A GIS-based Method for Assessing the Potential Agronomic Impact of Agrivoltaics in Grassland

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INTRODUCTION

- Agrivoltaics (Agri-PV) on grassland offers a promising solution to support renewable energy deployment and maintain agricultural productivity.
- Key challenge: assessing the agronomic impact of PV shading across diverse soil, climates and configurations using geospatial analyses [1].
- The open-source Python Agrivoltaic Simulation Environment (PASE) [2] can be enhanced for territorial analysis.

OBJECTIVES

- Evaluate how design parameters (GCR, panel height/orientation) in Tab.1 affect crop yield using 3D simulations and parametric grassland model (Gras-Sim) [3], EU databases (ESDB [4; 5], CORINNE) and meteo databases (PVGIS, Agri4Cast).

Tab. 1: Four configurations used in the study.

Configuration	Tilt (°)	Azimuth (South=180°)	Height (m)
Canopy	12	232.5	5
Vertical	90	90	3
South-oriented (2m height)	25	180	2
South-oriented (1m height)	25	180	1

METHODOLOGY

- Relative yield, the average biomass under panels (40 regularly spaced samples in Fig.1, x-axis transect) divided by the control region (no panels), averaged over 10 years.
- Each configuration is simulated for GCR values between 0.2 and 0.5, with the transect length equals to twice the row spacing.

$$Rel_{yield}\,[\%] = 100\,x\,\frac{Productivity_{\mathrm{crop,AV}}}{Productivity_{\mathrm{crop}}}$$

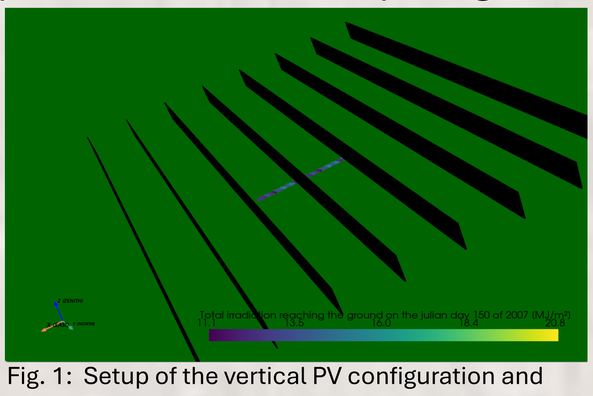

Fig. 1: Setup of the vertical PV configuration and choice of the interest region.

- PFT composition: 100% PFT A.
- No fertilisation.
- Mean sward height: 5cm.
- Five cuts per year.
- Fixed dates (18/05, 23 /06, 17/07, 18/09, 14/11).
- Single hourly simulation run on the centroid for each pedo-climatic region averaging on the soil parameters (sand, clay, coarse fragment) with uniform soil depth in the region [4].
- Benchmark on the Walloon region, Belgium (139 regions).

RESULTS AND DISCUSSION

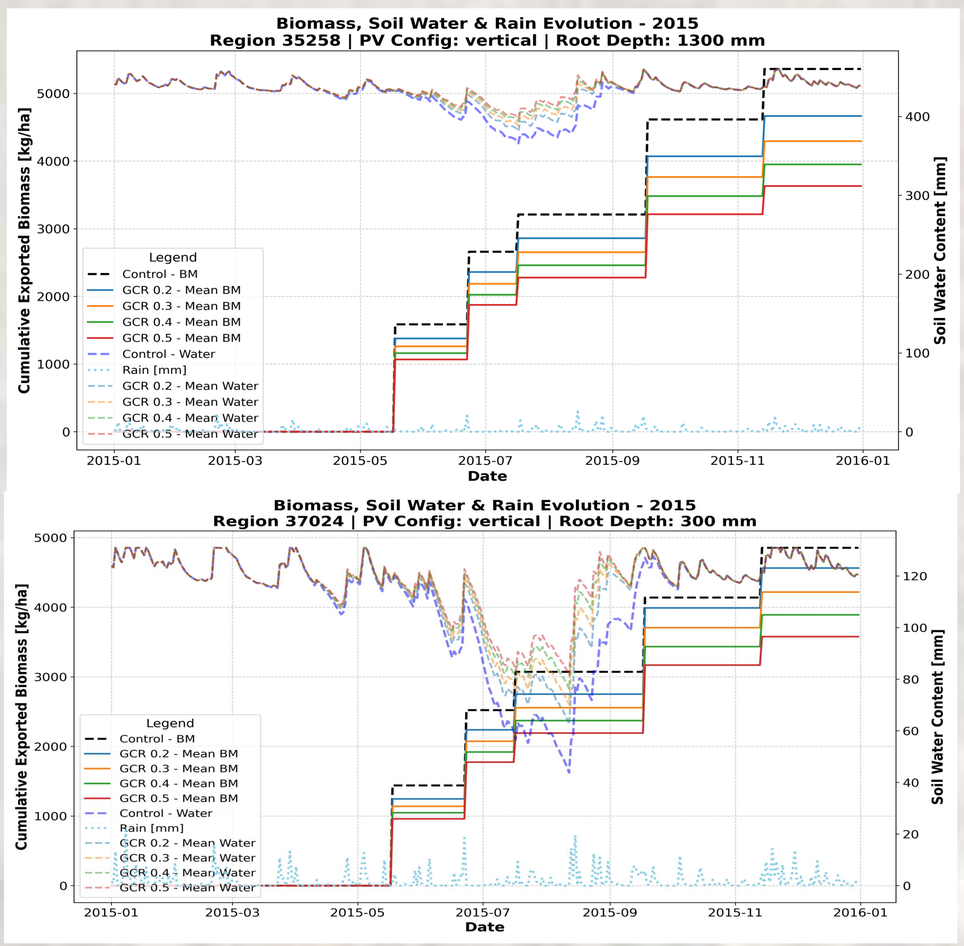

Fig. 2: Harvested biomass and water availability (year 2015) for two contrasted regions.

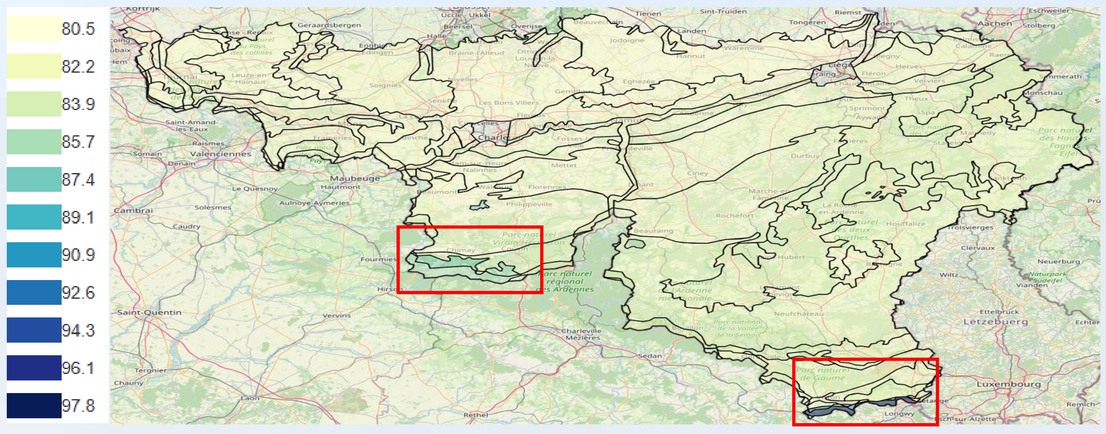

Fig. 3: Maximal Rel_{yield} (300mm root depths underlined). Vertical configuration with GCR=30%.

- An interannual and interregional variability is observed, with differences up to 18% on the Rel_{yield} in Wallonia (Fig.2, Fig.3) .
- While the overall effect of Agri-PV remains limited (e.g. vertical configuration), it can mitigate drought phenomena (at lower root depths), leading to Rel_{yield} values exceeding 100% (Fig. 4).

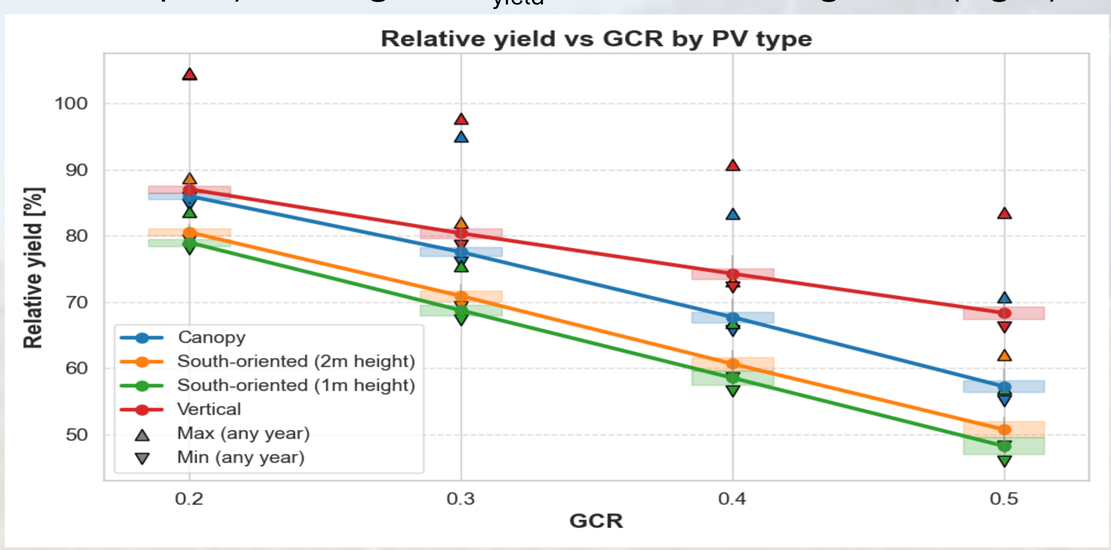

Fig. 4: Mean, maximal and minimal Rel_{yield} evolution per ground cover ratio and PV type.

- Configurations with lower height and higher GCR lead to higher crop shading, reducing the Rel_{yield} (Fig. 4).
- More homogeneous light distribution in vertical and canopy setups leads to higher Rel_{yield}.

FUTURE INSIGHTS

- Alternative management practices, such as free-range grazing dynamics, may have an impact into biomass simulations.
- Improve spatial resolution and refine assumptions on soil depth variability for accurately assessing the impacts at regional scale.
- Improved access to high-resolution meteo data enables to study more than a single-point simulations per region.
- The model neglects the PV structure shading, field slope, local microclimate, lateral water transfer and runoff phenomena.

CONCLUSION

- A GIS-based simulation with PASE enables large-scale assessment of Agri-PV impacts on pastures, with limited hardware request.
- This scalable method can be extended to EU studies for Agri-PV tools and planning.
- Taller designs and vertical configuration, with GCR up to 30%, preserve the crop productivity and can even enhance it.

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