Grapevine yield estimation in a context of climate change: the GraY model

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Book of abstracts

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Grapevine yield is a key indicator to assess the impacts of climate change and the relevance of adaptation strategies in a vineyard landscape. At this scale, a yield model should use a number of parameters and input data in relation to the information available and be able to reproduce vineyard management decisions (e.g. soil and canopy management, irrigation). In this study, we used data from six experimental sites in Southern France (cv. Syrah) to calibrate a model of grapevine yield limited by water constraint (GraY). Each yield component (bud fertility, number of berries per bunch, berry weight) was calculated as a function of the soil water availability simulated by the WaLIS water balance model at critical phenological phases. The model was then evaluated in 10 grapegrowers' plots, covering a diversity of biophysical and technical contexts (soil type, canopy size, irrigation, cover crop). We identified three critical periods for yield formation: after flowering on the previous year for the number of bunches and berries, around pre-veraison and post-veraison of the same year for mean berry weight. Yields were simulated with a model efficiency (EF) of 0.62 (NRMSE = 0.28). Bud fertility and number of berries per bunch were more accurately simulated (EF = 0.90 and 0.77, NRMSE = 0.06 and 0.10, respectively) than berry weight (EF = -0.31, NRMSE = 0.17). Model efficiency on the on-farm plots reached 0.71 (NRMSE = 0.37) simulating yields from 1 to 8 kg/plant. The GraY model is an original model estimating grapevine yield evolution on the basis of water availability under future climatic conditions. It allows to evaluate the effects of various adaptation levers such as planting density, cover crop management, fruit/leaf ratio, shading and irrigation, in various production contexts.

Keywords: semi-empirical model, grape yield, water constraint, climate change, vineyard management

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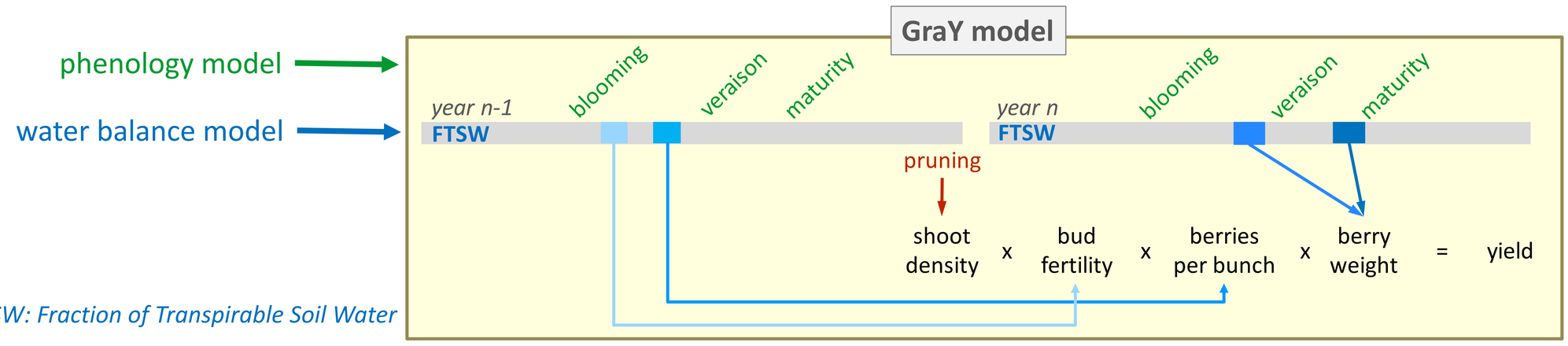
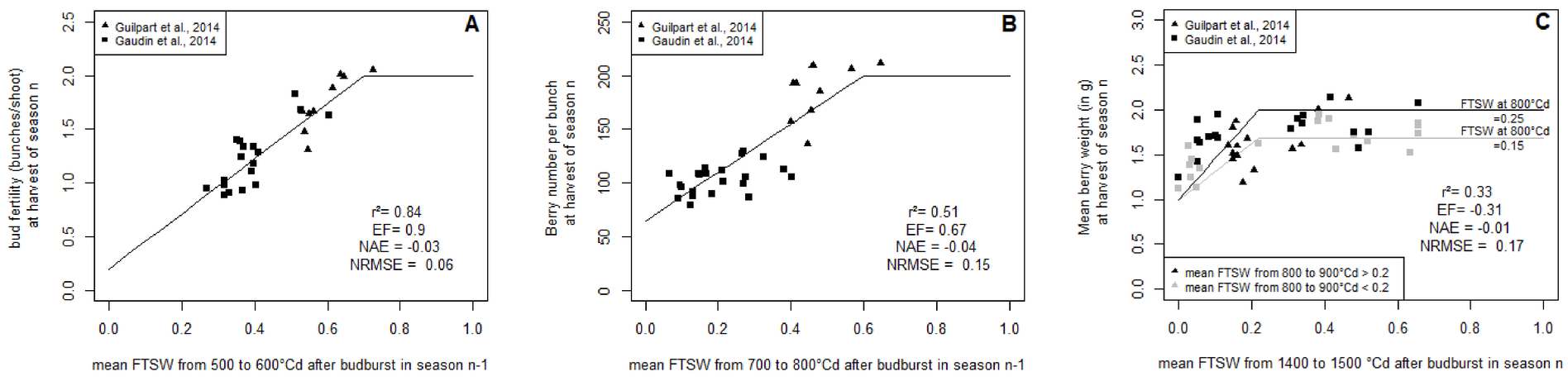
Grapevine yield is a key indicator to assess the impacts of climate change and the relevance of adaptation strategies in a vineyard landscape. At this scale, a yield model should need a limited number of parameters and be based on available or easy to obtain data. It should be able to simulate climate change adaptation techniques, such as soil, canopy and water management.

A sink-based grape yield model

The GraY (Grape Yield) model is based on 2 main hypotheses:
- grape yield is mainly driven by sinks i.e. by the number of clusters and berries, and by berry growth;
- the establishment and growth of these sinks depend on water stress at critical periods (Guilpart *et al.*, 2014).

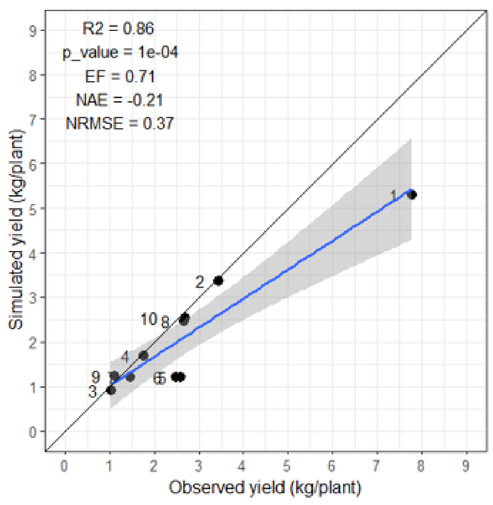


The 4 critical periods were those with a mean FTSW highly correlated with one of the yield components (bud fertility, berries per bunch, berry weight). FTSW was calculated with the WaLIS model (Celette et al 2010) and phenology with Morales-Castilla et al (2020)'s model. The GraY model was calibrated with 2 databases with the shiraz variety (Gaudin *et al.*, 2014; Guilpart *et al.*, 2014).

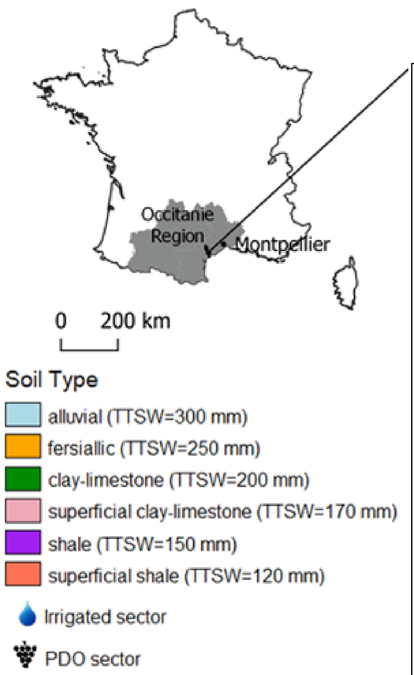


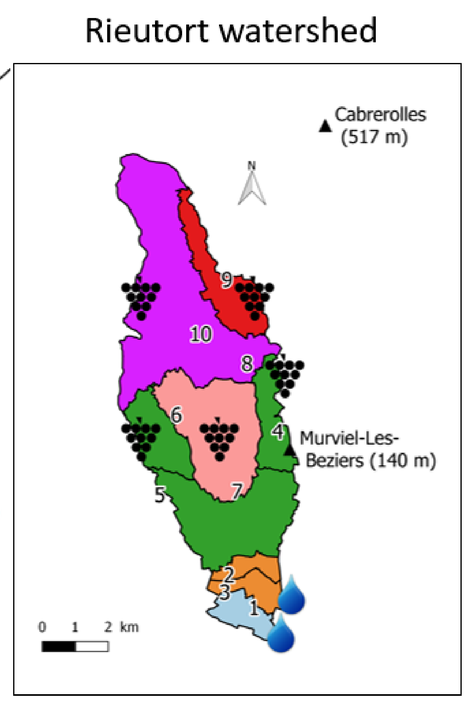
Simulation of the spatial distribution of grape yields in a watershed, at present and in the future

The GraY model was assessed with yields measured in a network of 10 vineyards with contrasted soil and management conditions within a Mediterranean watershed in the south of France.



Each point on the figure corresponds to a plot whose number appears on the map.

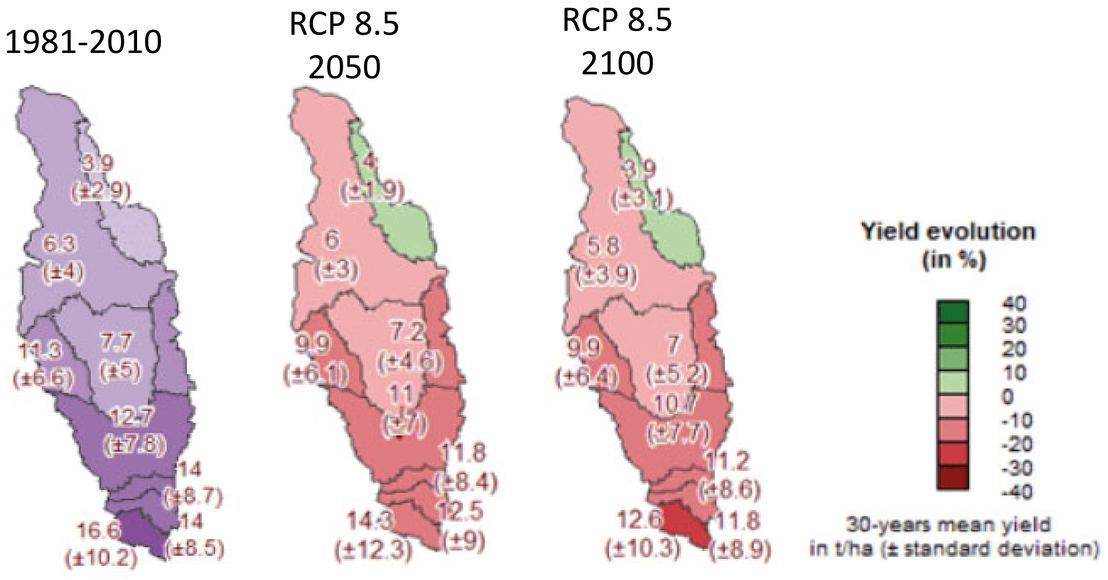




It was then linked to the phenology, water balance and hydrological models within the OpenFLUID platform to map grape yields in 8 sectors with contrasted soil water holding capacities, climates and production objectives (Naulleau et al., 2022). Grape growers validated the mean yield values simulated in the 8 sectors for the recent past (1981-2010).

Under severe climate change (RCP8.5), yield losses would be more pronounced in deep soils, high yielding areas, even if irrigated, than in PDO areas with moderate yields.

This modelling tool could be used later to assess local adaptation strategies designed with stakeholders (cf. Naulleau *et al.*'s oral presentation).



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