Hyperspectral imaging data combined with climate data to predict stomatal conductance and transpiration of grapevine plants

Using Sequentially-Orthogonalized Partial-Least-Square Regression (SO-PLS)

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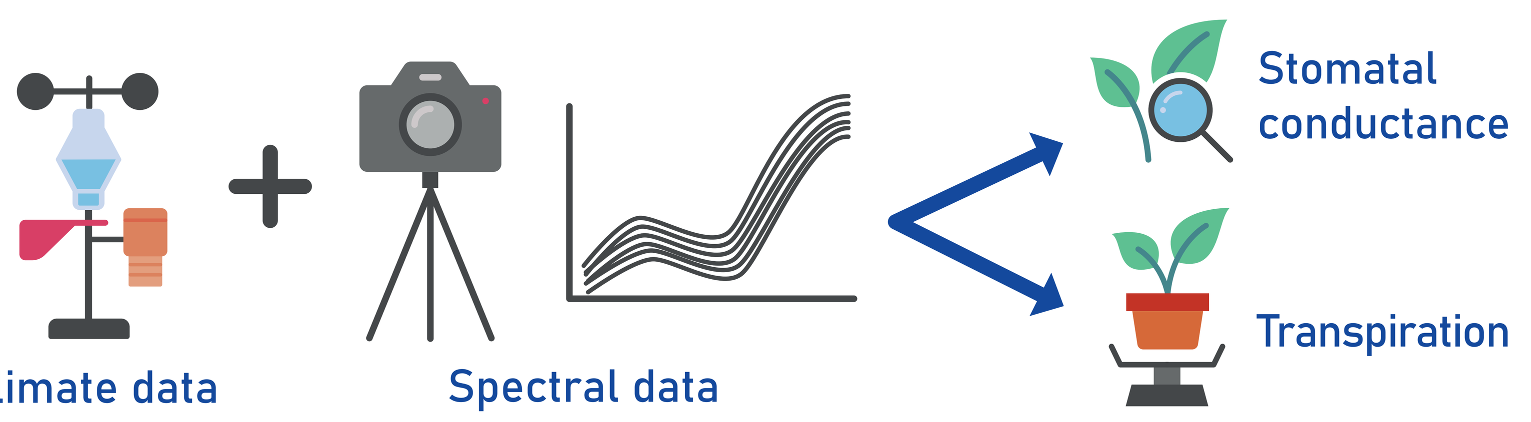
INTRODUCTION

Digital agriculture driven by new intelligent sensors is one of the main ways to improve farm management.

Accessing physiological variables such as transpiration (E) and stomatal conductance (gs) in real time with optical instruments is challenging. These are the privileged variables to detect water stress.



OBJECTIVE

The objective is to evaluate predictions of transpiration (E) and stomatal conductance (gs) of grapevine (Vitis vinifiera L.) by combining visible-near infrared spectral images with climate data, using Sequentially-Orthogonalized Partial-Least-Square Regression (SO-PLS).

EXPERIMENT

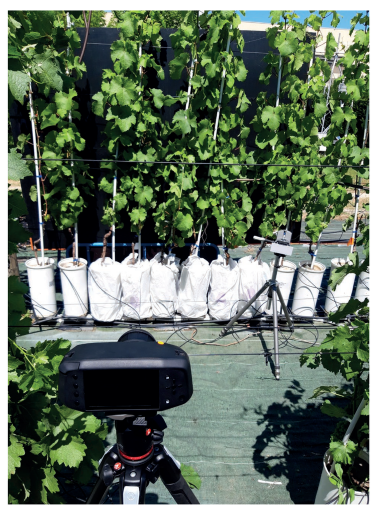
Pots of three grape varieties (Syrah, Merlot, Riesling) tested under two water conditions were studied to obtain water stress gradient. Hyperspectral images were acquired and a weather station provided radiation (Rg), relative humidity (RH), temperature (Ta) and wind speed (Ws). Precise monitoring of physiological variables was performed to obtain reference values.

Experimental design (Repeated twice)

Period: Summer 2020 / Location: Montpellier, la Gaillarde

Treatment	Varieties	Pots
Irrigated	Syrah	
None	Merlot	
	Riesling	

Hyperspectral and climate data acquisitions



Block 1
X: Hyperspectral imaging, Specim IQ, 204 bands between 397 and 1003 nm

Block 2
Z: Temperature, Humidity, Global radiation, Wind Speed

Physiological variables

y1 — Stomatal conductance: Porometer Delta-T

y2 — Transpiration: Load cell

METHOD

Sequentially-Orthogonalized Partial-Least-Square Regression (SO-PLS) was used to build a prediction model.

$$y = Xb + Zc + r_{x,z}$$

Steps of the SO-PLS

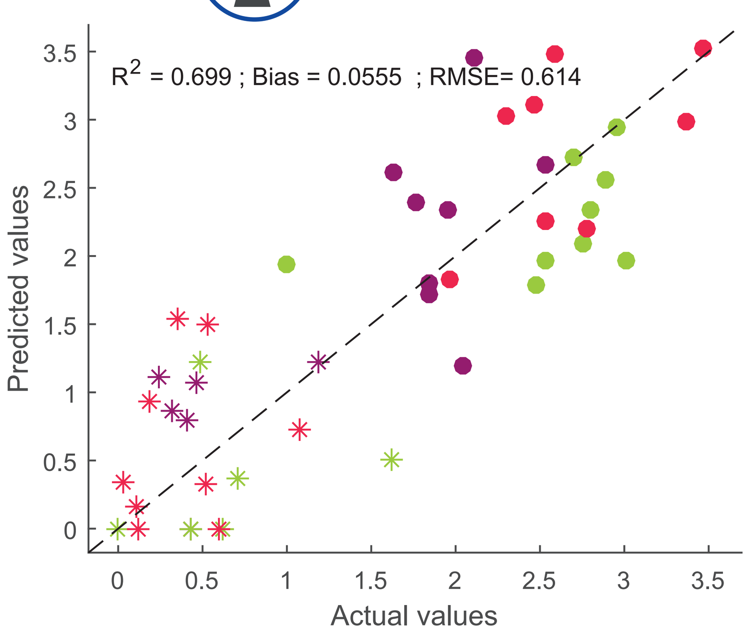
1 - fit y to X .... $y = Xb + r_x$

2 - orthogonalize Z to X-scores .... $Z_\perp = Z - T_x (T_x^t T_x)^{-1} T_x^t Z$

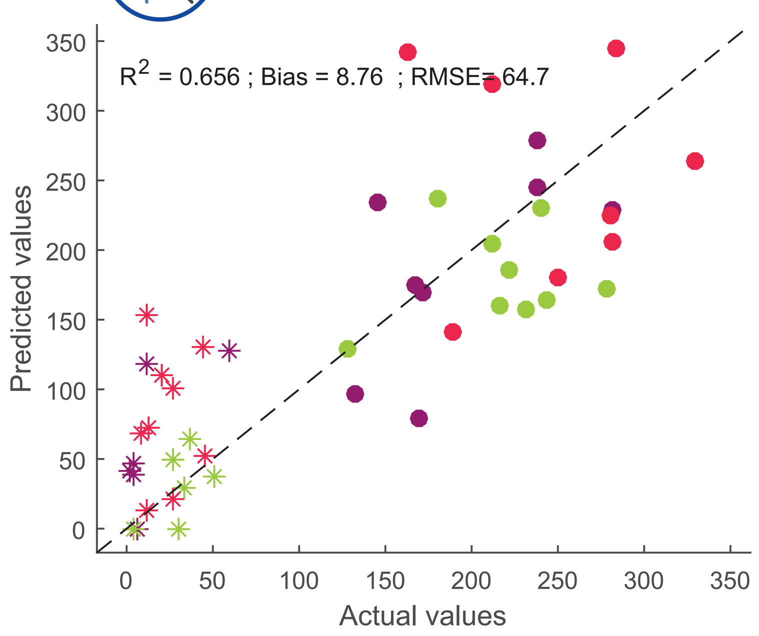
3 - fit rx to $Z_\perp$ .... $r_x = Z_\perp c^* + r_{x,z}$

RESULTS

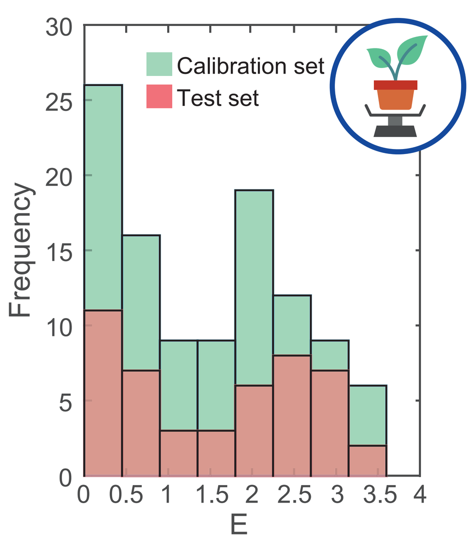
Transpiration

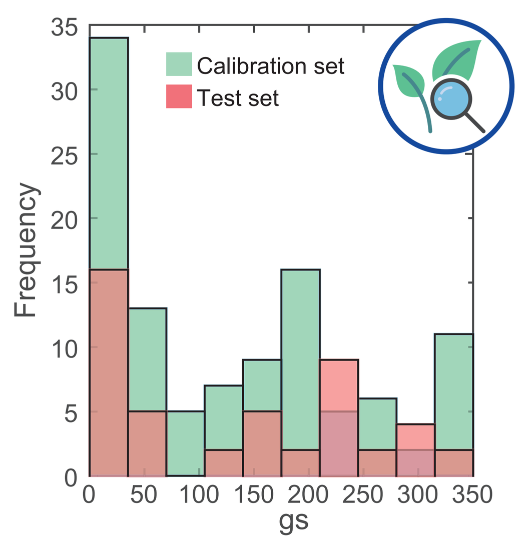


Stomatal conductance



MODEL EVALUATION

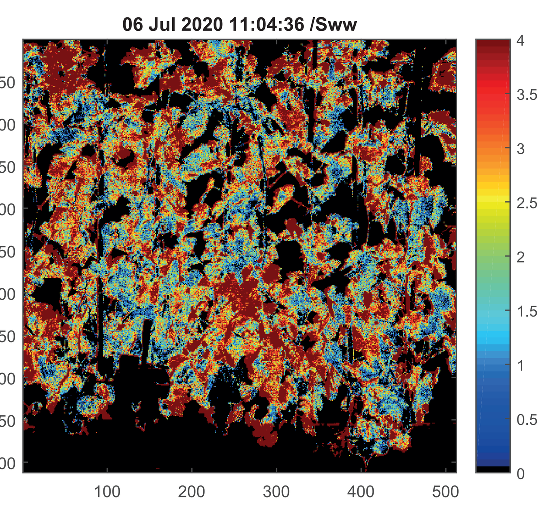




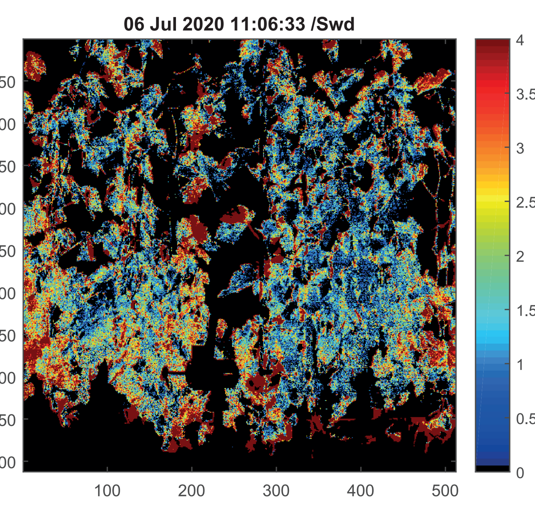
- A calibration set of 106 hyperspectral images
- A test set of 54 hyperspectral images (reflecting all modalities of the experimental design)

MODEL APPLICATION

Syrah — Irrigated



Syrah — None



- Opportunity to study spatial distribution of stresses over the leaf stages
- Within-variability as a new phenotyping trait for breeding varieties

CONCLUSION AND PERSPECTIVES

The combination of climate data and hyperspectral images provides models with good performance to predict physiological variables. Quality of these prediction models could be improved by defining varietal models on a larger data set. These encouraging results offer prospects for the use of spectral imaging to study water stress of grapevine plants.

Reference
Ryckewaert, Maxime, Daphné Héran, Thierry Simonneau, Florent Abdelghafour, Romain Boulord, Nicolas Saurin, Daniel Moura, Silvia Mas-Garcia, et Ryad Bendoula. « Physiological Variable Predictions Using VIS–NIR Spectroscopy for Water Stress Detection on Grapevine: Interest in Combining Climate Data Using Multiblock Method ». Computers and Electronics in Agriculture 197 (juin 2022): 106973. https://doi.org/10.1016/j.compag.2022.106973.

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