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Sensitivity and Uncertainty Analysis of Algae Production Models for Flat Panel Photobioreactors

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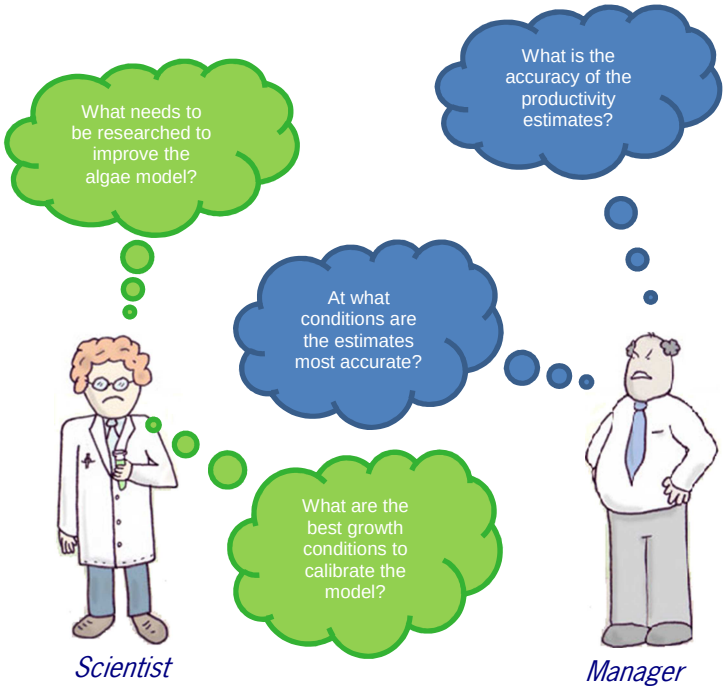
Introduction

Technical, techno-economical, and life cycle assessment studies guide the research and development effort in algae technology. Large scale biomass productivities irrespective of production locations, system layout, algae species, and weather conditions are used. A model for flat panel photobioreactors has been developed to study large scale biomass productivity as a function of decision variables (Slegers, et. al. 2011). In this work we study the accuracy of the model.



Approach

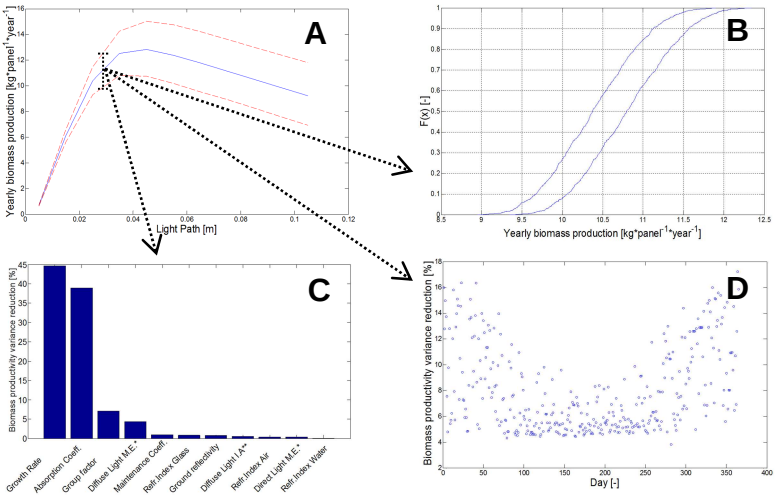
First, the uncertain parameters and model structures are assigned limits based on experience. Second, some physical and biological parameters are assigned probability distributions based on reported experiments. The uncertainty is propagated by constrained optimization and pseudo-Monte Carlo simulation.

Then, the expected reduction in the biomass productivity variance on neglecting uncertain factors is estimated. Finally, the same is done for parameters suitable for calibration. These global sensitivity analyses are carried out with quasi–Monte Carlo methods.

Results

Analyses of the model for scenarios used in the original work of Slegers, et al, 2011 show:

- The biomass productivity estimates are within 35% of the true values. [Fig 1,2]
- Biomass productivity estimates are more accurate at shorter light paths. [Fig 1,2]
- The maximum algae growth rate and algae light absorption coefficient are the most influential and should be researched first. [Fig 3]
- Calibration parameters are most sensitive and should be estimated on short, cloudy days. [Fig 4]



Simulations for P. tricornutum *(The Netherlands, weather data from 2009)*
A) *Bounded accuracy of the biomass productivity estimates for various light paths at 3.5 kg*m^{-3} biomass.*
B) *Imprecise probabilities of the biomass productivity estimates at light path 0.03 m.*
C) *Sensitivity analysis on yearly basis at light path 0.03 m.*
D) *Sensitivity analysis on daily basis at light path 0.03 m for the Group Factor (calibration parameter)*
**M.E. = Measurement error, ** I.A. = Incidence angle*

Conclusion

The flat panel photobioreactor models of Slegers, et al, 2011 are reasonably accurate for use in technical, techno-economical, and life cycle assessment studies. This is valid as long as they are used for scenarios discussed in that work. The next step is to prove that results/trends apply in general, e.g. all countries, algae species, etc.

Reference: Slegers, P. M., Wijffels, R. H. ,et al. (2011). "Design scenarios for flat panel photobioreactors." Journal of Applied Energy 88(10): 3342-3353.

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