ComPhot

Learning Platform for Computational Photosynthesis

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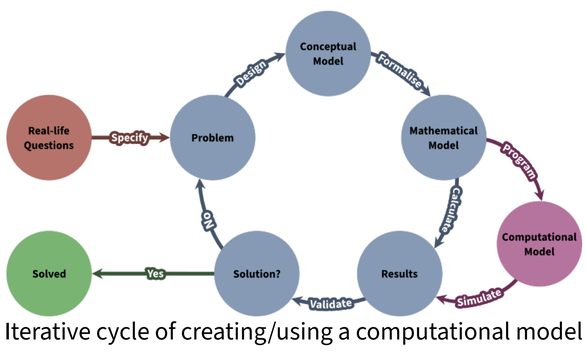
Motivation

- Computational modelling allows a simplified, but cost-effective approach to system simulation
- Translation of complex construct into known mathematics

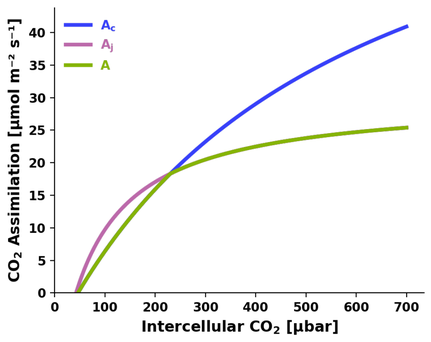


Iterative cycle of creating/using a computational model

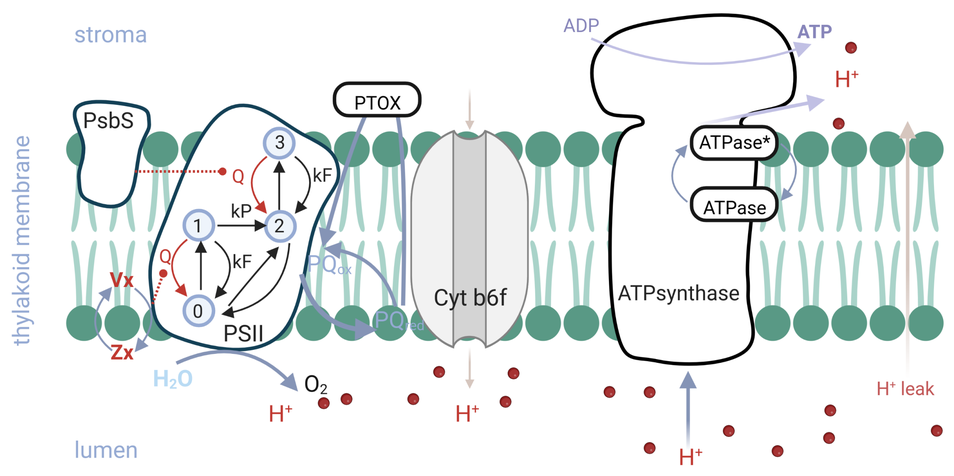
- Goes through an iterative cycle to find a viable answer to a problem
- Rise of complexity also means rise of programming need

Implementation

- No-code, simple WebApp based on Streamlit[1]
- Seperated versions based on differences of biological knowledge
- Includes different mediums to show introductory teaching materials
- Gives in-depth explanation of modelling and provides several examples of models of photosynthesis, e.g. Farquhar, von Caemer, Berry *(FvCB)* model[2] of carbon assimilation



Result of interactive FvCB model



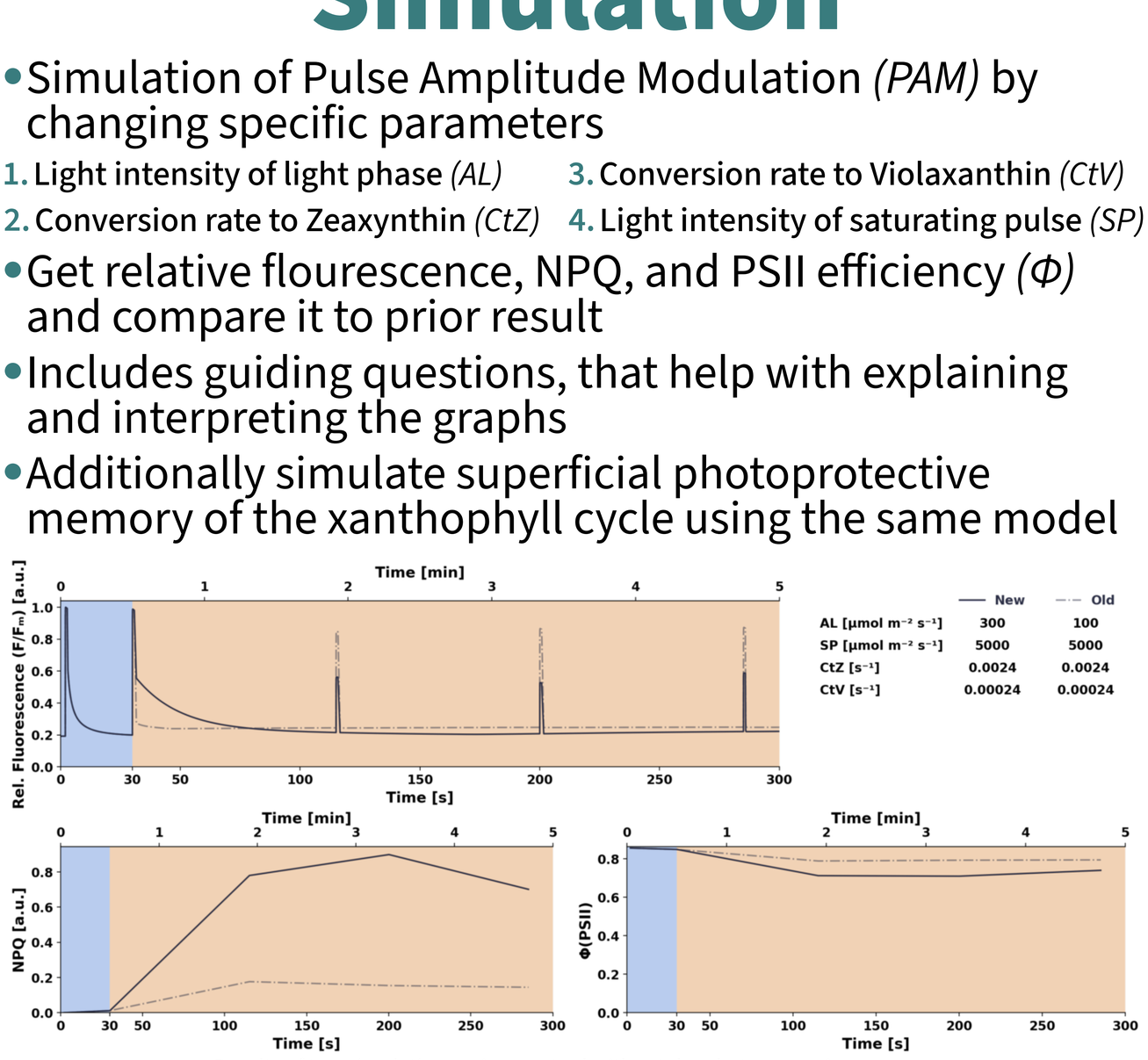
Model

- Only includes processes affecting/regulating non-photochemical quenching *(NPQ)*[3]
- Uses in-house package *modelbase* and solely Python
- Strict reductionist approach allows system of six ordinary differential equations

1. The reduced fraction of the plastoquinone pool *(PQH_2)*
2. The stromal concentration of ATP *(ATP)*
3. The luminal proton concentration *(H^+)*
4. The fraction of non-protonated proteins *(PsbS)*
5. The fraction of violaxanthin in the total pool of xanthophylls *(Vx)*
6. The fraction of active ATPase enzyme *(ATPase*)*

Simulation

- Simulation of Pulse Amplitude Modulation *(PAM)* by changing specific parameters
  1. Light intensity of light phase *(AL)*
  2. Conversion rate to Zeaxynthin *(CtZ)*
  3. Conversion rate to Violaxanthin *(CtV)*
  4. Light intensity of saturating pulse *(SP)*
- Get relative flourescence, NPQ, and PSII efficiency *(Φ)* and compare it to prior result
- Includes guiding questions, that help with explaining and interpreting the graphs
- Additionally simulate superficial photoprotective memory of the xanthophyll cycle using the same model



	New	Old
AL [µmol m⁻² s⁻¹]	300	100
SP [µmol m⁻² s⁻¹]	5000	5000
CtZ [s⁻¹]	0.0024	0.0024
CtV [s⁻¹]	0.00024	0.00024

Results of two simulations using our tool without the photoprotective memory

Open-Source

- Project is completely available to public
- Code is modular, so own changes can easily be done locally
- Tool is available in various languages:
- We encourage making changes which we may implement in the future, e.g. more translations
- Contact us for any questions or wishes for changes! (elouen.corvest@rwth-aachen.de)

Article

References

[1] S. Inc., "Streamlit • A faster way to build and share data apps," Streamlit, https://streamlit.io/ (accessed Jun. 14, 2024).

[2] G. D. Farquhar, S. von Caemmerer, and J. A. Berry, "A biochemical model of photosynthetic CO2 assimilation in leaves of c3 species," Planta, vol. 149, no. 1, pp. 78–90, Dec. 1980. doi:10.1007/bf00386231

[3] A. Matuszyńska, S. Heidari, P. Jahns, and O. Ebenhöh, "A mathematical model of non-photochemical quenching to study short-term light memory in plants," Biochimica et Biophysica Acta (BBA) - Bioenergetics, vol. 1857, no. 12, pp. 1860–1869, Sep. 2016. doi:10.1016/j.bbabio.2016.09.003

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