Simulation of a reference line for plant growth in *Ficus benjamina*

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In the Netherlands, ca 80% of the total energy consumption by agriculture in 2010 was used for cultivation under glass, which covered only 0,5% of the total utilised agricultural area.

EUROSTAT, 2016

Set-up

Experiment

- *Ficus benjamina*
- March – June 2016
- Ornamental Plant Research Centre (PCS)

Goal

- Collecting data on plant development of *Ficus benjamina*
- Simulating long-term stem diameter variations and growth based on simulated transpiration
- First step towards integrated plant-greenhouse model

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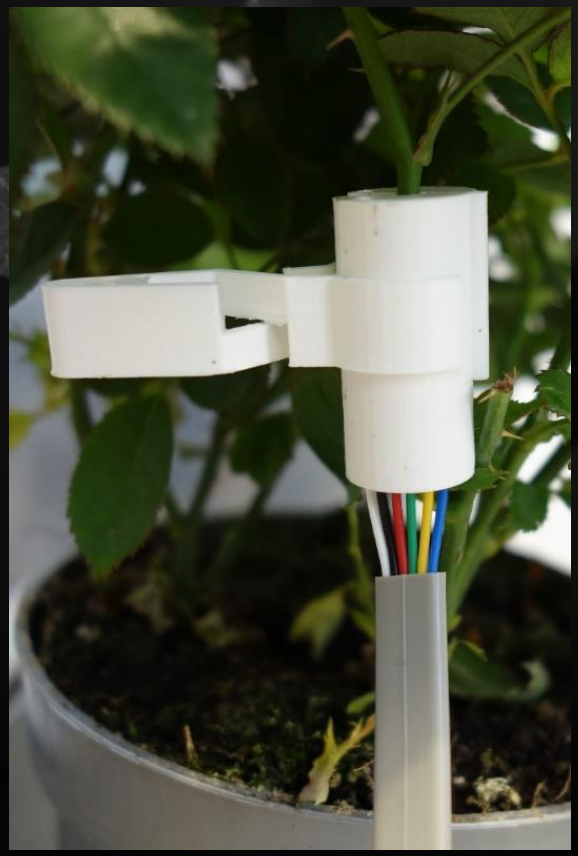
Continuous plant-based measurements

Stem diameter variations and growth: LVDT

Sap flow: custom-built mini-HRM



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Discrete plant-based measurements

- Leaf area
- Projected crown surface area
- Stomatal conductance
- Stem water potential
- Photosynthesis

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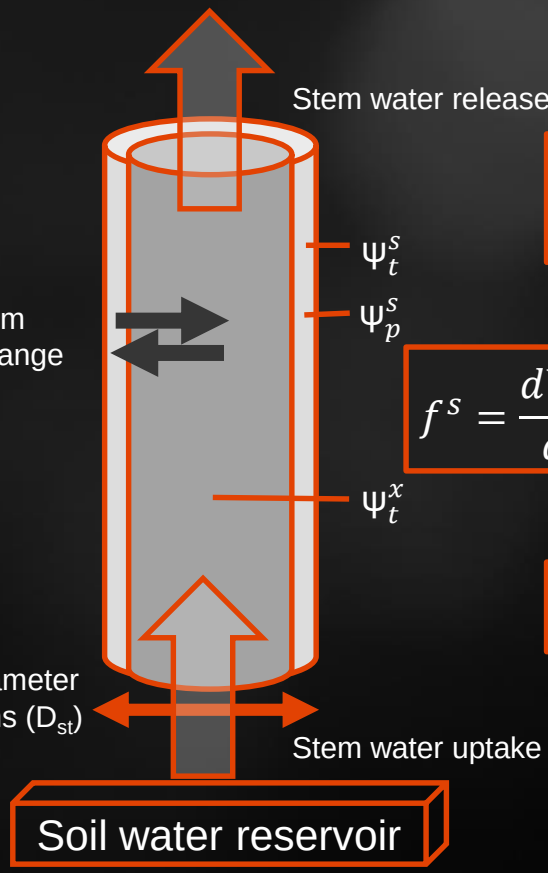
Stem diameter variation and growth mechanisms



$$\Psi_t^s = \Psi^m + \frac{W^s}{C^s}$$

$$V^s = \frac{a.\pi.L.D_{st}^2}{4}$$

$$\frac{dD_{st}}{dt} = \frac{1}{2.\varepsilon_0.\Psi_p^s}\frac{d\Psi_p^s}{dt}$$

$$f^s = \frac{dW^s}{dt} = \frac{\Psi^m - \Psi_t^s - R^x.F_{st}^x}{R^x + R^s}$$

$$\frac{d\Psi_p^s}{dt} = \frac{\varepsilon_0.D_{st}.\Psi_p^s}{\rho_{H_2O}.V^s} f^s$$

NO

$\Psi_p^s > \Gamma^s$

YES

$$\Psi_t^x = f^s.R^s + \Psi_t^s$$

$$\frac{dD_{st}}{dt} = \frac{1}{2.\varepsilon_0.\Psi_p^s}\frac{d\Psi_p^s}{dt} + \frac{D_{st}}{2}\Phi^s.(\Psi_p^s - \Gamma^s)$$

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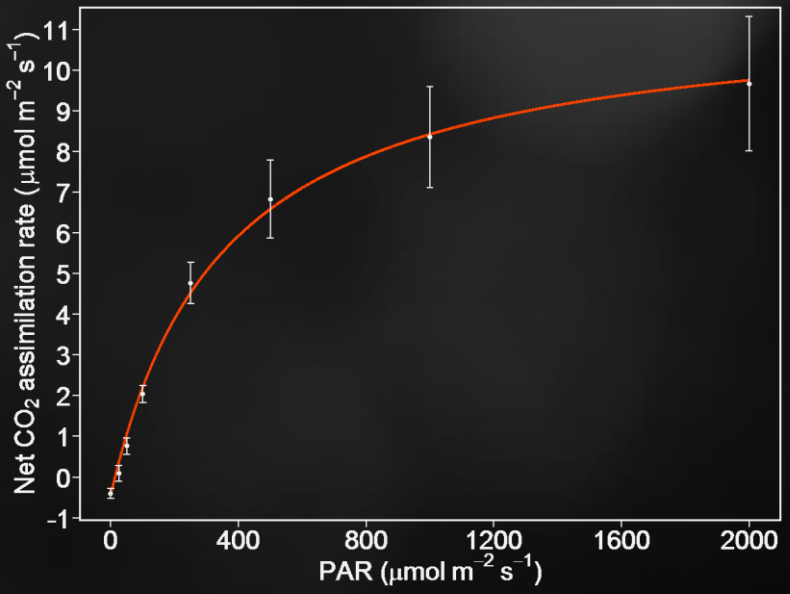
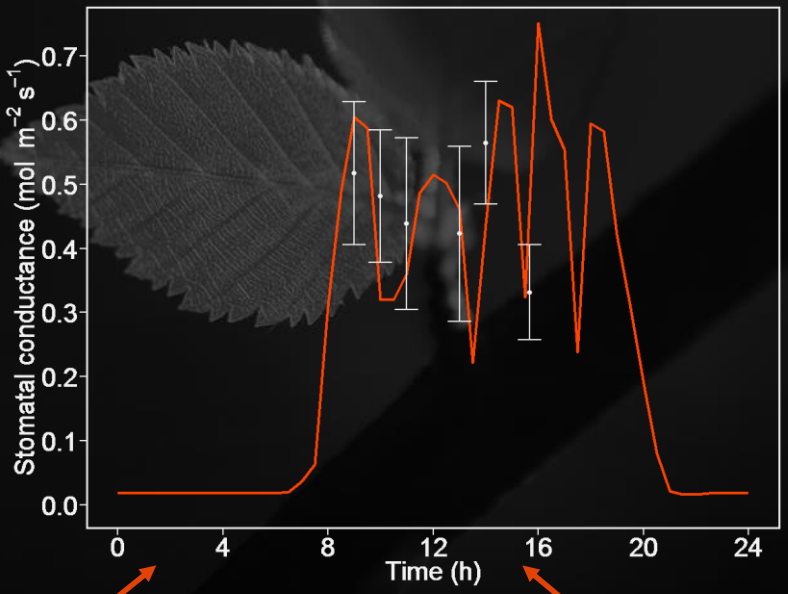
Simulation of photosynthesis and stomatal conductance

Rectangular hyperbola



Stomatal conductance model



Vapor pressure deficit

CO_2 concentration

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Simulation of transpiration

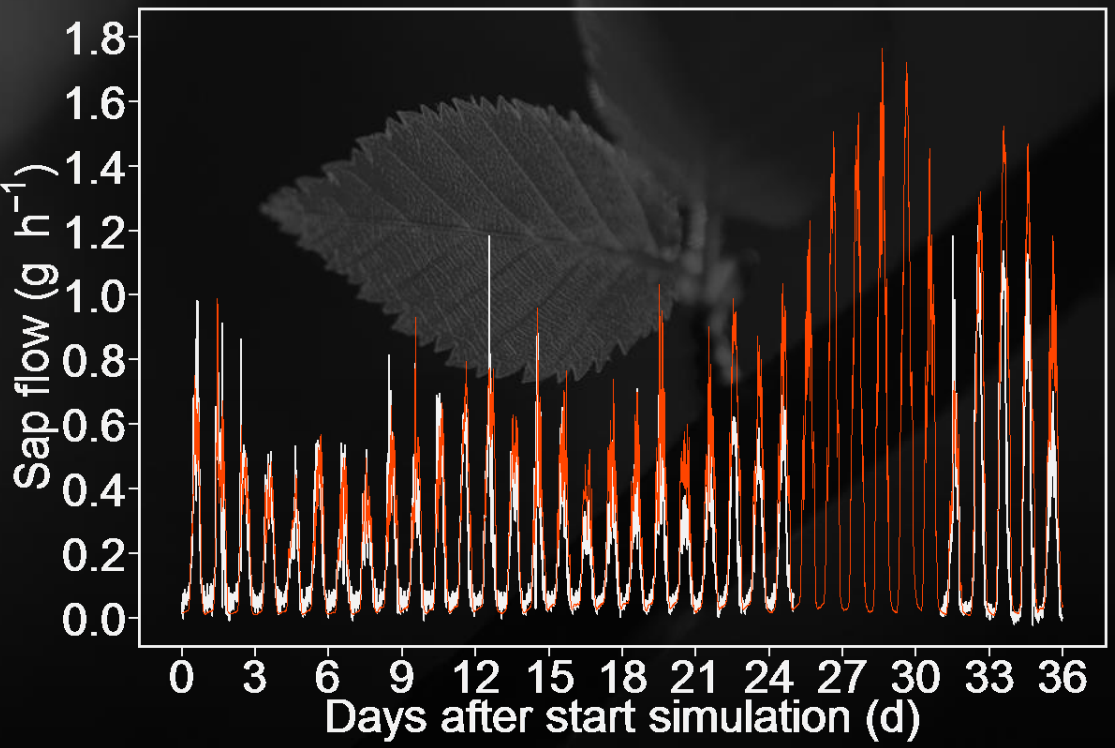
Penman-Monteith equation

Projected crown surface area

Leaf area index

Stomatal conductance

Environmental variables + leaf temperature



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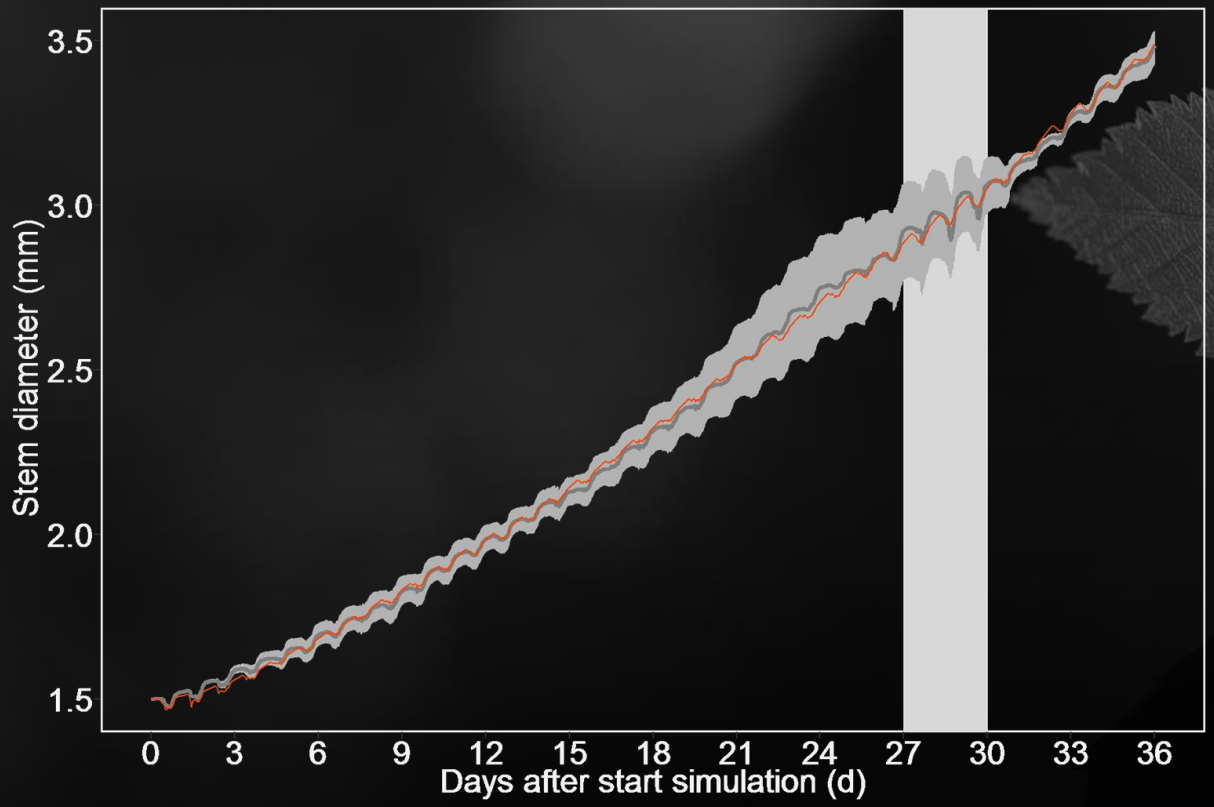
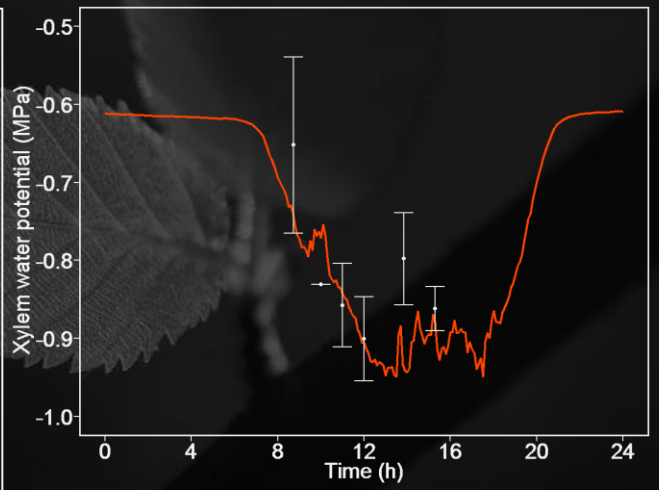
Simulation of stem diameter variation and growth

Mechanistic stem diameter model





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Stress detection

- Using a moving window calibration
- 2-day calibration, 1-day simulation
- Error bar on simulation
- Stem diameter < lower error bar → alarm

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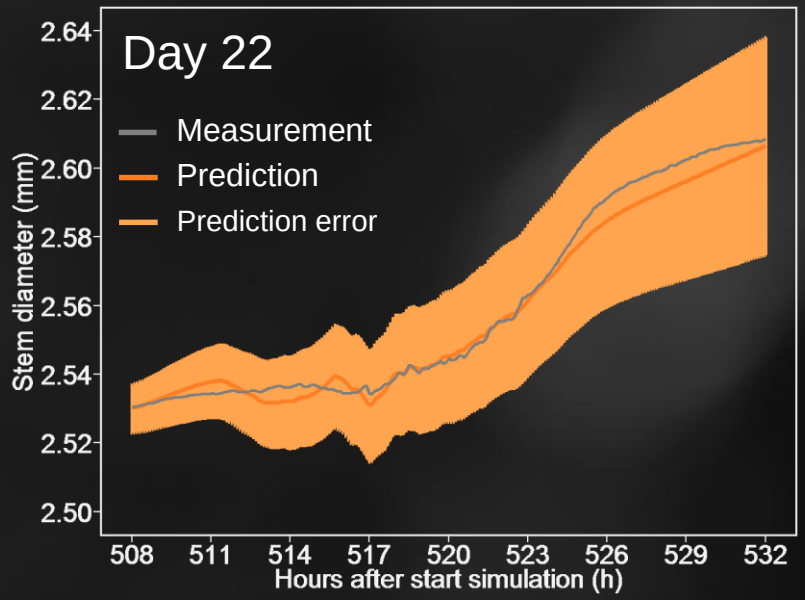
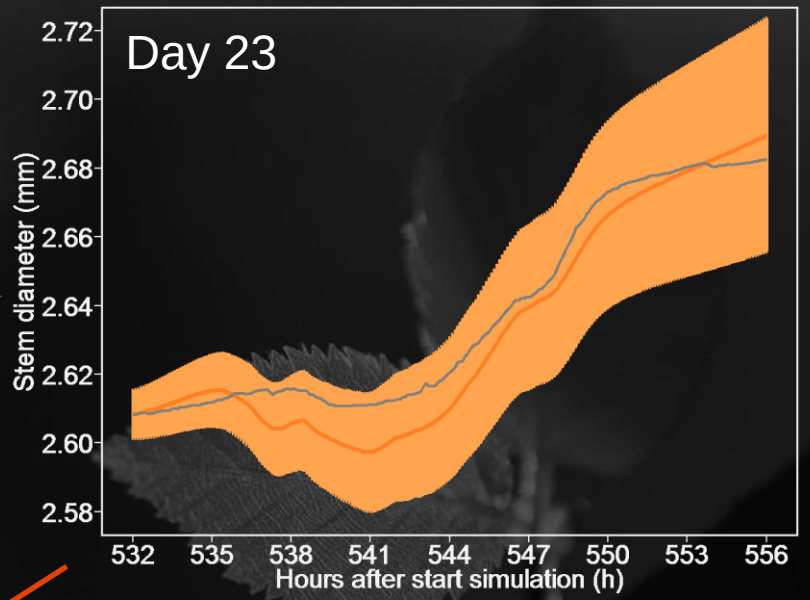
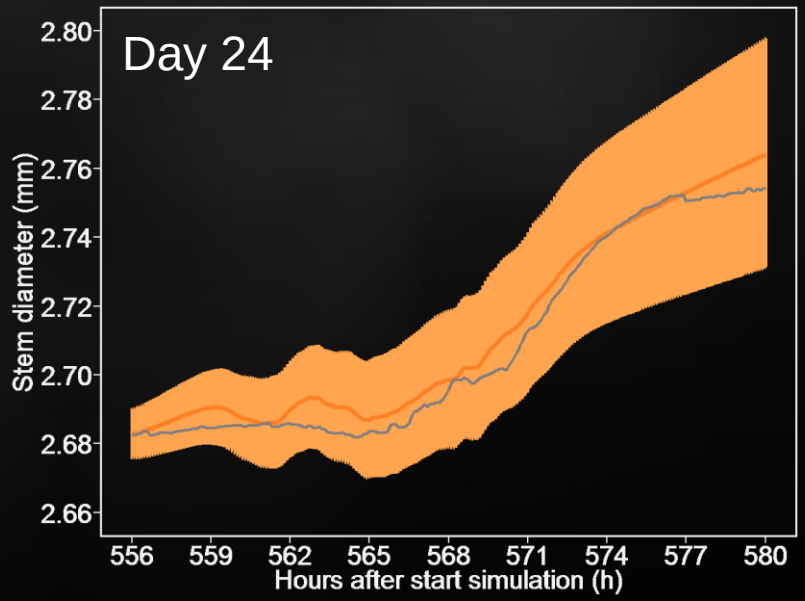
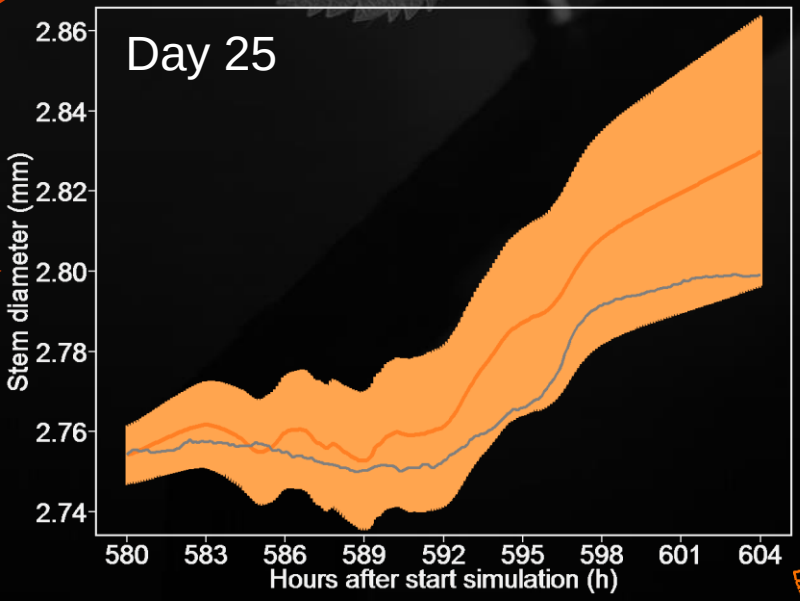
Stress detection









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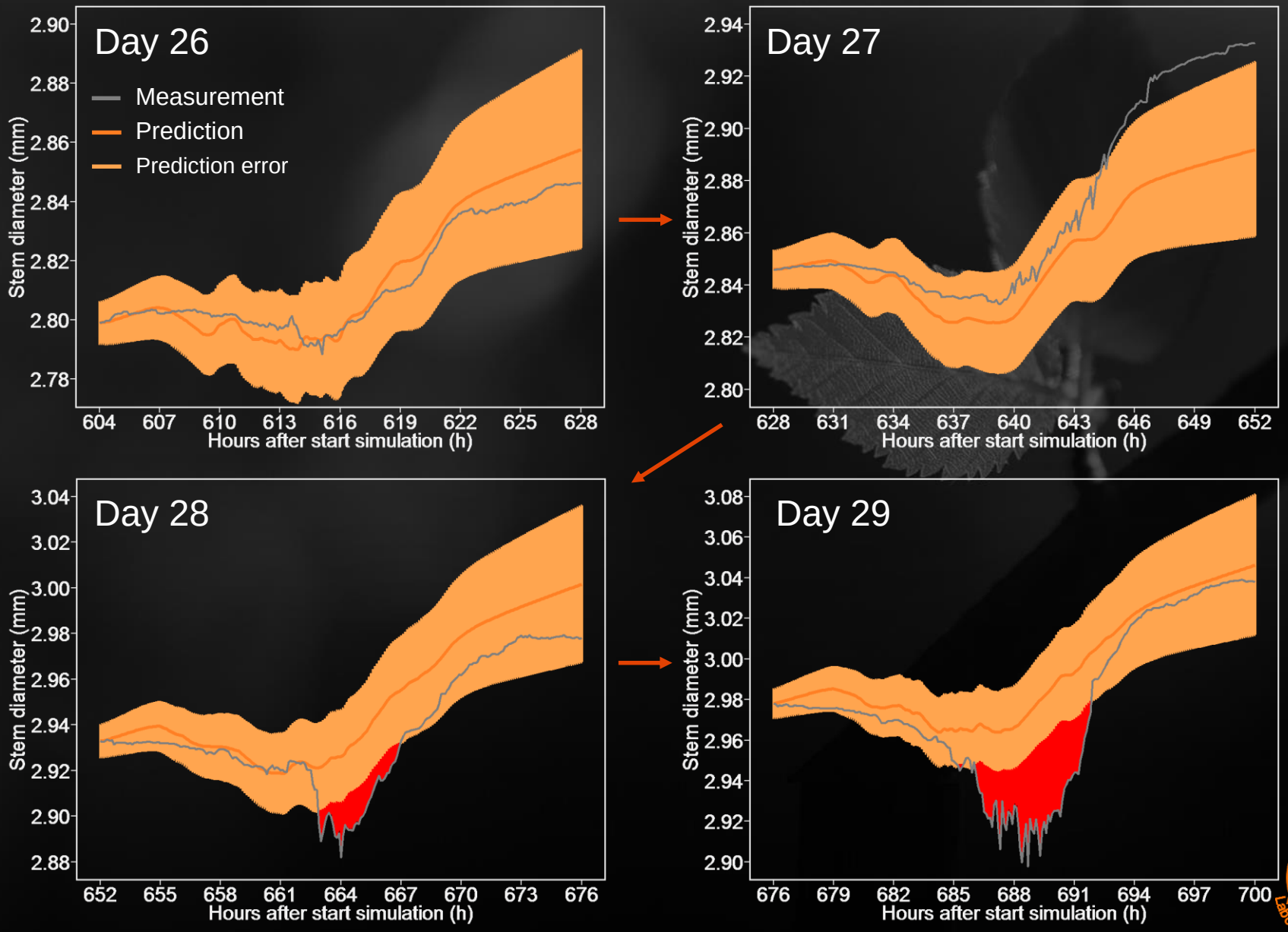

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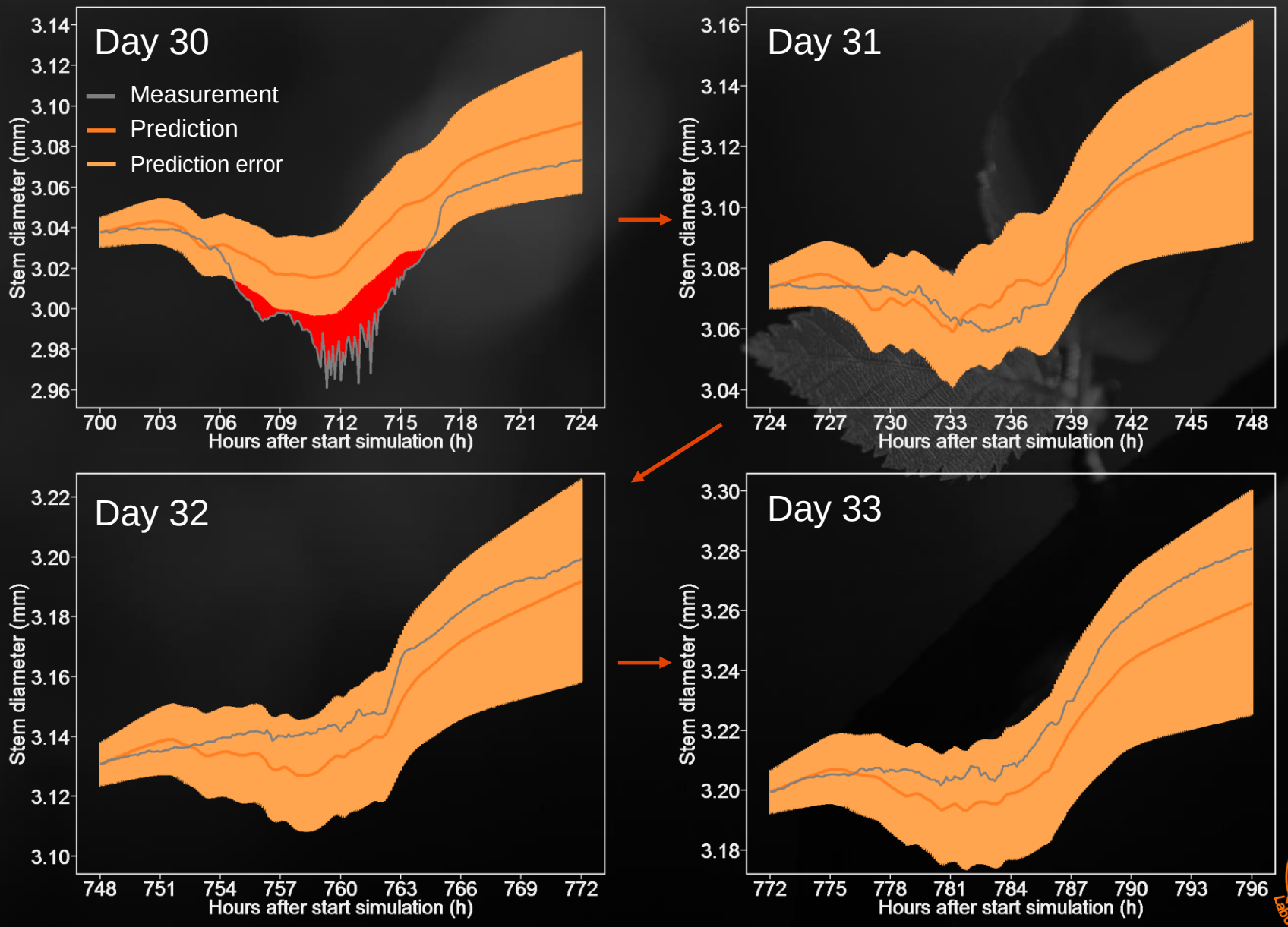
Stress detection



Conclusions

- Long-term stem diameter variation and growth were successfully simulated
- Using simulated transpiration is an important step towards an integrated plant-greenhouse model
- Plant stress can be detected by using a moving window calibration

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Future research

- Test model on *Rosa chinensis*
- Develop integrated plant-greenhouse model
- Possible improvements:
  - Use Farquhar model instead of rectangular hyperbola
  - Describe cell wall extensibility, projected crown surface area and leaf area index based on microclimate

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Thank you for your attention!

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Vlaanderen is ondernemen

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