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DynA_Cof, a model for growth, yield, carbon, water, energy balances and ecosystem services of *Coffea* in agroforestry

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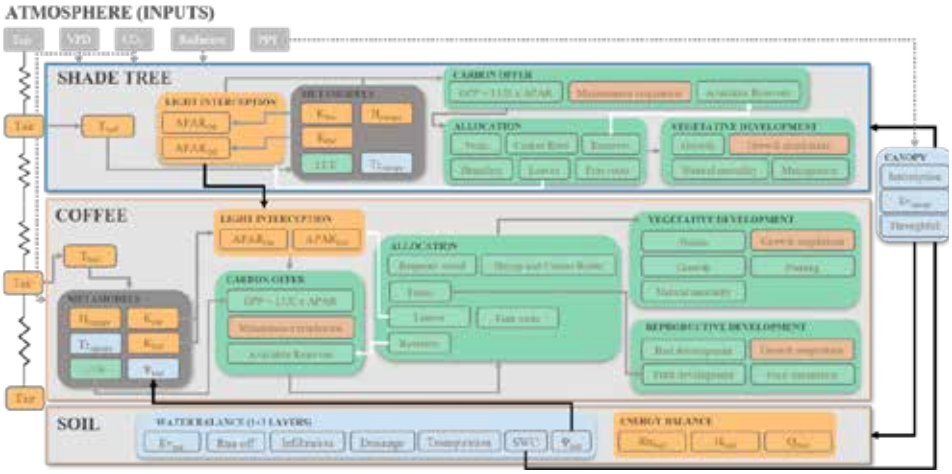
Agroforestry systems (AFS) are complex to model mainly due to the high spatial variability induced by the shade trees. Recently, the microclimate and light heterogeneity issue in AFS has been addressed using the 3D ecophysiological process-based model MAESPA (Charbonnier et al., 2013; Vezy et al., 2018). MAESPA surpassed the classical sun/shade dichotomy in AFS (Charbonnier et al., 2014) and provided continuous maps of e.g. available light, light-use-efficiency and canopy temperature within *Coffea* Agroforestry Systems (CAS).
A step further was to design a crop model for *Coffea* grown under agroforestry that would benefit from this continuum to estimate ecosystem services on the long term and under climate change scenarios. We designed DynA_Cof, a new process-based growth and yield model to compute plot-scale net and gross primary productivity, carbon allocation, growth, yield, energy, and water balance of CAS according to shade tree species and management, while accounting for fine-scale spatial effects using MAESPA metamodels (Figure 1). DynA_Cof satisfactorily simulated the daily plot-scale gross primary productivity (RMSE= 1.69 g_C m^{-2} d^{-1} on 1562 days) and the energy and water balances (RMSE: AET= 0.63 mm d^{-1}, H= 1.27 MJ m^{-2} d^{-1}, Rn= 1.98 MJ m^{-2} d^{-1}) compared to measurements from an eddy-flux tower in Aquiares (Costa Rica) and also the NPP for above and below-ground organs, coffee bean yield and shade tree wood production compared to a comprehensive database from this site.



Detailed DynACof model workflow. The air temperature is recomputed within the shade tree layer and Coffea layer canopy, and above soil surface using a series of resistances. The precipitation interception, evaporation and throughfall are all computed at plot scale. Carbon-related computations are coloured in green, energy-related in orange, and water-related in blue. Black arrows represent the interactions between layers, grey arrows the interactions within a layer, and white the retro-actions. VPD: vapor pressure deficit, PPT: precipitations, T: temperature, Ψ: water potential, LUE: light use efficiency, K: light extinction coefficient, Tr: transpiration, GPP: gross primary productivity, APAR: absorbed photosynthetically active radiation, Ev: evaporation, SWC: soil water content, H: sensible heat, Rn: net radiation, Q: heat storage.

Keywords: process-based, Coffea arabica, Erythrina, NPP, growth.

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