYAN[1], Iñaki GARCIA DE CORTAZAR ATAURI[2], Nadine BRISSON[2], Isabelle de MUNTER[1]
(1) : ITV France - unité de Montpellier, Domaine de Piquet, route de Ganges, F-34790 GRABELS
Tél. : 04 99 23 33 00 Fax : 04 99 23 33 09 E_mail : jean-christophe.payan@itvfrance.com
(2) : INRA - unité Climat Sol Enironnement, Site Agroparc, Domaine Saint-Paul, F-84914 AVIGNON CEDEX 9

DOI: 10.5344/ajev.1987.38.1.54

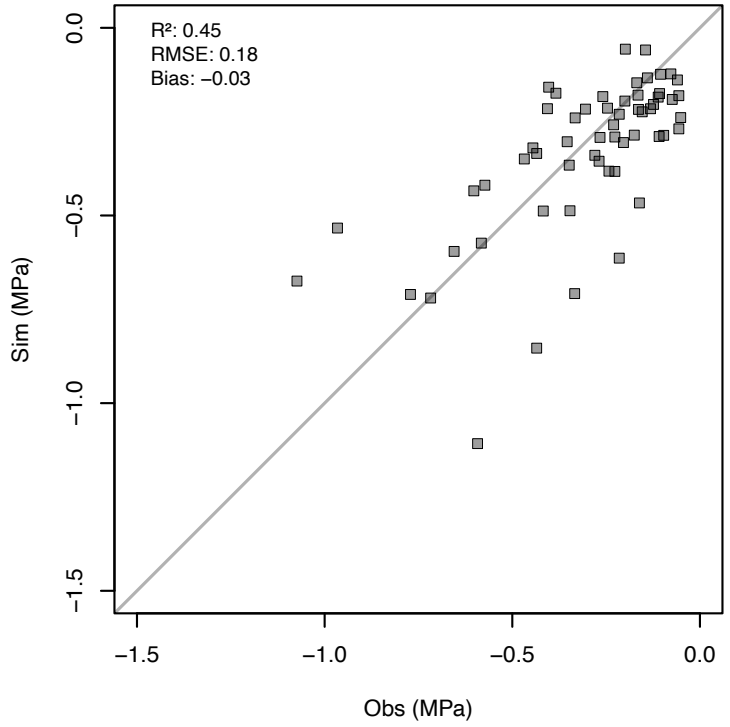
Psibase - Merlot

STICS v10.4.1

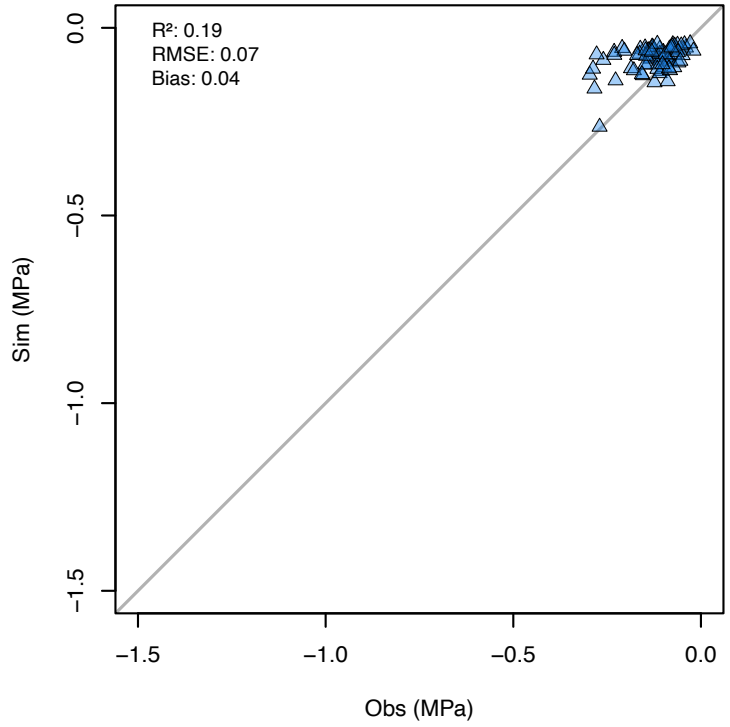
A



G



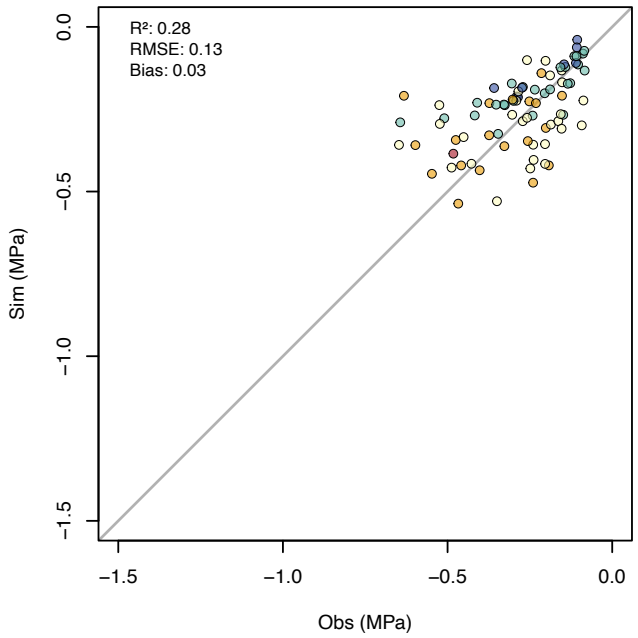
S



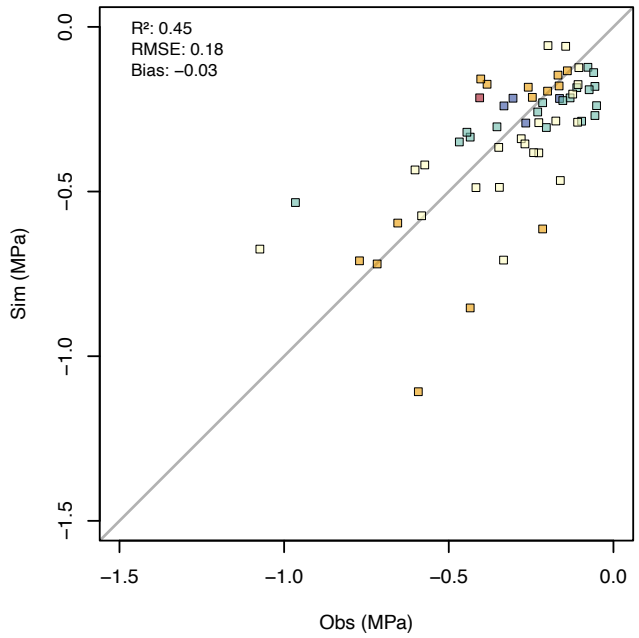
Psibase - Merlot

STICS v10.4.1

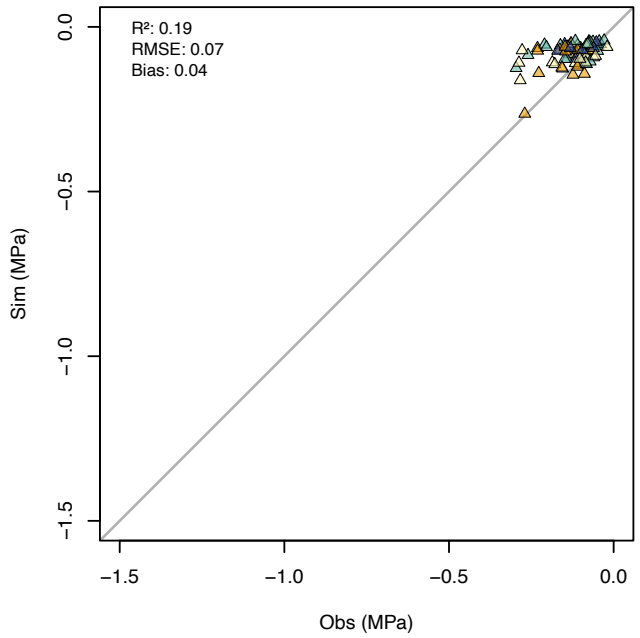
A

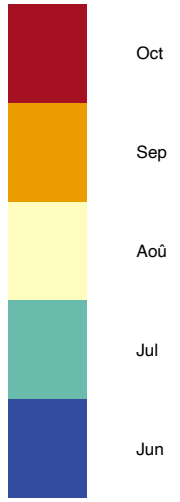


G



S

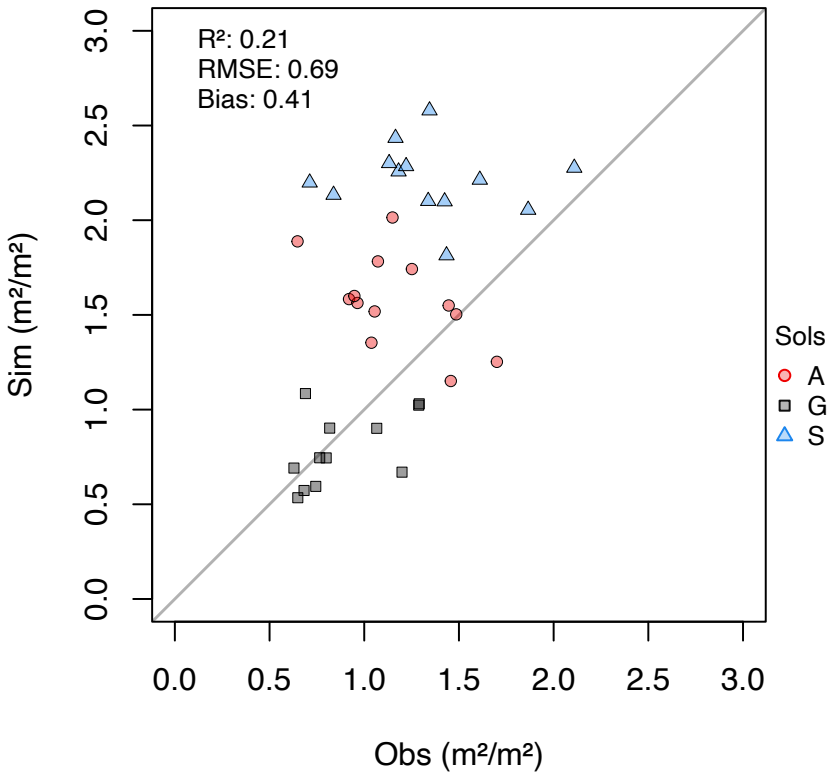




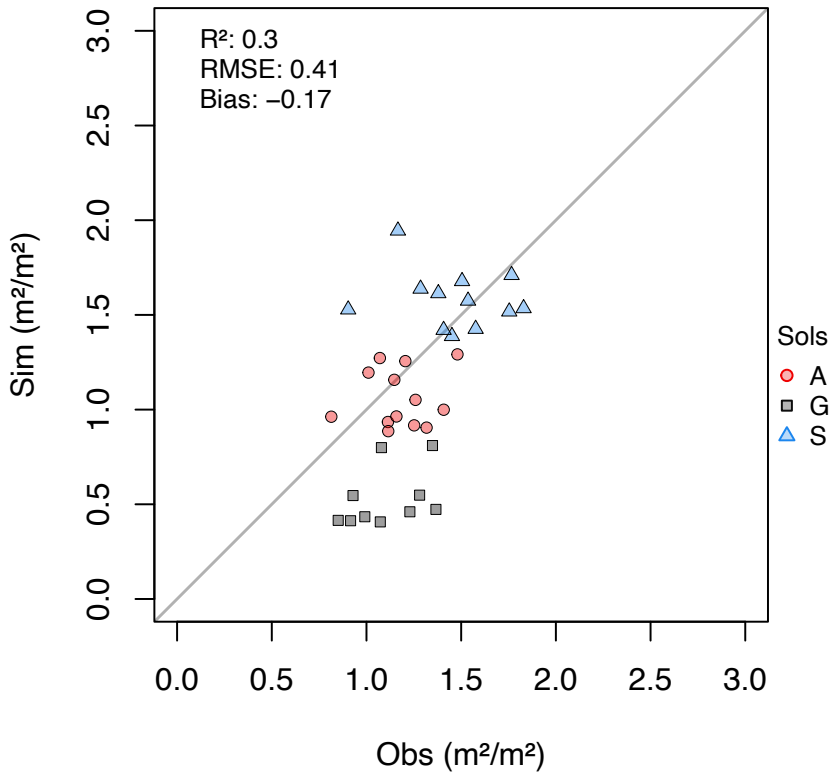
LAI

STICS v10.4.1

Cabernet franc



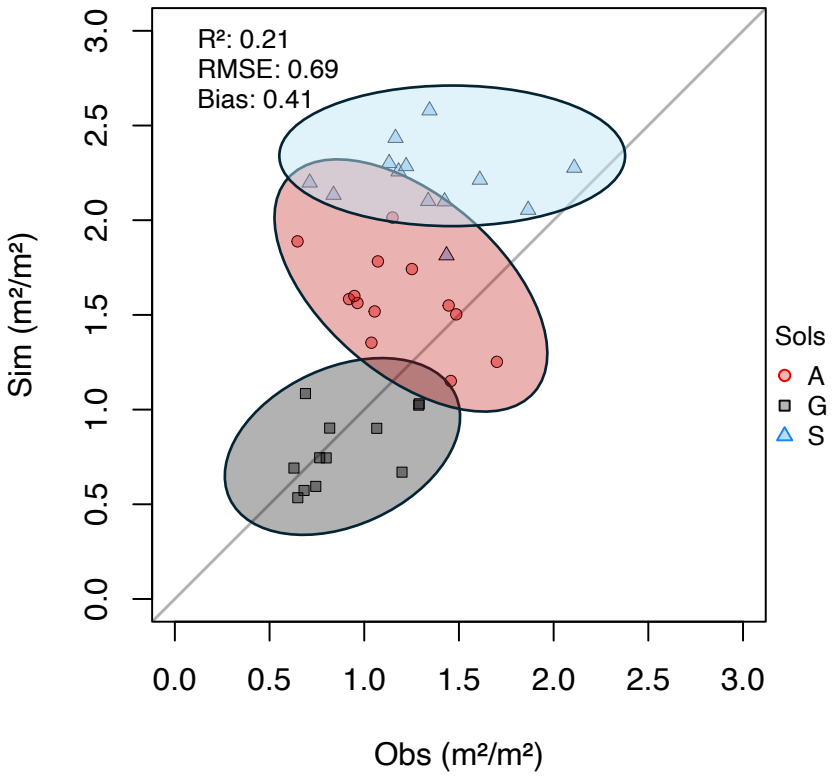
Merlot



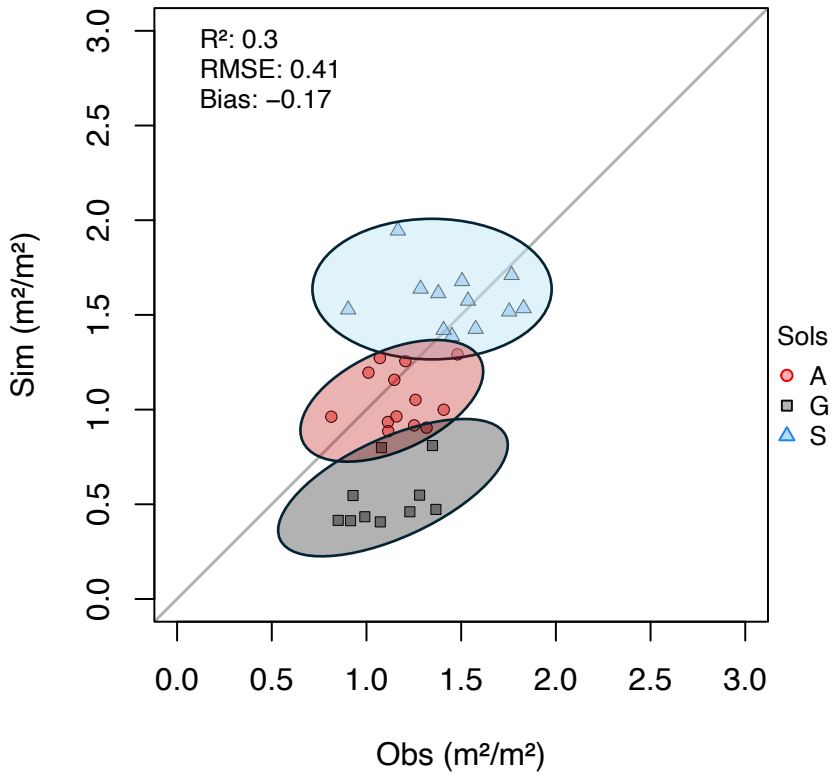
LAI

STICS v10.4.1

Cabernet franc



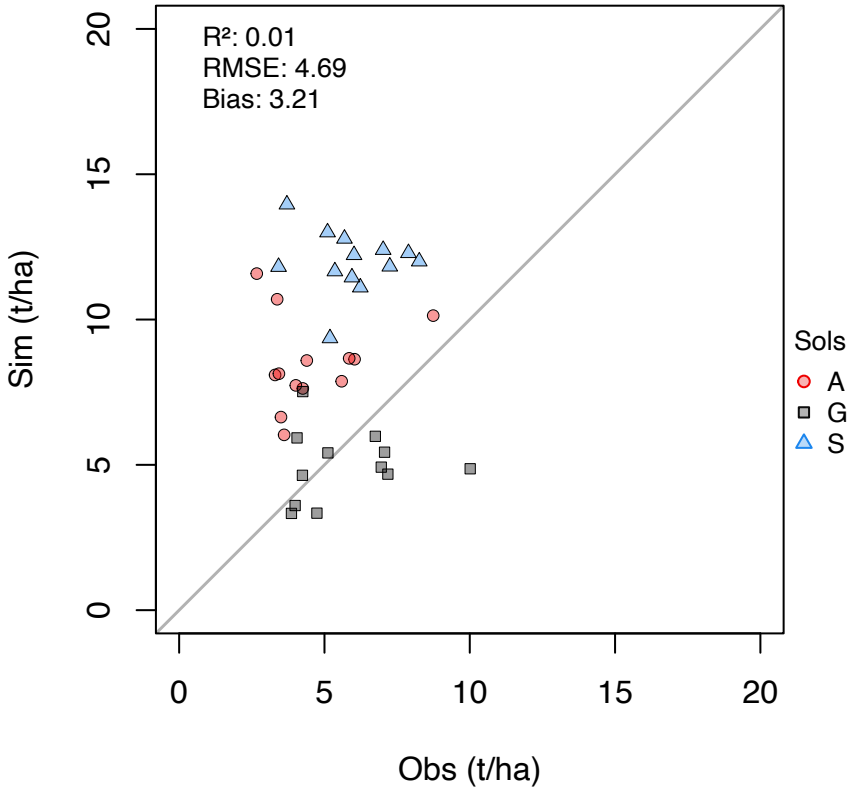
Merlot



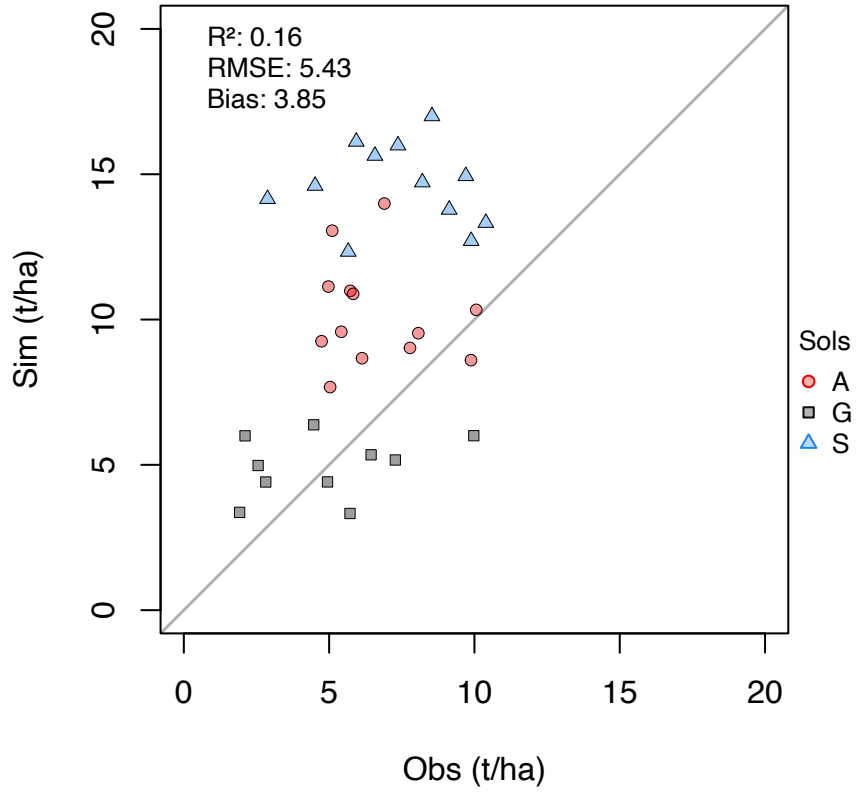
Pdsfruitfrais

STICS v10.4.1

Cabernet franc



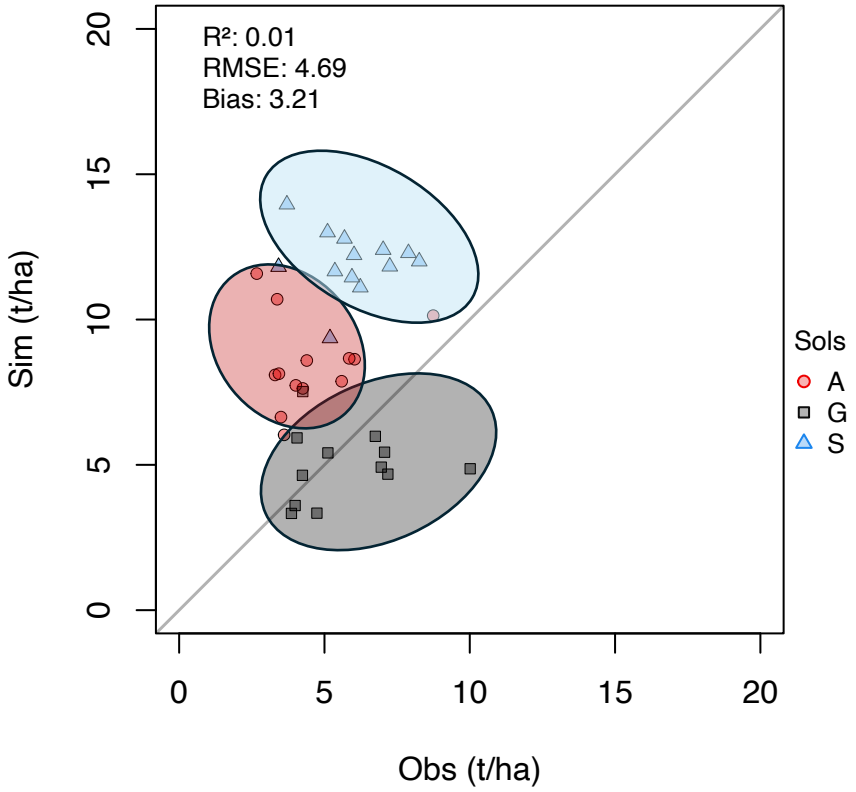
Merlot



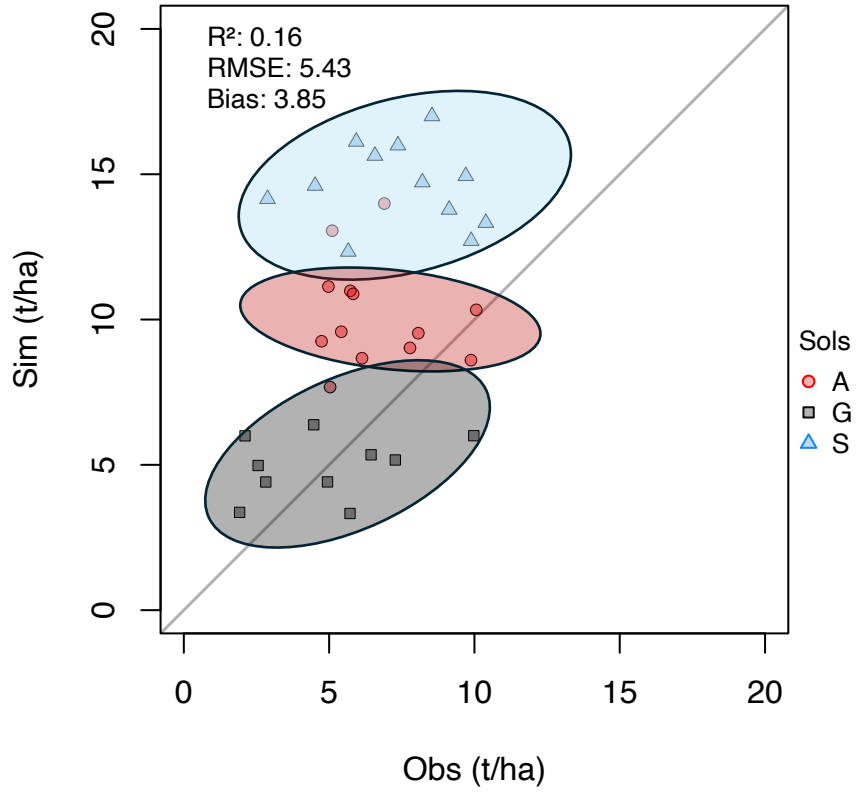
Pdsfruitfrais

STICS v10.4.1

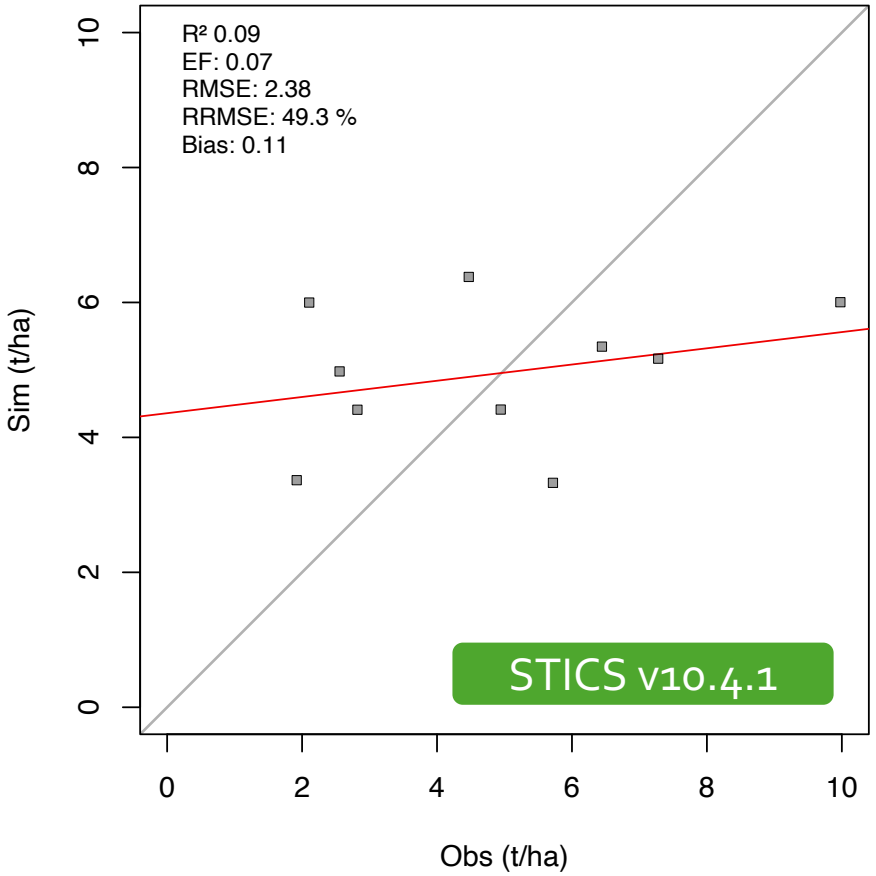
Cabernet franc



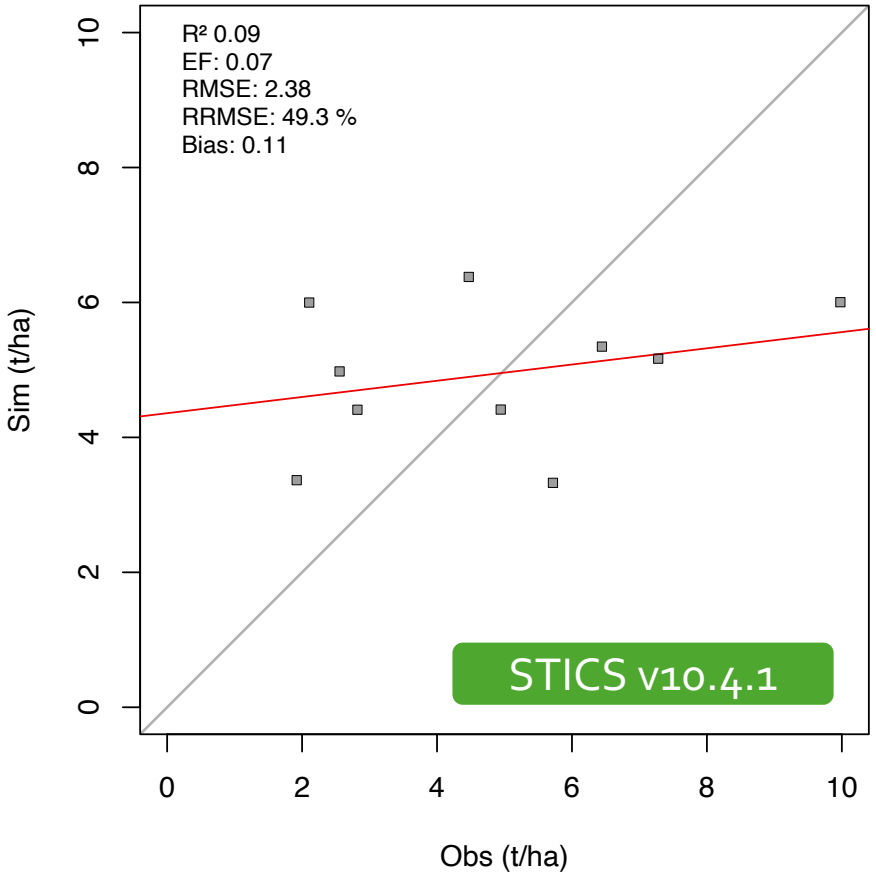
Merlot

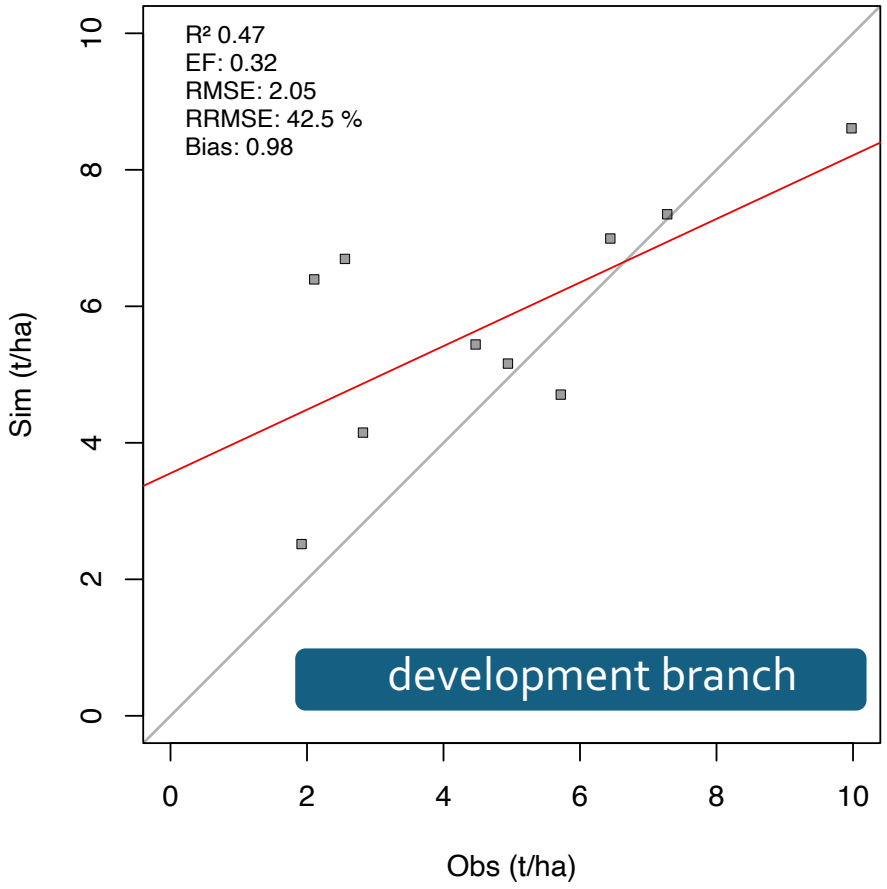


Yield comparison – Merlot G



Yield comparison – Merlot G





*The sink strength formalism better captures **interannual yield variability** and shows **improved** statistical performance*

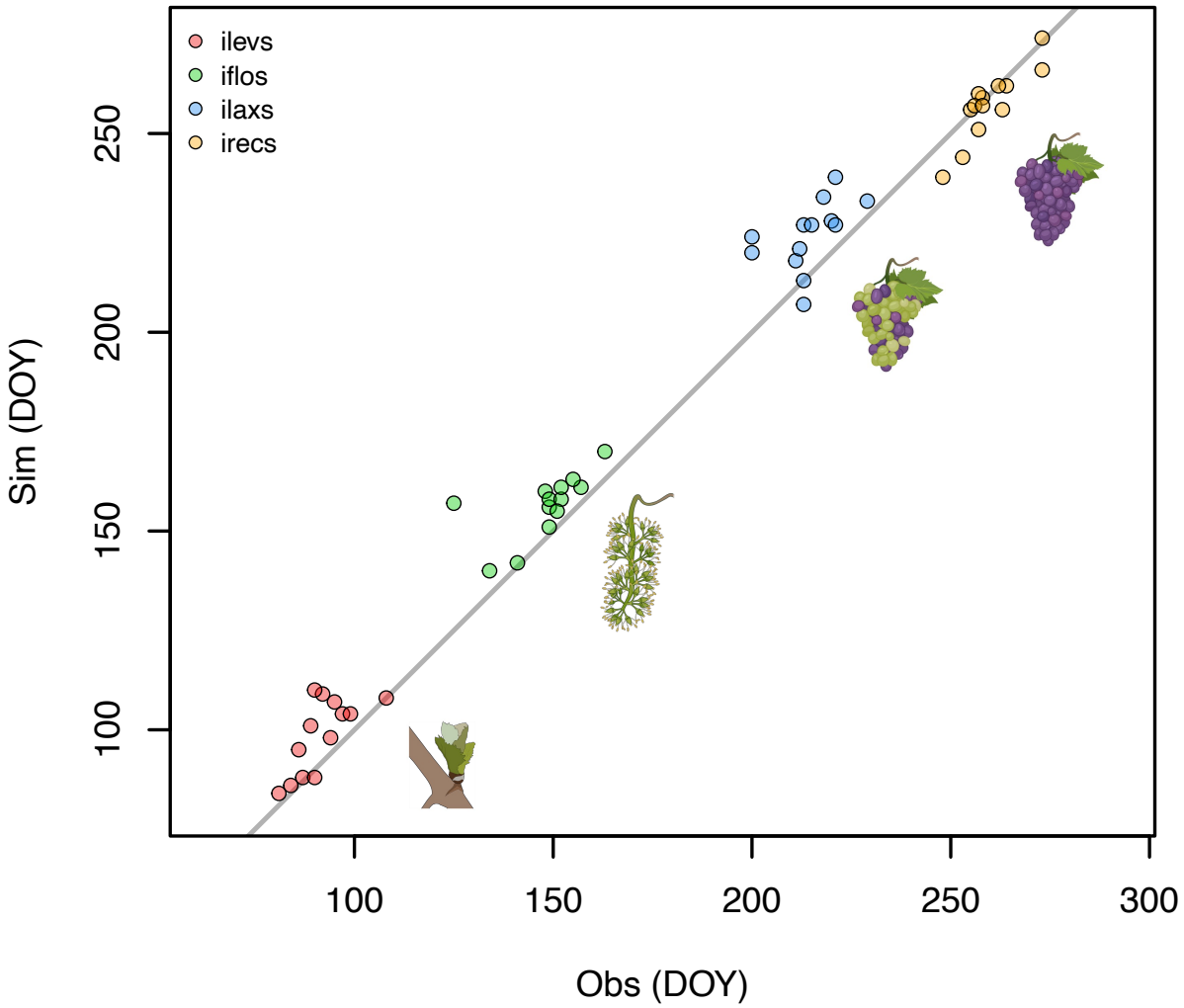
Phenology – Merlot A

Budbreak — ***RMSE*** : 9.47 days

Flowering — ***RMSE*** : 11.1 days

Veraison — ***RMSE*** : 12.94 days

Harvest — ***RMSE*** : 4.93 days



Key home message

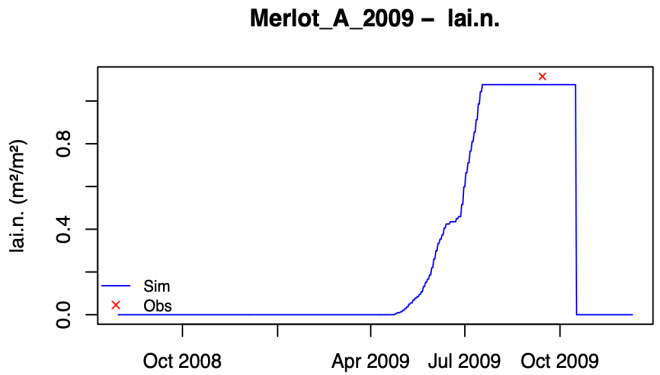
LAI is not well reproduced in the simulations

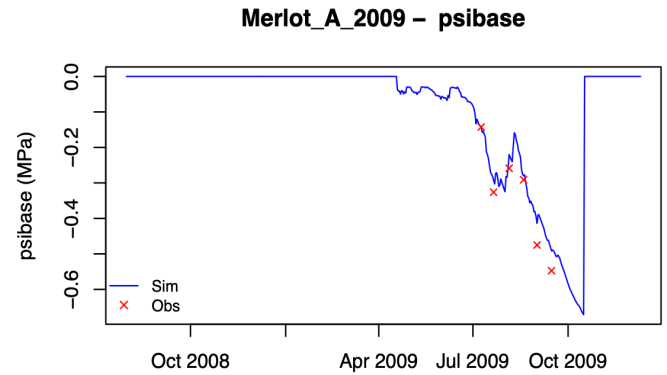
Yield is overestimated on clayey and sandy soils (STICS v10.4.1)

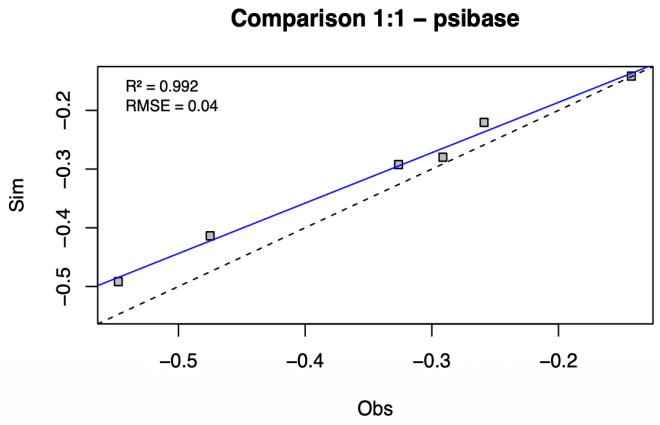
The sink strength formalism, included in the development branch, improves the model's to simulate yield

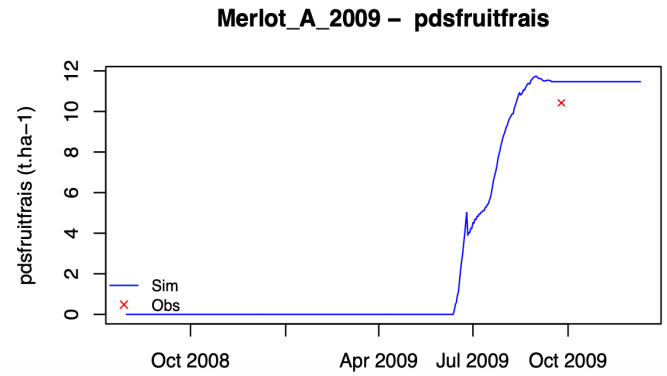
The soil effect is accurately captured

Example of output for the USM Merlot A 2009









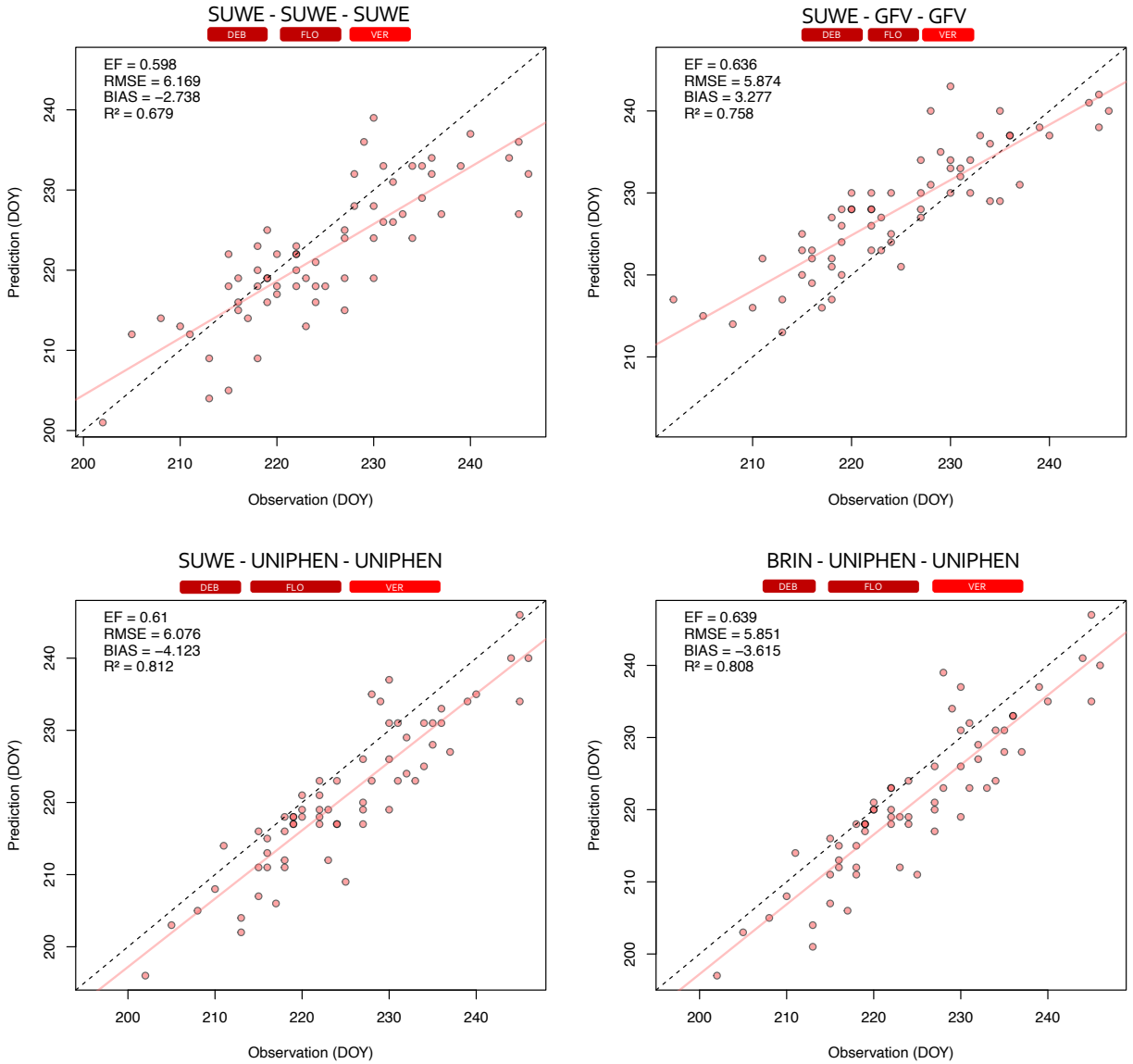
Limits

- Myself
- The cultivars were not recalibrated (e.g., *Afruitpot*, *Pgrainmaxi, Slamin, Slamax*)
- Biotic effects (botrytis, coulure) in some years
- The initialization file was kept identical across years for each soil
- Seasonal fluctuations of the water table in sandy soil were not represented
- Meteorological data from SAFRAN (8 × 8 km grid)

Phenology modelling

Framework for integrating other phenology models in STICS

- GFV (Parker et al., 2011, 2013)
- GSR (Parker et al., 2020)
- UniPhen (Molitar et al., 2020)
- SUWE (Morales et al., 2020)



vitilience

Defining a minimal yet reliable input protocol for STICS

Apply STICS in contexts where it is appropriate and data-supported, to answer specific questions and improve process understanding

Co-constructing modelling approaches

Leverage other existing models (APSIM, GrapeSoil, etc.) to integrate new formalisms into STICS

BIBLIOGRAPHIE

1. **Leeuwen**, C. van, Friant, P., Choné, X., Tregoat, O., Koundouras, S., & Dubourdieu, D. (**2004**). Influence of Climate, Soil, and Cultivar on Terroir. *American Journal of Enology and Viticulture*, *55*(3), 207-217. https://doi.org/10.5344/ajev.2004.55.3.207

2. **Strullu**, L., et al., **2023**. Improvement of grapevine yield simulation in Champagne with the STICS model. XIII Séminaire STICS. https://www.researchgate.net/publication/377241070_Improvement_of_grapevine_yield_simulation_in_Champagne_with_the_STICS_model/references

3. **Nagarajah**, S. (**1987**). Effects of Soil Texture on the Rooting Patterns of Thompson Seedless Vines on Own Roots and on Ramsey Rootstock in Irrigated Vineyards. *American Journal of Enology and Viticulture*, *38*(1), 54-59. https://doi.org/10.5344/ajev.1987.38.1.54

4. **Payan** Jean-Christophe, Inaki Garcia de Cortazar Atauri, Nadine N. Brisson, Isabelle de Munter. Assimilation des caractéristiques du système sol-racines par simulation du potentiel de base en parcelle viticole. *Séminaire STICS*, Mar 2005, Carry-le-Rouet, France. ⟨hal-02763712⟩

5. **Zhu**, J., Parker, A., Gou, F., Agnew, R., Yang, L., Greven, M., Raw, V., Neal, S., Martin, D., Trought, M. C. T., Huth, N., & Brown, H. E. (**2021**). Developing perennial fruit crop models in APSIM Next Generation using grapevine as an example. *In Silico Plants*, *3*(2), diab021. https://doi.org/10.1093/insilicoplants/diab021

6. **Parker**, A., De Cortázar-Atauri, I. G., Chuine, I., Barbeau, G., Bois, B., Boursiquot, J.-M., Cahurel, J.-Y., Claverie, M., Dufourcq, T., Gény, L., Guimberteau, G., Hofmann, R. W., Jacquet, O., Lacombe, T., Monamy, C., Ojeda, H., Panigai, L., Payan, J.-C., Lovelle, B. R., … Van Leeuwen, C. (**2013**). Classification of varieties for their timing of flowering and veraison using a modelling approach : A case study for the grapevine species Vitis vinifera L. *Agricultural and Forest Meteorology*, *180*, 249-264. https://doi.org/10.1016/j.agrformet.2013.06.005

7. **Parker**, A. K., García De Cortázar-Atauri, I., Gény, L., Spring, J.-L., Destrac, A., Schultz, H., Molitor, D., Lacombe, T., Graça, A., Monamy, C., Stoll, M., Storchi, P., Trought, M. C. T., Hofmann, R. W., & Van Leeuwen, C. (**2020**). Temperature-based grapevine sugar ripeness modelling for a wide range of Vitis vinifera L. cultivars. *Agricultural and Forest Meteorology*, *285-286*, 107902. https://doi.org/10.1016/j.agrformet.2020.107902

8. **Molitor**, D., Fraga, H., & Junk, J. (**2020**). UniPhen – a unified high resolution model approach to simulate the phenological development of a broad range of grape cultivars as well as a potential new bioclimatic indicator. *Agricultural and Forest Meteorology*, *291*, 108024. https://doi.org/10.1016/j.agrformet.2020.108024

9. **Morales-Castilla**, I., García De Cortázar-Atauri, I., Cook, B. I., Lacombe, T., Parker, A., Van Leeuwen, C., Nicholas, K. A., & Wolkovich, E. M. (**2020**). Diversity buffers winegrowing regions from climate change losses. *Proceedings of the National Academy of Sciences*, *117*(6), 2864-2869. https://doi.org/10.1073/pnas.1906731117