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Introduction

The Agri-PV concept refers to the combination of both agricultural and electrical productions on the same area. The presence of photovoltaic panels above a crop implies sharing of sunlight. The panels create shading on the crop and thus reduce the light available for plants. Previous studies has already been done to evaluate this association. The results are conclusive but optimization still needs to be done. It is essential to define strategies in order to determine the optimum orientation of the PV modules that are favourable for crop growth. First, a modelling approach is done in order to understand the interaction between the plant and the irradiation. Indeed, in order to adapt plant growth models, it is necessary to define new formalisms.

Context

This work is supported by the quite new installation of a demonstrator on the EDF Lab les Renardières site (Seine-et-Marne, 60 km south of Paris). It consists of a structure equipped with photovoltaic panels located 4.5m above the ground on a surface area of 3000 m², half of which is in the control zone. In addition, the panels are located on trackers that allow them to be oriented along two axes of rotation. This demonstrator will serve as an experimental support to test the hypotheses put forward.

Our study based on three models

The study seeks to estimate electricity and agricultural production in this context and for different crops. The aim is to optimize these two types of production. To do this, the simulations are based on three models:

- L-egume is an individual based model on fodder crops. This model simulates the dynamics of grassland communities but accurately computes the interception of radiation by the plant. This model will thus be used to understand the changes observed experimentally in shade situations.
- The second model used is the STICS crop model. It is widely used and can simulate a large number of crops. This more simplified model of radiation interception will allow optimization between the power generation and the crop production.
- Both crop growing models are coupled with a ray-tracing model (PVarray) that allows to determine the irradiation on top and below the PV panels at any time during the whole year.

The way the input variables are couples with the modelling bricks is shown in the illustration below (Figure 1). From the irradiation below the panels, the local microclimate is calculated, which allows to predict crop growth.

Future investigation of the study

In the rest of the work, the objective is to calibrate and adapt the model by conducting experiments on different crops in the Agri-PV context. To do this, it will be essential to take into account the interception of radiation at the height of the vegetation cover in the presence of the panels and their inclinations. Infraday dynamics will also be studied to determine a photosynthesis threshold to control shading. From an operational point of view, the interest will be to provide the most efficient panel orientation algorithm for the association.

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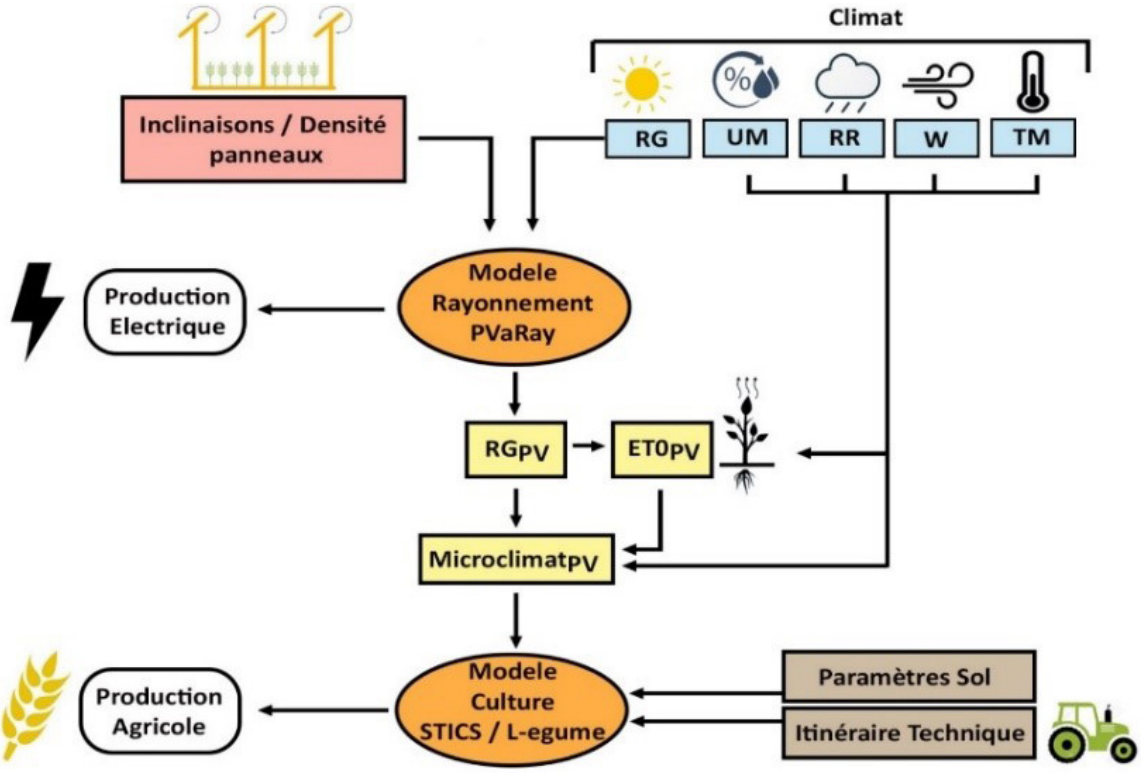

Agri-PV simulation block diagram.

Keywords: agrivoltaic, shade, modelling, crop.

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