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Supplement of

Modeling sugarcane yield with a process-based model from site to continental scale: uncertainties arising from model structure and parameter values

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Supporting Information

Model optimization at multiple sites

In order to have an observation-based estimate of parameters range to constrain the uncertainty analysis, we optimize at 7 sites independently the ORCHIDEE-STICS key parameters, previously identified through a screening procedure.

For this, we applied a bayesian calibration of the model parameters, using a standard variational method based on the iterative minimization of a cost function that measures both the model data misfit as well as the parameter deviations from a prior knowledge. The cost function used is the Root Mean Square Error.

The iterative scheme is described in (Tarantola, 1987) with the hypothesis of Gaussian error on the observations and the parameters.

We prescribe for each parameter a prior value, an a-priori error and a perturbation value, epsilon. The epsilon assigned to each parameter is the increment around the parameter used to calculate local derivatives with the method of finite element method as in equation (1).

$$(1)\quad \frac{\partial J}{\partial x_k} = \frac{J\left(x_1,...,x_k+\varepsilon,...,x\right) - J(\mathrm{x})}{\varepsilon}$$

where J is the variable optimized
x is the vector of parameters that consists in x_k members
ε is an infinitesimal perturbation applied to parameter x_k

Its definition requires prior testing to avoid numerical artifacts but still remain in the linear vicinity of the variable.

At each site, parameters values are varied iteratively until the best match between simulation and observations is found. On figure 1 we see the optimized values for each site after normalization within the initial range of variation (minimum and maximum values normalized normalized to 0 and 1 respectively) to allow comparison between parameters ranges.We can see that the optimization at multiple sites highly reduces the ranges of variations of most parameters (humcste, maint_resp_slope or croirac), or does not have impact on the range like for Tphoto_min for which the optimized values span the entire variability range. For the parameter INNmin setting a threshold for nitrogen stress, we are faced with the limits of this method of optimization since the dependence of the model to this parameter is non linear (threshold function) and the optimization function therefore does not go passed the prior set in the model.

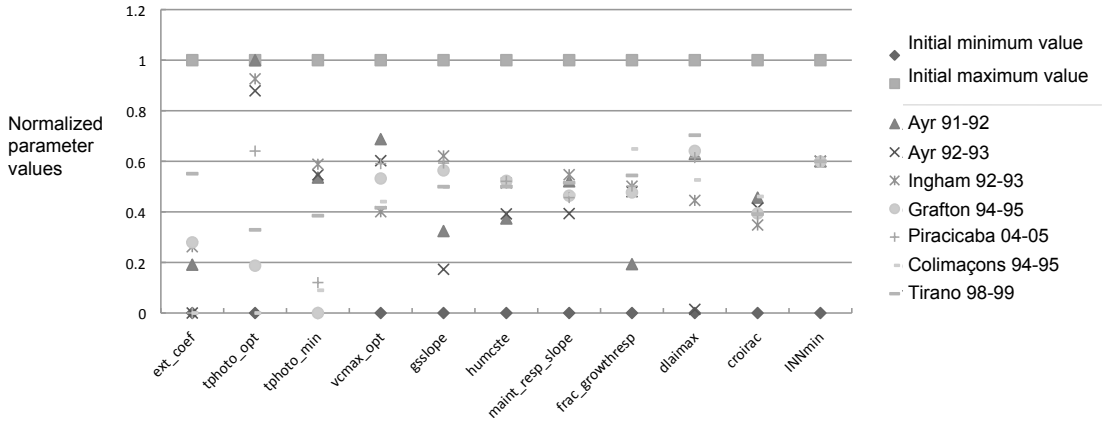

Figure 1: Optimized values (y-axis) for all parameters (x-axis) and for the 7 sites (symbols). The parameters values have been noramlized within their initial range of variation for better readability

Morris screening analysis indices

The direct results of the Morris screening analysis are shown below with σ versus μ* scatterplot. All parameters with significant effect on biomass simulation (large values of μ*) are well below the σ=2μ* line.

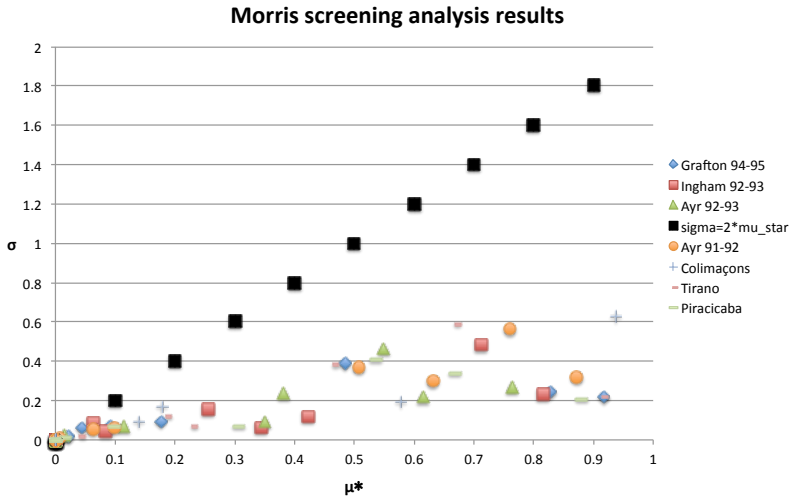

Figure 2: Morris screening analysis' results. Each symbol represents a site and the color points are the different parameters tested. Black squares are the σ=2μ* line. None of the points with large μ* (parameters with significant impact on simulation of biomass) is above this line.