A model-based approach for adapting cropping systems to climate change.

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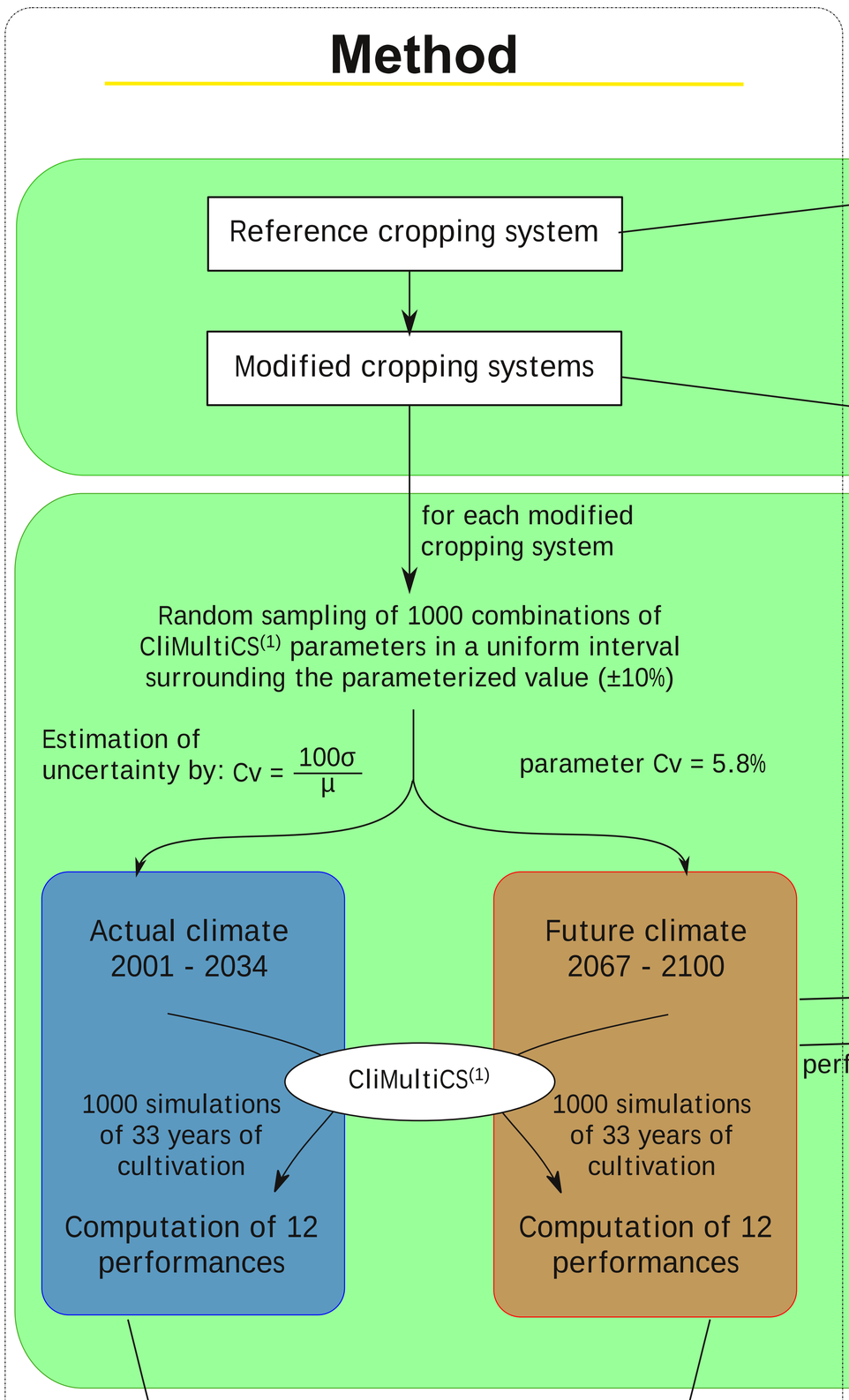
Context and objectives

- Models are powerful tools to assess prototypes of cropping systems under different pedoclimatic conditions.
- Present a methodological framework to virtually assess adaptations of cropping systems to climate change (A1B):
  - Assess the robustness of modelling results to parameter uncertainty and the capacity of the model to sort cropping systems according to performances.
  - Assess whether a cropping system modification improves agronomic and environmental performances compared to an actual system under climate change.

Conclusions

- The model CliMultiCS(1) can be used to sort cropping system modifications according to performances in spite of the uncertainty on the absolute values simulated.
- Estimations of crop yields and nitrate leaching with CliMultiCS are highly uncertain (10% < Cv < 34% vs parameter Cv=5.8%).
- Returning and incorporating all crop residues into soil virtually better increase crop yields in future climate than in actual climate but emit more greenhouse gas and slighly increase nitrate leaching.
- Multiple conflicting performances should be taken into account to avoid misadaptations of cropping systems to climate change.

Method



Results

example of modifying a typical cropping system of French Burgundy

REFERENCE:
SUCCESSION: Winter rapeseed - Winter wheat - Winter barley
TILLAGE: Reduced tillage (not plowed)
CROP RESIDUE MANAGEMENT: crop residues exported from the field
PHOSPHORUS: 60 kgP.ha^{-1} before rapeseed
NITROGEN: 180 kgN.ha^{-1} for each crop

MODIFIED: Plowing before each crop & crop residues left on the field

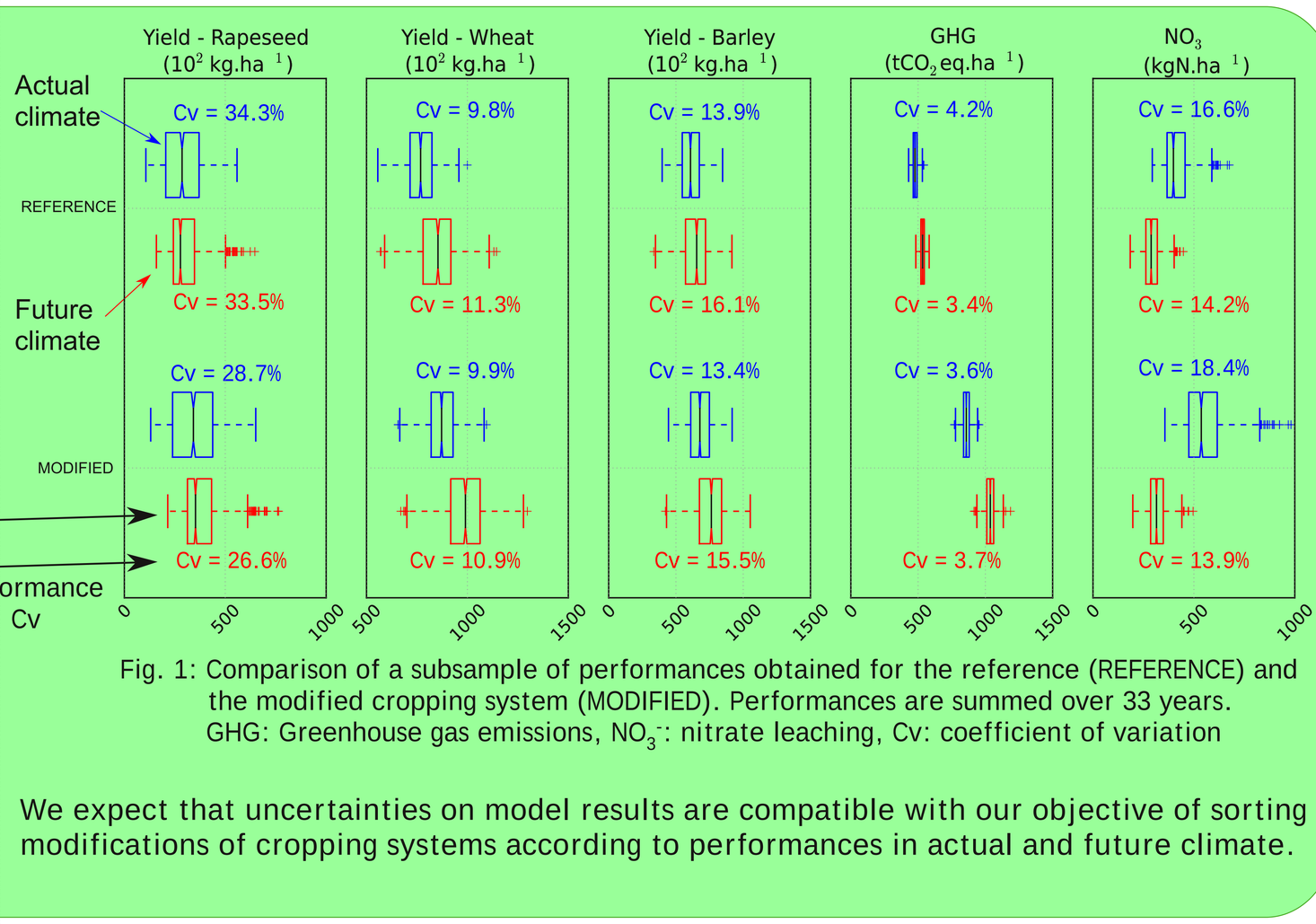


Fig. 1: Comparison of a subsample of performances obtained for the reference (REFERENCE) and the modified cropping system (MODIFIED). Performances are summed over 33 years. GHG: Greenhouse gas emissions, NO_3^-: nitrate leaching, Cv: coefficient of variation

We expect that uncertainties on model results are compatible with our objective of sorting modifications of cropping systems according to performances in actual and future climate.

	Actual climate MODIFIED - REFERENCE	Future climate MODIFIED - REFERENCE
Yield rapeseed (10^2kg.ha^{-1})	49***	78***
Yield wheat (10^2kg.ha^{-1})	103***	142***
Yield barley (10^2kg.ha^{-1})	71***	109***
GHG (tCO2eq.ha^{-1})	380***	503***
NO_3^- (kgN.ha^{-1})	137***	26***

Table 1: Differences of the mean performances of the MODIFIED cropping system and the REFERENCE cropping system under actual and future climate. Performances correspond to cumuls over 33 years. GHG: Greenhouse gas emissions, NO_3^-: nitrate leaching, ***: p-value<0.001

MODIFIED system has better mean yields than REFERENCE system in actual and future climate. Yield increases are higher in future climate than in actual climate.
MODIFIED emits more GHG and nitrate than REFERENCE in future climate. The increase of GHG emissions is higher in future climate than in actual climate while nitrate leaching increase is lower.

(1)CliMultiCS is a model assessing the effects of cropping systems and climate change on 12 performances including crop yields, greenhouse gas emissions, nitrate leaching, phosporus conservation, erosion, water conservation, soil carbon and other environmental performances. CliMultiCS is build on modules from EPIC, APSIM and CERES. It also integrates indicator based modules to assess weed presure and soil compaction risk.