HOW TO REDUCE THE NUMBER OF MEASUREMENTS NEEDED FOR THE CALIBRATION OF A SPATIAL MODEL?

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Introduction

Adapting vineyard management practices according to within field spatial variability is a useful approach to improve grape and wine production and to optimize resources allocation to areas that need it the most.

LIMITATION: the cost of taking direct measurements with enough spatial resolution.

A SOLUTION: a spatial model coupling high quality, high cost punctual vine measurements with low cost, medium-high density ancillary measurements. To be operational such model needs to be calibrated with a small number of high cost measurements.

Objective

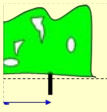
Propose and test a sampling method to optimize the location of high cost vine measurements in order to calibrate a regression spatial model with a very small number of measured sites (3-5).

Case study

49 sites measured in a regular grid

1.2 ha unirrigated Syrah field

Ancillary measurements



Exposed Leaf Area (ELA): seasonal vegetative growth

Trunk circumference (TC): average vigor of the vines since plantation

MODEL

Pre-dawn leaf water potential (PLWP): Spatial variability of Plant water status

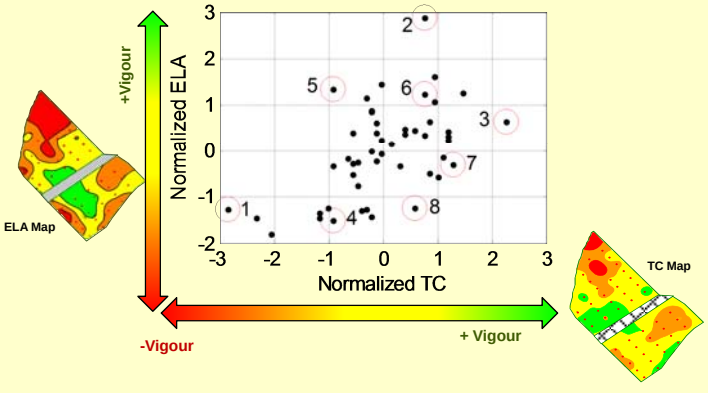
impact on yield and wine quality.

High cost measurements

Sampling method

Kennard and Stone [1] sampling method:

- Designed to optimize the site selection for the calibration of linear regression models.
- The site selection is **based on ancillary data maps**
- The method sequentially **selects** the sites which would best represent the whole variation on TC and ELA within the parcel for any affordable sample size (maximizes the sample variance in TC and ELA).
- **Provides a rank** to describe in which order the "candidate" sites have to be sampled to optimize the model calibration.



Plotting of 49 "Candidate" sites potentially useful to calibrate the spatial model. The first 8 sites of the rank provided by the sampling method are identified in the figure.

- The sampling method would allow to select the sites which **complement** best **any already collected sample.**

Results

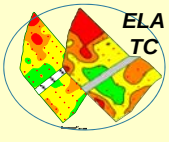
Site Selection

Measurements at 3 calibration sites:
PLWP
ELA
TC

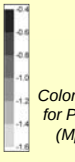
Model calibration:

PLWP = b0 + b1 *TC + b2 ELA

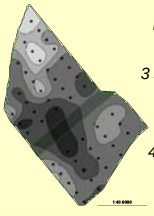
PLWP = -3,13 + 0,15 *TC + 0,36 ELA



Model validation:



Color code for PLWP (Mpa)

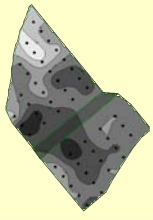


Estimated Plant Water Status

3 sites measured for PLWP

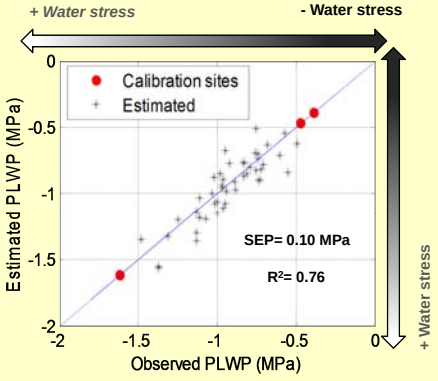
+

49 sites measured for ELA and TC



Observed Plant Water Status

49 sites measured for PLWP



Results *of the spatial model calibrated with 3 sites*

Similar zoning is obtained for the observed and estimated PLWP

Conclusions

A sampling algorithm based on an experimental design was tested to select the best sites for the calibration of a spatial regression model. This model uses vine vegetative vigour and growth measurements to estimate plant water status.

The current work proves that a spatial model can be successfully calibrated using a very reduced number of measurements of plant water potential (3 measured sites)

APPLICABILITY OF THE WORK:

Delineation of different homogeneous within-field zones → Improving the management of field operations like irrigation or fruit sampling.

This method can be extended to other variables → Estimation of spatial variability for other key production parameters (such as yield, plant water status or fruit composition)

This work represents a first step towards the development of improved routine practices in a commercial context in order to optimize vineyard management.

References

[1] **Kennard, R., and L. Stone. 1969. Computer Aided Design of Experiments. Technometric 11(1)**